Design & Construction of Pedal Powered Water Pump and It's Performance Analysis

A Thesis

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SONARGAON UNIVERSITY (SU)

SEPTEMBER 2025

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Submitted to the Department of Mechanical Engineering Sonargaon University (SU) In partial fulfillment of the requirements for the award of the degree of
Bachelor of Science in Mechanical Engineering

SEPTEMBER 2025

ACKNOWLEDGEMENT

First, we started in the name of almighty Allah. This thesis is accomplished under the supervision of Md Ahatashamul Haque Khan, Assistant Professor, Department of Mechanical, Sonargaon University. It is a great pleasure to acknowledge our profound gratitude and respect to our supervisor for this consistent guidance, encouragement, helpful suggestion, constructive criticism and endless patience through the progress of this work. The successful completion of this thesis would not have been possible without his persistent motivation and continuous guidance.

The author are also grateful to Prof. Md. Mostofa Hossain, Head of the Department of Mechanical Engineering and all respect teachers of the Mechanical Engineering Department for their co-operation and significant help for completing the thesis work successfully.

ABSTRACT

This project explores using bicycle-powered mechanical energy to pump water, providing a sustainable alternative to electric or fuel-based systems. In rural or off-grid areas where energy access is limited or expensive, this method offers a cost-effective solution. By coupling a bicycle to a water pump, pedaling motion is converted into kinetic energy to drive the pump. This eliminates reliance on external power sources and reduces operational costs. The system is ideal for small-scale agricultural or household use, especially in communities with limited electricity access. It also reduces manual labor needed for water collection. The approach supports environmental sustainability by utilizing renewable human energy. While not a replacement for large-scale systems, it offers a practical, low-maintenance solution for water pumping in underserved areas.

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Chapter 1

Introduction

1.1 Background and Motivation

This section outlines the global challenges of water scarcity and energy access, which disproportionately affect rural and off-grid communities. Water scarcity, driven by climate change, population growth, and inefficient management, is a growing crisis, especially in developing regions. Meanwhile, many rural areas remain without reliable energy access, relying on traditional methods like kerosene and wood for daily needs. The reliance on conventional energy sources for essential services, such as water pumping, adds to both financial and environmental burdens. Diesel-powered pumps, for example, are costly to operate and contribute significantly to carbon emissions.

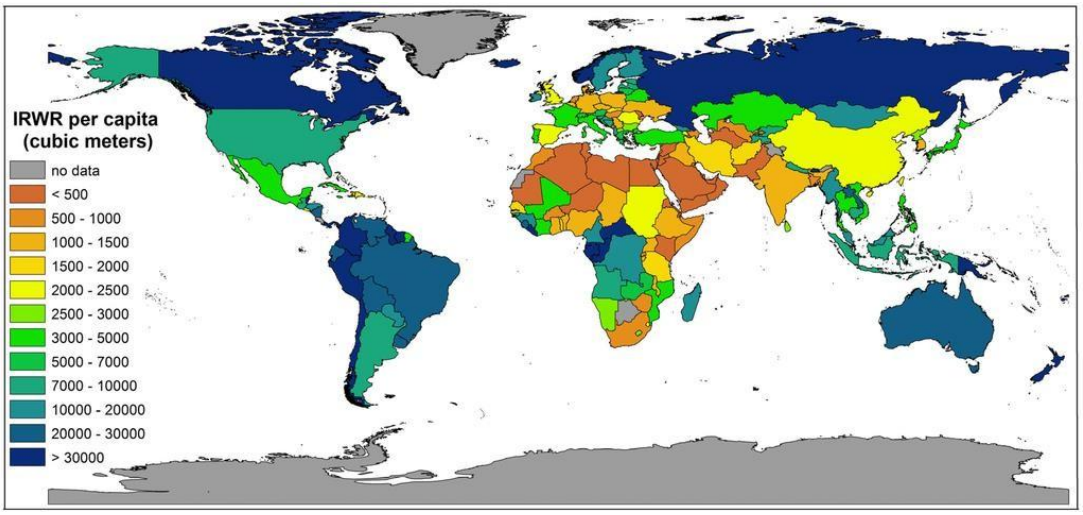


Figure 1.1: Water Scarcity and Future Challenges for Food Production

As a result, there is an increasing push for renewable energy solutions, such as solar, wind, and micro-hydropower. These alternatives offer a more sustainable, affordable, and eco-friendly approach to addressing both water and energy shortages. Renewable

