The Role of Water Bladders in Storing Rainwater for Irrigation Practices in Nepal

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Contents

Objective

The purpose of this report is to investigate the feasibility of introducing portable water storage bladders, through export from Canada, to the country of Nepal. The bladders are for containment of harvested monsoon rainwater to be used in crop irrigation on an as needed basis during seasonal drought.

Part 1: Product Information

Rationale for Product Choice

Investment in agriculture has been hugely lacking for years in Nepal. This has contributed to food scarcity, resulting in extreme poverty; 25.2% of the population lived below the poverty line in 2010 (“Nepal”, 2015). It is estimated that agriculture employs approximately 65% of the population, in mainly subsistence operations, and contributes 35% to the GDP (Prasai, 2010). This is an industry that demands attention and requires aid. It is interesting to note that government investment has not kept pace with the contributions of agriculture to the economy. Spending on agriculture by the Ministry of Agricultural Development (MoAD) is on the decline, from 3.7 % in 2003 to 2.6% in 2013, while general government spending is on the rise (“Analysis: The Trouble with”, 2013). The decreased spending on agriculture is impeding farmers, specifically those who cannot generate enough income to rise above the poverty line. Farms themselves are shrinking in size with the average farm dropping from 1.1 hectares in 1995 to only 0.7 hectares in 2010 (“Analysis: The Trouble with”, 2013). The country has seen a positive turn away from poverty over the past few years, except in the agricultural sector where it has increased by 10% (“Analysis: The Trouble with”, 2013).

In addition to the lack of government support for farmers, variable seasonal weather patterns provide challenges to crops in different regions of Nepal (Malla, 2008). Heavy monsoon rains fall from June through to August, but these monsoons both follow and give way to much drier seasons (Malla, 2008). For this reason, investment in irrigation is important if farms are to achieve sustainable subsistence, including profitability through the sale of excessive crop yields. Less than a quarter of the land (21%) is suitable for cultivation (Prasai, 2010), and of that amount only 28% is currently irrigated ("Nepal: Irrigation", 2014). This is a problem in a country where, although glacial melt does occur, extreme drought conditions can prevail. Due to the volatility of the banks of larger glacial melt rivers, most irrigation systems are developed on the shores of small and medium size rivers; these rivers depend on rainwater for volume and are thus empty during drier months ("Nepal: Irrigation", 2014). With an average rainfall in Nepal of approximately 1500 mm ("Average Precipitation", 2014) harvesting rainwater and storing it for periods of drought could provide benefits to Nepalese farmers in maintaining and improving their cropping opportunities.

Product Description and Markets

SEI Industries Ltd., located at 7400 Wilson Ave, Delta, British Columbia (V4G 1H3), designs, engineers and manufactures remote site liquid storage bladders using industrial fabrics (Industry Canada, 2013). The company has been in existence since 1978 (Industry Canada, 2013). They focus on providing solutions for the military, industry, and humanitarian efforts and have two international offices in addition to seven international repair facilities (Industry Canada, 2013). Their products are used in 110 countries in the world (Industry Canada, 2013). According to Industry Canada, their total sales are in the $10 million to $25 million bracket and their current export sales are in the $5 million to $10 million bracket, including experience with exports to Nepal (Industry Canada, 2013). SEI employs 88 people in the areas of sales, engineering, production, and management (Industry Canada, 2013).

As a leader in the supply of equipment for mobile firefighting operations, their Bambi Bucket is an essential tool in the control of remote site wildfires, and has a 90% share of the global market ("SEI Industries Products", 2015). Other SEI innovations include their Arctic-King, Desert-King, and Jungle-King fabrics, all designed for long lasting performance for a variety of applications including: oil, gas, environmental spills, mining, aviation, military, emergency drinking water, and agriculture ("SEI Industries Products", 2015). SEI products have been tested in extreme conditions for outdoor use ("SEI Industries Products", 2015) which makes them a leading contender for long term water storage over alternatives such as open air portable lagoons. While both bladders and lagoons boast easy setup, lagoons would require additional evaporation prevention materials to ensure maximum containment of captured rainwater. For this reason, the product that is being investigated is the Terra Tank ® (see Figure 1), a durable bladder tank meant for long-term on-site water storage ("Terra Tank", 2015).

