A new irrigation system without any external sources

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Abstract

India is the second most populous country in the world and relies heavily on agriculture as its main source of income. The combination of agriculture and technology is needed to accelerate the development of agriculture, especially in rural areas, to increase productivity, efficiency and profitability. Application of technology in agriculture will enhance the farmers to involve in their occupation. Agriculture mainly consists of field grounding, transplantation, harvesting. In each steps of agriculture irrigation is the main requirement. Farmers are spending more to irrigate their farm for agriculture. So application of technology on irrigation is the most important requirement to sustain the farmers. In this work a pendulum operated irrigation model is presented. The designed model is required to attach with the hand pump. The developed system will work without any external source of power, which will provide maximum profit to farmers.

Introduction

Agriculture is the primary source of lively hood for more than 58% of population in India. Proper irrigation in agriculture results in improved yield. Irrigation is generally done by using electric, petrol or diesel operated pumps attached with the hand pump. In some cases to irrigate for small part of farms, farmers operate the hand pumps manually to lift water. The hand pump consists of plunger, piston, a valve on the piston, foot valve, and cylinder. The reciprocating motion of the plunger, opening, and closing of the valve on piston and foot valve helps in lifting water. Manual operation of the hand pump to lift water for irrigation is a time consuming and cumbersome method. However, lifting of water by electric, petrol or diesel operated pumps is an expensive method. There are various irrigation methods which have been described by different researchers. Zhao *et al.* [1] studied the assessment of irrigation in Southern China and found that the estimation results were in a good pact with the real state of affairs. Brunel *et al.* [2] studied easy water stress recognition structure for vineyard irrigation administration and found that the established application makes it conceivable to envisage the collective liquid stress monitoring. Bozorg-Haddad *et al.* [3] studied structure risk administration of irrigation dams and observed that the chances of finishing the aforesaid earth and concrete dams on time are 65% and 50% respectively. Sadr *et al.* [4] studied a cluster decision-making device for the application of sheath technologies in different water reclaim scenarios and found that this approach is capable of enabling orderly and rigorous investigation in the comparison and assortment of membrane supported technologies. Shiri *et al.* [5] studied global cross-station valuation of neuro-fuzzy replicas for estimating daily locus evapo transpiration and found that the proposed model is capable in guessing reference evapo transpiration in changed climatic regions. Grillone *et al.*[6] studied approximation of daily solar energy from measured air temperature excesses in the mid-Mediterranean zone and found the appropriateness of each anticipated model from the temperature range. Vekariya *et al.* [7] studied fluid mechanics of micro tube emitters and found that the goodness of fitting and efficiency coefficient declined with the upsurge in the micro tube diameter. Howell *et al.* [8] studied deceitful trickle irrigation laterals for homogeneousness and found that for a given regularity the result is a linear log-log line with slope. Song *et al.* [9] studied Electrochemical bio film regulator by renovating microbial community in agronomic water circulation systems and found that higher absolute abundance and little bio film exclusion was recognized in nonstop electrochemical treatment (ECT) as compared with intermittent ECT. Stępień *et al.* [10] studied the eco-efficiency of minor-scale agro-business in Poland and presented the importance of agriculture on the economic growth of a country. They also developed a relation between eco-efficiency and formal descriptive variables. Honc and Merta [11] studied smart, precision, or digital agronomy and farming and conducted a current state survey along with determination of its applications and future prospects. Rutebuka *et al.* [12] studied the efficacy of terracing practices for controlling soil wearing away by water in Rwanda and found that progressive terraces (PT) showed suggestively lesser chemical fertility in comparison to bench terraces and conventional slope farming. Araujo *et al.* [13] studied a supportable agronomic landscape model for humid drylands and found that enhancing the percentage of agronomic land in the landscape amplified the creation of all ecosystem services. Soteriades *et al.* [14] studied preserving production while dropping confined and overall environmental discharges in dairy agro business and found the connection between data envelopment analysis, eco-efficacy and a sequence of pointers of dairy agro-business intensity. Moulick *et al.* [15] studied the latent use of nanotechnology in supportable and ‘smart’ agronomy and found that nanoparticles and nano sensors have vast latent in agronomic advancements. Jouan*et al.* [16] studied a provincial bio-economic archetypal analysing farm-to-farm interactions and creation to boost agronomic sustainability and found that legume production enhanced but N losses augmented due to an escalation of pig production. Sharma *et al.* [17] studied prognostic agronomic demand visions using machine learning and found an end-to-end supply chain structure that benefits both farmers and end consumers thus increasing the economy. Volschenk [18] studied water management strategies and irrigation methods of pomegranate trees and found that the pomegranate inclined to have inferior crop coefficient values than peach grapevine, and other fruits. The prediction of the stream of solute along with the irrigation flow and its final longitudinal circulation along the field was done by Bautista and Schlegel [19] by using a solute transport model and they found that the model could generate important estimates under distinctive irrigation conditions. A sap flow sensor was developed by Venturin *et al.* [20] offering a critical water stress index (CWSI) for coffee plants and found that a critical value of 0.4 provides the superlative time to commence irrigation thus shunning physical damage to the plant. Lyu *et al.* [21] studied the influence of stable isotopes on the modification elements/ions by biogeochemical processes with their integration into drip water and found that changes in vegetation is an important factor manipulating the inter annual variation of the drip water. Nayak *et al.* [22–23] developed a simple gear train operated irrigation method to irrigate the farm. Nayak and Roul [24] developed a epicyclic gear train operated irrigation system and they compared their work with simple gear train operated irrigation system. The present work deals with the design and development of a new innovative system to reciprocate the plunger of the hand pump without using external sources like electric, petrol or diesel.

