Shell-ex: liquid fish hydrolysate fertilizer

Ford Laxdal

The aim of this report is to evaluate the potential of implementing the use of Canadian liquid fish hydrolysate fertilizer in Nepal. The following paper is split into two sections that will evaluate the potential benefits and challenges the product poses in both Canada and Nepal. Firstly, a comprehensive analysis of the production of liquid fish hydrolysate, followed by an evaluation of the market potential, competition and benefits the product has to offer. Secondly, the paper will look at current issues affecting Nepalese agriculture, as well as provide a critique of the usefulness of implementing fish fertilizer in Nepal. Lastly, recommendations on implementing the product will be offered. These recommendations are aimed at introducing this fertilizer processing directly into areas around Nepal.

Part 1: Information pertaining to Canadian liquid fish hydrolysate fertilizer

The product advocated by this paper is an organic liquid fish fertilizer, known as fish hydrolysate. This fertilizer is developed at a marine bio-refinery in Twillingate, Newfoundland known as Shell-ex. Shell-ex produces a number of marine derived agricultural inputs and their fish hydrolysate has various world-wide benefits associated with it.

I. Production inputs

The process of creating fish hydrolysate is relatively easy and does not require large amounts of labour. The production cycle begins with sourcing fish trimmings known as offal from local fishermen and processing plants (Shell-ex, 2015.) During fish processing large amounts of offal are produced, this is an issue for small processing plants as they have no outlet for their by-product. Utilizing offal for the production of fish hydrolysate is the best use for excess offal because of its relatively simple and cheap production process, as compared to a production substitute, fish meal (FAO, 2001.) The offal is then analyzed for freshness and quality at nearby fish-plants, offal must be fresh and decomposing offal should never be utilized. Suitable offal is then forwarded to Shell-ex's marine bio-refinery in food grade insulated boxes for daily processing of fish hydrolysate (Shell-ex, 2015.)

II. Production process

Producing fish hydrolysate is an easy four-step process, the main phases of this process are: grinding of fresh offal, hydrolyzing and pH balancing the by-product, before finally filtering the product to produce thick liquid fish hydrolysate (Shell-ex, 2015.) The method by which Shell-ex uses to produce their fish hydrolysate begins with grinding the fresh offal in a grinder, the freshly ground offal is then loaded from the dispenser to the mixing drum (FAO, 2001.) Here the ground product is mixed for approximately ten minutes while being hydrolyzed by natural enzymes and pH stabilized using phosphoric acid to a suitable target pH of 3.5-3.8. This acidic compound is then filtered to 80 mesh, and finally resembles thick chocolate milk with a mild fish odor (Shell-ex, 2015.) The mixture is then mixed for approximately five to seven minutes before being stored directly into 120L retaining barrels (FAO, 2001.) The retaining storage barrels should be stored in the shade to avoid solar radiation, stirred periodically and kept at approximately 15-20ºC. Under these conditions fish hydrolysate can be stored up to 6 months (FAO, 2001.)

III. Machinery and labour

As mentioned, the production of fish hydrolysate is the cheapest way to utilize offal, this is partly due to the low machinery and labour requirements. The process of making fish hydrolysate consists of only four machines (**See Figure 1**.) The processing equipment starts with a grinder, specifically one with sieve openings of 6-10mm, and an output capacity of 400kg per hour (FAO, 1996.) Once grinded the product is extruded into a dispenser equipped with a worm-wheel unloading conveyor dispenses the ground offal into a rotating mixer with a 150L volume drum. After the hydrolysis/ balancing has finished in the drum, the final mixture is stored in 120L plastic barrels (**See Figure 1).** Due to the simplicity of production these four machines can be operated by one unskilled worker. One worker can produce up to two tons of fish hydrolysate per shift (FAO, 1996.)

