Canadian Ram Pumps for Export to Nepal

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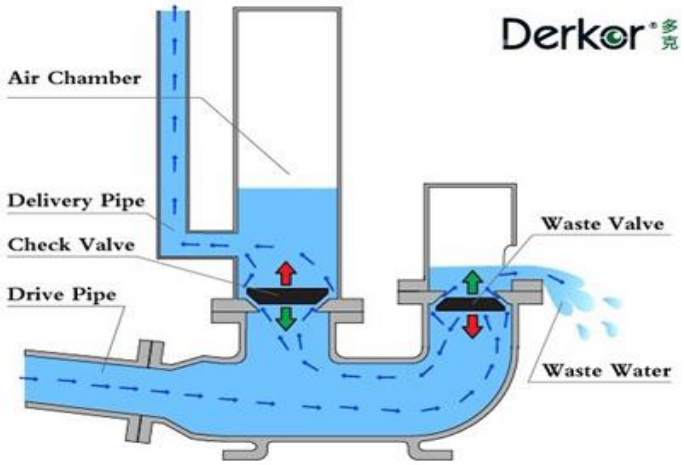
Product info

Ram pump technology and description

The export idea outlined in this report is a water pump which uses gravity and the water hammer effect to force water uphill (Inthachot, 2015). Typical construction of the pump requires three main pieces; two one way check valves and one long tube with some form of bladder which acts as a pressure chamber. Figure 1 illustrates the components of a generic ram pump. As outlined in the diagram, water will flow in from a source located above the pump and force the waste valve to slam shut.



http://www.rampumps.net/face/20120410150106.html

Inertia carried by water flowing in will push up through the check valve and into the air chamber. When a large enough volume of water passes into the air chamber, it becomes compressed exerting a force back down towards the one-way check valve which slams shut. The water attempting to re-enter through the closed valve is then forced out the delivery pipe and up through a hose either into a field, tank, or other storage medium (Inthachot, 2015). Ram pumps require the topography to be hilly with enough change in elevation for the pump to function making Nepal an excellent location for this technology.

Commercial vs Proposed design

Comparison

Commercial ram pumps are constructed from heavy duty steel and brass with all the parts being threaded into each other. Moving parts consist of two one way check valves with one being used as a waste valve and one being used as a check valve. All pumps require an air chamber of some sort to pressurise water. Commercial pumps can move thousands of liters of water per day however to make it beneficial and cost effective to Nepalese farmers a much lower level of construction is required to meet demand (Lehman's 2016). A suitable and effective pump can be constructed from lightweight PVC tubing, brass check valves and a couple other fittings (Clemson 2003). Figure 2 and 3 compare the construction of both a commercial and proposed Nepalese ram pump.

http://www.riferam.com/rams/index.php

http://www.instructables.com/id/Hydraulic-Ram-Pump/

What It "Could" Be

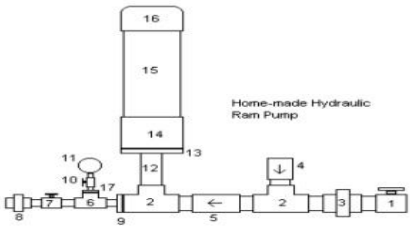
There is no Canadian company which offers lightweight PVC ram pumps. There are therefore no constraints on design and so the product should be based off the design worked out by Clemson University. It provides a functional pump, constructed from lightweight materials which are essential for low cost shipping coupled with an overall price point which is extremely attractive for consumers located in a developing country. As outlined in the diagram, total cost of the pump would be 120.00 however additional costs would be saved by removing parts 11, 12, 17, and 6 as the pressure gauge is non-essential to the functioning of the pump (Clemson 2003). Expected savings from this adaptation are between $20.00 and $32.00 bringing total cost to between $88.00-$100.00 (Amazon 2016). Inlet flow would pass in through a 1-1/4" valve and flow out through a ¾" valve. This design with inflows between 2.5 and 15GPM is expected to deliver 0.33-1.75GPM resulting in 475.2-1995 gallons per day.

Home-made Hydraulic Ram Pump

CLEMSON UNIVERSITY — Cooperative Extension Service

Home-made Hydraulic Ram Pump

This information is provided as a service to those wanting to try to build their own hydraulic ram pump. The data from our experiences with one of these home-made hydraulic ram pumps is listed in Table 4 near the bottom of this document. The typical cost of fittings for an 1-1/4" pump is currently $120.00 (U.S.A.) regardless of whether galvanized or PVC fittings are used.