Experimental Setup And Procedure

Generally, there are two types of hand pumps available in India, they are shallow and deep well types hand pumps. Shallow types of hand pumps are suitable to lift water from small depth of water level, and deep well types hand pumps are suitable to lift water from large depth of water level. Both these types of hand pumps are reciprocating types and are hand-operated. Cylinder and piston arrangements are provided above the ground for shallow type hand pumps, whereas piston and cylinder arrangements for deep well type hand pumps are provided below the water level.

Figure1and Fig. 2 shows the arrangement of a hand pumps for water entry into the cylinder and water exit from the hand pump. The arrangement consists of a piston, piston valve, piston rod, foot valve, cylinder handle, and lever. The reciprocating motion of the piston rod is possible by force applied to the handle.

Initially, for the upward stroke of the piston, there is a vacuum created between the piston and foot valve. So, air pressure in the suction pipe causes to push the foot valve upward. So, air from the suction pipe enters into the space between the piston and foot valve. This continues up to the piston and reaches to the top of the cylinder and the foot valve closes due to its own weight. For the downward stroke of the piston, the air is compressed between the piston and foot valve. This higher pressure of air causes to open the piston valve and this compressed air moves up through the priming water. For the next upward motion of the piston, more air is sucked from the suction pipe through the foot valve and causes to lift water through the foot valve to the cylinder.

During the next downward stroke of the piston, water pressure causes to open the piston valve and moves up through the piston valve. When the piston reaches the bottom of the cylinder, the foot valve closes. For the next upward stroke of the piston, some water above the piston moves out of the cylinder, and at the same time, more water is sucked into the cylinder through the foot valve. In this way, the process continues.

Figures1 and 2 represent the methods of lifting water from the hand pump manually. Farmers in rural areas generally use these methods for irrigating their farms. Irrigation by these methods is free from an external source of power but these are time-consuming. So, farmers are unable to get maximum profit from this traditional way of irrigation. So, we have developed a new way of irrigation system that has to attach to the hand pump. Figures 3 and 4 represent the working principle of a hand pump with our designed attachment. The developed system consists of a pendulum attachment, lever arm, support frame, and stopper. Water is lifted from the developed arrangement by the oscillating pendulum. The effort required at the pendulum is very less to lift water from the hand pump. The lever arm is pinned at the fulcrum. One end of the lever is attached to the pendulum, and the other end is connected to the piston rod. The piston rod carries the piston, piston valve arrangement at its end. The stopper is provided on the support frame to restrict the motion of the piston rod. The weight of the pendulum is 15.5 kg. The distance from the fulcrum to the pendulum attachment is 0.508 m and the distance from the fulcrum to the piston rod attachment is 1.09 m. It is possible to lift water from the well and discharge it from the hand pump by changing the position of the pendulum,