Figure 1: Terra Tank. Retrieved from http://www.sei-ind.com/products/terra-tank-water

The Terra Tank is constructed from one of two proprietary fabrics through sewing and welding. Depending on the intended application, the tank will be outfitted with either an Aqua-Shield or a Chem-Shield (“Terra Tank”, 2015). The Chem-Shield is designed for use in industrial operations to hold chemicals or fuel, while the Aqua-Shield is purposed for the storage of water (“Terra Tank”, 2015). The Aqua-Shield is constructed from a nylon product with polyurethane coatings inside and out (R. Cnudde, personal communication, November 18, 2015). The Terra Tank requires no onsite setup beyond unfolding it, and can be packaged efficiently for shipping due to its foldable nature (Industry Canada, 2013). Optional tank sizes range from 500 US gallons to 30 000 US gallons on their stock chart, though custom sizes are also available (“Terra Tank”, 2015). See Appendix for Tank Specifications. A 12 000 US gallon tank will fit in a 4 foot by 4 foot by 3.3 foot shipping crate weighing 560 pounds (Appendix).

In Part 2 of this report, detailed calculations are shown that determine the optimal volume for a rainwater storage bladder on an average Nepalese farm. Rationale is provided for the purchase of the 12 000 US gallon tanks. In addition to the tank itself, the parts listed in Table 1 would be necessary for full implementation of the bladder. Sales staff from SEI Industries highly recommended that a sunshade be used with each tank in order to improve the longevity of the tank life to upwards of 20 years (R. Cnudde, personal communication, November 18, 2015).

Table 1: **Components Required for Bladder Implementation**
(R. Cnudde, personal communication, November 18, 2015)

Description	Approximate Pricing
Terra Tank - 12 000 US Gallon	$8 455.00
Sun Shade Assembly - High Wind	$2 079.00
Bladder Ground Sheet	$773.00
Total Cost without HST	**$11 307.00**

Benefits to Canada

The benefits of this export opportunity to Canada will be seen in four main areas. First, SEI Industries itself stands to realize increased sales revenue and profit from the sale of additional units in Nepal. The exact financial benefit to the company would be based on the number of units that are sold, though profit margins for the various bladders could not be shared. It is important to note that SEI will need to remain competitively priced with other global suppliers of water bladders in order to secure sales. If the export of this product to Nepal is successful in showing a gain in farming income, SEI could stand to benefit even more by marketing to additional global regions with similar drought/flood cycles.

A second benefit would be in employment opportunities for Canadians. An increase in sales and production for SEI would require an increase in staffing for sales, production and product support. Additionally, SEI currently engineers their own products, meaning improvements or changes in design could also lead to employment for additional engineers.

Third, there could be spin-off benefits to the companies that supply both the raw fabric used in the tanks, and the machinery required in the production and assembly of the tanks. A list of SEI's equipment, as stated on the Industry Canada website, is below in Figure 2.

Finally, there will be indirect benefits through increased business to the logistics companies that would be employed to transport the goods, whether they are via air, ocean, truck, or rail.

SEI Industries' Equipment (Source: Industry Canada)

One (1) 45 kW programmable radio frequency (RF) track welder

Five (5) 15 kW radio frequency (RF) welders;

One (1) hot air welder;

One (1) NC fabric cutting table;

In-house fabrics testing laboratory;

11,000 gallon (50,000 liter) test tank with crane;

Industrial sewing capabilities;

Aluminum welding capabilities;

Assembly capabilities

Figure 2: List of SEI Equipment (Industry Canada, 2013)

Global Competitors

There are a number of competing companies globally that sell bladders for water storage. This means that SEI Industries would need to provide competitive pricing and a superior product in order to stand out as a viable supplier. Unfortunately, none of the websites advertise costs and so comparative pricing is not available at this time. Table 2 provides a sampling of five companies from five countries that distribute water bladders, along with details of the holding capacity, fabric material, and warranty. An attempt was made to relate the size and mass of shipping crates in comparison to SEI Industries own 12 000 US gallon tank. Unfortunately this data was only available for one of the competing companies. The information in Table 2 can be used in the event that a pilot project involving water storage for irrigation is successful and other competitive suppliers need to be investigated.

