

USES OF HYDRAULIC RAMS (HYDRAMS) IN HILL AREA

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INTRODUCTION

Backwardness of the hill areas in India is attributed mainly to peculiar geographical factors, varying agroclimatic conditions, and lack of communication. A large percentage of the terraced agricultural land in the hills is situated above water sources, so water goes unused due to unavailability of suitable water-lifting devices. The existing irrigation facilities in the hills are gravity channels and tanks which provide irrigation to a small percentage of land below the diversion-point level of the stream. Lift-irrigation projects operated with electric and diesel pump-sets have hardly achieved tangible results due to their high recurring expenditure and maintenance costs. Difficulties of communication and after-sales services are some of the bottlenecks to making electric and diesel-operated systems acceptable in the hills where small land holdings exist.

The energy crisis today has led scientists and technologists in many countries to explore new sources of energy and make better use of existing ones. In India, efforts are being made to harness energy from sun rays, biogas, and tidal waves through research and development work. With increasing demand for power in industry, agriculture, and domestic uses, any device which can work without relying on power from outside is welcome. The hydraulic ram, commonly known as hydam, therefore assumes

importance in meeting increasing water requirements in the hills.

The hydam lifts water using energy from flowing water with a small head. It requires no external prime mover, like a motor or an engine, for operation. The overall efficiency of the hydam in terms of energy utilization can be as high as 98 percent and water can be lifted to a height 30 times the water head. The mechanical efficiency reaches 98 percent (from 4 to 10 times the working head); and it comes down to 35 percent at 30 times the lift of water head. Normally 3 to 25 percent of the water flowing through the ram is lifted at various lift magnifications. Since the ram does not have rotating or reciprocating valves, maintenance costs are negligible and little technical expertise is required for operation. Hydam technology has tremendous scope to help meet pressing water requirements both for irrigation and drinking water in the hills. (Figure 1)

Hydam Efficiency

Mechanical efficiency is a measure of the percentage of successful transfer of energy from one form to another. Similarly, the volumetric efficiency is calculated by dividing the quantity of water raised by the hydam from the quantity of water supplied in the machine. As shown in Figure 2, in the