Click here to see a picture of an old-style assembled ram pump with a threaded plug
(see notes below concerning glue cap (#16) versus threaded plug)

Table 1. Image Key

1	1-1/4" valve	10	1/4" pipe cock
2	1-1/4" tee	11	100 psi gauge
3	1-1/4" union	12	1-1/4" x 6" nipple
4	1-1/4" brass swing check valve (picture)	13	4" x 1-1/4" bushing
5	1-1/4" spring check valve	14	4" coupling
6	3/4" tee	15	4" x 24" PR160 PVC pipe
7	3/4" valve	16	4" PVC glue cap
8	3/4" union	17	3/4" x 1/4" bushing
9	1-1/4" x 3/4" bushing		

http://virtual.clemson.edu/groups/irrig/Equip/ram.htm (1 of 7) [1/11/2005 12:21:21 PM]

http://image.slidesharecdn.com/rampump17-130607092419-phpapp01/95/homemade-hydraulic-ram-pump-clemson-university-1-638.jpg?cb=1370597230

Canadian Benefits and Opportunity

Pricing

An enormous economic opportunity exists for an emerging Canadian company. Competition would consist of two large American producers, Rife Ram and Lehman's. The Canadian company would easily outcompete rivals as the Clemson pump constructed from PVC and brass fittings is $88.00-100.00 compared the $564.00 or $625.00 for base commercial models (Clemson 2003)(Rife Ram 2016)(Lehman's 2016).

Table 1: Specifications of Leihamn's small classification of ram pumps

Leihman's Model	Intake	Intake requirements	Delivery size, Abilities	Dimensions(HxWxL)	Price
DAV2	3/4"	¾-2gal/min,3-20'fall	½", up to 860 gal/day	12"x8"x9"	564.00
DAV3	3/4"	1.5-4gal/min,3,20'fall	½", up to 1700 gal/day	13.5"x9"x12"	624.00
DAV4	1-1/4"	3-7gal/min, 3-20'fall	¾", up to 3000gal/day	13.5"x10"x12-1/4"	684.00
DAV5	2"	6-14gal/min, 3-20' fall	1", up to 6000gal/day	23"x11"x12.5"	799.00

(Lehman's 2016)

Manufacturing

With the $7.25 federal minimum wage of the United States, the minimum wage in Ontario Canada is very competitive at $8.40(GOC, 2016)(US Government, 2016). All dollar values are given in US currency unless otherwise stated. Total manufacturing time is roughly 1/3 that of a commercial pump and machinery for fabrication would be minimal with simple saws and basic epoxies being the only tools required to assemble the pumps. In terms of numbers,

49.8% of Nepalese occupy hill or mountain regions where the pumps would be effective. Population in these areas is around 13 million (Worldbank, 2016). If these numbers consist of families of four, then 3.25 million families could benefit from a pump. Even if only half that number purchase a pump, 1.625 million families, then economic contributions to Canada would still be $143-162.5 million. Job creation would be roughly 40,625 hours for pump construction for a total of $341,250 worth of labour.

Table 2: Specifications of RiteRam small classification of ram pumps

Rife Model	Inlet	Outlet	Min-Max intake (GPM)	Min. Fall	Shipping weight(lbs)	Price
X2	¾”	½”	¾-2	2’	10	625.00
X3	1”	½”	1.5-4	2’	16	699.00
X4	1-1/4”	¾”	3-7	2’	18	775.00
X5	2”	1”	6-14	2’	28	899.00

(RiteRam, 2016)

Sourcing

Because no company currently exists, outsourcing the idea to a production facility would be ideal. Companies listed on the Toronto Directory under “Industries & Manufacturers” range from “Engineering” to “Plastic Products” and would most likely be able to accommodate a project of this scale (Toronto, 2016). To make it cost effective ordering all parts from one supplier such as Canadian owned and operated TRUSERV would ensure delivery and costs were kept to a minimum. TRUSERV distributes to 775 dealers across Canada and employs over 240 people at its head office in Winnipeg (TRUSERV, 2016). If a company which makes their own

plastics is chosen to fabricate, it may be more cost effective to produce in house and outsource only for parts not readily formed in factory. Keeping everything centralized in Toronto and near an airport would facilitate local transportation as well as global exportation.