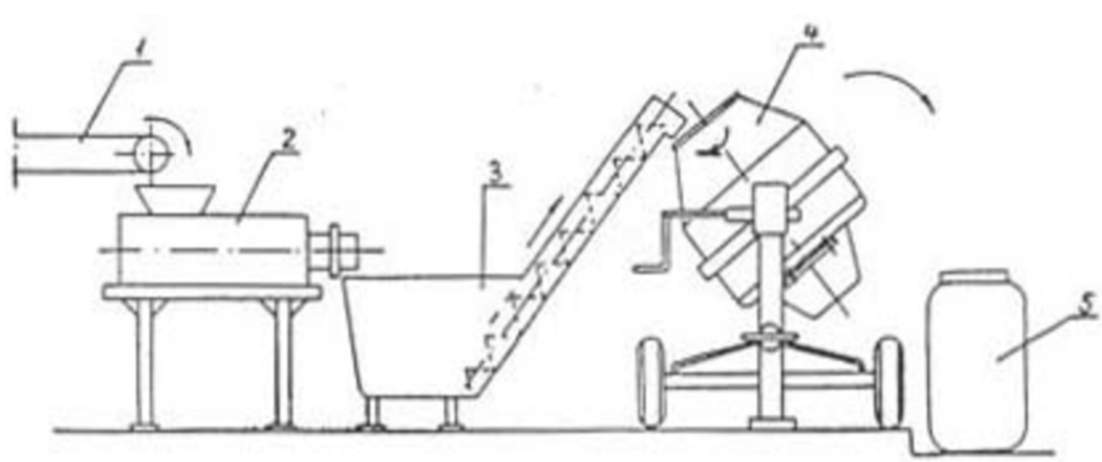


Figure 1: *Simplified layout of fish hydrolysate production* (FAO, 2001)

1- *Feeder,* ***2-*** *Grinder,* ***3-*** *Tank w/ elevator,* ***4-*** *Mixer,* ***5-*** *Retaining barrel (120L)*

IV. Costs

Costs for producing fish hydrolysate are variable, as there is no limit to the size of plant. Each operation has to be considered individually as the prices of producing fish fertilizer can range cheap homemade operations to million dollar plants (FAO, 2001). No information was received from Shell-ex regarding their individual costs.

V. Nutritional information

Shell-ex's fish hydrolysate is a slow release fertilizer used to maximize nitrogen (N), phosphorous (P) and potassium (K), essential amino acids and micronutrients (Degebassa & Lema, 2012). Compared to synthetic fertilizers, fish fertilizers have relatively low nutrient levels but they perform several important soil restoring functions. Fish hydrolysate improves the physical structure of soil, this allows more air to reach the plant roots in turn increasing bacterial and fungal activity in the roots (Degebassa & Lema, 2012).

NPK Analysis:	
Total Nitrogen	3%
➢ Water soluble nitrogen	2.5%
➢ Water insoluble nitrogen	0.5%
Available phosphoric acid (P_2O_5)	1%
Soluble Potash (K_2O)	1%

Table 1: NPK analysis for fish hydrolysate (http://ag-usa.net/fish%20fertilizer.htm)

Nutrient Content	
Amino acid profile:	Theonine, Aspartic Acid, Serine, Proine, Glutamic Acid, Glycerine, Alanine, Cystine, Valine, Methionine, Isoleucine, Tyrosine, Phenylalanine, Lysine, Histidine, Agrinine, Hydroxyproline
Elements:	Nitrogen, Phosphorous, Potassium, Calcium, Sulfur, Magnesium, Iron, Manganese, Copper, Zinc, Boron, Molybdenum, Cadmium
Vitamin content:	Thiamine, Biotin, Riboflavin, Niacin, Vitamin B-6, Pantothenic Acid, Folic Acid, Vitamin B-12, Vitamin A, Vitamin C, Vitamin D, Vitamin E

Table 2: Nutrient content of fish hydrolysate (http://ag-usa.net/fish%20fertilizer.htm)

VI. Competition

Fertilizer is a critical input in agriculture the world over, and over the years' chemical fertilizers have been used to enhance soil fertility internationally (Degebassa & Lema, 2012). Chemical fertilizers are beneficial as they work quickly and can be personalized for the plant you are growing. However, there are many negative side effects associated with the use of chemical fertilizers. These drawbacks include high price range, chemical fertilizers are leached before the nutrients are absorbed and they cause dangerous chemical runoff that alters the composition of waterbodies- leading to algal blooms (Degebassa & Lema, 2012). As mentioned, fish fertilizers do not have as significant levels of nutrients compared to synthetic fertilizers but this comes with the added benefit of containing marine organics that rejuvenate plant structure and soil. Another benefit of fish fertilizer is that they do not leach from the soil and into waterbodies – reducing water pollution (Degebassa & Lema, 2012). In a study from 2012, scientists compared the effects of synthetic fertilizer, fish fertilizer and manure. It was found that fish fertilizer yielded the heaviest final tomato plants, as compared to synthetic and manure. (**See Figure 2**).