Table 2: Global Competitors (Sources of information are listed in the Website column)

Company Name and Country of Origin	Compare/Contrast Details of Competitive Products	Website
Fabric Solutions Australia	• water bladders with capacities up to 258 000 US Gallons • heavy-duty PVC or Polyurethane Polymer • Life Expectancy: minimum 10 years • size and mass for shipping not stated	http://www.fabricsolutions.com.au/pillow-tanks/
Flexico St. Petersburg, Russia	• water bladders from 250 to 31 000 US Gallons • advertised as ecologically safe • Life Expectancy not stated • size and mass for shipping not stated	http://rusinflex.com/
Alligator Win Systems Wageningen, The Netherlands (Distributed through Cadman Power Equipment, Canada)	• water bladders from 528 to 132 086 US Gallons • PVC Coated Polyester Fabric • Life Expectancy is 5-20 Years • size and mass for shipping not stated	http://www.albersalligator.com/en/taxonomy/term/52
GTA Containers South Bend, Indiana, USA	• water bladders from 3 000 to 210 000 US gallons • polyurethane PVC and nitrile or neoprene rubber coated with nylon or polyester. • Life Expectancy is 10-20 Years (outdoor expectancy is lower) • 20 000 US gallon tank has a crate dimension of 7 feet by 5 feet by 2.5 feet with a mass of 910 lb including crate. • Therefore it is heavier than the comparable Terra Tank and based on dimensions would allow for fewer to ship in a single container.	http://www.gtacontainers.com/

Qingdao David Chemical Co.,Ltd Shandong, China	• water bladders with capacities from 265 to 132 000 US Gallons • Plastic, PVC, TPU • Life Expectancy: 5-8 years • size and mass for shipping not stated	http://www.alibaba.com/product-detail/1000L-500-000L-pillow-tank-bladder_629704941.html?spm=a2700.7724838.30.1.TJgNrX

Part 2: Introduction of Product to Nepal

Seasonality in Nepal

Crop agriculture in Nepal is an engrossing system, as the annual climate differs from the north to the south of the country, a distance of only 200 km (Prasai, 2010). Crops are grown year round on much of the country's soils, but the crop types are dynamic from season to season as both temperature and rainfall vary throughout the year (Bhandari, 2013). Like many countries in Southeast Asia, Nepal experiences a monsoon season (Urmann, 2015). The monsoon in Nepal is driven by the cooler, saturated ocean air travelling north over India and into Nepal (Urmann, 2015). It is preceded by the summer, and is drawn inland due to the warm, low pressure air hanging over the land (Urmann, 2015). The Himalayas contribute to the monsoon by providing a physical blockade for the saturated air and preventing it from moving further north (Urmann, 2015). At the same time, periods of drought can exist which negatively affect the growth of crops (Bhandari, 2013). Capturing the excess rainwater from the monsoon season, to be used in periods of drought, could increase crop yields thereby improving the economic situation for farmers.

The Market Opportunity in Nepal

While all farmers would benefit from additional water for irrigation, the cost of a bladder for each individual farmer would be prohibitive without substantial government assistance. Fortunately, Nepal already has some structures in place that could assist in the introduction of water bladders to complement existing irrigation practices. In particular, the Irrigation and Water Resources Management Project (IWRMP) was initiated in 2008 ("Nepal: Irrigation", 2014). Their role is: "…improving agriculture productivity and the management of selected irrigation schemes in Nepal, in addition to enhancing institutional capacity for integrated water resource management." ("Nepal: Irrigation", 2014) The organization is helping approximately 415 000 water users improve growing conditions on almost 27 000 hectares ("Nepal: Irrigation", 2014). The results have been promising, with yields of some of the staple crops (e.g., rice, wheat, maize) increasing by over 50% ("Nepal: Irrigation", 2014).

