Fertilisers

16 July 2021

Mining

Potash & Phosphate - Investing in Global Growth

Summary

- **Global population forecast to peak at 9.7Bn in 2064**
- Decreasing arable land implies increasingly higher fertiliser consumption
- Global transition from wheat/rice, toward proteins and fruit/vegetables
- 30-50% of modern crop yields reliant on natural and/or synthetic fertilisers
- Global potash demand over the past six years ~ 3.1% CAGR
- 26-year seaborne potash demand ~2.4% CAGR
- Est. 34% upside from spot to our LT potash price
- 21-year seaborne phosphate shipments growing ~2.8% CAGR
- Est. 50% upside from spot to our LT phosphate-rock price
- **BUY Recommendation Nutrien (TSX: NTR) and Mosaic (NYSE: MOS)**

The fertiliser industry for the better part of a decade, has been plagued by overcapacity and poor utilisation. Our analysis suggests that fundamentally, both the potash and phosphate consumption is approaching production constraints. Unlike other commodities, the demand drivers for these two fertilisers are related to long-run improvements in human habitation. As economies develop and become more technologically advanced, hard commodity requirements lessen, but in contrast, consumption of proteins, fruit and vegetables have increase dramatically. To sustain this dietary transition, coupled with an increasing global population, the continued economic development in many jurisdictions is directly related to the unremitting growth and supply of fertilisers.

We think that fertilisers are an opportunity to invest in global growth and development without the risk of strong price fluctuations as seen in other commodities, which are more leveraged to the ongoing business cycle.

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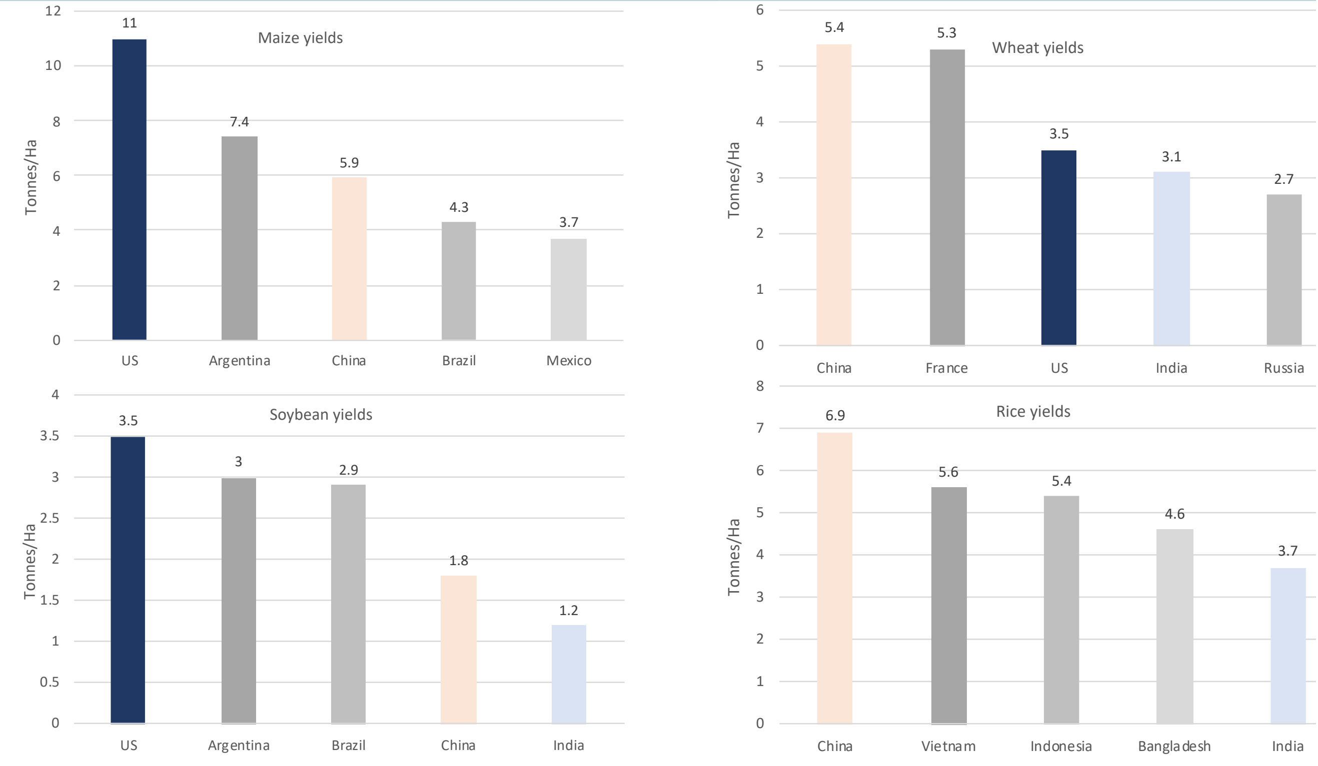
Introduction – Potash, Phosphate and Nitrogen

Potash, phosphate and nitrogen are natural fertiliser substances used in the agricultural industry. Some conservative estimates suggest that 30-50% of modern crop yields can be directly attributed to the application of natural and/or synthetic commercial fertilisers. As a result of agricultural extraction, a variety of macro- nutrients can become so depleted that their absence can inhibit the normal biological process. An optimal fertiliser application involves a combination of all three of these crop macro-nutrients, each have different biological attributes, and for the most part, do not compete with one another. Typically, soils that are rich in one area are normally deficient in another.

Figures 1, 2, 3 & 4: Fertiliser consumption patterns vary dramatically from country to country and crop-type to crop-type. Weather, geography and soil differences in soil quality imply that not all regions are able to achieve the same yields. The US is the biggest producer of maize and soybeans, while China is the largest producer of rice; both rely on significant applications of fertiliser.

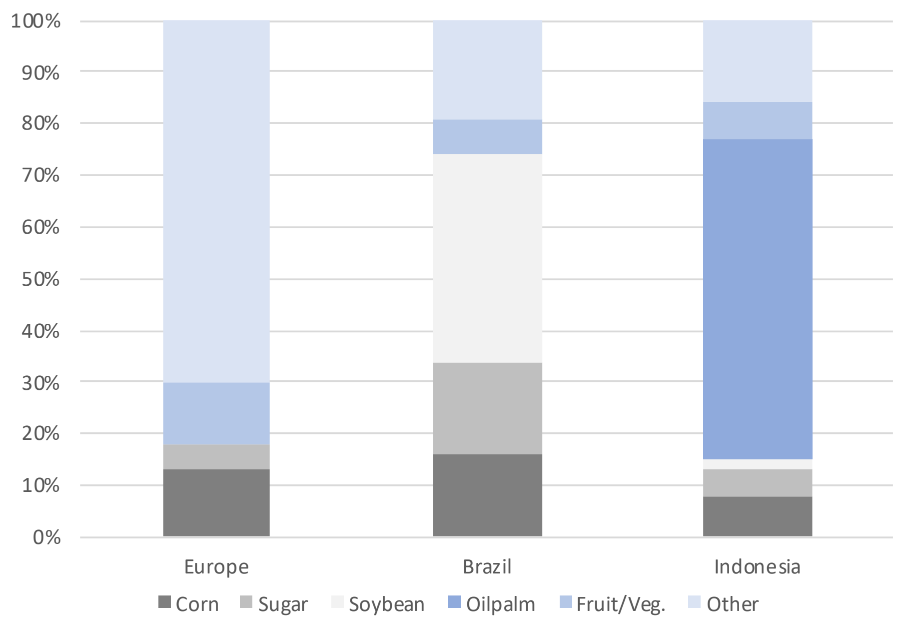


Source: FAOSTAT (2016), FD

The Green Revolution describes a period post WWII, associated with the development of high-yield cereal crops, the expansion of irrigation infrastructure, pesticides, and critically, the application of fertilisers. The net result was that the price of corn, rice and other staples became 75% lower in real-terms by the middle of the 1980s than what they were in the 1950s. Furthermore, prices remained at those lower levels, largely achieved without the expansion of farmland and/or pasture via increasing yields. Presently, cereals account for more than half of the world's food consumption (if grain for livestock is included), with yields averaging three tonnes per hectare, approximately double that of the 1960s (see Figures 1 to 4, e.g. coming Indian soybean yields with that of the US).

Potassium (Potash) - has been biologically proven to improve root strength, water retention, yield, nutrient value, taste, colour, texture and disease resistance of food crops. With a high solubility, it leaches quickly out of rocky or sandy soils that typically display potassium deficiency. It serves as an activator of enzymes in photosynthesis and respiration, is used to build cellulose and aids the formation of a chlorophyll precursor. In China, the cultivation of fruit and vegetables consumes 50% of its domestic potash demand, with rice taking a further 28%. In Brazil, 75% of its potash is utilised to produce soybean, sugar cane and corn cultivation (see Figure 5). In Malaysia and Indonesia, 70% of potash is directed toward palm oil cultivation. More than 45% of potash consumed in the United States is dedicated to growing corn, much of it is eventually directed toward feedlot and biofuel industries. By contrast, India produces no potash domestically, but consumes six times more nitrogen as a result of high import duties and domestic subsidies.

