Aquaponics in Nepal

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Part 1

Product Description

Aquaponics is the combination of two farming practices; aquaculture and hydroponics (Love et al., 2014). Aquaculture is the process of farming fish intensively while hydroponics is growing plants without soil (Love et al., 2014). Aquaponics is an example of a symbiotic relationship between fish and plants (Somerville et al., 2014). There are three different construction types for aquaponic systems; media beds, deep water culture (DWC), and nutrient film technique (NFT)(Somerville et al., 2014). The three systems are described in Table 1 found below. After comparing the three systems, it was found the media bed style would be most successful for Nepalese people.

Description of How the Product Works

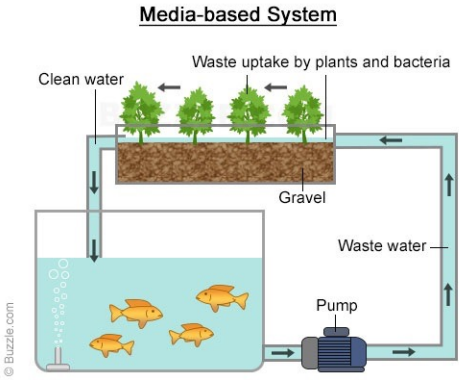
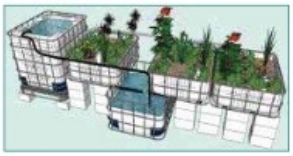


Figure 1 Media Bed Aquaponics Retrieved from http://organicdailypost.com/wp-content/uploads/2015/02/aquaponics-

The media bed aquaponic (Figure 1) system begins by growing fish in a fish tank. The water is pumped from the fish tank to the grow bed, where plants are grown (Somerville et al., 2014). Water flows through the plants' roots and nutrients present in the water are absorbed (Somerville et al., 2014). Bacteria that is present throughout the grow bed converts ammonia, a compound produced by the fish, into nitrites and nitrates (Somerville et al., 2014) (figure 2). If there is an abundance of ammonia in the fish tank's water, it could kill the fish (Somerville et al. 2014). The removal of ammonia by the plants purifies the toxic water, making it clean and able

Table 1 Strengths and weaknesses of aquaponic techniques (Somerville et al., 2014)

System type	Strengths	Weaknesses
Media bed units 	Simple and forgiving design Ideal for beginners Alternative/recycled parts can be used Tall fruiting vegetables are supported All types of plants can be grown Multiple irrigation techniques Many types of media can be used High aeration when using bell siphons Relatively low electrical energy Medium captures and mineralizes solids	Very heavy, depending on choice of media Media can be expensive Media can be unavailable Unwieldy at large scale Higher evaporation than NFT and DWC Labour-intensive to construct Flood-and-drain cycles require careful calculation of water volume Media can clog at high stocking density Plant transplanting is more labour-intensive as the media needs to be moved If water delivery is not uniform, plant performance may differ from bed to bed
NFT units 	More cost-effective than media beds on large scale Ideal for herbs and leafy green vegetables Minimal water loss by evaporation Light weight system Best method for rooftops Very simple harvesting methods Pipes spacing can be adjusted to suit different plants Well researched by commercial hydroponic ventures Smallest water volume required Minimal labour to plant and harvest	More complex filtration method Water pump and air pump are mandatory Cannot directly seed Low water volume magnifies water quality issues Increases variability in water temperature with stress on fish Water inlet pipes can easily clog Vulnerable to power outages
DWC units 	More cost-effective method than media beds on large scale Large water volume dampens changes in water quality Can withstand short interruptions in electricity Minimal water loss by evaporation Well researched by commercial hydroponic ventures Polystyrene rafts insulate water from heat losses/gains keeping constant temperatures Shifting rafts can facilitate planting and harvest Rafts provide biofilter surface area DWC canals can be fixed with plastic liners using almost any kind of wall (wood, steel frames, metal profiles) Can be used at multiple stocking densities	More complex filtration method Very heavy unit High dissolved oxygen required in the canal, and a more sophisticated air pump is required Plastic liners must be food-grade Polystyrene sheets are easily broken Tall plants are more difficult to support Large water volume increases humidity and the risk of fungal disease

