Back Ground:

India is primarily an agrarian economy, but still Indian farmers continue to be among the poorest in the world. With the diverse climatic conditions and abundant raw materials in the form of natural resources, India lags behind in ensuring food security for its own citizens. This state is a combined consequence of various factors, such as lack of advance scientific package of practices, erratic rainfall, undulating topography, lack of farm mechanization, lack of requisite storage structures, marketing and irrigation.

Amongst all lack of proper irrigation system demoralize the farming community to invest in agriculture which progressively lowers productivity and devalues farming as an occupation. Mono-cropping is the predominant practices. So after sowing in kharif season is over, larger section of the farmers from the rain fed areas migrate as farm labour or industrial labour to nearby urban areas for earning their bread and butter.

In some cases there is no water body at all near by the crop land and in others perennial water resources like river/springs are flowing much below the rural habitation and land holding. The poor community cannot afford to lift the water by means of petrol/ diesel/ kerosene/ electric operated pump to mitigate the crop water requirement. Hence, the down trodden community is unable to utilize the abundant and ample water available for agricultural & domestic purpose due to higher elevated land holding as compared to the water resource.

In such conditions, especially women and children have to walk for hours to springs/steams flowing below their hamlet for collecting water for household purposes. In addition, managing water for irrigation purpose is still a big challenge for them. "Water and energy... are activities that take up an enormous amount of women's time and pose a major bottleneck to their productivity as well as their contribution to society as care providers".

**Hydraulic Ram Pump System under Diversion Based Irrigation Programme-A Solution**

Renewable Energy development program has emerged as a viable option to achieve the goal of sustainable development. Hydraulic Ram pump is an important mechanical device using renewable energy source (Hydro power) to lift water. Hydraulic ram pumps are water lifting devices with a time-tested technology is one of the best solutions for the above said site conditions to address the issue of water, productivity, energy as well as drudgery. It should be considered for installation in locations where sustainable water resources exist for lifting water against the gravity without additional power sources in the remote villages.

**Advantages of the Hydraulic Ram Pump System:**

This Hydraulic Ram pump has many advantages over other pumps powered by hand, animal, wind, or motors, despite the fact that it wastes a lot of water.
The following advantages mentioned below make hydraulic ram pumps suitable for water supply to resource poor rural community dwelling in hilly terrains.

1. It operates automatically and continuously for 24 hours with continuous flow of water.
2. It does not need any additional power source like electricity or hydrocarbon fuel (diesel, petrol, kerosene). It uses a renewable energy source (Hydro power), hence ensures low running cost.
3. Hydraulic ram pumps are simple, reliable and require minimal maintenance.
4. Hydraulic ram pumps can be easily maintained by rural community.
5. It imparts absolutely no harm to the environment due to zero emission (Environment friendly).
6. It works efficiently over a wide range of flows, provided pump is tuned correctly.
7. It can be fabricated using simple work shop equipment in a rural lathe setting with low cost as compared to commercial pumps.
8. It will give trouble-free service for many years, if properly installed.

**Brief Description on Hydraulic Ram Pump System**

Hydraulic Ram Pump System

The diagram in Fig. 1 shows all the main components of a hydraulic ram pump system. Water is diverted from a flowing river from check dam or taken from intake structure of a spring. A drive tank is usually built between the ram pump and the intake to ensure constant flow of water to the ram pump. The ram pump lifts part

![Fig. 1 Components of a Hydraulic Ram Pump System](image)

**Outline of the Hydraulic Ram Pump System:** The Hydraulic Ram Pump System constitutes the following components:

- Intake structure Construction (Check dam/Weir/Box type Intake)
- Feeding pipe from intake to feeding tank
- Construction feeding tank/Drive tank
- Drive pipe from Feeding tank/Drive Tank to Ram pump
- Construction of pump installation stretcher and Pump House
- Ram pumps for the available head
- Delivery pipe from Ram pump to over head Delivery/Storage tank
- Storage tank at a suitable location.
- Distribution System-Distribution Pipe line field/ Backyard Kitchen Garden/House Hold Supply

**Intake Structure:**

The drive water for ram pump system is normally drawn from a spring or a stream and diverted in to a feed pipe by the construction of Check dam/Weir/Gabion structure /Box type Intake. An intake structure is required to
chosen water source to collect the water and keep feed pipe properly supplied. Generally masonry intake structure is to be constructed, as it will always take water pressure of stream or spring. A number of features should be built in to any dam or weir type intake like feed pipe socket, screen and de-silting pipe. The check dam type intake structure is shown in Fig. 2.