energy systems can empower rural communities, reducing dependency on fossil fuels and contributing to global climate goals. The transition to clean energy is particularly crucial in areas that lack reliable grid infrastructure.

1.2 Problem Statement

This study addresses the heavy reliance on non-renewable energy sources for water pumping in remote, off-grid locations. In many rural areas, access to water is dependent on energy-intensive systems powered by diesel or other fossil fuels. These methods are expensive, inefficient, and environmentally harmful, contributing to high operational costs and carbon emissions. With rising water demand and energy shortages, these communities face increasing challenges.



Figure 1.2: Human-powered devices traditionally were used to move water short distances and up low grades. This irrigation wheel in Japan was still being used in 1958 to irrigate a small plot.

There is a critical need for affordable, sustainable alternatives that reduce dependence on fossil fuels. Human-powered and renewable energy solutions, such as solar, wind, and small-scale hydropower, offer potential alternatives. These systems can provide

reliable, low-cost energy to power water pumps, helping address both water scarcity and energy access. This study explores these renewable alternatives as viable solutions to ensure sustainable water access in underserved regions.

1.3 Research Objectives

i. To design and develop a Bicycle-Powered Water Pump System.
ii. To test the performance of our constructed project.

1.4 Scope and Limitations

This study focuses on the design and development of a small-scale, bicycle-powered water pump system intended for use in rural and off-grid communities. The primary goal is to provide a sustainable and affordable water pumping solution that operates on human power, making it suitable for areas with limited access to electricity or fuel. The research is limited to manual water pumping applications, specifically targeting household or community-level water needs. The scope includes the system's design, functionality, and efficiency in pumping water, as well as its potential for improving water access in underserved regions.

However, there are several limitations to this study. The scalability of the bicycle-powered pump system is constrained, as it may not be suitable for large-scale agricultural or industrial water pumping needs due to capacity limits. Technical constraints, such as the mechanical efficiency of the bicycle pump and the durability of the components, may also impact long-term performance. Additionally, the operational limits of the system depend on factors such as the physical strength of the user and the availability of spare parts for maintenance. These limitations need to be addressed for broader implementation in varying environments.

1.5 Significance of the Study

This study highlights the potential of the bicycle-powered water pump as a sustainable, renewable energy solution for water pumping in remote regions. By utilizing human power, the system offers an alternative to fossil fuel-based pumps, which are expensive to operate and harmful to the environment. The bicycle-powered pump could significantly reduce fuel costs for water extraction, making it a more affordable solution for rural communities with limited access to electricity.

The study also emphasizes the importance of this technology in promoting environmental sustainability, as it reduces carbon emissions and dependence on non-renewable resources. In agricultural communities, the bicycle pump could provide a reliable, low-cost water source, improving irrigation and supporting food security. For domestic use, it can ensure access to clean water in off-grid areas, contributing to better health and quality of life.

Overall, the project could serve as a model for low-cost, renewable solutions in underserved regions, fostering self-sufficiency and resilience. Its broader implementation could lead to greater social and economic stability, reducing reliance on external aid and enhancing community sustainability.

