Canada to Nepal Export Report: Stabilized Nitrogen Fertilizer

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Introduction

Nitrogen fertilizer is critical for increasing yields in many crops. When urea, one of the cheapest forms, is applied as a granular or a liquid a lot of it is lost to the atmosphere (Watson, Akhonzada, Hamilton, & Matthews, 2008). For urea to be used it must be broken down by the soil enzyme urease into nitrate and ammonia (Watson et al.). The nitrate can quickly leach through the soil due to irrigation or rainfall and the ammonia is lost to the atmosphere through volatilization (Watson et al.). The product that will be investigated is Agrotain® nitrogen fertilizer, which is produced by Koch Fertilizer Canada, ULC. This product reduces the amount of nitrogen lost to the atmosphere.

Part 1 – Product Information

Product description

One of the major crops that are grown in the Terai and Hill Districts of Nepal is rice. M.Thapa (2013) found that urea applications increased yields in the Makawanpur district. Makawanpur is located in the south portion of the Hill District, bordering the Terai region. In 2013, B. Adhikary and R. Adhikary showed that higher nitrogen levels and higher planting densities increased yield in maize production in the Chitwan valley, Terai region. Nepal is an extremely food deficit country so increasing farmland yields is very important to its future. Agrotain® contains an additive: N-(n-butyl)-thiophosphoric triamide (NBPT) that inhibits the urease enzyme from breaking down urea (Watson et al., 2008). This leads to less nitrogen loss from leaching and volatilization and more nitrogen available to the plant.

The mountain and Terai regions are particularly food deficient. The most important thing for a population to thrive is an adequate food supply. Modern agriculture is thought to be pivotal in our cultural development because the less time people spend obtaining food, the more time they can spend on other activities (science, English, philosophy etc.).

Producer Information

Figure 1: Production Plant in Brandon, Manitoba, Canada. Retrieved from http://www.kochcareers.com/kaes/

The company that produces this product is Koch Fertilizer Canada, ULC. This is a branch of the larger company Koch Industries, Inc., which has locations all over the world. Koch companies have operations in Alberta, Manitoba, Saskatchewan, and Ontario. There are about 2,000 Canadians employed by Koch companies (Koch Industries inc., 2014). Koch Industries has production plants in North and South

America, as well as terminals located all over the world (Koch Fertilizer, 2015). The plant in Canada is located in Brandon, Manitoba. It produces various forms of nitrogen fertilizers including; anhydrous ammonia, urea, nitric acid and ammonium nitrate solution (Koch Fertilizer, 2015). The customer service representative in Manitoba for Koch Fertilizer is Marc Dotremont and his contact information is as follows (Koch Fertilizer, 2015):

Phone: 204-256-4456
Fax: 204-256-4475
Cell: 204-771-2776
Email: Marc.Dotremont@kochind.com

The representative from Beijing, China is Julia Wang, her contact information is as follows (Koch Fertilizer, 2015):

Phone: 316-828-5619
Fax: 316-828-4084
Cell: 316-253-8460
Email: wangjulia@kochind.com

Production of Urea

Fertilizer production in Canada is a huge industry providing thousands of jobs, contributing $12 billion dollars annually to our economy (Fertilizer Canada, 2015). Canada exports fertilizers to more than 80 countries around the world (Fertilizer Canada, 2015). Canada exports approximately 85% of its potash and 24% of its nitrogen production (Agriculture and Agri-Food Canada [AAFC], 2012). Tables 1 and 2 show the capacity of ammonia production for various companies and different types of fertilizer production in Canada, respectively.

Table 1: Capacity of ammonia production in Canada for various companies. Data retrieved from Agrium Fact Book (2014).

Company	Site	Capacity of NH_3 ('000 metric tones of ammonia

		per year)
CF Industries, Inc.	Medicine Hat, Alberta	1,250
Agrium Inc.	Redwater, Alberta	960
Koch Fertilizer Canada, ULC	Brandon, Manitoba	430

Table 2: Canadian fertilizer production, by product type and fertilizer year, cumulative data, annual (metric tonnes x 1,000)(1,2,3,10,11). Data retrieved from Statistics Canada (2015).