Figure 5: Potash by selected country.



Source: FAO (2017), FD

Phosphorus (Phosphate) – helps with photosynthesis and plays a major role in biological molecules such as RNA and DNA, forming part of the structural framework. It is also an important component of bones and teeth, and is a critical constituent in the molecule adenosine triphosphate, more commonly known as ATP; used to transport cellular energy in all living cells. Known as "life's bottleneck" because it makes up 1% of an organism, but is only present in 0.1% of the Earth's crust (primarily granites).

Nitrogen builds proteins and enzymes, being a critical component in all amino acids and is present in nucleic acids. It is used in chlorophyll molecules, essential for photosynthesis and further growth. Nitrogen can be introduced into the soil several ways; organically via the growth of legumes (e.g. soybeans, peas and peanuts), or commercially, by sourcing hydrogen from natural gas and combining it with the atmosphere to create ammonia (NH_3). Ammonia is produced by reacting nitrogen with hydrogen from natural gas in a high P/T (200-300 bars and around 450°C) via the Haber process. The resultant anhydrous ammonia is then stored as a liquid under pressure or is refrigerated, then typically converted into other types of fertilisers. Urea is produced in a reaction of ammonia with carbon dioxide at high pressure. Ammonium nitrate and urea can be further combined (colloquially known as UAN) and the resultant concentrate is then converted into a solid granular form.

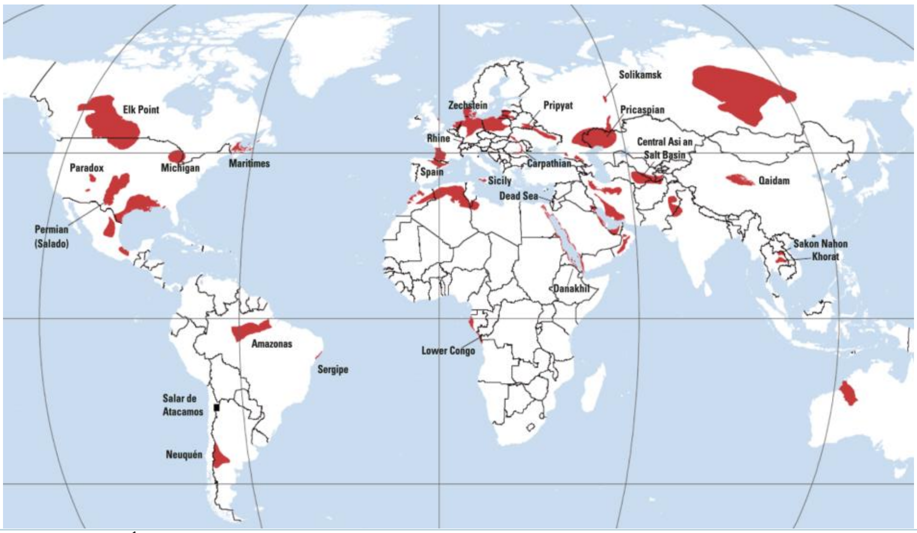
Although Nitrogen is a major fertiliser sector globally (e.g. ammonia, ammonium nitrate, and urea), with global production at nearly 100Mt pa, it is more of a manufacturing process, utilising natural gas as a primary feedstock and is outside the scope of this report; which concentrates on deposits that primarily display geological enrichment. Nitrogen's price and demand is strongly related to natural gas and other input costs. By contrast, potash or phosphate production costs have a greater extractive component to overall production costs, thereby a closer correlation to the eventual project profitability.

What is Potash?

Potash refers to potassium-bearing materials and compounds, the most common of which is potassium chloride (KCl). Potassium is the seventh most common element in the world and occurs in abundance. All major potash deposits are of marine origin and are formed by the evaporation of sea water under solar evaporation, usually in an arid climate. This process was repeated on and off over millions of years, resulting in salt layers with varying mineral contents and thicknesses. These layers are typically interspersed with impermeable clay preventing the various salt layers from being dissolved.

Global potash deposits typically grade around 10-30% K2O, and are found at depths of over 1km. Potassium oxide (K2O) is used to define the potassium content of fertilisers, with the conversion factor for KCl into K2O being 0.631 (KCl is typically 60- 63% K2O). Potash fertiliser most commonly comes in the form of "Muriate of Potash" ("MOP" or KCl), and less commonly in other forms such as "Sulphate of Potash" ("SOP" or potassium sulphate, K2SO4).

Figure 6: Evaporite hosted potash resources, including both potash deposits/occurrences and potash basins that could contain undiscovered economically viable deposits.



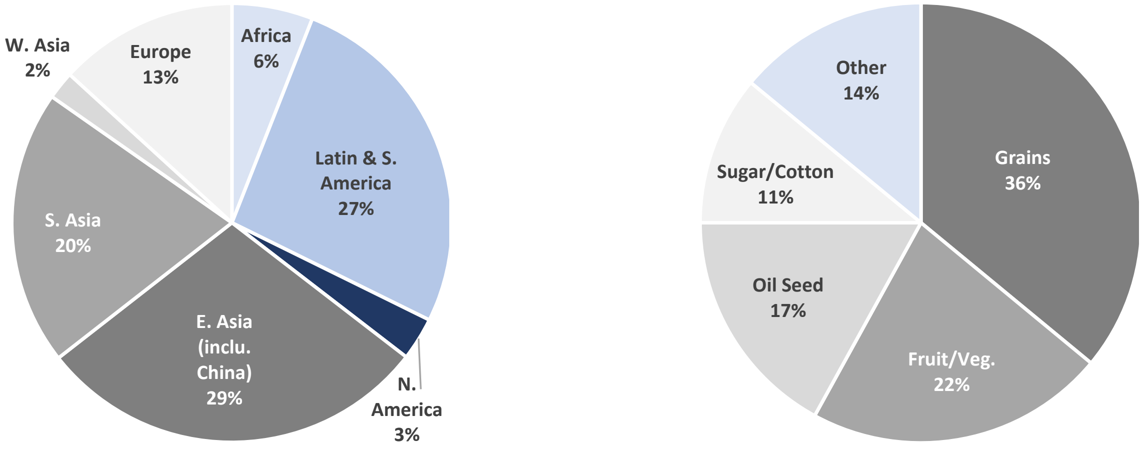
Source: Cocker *et al*.[1] (2016)

Geologically, MOP potash-bearing minerals occur naturally as sylvite (KCl), sylvinite (KCl plus salt, NaCl) or, less commonly, as carnallite (potassium magnesium chloride). Generally, sylvinite can be processed by conventional processing methods, while carnallite requires additional energy to break down the magnesium component. SOP (hydrated sulphate of potassium, containing calcium, magnesium, but no chlorine) commands a price premium of 35-45% (higher cost of production) is dominated by China, accounting for more than 45% of global demand being the world's largest producer of tobacco, fruits and vegetables; premium crops better suited to the application of SOP. Polyhalite (e.g. Sirius) has a small and relatively untested market. Many other types exist

[1] Cocker, M.D., Orris, G.J., and Wynn, J., (2016) "U.S. Geological Survey assessment of global potash production and resources..." (abbrev.) in *Geological Society of America* Special Paper 520

too. Unsurprisingly, the largest markets for potash are China (20%), Brazil (16%), the USA (15%) and India (14%) (see Figure 7); with the largest consumption by crop being grains, fruit and vegetables, oil seed and sugar/cotton, in that order (see Figure 8).

Figures 7 & 8: Geographical growth in absolute terms per region (left); and Potash use by crop, with largest consumer being grains (right).



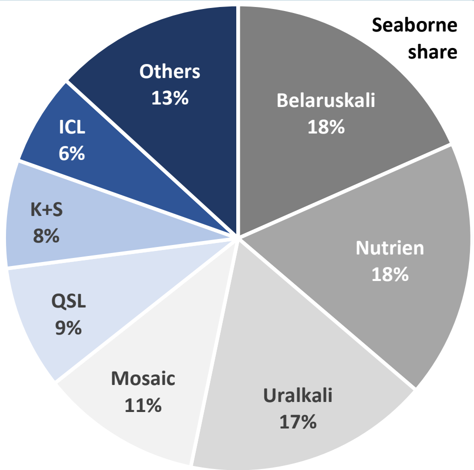
Source: FAO (2017), FAO, IFA, FD

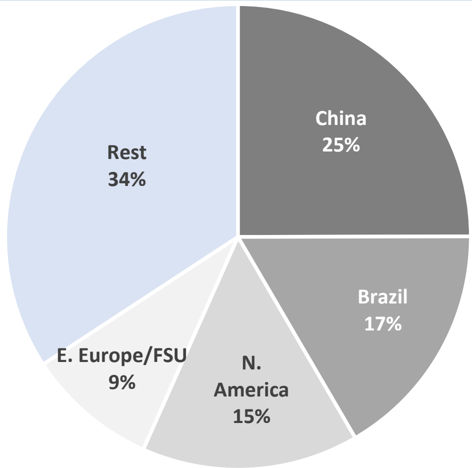
Potash Market Structure

The potash market is best described as being relatively oligopolistic/collusive, with suppliers curtailing supply when perceived demand has diminished. With the price set by the larger manufacturers, smaller producers are typically price-takers. Thus, the oligopoly-controlled price market is arguably a positive attribute because it reduces market risks inherent in typical commodity investment via price volatility and product development.

