Design & Analysis of 100KW Hydro Power Energy Production in Rural Sectors of Ganga River Basin

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Abstract

This research was done with the idea to design, analyze, and compare efficiency low head turbine's hydropower energy generation capability in rural sectors of the Ganga river basin for the utilization by the local population. For the past decades, CFD ANSYS (Fluent) has been the preliminary choice of engineers for designing and analyzing the flow of fluids across structures and sections. Small Scale Hydropower (SSHP) has proven to create energy from Run of the River segment of water streams, making the world shift towards a cleaner and greener environment with minimal impacts on the aquatic ecosystem. To locate these zones of Hydropower Potential is a relatively challenging task, but with the exponential growth of Geographic Information System (GIS), the application of this system will make the challenge easier. Also with the rise in demand and to decrease the load on the central grid, a decentralized system such as solar, hydro, or wind does exist to meet with the basic needs of the local isolated areas where transportation of electricity is not feasible neither economical. The Existence of various turbines of standard design and dimensions do exist, with an efficiency of 40-70%, overheads ranging from 5 to 15 m. The study produced the conclusion that Geotagging of location having Hydro-potential can be done based on the GIS DEM data of the region having possible water heads of 0.5 meters and above in the river basin. The vortex flow design of the turbine chamber showed excellent results in the stable production of energy. Based on the data inputs on flow, Hydraulic head, and DEM, selection of turbine type was explored. The range of Head taken is 0.3 to 5 meters. Initial designing was done in AUTOCAD with simulation runs on ANSYS (FLUENT), variation parameters included intake angles, discharge variations, dimension modeling & optimization. The resulting conclusions of this study indicated that the Singular designed system with Vortex Flow and different turbine types based on geolocation specifications has 70 -80 % efficiency in the Ganga river basin with an average output power capacity of 100KW.

Keywords: - CFD ANSYS (Fluent), Small Scale Hydro-Power (SSHP), Geographic Information System (GIS), Digital Elevation Modelling (DEM), Vortex Flow, Decentralized System.

Introduction

With the overall success of huge hydropower as the world's leading source of renewable energy, it's only affordable that countries contemplate small hydro, which is run-of-river, development additionally. This can be significantly relevant for the Republic of India, a country that hasn't broached its voluminous hydropower resources for nearly a century after the introduction of the technology within the country. All of India's major hydropower developments are giant, and although they already contribute 13.2% of India's electricity, there remains a growing want for additional energy. large hydro dams are pricey to create, and new facilities require extensive timelines for consultation, planning, environmental assessments, and construction. Besides, most of the more favorable hydropower sites in India have been developed. These factors have propelled small hydro into the energy scene.

A previous technology with several recent innovations, tiny hydro is appealing for its reduced environmental impacts, potentially cheaper development, and plentiful prospective sites. The public discourse regarding small hydro usually mistakes the reduction of environmental and social impacts for the elimination of them. It's vital to know that small hydro inflicts a smaller impact on aquatic ecosystems and native communities, however like all types of energy cannot utterly forestall stresses on the plant, animal, and human well-being. Besides, the negative, cumulative effects of the run of river systems in operation along identical river networks might present additional issues, and analysis during this area is severely lacking. although not nonetheless value corresponding to large hydro, small hydro remains capable of yielding lower prices per kWh than other sources, like diesel-electric. In India, small hydro has found a distinct segment in replacing polluting diesel generators in remote, usually 1st Nations, communities.

This development should be undertaken with care, however, because the risk of affecting river ecosystems directly connects to the stability of traditional lifestyles. The linkage between social and environmental issues is closely bonded in these places. Long and infrequently confusing permitting processes have slowed the progress of small hydro in India, alongside hesitancy created by unaddressed social and environmental issues.

Hydropower is the foundation of "CO2 free" energy conversation; about 22% of the world's power creation originates from hydro-power establishments, the smallest amount of advanced approach to delivering the volumes of falling water expected to create power has been to fabricate a dam. A dam stops the regular progression of a waterway, developing a profound repository behind it. Be that as it may, huge dams and repositories don't seem to be typically correct, significantly within the additional environmentally delicate territories of the earth. for creating restricted quantities of power while not building a dam, the small scope hydroelectric generator is often the most effective arrangement, significantly wherever fast streaming water accessible.[1]

Energy Production has become extremely costly worldwide and its shortage has led to intensified analysis studies for developing alternate sources of energy. due to increasing worldwide enthusiasm on the conservation of surroundings, conveyed generation of power is discovering picking up.[2] They do not encounter the issues of population displacement and might improve the overall energy image of the planet. These are the clean, pollution-free, eco-friendly energy sources. With the advancement of technology, it's potential to harness electrical power with efficiency with heads as low as two meters.[3]

The hydraulic turbines are classified according to the kind of energy obtained at the inlet of the turbine, direction of flow through vanes, head at the inlet of the turbine, and specific speed of the turbine.[4]

According to the specific speed of turbine classification is done into:

1. Low specific speed and high head turbine (Pelton)

2. Medium specific speed and medium head turbine (Francis)

3. High specific speed and low head turbine (Kaplan and Propeller)

Electricity generation within the low headwater sources is suitable for application in remote areas where the enlargement of the distribution system isn't possible. the strategy is additionally applicable for electricity generation in areas with a continuous flow of water all year round [5].

There are three primary classifications of SSHP (Small Scale Hydro Power) plants on basis of power generated are referred to in Table 1:

SSHP TYPES/CLASS	POWER (STATION CAPACITY)	HEAD (Meters)
MICRO	UPTO 100 KW	1 – 5
MINI	101 KW – 2 MW	2 – 10
LOW	2 MW - 25MW	10 – 20

Table 1: Classification of SSHP Turbine types based on Head.

Hydro-power systems are measure in KW's and we size them based on the amount of electricity they produce. Currently, the generation of electricity in the low headwater sources has been based conventionally on different forms of generating turbines which include: horizontal spiral turbine, small undershot water wheel, Kaplan hydro turbine, and gravitational vortex power plant [6].