**Feeding pipe:**
When the source is remote from the ram pump site, the supply line (as shown in Fig. 2) can be designed to conduct the water to a feeding tank.

The feed pipe carries a steady flow of water from intake to the feeder/drive tank. It must supply sufficient water to feed all of the ram pumps running from the drive tank plus a small surplus that will overflow from the tank and ensure constant supply should be maintained. The feeding pipe, if needed, should be at least one pipe diameter larger than the drive pipe. The pressure of the water in the feed pipe is generally low, so cheap and low pressure PVC pipe is buried 0.6-0.9 meter under earth to supply water from intake to feeder tank.

**Feeder/Drive tank:**
The drive tank is an important component in the operation of a ram pump system which is being supplied though the feeder pipe from an intake. It keeps a steady water level, ensuring a regular supply to the pumps and a constant drive head. It provides a large body of water with an open surface that reflects the pressure waves traveling up the drive pipe when the pump is running and also prevents air from being sucked in to the drive pipe. The drive tank is in the shape of a square or rectangular type made from cement block or fired bricks with inner and outer plastering. The height of the tank is usually not greater than 2.0 meter (as shown in the Fig. 3). As a rough guide, the cross sectional area of the tank should be at least 20 times the total area of the total area of the drive pipes being supplied from it. It is recommended that the depth of water above the drive pipe inlets be at least 0.5 meter.

**Drive Pipe:**
The drive pipe supplies water from the drive tank to the ram pump to operate. Most of the pumps are designed for a particular diameter of drive pipe and this recommended size should be used under normal range of drive flows and pipe length. Well sealed threaded joints can be used in most of the situations, provided that pipe is properly anchored to avoid vibration. The drive pipe must be made of a non-flexible material for maximum efficiency, preferably galvanized iron pipe. The length is 6 to 12 times the vertical fall. In order to reduce head loss due to friction, the length of the pipe divided by the diameter of the pipe should be within the range of 150-1,000.

**Ram Pumps:**
The pump itself should be considered as one of the major component of this system. The ram pumps can be brought from commercially manufacturers (high cost) or fabricated in local lathe (low cost). Before buying a ram pump from commercial outlet, the following things should be found out from manufacturer's instruction.

- The size of the pump’s drive pipe (Internal Diameter)
- The pump’s maximum and minimum drive flow (used by the pump to run).
The pump’s maximum drive head (that can be used by pump to operate). The pump’s maximum delivery head (highest elevation up to which pump can lift). The efficiency of the pump.

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- The pump’s maximum delivery head (highest elevation up to which pump can lift). The efficiency of the pump.

**Pump Base:**
When designing a drive system, choose a suitable site for casting the pump base with concrete which must be firmly anchor the pump on it with pump cradles (shown in **Fig.4**). The anchoring prevents the continual vibration of the pumps, damaging it or separating the entire base from the material surrounding. The site must also allow for drainage of the waste water from the pumps to prevent flooding around them.