There are two main marketing collectives that supply potash. The first being Cantopex (Canada) - comprising Nutrien (TSX: NTR - combined entity of Agrium and Potash Corp) and Mosaic (MOC.US); and Balarussian Potash Company ("BPC" – Russia and Belarus), comprising Balaruskali and Uralkali (see Figure 19). Other producers include Vale, Rio Tinto, Intrepid, Kali & Salz (K+S), Migao, Sinofert, Arab Potash Company (APC) and BHP Billiton (not yet in production, with expansion FID expected 2H21).

Figures 9 & 10: Potash suppliers, with the top ten producers (via four marketing organisations) controlling 85% of global capacity (left); and seaborne potash shipments to end-user consumers, with China, Brazil and North America accounting for just under 60% (right).





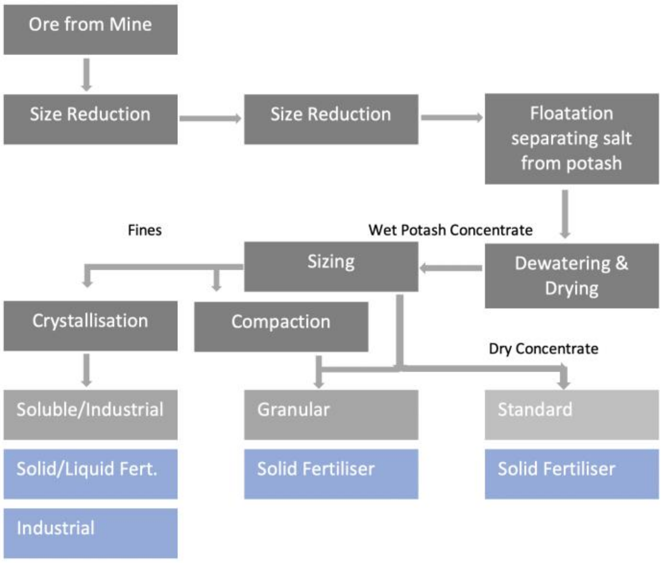
Source: CRU (2020), IFA, Mosaic (2020), FD

In an industry dominated by high capex and deep resources, we believe there is a unique opportunity for minor operators to develop smaller, relatively low capex projects supplying localised demand without inciting a market response from any of the major participants. We believe, in many cases, operating margins will likely outperform other commodities over the length of an economic cycle; the combination of consistent returns coupled with long-life assets are attracting participation by majors, including BHP and Rio, among others.

Potash Production Techniques

The majority (~80%) of potash supply is mined from underground ore deposits utilising conventional mining techniques (e.g. room & pillar), with the ore typically being extracted via conveyor belt systems and shafts. Once on the surface, the ore is crushed and (using a floatation process) impurities such as salt and clay particles are removed. The coarse fraction is screened and is typically ready for distribution, while the fine fraction is usually compacted into sheets, then crushed and re-screened. Flotation is the most common method of processing; less commonly, utilising electrostatic separation, thermal dissolution and heavy media separation.

Figure 11: Potash beneficiation flow chart.



Source: PotashCorp, FD

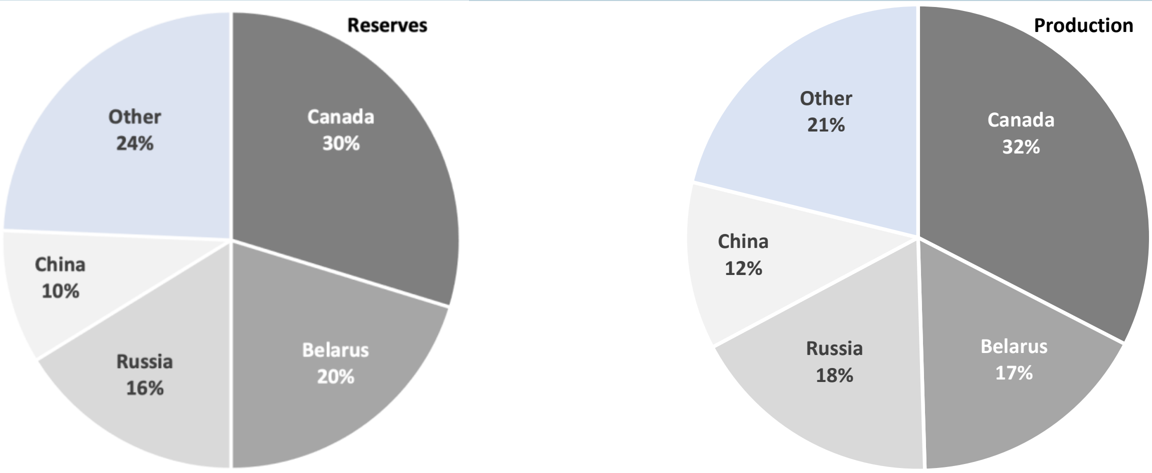
Several operations, especially deeper deposits in the Saskatchewan (up to 3,000m), utilise solution mining techniques where warm water (typically +40º C.) is injected into the ground, dissolving the potash minerals, which are then extracted and pumped into evaporation ponds. As the brine cools, salt and potash re-precipitate and settle at the bottom of the ponds. The precipitate is dried and then screened using a similar process to the one above. These typically have a lower capital cost and reduced construction time but higher operating costs, due mainly to increased energy usage. An example of potash being harvested from a surface brines include that which occurs in the Dead Sea, Israel.

Potash Supply Dynamics

The global potash market is relatively small at ~61Mt KCl, with around 95% of supply used in agriculture as an essential plant nutrient, whilst the remaining 5% is consumed in a wide range of industrial applications. Only 12 countries produce potash, but it is consumed by more than 180 globally, and as a result, approximately 75-80% of potash production moves across international borders.

In North America, Canpotex controls export sales of Nutrien and Mosaic; each firm is assigned a quota in line with their productive capacity. In Eastern Europe, a second syndicate, the Belarusian Potash Corporation (BPC) control sales from both Russian and Belarusian production. Cooperatively, these two syndicates hold a dominant position in the potash market at round 56% of the global total (see Figure 13). Moreover, there is a history of close cooperation between the two syndicates, with Russian producer Uralkali being a member of Canpotex between 2001 and 2003.

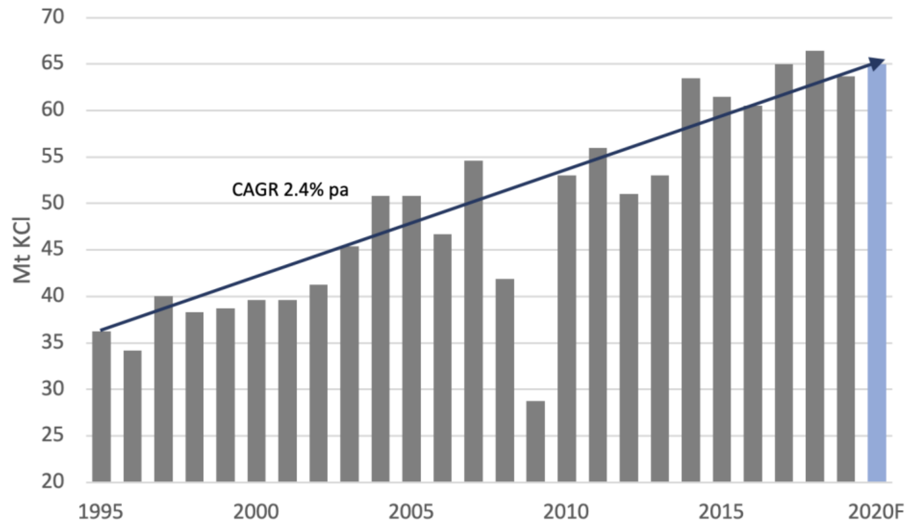
Figures 12 & 13: Global potash Reserves (K_2O basis) (left); and Global 2020E potash production (right).



Source: USGS (2021), FD

At last count, there were more than three dozen proposed potash mines or capacity expansions that had been announced publicly. We believe, for a variety of reasons, ranging from the size of capex, technical issues and the general lack of finance, that very few of these projects outside existing major potash producers will be developed anytime in the near-future. Potash projects are typically very capital intensive: BHP's Jansen Stag 1 project has an expected capex ~US$5.7Bn to bring an 8Mtpa greenfield potash mine and mill into production, taking a minimum seven-year timeframe with the commencement of construction reaching nameplate production. This figure does not include infrastructure outside the plant gates, including rail/road networks, utility systems, and port facilities.

