Desang River Flow Analysis for Micro Hydropower Potentiality Assessment

Tasaduk Ariful Hussain[#1]
[#] *Research Scholar, Department of Applied Geology, Dibrugarh University*
Dibrugarh – 786004, Assam, India

Abstract – *Desang is a perennial tributary of the River Brahmaputra in India. This tributary originates in the foothills of Arunachal Himalaya and confluences in the southern part of the River Brahmaputra. The Stage-Discharge Rating Curve has been prepared based on the Stage and Discharge information of the year 1995. This rating curve is used for discharge estimation based on stage data of 19 years, from the year 1994 to 2012. Equation of power regression is used, as it is the 'Best Fit' relationship, for this river to assess the Micro Hydropower harnessing potentialities. Desang is found to had have maximum annual discharge of around 7,547million cumec in the year 1995 and minimum annual discharge of around 3,977 million cumec in the year 2001. Based on the stage discharge rating curve, the daily discharge of 6,942 days is estimated before preparing discharge hydrographs. The flow duration curve is prepared for the stream along with assessing possible power generation potentialities at different head situations in the stream. The flow duration curve reveals that the Desang has enough discharge to produce more than 2.5 MW run-of-the-river electricity with 90% excedence at any geologically conducive point of 10 metres head.*

Keywords — *(Desang River, Micro Hydropower, Stage Discharge rating curve, Flow Duration Curve, Flow Head, North East India*

I. Introduction

The North Eastern States of India have hundreds of perennial streams passing through undulating topography, providing interesting heads at different positions; suitable for hydro-power generation and diversion based irrigation. However, attempts for harnessing such potentialities are extremely limited in the state of Assam. The emphasis on large scale hydro power generation and exploitation of shallow tube well (STW) based ground water utilization has overshadowed the small, mini and micro hydropower potentialities as well as diversion based irrigation potentialities. Utilization of small hydropower potentialities is less harmful for the ecology and environment, less risky in the face of manmade disasters and less prone to centralized exploitation of the 'power market'. However, it is also less profitable in terms of Return-on-Investment (ROI). It seems, only to have better return on investment and to make more economic benefit, the environment, the ecology, the human life and property are being compromised in the region by promoting mega hydropower projects here. In this paper, contrary to the regional trend, a small perennial stream called Desang River is studied to find out its potentialities to harness hydropower for the riparian communities for decentralized power production and multipurpose utilization of water resources for hydropower and diversion based irrigation.

II. The Desang River

Though the Water Resource Department, Govt. of Assam, has recorded the name of this river as 'Desang', the river is mentioned as 'Disang' in the Toposheet and also known as 'Dilli' in different points of its traverse. The office of the Executive Engineer, Jorhat Investigation Water Resource Division, Assam, India had been measuring the Gauge Discharge of Desang River by the current meter method in National Highway Crossing site situated in the coordinates $27^0$3'12"N -$94^0$40'42"E.

The Upper Assam Investigation Division, Jorhat of the Water Resource Department, Govt. of Assam had been collecting water level (stage) information of Desang River 3 times a day at 8.00 AM, 12.00 Noon and 4.00 PM every day since January 1994. The Reduce Level Zero of Gauge is set at 86.41 metre and the Gauge reading is taken above this in the metric system.

Daily mean water level is calculated and manually recorded in the field site by a designated Sectional Assistant and copied by Assistant Engineer or Junior Engineer responsible for the site before transferring the record to the Assistant Executive Engineer of Dibrugarh Investigation Sub-Division which is finally approved by the Executive Engineer of Upper Assam Investigation Division, Jorhat and archived in their Jorhat Office as hard copies without computerizing or cataloguing the information

III. The Discharge Information

The detail discharge information of the Desang River was recorded by the Water Resource Department, Govt. of Assam in the year 1995. Daily water level on site, cross section area in square metre and average velocity in metre per second had been recorded before calculating discharge in cubic metre per second (Cumecs) for every day. The highest cross section area was found to be 668.00 Sq.M. on 27th September 1995 and the lowest cross section was found to be 289.37 Sq. M. on 31st December 1995. The average cross section of the Desang River was estimated at 381.17 Sq. M. for the year 1995.