Figure 3 shows the water entry condition to the cylinder from the well. In this condition the pendulum position is vertical. For the vertical position of the pendulum, the total weight of the pendulum acts on the lever end, which causes to lift the piston rod in the upward direction. Due to the upward motion of the piston rod, the foot valve opens and water from the well enters the cylinder. This continues up until the piston reaches to top dead center of the cylinder. Whenever the pendulum changes its position from vertical to the right or left, the piston rod moves down as shown in Fig. 4. In this condition the foot valve closes and the piston valve opens. So, water inside the cylinder goes out through the exit tube. To swing the pendulum minimum effort is required. Anybody can perform this task comfortably with less effort. It is found that due to the swing of the pendulum, the load on the piston rod causes to lift water from the deep well type hand pump. With this attachment, a shallow hand pump works like a deep hand pump. The pumping stroke of a hand pump is developed by using this attachment.

Result And Discussion

The present model was attached with the hand pump in a farm having one acre of land area, where vegetable farming was being done. Earlier farmers of that farm were using diesel, petrol or electric operated pumps to lift water from the hand pimp for their irrigation purpose. We conducted a survey regarding their expenditure earlier and compared the expenditure after attaching the present model for irrigation. In this present study, we observed that our present model gives advantages to farmers. We have presented a comparison statement of our model with the external source operated model. Table 1 shows the expenditure details including purchase cost and running cost of different pumps along with our designed model for irrigation of crops in one acre area of land.

Table 1. Comparison of various pumps with the designed model.

Sl. No	Parameters	Pumps operated by an external source			Our model
		Diesel operated Pump(1 HP)	Petrol operated Pump(1 HP)	Electric operated Pump(1 HP)	
I	Initial Cost (INR)	8000/-	8500/-	7500/-	6500/-
II	Running cost (INR) per day due to power consumption	300/-	250/-	50/-	Nil
III	Upholding cost (INR) per week	100/-	100/-	100/-	Nil

From table 1 it is found that the designed model requires only initial purchase cost, which is very less as compared to other arrangements, and our designed model does not require any other costs like daily expenditure, uploading cost per week as other pumps on the basis of power consumption for comparison between petrol, diesel, and electric operated pump with our designed model. It found that there is no requirement for any external source of energy for the operation of our model. It only requires less manual effort for its operation.

Table 2 below shows the comparison between our developed system with the manual-operated hand pump for irrigation of a 1-acre vegetable farm.

Table 2. Comparison between manually operated hand pump with our designed system

Sl. No.	Factors	Manually operated hand pump	Developed system	Remark on developed system
1	Deep of water lift	22 feet	60 feet to 80 feet	Our system lifts water same as deep well pump
2	Time required to irrigate 1 acre farm	10 hour	5 hour	Less time provides profit to farmers
3	Chance of accident	Yes	No	Zero accident possible by the developed system
4	Nature of work	More sound and Less powerful operation	Smooth work and powerful operation	Provides better environment to work
5	Term of work	Limited to 5 hours per day	Withstand severe use and can use for 8 hours per day	Maximum hour use is possible by our developed system

From table 2 it is found that the developed system provides a better environment to do work. All types of farmers can operate our system to lift water from the hand pump without any external sources. The developed system can lift water from deeper as compared to the manually operated hand pump.

Our model requires very less effort as compared to manually operated pumps. The present model is also used for curing construction parts like brick and concrete parts. Generally, during construction work, water for curing purposes is taken from the hand pump, which is drilled in the construction area. The hand pump is operated manually by workers engaged in construction work. So, to help such farmers, we have conducted a survey in 2000 square feet building during construction and presented the comparison of cost and effort on curing by manually operated tube well with our designed model.