Fertilizer product type (4)	Period (3)	2011/2012	2012/2013	2013/2014	2014/2015	2015/2016
Ammonia (NH3) 82-0-0-0 (5)	July to September	1086	1093	1154	1133	1202
Urea 46-0-0 (6)	July to September	787	898	836	906	923
Urea ammonium nitrate (UAN) 28-0-0-0 (7)	July to September	303	179	326	275	260
Ammonium nitrate/calcium ammonium nitrate (AN/CAN) 34-0-0-0	July to September	x	x	x	x	x
Ammonium sulphate (AS) 20-0-0-24 (8)	July to September	230	230	246	219	240
Monoammonium phosphate (MAP) 11-52-0	July to September	x	x	x	x	x
Diammonium phosphate (DAP) 18-46-0	July to September	0	0	0	0	0
Potash 0-0-60-0	July to September	3878	x	3209	x	x
Other fertilizer products (9)	July to September	x	x	x	x	42

Footnotes:

1	Historical annual production data are available in terminated CANSIM table 001-0063.
2	Fertilizer production includes Canadian producers.
3	Data are compiled on a fertilizer year basis starting July 1 and ending June 30

	the following year.
4	Metric tonnes for some fertilizer products have been converted to the standard categories published.
5	Tonnes for aqua ammonia (NH3) 24-0-0 are divided by 3.4; tonnes for aqua ammonia (NH3) 27-0-0 are multiplied by 0.329.
6	Tonnes for ESN 44-0-0 are multiplied by 0.9565.
7	Tonnes for nitrogen solutions/urea ammonium nitrate (UAN) 32-0-0 are multiplied by 1.142.
8	Tonnes for ammonium thiosulphate (ATS) 15-0-0-20 are multiplied by 0.83. Elemental sulphur (0-0-0-90 and 0-0-0-85) is excluded from this category (included with other fertilizer products).
9	Other fertilizer products includes ammonium polyphosphate, phosphate and sulphur solutions, mixed fertilizer materials, elemental sulphur fertilizers and all other fertilizer products not included in the other product categories.
10	Estimates for the most recent year are preliminary. Preliminary data are subject to revision. Due to rounding, components may not add to total (where applicable).
11	The 2014 fourth quarter estimates for Ammonia (NH3), Urea and Urea ammonium nitrate (UAN) have been corrected.

Ammonia is produced using a method known as the Haber-Bosch process (Kandemir, Schuster, Senyshyn, Behrens, & Schlögl, 2013). The process is named after Fritz Haber and Carl Bosch, who developed it about 100 years ago (Kandemir et al.). It involves using nitrogen and hydrogen gas to produce ammonia. The reaction is given by the equation $N_2 + 3\ H_2 \rightarrow 2\ NH_3$ (Kandemir et al.). The process fixes atmospheric nitrogen into ammonia that is used for fertilizer and other nitrogen containing products (Timmer, 2001). Fritz Haber developed the method to synthesize hydrogen and nitrogen into ammonia and received the Nobel Prize for his work in 1918 (Encyclopedia Britannica, 2015). Carl Bosch developed this into large scale industrial processing using a catalyst to help with production (Encyclopedia Britannica, 2015). Figure 2 shows

simple flow chart to show the main steps of the Haber-Bosch process.

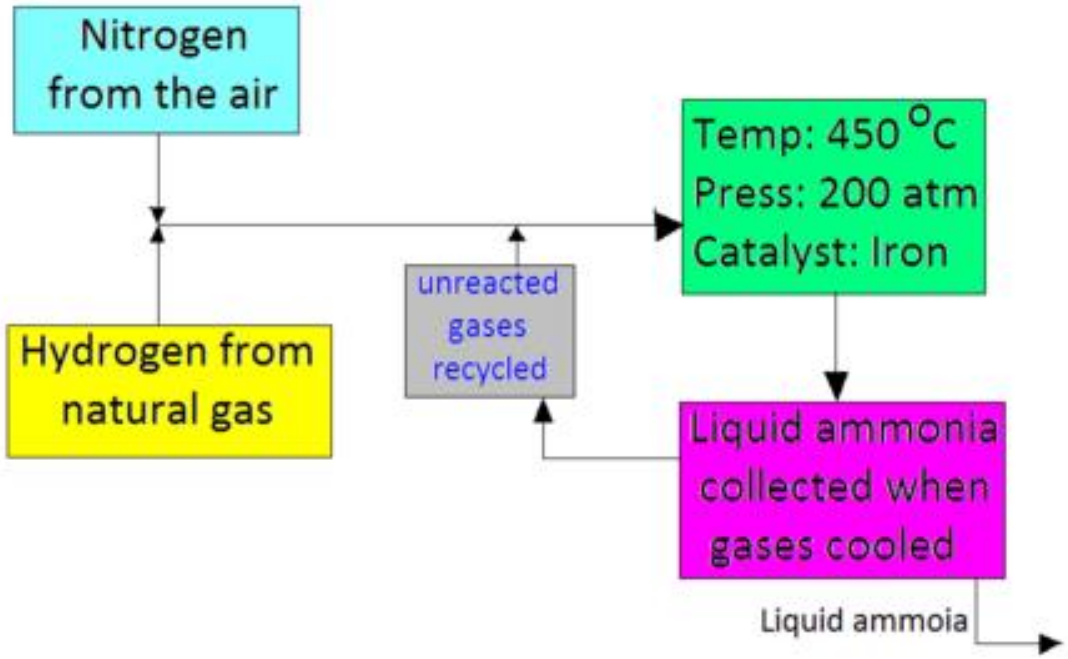

Figure 2: A depiction of the Haber-Bosch process that produces ammonia. Retrieved from http://sustain.sfsu.edu/content/our-man-made-landscape