WORKING OF HYDRAM MACHINE

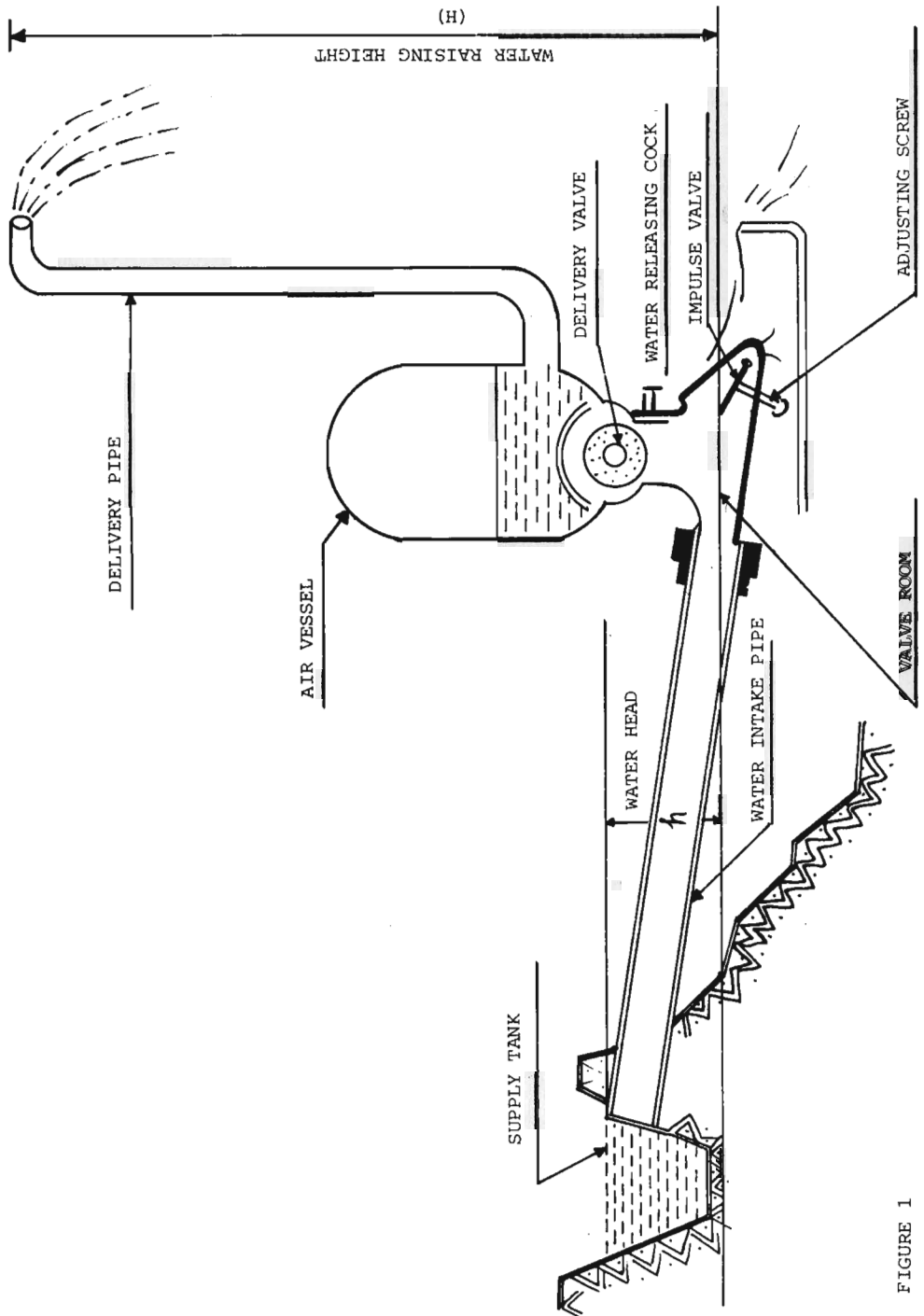
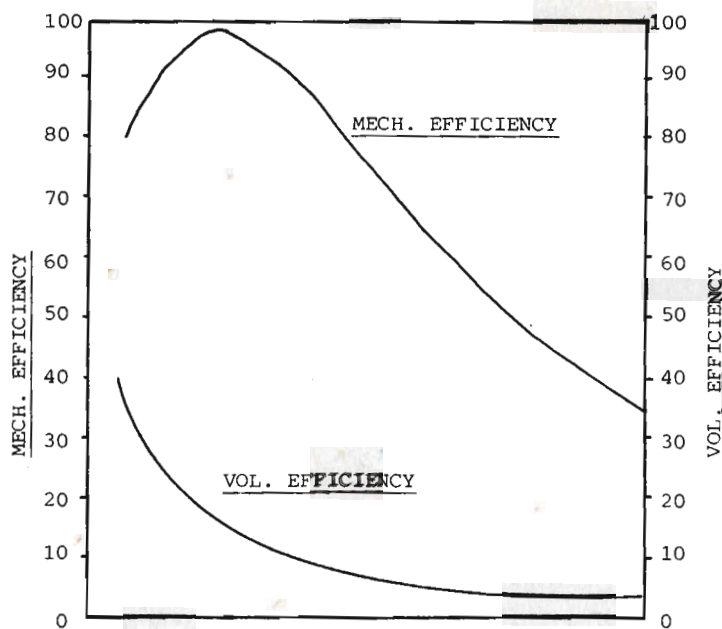


FIGURE 1

<u>LEFT MAGNIFICATION</u> <u>FACTOR</u>	<u>MECH. EFFICIENCY</u>	<u>VOL EFFICIENCY</u>
2	80	40
4	92	23
6	98	16.33
8	97	12.126
10	94	9.4
12	85	7.08
15	75	5.00
20	80	3.0012
25	45	1.8009
30	35	1.166

EFFICIENCY CHART



LIFT MAGNIFICATION FACTOR. (OISCA MAKE)

FIGURE 2

case of the Oisca hydram, the mechanical efficiency reaches a maximum of 98 percent at six times the lift of the working head and 35 percent at 30 times the lift of the working head. The volumetric efficiency obtained is 40 percent at twice and 1.16 percent at 30 times the lift of the working head. The maximum mechanical efficiency of Blake's type of hydram is 72 percent at lift magnification of 4 and 4 percent at lift magnification of 24.

2.5 Sizes of Hydram pump

Hydram pumps are manufactured in many sizes, including 12"x6", 8"x4", 6"x3", 4"x2", and 2"x1". Pump size is determined on the basis of the size of intake and delivery pipe fitted with the valve room and in the vessel. Discharge available from various sizes of pumps at different lift magnification factors are given in Table 1.