Chapter 2

Literature Review

2.1 Overview of Water Pumping Technologies

This section provides an in-depth review of various water pumping technologies, focusing on their suitability for rural and off-grid environments. Conventional electric pumps are widely used but often rely on grid power or diesel generators, which can be costly and unreliable in remote areas. These pumps offer high efficiency but are unsustainable in regions without stable energy access. Solar-powered water pumps use photovoltaic panels to generate electricity, making them a popular choice for off- grid areas with ample sunlight. They are low-maintenance and environmentally friendly, though their efficiency can be impacted by weather conditions and initial setup costs. Wind-powered pumps harness wind energy to pump water, suitable for regions with consistent wind patterns. These systems are also renewable and environmentally friendly, but their effectiveness depends heavily on local wind conditions and may not be suitable for all regions. Manual pumps, including bicycle- powered pumps, offer an affordable and sustainable option for small-scale water extraction. While they require human effort, they are highly accessible and inexpensive but may be physically demanding for users over long periods. Each method has unique strengths and limitations, and their effectiveness largely depends on the geographic and economic context in which they are deployed.

2.2 Human-Powered Energy Systems

This section reviews existing human-powered energy generation systems, focusing on mechanical devices that convert human effort into usable energy. Bicycle-powered machines have gained attention due to their efficiency and practicality, using the mechanical energy from pedaling to power water pumps, generators, and other systems. Bicycle-powered pumps are particularly suitable for small-scale water extraction, offering a cost-effective solution for rural and off-grid communities. Hand

pumps represent another common human-powered system, traditionally used for groundwater extraction. These pumps are simple, durable, and require minimal maintenance, making them well-suited for basic water needs in remote locations. However, they often have limited capacity and may require significant physical effort over extended periods. Other mechanical devices—such as treadle pumps, windlasses, and crank-operated systems—have also been developed to harness human power for tasks like irrigation or lifting water. These systems offer the advantage of being accessible, environmentally friendly, and sustainable, but their effectiveness depends on user effort and the specific demands of the application. Overall, human-powered energy systems provide a practical, renewable solution for addressing water pumping needs, especially in areas with limited access to conventional energy sources. Their scalability and adaptability make them a viable option for promoting self-sufficiency in underserved regions.

2.3 Renewable Energy Solutions for Water Pumping

This section explores the role of renewable energy sources—solar, wind, and hydroelectric systems—in water pumping applications, particularly in rural and off-grid environments. Solar-powered water pumps are widely adopted due to their low operational costs and scalability, especially in areas with abundant sunlight. Solar systems are efficient for consistent, small to medium-scale water extraction but can face limitations during cloudy weather or at night, requiring battery storage or backup systems. Wind-powered pumps harness wind energy to drive water pumps, making them ideal for regions with steady wind patterns. Wind systems are highly reliable and environmentally friendly but require suitable wind conditions for optimal performance. Their initial installation cost can be higher than solar pumps, and their efficiency varies with location. Hydroelectric systems, particularly small-scale micro- hydropower, offer a constant power source for water pumping in areas with flowing water. These systems provide reliable, continuous energy but are geographically limited to regions with access to rivers or streams. While they offer high efficiency and low operational costs, they also involve significant initial setup and infrastructure costs. In comparison, bicycle-powered pumps offer a low-cost, human-powered alternative. They are particularly beneficial for small-scale, intermittent water needs and require minimal infrastructure. While they are affordable and reliable, they

depend on physical labor, which can limit their capacity for large-scale or continuous pumping. Each renewable energy solution offers distinct benefits and limitations, with the choice often dependent on local resources, infrastructure, and specific needs in rural settings.

2.4 Technological Gaps and Research Opportunities

This section identifies key gaps in the existing literature concerning bicycle-powered water pumping systems. While much research has been conducted on traditional energy sources and renewable technologies like solar, wind, and hydro for water pumping, few studies focus specifically on the potential of human-powered solutions, particularly bicycle-driven pumps. Existing research on bicycle-powered pumps is often limited to basic design and functionality, with limited exploration into optimization for efficiency, scalability, and long-term durability. Opportunities for innovation lie in refining the mechanical design to enhance energy conversion, reduce physical strain on users, and increase the pump's operational capacity. Additionally, there is a lack of comprehensive studies on the integration of bicycle-powered pumps with other technologies, such as hybrid renewable energy systems, to address water needs more effectively. Further research is needed to evaluate the economic feasibility and environmental benefits of bicycle-powered systems in diverse rural settings. By exploring these gaps, this study aims to advance knowledge in the field, offering insights into how bicycle-powered water pumps can be optimized for greater efficiency and broader application. This research could significantly contribute to improving water access in off-grid communities, fostering innovation in sustainable, human-powered technologies.