Urea is produced by reacting ammonia with carbon dioxide to form ammonium carbamate (United States Environmental Protection Agency [EPA], 1981). Using dehydration, the carbamate is used to form urea and water (EPA, 1981). There are seven main steps to creating urea fertilizer. They include; solution synthesis, solution concentration, solids formation, solids cooling, solids screening, solids coating and bagging (EPA, 1981). Figure 3 shows gives a general depiction of this process.

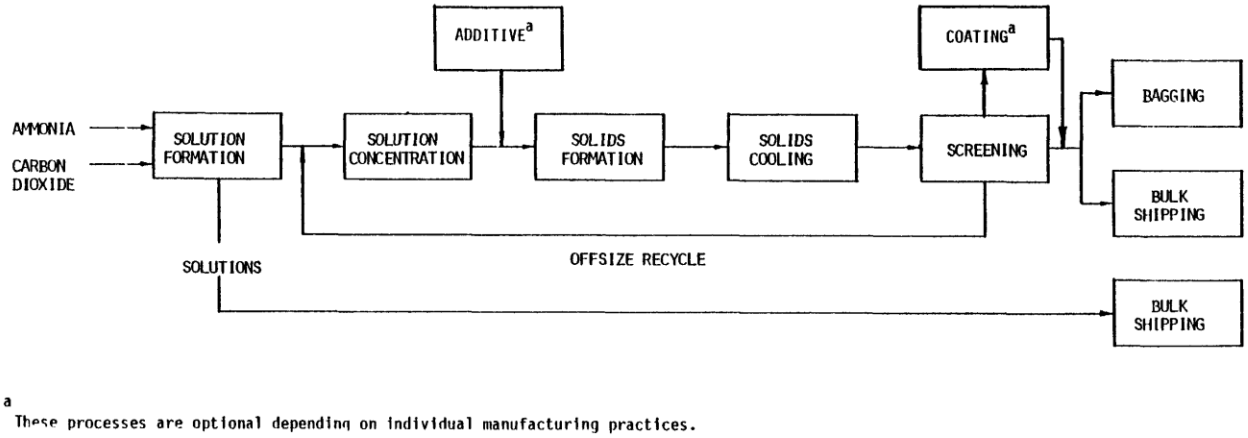

Figure 3: The production process of urea. Retrieved from (EPA, 1981).

Machinery Required and Cost

There are many dynamic factors that affect the production and price of nitrogen fertilizer. Some of these factors are production costs, market demand and competition (AAFC, 2012). According the the AAFC (2012), natural gas accounts for 70-90% of the production cost of ammonia. Therefore, the price of natural gas is positively correlated with the price of ammonia based nitrogen fertilizers. A relatively steady increase in the cost of United States (US) natural gas between 1991 and 2011 was coupled with a similar increase in the cost of anhydrous ammonia (Figure 4).