**Pump House and Hydraulic Ram Platform:**
A structure should be built around the pumps to be installed in a concrete platform, which is not essential for the operation of a Ram pump system. However, a pump house is recommended to provide security and protection. Curious children can easily damage a ram pump left operating in the open and it also makes an easy target for thieves. The pump house will be made large enough to allow complete access to all parts of pumps for installation and maintenance. As a general guide line, allow at least 0.3mt.-0.5mt. between any parts of the pump and the walls of the pump house or another pump (**Fig.5**)

**Delivery Pipe:**
The delivery pipe either connects to the outlet of the ram pump air vessel that carries the water to the delivery storage tank at higher elevation (point of use). The delivery pipe can be made from any material capable of carrying the pressure of water leading to the delivery tank. In all except very high head applications, PVC pipe can be considered. With high heads, the lower end of the delivery line might be better as steel pipe and rest of the portion be taken HDPE or PVC pipes. The engineer should choose the diameter of the delivery pipe making a balance between a small diameter to reduce the cost or a large diameter pipe to reduce head loss and maximize delivery flow along with the length to which water is to be delivered. Drive Pipes of 2” (from feeder tank to Hydraulic ram s)

It is recommended that a hand-valve or check-valve (non-return valve) should be fitted in the delivery line near the outlet from the hydraulic ram, so that the delivery line does not have to be drained, if the hydram is stopped for adjustment or any other reason. This will also minimize any back flow past the delivery valve in the air chamber and improve efficiency.

**Storage Tank:**
It is particularly important to involve the whole community in the design of storage tank along with the distribution system and the social organization of the water use is planned before construction. Most of the ram pump systems for irrigation and domestic use requires a storage tank at the end of the delivery pipe. The storage tank should be located in such a ridge place that water can be easily supplied to fields and households by gravity though a distribution system (shown in **Fig.6**). The size of the storage tank is calculated from the maximum water requirement per day (Demand). A ram pump operates for 24 hours each day, hence the water pumped overnight must be stored for use during the times of peak demand. The total capacity of the delivery tank should therefore be sized to hold at least 12 hours supply and preferably 16 hours supply. The storage requirement can
For delivery flow of 1 liter per minute, storage required = 1x60x12 = 720 liters (Capacity/Size of storage tank)

Storage required in liters = Delivery flow in liter per minute x 60 minutes x 12 hours

be calculated as below:

**Basic Requirement and Site selection of a Ram pump System:**

**Intake side:**
- The water must be required at a level higher than the source for irrigation, domestic use or drinking purpose.
- There should be the availability of suitable and reliable source which is supplying constant & uninterrupted flow of water with a sufficient fall to operate the pump (at least 1 meter drop/fall between source of water supply and ram pump).
- The supply of water can be from any source of flowing or stagnant water such as a spring, stream, river, lake, dam or even a pond fed by artesian well. The ram pump needs free flowing water (it can't run on a shallow or deep well).
- A ram pump system should be considered when there is a source that can provide at least seven times more water than the amount of water to be lifted by hydraulic Ram Pump.
- The water available in the source should be made free of trash and sand to be used by pump.
- In some cases where there is no immediate drop, this can be created by a diversion weir/Check Dam (creating a drop over a certain distance) or Putting the Ram pumps below the Ground level (Artificial Head creation up to drainage level to drain the wastage water).
- The smallest ram pump can run by the input water supply of 15 liters/min (lpm). The standard range of input water supply for operating ram pump varies from 30 lpm to 120 lpm.

**Delivery side:**
- Depending on the difference in heights between the source to hydraulic ram pump and the Ram pump to delivery point, these pumps can lift 1-20 percent of the water that flows into the ram pump. In general, a Hydraulic Ram pump can lift approximately one tenth of the received water volume to a height ten times greater than the source.
- The routes of drive pipe and delivery pipe routing should be selected to minimize the number of high and low spots in the line.
- For every meter drop available up to the Ram pump, it can lift the water up till 10 times than the source of supply. The pump delivers less water at higher delivery point, if the drop available from the source is less. Water can be stored in low cost Polythene lining tanks/Ferro cement tanks/Syntax tanks/Masonry tanks at the delivery point.

**Hydraulic Ram Pump site:**
- During selecting a potential site for hydraulic ram pump installation, it is essential to supply input water to ram pump along with proper drainage of the waste water away from the ram pump house.
- Generally the pump house location is considered nearer to the nala/stream to easily dispose the excess wastage water. Hence, it reduces the cost of earth work excavation up to stream for wastage pipe.
The High Flood Condition (HFL) of the stream should be taken in to consideration before positioning of the Pump house nearer to the stream.