Compared with other renewable energy resources like wind power and solar power, the small scale hydropower system can offer a longer lifetime and stable good quality power can be supplied. For this reason, small-scale hydropower systems apply to various sites such as dams, rivers, agricultural channels, city water and sewage water plants, and factories. The hydropower potential of India is estimated at 84,000 MW (at 60% load factor) and supreme possible installed capacity of 145,320 MW in stations with installed capacity over 25 MW. While water may be a State subject, electricity may be a subject in Concurrent List. The development of hydropower in India is governed by the Indian Electricity (Supply) Act, 1948, and its amendment Indian Electricity Act, 2003 [7].

Bhuvan is an Indian electronic utility which permits clients to investigate map based substance arranged by Indian Space Research Organization. The substance which the utility serves is for the most part confined to Indian limits and is offered in 4 territorial dialects. The substance incorporates topical guides identified with debacles, agribusiness, water assets, land spread, and prepared satellite information of ISRO. Bhuvan is known for its relationship with different areas of the Government of India to empower the utilization of Geospatial innovation. Bhuvan has since its beginning empowered the Indian government to have open geospatial information as Information layers for perception and open utilization. Many DEMs are available with the Indian Space Research Organization collaborative program with Indian Remote Sensing Institute on CARTOSAT 30M satellite imagery. Further ArcGIS is also available to prepare a DEM based on ASTER 30M data or SRTM 30M/90M data of the particular region to delineate and prepare contour graphs. Use of Bhuvan has a direct application for creating the DEM of geotagged location proving the necessary head requirements for the SSHP's setup and power generation capacity measurement without practically vising the site in the initial phases of designing.

Using the BHUVAN platform for the linear terrain modeling multiple locations were studies for the possibility to install SSHP's to create an energy generation source for the local population. The idea was to create a separate Grid for electricity in the isolated region where transmission of electricity from point of generation was not feasible and also to promote the sustainable development goal in the locality by creating an opportunity for locals.

Hydropower is an important energy strategy that reshapes the ecological functions and services of a river system. Huge dams were fabricated soon after Indian Independence as a major aspect of the national turn of events and noteworthy protections from these enormous dams created in the accompanying three decades. The current wave of dam investment is motivated by the twenty-first-century interest in industrial growth and urban expansion, and by expanded water consumption. In 2002, the Government of India announced a 50,000 MW initiative to narrow the gap between supply and the growing power demand. This hydropower push has concentrated on the Indian Himalayas where the precarious drops of tributaries to the Indus, Ganga, and Brahmaputra streams can produce bigger yields of intensity. The sites of current development are located across the northern region of India, in the states of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Uttar Pradesh, Sikkim, Arunachal Pradesh, and Assam [8].

The Ganga Basin is the world's most populated river basin, home to half of India's population, including two-thirds of the poor people of the country. The basin provides over one-third of the available surface water in India and contributes to more than half the national water use of which 90 percent is diverted to irrigation. The Ganges River follows a 900 km (560 mi) arching course passing through the cities of Kannauj, Farukhabad, and Kanpur. It is joined by the Ramganga along the way, which contributes an average annual flow of approximately 500 m3 / s (18,000 cu ft. / s). The Gandaki River, at that point the Kosi River, join from the north spilling out of Nepal, contributing around 1,654 m3/s (58,400 cu ft./s) and 2,166 m3/s (76,500 cu ft./s), separately. The Kosi is the third biggest tributary of the Ganges, after the Ghaghara (Karnali) and the Yamuna. The Kosi converges into the Ganges close Kursela in Bihar. Choosing a perennial river for adopting an SSHP's scheme is the best solution for meeting up with the basic demands of the rural populations residing on the river bank. Ganga is one of the oldest flowing rivers and having huge discharges throughout the year has huge potential for the run of river scheme set up to generate 100KW hydropower at a specifically studied location with the available head and flow design parameters.

Methodology

The steps for designing and setting up of small scale hydropower (SSHP) system is done in 3 simple steps keeping, in contrast, the need for rural people to gain maximum output from it. The 3 steps involve the following:

1. Designing of SSHP's based on CFD modeling of the system for Run of River Scheme in ANSYS FLUENT
2. Geotagging locations based on ISRO geospatial portal BHUVAN with Cartosat 30M/90M data for Digital Elevation Modelling (DEM) of the location.
3. Experimental analysis of the model designed in CFD simulation, in a Laboratory-scale environment to get accurate details about the adopted system confining to the selected location.

The 3 steps were followed throughout the geotagged location across the Ganga river basin in the state of Bihar for capturing location which had the potential to generate electricity in regions that were isolated from the centralized electricity grid and could not afford the high budget electric connection.

These locations proved to have heads ranging in various degrees and an annual flow of river stream nearby them, most of the population residing nearby the location lived in small constructed houses requiring electricity for basic items like a fan, light bulbs, communication devices. Installation of a decentralized grid at these locations will make the community grow in this era of technology as everything now days have gone digital and every electronic equipment need to connect to this digital platform requires electricity to function.

The explanation of steps involves for the analysis and setup is mentioned below:

I. Design & Analysis on CFD ANSYS FLUENT.

DETAILS OF THE PROTOTYPE FOR ANSYS SIMULATION:

- The average discharge variation for the study of the model will be varied between 1m3/s to 5m3/s.
- The width of the mainstream section is kept = 600 mm
- The width of the bifurcating canal from the mainstream is kept = 200 mm
- Radius of turbine vortex flow zone = 150 mm
- The maximum radius of the turbine blade is = 145 mm
- The total length of the design is limited to = 2000 mm
- Length of bifurcating flume in horizontal direction = 1000 mm
- The average range of head to be studied is kept between 0.3 to 1 meters w.r.t the bottom of the channel.

The flow across the designed channel was kept laminar and the velocity of flow at the inlet section was kept at 1m/s and was varied accordingly to obtain a needed discharge.