Table 1: Discharge in litres per minute of various sizes of Oscia make hydram at various lift magnifications

Lift Magnification	2"x1"	4"x2"	6"x3"	8"x4"	12"x6"
2	27	109	240	412.5	1000
4	18.5	76	190	350	840
6	14.2	60	190	300	680
8	11.0	46	158	300	500
10	9.0	38	111	210	420
12	8.5	34	102	190	318
15	6.6	28	88	160	280
20	5.0	18	70	130	180
25	3.8	16	64	110	160
30	2.6	11	60	85	140

Survey and Pumping Unit Design

Before preparing the hydram project, it is necessary to consider the following:-

- Vertical fall from source to hydram
- Vertical lift from pump to delivery spot
- Quantity of water available in the stream
- Quantity of water required at delivery spot
- Delivery pipe length from pump to delivery site
- Arrangement for unused water disposal
- Necessary space for laying the desired length of intake pipeline
- Minimum length of supply channel required to create the working head and also safety from flood, landslides, etc.

For the selection of proper hydram size, four main factors are taken into consideration: quantity of water required at delivery site; quantity of water available in the stream; the lifting height; and working head. First, the quantity of water required at the delivery site is calculated. Then, the flow of the stream is measured. The lift magnification factor can be obtained by dividing the delivery height with the working head. Taking into consideration the requirement for water coupled with the lift magnification factor, the suitable size of hydram may be selected. If one hydram machine is not enough to meet the requirement, a battery of hydrams can be used in one project; the intake pipe is then joined to force the water in one pipe. A battery of two hydrams is shown in Figure 3. In Appendix 1, the water lifting capacity

of different sizes of hydrams at various lift magnification factors in 24 hours are calculated. The area irrigated per day for various depths of irrigation is also shown.