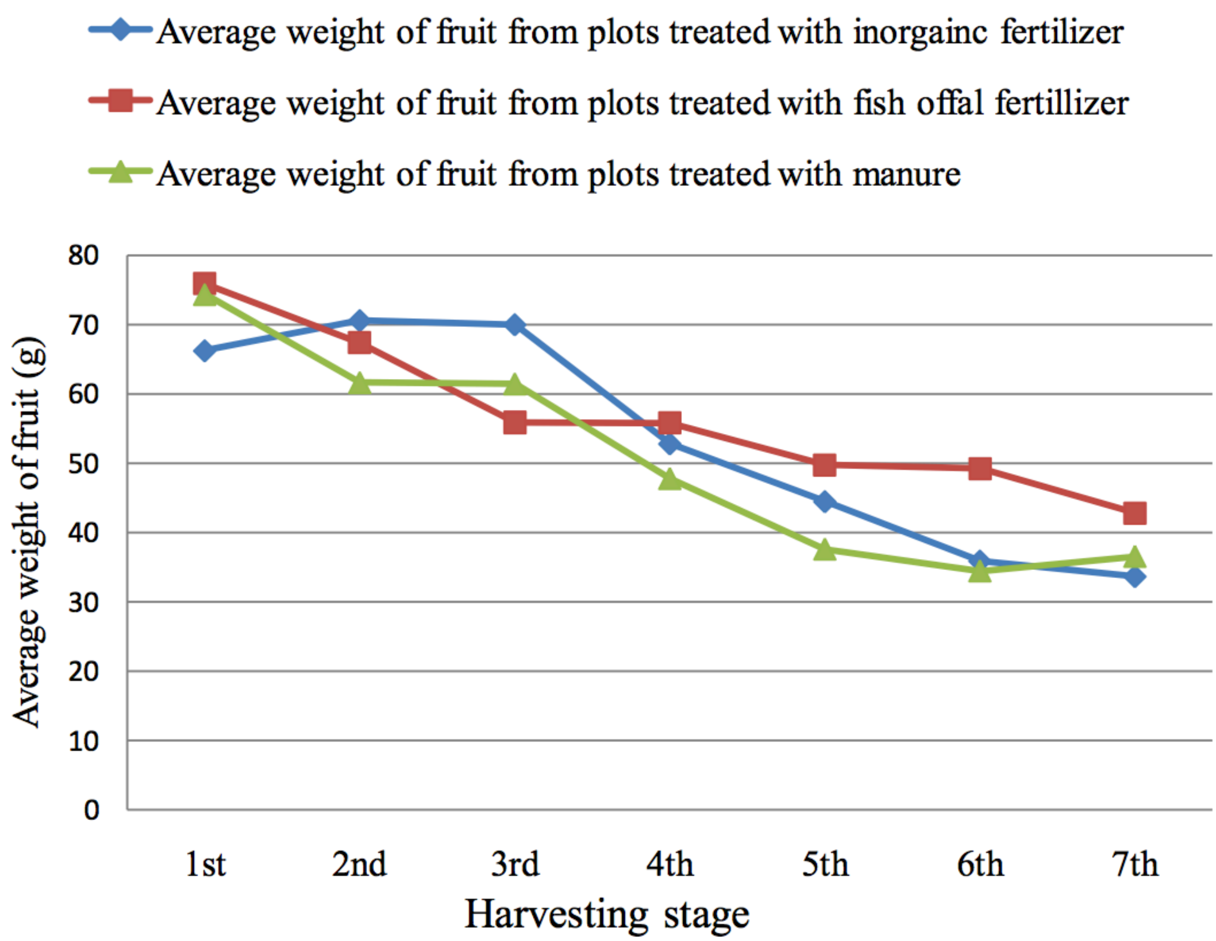


Figure 2: Average tomato weight in grams collected from six plants with an area of 1.8m^2 (Degebassa & Lema, 2012).

As displayed in **Figure 2**, during the early stages of development the yield of plots treated with fish fertilizer was lower comparatively, but the fish fertilizer had retained the highest weight at the latest (7th) harvesting. It was seen that these tomatoes were still green, while the other two varieties had dried up (Degebassa & Lema, 2012). This is because nutrient in chemical fertilizers are very readily available but do not sustain well, while fish fertilizer's nutrients sustain well and promote extended growth (Degebassa & Lema, 2012).