to return to the fish (Somerville et al., 2014). The water is therefore in a recirculating system that only requires the addition of water to replace the lost due to evaporation (Diver, Rinehart, 2010). The types of plants best suited for growing in this system are leafy greens, which would include all types of lettuce, kale, swiss chard, and many types of herbs (Love, 2014). After the system is

mature or established, tomatoes, peppers, cucumbers, beans, peas, and broccoli can also be grown (Love et al., 2014). The fish that are grown in this system are a fresh water fish that have a high tolerance for temperature and pH fluctuation (Love et al., 2014). Varieties used most often are tilapia, sunfish, and blue gill (Love et al., 2014). Aquaponic systems are ideally suited to greenhouse locations where temperature and humidity are controlled and the growing season is prolonged (Love et al., 2014). However, a heated or partially heated building and some form of artificial grow lighting would also help to extend the season along with the planting of seasonally appropriate crops (Love et al., 2014).

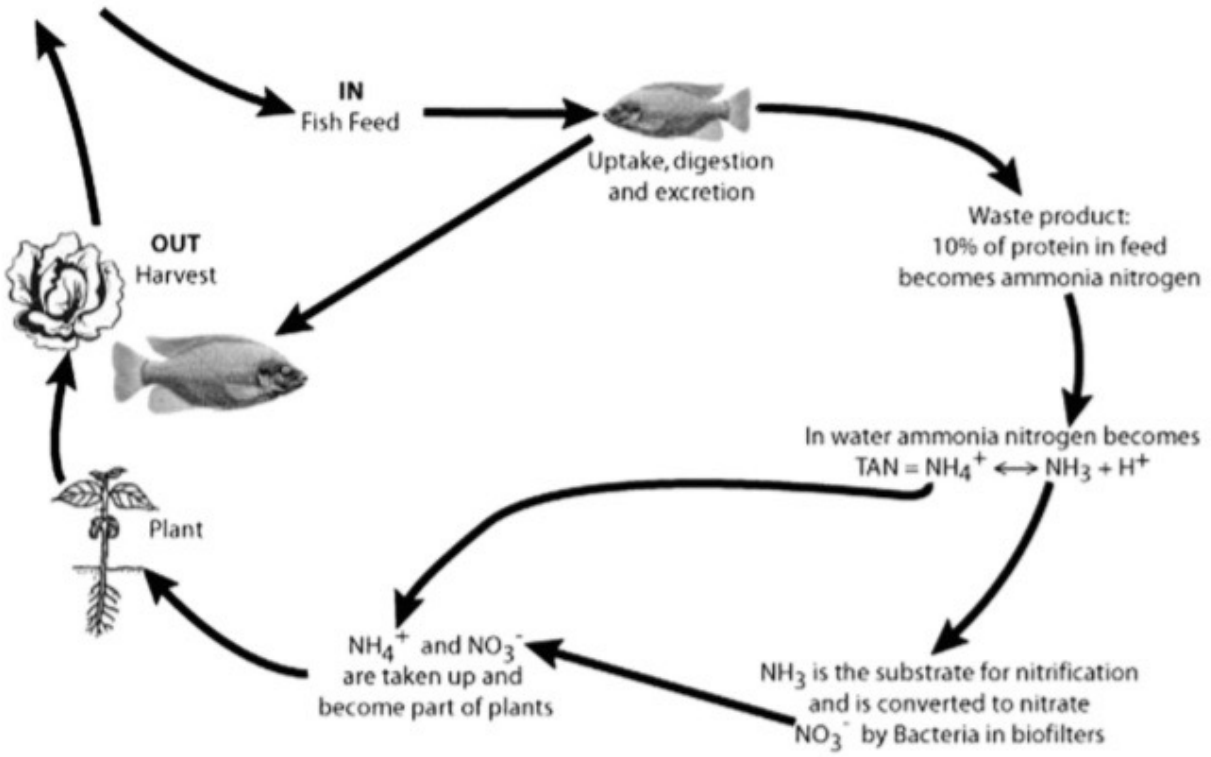


Figure 2 Aquaponic flow chart
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horttech.ashspublications.org.subzero.lib.uoguelp
h.ca/content/21/1/6.full?
sid=3aff481b-1a79-4f5e-94ca-27e274f1d4f4

Machinery Required and Cost

There are three basic items needed for an aquaponic system: a fish tank (Figure 3), a grow bed (Figure 4), and a water pump (Somerville et al., 2014). The other key equipment includes grow media (typically expanding clay) (Figure 5), the ammonia converting bacteria, and pipes to move the water to and from the various tanks and beds (Somerville et al., 2014). For the small scale aquaponic system that could be exported the equipment that is needed is a 150 litre fish tank, 100 litre grow bed, two bags of 50 litre grow media, and a water pump. The total cost of this system in Canadian dollars would be $260.00 (not including shipping). The breakdown of the total cost is the fish tank costs $59.00, grow bed is $84.00, water pump is $39.00, grow media is $76.00. These prices were quoted from JustAquaponics, a Canadian aquaponic supplier. This system would produce about 18 kilograms of fish per year and around 320 heads of lettuce per year (Nelson Pade, 2015). This size of system would be ideally suited to individual families rather than multiple families. In a larger system that has an 800 litre fish tank, there can be approximately 95 kg of fish and about 1800 heads of lettuce produced each year (Nelson and Pade, 2015).

Figure 3 Fish Tank
Retrieved from http://www.justaquaponics.ca

Figure 4 Media Bed
Retrieved from http://www.justaquaponics.ca