Exporting

Neither of the competitors offer affordable or easily shipped products with the lightest pump weighing 10 pounds between the two (RifeRam, 2016) (Lehman's, 2016). The weight of the Clemson design is under eight pounds making it a much more realistic option. Shipping out of Toronto would be simple as A1 Freight Forwarding flies out of Pearson International Airport and, according to their website, can fly direct to Kathmandu. Because the product has no biological significance in terms of potential parasites, invasive species, or pathogens, it is ready to be shipped as soon as it is packaged and cleared by A1 (A1 Freight Forwarding, 2016). Costs associated with shipping would be $20.5/unit when shipping in bundles of 20. Total cost of the pump at this stage would be $116.9-128.9 (A1 Freight Forwarding, 2016).

http://www.a1freightforwarding.com/

Issues

Issues surrounding production are due to lack of facilities designated to pump production. The entire distribution chain would have to be put in place before production could begin. There is also the issue that production may not be able to meet demand as it would not be economically suitable to employ a large number of people if there is only 341 thousand dollars worth of labour available. Any company that puts the pump into production would have to subsidize cash flow

with other projects to ensure there was a sustainable business model. The possibility of payment and transactional errors is also an issue as the pumps would have to be purchased first by the Government of Nepal and then by the citizens. If the government sees an opportunity to make money, they may increase the price of the pump before redistribution, making it less economical and thus less demanded than previously expected. Lower sales would translate back to the manufacturer who then has less ability to pay for labour or profit as well as leading to uncertainty in ordering more materials from TRUSERV or other producers.

Patents or constraints

There are multiple patents held by commercial models however "homemade" versions of the pump constructed from PVC are not subject to the oversight of the patents. Clemson and its beneficiaries would have to be approached before large scale production could begin as the construction process would almost exactly follow that outlined within the text. It is to be noted that in the introduction they state "This information is provided as a service to those wanting to try to build their own hydraulic ram pump.", however this may not include the idea of large scale production based of intellectual properties provided (Clemson 2003).

PART 2: Benefits To Nepal

Why pumps?

Lifestyle

Of the 28.5 million inhabitants of Nepal, over 80% are located in rural areas and practice subsistence agriculture (World Bank, 2016). This form of agriculture entails growing enough to feed ones' self and family with little to no excess produced (Rijal, 1991). Crops grown for subsistence agriculture are food crops versus cash crops, the difference being that food crops are

consumed while cash crops are generally dedicated to further production. With crops and livestock representing the majority of day to day activities, having water pumped directly to where its needed would greatly augment the quality of life of anyone who purchased a pump. More time could be spent tending to crops resulting in higher yields, raising livestock resulting in higher milk and meat production or improving knowledge of current techniques and technologies.

Common food crops grown in the Hill and Mountain regions consist of maize, millet, paddy, potatoes, sugarcane, and vegetables. Seasonality in the upper hills and mountain regions limits production of certain crops such as vegetables and sugarcane to the lower areas of the hills and terai regions. Overall consumption and diet is largely dependant on rice (paddy) as it is a staple crop which is easily stored and is calorie dense (McDonald, 2006). One study done by Rajendra Parajuli examined the diets of Nepalese from three different villages and found that males consumed 627.5 grams of rice per day with another 436.5 grams being consumed per female. This equates to 1064g/day for one couple which translates to 1.064 kg/day (Parajuli, 2016). Rice presents a challenge as it requires large amounts of irrigation and water to grow productively. The

How much water is needed to produce food?

Product	Average water need per kg product	Average water need per 100 Kcal
Rice	1,111 litres	80 litres
Corn	870 litres	25 litres
Wheat	1,429 litres	45 litres
Potato	200 litres	20 litres
Apples	333 litres	67 litres
Olives	500 litres	43 litres
Beef	16,667 litres	741 litres

Source: UNESCO world water development report 2009

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chart from UNESCO outlines the demand for water per kilogram of rice (UNESCO, 2009). Conversion rates for liters to gallons are 0.26L/G meaning that 293 gallons are required for 1kg of rice (Metric Conversion, 2016).

Livestock rearing is another aspect life for the average Nepalese family with 96% of both hill and mountain inhabitants owning between 5.4 and 7.7 animals per household (Rijal, 1991). Typical animals raised are goats and cattle with cattle including buffalo, yaks, and Brahman varieties. Below is a water intake chart for cattle. Goats consume much less water at an average of 1-2 gallons per day (Ontario Goat, 2016). With animals requiring an additional 10.8-75.6 gallons per day for 5.4 animals or 15.4-107.8 gallons per day for 7.7 animals, additional strain is put on families who travel to collect or who divert streams for irrigation (Agri-food Canada, 2015). With a pump, more water would be available for thirsty livestock increasing both the ability to subsistence farm and the opportunity for excess produce in the form of milk or meat to be sold for profit.

Table 1. Typical daily requirements for range livestock. Source: Agriculture and Agri-Food Canada.