Currently 80% of the water in Nepal is used for irrigation and it is not enough to prevent water deficits during the growing season (Gaire, 2008). A water bladder completes the irrigation scheme in areas not well served by rivers, canals or other waterways by storing rain water until it is needed by the crops. Working with agencies that are already supporting irrigation installations, such as the IWRMP, will benefit the introduction of this technology into Nepal. It is suggested that water bladders could be initially introduced into the country on a pilot project basis, through a partnership between IWRMP and aid organizations as described below in the **Pilot Project Funding** section. One larger sized bladder could be shared by several small farming operations, for example 4-6 neighbouring plots of land. Alternatively, depending on the existing irrigation infrastructure, it may be more cost effective to provide a smaller bladder to individual farmers. Regardless of the approach, due to the cost of the bladders, they would need to be introduced into the economy with the assistance of existing organizations that work closely with irrigation equipment. Farmers would initially require assistance in determining where to place bladders, as they need to be placed in strategic locations with access to existing irrigation equipment to test their role in providing additional water needs. Once a viable and reliable system is in place, the IWRMP could work with the Nepalese government to determine the availability of grants (see section on **Loan or Grant Programs**) to assist individuals or small groups of farmers with the purchase and setup of the bladders.

Target Area in Nepal

The introduction of water bladders could benefit several crops and regions of Nepal; however for the purpose of the pilot project, wheat production in the Makwanpur District (Terai Region) has been chosen (See Figure 3). The Makwanpur District is central to Nepal making it easily accessible for receiving imported materials either through air in Kathmandu, or truck freight from the shipping ports of Kolkata, India. Flooding in this district is problematic for cropping between June and August, and often crops are entirely decimated (Gaire et al, 2008). Because wheat is planted in October/November and harvested in March/April in Nepal (Niraj et al, 2011), its growing season coincides with the dry season meaning it would benefit from irrigation practices.

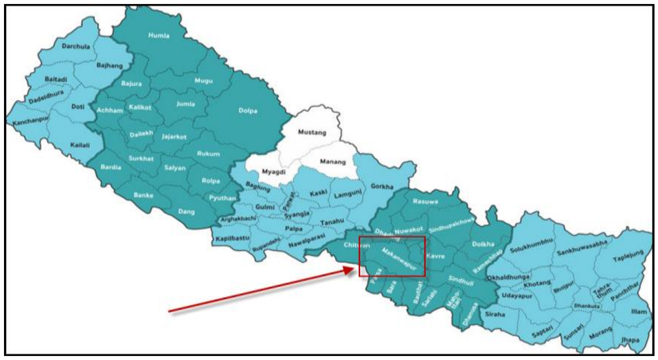


Figure 3: Map of Nepal showing the Makwanpur District.
Retrieved from http://www.ims-np.com/bootstrap/images/map-of-nepal.jpg

For wheat to thrive, 150-200 mm of rain is optimal (Bhandari, 2013). Over a recent period of 12 years, measurements have shown that an average of only 81 mm of rain has been recorded during this region’s wheat season from October to April (“Makwanpur Garhi Monthly Climate”, 2012). Therefore, with a shortage of at minimum 70 mm (150mm subtract 81mm) of rain for optimal wheat production, it is clear that wheat crops would benefit from the use of harvested rainwater for irrigation during an average season.

Size and Cost Calculations of Water Bladders

For the purpose of determining the size and cost of water bladders for a typical Nepalese farm, the average farm size of 0.7 hectares will be used (“Analysis: The Trouble with”, 2013). It will be assumed for illustration purposes that the entire farm is planted in wheat. Table 3 details the calculations.