Figure 5 Grow Media
Retrieved from http://278p0sa1g2j3s8q0n3gpe0wo.wpengine.netdna-cdn.com/wp-content/uploads/2014/10/hydroton

Inputs Required

Aquaponic systems require three inputs; water, fish food, and energy (Love et al., 2014). The usual source of water for the systems is filtered well or community water (Love et al., 2014). But this source would not always be feasible for systems in Nepal. Rainwater is another source of water that is suitable for aquaponic use, and would be the best water supply for the Nepalese (Love et al., 2014). The average precipitation each year in Nepal is 1500 mm, but it can reach 5000 mm in some areas (Domènech et al., 2012). Most of the precipitation occurs during the months of June to September (Domènech et al., 2012). This would be the preferred time to start an aquaponic system in Nepal since the initial water input requires the most water (Somerville et al., 2014). The use of harvested rainwater could provide sufficient water to supply the system for the duration of the year. Food to feed the fish is also an important input. The most common feed is feed pellets (Love et al., 2014). There are multiple feed suppliers in Nepal where this feed would be available. The third input is energy. This is the energy required to power the water pump that moves water from the fish tank to and from the grow bed (Love et al., 2014). Electric energy in Nepal is extremely underdeveloped (Sovacool et al., 2013). Only 14% of the total population in Nepal have access to electricity, which is usually only available for a few hours during the day (Sovacool et al., 2013). A solution to this would be using solar panels to power the water pumps (Love et al., 2014). A final requirement of this system is time. When the system is first set up, there is no bacteria present in the grow bed that would convert ammonia into nitrites and nitrates (Somerville et al., 2014). Once the system has been operating for a few weeks, the bacteria will thrive and the levels of ammonia will , nitrites, and nitrates will convert to steady amounts (Figure 6) (Somerville et al., 2014). This process is called the nitrogen cycle

(Somerville et al., 2014). The plants also need time to grow, so it will take a few weeks until crops can be harvested. After that, crops can have staggered planting times so there is always fresh produce available. This is also true for the fish, itwill take time until they are big enough to be worth removing from the system. The aquaponic system needs time to mature, or be working with the right amount of bacteria and levels of ammonia must remain constant. Once this happens the crops that can be grown will change from just lettuces and herbs to bigger plants such as tomatoes and peppers.