The process for analysis of the complete setup is done in 3 parts:

- The zone of bifurcation,
- The zone of vortex flow and;
- The zone of release.

The ANSYS simulation steps involved were the same for every zone only the design parameters were different standard atmospheric pressure to be considered was 1 atm. The flow considered was uniform & steady across every zone to replicate the streamflow of the Ganga River in the natural state in the regions of Bihar.

The analysis of the different sections resulted in the various profiles of pressure distribution, velocity vector flow, variation across the wall domain of the structure.

II. Geotagging of potential locations and creating linear DEM across the terrain profile

This process involved the application Geographic Information System (GIS) database for different locations based on ISRO's BHUVAN Cartosat 30M/90M satellites. Using the digital platform available DEM of selected location was generated in a linear terrain profile depicting the flow path of the SSHP canal network.

The generation of the Digital Elevation Model (DEM) gave a transparent insight into the nature of the terrain, the available head, the slope variation across the selected location for its potential in creating electrical power. Also, the distance from the nearest residential populations was taken into consideration while planning to select these pivotal points.

The application of GIS in depicting the potential capacity of the nearby stream to generate hydropower output for the local population was studied briefly and was calculated to meet the basic needs and facilities for people. The dashboard image of Bhuvan DEM in raw form is depicted in Figure 1 below:

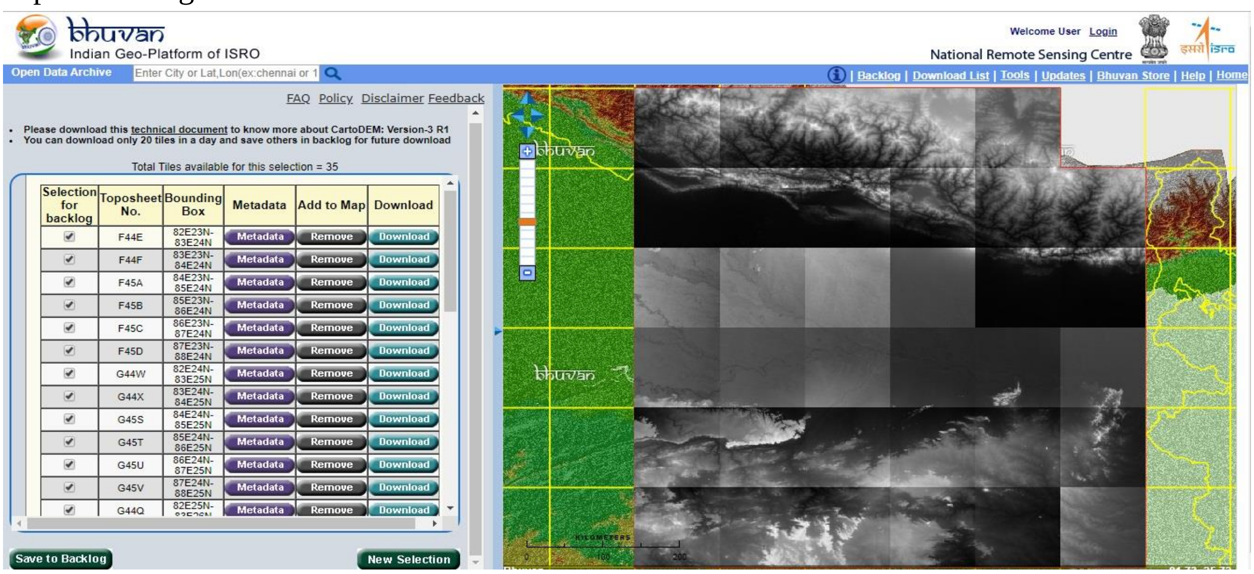


Figure 1: DEM data for the state of Bihar with river Ganga flowing in the middle has been presented to get an insight into the terrain profile.

Further linear DEM of the complete Ganga river flow basin flowing across Bihar is represented in Figure 2 as below:

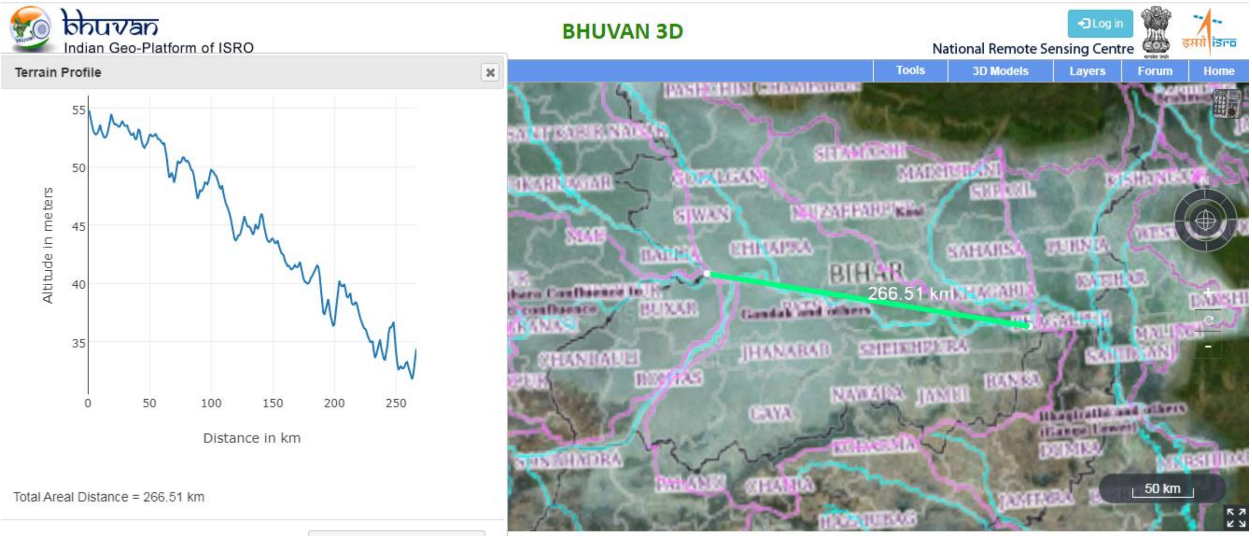


Figure 2: Digital Elevation Model (DEM) of Ganga River from BUXAR to BHAGALPUR. (Stretch is assumed simply to generate a linear DEM of terrain in Ganga river basin)

The linear topographical variation on the river basin includes the idea that necessary head availability is there for general small scale production of hydro-power from potential locations. Here the topographical height difference is 40 m over a range of 250KM's.