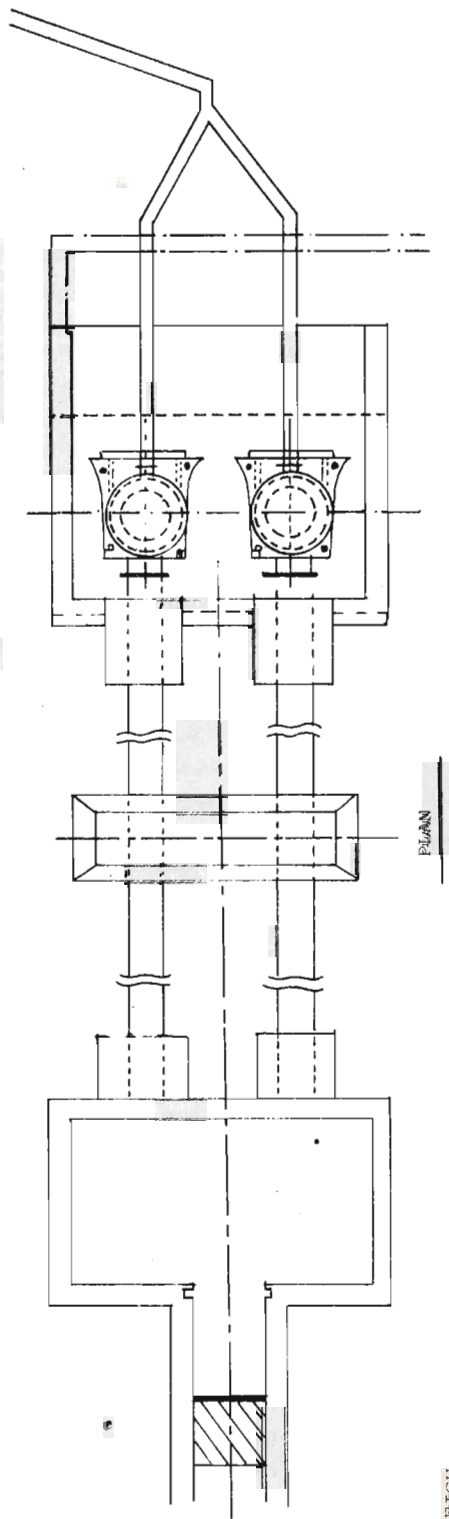
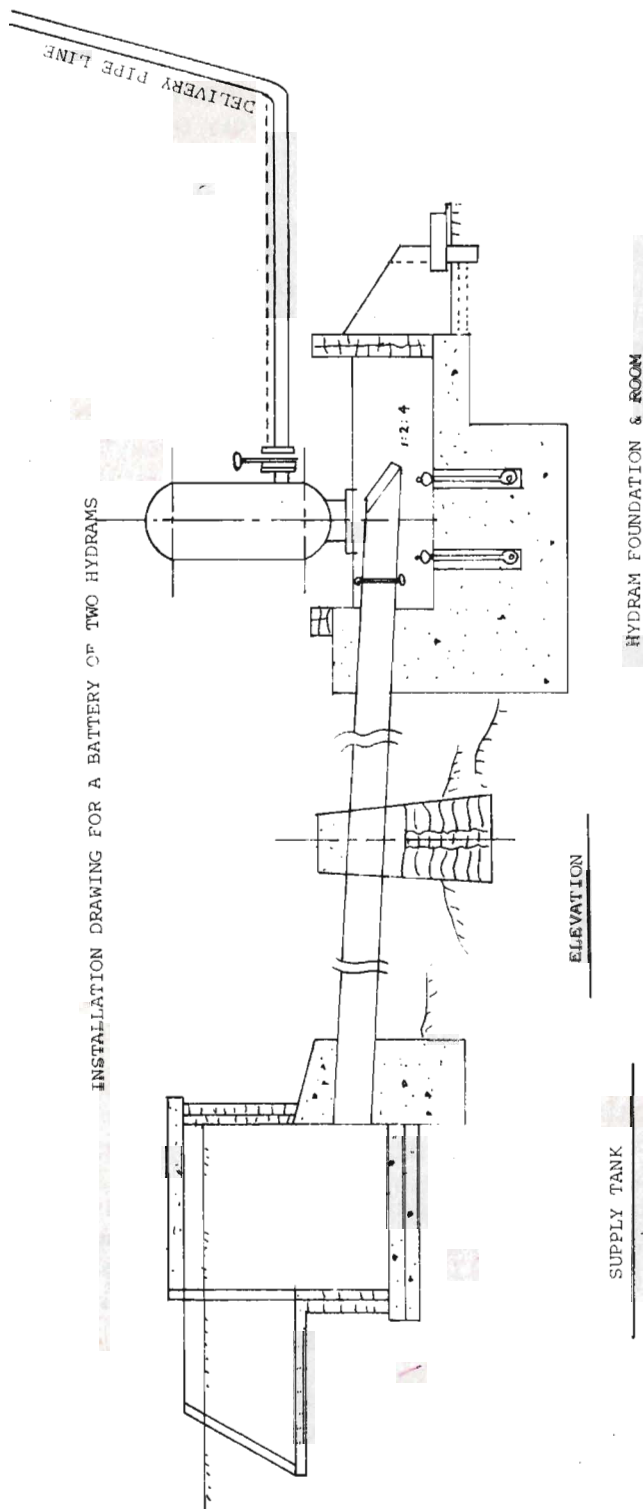
Hydram Project Construction and Installation

The following civil and mechanical work is required for setting up the hydram pumping unit:

Diversion Work. At the source of water diversion, work is done to divert water into the supply channel so that minimum damage is caused in the event of a flood.

Supply Channel. To create the desired working head and to bring the water where the hydram is to be installed, the water is carried from the source through the channel. This channel, constructed with random rubble stone masonry or concrete, is called the supply channel. This can be opened or closed as need be. The cross-section of the channel is designed to be suitable to the requirements of the hydram. The layout of the supply channel is done so that chances of damage by landslides and floods are reduced to a minimum.

Supply Tank. This is a small tank constructed at the end of the supply channel to regulate the flow of water into the intake pipeline. It is constructed so at least a head of at least two to three feet of water is always maintained above the mouth of the intake pipe. The supply tank creates discontinuity in pressure between the water of the supply tank and the water of the intake pipe, thus resulting in negative pressure waves moving backward toward the impulse valve and



FIGURE

closing it. It should be strong enough to resist the vibration of the pipe.

Hydrum Foundation. Hydrums are anchored with the foundation bolt in a three-to four-foot deep reinforced concrete foundation. The foundation three-to four-foot should be strong enough to withstand the vibrations. It is observed that any shock-absorbing device at the intake joint of the hydrum creates problems. Small vibrations concentrated entirely at the foundation may break the foundation bolt and are liable to damage the machine also.