Chapter 3

System Design and Methodology

3.1 Methodology

The mechanism consists of regenerative turbine pump which is connected with the rear wheel of bicycle with the help of V-belt. Paddling for just a minute or two is enough to pump 30-40 liters of water to a height of 100 feet. Our project could prove helpful for rural areas. Which are facing load shedding problem? It can be used mainly for irrigation and water drawing water from wells and other water bodies. This is a regenerative turbine water pump which is run by rotating the pedal of a cycle.

The system comprises a bicycle, rim, regenerative turbine pump, impeller, pulley and inlet and delivery pipes. A rim is connected to another pulley with a smaller diameter the final supporting shaft is connected with an impeller through this process of paddling is used to lift water from a pipe into the form for cultivation. This innovation is useful for pumping water from river, ponds, wells and similar water sources thus enabling poor farmers for pumping water for irrigation and cultivation. We drive a bicycle by using a paddling the wheel of the bicycle rotates at a particular rpm. In process operations, liquids and their movement and transfer from place to place, plays a large part in the process. Liquid can only flow under its own power from one elevation to a lower elevation or, from a high pressure system to a lower pressure system. The flow of liquid is also affected by friction, pipe size, liquid viscosity and the bends and fittings in the piping.

To overcome flow problems, and to move liquids from place to place, against a higher pressure or to a higher elevation, energy must be added to the liquid. To add the required energy to liquids, we use 'PUMPS. A pump therefore is defined as ' A machine used to add energy to a liquid'. Pumps come in many types and sizes. The type depends a large part in the process. Liquid can only flow under its own power from one elevation to a lower elevation or, from a high pressure system to a lower

pressure system. The flow of liquid is also affected by friction, pipe size, liquid viscosity and the bends and fittings in the piping.

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3.2 Components and its specification

3.2.1. Centrifugal Metal Water Pump Kit V4

Power: 0.2 hp
Impeller diameter: 15 mm
Outlet diameter: 20 mm
Inlet diameter: 17 mm



Figure 3.1: Centrifugal metal pump

3.2.2. Pulley

Diameter: 8.5 cm

Material: Grey cast iron



Figure 3.2: Pulley

3.2.3. Belt: V-

Type Type:

A106

Material: Polyester cord

3.2.4. Bearing : Deep grove ball bearing



Figure 3.3: Bearing

3.2.5. Shaft: Mild steel



Figure 3.4: Shaft

3.2.6. Nut & Bolt

3.2.7. Inlet Pipe:
Material: Plastic.



Figure 3.5: Inlet Pipe

Chapter 4

Process of fabrication

4.1 Process of fabrication

1. The first step of making power operated water pump is the preparation of the stand.

2. Scarp mild steel pipes are malle into sufficient pieces and are welded together to get the stand.

3. The stand is then connected with the back wheel of the bicycle.

4. By considering the wheel and rotor shaft space the centrifugal metal pump is connected with the stand by using the nut and bolts.

5. The suction and delivery pipes are then connected to the suction and delivery ports respectively.

6. Manual priming of the centrifugal pump is done next.

7. By pedalling the Rpm of the rotor shaft is measured using tachometer.

8. The flow rate of water is measured by using measuring tank and stop watch.

4.2 Working principle

As in our project pump shaft is connected with the pulley and the pulley is connected with the cycle rim with the help of v-belt. When we pedal the bicycle then the back wheel rotate which rotates the pump shaft. Thus rotating the impeller and rotating impeller creates vacuum at the inlet area and that leads to suction of water from the sump and rotating impeller also increase the kinetic energy and pressure of the water and discharge the water.