Table 3. Comparison of manual operated tube well with our model in constructional area

Sl. No.	Factors	Systems		Remarks
		Manually Operated hand pump	Hand pump with designed attachment	on our model
1	Effort required	More	Less	Less effort provides more comfort to the workers.
2	Time required for curing 2000 sq. ft. Construction area	4 hours	2 hours	Cost reduces with the reduction of time.
3	Sound and Friction	More	Less	Provides a healthy atmosphere.

Table 3. shows the comparison between the manually operated hand pump and the hand pump attached to our designed model. The factors for comparison are taken as effort required, number of workers required, sound and friction. Considering all the aspects stated above, the designed model provides advantages over manually operated hand pumps for curing as well as agricultural purposes.

The discharge from the hand pump is calculated by using the relation

$$Q = \frac{\pi}{4} \times D^2 \times S \times N$$

Discharge of water from the hand pump for the values of D = 5 inch (0.127m), S = 11inch (0.279m) with respect to the possible pumping stroke per minute for the existing hand pump and hand pump attached with our system is given in Table 4.The Table 4. shows the possibility of discharge relating to pumping strokes for existing hand pump.

Table 4. Discharge for pumping strokes of existing hand pump

Sl. No.	Type	Pumping stroke per minute	Discharge from the hand pump (m^3/min)
1	Existing hand pump	30	0.105
2	Hand pump with the designed system	50	0.175

From Table 4, it is observed that for an existing hand pump the maximum discharge is 0.105m^3/min, whereas for an existing hand pump with our designed system, the maximum discharge is 0.175 m^3/min

The specific speed for the hand pump is calculated by using the relation

$N_s = N \times S$

For the existing hand pump, the maximum specific speed is 8.37 and for hand pump with our designed attachment the maximum specific speed is 13.95.

The load on piston of the hand pump is calculated by using the relation

$F_p = \frac{\pi}{4} \times D^2 \times S \times \omega$

For the values of D = 5 inch (0.127m), S = 11inch (0.279m) and ω = 1000N/m^3. The load on the piston is 3.53 N.

Figure 5 shows the lever arrangement for the existing hand pump and Fig. 6 shows the lever arrangement for hand pump with our designed system.

$M.A = \frac{L_h}{L_p}$

For the existing hand pump, the Mechanical advantage is 4.39 and for the hand pump with our designed system is 0.466.

$F_h \times L_h = F_p \times L_p$

$F_h = F_p \times \left(\frac{\mathrm{Lp}}{\mathrm{Lh}} \right)$

$F_h = F_p \times \left(\frac{1}{\mathrm{M.A}} \right)$

$M.A = \frac{\mathrm{Fp}}{\mathrm{Fh}}$

For the existing hand pump effort required at end of the lever is 0.804 N to lift water. The effort required to lift water for the hand pump with our designed system is calculated by using the relation.

Ep = Energy available at the pendulum

$$Ep = m \times g \times r$$

For the value of m = 15.5 kg, r = 50cm, the energy available at the pendulum is 76.02 Joule.

Conclusion

In this work, an innovative model of irrigation for better crop yield has been presented. The model with a simple arrangement is required to be attached with the hand pump. The designed model is unique due to its simpler design and working principle. The manufacturing cost of this model is very less. Poor farmers can use this unit with their hand pumps. From this study, it was observed that our system can be attached to both types of hand pumps to lift water with less effort.

Material required for manufacturing of the model is easily available and less skilled workers can fabricate this model easily. Due to large demand on agriculture sector this will provide great opportunities for young entrepreneurs.

The designed model has also been tested in a construction site for curing of bricks and concretes. Curing of construction area is generally done by lifting water from hand pump manually. It is cumbersome and uncomfortable for the workers if hand pumps are operated manually by them. This problem has been addressed by our designed model in which less effort is required with increase in mechanical advantage and efficiency to lift water from hand pump. The present model provides better environment for workers as well as maximum profit in construction work.