Intake Pillars. When the machine is in operation, the vibrations are spread along the length of the intake pipeline up to the supply tank. If the pipes are not properly anchored, it may break the joints or damage the supply tank. Therefore, the entire pipeline is anchored in the reinforced concrete pillars.

Intake Pipeline Fitting. Also called the drive pipe, this should be strong enough to withstand tremendous water hammer pressure. It is made of steel, preferably galvanized. It is necessary to keep the diameter of the entire pipeline uniform and a minimum number of joints is advisable. The intake pipe is laid according to the design recommendation of the hydrum. The Oisca design requires the length of the intake pipe to be eight times that of the working head, and five to six times the working head in others. The intake pipeline should be straight and leak-proof. Mild and ungalvanized pipes require coating of anti-corrosive paint year after year.

Delivery Pipeline. The delivery pipeline is used to carry pumped water to the

delivery spot. The layout of this pipe is such that minimum joints and bends are used to keep efficiency high. The diameter of the delivery pipe is reduced at different lift magnifications. Like the Oisca make, the diameter of the delivery pipe is kept to half the intake pipe up to 10 lift magnifications; between 11 to 20, it is one-fourth; and between 21 to 30 times, it should be one-sixth of the diameter of the intake pipe. In Blake and Wama's designs, the sizes shown in Table 2 are used if the pipeline exceeds 250 meters. For shorter lengths, the appropriate diameter is chosen.

Table 2: Diameter of Intake and Delivery Pipe in Blakes/Wama type Hydrum

Size of Intake Pipe	Diameter of Delivery Pipe
(inches)	
.75	.375
1	.5
1	.75
1	1
2	1
2	1
3	1
4	1
5	2
6	2

Being flexible, polythene or plastic pipes are not suitable. They also have joining problems and remain exposed to weather. It is, therefore, advisable to use galvanized iron pipes.

Storage Tank. Hydrums work round the clock with no interruption. If desired, water can be stored at night. Tank

capacity can be decided on the basis of expected quantity of water required for further use.

If the hydram is used for irrigation, channels are also constructed in the field to distribute water properly. Concrete or pre-cast channels are suitable as these require minimum space and are also easy to construct. Since the quantity of pumped water is limited, sprinklers should be used for judicious distribution.

Pump Operation and Maintenance

1. When the water reaches the intake pipeline and accelerates its speed, the impulse valve is closed. The valve needs to be pushed back by the starting handle. Consequently, the water is released and the impulse valve will automatically close due to the pressure of incoming water in the valve room. After repeating the motion of valve two or three times, the valve starts moving, making the pump operational.
2. The air entering through the impulse valve improves efficiency of the pump. Drained water should be adjusted to a height allowing entry of the air to the valve room. If the breathing is more than required, the quantity of water raised has to be reduced. Air breathing in lesser quantity will also reduce water raising efficiency. Therefore, the height of the surface of drainage water is adjusted to keep the efficiency high.
3. Beating counts of impulse valve or

beating frequency also effects the water raising efficiency of the hydram. Beating counts through the screw located in the impulse valve are adjusted for efficiency.

4. The weight of the impulse valve is required to be added or subtracted so that water in the drive pipe obtains maximum velocity before closure. This ensures maximum conversion of available energy into raised water.
5. In the intake pipe, joints must be kept absolutely tight and the impulse valve and delivery valve in the hydram tightened properly. A slight leak seriously impairs the efficiency of the machine.
6. For the stoppage of the pump operation, the impulse valve must be held steadily for five or six seconds and the valve will then cease functioning. If the water feeding is stopped, then the pump will come to a grinding halt also.

The pump can operate for 20 to 30 years if the following points are kept in mind for proper maintenance:

1. Keep the water source in good shape by maintaining the diversion works, supply channel, and other civil works.
2. Remove the silt from the supply channel, supply tank, and hydram room, as and when required.
3. After every 24 hours of operation, check the nuts and bolts of the hydram machine.
4. Keep the intake and delivery pipeline leak-proof.

5. Change the rubber pad of the impulse and delivery valve when necessary.
6. Paint the air vessel with anti-corrosive paint.

Project Cost

The cost of the hydam project ranges between Rs.80,000 and Rs. 150,000 depending on the size of the hydam and site of the project. The cost of hydam equipment is estimated to be 15 percent of the total expenditure on the project; the rest of the expenditure is for civil work, such as diversion work, supply channel, supply tank, delivery tank, the cost of the pipeline, and installation work. The cost in terms of area irrigated is estimated at about Rs. 20,000 per hectare. The average total cost of various sizes of hydam units are as follows:

Comparative Costs

Compared to diesel engines or electricity-driven engine pump sets, hydrams are the cheapest mode of lift irrigation. It is also economical in comparison to the gravity channel system, as the latter requires a long gravity channel. Maintenance of long channels is a costly affair.