VII. Benefits to Canada

The fish processing and synthetic fertilizer industries are responsible for massive amounts of waste and greenhouse gas emissions that both contribute climate change (Chamcheun et al., 2015). The production of fish fertilizer is a good solution for mitigating the effects of these two industries. As mentioned, the production of fish hydrolysate uses sustainable inputs known as offal, annually approximately 100,000 tons of offal are produced per year (Chamcheun et al., 2015). It was found that in North Atlantic communities the cost of disposing of offal was high and the disposal of this waste has resounding negative impacts on local environments. Unutilized fish matter is usually disposed of in a landfill, incinerated or dumped in the ocean – indicating an urgent need for new uses of fish waste (Chamcheun et al., 2015). Fisheries have indirect effects on the structure of marine ecosystems. Dumping offal proliferates scavenger species, such as crabs (Goñi, 1998). During a study in New Zealand it was found that dumping of large quantities of offal results in anoxic waters. Specifically, oxygen concentration depleted to 45-55% saturation after dumping 47,800 tons of offal over a 60-day period (Goñi, 1998). Depleted oxygen concentrations lead to marine mortality or emigration, further distorting the composition of marine biodiversity (Goñi, 1998). The production of synthetic nitrogen fertilizers produces both nitrous oxide (N_2O) and carbon dioxide (CO_2) emissions, and contributes to nearly 1.2% of total greenhouse gas (GHG) emissions (Wood & Cowie, 2004). A primary input for nitrogen fertilizers is ammonia (NH_3), during the production of ammonia subsequent nitrous oxide emissions stem from the nitric acid production during the Haber-Bosch process (Wood & Cowie, 2004). The production of ammonia is very energy demanding, requiring around 25-35 GJ/tonne of ammonia. Ammonia production requires large amounts of steam for the 'steam reforming process,' producing such large amounts of steam is driven by burning natural gas or other hydrocarbons, resulting in CO2 emissions (Wood & Cowie, 2004). Carbon dioxide emissions compose the majority of the fertilizer industries GHG emissions, where other sources (eg. Transport) only have minor contributions (Wood & Cowie, 2004). By utilizing the large amounts of offal produced each year to produce fish hydrolysate Shell-ex is able to divert large amounts of waste that would otherwise negatively affect both marine and terrestrial environments. Using offal for the production of fish hydrolysate utilizes the otherwise-wasted valuable proteins and amino acids. Therefore, by improving both the quantity and quality of unusable offal via hydrolysis, this can be an appropriate strategy for achieving economic gain in North Atlantic communities (Chamcheun et al., 2015). The production of fish hydrolysate has many environmental and economic benefits for Canada. By using rather than wasting offal Shell-ex is able to create high value products while diverting mass amounts of organic waste, as well as "divert tens of thousands of tons per year of greenhouse gas emissions" (Shell-ex, 2015).

Part 2: Export potential to Nepal

I. Introduction to Nepal

Nepal is a country landlocked between India and China and houses approximately 29.5 million people (Chapagain, 2016). Canada is 64 times larger than Nepal, and houses only 6 million more people (Chapagain, 2016). Comparatively, the population density (density/ sq mile) in Nepal is 206 people/ sq mile, while the density in Canada is only 3 people/ sq mile (Chapagain, 2016). Agriculture is a very large and important industry in Nepal as it employs over 70% of their population, and accounts for 38% of their gross domestic product (Chapagain, 2016). Nepal encompasses a total of 147,141km^2, and approximately 28% of that land is used for agriculture. Nepal has a total cultivatable area of 3.1 million hectares and experiences a cropping intensity of 183% (Chapagain, 2016). Nepal has a very diverse landscape that ranges from largest mountains in the world to plains of the terai region, because of this Nepal has three distinct agro-ecological zones; the mountain, hills and terai regions (**See Figure 3**).