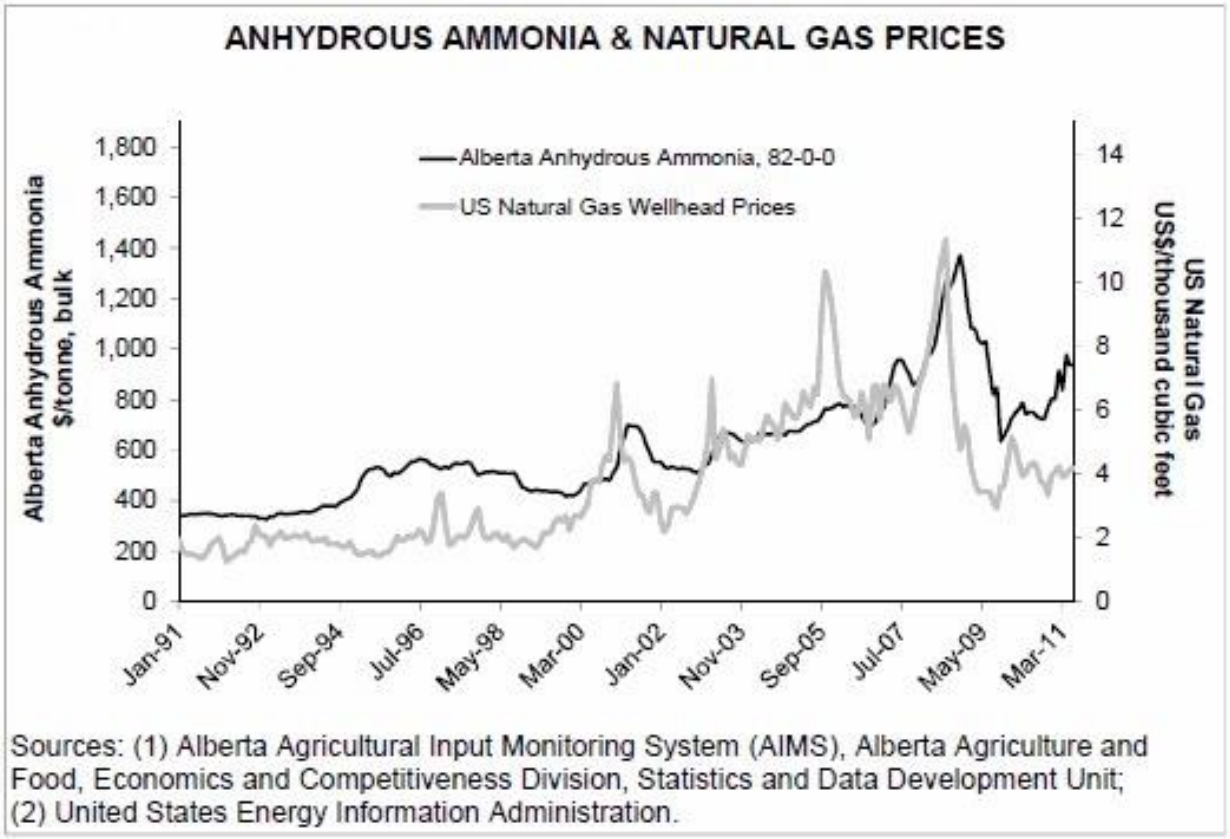

Figure 4: The correlation between anhydrous ammonia and natural gas prices from January 1991 to March 2011. Retrieved from Agriculture and Agri-Food Canada (2012).

Shipping costs will also add to the price of fertilizer for Nepalese farmers. One of the major influences that increase fertilizer costs for Nepal is the poor infrastructure, especially in the Hill and Mountain Regions of Nepal, which serves to increase the cost of shipping the product. To ship fertilizer from Canada, China, or India to Nepal it must travel by truck, train, or railway. Shipping is expensive but costs can be reduced through various means that will be discussed in subsequent paragraphs.

Investing in Agrotain®

The price for an Agrotain® fertilizer is more expensive than normal urea because of the addition of NBPT during the manufacturing process. Any fertilizer can be expensive for people of Nepal, therefore the lowest possible cost is essential for the implementation of this proposal. Those that are able to afford fertilizers hope to increase

their yields and get a return on their investment. B. Adhikary and R. Adhikary (2013) found that nitrogen could increase yield in maize production in the Chitwan valley of Nepal. These results show that investing in a urease inhibiting fertilizer could be a very beneficial investment.

Application Methods

Once a farmer has obtained the fertilizer they will need methods to disperse it.

Figure 5: Broadcast spreader mounted on a tractor. Retrieved from https://www.deere.com

There are a number of methods to do this, such as a broadcast spreader. This method would require a tractor and could be only be used by the largest farm operations. Most Nepalese farmers would need to use another method such as dispersing it in handfuls. These methods are inaccurate and result in wasted product. The best method for small scale farmers to apply granular fertilizers is by microdosing which is done by applying it directly to the base of the plant (Raizada, 2015). If the fertilizer is just applied where it is needed, then more of it will be used by the plants. A demonstration of this is shown in the picture on the left.

Figure 6: Microdosing a plant using a small bottle cap. Retrieved from http://www.icrisat.org

Benefits to Canada

The benefits to Canada from the sale of this product to Nepalese farmers would likely be small in comparison to the benefits from our other trade partners. In 2014 Canada's gross domestic product (GDP) was about $1.785 trillion compared to Nepal's $19.76 billion (Central Intelligence Agency [CIA], 2014). Canada's economic power is so much greater than Nepal's, that trade between the countries would not have a significant impact on Canada. However, there are about 2,000 Canadians employed by Koch companies through their various operations (Koch Industries inc., 2014). Increasing their sales can help them to expand in Canada and improve our economy by providing more jobs for Canadians.

Part 2 – Export potential to Nepal

A Brief Introduction to Nepal

Nepal is located in between the countries India and China, in Southern Asia (CIA, 2014). It has a total area of approximately 147,000km^2 and a population of 31.5 million (CIA, 2014). Although there are many religions in Nepal, the largest one is Hinduism (K. Thapa, 2010). A census conducted in 2001 showed that about 80% of the population was Hindu (K. Thapa, 2010). The people of Nepal are also very poor, in 2011 about 25% of the population lived below the poverty line (CIA, 2014). Nepal's population could benefit greatly from the help of developed nations such as Canada, China or the United States.