In India, investment in irrigation projects is determined by the cost-benefit ratio. Presently, the irrigation cost in gravity channels is estimated at Rs. 20,000 per hectare. For electric and diesel-operated pumping units, the cost is estimated to be Rs. 25,000 per hectare. There is, however, no estimate fixed for hydam projects. The capital expenditure and operational and

maintenance costs per hectare per year are given below. These indicate that irrigation through hydrams is more economical than other sources of irrigation, including the gravity channel.

Scope for the Hydam

Innumerable flowing water sources in the Himalaya region, if tapped properly, can provide a vast energy source. They can be fully utilized through hydrams for irrigation and meeting the drinking water needs of villages at high altitudes. The U. P. hills can boast to be the pioneer in setting up more than

Table 3: Cost of Hydam Project by size of Hydam Unit

S. No.	Particular of work	Size of Hydam Unit		
		4" x 2"	6" x 3"	8" x 4"
		Cost in Rs.		
A. Mechanical work				
1 - Hydam Machine	9500	14000	19000	
2 - Intake pipe	7000	15000	22000	
3 - Delivery pipe	8500	13000	17000	
Total	25000	42000	58000	
B. Civil work				
1 - Diversion work	3000	5000	95000	
2 - Supply channel and Chamber	24000	35000	42500	
3 - Foundation	10000	13000	15000	
4 - Storage Tank and Distribution System	18000	25000	25000	
Total	55000	78000	92000	
Grand Total	80000	120000	150000	

Table 4: Comparison of cost of investment, operational and maintenance cost in Rs. per year per hectare

Item	Gravity Canal	Electric	Diesel	Hydram
A. Investment cost per hectare	20000	25000	25000	20000
B. Operational cost per hectare				
i. Depreciation per year - Canal				
10% Diesel/relectric 7%, Hydram				
5%	2000	1750	1750	1000
ii. Interest 10%	2000	2500	2500	2000
iii. Overhead 2%	400	500	500	400
iv. Fuel/electric	Nil	500	1400	Nil
v. Maintenance 2.5% others	500	500	625	500
Total	4900	5750	6775	3900

350 units during the Fifth Five-Year Plan period and many more are planned for implementation during the Seventh Plan. The projected schemes can be further augmented subject to the availability of resources; for this, a detailed survey needs to be done. Land 200 to 250 feet above the water source can be irrigated through hydrams. Beyond this height, schemes may be prepared on the basis of a cost-benefit ratio.

Report of the Central Team

A team of experts and planners from the Central Government Ministry of Agriculture and Irrigation, Planning

Commission, Ministry of Home Affairs, and the State Governments of Jammu and Kashmir, U.P., Sikkim, Assam, Manipur, and Tamil Nadu, besides the Indian Council of Agricultural Research, Planning Research and Action Division, U.P., and Agricultural Refinance Corporation, visited the Garhwal region to assess the general utility of hydraulic rams in the hill area. Following is the summary of observations and conclusions:

- The team was impressed with the utility in areas where gravity irrigation is not possible or is expensive. The hydraulic ram is considered to be economically

feasible for hill areas.

- Sprinkler irrigation is considered useful in areas where the leveling of land is not possible or where irrigation water must be highly economized.
- The farmers had not been adequately trained to make the full use of irrigation. Extension support for growing improved varieties of crops and application of fertilizers and agro-implement practices were missing.

Evaluation

A case study of the hydram sprinkler at the irrigation pilot project, Gadaura District, Chamoli, U.P., was conducted by the Planning, Research and Action Division of the State Planning Institute, U.P., Lucknow, in May 1977. Extracts from the conclusions and recommendations of the division are as follows:

Conclusions

1. The Gadaura Hydram project has a capacity to raise water to the height of 225 feet from the source, and irrigation is possible in fields at this elevation to the extent of 20 acres.
2. The comparative analysis of the cost-benefit ratio of hydrams and other traditional means, in relation to capital investment and cost of maintenance, reveals that the installation of hydrams is economical.
3. The cost-benefit ratio, pay-back period, and internal rate of return of the hydram project with a lifespan of

20 years and potential of 20 acres is = 3.3:1, 4 years and 40.5 percent respectively, which may be considered highly economical from the point of view of speedy multiplication.