Cattle type	Gallons/day (Winter)	Gallons/day (Summer)
Cow-calf pairs	13	18
Dry cows	10	14
Calves	6	10
Growing cattle (400-800 lb)	6-10	10-14
Finishing cattle (800-1200 lb)	14	23
Bulls	10	14

http://www.fbcattle.com.au/sire_charles.htm

With little infrastructure in the hills, water collection and transportation is long and arduous requiring multiple trips with heavy containers either carried by family members or livestock. Being able to pump the water would free up time for agriculture, allow more animals to be raised and would improve the overall quality of life for anyone who purchases the pump (Bardsley, 2005). The Clemson design is capable of pumping 475.2-1995g/day meeting and

surpassing daily requirements of both crop and livestock, leaving more than enough water for washing, bathing, cooking and other tasks (Clemson, 2003).

Geography

With terrace farming being the only cultivatable form of agriculture in the hills which dominate 38% of the arable landscape, it is essential that water can travel both horizontally and vertically to irrigate crops. This method of farming is energy intensive as it requires sections of the hill to be cut out and excavated to create a plateau in the hillside (Kegang, 1996). These plateaus are then inundated and a variety of crops, usually rice or wheat are grown in the moist environment created. The drastic changes in elevation ranging from 60-8448m means there is plenty of potential kinetic energy available to power ram pumps (Karki, 2016). There are more than 6,000 rivers flowing in Nepal and according to a study by Arun B. Shrestha and Raju Aryal, they stem from the four major river basins that originate in the snow-clad Himalayas. The Mahakali, the Karnali, the Gandaki and the Koshi make up the catch bin area and provides plentiful water to those located nearby (Shrestha, 2011). Those not located immediately adjacent to the rivers or streams would still have access to them if they had a pump. With a multitude of rivers coupled with varied altitudes, the perfect scenario for optimal pumping is present in the hills of Nepal.

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Importing into Nepal

Canada to Nepal

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The customs office involved in air route trade, which is how the pumps would be delivered through A1 freight forwarding, is the Tribhuvan International Customs Office (Ministry of Finance, 2016). By agreeing to ship air freight to Nepal A1 will need to:

- Be registered as agent in DoCSM
- Have certificate of registration for Value Added Tax
- Invoice of description, quality, and value of goods

A bank will then have to setup an L/C account, letter of credit, to ensure there is a mode of payment for goods being imported and exported. A full payment into the L/C account must then be made before the customs office receives all documentation. After the customs office, Tribhuvan International Customs Office, receives the Bi Bi 4 declaration form, all chargeable taxes and duties can be payed and the item can be cleared to the owner. A list of 21 documents required can be found on the Government of Nepal's Ministry of Finance website (Ministry of Finance, 2016). Canada is considered a Third country as it is not China or India and so it must adhere to the additional rules outlined above. There are no laws prohibiting the import of a PVC and brass pump into the country so long as it follows all the protocol.

Tribhuvan to Warehouse

Once the pumps have landed, they will be stored in a warehouse which is owned and operated by Speedway cargo PVT (Speedway Cargo, 2016). Transport will be simple as the warehouse is located 22 minutes from the airport (Google Maps, 2016). The location has a 4/5 rating and is located near major highways making it an excellent distribution point.

Warehouse to Individual

The hardest part of the journey will be getting the pumps from the main city to the remote regions of Nepal. In order to reduce costs, it would be crucial for the pump to be imported and distributed as quickly as possible. The government would need to be involved as they would have more accurate data relating to locations and geographic distributions of Nepalese farmers. After contacting individuals or villages who required a pump, truck transport to the nearest region or road would have to be arranged and the villagers would have to meet at a predetermined location. Funds would then be transferred based on a predetermined value which incorporates the cost of transport and the initial cost of the pump itself. As Nepal is only 800x175km, distance is not the main issue as pumps are easily transportable, road systems on which to deliver the pumps pose the challenge (Tuldahar, 1982). Government grants within Nepal are minimal due to the recent earthquake which hit in 2015. This has both impacted

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infrastructure and roads and has made it impractical to ship any product which is so widespread at this point in time. (Ohsumi, 2016).

Inputs

- **Installation**

Level Installation of the pump is critical for optimal efficiency. The pump should be located in or near a continuously flowing source of water to allow easy access and minimal erosion due to water escaping from the waste valve. The correct amount of fall, vertical distance between top and bottom of the inlet pipe, should be determined prior to construction to allow the correct amount of water to be pumped to the farmer. Once the inlet/drive pipe has been set and outlet hose has been connected, the inlet valve can be opened and the waste valve can be depressed to prime the pump. Total installation time will vary based on location however an average of 1-3 hours is required to effectively setup the device (Clemson, 2003).