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Figures

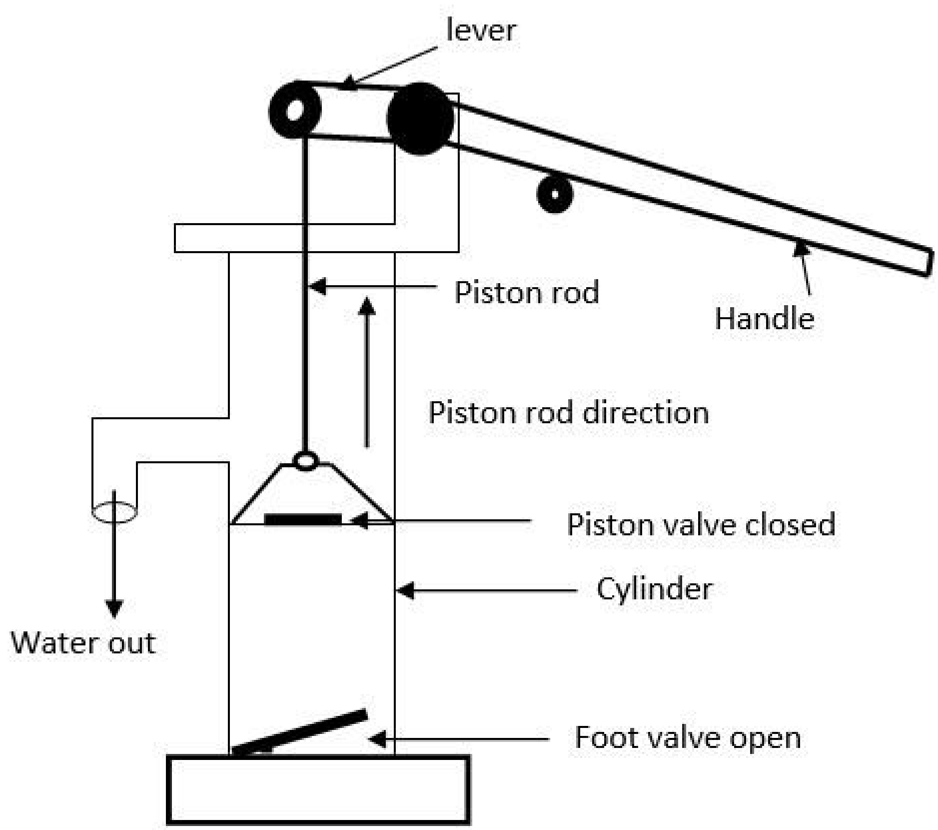

Figure 1

Condition for water entry into the cylinder of existing hand pump