4. As a result of installation of hydrams in Gadaura, considerable changes were brought about in cropping patterns. *Manduwa*, one of the common crops of the hills, has been almost eliminated.
5. The installation of hydrams has shown a favorable impact on the sowing of improved varieties of wheat and paddy.

Recommendations

1. The farmers must be persuaded to make full use of irrigation potential, which is far behind actual irrigation capacity.
2. *Manduwa* and other uneconomical crops may be gradually eliminated and cash crops may be included in the cropping pattern.
3. Small, scattered, and fragmented agricultural holdings are mainly responsible for non-utilization of irrigation potential. Hence, consolidation of holdings may be explored to raise productivity in the hills.
4. Due to poor economic conditions, the majority of the farmers are not favorably responding to the improved agricultural program and to the maximum use of irrigation potential. In such cases, some economic assistance in the form of seed or fertilizer, besides irrigation water, may be

provided.

5. The possibility may also be explored for developing a suitable local organization for water management and operation of the scheme. Training to develop management capabilities should be provided.

Other Uses of Hydrum

Hydrum, or micro-hydropower, has many other uses. For example, small flour mills, rice hullers, oil expellers, and other cottage industries such as sawmills can run with the help of watermills. More than 75 percent of the intake water in hydrums goes to the river. The unutilized water can be used further to generate micro-hydropower for other purposes. The watermill can also be connected directly with the supply channel or hydrum project as need be.

A successful experiment has been made on this at Chandroti, in Dehra Dun District, where a turbine-type watermill is connected with the supply channel of the hydrum for running the flour mill, rice huller, and oil expeller. A generator is also installed at the Chandroti Project for generating electricity.

Constraints

Usefulness of hydrums is well known in the hill areas. However, remedial measures to overcome constraints faced in installation and operation must be considered.

There have been reports of improper installation, maintenance, and operation of hydrums due to a

dearth of trained personnel at the project site. For achieving full benefits of the hydrum scheme, the field staff is supposed to man the operation of the hydrum to make irrigation facilities available.

- In the absence of Indian Standards Institution specifications and quality control, manufactures of the hydrum machines have their own designs. To avoid diversity in design and to facilitate interchangeability of components, efficient equipment designs should be standardized.
- Short supply of hydrum machines, steel pipes, and cement, delays completion of the projects which in turn escalates project costs. The existing procurement procedure is time-consuming and does not provide quality control. A departmental purchase committee should be constituted at a suitable level to expedite purchases and quality control.
- Presently, hydrums are manufactured by private firms, some of which obtain supply orders beyond their manufacturing capacity without having requisite technical knowhow. Letters of intent should be issued to only those fulfilling norms fixed by the department in this respect. State public sector undertakings with workshop facilities can also be used to manufacture hydrums.
- Agricultural land under the command of a hydrum project should be properly leveled so as to deliver water evenly. In Uttar

Pradesh, the Soil and Water Conservation Department has been engaged in leveling the fields under the hydram command.

- The backward hill areas need adequate extension support. Farmers should be persuaded to practice intensive farming to make use of the pump throughout the year. Appropriate application of fertilizer, pesticides, and suitable implements will go a long way toward producing high-yielding varieties.
- Land holdings in hill areas are small and the fields are terraced; irrigation potential is not fully utilized. In many places, land for the installation of hydrams is not available. Efforts should be made to consolidate land holdings.
- Traditional watermills in the hills have identical conditions to those required for the installation of hydrams. These watermills create problems for the installation and operation of the hydram, the former consuming more water for less output. With limited quantities of water supply, the hydram should get priority, keeping in view the larger interest of the village as a whole. The watermill should be redesigned with improved turbine-type mills.
- The supply channel, supply tank, pipeline, and hydram machine are prone to siltation during the rainy season. It is imperative to select a proper site. Iron gates and silting chambers should be provided where necessary.

- Most of the hydram units are set up far from the roadside in inaccessible places. In the event of leakages or any breakdown, arrangements for welding to plug the leakages are not possible due to unavailability of lightweight generator-cum-welding sets. Lightweight welding sets should be made available, which are easy to transport and convenient to handle.