III. Experimental Analysis of different low head turbine (Crossflow, Kaplan, and Francis)

The experimental analysis was done in fluid mechanics laboratory with a lab-scale model available for study. The result obtained on multiple set parameters such as discharge, velocity, head, energy output (actual), energy output (theoretical) were correlated to obtain the range and parameters under which what category of the turbine will be more efficient to install.
Experimental analysis is done such as to validate the conceptual idea obtained through ANSYS FLUENT simulation and theoretical concepts for power generation. This data will help in understanding the effectiveness of the different turbines in different head conditions prevailing to the ranges available in the geotagged locations of the Ganga River Basin.
The result obtained was as per the max generation capacity of the model scaled version of the turbine considering certain ideal case situation, which might vary with the actual data obtained by on site investigation and experimentation.

The experimental analysis data is as below:

- For Crossflow turbine:-

S.No	Head	Discharge	Velocity	Power Theoretical(kW)	Power Actual	Efficiency
1	0.3	0.363916199	2.426107994	1.071005374	0.676	63.11826405
2	0.4	0.420214231	2.801428207	1.648920643	0.998	60.52444091
3	0.5	0.469813793	3.132091953	2.304436654	1.562	67.78229279
4	0.6	0.514655224	3.431034829	3.029260651	2.097	69.22481231
5	0.7	0.555891176	3.705941176	3.817304708	2.841	74.42423954
6	0.8	0.594272665	3.961817765	4.663851873	3.305	70.86417173
7	0.9	0.630321347	4.202142311	5.565107169	4.311	77.46481548
8	1	0.664417038	4.429446918	6.51793114	5.032	77.20241119
9	1.2	0.727832398	4.852215989	8.568042993	6.516	76.05003856
10	1.4	0.786148841	5.240992272	10.79696818	8.309	76.9567888
11	1.8	0.891408997	5.942726647	15.74050007	11.784	74.86420347
12	2	0.939627586	6.264183905	18.43549323	14.429	78.26750181
13	2.4	1.029310449	6.862069659	24.23408521	18.504	76.35526508
14	2.8	1.111782353	7.411882352	30.53843767	23.205	75.98620549
15	3.3	1.206973488	8.046489918	39.07335272	30.735	78.659746
16	3.7	1.27803169	8.520211265	46.38871624	37.021	79.80604552
17	4.5	1.409441379	9.396275858	62.21978966	49.144	78.98451645
18	5	1.485681662	9.904544412	72.87268551	58.432	80.18367869
19	7	1.757882249	11.71921499	120.713774	96.905	80.27667165
20	9	1.993251113	13.28834075	175.9841408	142.43	80.93342921

- For Kaplan Turbine:-

S.No.	Head	Discharge	Velocity	Power Theoretical (kW)	Power Actual	Efficiency
1	0.3	0.363916199	2.426107994	1.071005374	0.67	62.55804277
2	0.4	0.420214231	2.801428207	1.648920643	1.08	65.49739096
3	0.5	0.469813793	3.132091953	2.304436654	1.62	70.2991769
4	0.6	0.514655224	3.431034829	3.029260651	2.223	73.3842431
5	0.7	0.555891176	3.705941176	3.817304708	2.86	74.92197292
6	0.8	0.594272665	3.961817765	4.663851873	3.27	70.11371908
7	0.9	0.630321347	4.202142311	5.565107169	4.28	76.9077732
8	1	0.664417038	4.429446918	6.51793114	5.06	77.63199536
9	1.2	0.727832398	4.852215989	8.568042993	6.77	79.01454283
10	1.4	0.786148841	5.240992272	10.79696818	8.39	77.70699941
11	1.8	0.891408997	5.942726647	15.74050007	11.37	72.23404561

12	2	0.939627586	6.264183905	18.43549323	13.665	74.12332194
13	2.4	1.029310449	6.862069659	24.23408521	18.507	76.36764434
14	2.8	1.111782353	7.411882352	30.53843767	23.95	78.425754
15	3.3	1.206973488	8.046489918	39.07335272	30.298	77.54133672
16	3.7	1.27803169	8.520211265	46.38871624	38.367	82.7076132
17	4.5	1.409441379	9.396275858	62.21978966	51.286	82.42715104
18	5	1.485681662	9.904544412	72.87268551	60.293	82.73744762
19	7	1.757882249	11.71921499	120.713774	99.97	82.81573567
20	9	1.993251113	13.28834075	175.9841408	145.369	82.60346606