Figure 4.1: Pedal Powered Water Pump

Chapter 5

Results and Discussion

5.1 Results

Pump was able to pump at maximum of 23 feet. At desired height of 18 feet pump pumped at rate of 10 ℓ /min.

Minimum rpm required for impeller shaft = 800 to 1000 rpm

Rpm available in rear wheel = 794 rpm

Velocity ratio between rim & pump pulley =1/11

Actual maximum speed available at impeller shaft = 500 rpm

Here formula required,

1. $Q_2 = Q_1 \times \frac{N2}{N1}$

2. $t = \frac{V}{Q}$

Where,
Formula (1)

1. $Q_2 = Q_1 \times \frac{N2}{N1}$

Q_1 = Initial discharge (L/s or m^3/s)

N_1 = Initial rotational speed (rpm)

N_2= Modified rotational speed (rpm)

Q_2 = Modified discharge (L/s or m^3/s)

This relationship indicates that the discharge () of a pump or turbine is directly proportional to its rotational speed (). Therefore, an increase in speed leads to a proportional increase in discharge, while a decrease in speed results in reduced discharge.

Formula (2)

2. $t = \frac{V}{Q}$

Where:

t = Time required (s)

V = Volume of water discharged (L or m^3)

Q = Discharge rate (L/s or m^3/s)

This equation expresses the time required to discharge a certain volume of water. It shows that the required time is inversely proportional to the discharge rate: a higher discharge rate reduces the time needed, whereas a lower discharge rate increases it.

So,

1. $Q_2 = Q_1 \times \frac{N2}{N1}$

i) $Q = 9 \times \frac{900}{800} = 10.1$ ℓ/min

ii) $Q = 9 \times \frac{1000}{800} = 11.25$ ℓ/min

iii) ii) $Q = 9 \times \frac{1100}{800} = 12.37$ ℓ/min

iv) ii) $Q = 9 \times \frac{1200}{800} = 13.5$ ℓ/min

2. $t = \frac{V}{Q}$

i) $t = \frac{10.1}{60} = .16$ sec/ ℓ

ii) $t = \frac{11.25}{60} = .18$ sec/ ℓ

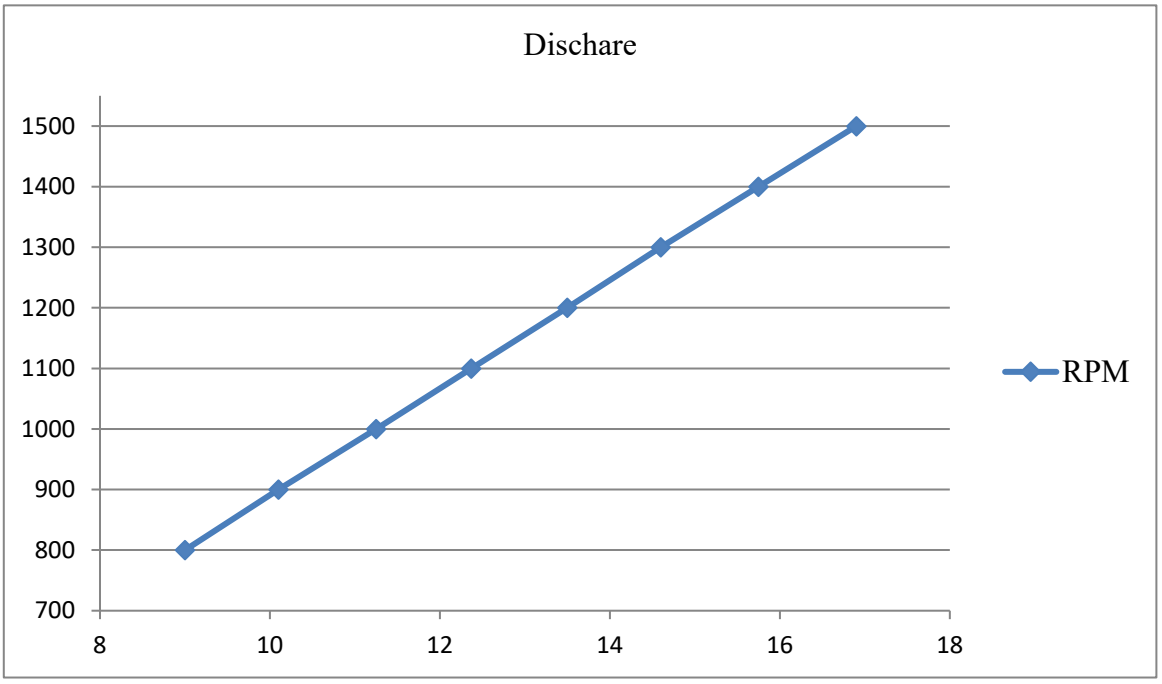
iii) $t = \frac{12.37}{60} = .20$ sec/ ℓ