Need for Further Techno-Economic Research

A great deal of techno-economic research and development work remains to be done on hydrams in a number of areas, including the following:

- Standardization of efficiency and specifications so that uniformity of high standards in mechanisms ensured, in view of the fact that the demand for hydrams is rapidly increasing.
- In order to further reduce the cost of irrigation per hectare, size of hydram, optimum number, and height of discharge point should be investigated.
- Hydram projects can be used for producing microhydro- power for meeting requirements of village industries.
- Reduction in the cost of civil works, which presently accounts for about 50 percent of the total expenditure, requires attention.

- Judicious use of pumped water is essential. The fields in the hills are terraced, which requires an effective water distribution system.
 - The large size hydraulic machines (12"x6" and 8"x4") are too heavy. In some places, these may be very difficult to transport to the installation site. Further study is required to reduce weight.
2. M/s. Inteco, 27/31 Badali, Delhi-2
 3. Walia Engineering Co., Patel Marg, Ghaziabad (UP)
 4. M/s. Premier Irrigation Equipment Ltd., 3 Netaji Subhash Road, Alipur, Calcutta

List of Manufacturers

1. M/s. Saiba Engineering and Commercial Enterprise, 113/225, Swaroop Nagar, Kanpur

5. Shiva Industries, 77/156 Latouche Road, Kanpur

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1977 *A Case Study of Hydram - Sprinkler Irrigation Pilot Project.*
Gadoura District, Chamoli, Lucknow, May.

Government of India, Ministry of Agriculture and Irrigation,
Department of Agriculture
Letter No. 1-28/76 - May (Imp)
Dated July 25, 1977

APPENDIX - 1

TABLE SHOWING THE WATER-LIFTING CAPACITY IN 24 HOURS FOR VARIOUS SIZES OF HYDRAM AT VARIOUS LIFT MAGNIFICATION FACTORS AND AREA COVERED FOR VARIOUS DEPTH OF IRRIGATION

Lift Magnifi- fication	Sizes	2" x 1"			Size	4" x 2"		
	Gallons per day	Area covered per day (acres)			Gal. per day	Area covered per day (acres)		
		1"	2"	3"		1"	2"	3"
2	8256	0.37	0.18	0.12	34880	1.55	0.77	0.516
4	5808	0.26	0.13	0.086	24312	1.08	0.54	0.36
6	5808	0.20	0.1	0.066	19200	0.85	0.42	0.28
8	3504	0.16	0.08	0.053	14721	0.65	0.32	0.21
10	2880	0.13	0.06	0.04	12144	0.54	0.27	0.18
15	2112	0.09	0.045	0.03	8952	0.40	0.20	0.13
20	1392	0.06	0.03	0.02	5760	0.26	0.13	0.086
25	1200	0.05	0.025	0.02	5112	0.23	0.12	0.08
30	816	0.04	0.02	0.01	3504	0.15	0.075	0.03

Lift Magnifi- fication	Sizes	6" x 3"			Size	8" x 4"		
	Gallons per day	Area covered per day (acres)			Gal. per	Area covered per day (acres)		
		1"	2"	3"		1"	2"	3"
2	76800	3.41	1.71	1.14	132000	5.87	2.93	1.95
4	60792	2.70	1.35	0.90	111984	4.98	2.49	1.66
6	50544	2.25	1.122	0.75	96000	4.27	2.13	1.42
8	42240	1.88	0.94	0.63	79992	3.56	1.78	1.18
10	35520	1.58	0.79	0.53	67200	2.99	1.49	0.99
15	28152	1.25	0.62	0.42	51120	2.27	1.43	0.75
20	22392	1.0	0.5	0.33	41592	1.85	1.42	0.61
25	20492	0.91	0.45	0.30	35184	1.56	1.28	0.52
30	19200	0.85	0.42	0.28	27192	1.21	0.60	0.40

Lift Magnifi- fication	Sizes	12" x 6"		
	Gallons per day	Area covered per day (acres)		
		1"	2"	3"
2	320000	14.22	7.11	4.74
4	268800	11.96	5.97	3.98
6	217600	9.67	4.83	3.22
8	160000	7.11	3.55	2.37
10	134400	5.97	2.98	1.99
15	89600	3.98	1.99	1.32
20	57600	2.56	1.28	0.85
25	51200	2.28	1.14	0.76
30	44800	1.99	0.99	0.66

NOTE: If a battery of two or more hydrams be placed in parallel, the amount of water raised may almost be multiplied by the same number (excluding losses) with separate intake and common delivery pipeline.