- For Francis Turbine:-

S.No.	Head	Discharge	Velocity	Power Theoretical (kW)	Power Actual	Efficiency
1	0.3	0.363916199	2.426107994	1.071005374	0.34	31.74587245
2	0.4	0.420214231	2.801428207	1.648920643	0.65	39.41972604
3	0.5	0.469813793	3.132091953	2.304436654	1.08	46.86611793
4	0.6	0.514655224	3.431034829	3.029260651	1.98	65.36248373
5	0.7	0.555891176	3.705941176	3.817304708	2.03	53.17888288
6	0.8	0.594272665	3.961817765	4.663851873	3.36	72.04345446
7	0.9	0.630321347	4.202142311	5.565107169	4.02	72.23580567
8	1	0.664417038	4.429446918	6.51793114	4.68	71.80192456
9	1.2	0.727832398	4.852215989	8.568042993	5.98	69.79423429
10	1.4	0.786148841	5.240992272	10.79696818	8.03	74.37273006
11	1.8	0.891408997	5.942726647	15.74050007	11.48	72.93287983
12	2	0.939627586	6.264183905	18.43549323	13.743	74.54641883
13	2.4	1.029310449	6.862069659	24.23408521	18.31	75.55473971
14	2.8	1.111782353	7.411882352	30.53843767	23.2	75.96983268
15	3.3	1.206973488	8.046489918	39.07335272	29.24	74.83360901
16	3.7	1.27803169	8.520211265	46.38871624	33.48	72.1727237
17	4.5	1.409441379	9.396275858	62.21978966	46.88	75.34580276
18	5	1.485681662	9.904544412	72.87268551	54.02	74.129284
19	7	1.757882249	11.71921499	120.713774	90.05	74.59794935
20	9	1.993251113	13.28834075	175.9841408	133.49	75.853426

The Experimental data obtained showed a particular case of flow and didn't replicate the actual case scenario of the Ganga River Basin due to its huge discharge capacity and vast variation of flow velocity. The obtained data still showed that the system even with a variation of 10%-30% was capable of having a certain generation potential with the current technological advancements in a Vortex flow. Experiments with different turbine setups and blades still have to be studied to get a proper idea of obtaining better efficiency and power output to support the need for electrical power in isolated rural areas with a decentralized approach towards power generation.

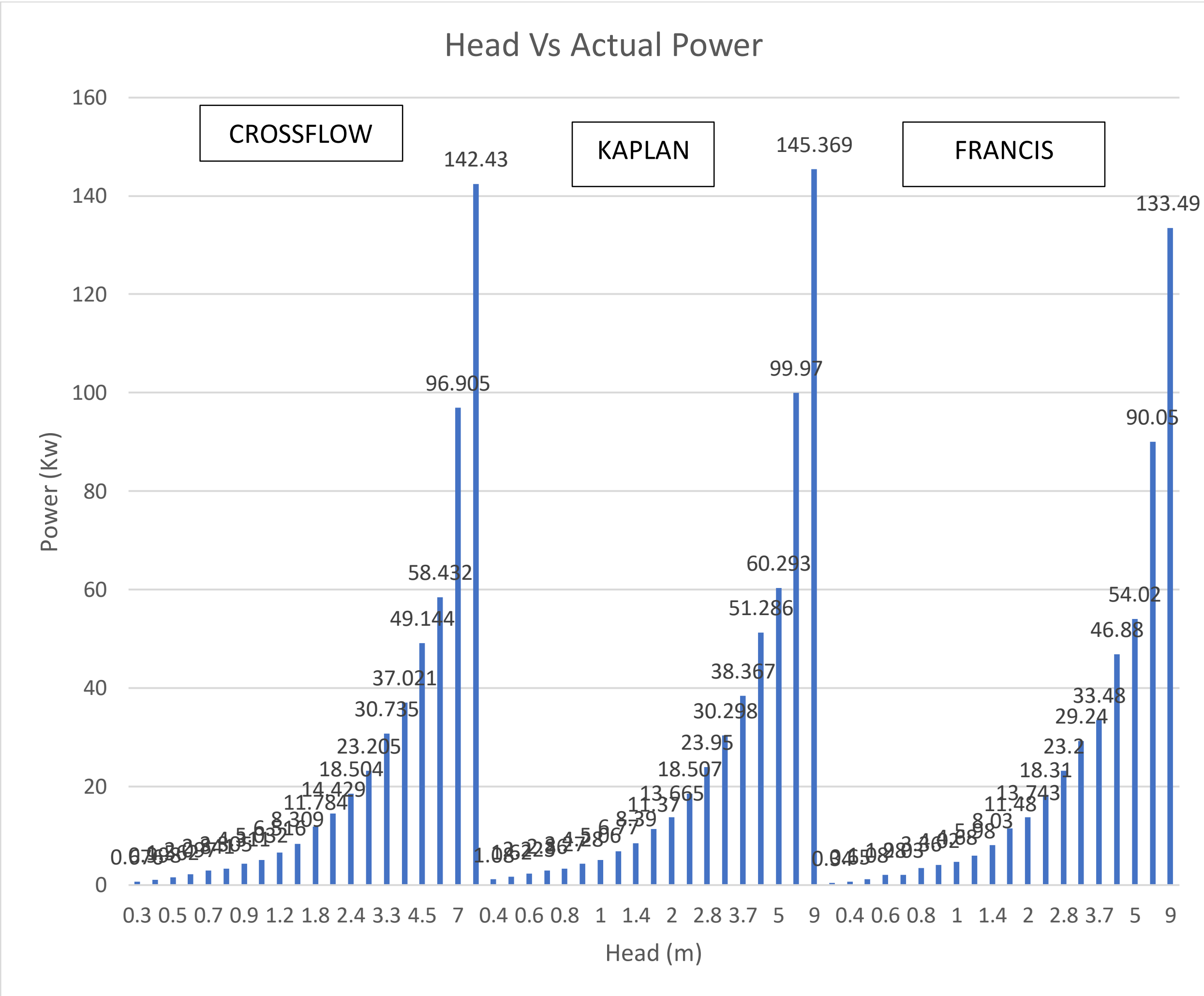
Result

The results involving the data from the experimental study revealed that between the head range of 0.3 to 3 meters cross-flow turbine showed the progressive result in electrical power output and was much economical for the installation of decentralized SSHP's at respective locations.