The maximum velocity of the Desang River was found to be 1.576 m/s which was recorded on the 17th of July 1995 and the minimum velocity of 0.168 m/s was recorded on 13th February 1995. The average velocity of the river was estimated at 0.524 m/s. It is to be noted that the highest cross section is in no way coinciding with the highest velocity and lowest cross section is also not coinciding with the lowest velocity. It infers that both the variables 'cross section' and 'velocity' are independent of each other.

The maximum discharge of 996.250 cumecs was recorded in the Desang River on 27th September 1995 and the minimum discharge of 48.59 cumecs was recorded on 13th February 1995. This information envisages that one coincides with the highest cross section and the other coincides with the lowest average velocity. The average daily discharge of the Desang River for the year 1995 was estimated at 239.323 cumecs.

"The Desang River is estimated to have more than 7 billion cubic metres (7,547,297,184 cubic metres) of annual discharge. This river has demonstrated a good deal of possibilities for micro hydropower and diversion based irrigation potentialities. The Average daily discharge of the river is estimated at 6,292,512 cubic meters with maximum daily discharge of 8,159,616 cubic metres and minimum daily discharge of 4,425,408 cubic meters. If a hydropower project is designed to meet the peak hour power requirement, the average daily storage during the non-peak period (10pm to5pm) of 17 Hrs could be 4,457,196 cubic meters with maximum daily storage of 5,779,728 cubic meters and minimum daily storage of 4,425,408 cubic meters. In this estimation 'minimum ecological flow' of the stream is not considered."[1]

IV. Stage Discharge Rating Curve

In an earlier work, the stage discharge rating curve was prepared for the Desang River based on the 365 days' information collected for the year 1995. Logarithmic Regression, Linear Regression, Exponential Regression and Power Regression tests were carried out in the scatter plot of the daily information of the year. All the models of regression had shown an R value above 0.8, establishing a strong correlation between the Stage and Discharge data. Statistically, any of the above regression was good enough for estimation of discharge based on the information of stage. It was found that the Power Regression had the highest 'goodness of fit' for any further experimentation and investigation. The relationship of Stage and Discharge in this

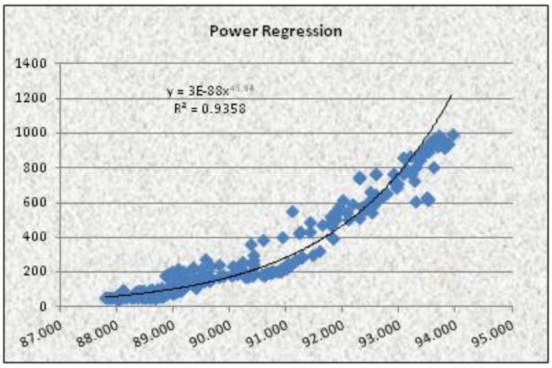

Fig 1 – Power Regression of Stage Discharge

regression was found to be $y = 3E\text{-}88x^{45.94}$, where x denotes stage and y denotes discharge. Based on this equation the discharge estimation of the other years was carried out till 2012 for further analysis and assessment.

V. Hydrographs of Desang River

Daily discharge estimation of Desang River was carried out for 6,942 days over a period of 19 years starting from 1994 to 2012. Total annual run-off of the river is calculated for each year before preparing the Annual Discharge Histogram. In the year 1995 and 1998 total Annual Run-off was found to be more

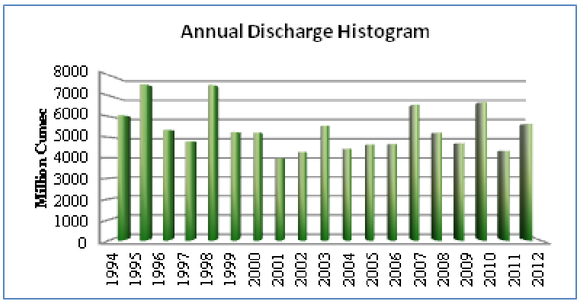

Fig 2 – Annual Discharge of Desang River

than 7 Billion Cubic Metre and in the year 2001 the annual discharge was estimated the lowest with a little less than 4 Billion Cubic Meter. The mean annual discharge of the Desang River is 5,387 Billion Cubic Metre. This huge volume of natural discharge of water had never been used for hydropower generation or for any large scale diversion based irrigation.