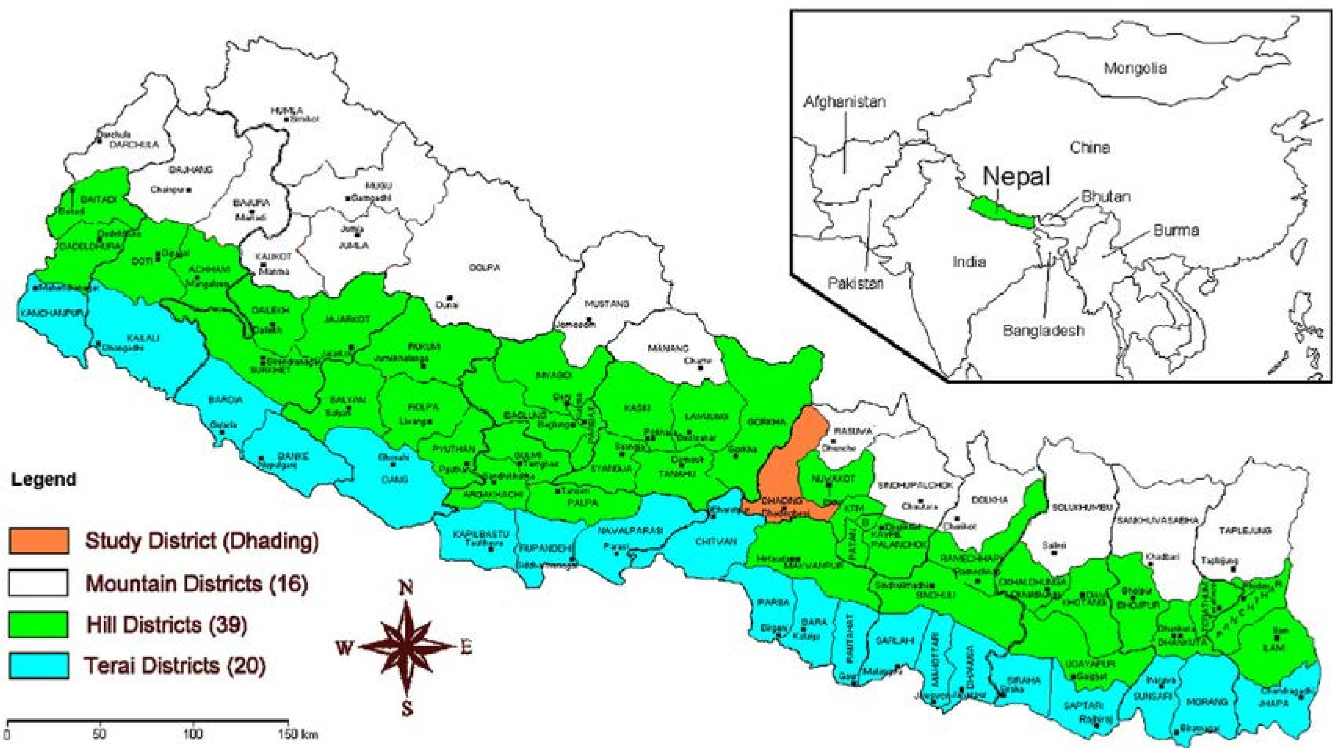


Figure 3: Agro-ecological regions of Nepal ([https://www.researchgate.net/figure/227417012_fig1_Fig-1-Political-map-of-Nepal-showing-study-district-and-other-districts-by-ecological)](https://www.researchgate.net/figure/227417012_fig1_Fig-1-Political-map-of-Nepal-showing-study-district-and-other-districts-by-ecological)

The three regions are distinct in their altitude, landscape, topography, temperature and crop and livestock production practices. The climate in Nepal ranges from alpine climate in the mountains to subtropical in the terai region. The terai region encompasses only 23% of Nepal, and is responsible for the production of large amounts of small grains. The mountain and hill regions cover 35% and 42% of Nepal, respectively. These two regions are mostly responsible for production of fruits, vegetables and livestock (Chapagain, 2016).

II. Agriculture in Nepal

There are many factors that contribute to what is grown in each region in Nepal, these factors include altitude/climate and soil composition. The variances in these factors affects the cropping systems and crop management practices used in each region (**See Table 3).**

	Terai	Hills	Mountain
Climate:	Sub-tropical climate	Sub-tropical to warm temperate	Warm temperate to alpine
Altitude:	<500 masl	500-2500 masl	>2500 masl
Soil:	Alluvial and highly fertile; 57% irrigated	Clay loam to sandy loam, 29% irrigated	Rocky to sandy loam with small stones, 28% irrigated
Cropping systems:	Double or triple cropping	Double or triple cropping, agroforestry systems	Monoculture
Crop management practices:	Semi-mechanized	Traditional/ subsistence farming	Nomadic farming, <1% of land is cultivated

Table 3: Agricultural differences between Nepal's agro-ecological regions (Chapagain, 2016).