- **Operation**

Ram pumps require no source of fuel, only a continuous flow of water.

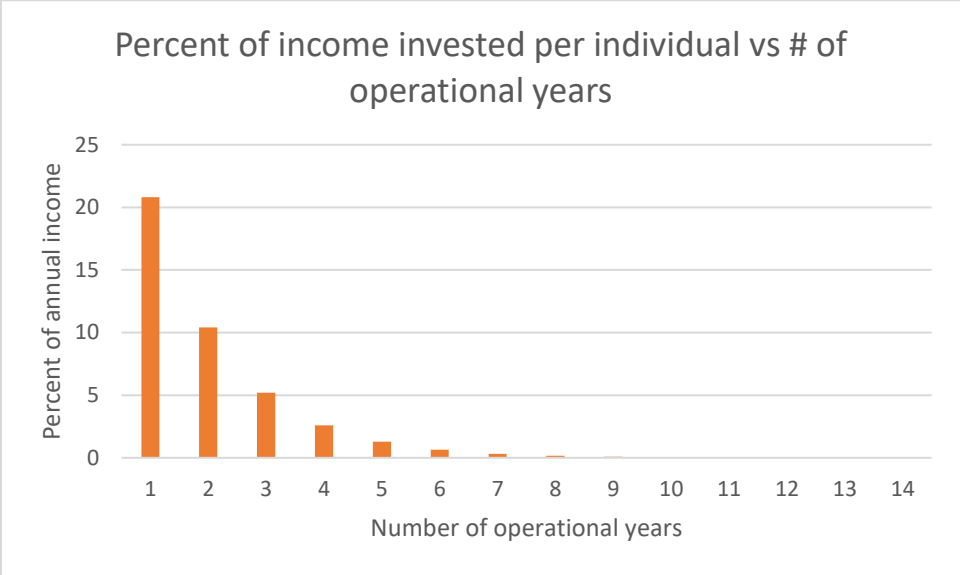
- **Maintenance**

Every six months the pump should be checked to ensure all check valves are functional and that water has not filled the air chamber. To do this the customer would simply turn the valve located near the inlet to stop the flow of water, examine the check valve visually for signs of wear, depress the waste valve to allow water which has collected in the air chamber to escape and then reopen the inlet valve. As water flows back into the pump, the waste

valve may have to be depressed multiple times to prime the pump before it begins pumping autonomously. After normal functioning has resumed, the pump is operational and ready to work for another six months. Regular inspections of the drive pipe once every two days are necessary to ensure debris have not become lodged. Placing a screen near the mouth of the inlet pipe will prevent debris from entering the pump.

Cost Benefit Analysis

With the average GNI per capita equal to $730, the pump is economically viable if the correct infrastructure is in place to support it (Worldbank, 2015). Total costs including shipping and warehousing should come to $151.9-163.9 representing 20.8-22.4% of the total earnings of the average individual. If the pump is purchased by a family consisting of two adults, total input will be between 10.4-11.2% of the yearly income of each. Regarding longevity of the pumps, 10-15 years can be expected for models that ae properly maintained. Dividing total input cost by the number of years the pump will be active, required monetary inputs are brought



Calculated based on price of one pump including shipping and storage compared to the average GNI per capita in Nepal at $730 US

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to $15.19-16.39 per year which is very affordable. The only drawback to the system is that additional drive pipe, outlet hoses, and storage tanks need to be purchased for the pump to be fully optimized. One way around this is to supplement the inlet pipe with bamboo that has been fitted together tightly enough to remain water tight (Atanda, 2015). The only additional construction required would be to thread a 1-1/4" adaptor onto the end of the bamboo leading into the pump. The outlet hose would have to be sourced from a Nepalese distributor along with some form of storage tanks. Storage tanks could range from multiple oil drums or food barrels to large water bladders built into a structure made of mud or stone. Additionally, small reservoirs or ponds dug into the hillside would also be effective at holding water for livestock and crops.

Final Recommendations

Due to the current state of Nepal and its infrastructure coupled with a lack of instituted programs to communicate with rural farmers, the idea of exporting a ram pump to Nepal is not feasible. Once infrastructure is in place and ties have been made between government and farmers, it is economically sustainable to export ram pumps to Nepal. The initial investment is high but the improved quality of life, ability to raise higher numbers of livestock and more productive crops outweigh the costs. The topography and geography of the landscape is perfectly suited for the apparatus and the lifespan provides long term benefits. In conclusion, it will be viable to export ram pumps to rural Nepalese in the future.

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