Analysis of the discharge information for the mentioned period reveals that the maximum

[1] Hussain, T.A., "Discharge Estimation of Desang River, Assam, for Micro Hydropower and Diversion Based Irrigation Project", Imperial Journal of Interdisciplinary Research (IJIR), Vol-3, Issue-10, 2017, ISSN: 2454-1362, http://www.onlinejournal.in

discharge of Desang River was recorded as 1,326 Cumecs on 11th September 2007 and the minimum discharge was recorded as 21.36 Cumecs on 1st March 2007. The mean discharge of the Desang River is found to be 170.65 Cumecs for the 19 years of discharge analysis. Within the study period, the maximum discharge of the River has crossed 1,000 Cumecs marks in 6 discrete years.

The discharge hydrograph of the Desang River is prepared based on the data available for the period

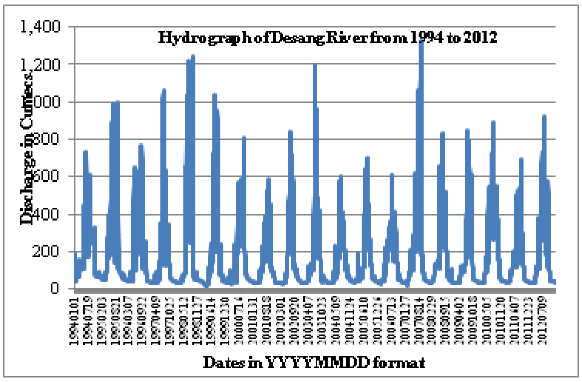

Fig 3 – Hydrograph of Desang River

and found to have a distinct seasonal pattern of annual peak and non-peak discharge. Roughly from July to September, the Desang recorded peak discharge and from November to March every year it has its lean discharge period.

Discharge hydrograph is the result of precipitation in the catchment area of a particular stream. Precipitation influences discharge in four ways. The most influential way is the surface runoff. "Surface run-off is by far the fastest route to the river. Therefore, drainage basin factors that encourage surface run-off and limit infiltration are likely to lead to a more 'peaky' hydrograph". Reduced forest and vegetative cover enhances the surface runoff phenomenally. The second most important way that the discharge of a stream is being influenced is the 'throughflow'. The rainwater falling in the vegetative cover takes substantial time to reach the surface. As a result these portions of the rain water undergo evapotranspiration and infiltration before reaching the stream. The lag-time, i.e. the time gap between the precipitation and discharge, is more in case of throughflow and is gradual in nature. Throughflow rarely creates a sharp peak in the discharge hydrograph but shows a gentle raising and falling of the hydrograph.

The third factor influencing the discharge hydrograph is the rainwater that percolates through the soil and rock to an extent to reach the ground water table. The lag time for this factor to influence the discharge is even more and can never create a sharp peak. However, this factor contributes to the increase of the baseflow of a stream for a substantial period. The fourth way that discharge of a river is being influenced by rainfall is the raindrops that falls in the stream itself. The volume of it is so nominal that it could be easily ignored for any hydrographical analysis.

Apart from these, many other geological factors including size, shape and steepness of slope, permeability of rocks, drainage density, basin shape, climate factor etc. also influence the impact of rainfall to the discharge regime of a stream.

VI. FLOW DURATION CURVE OF DESANG RIVER

Any hydropower project is designed based on the flow duration curve. This curve helps the hydropower project planner to understand the percentage exceedence of different magnitudes of discharge. The available information of 6,942 days' discharge is tabulated and ranked in decreasing order before plotting it in graph for drawing the smooth line that represents the flow duration curve of the Desang River.

In this Flow Duration Curve (FDC), any point indicates its percentage value that implies the flow rate of the stream is equal to or exceeds that value. As for example, 60% exceedence value is 58.318 Cumecs. It means that the discharge of the Desang River is equalled or exceeded 58.318 Cumecs for 60% of the time.

Discharge between 0% and 10% are considered high discharge rates, and 0% to 1% would be extreme flood events. It is important to assess these values and hydropower projects are designed to cope with such extreme discharges. The discharge exceedence value 10% to 90% could be considered as the 'medium' range of discharge and could be considered that the hydropower project would operate efficiently at this discharge. Discharge rates from 90% to 100% exceedence are in the 'low discharge' category when hydropower systems will just be operating at a low power output.