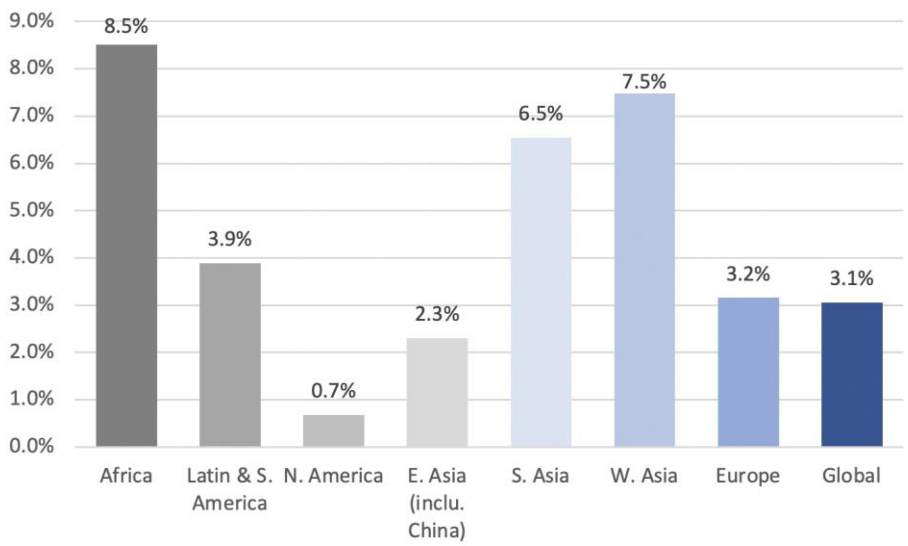
Figure 14: Global seaborne potash shipments (from 1995 to 2020F) on a KCl basis.



Source: IFA, CRU, Mosaic (2020), FD

With the exception of the sub-prime crisis in 2008/09, seaborne consumption of potash globally has been relatively consistent (see Figure 14), with a ~2.4% CAGR over the past 26-years; implying that demand doubles roughly every 30-years. The key consideration is that although global potash resources are significant, their distribution is inequitable, and importantly, not yet developed in many countries where large national population and economic requirements underlie increasing demand.

Figure 15: Global Potash consumption growth (CAGR between 2015-2020).



Source: FAO (2017), FD

Currently, the largest consumers of potash have been developed economies, namely the US and Europe; with global growth in demand over the past six-years at ~3.1% pa (see Figure 15), materially higher than the 2.4% CAGR average in Figure 14 covering a 26-year period. If this is representative of the new normal, it would imply that global consumption will double every 23 years. Interestingly, this growth in demand is being driven by Africa and South and

West Asia, which not only share similar climatic conditions, but have a robust population and economic growth. BHP believe that demand for potash could double by the late 2040s, at which point, it could be a ~US$50Bn market.

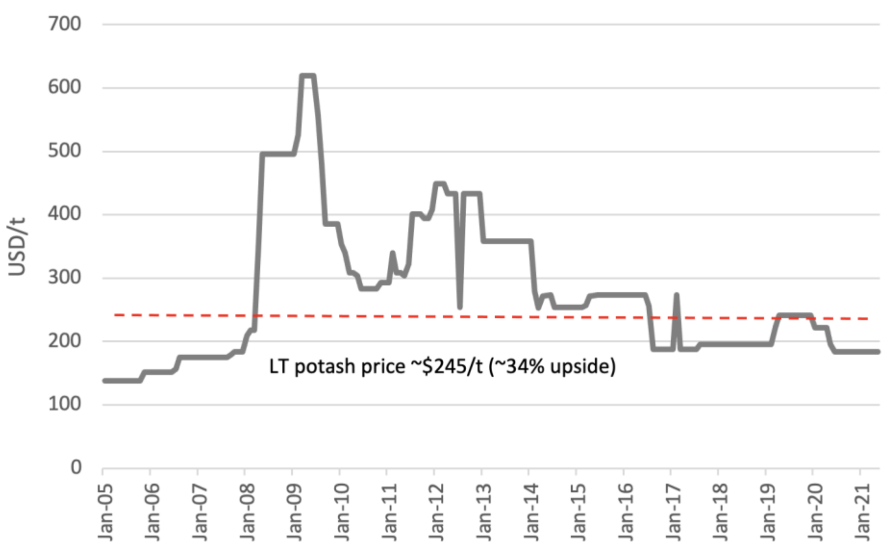
The largest fundamental driver of potash consumption is the growth in cereal cropping, in large part, driven by protein production via feed lots. Negative K balance (K removed > K inputs) in soils are typically observed among many cereal cropping systems, beans, millets, grasslands and other staple crops. The colloid-chemical interaction of mono- and bivalent cations (K+ and Mg) regulates the permeability of plasma colloids, whilst cation saturation determines water uptake and release, favouring the fluid uptake of plants via their mycorrhizal root network, whilst lowering moisture release via the stomata of leaves; together enabling plants to withstand and adjust to weather extremities. For example, Brazilian soils are naturally deficient in potassium, and as a nation, is reliant on importing ~90% of its demand to maintain current production of sugar cane, soybeans, rice and corn. Brazil is also the world's second largest beef exporter, much of it reliant on industrial-scale feed-lots, which in turn is reliant on grain supplies that need regular potash application to optimise yields.

Potash Pricing and Forecast

The relatively tight demand/supply dynamics is, in large part, due to an oligopolistic market, whereby producers (in the medium term) are able to tailor outputs to meet perceived demand. The quadrupling in price in mid 2008 (see Figure 18) over a relatively short period of time (>$800/t at its peak) was due, in part, to the speculative nature of the materials boom which was prevalent at the time, together with rampant demand for biofuels (supported by generous subsidies in some jurisdictions) leading to food shortages in some parts of the world. Additional supply was brought online following elevated pricing from 2008 through to 2013, primarily from Russia, Belarus and Canada, which inundated prevailing demand, thereby depressing prices for most of the following decade.

Unlike most other commodities, potash demand is not cyclical; although related to soft commodity pricing, potash consumption overall is highly correlated to long-term economic development within jurisdictions, with demand only declining temporarily during periods of economic dislocation (e.g. see 2008/09 in Figure 14); even then, arguably, only having a modest impact of pricing (see Figure 16). It wasn't until 2014, when a number of large expansion projects came online, that the long-term price found a new lower equilibrium.

Figure 16: Potassium Chloride Monthly Price (US$/t).

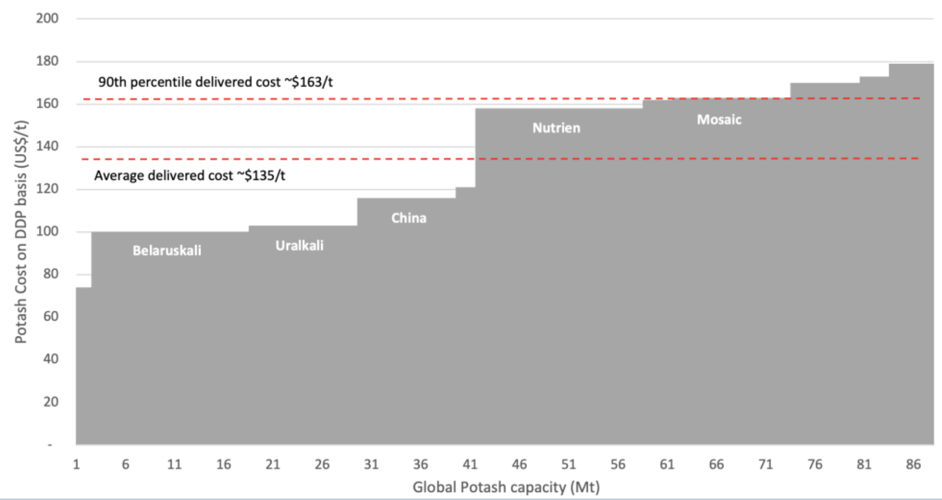


Source: IndexMundi (2021), FD

In recent times, the over-supply dynamic has begun to wane as demand is quickly approaching nameplate capacity. Considering the enormous capex investment required to establish a new operation, it may come as a surprise that a number of new mines in Belarus and Russia (e.g. Uralkali's Solikamsk-3 and Belaruskali's Petrikov), in addition to several facility expansions in Canada (e.g. BHP Group in negotiations with Nutrien to develop Jansen), have recently, or are about to be, completed this year, are in anticipation to perceived growing demand. All of which flies in the face of assertions by many that suggest that the market will remain over-supplied into the future. This "Bow-wave" of supply is observed in many markets, including lithium, iron-ore, coal, etc., perennially threatening to inundate any sense of proprietary demand, thereby crushing pricing. But as the analogy implies, the boat that follows behind never quite catches the "bow-wave". It is our observation that commodity supply forecasts typically rely on management project scheduling that include numerous projects that are ambitious (to say the least); collectively, overstate future product stream, for several reasons:

- Firstly, collating the number of new potash projects and potential expansions without any reference to the likelihood of individual projects in our opinion does not represent likely on-coming supply. The timing and the ability of juniors to fund such ambitious projects is often highly questionable.
- Secondly, nameplate capacity for new potash projects typically over-states actual operational capacity, which is often constrained by transportation or shipping nodes. Much like the iron ore sector over the past decade, with actual production continually falling short of forecasts due to financing, construction, and ramping up delays.