Due to the lack of cultivatable land (<1%) in the mountain regions, farmers must use nomadic farming practices that require them to move from place to place in search of food, water and grazing land (Chapagain, 2016). In the hills regions farming practices are still traditional and there is minimal use of chemicals, improved cultivars and tools (Chapagain, 2016). In the terai region alluvial and fertile soils combined with large amounts of flat land have resulted in semi-mechanized farming systems; as the use of tractors, harvesters and synthetic fertilizers are rising each year (Chapagain, 2016).

III. Issues surrounding agriculture in Nepal

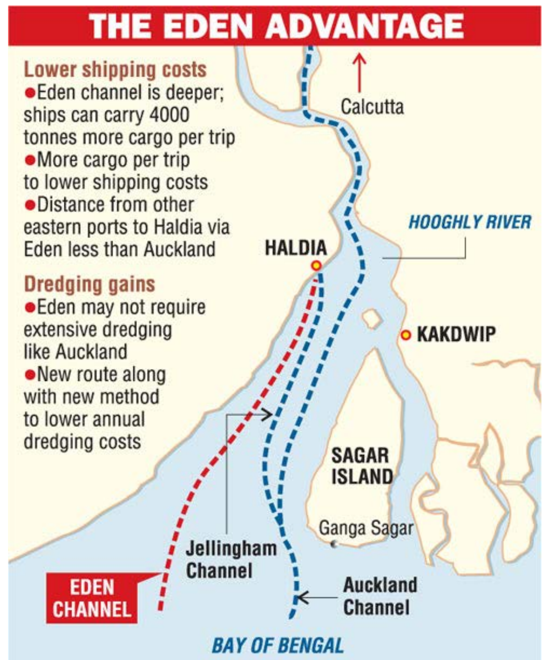
There are a plethora of challenges facing the agricultural sector in Nepal, namely soil degradation, small land holding, narrow and sloped land, poor access to agriculture markets and natural disaster. These challenges are perpetuating both unemployment and food insecurity within Nepal, with approximately 46% unemployment, and 18% malnourishment (Chapagain, 2016). With the rise of mechanized farming in Nepal there has also been an increase in the use of synthetic fertilizers (Chapagain, 2016). It has been found that the use of chemical fertilizers in Nepal is no longer sustainable from a soil health point of view as it produces undesirable salt deposits and leeches the soil of many nutrients, soil analysis has indicated a low to medium nitrogen content (Bhandari, 2013). Nepal’s crop sector would benefit from inputs such as fertilizers, improved seeds, and site specific equipment (Chapagain, 2016). After the earthquake in 2015 Nepal was plunged into food insecurity with nearly 3.5 million people in need of food assistance (FAO, 2015). It was found that the most urgently needed inputs were seeds and fertilizers (FAO, 2015). The challenges facing Nepal must be dealt with in a sustainable manner to ensure no further damage is done, as well to restore economic stability to post-earthquake Nepal.

IV. Means by which fish hydrolysate can alleviate issues in Nepal

The target consumers of fish hydrolysate are local crop farmers in Nepal, predominantly in the terai region, where large amounts of rice, maize, wheat and millet are grown (Chapagain, 2016). Maize (*Zea mays* L.) and millet (*Pennisetum glaucum*), a common crop rotation and two of Nepal’s main crops are both responsive to increases in nitrogen (Bhandari, 2013). As mentioned, fish hydrolysate is an appropriate nitrogen fertilizer that provides added soil rejuvenating benefits. Liquid fish fertilizer contains organic matter that stimulates microbial growth in the soils, this repairs degraded soils and allows more air to access the plant roots. Increased airflow to the roots incites bacterial and fungal activity, in turn improving crops health and yields (Degebassa & Lema, 2012). For this reason, fish fertilizer would be a good substitute for the increasingly popular synthetic fertilizers being seen in Nepal today. Fish fertilizer is a sustainable method for increasing post-earthquake crop yields and to reduce the incidence of food insecurity in the country, as mentioned the most needed inputs included fertilizers, and fish fertilizers soil restoring capabilities would help with restoring arable land damaged by the earthquake (Degebassa & Lema, 2012).

V. Logistics

Transportation of Shell-ex's fish hydrolysate from Twillingate to Nepal would have to be shipped by barge across the Atlantic. Nepal is located approximately 6640km from Twillingate, and due to being a landlocked country the most likely point of entrance for the product is India (AICL, 2016). Specifically, the product would enter the continent via the Eden channel to the CIF Kolkata/Haldia port in India (AICL, 2016). An advantage of shipping via the Eden channel is that it's cheaper (**See Figure 4**).