Table 3: Calculation of Size and Cost of Water Bladders

Description of Measurement	Calculations
Number of US gallons of water required to address the crop water deficit of 70 mm *Note: US gallons are used in the calculations as this is the unit of measure most commonly used in industry when referring to bladder tanks.	0.7 hectares = 7 000 square metres (1 hectare = 10 000 square metres) 70 mm of rain = 0.07 m of rain Therefore the total volume of 70 mm of rain that would fall on 7 000 squares metres of land is: $V = 7\ 000\ m^2 \times 0.07\ m$ $= 490$ cubic metres Since 1 cubic metre of water = 1 000 litres of water, Therefore 490 cubic metres = 490 000 litres Since 3.7854 litres = 1 US Gallon, Therefore 490 000 litres is equivalent to 490 000/ 3.7854 = 129 440 US Gallons To sustain the crop through its critical growth periods, it is estimated that a minimum of 25% of the optimal water requirements would be adequate at key points during the drought period (S. McQueen, Certified Crop Advisor, personal communication, November 21, 2015). Hence, at minimum, 129 440 / 4 = 32 361 US gallons of rain would need to be harvested and contained. *Recommendation:* For the greatest flexibility in both water management and economic investment, it is recommended that three of the 12 000 US Gallon Terra Tanks be combined to create containment for up to 36 000 US gallons per 0.7 hectare farm.
Cost of 1 Terra Tank including supplementary equipment (ground sheet, sunshade) plus tax	$11 307.00 (see Part 1) HST will be 13% of $11 307.00 = $1 469.91

Import Tax	Import Duty in Nepal on Greenhouse equipment for irrigation and other similar equipment is 1% (Government of Nepal, 2015). Total Import Duty = $113.07
Total Cost of 1 Terra Tank (12 000 US Gallons)	Total Price with HST and Import Duty is: $11 307.00 + $1 469.91 + $113.07 = $12 889.98
Total Cost of 3 Terra Tanks (12 000 US Gallons each) to provide rainwater for one 0.7 hectare farm	The total price for 3 tanks, which will create 36 000 US Gallons of rainwater containment is $38 669.94 in Canadian currency.
Recommended Number of Tanks	To make the pilot project feasible for both data collection and the determination of next steps, one full shipping container of Terra Tanks should be purchased and exported to Nepal. This will allow for 6 farm pilot projects (with 3 bladder tanks on each farm). The dimensions of the crate for an individual 12 000 US Gallon tank are: 48 inches by 48 inches by 40 inches (Appendix). The mass of one crate is 560 pounds or 255 kilograms (Appendix). Utilizing extra tall shipping containers, a 40 foot long container will allow for actual inside dimensions of 39 feet 8 inches in the length, 7 feet 9 inches in the width, and 8 feet 9 inches in height (A1 Freight Forwarding, 2015). Hence, given the size of crates required, they can be stacked 2 tall and 9 long, but only 1 wide. This will allow for 18 bladders/crates to be transported in a container, still leaving room for the additional components (ground sheets, sunshades) to fit in. With 3 bladders being required for each 0.7 hectare farm, the 18 bladders will outfit 6 farms for the pilot project. While more than one container could be shipped, it is recommended that this number of bladders would be sufficient for pilot testing purposes.
Total Value of product in a shipping container	With 18 crates in a container, the total value (including taxes and import duties) without freight, will be: **18 x $12 889.98= $232 019.64** NOTE: Freight calculations are in the following section.

Transportation Logistics

Transporting 18 crates from Delta, British Columbia to the administrative headquarters of Hetauda in the Makwanpur District will involve trucking on both ends, as well as air or ocean-going freight between continents. A comparison of the cost of air versus ocean-going freight follows in Table 4. The quotes are from A1 Freight Forwarding (A1 Freight Forwarding, 2015). Another logistics company that is sometimes used by SEI is Panalpina which services 6 continents; unfortunately quotes are not readily available on the website. (R. Cnudde, personal communication, November 18, 2015).