The CIA in 2014 found that 75% of the labor force worked in agriculture. A societies wealth can often be interpreted by how much of its population works in the agriculture industry. For example, in Canada 2% of the labor force works in agriculture

and in the United States only 0.7% (CIA, 2014). These statistics make it clear that Nepal is a poor nation in need of economic development. As discussed in the previous section, the less time people spend obtaining food, the more time they can spend on other activities, and likely stimulate their economy.

Transportation

When the fertilizer arrives in Nepal it will need be distributed by rail or trucks to various locations close to farmers so they can purchase it. In the Terai region transportation of bags of fertilizer can be done with trucks due to the more developed road infrastructure. To get to the Hill and Mountain Region's the bags may need to be carried by animals or humans. These regions have very poor infrastructure which is a contributor to the food deficiency in Nepal ((Raut & Sitaula, 2012).

Africa's subsistence farmers share many of the same difficulties with regards to transportation logistics. For farmers in Africa Morris, Kelly, Kopicki, and Byerlee (2007) suggested lowering international shipping costs by ordering in bulk for larger markets. These savings could immediately contribute to helping lower the cost of fertilizer for individual Nepalese farmers. The shorter the distance for transportation, the cheaper it is. Therefore, shipping in a urease inhibiting fertilizer such as Agrotain® from India or China would be significantly cheaper than importing it from Canada. In 2014 India and China accounted for 57% and 29.6%, respectively, of the total dollar value of imports to Nepal (CIA, 2014). These two countries are industrialized and have urea production plants that could provided the fertilizer to Nepal. Figure 6 and 7 show how fertilizer can be shipped into Nepal.