<u>Figure 4:</u> "The Eden Advantage"

Transporting fish fertilizer through India would be beneficial for marketing, as the "Canadian High Commission in New Delhi has organized trade missions to Nepal to promote trade between Canada and Nepal (Government of Canada, 2013)." One challenge the Nepalese agriculture sector faces is lack of market access for local farmers (Chapagain, 2016). Organized trade missions would be invaluable in marketing and would help in finding a suitable distributor for the product; one potential Nepalese distributor is Agriculture Inputs Company Ltd. Presently Agriculture Inputs Company Ltd. is working with 1378 cooperatives that are retailing fertilizer (AICL, 2016). One logistical challenge with transporting fish hydrolysate is the cost of transporting high volumes of liquids long distances. Liquid fish fertilizer is approximately five times as bulky as its production substitutes fish meal, making it more viable domestically (FAO, 2001).

VI. Cost effectiveness & Recommendations

Referring back to the cost of producing fish hydrolysate, each operation must be considered individually as the scale of your plant is what will determine the costs (FAO, 2001). It should be noted that depending on your desired output as well as the distance the product must be transported all contribute to price. For this reason, the production of fish hydrolysate should be considered for domestic use rather than international use, as the cost of transporting liquids is too high (FAO, 2001). With this realization, a potential recommendation would be initiating fish hydrolysate production within the Asian continent, specifically coastal India. This would likely be a better solution than transporting as the costs would be far too high for local farmers to use practically. Production in Asia would be possible as it will be cheaper and easier to source local offal, and import enzymes/ acid for the hydrolysis process. In India offal and excess fish can be sourced year round, but is most easily and abundantly sourced following monsoon season (Prabu, 2015). It was found that small scale fish hydrolysate production has already made its way into India, an organization called Vk-nardep has been introducing small scale production of fish fertilizer and has started outreach to educate on production/use (Prabu, 2015).

References:

Bhandari, D. (2014). An Overview of Agrochemicals and Their Effects on Environment in Nepal**.** *Progressive Sustainable Developers Nepal*, *2*(2), 66-73.

Bykowski, P., & Dutkiewicz, D. (1996). Freshwater fish processing and equipment in small plants. In, FAO Fisheries Circular. No. 905 (59). Rome: Food and Agriculture Organization of the United Nations.

Chamcheun, C., Kongruang, S., & Wisuthiphaet N. (2015). Production of Fish Protein Hydrolysates by Acid and Enzymatic Hydrolysis. *Journal of Medical and Bioengineering*, 4(6), 466-470.

Chapagain, T. (2016). Agriculture and Agri-food Systems in Nepal [Powerpoint Slides] Retrieved from https://courselink.uoguelph.ca/d2l/le/content/443268/viewContent/1445125/View

Cowie, A., Wood, S. (2004). A Review of Greenhouse Gas Emission Factors for Fertiliser Production. *Research and Development Division, State Forests of New South Wales. Cooperative Research Centre for Greenhouse Accounting*, 38, 1-20.

Degebassa, A., & Lema, A. (2013). Comparison of chemical fertilizer, fish offal's fertilizer and manure applied to tomato and onion. *African Journal of Agricultural Research,* 8(3), 274-278.

Hollet, D. (2015). *Newfoundland's Marine Bio-refinery - From Sea to Soil.* Retrieved Oct 18, 2016 http://shell-ex.com/index.html

Goñi, R. (1998). Ecosystem effects of marine fisheries: an overview. *Ocean & Coastal management*, 40(1), 37-64.

Prabu, M.J. (2015). *Farmer's Notebook; Using fish waste to make a low-budget crop nutrient.* Retrieved Nov 28, 2016 http://www.thehindu.com/sci-tech/science/farmers-notebook-using-fish-waste-to-make-a-lowbudget-crop-nutrient/article4459725.ece

(2014, March 10). *Canada-Nepal relations.* Retrieved October 20, 2016, from Government of Canada, http://www.canadainternational.gc.ca/india-inde/bilateral_relations_bilaterales/canada_nepal.aspx?lang=eng

(June 2015). *Nepal Earthquake: Agricultural Livelihood Impact Appraisal in Six Most Affected Districts*. FAO. GoN, FAO, FSC/UN. Web. 18 Oct. 2016.