iv) $t = \frac{13.5}{60} = .22$ sec/ ℓ

5.2 Observation

SL.No.	Speed (rpm)	Time to discharge one liter (sec/ ℓ)	Discharge (ℓ/min)	Height (in feet)	Depth (in feet)
1	800	.15	9	5	5
2	900	.16	10.10	5	5
3	1000	0.18	11.25	5	5
4	1100	0.20	12.37	5	5
5	1200	0.22	13.50	5	5
6	1300	0.24	14.60	5	5
7	1400	0.26	15.75	5	5
8	1500	0.28	16.90	5	5

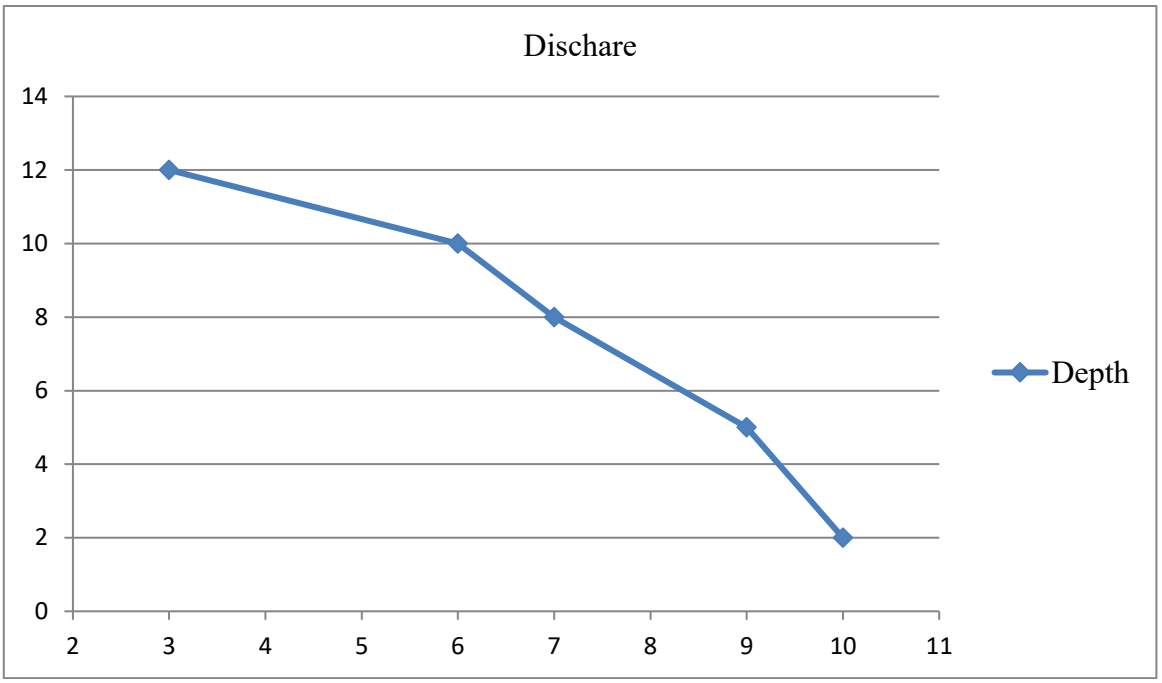
Table 1. Discharge rate at different speed