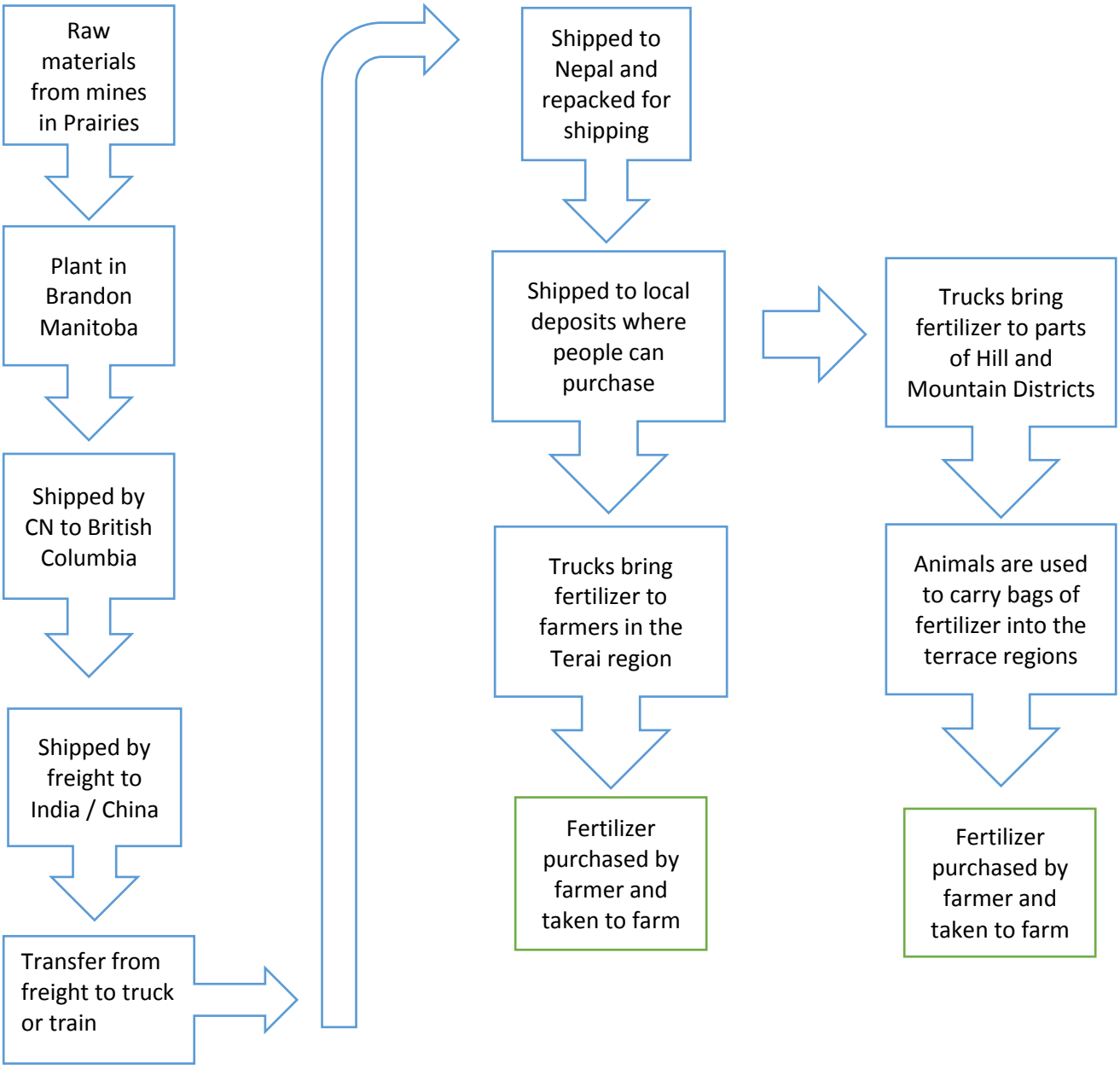

Figure 7: Flow chart showing how fertilizer would move from Canada to Nepal.

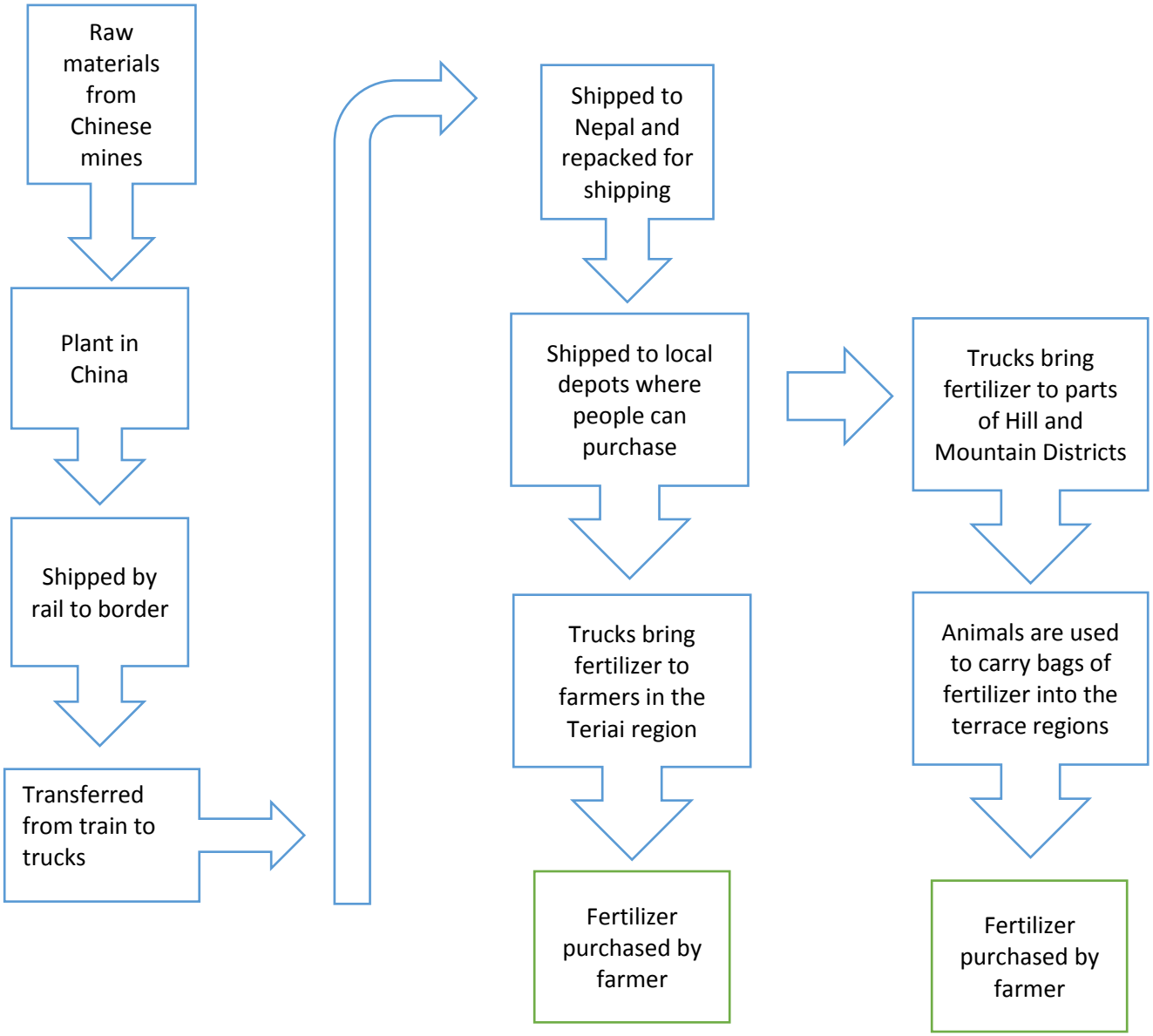

Figure 8: Flow chart showing how fertilizer would move from China to Nepal.