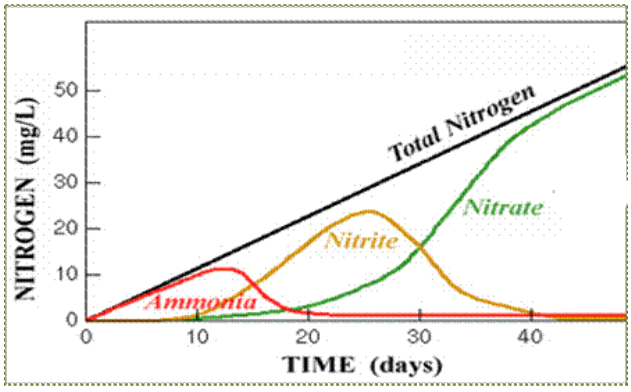

Figure 6 Nitrogen Cycle
Retrieved from http://278p0sa1g2j3s8q0n3gpe0wo.wpengi

Nutritional Information Associated With the Product

While the product itself would not impose health or nutritional benefits to the Nepalese directly, it would indirectly to the food availability. The system would be enabling Nepalese families to grow their own fresh vegetables and fish. These crops would have health benefits and create a better standard of living. 58 g of lettuce contains 1155 mcg of beta-carotene, 96 RAE of vitamin A, 19 mg of phosphorus, and 138 mg of potassium (HC, 2008). In 123 g of tomatoes there is 5 g of carbohydrates, 12 g of calcium, 292 mg of potassium, 52 RAE of vitamin A, and 3165 mcg of lycopene (HC, 2008). The fish that are produced are an excellent source of protein (HC, 2008).

Any Patent Property Constraints

There are patents on certain aquaponic system, but only on some specific designs. If there was to be the export of individual equipment components instead of complete systems there would be no worry of infringing on any patent constraints.

Evaluate Market Opportunities

Currently there is limited usage of aquaponic systems in Nepal. Importing small scale systems would allow Nepalese to benefit from aquaponics. There are other companies selling small scale systems, but none are exporting from Canada. By exporting these systems it will not only create a market in Nepal, it could open up trading partners in other countries. As well, it could encourage other Canadian companies to start manufacturing small scale systems, for export as well as to be sold through out Canada.

Benefits to Canada

If this export was to take place it would benefit Canada. The equipment that is being exported for the aquaponic systems are from a Canadian company. That means profits are staying in the Canadian economy and benefiting the Canadian market. There would also be an increase in the labour force, both at the company and possibly the manufacturing factory where the products are made. There could also be potential jobs found in Nepal to help Nepalese with the set up and maintenance of the systems. To ensure the aquaponic system were assembled properly by Nepalese people, an employee could be located in Nepal. This could be a local person or

company or a consultant going to Nepal occasionally to deal with setups and any problems that occur.