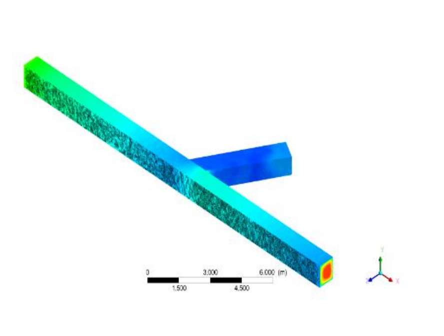
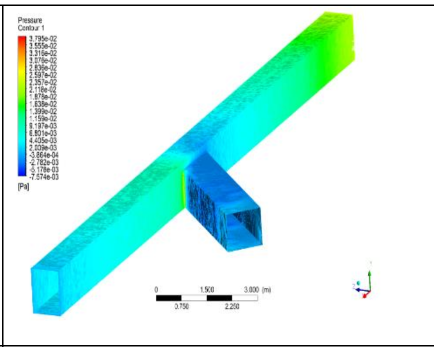
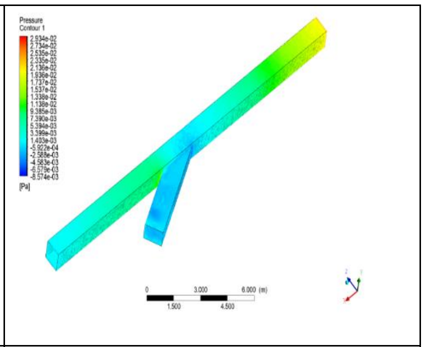
Also for the heads ranging from 3 to 9 meters Kaplan turbine showed a better rate of efficiency and economically was much more viable than Francis and crossflow turbine. This analysis is described based on the efficiency parameters of the turbines at a similar head.

Turbine Type	Head Range (m)
Cross Flow	0.3 to 3.30
Kaplan	3.31 to 9.0

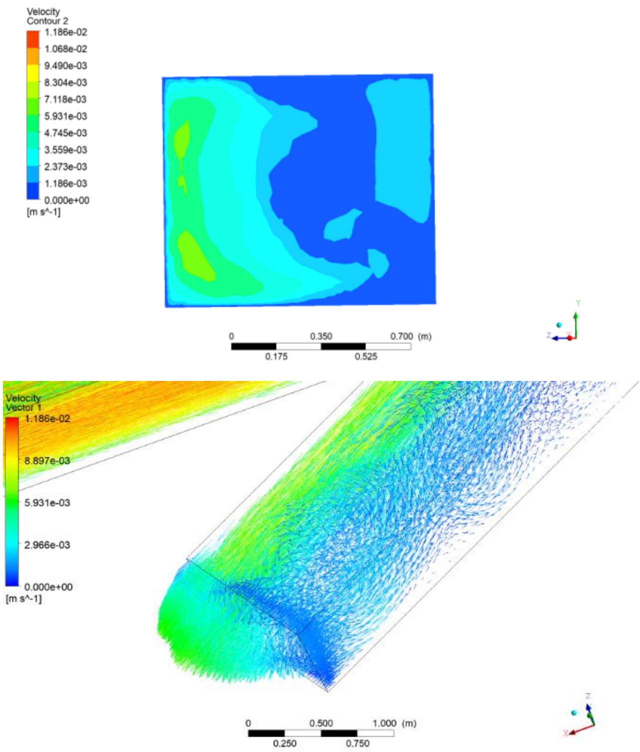
A graphical representation of the same is mentioned below showing a comparison of the available head to actual output power.



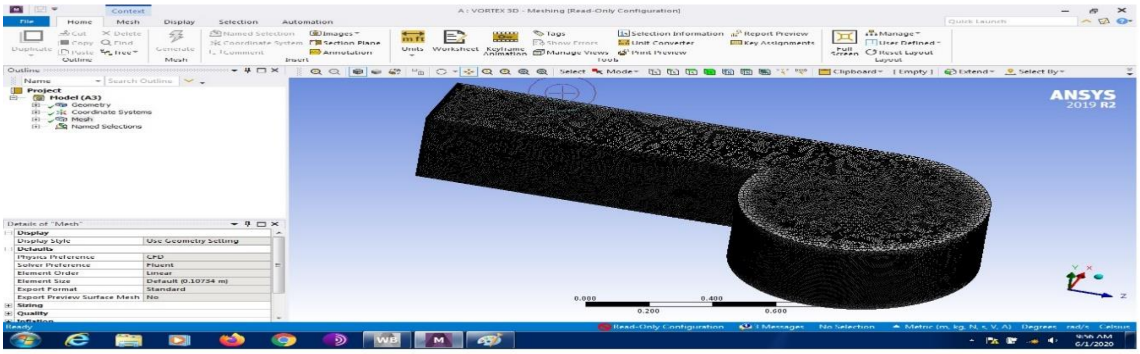
The results obtained from the study involves the variation of intake angles and streamline flow plotting to design the intake canal and vortex chamber accordingly to get maximum utilization of the stream velocity. The simulated result is depicted below with an explanation.

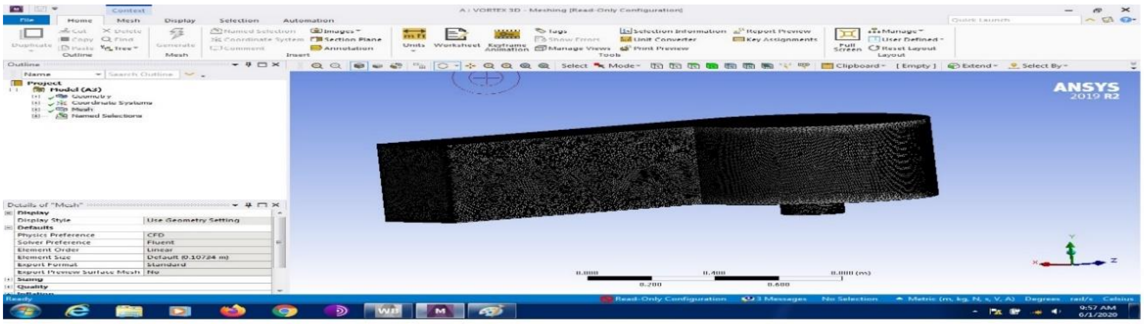
		
Canal Intake angle = 60^o	Canal Intake angle = 45^o	Canal Intake angle = 30^o

The canal intake angle having 30o inlet from the mainstream canal has maximum streamline flow traveling on the Right face of the Intake canal, resulting in the conceptual design of providing an inlet to the vortex chamber on the right side section. The graphical representation is mentioned below:



The above-mentioned figure represented that the majority of the flow line, contour, and the velocity vector has a concentration on the right face section of the intake canal. The design of the Vortex chamber was based upon the flow pattern result mentioned above. The below-depicted figure is of Vortex Chamber in which the turbine setup is to be installed.