In extremely High Flooded condition, the pump automatically stops due to submergence of level of waste valve.

The suitable positioning of Hydraulic ram pump platform can irrigate upland by gravity from the wastage water.

**Planning Procedure of Hydraulic Ram Pump System:**

The following items need to be considered prior to the selection of a hydraulic ram pump system during pre-feasibility study or survey work.

**Resource Inventory** – Information must be obtained when planning a hydraulic ram pump system (e.g. when will it be used, What is the water requirement of planned crop and how many acres will be benefitted, how many people are staying in the uphill village, what is the per capita per day water requirement for domestic use in the village, where is the source located).

**Planning map** – sketch a plan map of the system with the following information noted: location of intake & drive/feeder tank for the feeding line, location of drive tank & pump location for drive line, location of pump house & delivery tank for delivery line.

**System Available Input** – Determine the capacity/discharge (Q) of the water source (Bucket Method/Area Velocity Method). The measurement of minimum flow of source will be taken during the dry season. In order to ensure that the local people will be consulted about the flow patterns over recent years.

The fall in elevation between the intake and pump station (Hdrive) in meter and the lift elevation (H delivery) between the pump station and delivery tank in meter can be approximated with the aid of a Global Positioning System (GPS) or altimeter device. The feeding length, drive length and delivery length can be measured by a measuring tape or applying track option of GPS.

**System Required Output** – Determine discharge at delivery tank (Q discharge) by using available input. Calculate the water requirement for usage (D) to determine minimum required rate of flow in liter per day (lpd). If the water requirement for usage (D) is less than the water delivered by the Hydraulic Pump, the no. of pumps (n) can be increased to meet the demand, provided the discharge of the source is good enough to run battery of pumps.

**Basic Components of Hydraulic Ram Pump:**

A hydraulic ram pump has only two moving parts, a spring or weight loaded waste valve sometimes known as the clack valve/Impulse valve and a delivery or check valve, making it cheap to build, easy to maintain, and very reliable. In addition, there is a drive pipe supplying water from a source(spring or stream) and a delivery pipe, taking a portion of the water that comes through the drive pipe to an elevation higher than the source. The basic components of hydraulic ram, as listed below, are shown in Fig. 7.

1. Inlet — drive pipe
2. Outlet — delivery pipe
3. Waste valve or Impulse Valve or clack valve
4. Delivery or check valve or Non-return valve
5. Sniffer Valve or Air Valve
6. Air vessel

**Principle of operation of Hydraulic Ram Pump:**

A **hydraulic ram**, or **hydram**, is a cyclic water pump powered by hydropower. It functions as a hydraulic transformer that takes in water at one hydraulic head and flow-rate, and outputs water at a higher hydraulic-head and lower flow-rate. The device utilizes water hammer to develop pressure that allows a portion of the input water that powers the pump to be lifted to a point higher than where the water originally started. The hydraulic
Ram is sometimes used in remote areas, where there is both a source of low-head hydro power, and a need for pumping water to a destination higher in elevation than the source. In this situation, the ram is often useful, since it requires no outside source of power other than the kinetic energy of water.

Ram Pumps have a cyclic pumping action that produces their characteristic beat during operation shown in Fig. 8. The cycle can be divided into four phases viz. acceleration, compression, delivery, and recoil. The last part of each cycle is the first part of the next so that the pump keeps on working.

Factors in Designing the Hydraulic Ram pump system:-

Before a ram pump can be selected, several design factors must be known. These are shown in Fig. 9 and include:

1. The difference in height (F) between the water source and the pump site (called vertical fall).
2. The difference in height (L) between the pump site and the point of storage or use (lift).
3. The quantity (Q) of flow available from the source.
4. The quantity of water required (D).
5. The length of pipe (ldr) from the source to the pump site (called the drive pipe).
6. The length of pipe (ldev) from the pump to the storage site (called the delivery pipe).