The Flow Duration Curve of Desang River records 36.140 Cumecs discharge at the 90% exceedence. Literally, it means that 90% of time Desang River has minimum 36.140 Cumecs of discharge. This is a reasonable discharge value for planning a hydropower project or diversion based irrigation project in this stream course.

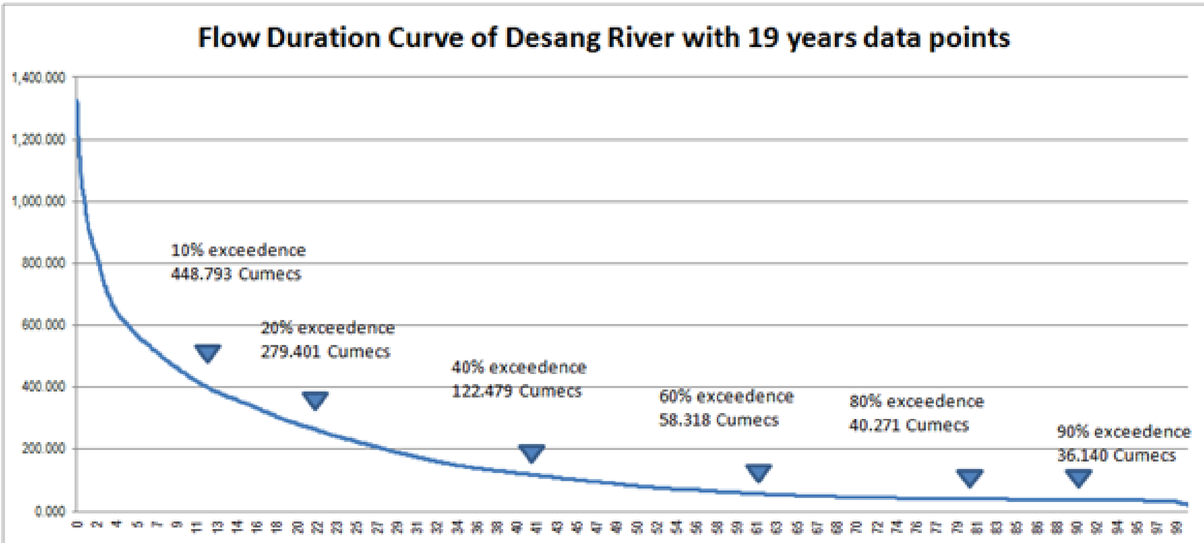

Fig 4– Flow Duration Curve (FDC) of Desang River with different percentage exceedence

VII. Hydropower Potentiality of Desang

Hydropower potentiality is all about dimension of flow and head of a stream in a specific location. Head is the difference in water levels between the intake point and the discharge point of a stream. It is the vertical height difference measured in metres. Hydropower potentialities of a plant are directly proportional to the head or the difference in vertical height.

More is the head in a particular location of discharge the water pressure is also more on that location. As a result the hydro turbine will have more impact in it and it will generate more power. Higher heads are beneficial not only for generating more power, but also can induce a higher flow rate through a smaller turbine. The cost of the turbine is dependent on its physical size. The higher-head turbines cost less than the lower-head one even if they might generate the same power.

I. Table

	Maximum Power Output (kW)				
	5	10	25	50	100
Head (m)	Flow required (m^3/sec)				
2	0.340	0.680	1.699	3.398	6.796
5	0.136	0.272	0.680	1.359	2.718
10	0.068	0.136	0.340	0.680	1.359
50	0.014	0.027	0.070	0.136	0.272
100	0.006	0.014	0.034	0.068	0.136

Renewables First, an UK based company has published a relationship of Head in Metre, Flow in Cumecs and Maximum Power Output in KW based on 14 years of experience in developing many hydropower projects across different parts of UK.