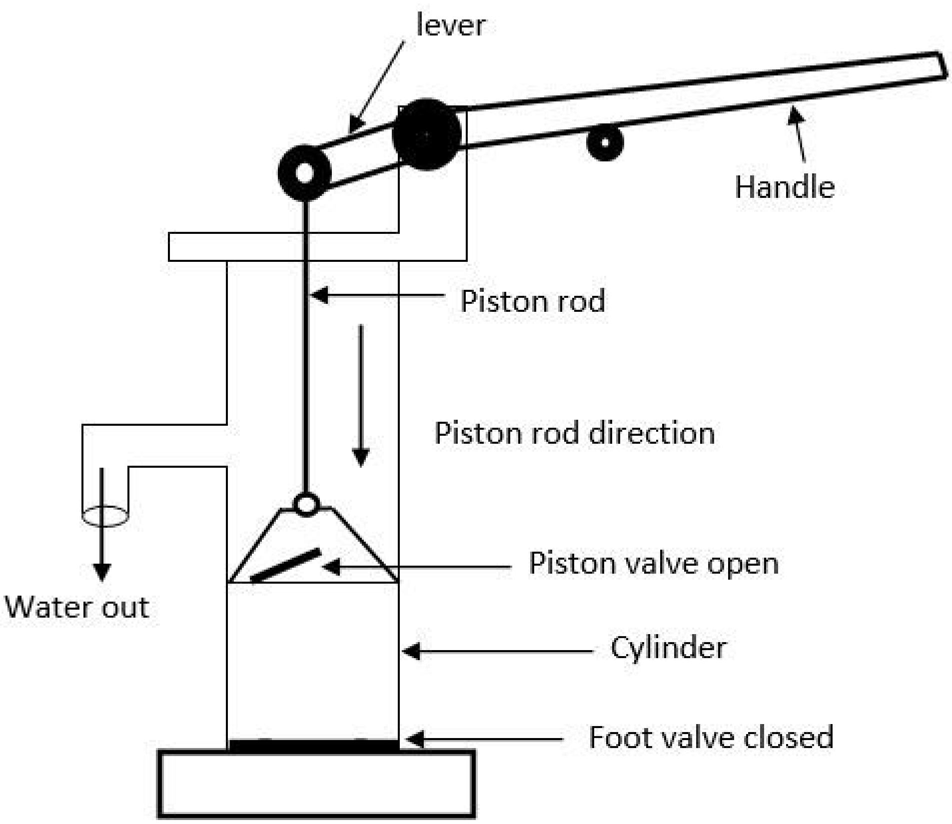

Figure 2

Water exit condition from an existing hand pump

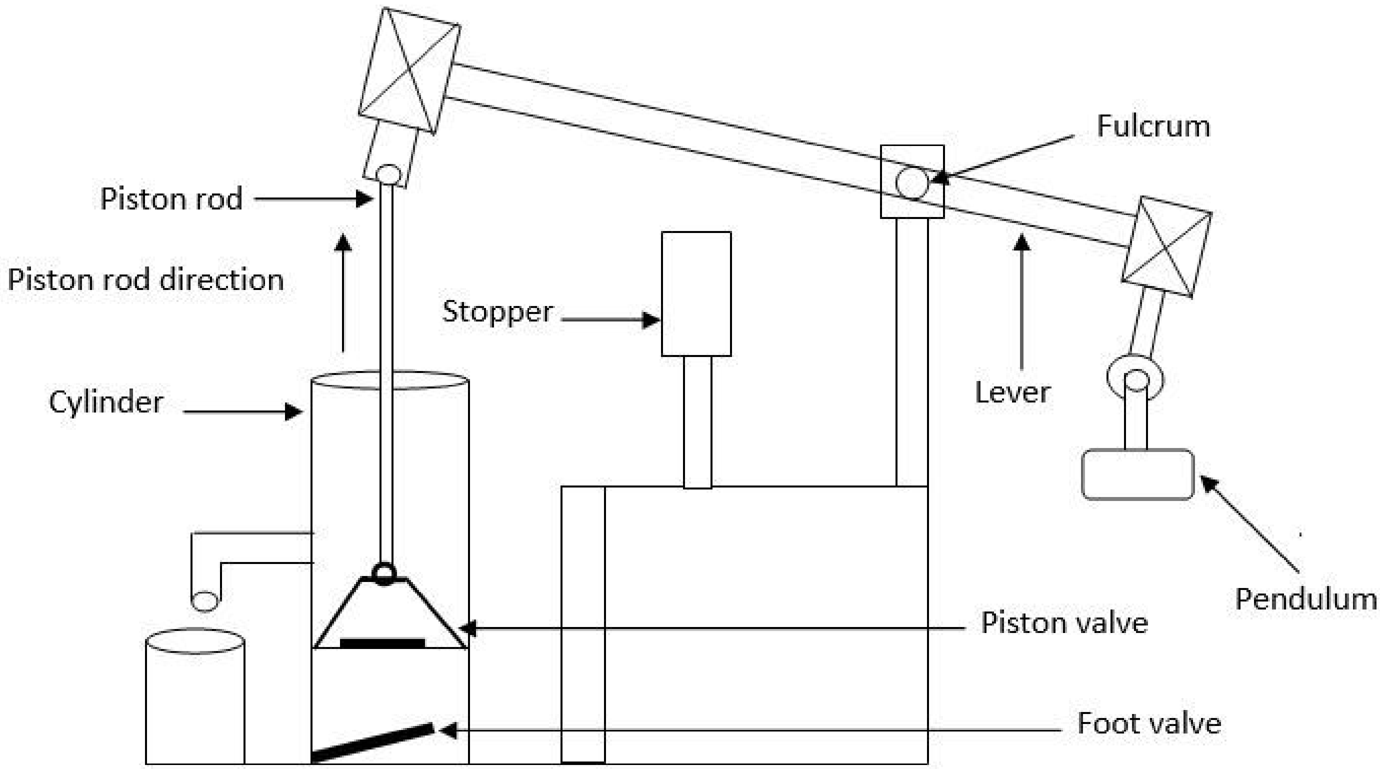

Figure 3