Once this information has been obtained, a calculation can be made to see if the amount of water needed can be supplied by a ram by using the formula given below:

\[
D = \frac{S \times F \times E}{L}
\]

Where D = Amount delivered in liters per 24 hours.
S = Quantity of water supplied in liters per minute.
F = The fall or height of the source above the ram in meters.
E = The efficiency of the ram (for commercial models use 0.66, for home built use 0.33 unless otherwise indicated).
L = The lift height of the point of use above the ram in meters.

Example:- As per the survey data collected in a Hydraulic Ram Pump Project, the discharge of the source was found to be 5 lps by bucket method. The drive head (H) and delivery head (Hd) measured by altimeter were 4mt. and 30 mt. The water requirement to run a hydraulic ram pump is 2 lps. Calculate the numbers of 2" hydraulic ram pumps required to meet the per day water requirement of a village comprising of 800 nos. of people. Consider the efficiency of the pump is 66%.
The water requirement per day per capita for rural conditions is 40 liters.
The water requirement per day for 800 people in the village is 40 liters per day (lpd) X 800 = 32000 liters per day (lpd).

As per the above equation (4) \( Q = \frac{S X F X E}{L} \)

Hence, the discharge at delivery head 40 mt. by a single Ram pump is (4mtX2lpsX0.66)/(30mt.) = 0.176 lps
The discharge at delivery head 40 mt. per day by a single Ram pump is 24 hrs X 60 sec X 60 sec X 0.176 lps
= 15206 lits. per day (lpd)

The water requirement of 800 people is more than the delivery supply by a single pump per day.
Hence, the number of ram pumps required to meet the water requirement of 800 people = 3200/15206 = 2.13
Or
Say 2 nos. (Ans)
As the discharge of the source is 5 lps, 2 nos. of pumps can be installed to be run with 4 lps which is less than the source capacity (5 lps).

Battery of Hydraulic Ram Pump System:

A battery of hydraulic ram pump system (shown in Fig. 10) is very useful in drought situations where the minimum flow can power one or two ram pumps and the maximum flow can drive more ram pumps. In a battery of hydraulic ram pumps, one can use in parallel, sharing a single drive tank and delivery pipe, but they must have separate drive pipe.

Using several pumps rather than one large one can have the following advantages:
- Each pump can be set for high efficiency.
- If the source flow falls below the required drive flow, one pump can be stopped, allowing a reduced delivery flow to be maintained.
- A single pump can be stopped for maintenance work to be carried out without stopping all delivery flow.
- Smaller sizes of pipe are often more readily available, where as large steel pipe may have to be imported at higher cost. It is also harder to work with large diameter pipe and to transport it.
- The maximum delivery head is generally higher on smaller pumps.
- In case where the supply water can power only one hydraulic ram pump, but the delivery flow does not quite meet the water demand, the waste water from the initial ram pump could be used to drive another ram pump.

Price and Costing of a Hydraulic Ram Pump System:

The costs of commercial hydrams are typically in the range from about £1500 for small 2-inch drive pipe sizes up to as much as £5000 for 4-inch or 6-inch sizes. The cost of the drive pipe can also be quite high for the larger sizes. The cost of local manufactured hydram vary from Rs. 20,000/- to Rs. 30,000/- for 2-inch size (Used in SDTT driven project). The cost of hydraulic system may vary site to site as it depends on the demand of water, no. of pumps to be used, the length of feeding/drive/delivery pipe used. It is part of surveyor who can assess the economical feasibility during the survey by locating the proper position of structures in the ram pump system. Therefore hydrams are best suited to relatively low flow rates and high head applications. Of course there are no fuel costs and negligible maintenance costs associated with hydrams.
A rough break down of the costs in involved is mentioned below.