The distance from Winnipeg to Nepal is approximately 11,000km where as the distance from Beijing, which is the farthest city from Nepal, to Nepal is about 3000km (Time and Date, 2015). This means that Canada is between three and four times farther away, which make transportation costs increase dramatically.

Market

For this product to reach Nepalese farmers it will first need to be purchased in a large quantity from a supplier. Only large distributing companies would be able to afford shipping it in bulk into the country. Once purchased by a group that can afford it, distribution of the product can begin. At this stage smaller groups of farmers could pool their money together and form a co-op, or an individual from a community could purchase a 50lb bag of fertilizer and repackage it into smaller bags to sell to individual farmers.

Storage

Proper storage of fertilizer is very important, especially with regards to granular products. Excessive moisture will cause urea to start breaking down and could lead to wasted product (Watson et al., 2008). Using covered storage containers during the shipping process is very important. Once the product is received in Nepal, it will have to be stored in warehouses until it can be distributed by trucks to a location close to farmers. After the product has been purchased by the farmer they will need to have somewhere to keep it dry. Plastic bags are a cheap and effective way to store small amounts of fertilizer in the home. For farmers purchasing larger amounts, a storage shed may be needed. Figure 8

Figure 9: Goat shack with elevated floor and tin roof. Retrieved from http://www.ewbchallenge.org

shows an example of a shed design that could be used for fertilizer storage. The goat shack has an elevated floor with a tin roof for protection from the sun and rain. Adding walls to a structure like this will make it an even better storage area.

Costs and Profitability

The people of Nepal could greatly benefit from the use of stabilized nitrogen fertilizer if it could substantially increase their yields. Farmers that are able to produce more crops will be able to make more money. If more of them could begin to make a profit and move from subsistence farming to profitable farming it will be good for the whole country's economic development. Farmers could begin to invest more money into their yields by investing in new technologies and equipment. This could include more mechanized equipment and therefore more accomplished with less physical work.

The cost of urea is approximately 250-300 United States (US) dollars for 1000 kilograms (Alibaba, 2015). This works out to about $0.25-0.30 US per kilogram (kg), without factoring in any of the other costs. There are other blended fertilizers such as a 19-19-19 (N, P_20_5, K_20), but these fertilizers are more expensive at $350-650 US per 1000kg (Alibaba, 2015). The multi-nutrient fertilizers will provide more nutrients for growth but cost about $0.35-0.65/kg.

For maize production, it is advised to apply 180kg of nitrogen (N) per hectare (ha) to increase yield (B. Adhikary & R. Adhikary, 2013). To do this with urea (46-0-0) a farmer would need to apply 390kg/ha and would cost approximately 98$-117US per ha. To achieve a rate of 180kg/N per ha a multi-nutrient product, such as a 19-19-19 would need to be applied at 947kg/ha. This would cost about $330-615/ha. Using Agrotain® would likely cost around $150-300US/ha if not for the urease inhibiting additive.

Subsidy Policy

The government of Nepal currently has a subsidy program to help farmers acquire fertilizers, but many of them do not know about these policies (Raut & Sitaula, 2012). This program involves the government buying fertilizer and shipping it to farmers, however there are many problems from issues such as poor road conditions (Raut & Sitaula, 2012).

Future Studies and Unknowns

Further research is required to understand exactly how much less nitrogen needs to be applied with Agrotain®. This research is important in determining whether it is economically beneficial to purchase a stabilized urea fertilizer. Nitrogen is the most important nutrient for most crops but other nutrients may be limiting as well. If a nutrient such as potassium (K) is the limiting nutrient in the soil, then adding more nitrogen will not improve plant health. Studies to quantify the benefit of using a homogenous fertilizer (N) versus a heterogeneous fertilizer (N-P-K) would be helpful in determining the benefits and drawbacks of each product.

Summary and Recommendations

The benefits to the Nepalese farmers from using fertilizers has been made clear. The main benefit being an increase in yields (M. Thapa, 2013). In order for them to maximize these benefits it is important for them to be able get the products at the cheapest cost. If a farmer can only afford one fertilizer it is important they know which is the best choice for them.