- Increase in speed in increases the discharge rate
- Maximum discharge rate is 16.90 ℓ/min at speed of 1500 rpm.

SL.No.	Depth (in feet)	Discharge (ℓ/min)
1	2	10
2	5	9
3	8	7
4	10	6
5	12	3

Table 2. Discharge rate at different depth



- Increase in depth cause decrease in discharge.
- At depth of 10 feet discharge rate is almost 6 Lt/min.

5.3 Applications

- For irrigation purpose
- For transferring water from one place to another
- For garden irrigation
- For pesticides spraying

Chapter 06

Conclusion and Future scope

6.1 Conclusion

This study concludes that a bicycle-powered water pump offers significant advantages, particularly for rural areas. In a country like India, where the energy crisis is a major concern, this pedal-powered water pump project can help conserve electricity while effectively supplying water for irrigation purposes.

The system works by using the pedaling motion of a bicycle to operate a water pump. As the bicycle is pedaled, the rear wheel rotates, which in turn drives a pulley attached to the wheel. This pulley is connected to a shaft, which rotates the impeller of the pump. As the impeller turns, the pump begins to move water and can deliver it to a desired height (head).

This setup is not only useful for irrigation but can also be used to fill household water tanks, assist in small-scale power generation, and support construction activities. The design is adaptable, allowing it to meet the specific needs of different communities.

Additionally, the system can be installed in home gardens, allowing users to combine gardening and cycling for an efficient and healthy lifestyle. The goal is to operate the pump as close as possible to its best efficiency point to maximize performance.

6.2 Future scope

In the current situation, where both electricity and fuel shortages are increasing day by day, this project stands out as a valuable solution since it operates without relying heavily on conventional energy sources. The initial investment required for this system is quite low, and with mass production, the overall cost can be reduced to nearly half.
This project relies on basic human physical effort for operation. One of its major advantages is its eco-friendly nature. It is also simple to maintain. Some performance issues do exist, but they can be minimized by implementing improvements in the pump

design and transmission mechanism.

There have been several notable attempts to develop human-powered machines, mostly in developing countries, often led by international aid groups or students. A particularly innovative group based in Chennai has created several pedal-powered tools such as corn grinders, nut shellers, and wood saws. YouTube also features a wide range of bicycle-powered inventions, most of which are designed to generate electricity. While that's a useful approach, the aim of this project is different — it focuses on using a bicycle to directly operate a water pump rather than generating electricity to power one.

REFERENCES

[1] Atul.P.Ganorkar, K.S.Zakiuddin, H.A.Hussain, "An Experiment on Development of Pedal Operated Water Pump". 1IOSR, e-ISSN:2278-1684, (2014).

[2] Vishal Garg, Neelesh Khandare, Gautam Yadav, "An Experimental Setup and Design of Pedal Powered Water Pump", International Journal of Engineering Research and Technology (Vol.2. Issue.1) (2013).

[3] Ademola Samuel Akinwonmi, Stephen Kwasi Adzimah, Fredrick Oppong, "An Experiment on Pedal Powered Centrifugal Pump for Purified Water Supply Device" ISDE (Vol.3. No.11) (2012).

[4] Bryan Lee. "A Design of Simple Human Powered Water Pump", International Journal of Technology (2007).

[5] M.Serazul Islam, M.Zakaria Hossal and M.Abdul Khadir. "Design and Development of Pedal Pump for Low Lift Irrigation", JARD, S(182)116-126 (2007).