Civil construction work (Intake, Feeder Tank, Hydram Platform, Pump house, Delivery tank) 30%
Earth work excavation for Feeding pipe, Drive pipe, Delivery pipe, Distribution Pipe 10%
Cost of the Pipes and fittings in feeding, drive, delivery and distribution line 40%
Cost of Pump(s) 15%
Cost of Transportation 5%

**Piloting Hydraulic Ram Pump System under JTT-DBI Program**

An Initiative was taken by Livolink Foundation with the support of SDTT and Implementing Partner-NGO under DBI programme to harness the benefit of Hydraulic Ram Pump for Irrigation of upland land. An innovative project, Hydraulic Ram Pump Fed Drip Irrigation Project under DBI programme was taken up in BARBA village under Nandapur Block of Koraput district in the year 2012-13. The ChandrimundaJholla perennial stream flowing below the patch of 26.9 acre of 26 families was laying fallow in this village. The water of this nalla was diverted by intake, feeder tank and fed into 6 nos. of Hydraulic ram pump, lifted and stored in 2 nos. of storage tanks at 15m and 30m elevation above the nala. The drip system is attached to storage tank to irrigate about 20 acres of land.

**Different aspects of BARBA-Hydraulic Ram pump project**

<table>
<thead>
<tr>
<th>Discharge at source</th>
<th>20 lps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delivery Head</td>
<td>3 mt, 15mt/30mt.</td>
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<tr>
<td>Discharge at delivery tank</td>
<td>9750 liter</td>
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<tr>
<td>Cost of the Project(SDTT support)</td>
<td>3.50 lakh</td>
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<tr>
<td>Area covered in Kharif-2013</td>
<td>19.81 Acres</td>
</tr>
<tr>
<td>Crops covered</td>
<td>14.81 Acres cultivation including Cereals-Ragi(SRI), Vegetables- potato, beans, tomato, chilly &amp; Spices – turmeric &amp; ginger, oil seeds -ground nut &amp; Niger &amp; Tuber crop- Sweet Potato(25 farmers each 0.75 acres), Sacres Banana cultivation</td>
</tr>
<tr>
<td>Convergence Programme</td>
<td>Drip Irrigation (8.5 lakh), Poly Vermibeds(0.192 lakh); Sweet Potato Demonstration(1 lakh)</td>
</tr>
<tr>
<td>Area Covered in Rabi-2013</td>
<td>Vegetables-13 acre</td>
</tr>
</tbody>
</table>

Implementing NGO partner –Pragati has adopted another Hydraulic Ram project in the Lungin village of Nandapur block in Koraput District under the in the year 2012-13. The Gangasnana perennial stream flowing below the patch of 15.7 acre of 16 nos. families, were unable to cultivate due to rain fed land condition and the poor tribal community cannot afford to lift the water using a diesel/petrol operated pump. The water of this nalla was diverted by intake/feeder tank and fed into 6 nos. of Hydraulic ramp pumps, lifted and stored in a storage tank at 15m elevation above the nala for cultivation purpose.
Different aspects of Lungin-Hydraulic Ram pump project

<table>
<thead>
<tr>
<th>Discharge at source</th>
<th>20 lps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delivery Head</td>
<td>15mt.</td>
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<tr>
<td>Discharge at delivery tank</td>
<td>65000 liter per day</td>
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<tr>
<td>Cost of the Project (SDTT support)</td>
<td>3.50 lakh</td>
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<tr>
<td>Area covered in Khari-2013</td>
<td>15.70 Acres</td>
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<tr>
<td>Crops covered</td>
<td>Paddy, Ragi and Vegetables like brinjal, tomato, and vegetables</td>
</tr>
<tr>
<td>Area Covered in Rabha-2013</td>
<td>Vegetables-15.7 acre</td>
</tr>
</tbody>
</table>