Part 2

Introduction to Nepal

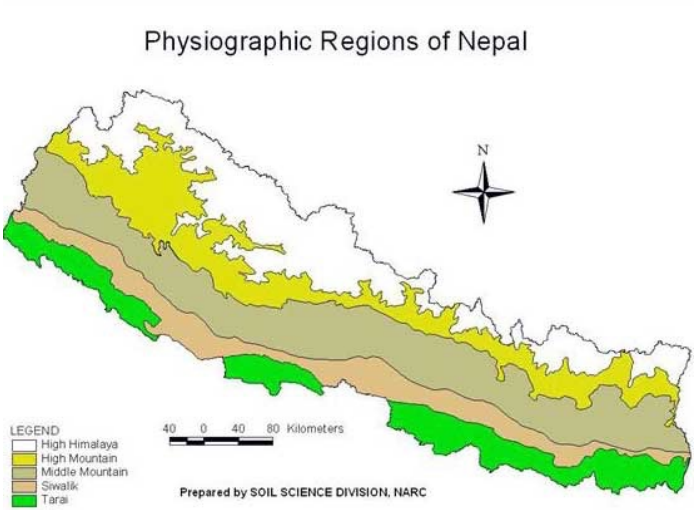

Figure 7 Physiographic Regions of Nepal Retrieved from http://www.fao.org/ag/agp/agpc/doc/counprof/nepal/images/fig2_regions.jpg

Nepal is landlocked between China, to the north, and India, to the south, in Southern Asia (CIA, 2015). Its capital city is Kathmandu and has a population over 30 million (CIA, 2015). The life expectancy for a Nepalese is 67 years of age (CIA, 2015). Most Nepalese people practice Hindu as a religion, with Buddhist and Muslim as the next popular (CIA, 2015). The landscape of Nepal is broken up into three main regions, stretching east to west across the country (CIA, 2015). The Terai region borders India and has flat fertile land (CIA, 2015). The hill region has terrace farming and the mountain region has little farming due to the climate and Himalaya Mountains (CIA, 2015). Nepal is about 147 000 square kilometres, compared to Canada's 10 000 000 square kilometres (CIA, 2015). Its GDP per capita is $3200, compared to Canada's $45000 GDP per capita (CIA, 2015). Nepal's currency is the rupee; one Canadian dollar is about $50 rupee (CIA, 2015).

Transportation Logistics

From the warehouse in Canada components will be shipped to Nepal. This can be done by ships and road transportation once it has reached South Asia. a1 Freight Forwarding is a shipping company with its headquarters in Toronto, Ontario (a1 Freight Forwarding, 2015). This company gave a quote for shipping an aquaponic system. Due to the size and weight of the equipment air transportation would be too expensive (a1 Freight Forwarding, 2015). To ship one complete aquaponic system from a port in Vancouver, British Columbia to Hong Kong, China would cost $250 USD (a1 Freight Forwarding, 2015). This system includes a 150 litre fish tank (11 kg), 100 litre grow bed (7 kg), and grow media (22kg).

Cost analysis to Achieve Profitability

This product would probably not be purchased by many individual families due to the cost. The equipment for the system is $260.00, plus shipping, fish and seeds, fish feed, fish and maybe the extra cost of an alternate power source. It is just not reasonable for a typical Nepalese family. But there is still a way for this product to be an affordable purchase if it were to be purchased co-operatively among multiple families. This way it would result in a more manageable start up cost. Another way could be for families to purchase a system that would produce a surplus of plants and fish so they could sell the extra. Nepalese families will need to think of the purchase as an investment that will benefit the family for the future. It will be a large start up cost, but will provide the family with ongoing benefits.

Benefits to Nepal

There are many benefits for the Nepalese people. The biggest benefit is aquaponics produces a source of food that does not need to be purchased. This would mean a lower food bill each month, which is important for a country where two-thirds of the population face food shortages (Panter-Brick et al., 1997). Since the landscape of Nepal is not suited for extensive farming, there are food shortages (Kahn, 2013). Aquaponic systems would help to lower this shortage by allowing individual/multiple families to grow some of their own food. As well, aquaponics systems can be operated throughout the year so there can be food when conventional farming terminates for the year. Aquaponic systems can produce 20% higher yields than conventional farming, which again is beneficial for a poverty stricken country (Somerville et al., 2014; Kahn, 2013). Because aquaponic is a soilless production, it does not require ploughing or tilling or weeding. For this reason it is also less physically intensive. This is beneficial for Nepalese women who spend most of their time completing these farming activities (Kahn, 2013). If aquaponic systems gain popularity in Nepal, there could be new companies start up that might offer systems for a lower cost. This could make a system available to a wider percent of the Nepalese population. The popularity could also create more government grants or loans, which again would make the systems more affordable for low income families.