References

Adhikary, B., Adhikary, R. (2013). Enhancing effect of nitrogen on grain production of hybrid maize in Chitwan valley. *Agronomy Journal of Nepal*, *3*, 33–41. http://doi.org/10.3126/ajn.v3i0.8984

Agriculture and Agri-Food Canada. (2012). *Canadian Farm Fuel and Fertilizer: Prices and Expenses*. Retrieved from http://www.agr.gc.ca/eng/industry-markets-and-trade/statistics-and-market-information/by-product-sector/crops/crops-market-information-canadian-industry/market-outlook-report/canadian-farm-fuel-and-fertilizerprices-and-expenses-march-2012/?id=1378845446435

Agrium®. (2013). *Sustaining a growing world fact book 2013-2014.* Retrieved from https://www.agrium.com/system/files/2013-2014-agrium-fact-book_0.pdf

Alibaba.com®. (2015). *Urea.* Date accessed: November 14, 2015. Retrieved from http://www.alibaba.com/trade/search?fsb=y&IndexArea=product_en&CatId=&SearchText=urea

Alibaba.com®. (2015). *Fertilizer.* Date accessed: November 14, 2015. Retrieved from http://www.alibaba.com/trade/search?fsb=y&IndexArea=product_en&CatId=&SearchText=fertilizer

Central Intelligence Agency. (2014). *The World Factbook.* Retrieved from https://www.cia.gov/library/publications/the-world-factbook/geos/np.html

Fertilizer Canada. (2015). *Why the Fertilizer Industry Matters to Canada.* Retrieved from http://fertilizercanada.ca/about-fertilizer-canada/what-is-fertilizer/why-the-fertilizer-industry-matters-to-canada/

Haber-Bosch process. (2015). In Encyclopedia Britannica. Retrieved from http://www.britannica.com/technology/Haber-Bosch-process

Haefele, S. M., Bhattachan, B. K., Adhikari, B. B., Jr., C. C. A., & Shresta, S. M. (2014). Spatial variability of fertilizer management and response in rainfed rice of Nepal. *Agriculture, Ecosystems & Environment*, *189*, 190–198. http://doi.org/10.1016/j.agee.2014.03.041

Kandemir, T., Schuster, M. E., Senyshyn, A., Behrens, M., & Schlögl, R. (2013). The Haber-Bosch process revisited: on the real structure and stability of “ammonia iron” under working conditions. *Angewandte Chemie (International Ed. in English)*, *52*(48), 12723–6. http://doi.org/10.1002/anie.201305812

Koch Industries inc.. (2014). *Canada Facts.* Retrieved from https://www.kochind.com/files/canadafacts.pdf

Koch Fertilizer, LLC. (2015). *Locations.* Retrieved from http://www.kochfertilizer.com/locations.asp

Morris, M. Kelly, V. A., Kopicki, R. J., Byerlee, D. *Fertilizer Use in African Agriculture*. (2007). *Directions in Development - Agriculture and Rural Development*. The World Bank. http://doi.org/doi:10.1596/978-0-8213-6880-0

Raizada, M. (2015) *AGR*1110 Introduction to Agri-Food Systems lecture notes.* Guelph, ON: University of Guelph

Raut, N., Sitaula, B. K. (2012). Assessment of fertilizer policy, farmers' perceptions and implications for future agricultural development in Nepal. *Sustainable Agriculture Research, 1*(2), 188-200. Retrieved from http://sfx.scholarsportal.info/guelph/docview/1069236849?accountid=11233

Statistics Canada. (2015). *Canadian fertilizer production, by product type and fertilizer year, cumulative data* (Catalogue no. 001-0067). Retrieved from http://www5.statcan.gc.ca/cansim/pick-choisir?lang=eng&p2=33&id=0010067

Thapa, K. B. (2010). Religion and Law in Nepal. *Brigham Young University Law Review, 2010*(3), 921-930. Retrieved from http://sfx.scholarsportal.info/guelph/docview/846781473?accountid=11233

Thapa, M. (2013). Factors affecting fertilizer use efficiency in dry season paddy production in Makawanpur district, mid hill, Nepal. *Agronomy Journal of Nepal*, *1*, 123–133. http://doi.org/10.3126/ajn.v1i0.7552

Time and Date. *Distance from Winnipeg to Kathmandu.* (2015). Retrieved from http://www.timeanddate.com/worldclock/distanceresult.html?p1=265&p2=117

Time and Date. *Distance from Beijing to Kathmandu.* (2015). Retrieved from http://www.timeanddate.com/worldclock/distanceresult.html?p1=265&p2=117

Timmer, C. P. (2001). Enriching the earth: Fritz Haber, Carl Bosch, and the transformation of world food production. by Vaclav Smil. Cambridge, MA: MIT press, 2001. pp. xvi, 338. $34.95. *The Journal of Economic History, 61*(3), 874-875. Retrieved from http://resolver.scholarsportal.info/resolve/00220507/v61i0003/874_etefhcmp2px3

United States Environmental Protection Agency. (1981). *Urea Manufacturing Industry – Technical Document.* (EPA-450/3-81-001). Retrieved from http://nepis.epa.gov

Watson, C. J., Akhonzada, N. A., Hamilton, J. T. G. and Matthews, D. I. (2008). Rate and mode of application of the urease inhibitor *N*-(n-butyl) thiophosphoric triamide on ammonia volatilization from surface-applied urea. *Soil Use and Management*, 24: 246–253. doi: 10.1111/j.1475-2743.2008.00157.x