Figure 17: Global potash curve 2021E, on a delivered basis (US$/t).



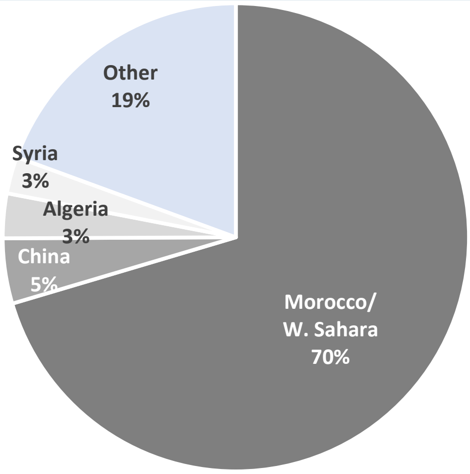
Source: EuroChem (2020), FD

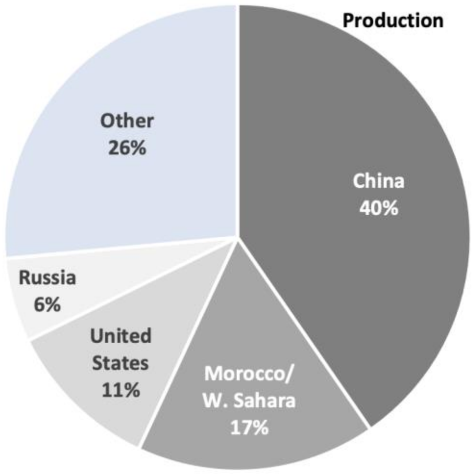
Forecasting the long-term potash price, we have generated a bottom-up methodology. We recognise that there are a host of methods to determine long-term price, some of which simply assume a spot price with an average growth rate based on projected demand. We have assumed that prices will naturally stabilise at a certain level based on the marginal cost of production. According to our estimates, delivered C3 production cost (inc. royalties) and freight costs (which we estimate ~ $25-50/t dependent on destination) on average is ~$163/t (based on the 90th percentile) which is a common method of calculating long-term prices for industrial metals). After adding a 50% margin to derive an "All-In Sustaining Cost" (including capex, opex, corporate G&A etc), it suggests that sufficient incentive needed to meet long-term demand will need a long-term price >$245/t.

What is Phosphate?

Phosphorus is essential for plant nutrition and plays a vital role in photosynthesis, energy transfer, root and seed formation, plant growth and improvement of the quality of fruits and vegetables. It is also an important element for animal nutrition, necessary for the growth/repair of body tissues and growth of bones and teeth. Occurring primarily as a sedimentary marine phosphorite it is a non-detrital sedimentary rock, the grade of which can vary significantly (4% to 20%) typically containing phosphorus pentoxide (P_2O_5). More than three-quarters of known global Reserves are located in North Africa, primarily in Morocco and Western Sahara (see Figure 18). Alternate occurrences have been identified on the continental shelves, specifically on seamounts in the Atlantic Ocean and the Pacific Ocean. Phosphate deposits are hypothesised to be originally sourced from the skeletal remains of dead sea creatures which accumulated on the seafloor.

Figures 18 & 19: Global Phosphate Reserves (left); and global phosphate production in 2019 (right).





Source: USGS (2021), FD

An estimated >200Mt of phosphate rock is extracted per annum, with only ~30Mt traded internationally; the balance is processed (at source) into either phosphoric acid (the key phosphate intermediate) or finished fertilisers (see Figure 23). The key products sold include ammoniated phosphates: ether diammonium phosphate (DAP) or monoammonium phosphate (MAP), accounting for ~38% of all finished product sold and ~60% of the total phosphate used by farmers. Europe is almost entirely dependent on imports of phosphate rock, with France, Germany, Italy, Spain, and the UK accounting for over three-quarters of phosphoric imports. Historically, supplies have been via Tunisia, Jordan and Syria[2], however, as political instability has increased within that region, long-term supplies are no longer guaranteed. The most

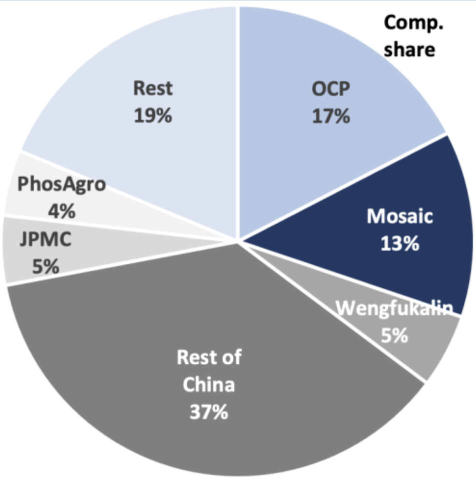
[2] Imports have virtually stopped due to ongoing conflict.

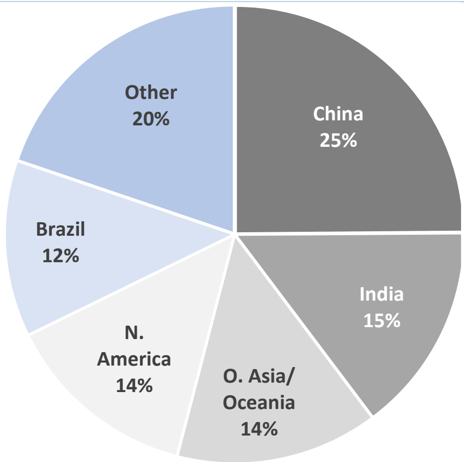
obvious implication being, an increased reliance on Moroccan phosphate imports[3] into the future.

Phosphate Market Structure

Unlike the potash, with strong market participants adjusting output according to perceived demand, the phosphate market has a plethora of smaller producers, with the quantum of production strongly influenced by localised consumption and supply factors. In recent years, prices were adversely afflicted by increased productive investment out of China (moving from being a net importer to a net exporter), Morocco, Saudi Arabia and Russia, which collectively account for 75% of global DAP and MAP exports. By contrast, Brazil, India and the United States are the three largest net consuming markets, accounting for over 40% of phosphate demand (see Figures 20 & 21). At present, both Brazil and India are the two key markets for phosphate imports, setting prevailing prices, with contracts typically traded on a spot pricing basis, with phosphate rock and phosphoric acid sold on a longer-term contractual basis.

Figures 20 & 21: Global phosphate suppliers (left); and phosphate shipments to end-user consumers (right).





Source: CRU (2020), IFA, Mosaic (2020), USGS (2020), Janus Analysis

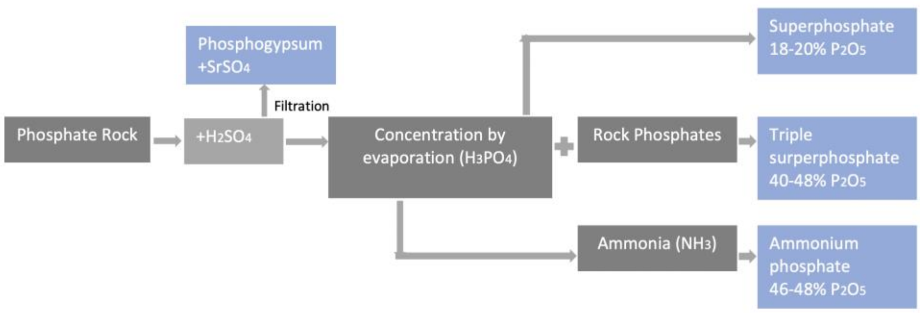
[3] Ongoing political stalemate over the status of Western Sahara as a potential supplier, makes it unlikely. In 2017, a European court ruled that Western Sahara should not be considered part of Morocco in European Union and Moroccan deals.

Phosphate Production Techniques

Rock phosphate, the primary raw material for fertiliser and phosphoric acid, occurs as high-grade ore (+30% P_2O_5), a medium-grade ore (20%–30% P_2O_5), and low-grade ore (15%–20% P_2O_5). Phosphate rock, when used in an untreated form, is not particularly soluble, providing little available nutrient input to plants, except in moist acidic soils. Treating phosphate rock with sulphuric acid produces phosphoric acid, the water-soluble material from which most phosphate fertilisers are derived.

The higher-grade ore blended with medium-grade ore can be used for direct sale. The lower-grade ores are beneficiated by reverse/inverse flotation techniques. Typically, phosphate has eight separate procedures, including grinding, a wet phosphoric acid process, acid concentration and acid clarification, being the major steps. Dried phosphate ore is typically processed into ammoniated phosphates by reacting the phosphate rock with sulphuric acid to produce phosphoric acid. The phosphoric acid is then reacted with ammonia to produce the ammoniated phosphate MAP (monoammonium phosphate) or DAP (diammonium phosphate).

Figure 22: Phosphate beneficiation flow chart, with the ultimate creation of superphosphate, triple superphosphate, ammonium phosphate (and sulphuric acid).