The above ANSYS FLUENT simulation of the vortex chamber is depicted in the meshing stage for which future study could be done to observe vortex flow behavior.

The next stage after designing the whole setup is to geolocate potential sites and 4 sites were studied in this research for having potential head to generate hydro-electric power. The locations are mentioned below:-

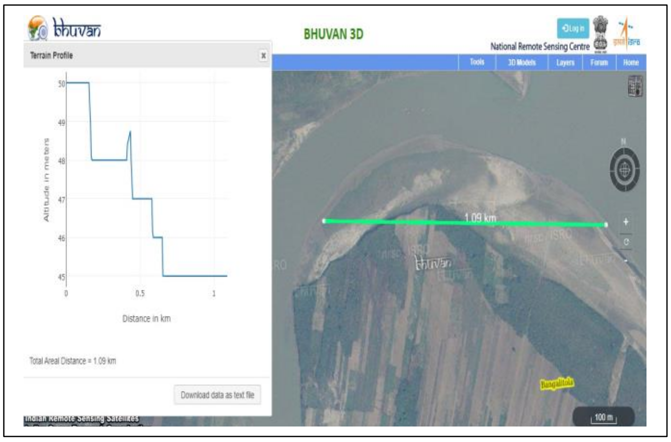
- LOCATION 1:

NAME	DIGHA BRIDGE
LAT & LONG	25.680092,85.114832
MAXIMUM ELEVATION	48m from MSL
MINIMUM ELEVATION	44m from MSL
LENGTH OF CANAL	1.17 Km

As per the available head and Experimental Data result the type of turbine adopted here will be KAPLAN TURBINE, with maximum power generation output of 50 KW at the max head of 4 meters.

- LOCATION 2:

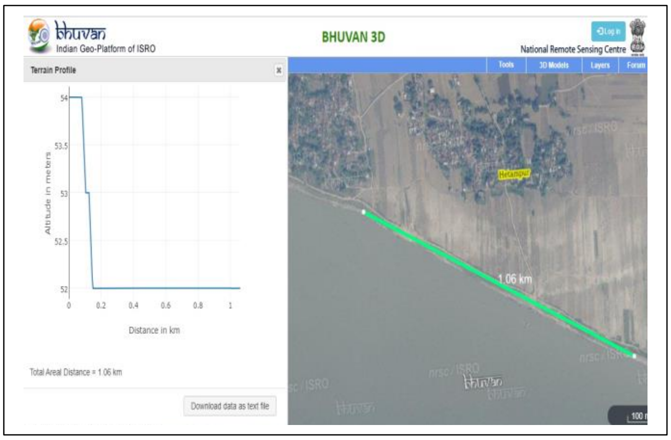
NAME	BANGALITOLA
LAT & LONG	25.526222,85.850145
MAXIMUM ELEVATION	50m from MSL
MINIMUM ELEVATION	45m from MSL
LENGTH OF CANAL	1.09 Km



As per the available head and Experimental Data result the type of turbine adopted here will be KAPLAN TURBINE, with maximum power generation output of 60.3 KW at the max head of 5 meters.

- LOCATION 3:

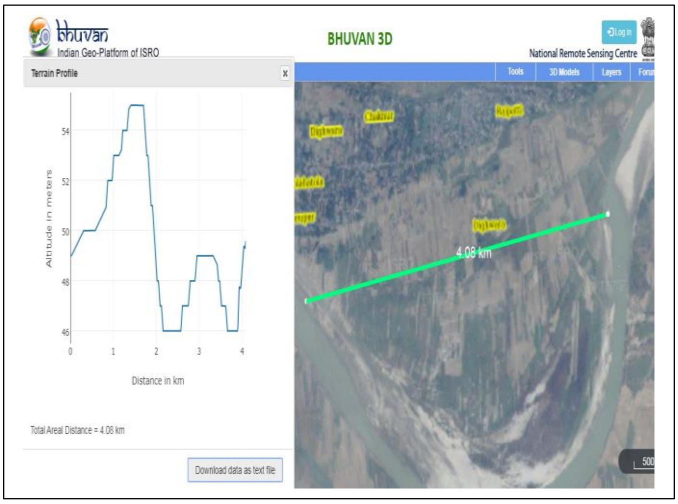
NAME	HETANPUR
LAT & LONG	25.678600,85.020990
MAXIMUM ELEVATION	54m from MSL
MINIMUM ELEVATION	52m from MSL
LENGTH OF CANAL	1.06 Km



As per the available head and Experimental Data result the type of turbine adopted here will be CROSSFLOW TURBINE, with maximum power generation output of 14.43 KW at the max head of 2 meters.