Table 4: Cost Comparison of Air versus Ocean-Going Freight

Air **From Vancouver Airport to Kathmandu, Nepal**		**Ocean-Going Freight** **From Vancouver Port, to Kolkata, India**	
Freight Charge	$16 895.09	Freight Charge	$ 6 720.04
Terminal and Screening Fee	$958.25	Terminal and Screening Fee	$ 0
Processing Fee	$75.00	Processing Fee	$75.00
Total Cost of Air	$17 928.34	Total Cost of Ocean Freight	$ 6 794.03

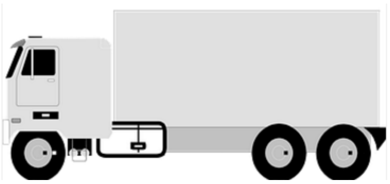
Based on these costs, it is clear that ocean-going freight is the preferred method of transportation between countries as it is approximately $10 000 cheaper. Even though ocean-going freight takes significantly longer than air freight, the extended delivery time is not a concern.

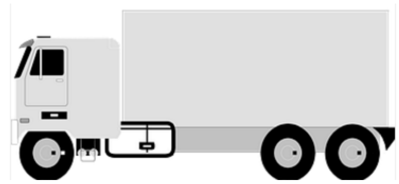
Trucking will be required to move the goods from Delta, BC to the Vancouver port, located 36 km away. Trucking will then be required to move the container from the port at Kolkata to the city of Hetauda, an 868 km journey.

The 18 crates plus additional sunshades and ground sheets will fill one 40 foot high cube container (dimensions described in Table 3). There are two trucking companies to consider when transporting containers from Delta, B.C. to the port in Vancouver: Harbour Link Container Services Inc., and South Fraser Container Services, both recommended by SEI Industries (R. Cnudde, personal communication, November 18, 2015). While quotes were not secured from these companies, the average cost of moving a container in Canada is $2.60 per mile (S. McQueen, personal communication, Nov 12, 2015). However, a flat rate will likely be applied to a delivery with such low mileage, to cover loading and off-loading the container (S.McQueen, personal communication, Nov 12, 2015). Therefore, the estimated cost of this delivery would be $150.

There are two recommended trucking companies to move the goods 868 km from Kolkata, India to Hetauda, Nepal: Shangri-La Freight and DHL. According to their websites, both companies deliver throughout India and into Nepal and will pick up containers in Kolkata. Using a similar rate in Canadian dollars, the estimated cost of this shipment will be 538 x $2.60 = $1 398.80. It is not expected that any surcharge would be levied on this larger run.

Logistics Map Summary





Delta, B. C. to Vancouver Port	Vancouver Port to Kolkata, India	Kolkata, India to Hatauda, Nepal
$150.00	**$6 794.03**	**$1 398.80**

Overall Total Cost of Freight

$8 342.83

Shipping cost per bladder = $463.49

Cost Analysis for Profitability

The Irrigation and Water Resources Management Project (IWRMP) has noted a significant improvement in the production of various crops as a result of targeted irrigation efforts. In particular, they noted a substantial increase of 53% for wheat production ("Nepal: Irrigation", 2014). The average 2013 yield for wheat in Nepal was 2570 kg/hectare ("Cereal Yield", n.d.), which equates to 37.7 bushels per acre (assuming 1 bushel of wheat is 27.3 kg and 1 hectare is 2.5 acres), which is very low compared to North American standards. With an increase of 53%, an additional 20 bushels/acre could be produced. On a 0.7 hectare plot of land, which is 1.75 acres (0.7

hectares x 2.5 acres/hectare), this equates to a projected increase of 35 bushels (20 additional bushels/acre x 1.75 acres).