Environmental benefits to Nepal

There are many environmental benefits to aquaponics. Aquaponics uses 90% less water than conventional farming practices, requiring replenishment of water only due to evaporation (Diver, Rinehart, 2010). The same plant that is grown in an aquaponic system will use 10% of

the water needed to grow it in soil. This means there would not be as much of a strain on limited water supplies to grow food (Domènech, 2013). It would also allow this system to function in places where irrigation was not possible or happened in limited use. This will help keep erosion to a minimum which is a problem in Nepal (Thapa, 1996). The landscape of Nepal is made up of a lot of hills, which is more difficult to farm on (Khan, 2013). This contributes to the food shortages (Khan, 2013). Aquaponics does not require herbicides or pesticides, so there would be less contamination of Nepal's soil. As well, aquaponic systems can be built on rooftops or concrete in cities, indoors or out, places that would not have been suited for conventional farming (Somerville et al., 2014).

Canadian Companies

JustAquaponics, located in British Columbia, sells aquaponic equipment and could provide all materials needed (contact number: 604-730-1842) (JustAquaponics, 2015). They sell equipment separately so it would be easy to purchases systems varying in size to meet the needs of the Nepalese (JustAquaponics, 2015). They also run information workshops about aquaponics including topics about starting a new system, daily operations of systems, and the best system design (JustAquaponics, 2015). These workshops are currently run in British Columbia, but could be developed to occur in Nepal (JustAquaponics, 2015). WaterFarmers is based in Toronto, Ontario (contact number: 647-771-9598) (WaterFarmers, 2012). While they do not sell aquaponic systems, they provide consulting of aquaponic practices (WaterFarmers, 2012; A. Venkat, personal communication, November 30, 2015). They currently have commercial aquaponic systems in multiple countries including the Middle East and Asia. There could be

potential to begin a project in Nepal (WaterFarmers, 2012). In a personal communication with Arvind Venkat, the founder and CEO of the company, he stated that they would be interested in sending one of their teams to Nepal to help with this project (A. Venkat, personal communication, November 30, 2015). Venkat said he would be interested in becoming involved with the project as well as the social impact it would have (A. Venkat, personal communication, November 30, 2015). They are working towards developing small community-sized aquaponic system, which would be more valuable for Nepalese (WaterFarmers, 2012).

Marketing Strategy

Aquaponics could be marketed very effectively to encourage Nepalese to buy the systems. Water conservation is a factor that should look attractive to most of the population. Many farmers would know the cost of irrigation and see the benefits in using less water to grow crops. They would also see the cost benefits to not having to buy fertilizer, herbicide and pesticides. It will also allow the use of land not traditionally suited to agriculture. This could allow people in the hill region to make use of land that is not viable for conventional practices. As well, marketing could occur in urban areas to promote aquaponic systems on the roofs of buildings as well as in unused buildings. The benefit of year round production is important for a country where there are food shortages. Promoting year round production will interest many people since crops are not able to be grown all year due to the winter in Nepal (CIA, 2015).