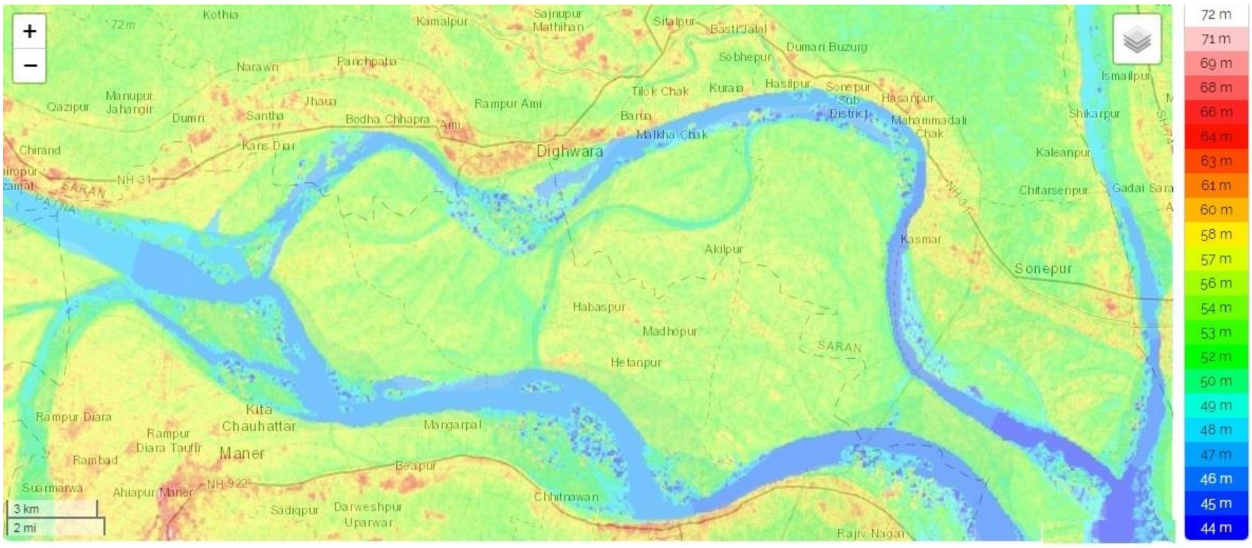
- LOCATION 4:

NAME	BATRAULI
LAT & LONG	25.733931, 84.995605
MAXIMUM ELEVATION	55 m from MSL
MINIMUM ELEVATION	46 m from MSL
LENGTH OF CANAL	4.08 Km



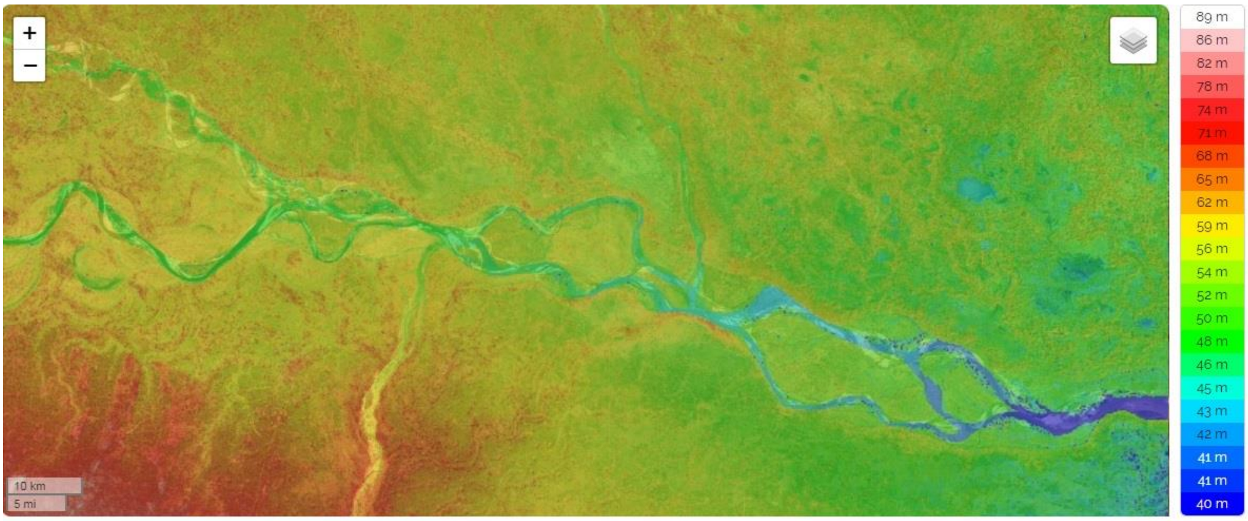
At location 4, the maximum available head is that of 9 meters, i.e. is the highest available head considered in this study for comparative analysis of low head turbines. The maximum power output here is 145.37 KW with a Kaplan turbine setup.

The above analysis for geotagging of potential location was a precedent result of the following delineation of the DEM of selected areas mentioned below:



Bihar, India (25.64408 85.90651)

Delineated topographical map of Bihar (DIGHWARA) of singular grid section



Bihar, India (25.64408 85.90651)

Delineated topographical map of Bihar (GANGA RIVER BASIN)

The above images represent the huge potential that GIS has in geo-locating regions of hydropower generating capabilities, which could further be analyzed to pinpoint regions having potential for electric power generation and local community for the consumption of the same.

Conclusion

The above study leads to the conclusion for the adoption of SSHP's system in isolated regions of the Ganga River basin which can produce a maximum power output of 145KW at the head of 9 meters and a minimum power output of 0.67 KW at the head of 0.3 meters. The study also gave significance for the use of a Crossflow turbine for extremely low head and low discharge flow and Kaplan turbine for heads ranging from 3 meters to 9 meters with medium discharge flow.

The analysis for Computational Flow Dynamics (CFD) in ANSYS FLUENT lead to designing the whole setup in such a way that the basic layout of the system can be understood for application of adopting SSHP in isolated regions. Furthermore, the study confined to a region lead to the result of locating multiple potential sites nearby residential zones that have hydropower generation capability.

Geographic Information System (GIS) based ISRO's BHUVAN portal had a direct application for the construction of DEM across the region to isolate the areas having potential for stream head which could be utilized for generating decentralized electric power with a singular grid network for the general utility of local residential populations.

With the continuous growth of technology and the digitally driven world, the consumption of electric power has increased significantly and this study has shown potential to meet with a certain section of the electric power need in the rural & isolated regions. With the development of the system mentioned in the above study, the reliability of people over a centralized network of electric grid will reduce to a certain limit and help in reducing the load a central electricity production units, leading to lesser consumption of coal and promoting sustainable development across different regions.

Data Availability

All data, models, and code generated or used during the study appear in the submitted article.

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