Source: Sattouf (2007)[4], FD

The greatest shortcoming associated with using phosphates, according to Columbia University, is that only 20% percent of the phosphorus contained in the mined phosphate rock reaches the food consumed globally. Approximately 30 to 40% of the in-situ content is lost during mining/processing; whilst 50% is lost in the general food chain. Much of this wasted phosphorus enters rivers, and lakes from agricultural runoff, or from phosphates in detergents and soda, and without careful environmental management, could result in eutrophication[5] of nearby waterways.

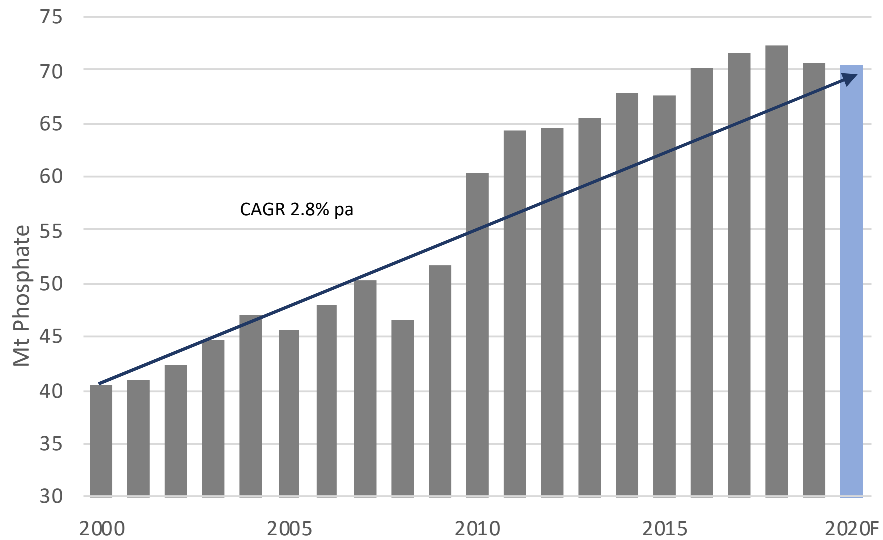
[4] Sattouf, M. *et al*. (2007) "Identifying the origin of rock phosphates and phosphorus fertilizers through high-precision measurement of the strontium isotopes ^{87}Sr and ^{86}Sr". *Landbauforschung Völkenrode*, v.57, p. 1-11.

[5] Eutrophication is the over-enrichment of aquatic ecosystems with nutrients (such as Phosphorous) leading to algal blooms and resultant anoxic events. A serious form of water pollution globally, occurs once the algae bloom consumes the nutrients, the algae die, the decay process by bacteria consumes the majority of available oxygen so that a large bloom can leave "dead zones" - where aquatic creatures are unable to survive.

Phosphate Supply Dynamics

Global phosphate rock extraction in 2020 was ~238Mt, growing >2.2% pa, with global demand expected to reach ~300Mtpa by 2030. Given its restricted distribution globally (see Figure 18), it is interesting to hypothesise about the possibility of "Peak Phosphorus", one could argue that growing demand could, within a relatively short period of time, exhaust existing smaller deposits, for which there is no realistic substitute. Our only long-term replacement are those occurring in northern Africa. Isaac Asimov referred to phosphorus as "life's bottleneck" because, although it makes up one percent of an organism, it is only present in 0.1% of earth's crust (primarily within granites), and is a critical constituent in RNA and DNA. For example, China, with 5% of global reserves, is currently responsible for 40% of global phosphate production; estimated by the USGS to be ~80-95Mtpa (as opposed to the official production statistics of 90-95Mtpa).

Figure 23: Global seaborne phosphate shipments (from 2000 to 2020F).



Source: IFA, CRU, Mosaic (2020), FD

Back in 2008/09 when prices spiked (see Figure 24), in a state of panic, China implemented a raft of export tariffs that were so high that all fertiliser exports ceased. Even now, the vast majority of additional capacity increases are from projects located in Algeria, Egypt, Guinea Bissau, Morocco, Senegal, and Togo; countries with the propensity for varying degrees of political strife. Somewhat surprisingly, given the concentration of global resources and its critical nature, in comparison with the oligopolistic nature of potash, phosphate by contrast has a plethora of smaller nationally based producers, thereby displaying market behaviour more akin to *perfect competition*[6].

We believe, however, that this market dynamic will evolve over the coming decade, given the distribution of world resources, and the number of smaller,

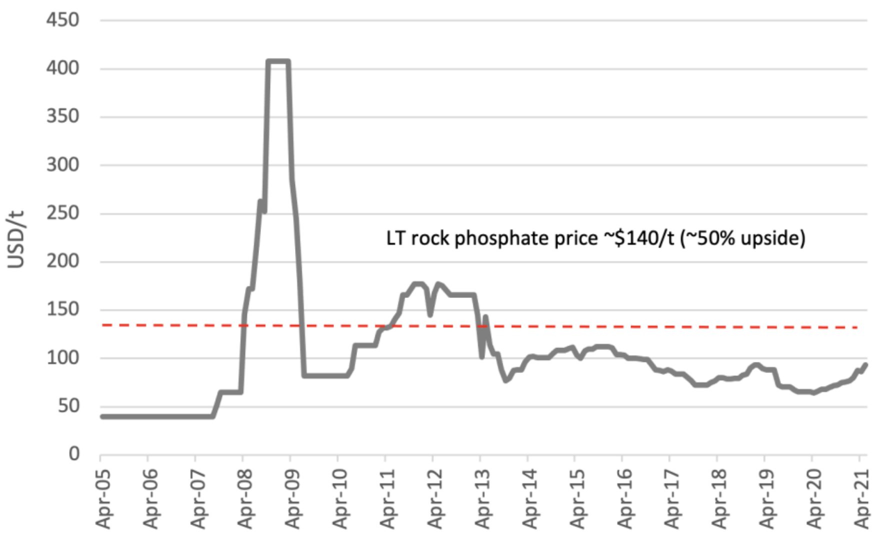
[6] In that all participating firms sell essentially a homogeneous product; they are price takers (they cannot influence the market price of their product); and that market share by any particular firm has no influence on prices.

higher-grade phosphate deposits that are steadily becoming depleted. Forcing the market to adopt a more oligopolistic (or monopolistic?) structure, entrenching existing larger corporate producer positions, or those whose secured tenure to large (often lower-grade) established resources, especially those in northern Africa. As an emerging trend, it will be further exacerbated by the phosphate industry becoming more sophisticated and vertically integrated, with mining companies seeking larger margins, producing increasingly more fertilisers, phosphoric acid and other derivatives of phosphate rock.

Phosphate Pricing and Forecast

The largest event affecting the phosphate sector more recently was Mosaic filing a petition with the US Department of Commerce, requesting a countervailing duty investigation; in particular, focussing on fertiliser imports from Morocco and Russia, claiming that imports from both countries were being subsidised by their respective governments[7]. Ignoring the merits associated with the claims, at the time of the announcement, US DAP was $273/t, but once the implications were realised a month later, prices climbed to $305/t. Currently, they are ~$575/t as global shortages become more evident, and the US relies primarily on domestic sources (which was the whole point to Mosaics petition in the first place). This recent price increase can largely be attributable to the rise in fundamental demand; with Africa, India, and South America accounting for 75-80% of the growth in phosphoric acid, fertilisers and other related products over the past six years.

Figure 24: Rock Phosphate Monthly Price (US$/t).



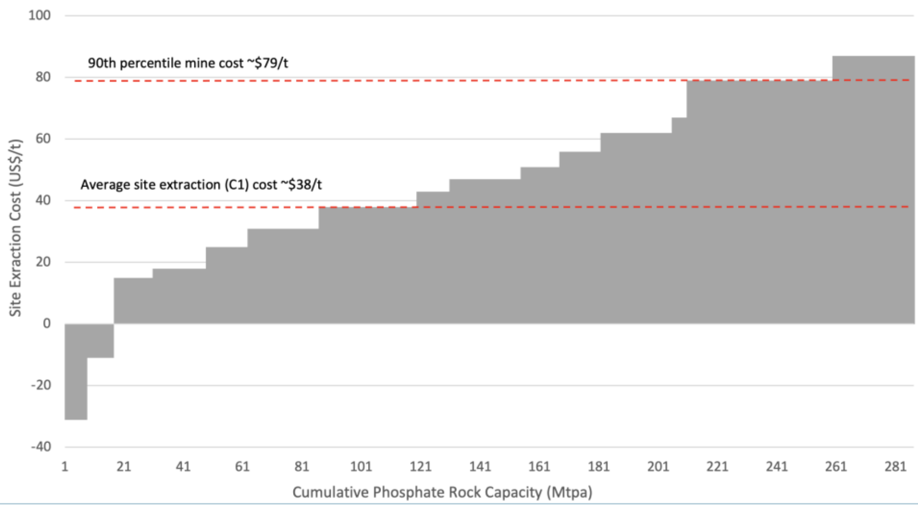
Source: IndexMundi (2021), FD

[7] Subsequent Moroccan and Russian phosphate exports have been diverted to Latin America and India as a result of an imposition of US duties.