Given the Chicago Board of Trade values on November 15, 2015, the price of a bushel of wheat is $4.585 US. This converts to $6.11 Canadian per bushel (using the Nov 15, 2015 US to Canadian dollar conversion rate). Therefore, the total increase in revenue for the farmer will be $6.11 per bushel x 35 bushels which is $213.85 Canadian dollars, or 16 994.33 Nepalese Rupees. It is interesting to note that the 2010/11 daily income for a Nepalese farm was $2.22 US per person or approximately $2.96 Canadian per day (Wiggins et al, 2014) for a yearly total of approximately $1 080.40 in Canadian currency. Hence, an increase of $213.85 annually would equate to an approximate growth of 20%. Nevertheless, the added income is exceedingly far below the cost of the bladders, even gauged over 20 growing seasons. Only if the bladder is subsidized or provided through grants will the annual increase of $213.85 to the farmer be substantial.

Pilot Project Funding

Due to the high cost of this product, Canadian aid sponsorships are an integral part of the initial success of this venture. They would need to assist in the purchasing, exporting and installation of bladders in Nepal. Two recommended Canadian sources for economic assistance, both viable contenders to help promote and move this venture forward, are IDE Canada and The Mosaic Company.

IDE Canada's mission is "Helping others help themselves without handouts" ("Who We Are", 2014). IDE Canada has been assisting impoverished areas across the world since 1983 by seeking and connecting donors with projects that build sustainability and independence (“Who We Are”, 2014). They aim to help farmers move from subsistence to profitability. “*Most farmers rely on rainwater for crops and when the rain stops, farms stand idle. Your donations changed this”* (“Who We Are”, 2014). IDE partners with the Canadian Government Department of Foreign Affairs, Trade and Development (DFATD) as well as other independent donors (“Who We Are”, 2014) and is already well connected with a variety of countries including Nepal. In 2014, the expenditures for assistance in Nepal totaled $451,379 (“Your Money at Work”, 2014). A clear benefit of working with IDE is that they have previous experience with the implementation of drip irrigation and water pumps (“Your Money at Work”, 2014), both important aspects of taking the water from the bladder to the cropping areas.

IDE relies on volunteers to help establish projects. This is a key benefit of working through this organization, as set up costs are minimized and the necessary training of locals in Nepal could be provided at a low cost. They also rely on the gifts of donors to bring ideas to reality. A key donor in the area of agricultural sustainability, particularly in the areas of food security and water scarcity, is Mosaic. Their mission: “*Helping the world grow the food it needs*” (“Mosaic Giving Map”, 2014) is partially realized through their donation efforts. Mosaic invests 1% of earnings each year into community projects. This translated into $27.16 million US in 2013 (“Mosaic Giving Map”, 2014).

Mosaic currently operates a project in the Mewat District of India, with the goals of alleviating water stress, and improving fertility through better fertilizer application (“Mosaic Giving Map”, 2014). As a partner in the proposed Nepal project they would not only be able to provide financial assistance in bringing water bladders to Nepal, but they could also take this approach to the nearby Mewat District, thereby assisting both regions, and potentially improving the export opportunities for Canada.

Loan or Grant Programs

In addition to funding through The Irrigation and Water Resources Management Project (IWRMP) another potential source of grant money is through PACT - The Project for Agriculture Commercialization and Trade. PACT was initiated in 2008 by the Ministry of Agriculture Development (MoAD) and is scheduled to continue until June 2018 (Government of Nepal, Ministry of Agriculture Development, 2014). This program is targeted directly at small farmers by helping them to engage in a profitable level of market-oriented production (Government of Nepal, Ministry of Agriculture Development, 2014). One of the key activities supported through this grant, Technology Support and Market Infrastructure, includes assistance for small irrigation systems (Government of Nepal, Ministry of Agriculture Development, 2014). Farmer groups are eligible for a 50% grant of up to $35 000 US (Government of Nepal, Ministry of Agriculture Development, 2014). If the pilot project is deemed successful, small groups of farmers and/or cooperatives could seek assistance from the government to set up bladder farms. However, even with a 50% grant, the cost to a farmer or group of farmers for a single bladder would be about $6 600 (half of $12 889.98 + $463.49 in shipping). Over the anticipated 20 year lifetime, this is approximately $333 per year per bladder, or $1000 per farm for the required 3 bladders. This is out of reach for the farmers who may only realize additional annual income of approximately $200.