After the success of these interventions, SDTT has sanctioned the hydraulic ram projects in pilot basis in the year 2013-14. Three nos. of projects have been finalized after the feasibility study by the technical team of Livolink Foundation mentioned below.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of the Partner</th>
<th>Name of the state</th>
<th>Name of the district</th>
<th>Name of the block</th>
<th>Name of the village</th>
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<tr>
<td>1</td>
<td>Madhyanam Foundation</td>
<td>Odisha</td>
<td>Nayagarh</td>
<td>Ranapur</td>
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<td>Chaklapadar</td>
<td>Chaklapadar</td>
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</table>

Further information

References


Suppliers (Note: This is a selective list of suppliers commercially available and locally available)

<table>
<thead>
<tr>
<th>Company</th>
<th>SRI JAYA RENEWABLE SYSTEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>I.S.Narayana (Managing Director), Paderu, District-Vishakapatnam, State-Andhra Pradesh</td>
</tr>
<tr>
<td>Email Id</td>
<td><a href="mailto:isnaryanay729@gmail.com">isnaryanay729@gmail.com</a></td>
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<tr>
<td>Phone</td>
<td>9493118019</td>
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<table>
<thead>
<tr>
<th>Company</th>
<th>S.N. Polymers Pvt. Ltd.</th>
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<tbody>
<tr>
<td>Address</td>
<td>27 Tilak Road, Hakimpura, Siliguri</td>
</tr>
<tr>
<td>Product/Services</td>
<td>PVC Pipes, PVC Flexible PVC &amp; HDPE Hose Pipes, Hydrams and Turbine Coupled Water Pumps</td>
</tr>
<tr>
<td>Phone</td>
<td>NA</td>
</tr>
<tr>
<td>Address</td>
<td>Gayatri Engineering Construction &amp; Consultancy Private Limited 1717/2379, Shriram Nagar, Kapileswar Kanai Road Bhubaneswar, Orissa - 751002 (India)</td>
</tr>
<tr>
<td>-----------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Product/Services</td>
<td>Hydraulic ram pumps and other water lifting devices</td>
</tr>
<tr>
<td>Phone</td>
<td>NA</td>
</tr>
</tbody>
</table>

| Green and Carter Rams | John Blake, a division of Allspeeds Ltd.  
Royal Works  
Atlas Street  
Clayton Le Moors  
Lancashire, BB5 5LP  
United Kingdom  
Tel: +44 (0)1254 615100  
Fax: +44 (0)1254 615199  
E-mail: sales@allspeeds.co.uk  
Website: www.allspeeds.co.uk |
|-----------------------|--------------------------------------------------------------------------------------------------|
| Vulcan Works  
Ashbrittle  
Wellington  
Somerset TA21 0LQ.  
United Kingdom  
Tel: +44 (0)1823 672365  
E-mail: general@greenandcarter.com  
Website: www.greenandcarter.com | |

| AID Foundation (Alternative Indigenous Development Foundation, Inc.)  
AIDFI Bldg., Muncro Road, Mansilingan, 6100 Bacolod City Philippines  
Tel: (+63) 034 - 4463629  
Fax: (+63) 034 - 4462330  
E-mail: aidfi@hotmail.com  
Website: www.aidfi.org | Development Technology Unit (DTU)  
School of Engineering  
University of Warwick  
Coventry CV4 7AL  
United Kingdom  
Tel: +44 (0)1203 522339  
Fax: +44 (0)1203 418922  
E-mail: dgr@eng.warwick.ac.uk  
Website: http://www.eng.warwick.ac.uk/DTU  
http://www.eng.warwick.ac.uk/DTU/pubs/lift.html |

| WOT - WerksgroepOntwikkelingstechneken - Working Group on Development Techniques  
Vrijhef 205/206  
P.O. Box 217  
7500 AE Enschede  
Netherlands  
Tel: +31 53 489 3845  
Fax: +31 53 489 2671  
E-mail: wot@tdg.utwente.nl  
Website: http://www.wot.utwente.nl | Demotech  
Biesenwal 3  
6211 AD Maastricht  
Netherlands  
Tel: +31 (0)6 174 771 77  
E-mail: info@demotech.org  
Website: www.demotech.org |

![Diagrams of hydraulic ram pump system](image-url)