Whilst there has been a plateau in meat consumption in places such as the U.S., Europe, and Australia, there has been a corresponding dramatic increase in protein intake throughout Southeast Asia and China that requires significantly more phosphate production; for example, overall meat consumption in China has increased >600% over the past three decades alone.

Despite a number of new and proposed, projects expected to become operational in the coming years (namely from Egypt, Morocco, China and Saudi Arabia) it is arguable whether this additional phosphate supply is sufficient to keep up with underlying growth in demand. On crop nutrient affordability metric, the ratio of a wholesale fertiliser price and crop prices indicate that fertiliser prices are, on an historical basis, increasingly affordable - and is a large part of the reason why phosphate prices have increased >40% over the past 12 months. Although, it has to be noted that this uptick has also been bolstered by higher input costs, particularly from sulphur and ammonia, as a result of refinery curtailments limiting supplies due to COVID-19 restrictions.

Figure 25: Global Phosphate rock mine site costs (US$/t).



Source: CRU (2017), FD

Not unlike the methodology utilised to determine a long-term price for potash, we have also assumed that phosphate will naturally stabilise at a certain level based on the marginal cost of production. According to our estimates, potash cost curves show that the average cost of production is around $125-150/t KCl (see Figure 24). This is a C2 production cost (inc. royalties), so it excludes freight costs, which we estimate are in the order of $15-25/t on average[8]. Adding an additional 50% to derive an "All-in Sustaining Cost" (inc. sustaining capex, corporate G&A etc), suggests a likely sustainable production cost of $140/t.

[8] The lower transport cost attributable is because we are only evaluating rock phosphate and not taking into account value add processing, which is increasingly done on or near to site as phosphate companies steadily become more vertically integrated.

Potash/Phosphate Recommendations

We are confident that the potash and phosphate markets are under-priced on a long-term basis (see Figures 16 and 24). We have elected several large, higher-cost producers as Buy recommendations; on the basis that increased revenues per unit sold will provide the investor greater leverage to upside profitability and capital appreciation.

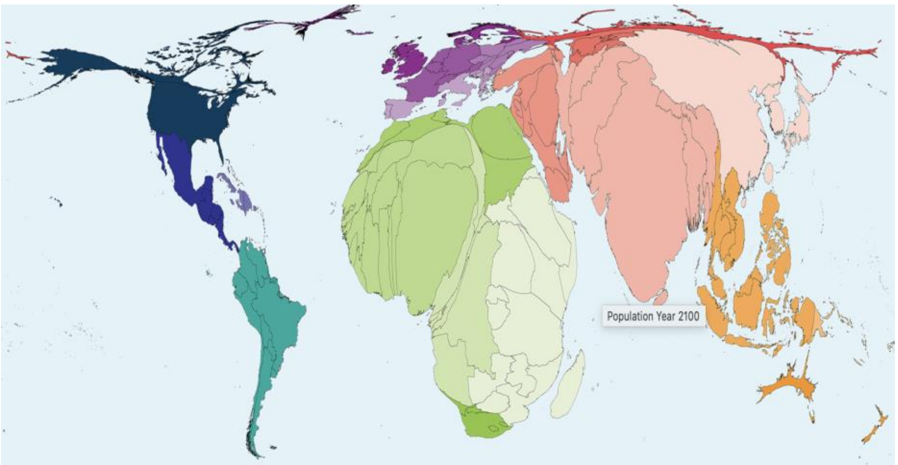
- **BUY Nutrien (TSX: NTR)**: Canadian fertiliser company, based in Saskatchewan, is the largest producer of potash and the third largest producer of nitrogen fertiliser globally; distributing >27Mtpa of product annually to agricultural, industrial and feed customers. With six large potash mines, NTR intends to increase 2H21 production by 500kt (currently 13-14Mtpa) in response to tightening global market conditions. According to Q121 results, adjusted EBITDA for the potash division was up an impressive 33% over the pcp, making up ~45-50% of EBITDA (compared with ~10% for phosphate). Its total retail margin at 10.1% (up from 9.3% in 2019), implies that its future profitability is highly leveraged to the underlying commodity price.

- **BUY Mosaic (NYSE: MOS)**: US based company operating in nine different countries, producing ~25Mtpa of finished potash and phosphate concentrate. Looking at Q121, MOS's potash division contributed ~21% (up.7.9% over the pcp) and phosphate ~34%, up 43% over the pcp (before corporate and other costs allocated) despite similar tonnages sold. By the end of Q122, MOS's potash production guidance forecasts an increase of 2Mtpa (up from ~9.5Mtpa currently) as Esterhazy K3 reaches nameplate capacity, and Colonsay commences operations.

Appendix A – Increasing Global Population

One of the critical reasons why fertiliser consumption growth rates have historically been so consistent over time is that the world's inhabitants are steadily growing, currently estimated at around 7.8Bn people, with an additional 81m (births minus deaths) added annually. According to the IHME[9], the global population is forecast to plateau at 9.7bn around 2064, before beginning to decline gradually. At which point, we would still expect primary fertiliser demand to increase, as diets transition to more affluent tastes, for a variety of reasons (e.g. increasing wealth, longevity, protein consumption, etc.); on current trends it will double over the next 30 years.

Figure 26: World Map if Size Reflected Population in 2100 based on 2017 UN population prospects using the "medium variant" projections. The most populous nations being India, Nigeria and China, in that order.



Source: Worldmapper (2018), UN (2017), CIA (2017)

Notwithstanding the overly Malthusian outlook, the African continent's share of the global population is projected to rise to ~49% of the global total by the end of the century, up from 16% in 2018; with Nigeria becoming the second most populous nation after India, overtaking that of China. The relative rise of the sub-continent and Sub-Saharan Africa will off-set projected decreases in populations elsewhere[10]. These projections are, however, always subject to change, as seen with China and the introduction of its new three child policy, in May this year, only five years since dropping the one-child policy in October 2015; although, it has to be said, that even if successful, its effects will take decades to implement.

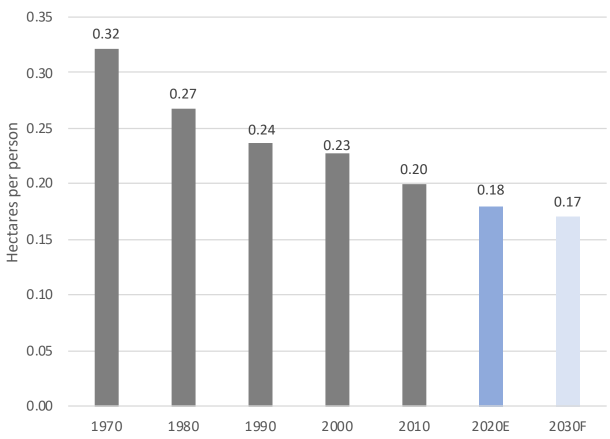
[9] http://www.healthdata.org/news-release/lancet-world-population-likely-shrink-after-mid-century-forecasting-major-shifts-global

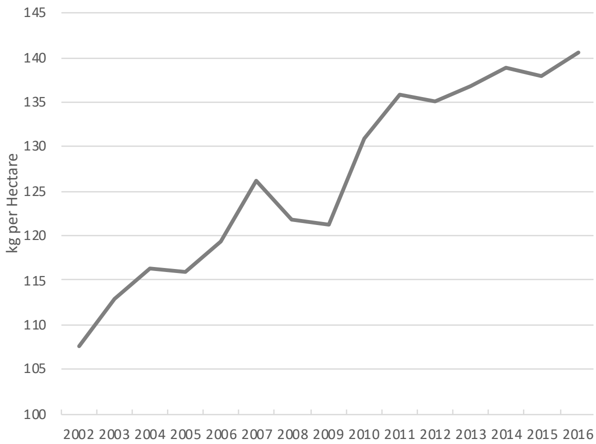
[10] The replacement fertility rate is roughly 2.1 live births per woman for most industrialised countries (the current average globally is ~2.66). Remarkably, with the exception of Israel, no developed nation has a replacement birth-rate. More surprisingly, more than half of the developing world has birth rates around (e.g. India at 2.2) or below (e.g. China at 1.7) replacement levels.

Appendix A (cont.) – Decreasing Arable Land

In the face of an increasing global population, current crop yields will have to be maintained, even in the face of major economic, climatic or political shocks; with approximately half of the world's useable land already under pastoral or intensive agriculture. As a result of urbanisation, industrial and infrastructure development, arable land availability in many developing nations is actually declining (see Figure 27). Crop growth is being achieved, however, despite increasing population and protein in-take. For an example, despite its population increasing by >500m over the past 30 years, India (which once faced chronic food shortages) is not only self-sufficient but now retains substantial grain reserves. Indonesia, formerly the world's leading rice importer, is increasingly a major exporter.

Figures 27 & 28: Hectares of arable land per person (left); and Fertiliser consumption (kg per hectare of arable land) (right).





Source: FAO (2020), World Banks (2020), FD

The continued global growth requirement for fertilisers is, in large-part, due to increased demand by a larger and wealthier world population desiring a higher-quality of nutrition. The investment narrative implies that declining arable-land, coupled with increasing population densities require additional fertiliser applications to achieve the required yields; equally, demand is highly related to increasing economic advancement and the transition from grains to proteins, vegetables and fruit. In the future, the growth in demand will continue to increase for Developing Nations.