Future Studies and Research

To determine the efficacy of this product, studies that involve a variety of crops in a variety of regions in Nepal need to be undertaken. In consultation with the Ministry of Agricultural Development (MoAD) and the Irrigation and Water Resources Management Project (IWRMP), careful examination of best practices in terms of the number, size and location of bladders is paramount in ensuring harvested rainwater is targeted where it needs to be. Bladders that are too small to contain the amount of water required to ensure optimal yield will undoubtedly provide some improvements to profitability, but will not provide best case results. Similarly, bladders that are too large and leave gallons of water untapped will incur unnecessary expenses.

Conclusion

As a product, the Terra Tank would be helpful to farmers of Nepal. Storing harvested water from monsoon rains would add flexibility to the crop types that growers could support during drier months, and mitigate at least some risk of the drought associated with a delay in the monsoon season. It would provide supplemental water to those growers relying on rivers for irrigation; rivers that dry as the rains recede. Unfortunately the cost of the product is profoundly prohibitive when compared with its economic return.

I truly believe the Terra Tank is a sound product to use as the method of storage for a pilot project, though I only suggest launching a pilot project if there is a valid upside to doing so. Will the new information be worth the price paid by financial backers in contrast to other initiatives they could support? Do researchers already know enough about the water budget of Nepal to understand how much water is necessary to save crops in the face of drought? The answers to these questions would dictate the necessity of such a pilot project, but I can say with near certainty that beyond a pilot, a cheaper solution must be found. Amongst alternative solutions, the one that sticks out to me is the creation of manmade irrigation ponds. Using either a claylike mineral or a synthetic material as a liner, Nepalese could dig shallow ponds over time. There isn't a limiting factor on how large the pond can be, and it can be improved over time. Harvesting of rainwater becomes simple, as the pond acts as its own catchment. The only caveat will be that evaporation will need to be monitored and possibly controlled.

Access to enough water for crop growth is important to not only local growers, but to organizations around the world who see access to water as a basic human right. As long as a financially sustainable solution can be found, there is no reason the storage of monsoon water shouldn't be a priority.

Appendix

Terra Tank Specifications

TERRA TANK SPECIFICATIONS

CAPACITY		MAXIMUM COLLAPSIBLE DIMENSION W X L		SHIPPING WEIGHT WITH CRATE		APPROX. SHIPPING CRATE DIMENSION	
USG	L	IN	CM	LB	KG	IN	CM
500	1900	85 x 119	220 x 300	140	64	36 x 38 x 17	92 x 97 x 43
1000	3800	96 x 181	240 x 460	185	84	36 x 38 x 17	92 x 97 x 43
1500	5700	119 x 181	300 x 460	220	100	48 x 48 x 12	122 x 122 x 26
2500	9500	162 x 181	410 x 460	265	120	48 x 48 x 12	122 x 122 x 26
3000	12000	165 x 214	420 x 540	270	123	48 x 48 x 18	122 x 122 x 46
5000	19000	193 x 238	490 x 610	357	162	48 x 48 x 24	122 x 122 x 61
7500	29000	207 x 300	530 x 760	412	187	48 x 48 x 36	122 x 122 x 92
10000	38000	243 x 300	620 x 760	500	227	48 x 48 x 40	122 x 122 x 102
12000	46000	266 x 300	680 x 760	560	255	48 x 48 x 40	122 x 122 x 102
15000	57000	271 x 362	690 x 920	575	261	48 x 48 x 40	122 x 122 x 122
20000	76000	314 x 382	800 x 970	760	345	48 x 48 x 48	122 x 122 x 122
24000	91000	314 x 438	800 x 1110	860	391	48 x 48 x 48	122 x 122 x 122
30000	114000	392 x 448	1000 x 1140	1100	500	48 x 84 x 30	122 x 213 x 76

Custom sizes available.

Source : http://www.sei-ind.com/sites/default/files/pdf/WEB_Terra_Tank_Brochure.pdf

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