Water entry condition from existing hand pump with our attachment

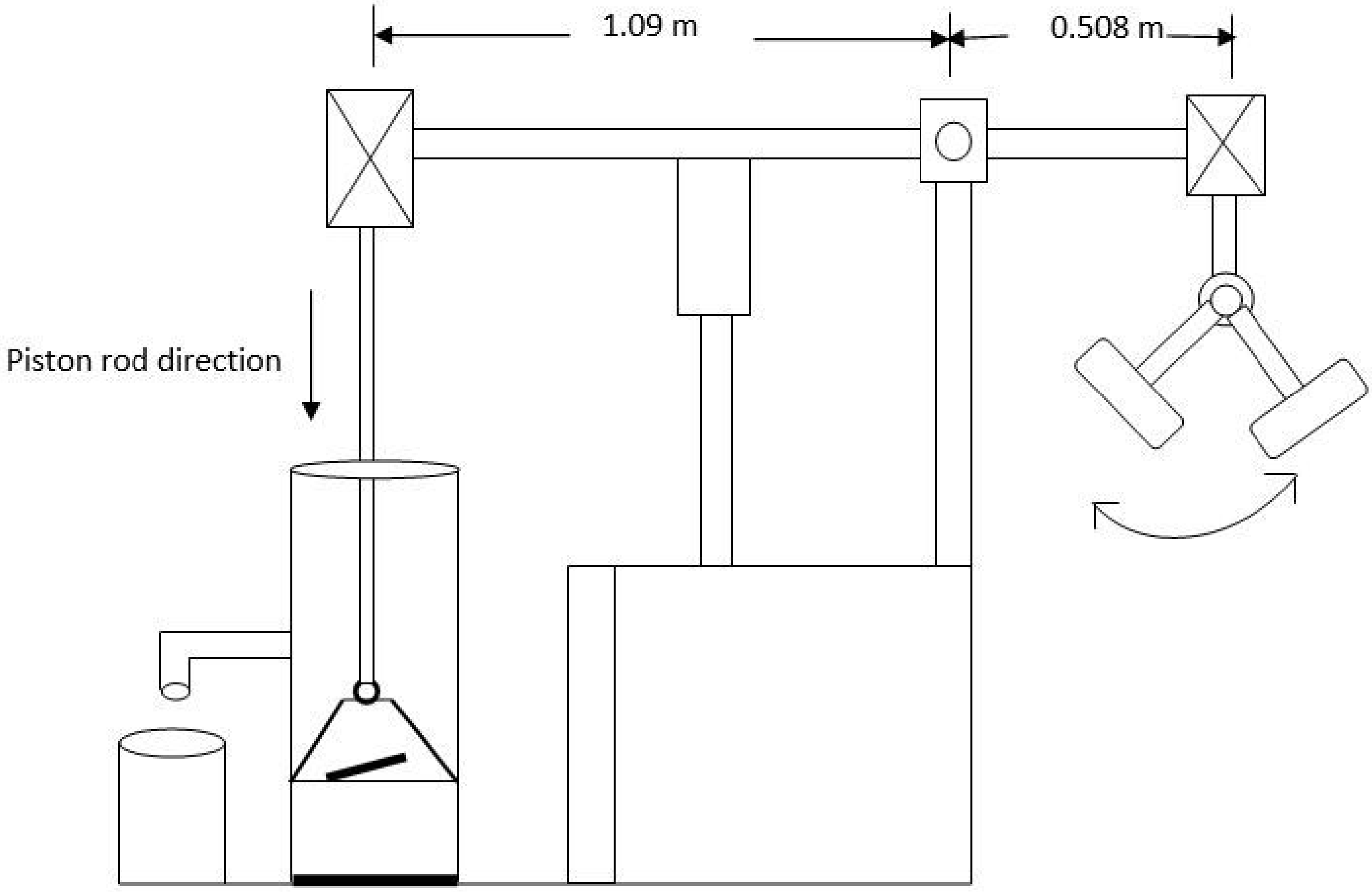

Figure 4

Water out condition from hand pump with our designed attachment

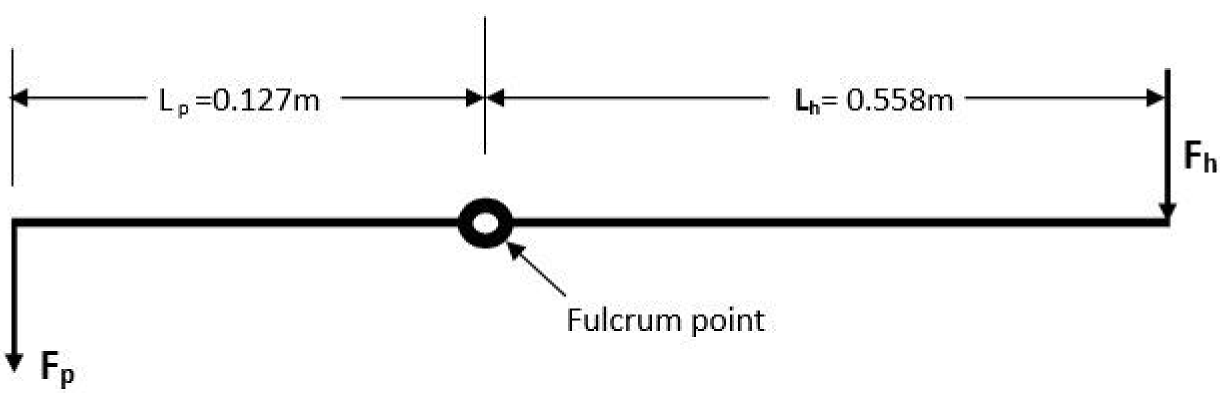

Figure 5

Lever arrangement for existing hand pump

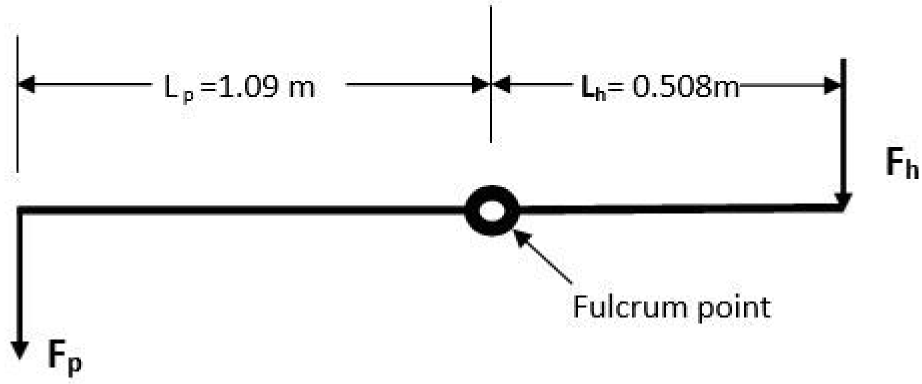

Figure 6

Lever arrangement for hand pump with our designed system