Grants Available

There are multiple Canadian grants available that would help fund this export idea. This would help the Nepalese people as it would lower the cost of the systems. The grants could help cover the cost of shipping the products or the cost of manufacturing the components. The Global Opportunities for Associations (GOA) provides funding for companies to expand their international business endeavours (CTCS, 2015). They offer contributions of $20 000 - $250 000 (CTCS, 2015). Since 2011 the National Research Council of Canada Industrial Research Assistance Program (NRC IRAP) has invested $2.5 million for small and medium sized aquaculture enterprises, including aquaponics (FOC, 2015). Through Funds for NGOs there are grants for sustainability (Kanti, 2015). This is not a Canadian based resource, but Canadian companies are able to apply to and accept grants. Two of these that would apply to aquaponic systems in Nepal are a grant called Global Innovation Fund: Seeking Innovative Solutions to Global Challenges- Especially for Poor and Vulnerable Groups in Developing World (Kanti, 2015). This grant requires an idea that would help improve the lives of people in developing countries (Kanti, 2015). Based on the idea, the investment is ranging from $50 000 to $15 million USD (Kanti, 2015). The second award is the ReSource Award offered by the Swiss Re Foundation for an idea that shows sustainability of watershed management (FundsForNGOs, 2013). The idea must be beneficial for the way of life of people in developing countries and promote water management (FundsForNGOs, 2013). Aquaponics would fit this criteria as it takes 90% less water to grow a plant in an aquaponic system versus conventional practices (Diver, Rinehart, 2010). This grant offers $150 000 USD (FundsForNGOs, 2013).

Global Competition

Nelson and Pade inc. is an American based company (contact number: 608-297-8708) (Nelson and Pade, 2015). They sell complete aquaponic systems ranging in size from small family systems to commercial grade (Nelson and Pade, 2015). Many of their aquaponic designs are patented (Nelson and Pade, 2015). They provide consulting and teaching of aquaponics to many countries past the borders of the United States including Europe, Asia, and Australia (Nelson and Pade, 2015). This company could be competition to any Canadian ventures in exporting aquaponic systems to Nepal. The Aquaponic Source is an aquaponic system supplier from the United States (contact number: 303-720-6604) (Aquaponic Source, 2015). They sell equipment separately or as some full systems (Aquaponic Source, 2015). Similar to JustAquaponics, Aquaponic Source offers informational sessions about how to run a successful aquaponic system (Aquaponic Source, 2015). These workshops could be conducted in different areas in Nepal (Aquaponic Source, 2015). The Aquaponic Source currently does not ship products to Nepal due to import restrictions, but does export to a number of countries (Aquaponic Source, 2015). Aqua Allotments is a European company which also sells small scale aquaponic systems (contact number: 07980 008 695) (Aqua Allotments, 2015). As well as the other companies listed, they sell equipment individually which can be shipped to where ever it is purchased (Aqua Allotments, 2015).

Unknowns

There are some unknowns when it comes to this export idea. Some of the shipping information was unable to be calculated. This included the cost to transport from a port in China

to Nepal. The equipment is relatively heavy and bulky, which is difficult to transport. Another unknown is the demand of the export product. It is hard to calculate this due to the expense of the product and how many Nepalese families are able to afford it. While there is information available on the import restrictions in Nepal, there is no information available on the importation of aquaponic equipment. After researching and speaking with Canadian companies, it is still unclear whether the products are manufactured in Canada or another country where labour is cheaper.

Conclusion

There are many benefits to exporting aquaponic systems to Nepal from Canada that would benefit the Nepalese as well as Canadians. Aquaponic systems would allow individual or multiple families to grow a portion of their own food. This would help save money on food costs, which is an important factor to consider in a country where two thirds of the population lives below the poverty line (Kahn, 2013). Perhaps most importantly it would reduce the use of water for faming practices, since it takes 10% of the water needed to grow a plant in water rather than soil (Somerville et al., 2014). It would also reduce the dependence for expensive fertilizers. Aquaponic systems can also be functioning where traditional farming cannot, for example urban areas (Love et al., 2014). A negative factor with aquaponic systems is that they are relatively expensive in respect to annual gross income of families, start-up costs and shipping being the biggest values (JustAquaponics, 2015; a1 Freight Forwarding, 2015). This could be managed by grants offered by government and/or private enterprise, or alternatively by groups of families purchasing an aquaponic system to share. There are multiple companies supplying equipment for

aquaponic systems could be forced from, including a number located in Canada. This would increase the labor force in Canada and keep money in the Canadian economy. To conclude, this product would help the lively hood of Nepalese families as long as the price of each unit was reduced.

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