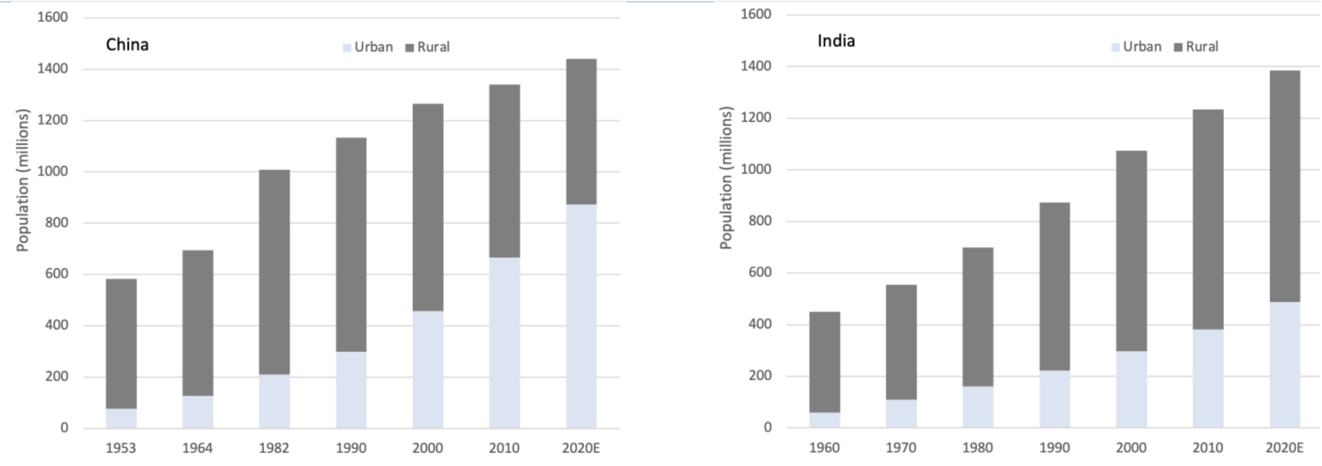
Appendix A (cont.) – Rise of the Urban Middle Class and Dietary Changes

This sudden increase in agricultural demand, however, cannot just be attributed to increasing population pressures. One important reason why food demand continues to grow is in large part, due to general improvement in living standards. It has been noted that as a country develops, there is a strong correlation between rising incomes and increased protein consumption per capita. People switch from staple foods such as rice or wheat to higher quantities of animal protein, fruit and vegetables.

Higher demand for meat requires additional feed grains. To produce one kilo of chicken, pork or beef, requires two, four and seven kilos of grain, respectively. Rather than replacing staple grains, it has been found that middle-classes typically augment them with more protein. It is clear, therefore, that the challenge of feeding the world depends in large part, not only the consumption of animal protein, but what type?

While pork and poultry remain China's proteins of choice, beef consumption is growing rapidly as Korean barbecue joints, hot-pot restaurants, and burger chains establish across the country. To meet this rising protein demand, China has set up large industrial pork and chicken farms. Resultant soybean meal import demand over the past several decades has increased ~800%, with soybean imports in 2020 estimated to be between 84 and 89Mt (primarily from North America and Brazil). With the advent of Swine flu and 40% realised inventory losses (collectively) throughout China, its diversification into other proteins has seen a dramatic rise in poultry output.

Figures 29 & 30: Urbanisation of China, based on National Population Census in 1953, 1964, 1982, 1990, 2000 and 2010 (left); and Indian urbanisation (right).



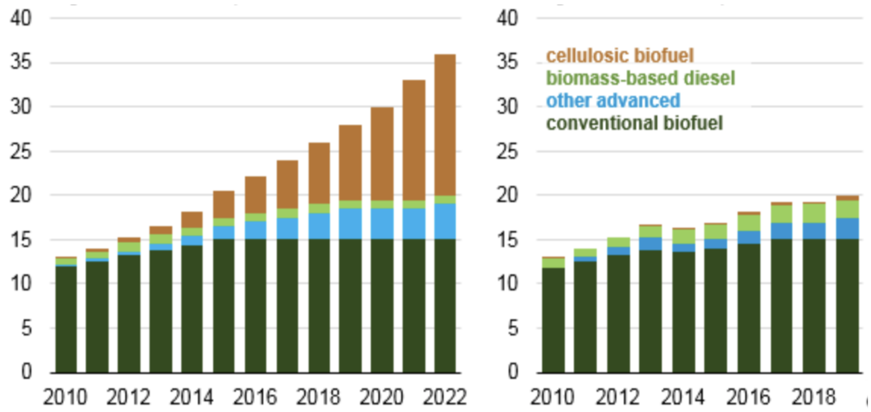
Source: Stats Gov. China (2011), Worldmeter (2020), World Bank (2020), FD

Forecasts suggest that the middle classes from China and India will, by 2030, account for approximately 45% of the global total. There are, however, fundamental differences between the two markets. Half of India's population is vegetarian for religious reasons, many of whom are the most economically advanced Indians, and for the most part, remain so (although this is slowly changing). Whereas in China, there has been a dramatic change in dietary habits; for example, it has been observed that over the period whereby average household incomes have increased by 50%, protein consumption increased by 130%.

Appendix A (cont.) – Future Biofuel Demand

According to the IEA (2020), biofuels account for ~10% of primary energy supply globally (even when traditional biomass is excluded, e.g. wood fires etc.). To put that in perspective, it is five times higher than wind and solar PV combined; driven in large part by state support in bioenergy for electricity and transportation biofuels. Although not yet a major demand factor, we believe potash could be increasingly important in the production of biofuels. Global biofuel production has risen substantially in recent years, driven primarily by US (corn-based) and Brazilian (sugarcane-based) ethanol production (estimated to be ~154Bn litres in 2018) - both of which utilise potash. A potential sea-change to envelope the biofuel industry is based on cellulosic ethanol, utilising the whole plant, rather than, at present, relying on food crops. This could allow a step-change in realised ethanol per unit of biomass, thereby transforming the economics of the entire sector.

Figures 31 & 32: EISA Volumes (2010-2022) billion gallons (US), ethanol equivalent (Left); and Renewable Fuel Standard volume requirements (2010-2019) billion gallons (US), ethanol equivalent.



Source: EIA (2018)

Cellulosic ethanol is a process that produces biofuel from wood, organic waste, grasses, agricultural residues, non-edible parts of plants, municipal biowaste, used vegetable oils, and even biological sludge from urban water purification plants, via cellular hydrolysis using enzymes. There are several commercial scale plants operational in Norway, the US, and Brazil. Conversion is achieved either via specialised enzymes/microbes that break down pre-treated biomass-based cellulose into sugars, which are then fermented into alcohols, or alternatively, by thermochemical methods, including gasification (using a third of the oxygen needed for complete combustion to produce monoxide and hydrogen – more commonly known as syngas) or pyrolysis (heating the biomass in the absence of oxygen to produce bio-oils). Both are possible avenues for large-scale biofuel production methods.

Despite limited production due to technical difficulties (pre-treatments, fermentation, hydrolysis, and by-products) and high energy costs, plant species such as Miscanthus[11] (also known as "elephant grass") is of particular interest, as it can be harvested annually with a standard sugar cane harvester, has high productivity per acre and can be grown in cool climates such as northern Europe. Critically, they do not compete with agricultural production for the food market, replacing current first-generation biofuel production utilising food crops.

An important consideration with biofuels is the fact that they can be mixed with traditional hydrocarbons, allowing an immediate reduction in greenhouse production without burdensome upfront infrastructure requirements. At present, ethanol production is centred around the fermentation of sugars into alcohol, utilising a variety of plant sources/feedstocks. Corn is the most common feedstock in the US, sugar cane in Brazil, with sorghum and other feedstock grains in parts of Europe. In terms of production, around 78Mt of ethanol was produced globally in 2018, most of which was from the US (56%), followed by Brazil (28%), EU (5%), and China (4%)[12].

[11] Default value associated to cellulosic ethanol is 16 gCO_2eq/MJ resulting in 83% GHG emission reduction compared with fossil fuels. https://www.clariant.com/en/Corporate/News/2018/09/Groundbreaking-for-Clariantrs quos-sunliquidreg-cellulosic-ethanol-plant-in-Romanianbsp

[12] Renewable Fuels Association. http://www.ethanolrfa.org/resources/industry/statistics/#1454098996479-8715d404-e546

Research Disclosures

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Gaius L.L King has 25 years' experience in mining, exploration, corporate finance, mineral economics and as a resource analyst. As a geologist, he worked five years in various underground operations, and was involved in discovering and delineating ~2.6 Mt @ 3.5% Ni from a variety of ore bodies. Gaius has analysed fundamental supply and demand of iron ore, nickel, PGE, uranium, gold, REE, borate and lithium, among others. As an analyst, he has specialised in the mid-tier/junior sectors, covering mining stocks on the ASX and AIM.

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