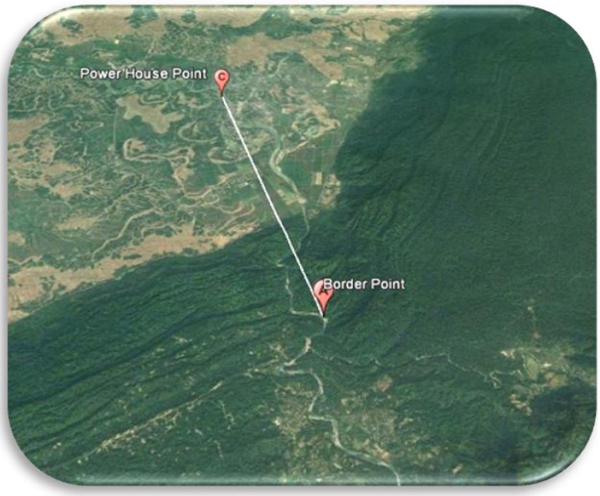

Fig 5 - Nagaland Border Intake Namrup discharge

The table developed by 'Renewables First' shows the average flow rates needed for a range of heads from 2 metres to 100 metres for systems with 100, 50, 25, 10 and 5 kW maximum power outputs. Generally, 25 kW of power is considered as the minimum for a commercially viable project, though a 10 kW system can still produce an acceptable return if the civil engineering works are simple and cost effective. The 5 kW systems are not normally viable, but the figures are shown for interest and may be useful for sites that can generate value from non-tangible benefits such as attracting tourists, using as demonstration site or for positive publicity.

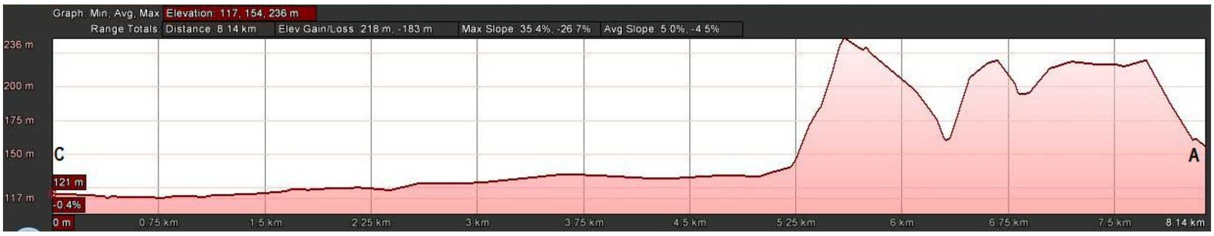

Fig 6 – Elevation Profile on AC Cross section

Based on this assessment, further estimations are carried out for the Desang River with 90% exceedence discharge condition. The elevation of Desang River in the Nagaland-Assam Boarder (27^{0}06’52.82”N, 95^{0}22’16.48”E) is recorded as 154 m and the elevation of Desang River near Namrup Town (27^{0}10’56.17”N, 95^{0}20’35.94”E) is 116 m where a power house could be set up easily. (Fig 5, Fig 6) The aerial distance between Nagaland-Assam Border (intake point) and Namrup Town (Discharge point) is 8.14 Km. Any hydropower project established in this location without any dam or reservoir will have a head of 38 m and 90% exceedence discharge of 36.140 cumecs would have a potentiality of 10.098 MW of power generation.

However, installation of ‘Intake’ point in the Nagaland-Assam Border might not be economically viable and physically accessible due to non-existing road connectivity and other logistic disadvantages.

Desang River in the foothills of Nagaland Hills (27^{0}08’29.07”N, 95^{0}21’59.06”E) could be another viable intake point where elevation of the River is 134 m (Fig. 7, Fig. 8). The combination of this intake point and near Namrup Town as discharge point could provide a Head of around 18 m. Any hydropower project established in this location without any dam or reservoir will have a head of 18 metre. Estimating power generation potentiality of Desang River with 90% exceedence discharge, i.e. 36.140 cumecs discharge at this combination of intake and power house, will have a potentiality of 4.783 MW of power generation.

The design of hydropower projects, in these locations, with storage to meet the peak load demands (from 5PM to 10PM) by the construction of dams in these locations might provide a different set of enhanced potentialities.

The analysis of 19 years’ information reveals that the minimum 1,307,439 cubic metre of water could be stored in the river by restricting discharge from 5PM to 10PM. The volume of storage could go up to 81,164,529 cubic metres. However, storage of only the minimum discharge is analysed to assess the possible enhancement in the peak hour discharge.

It is observed that around 72.63549 cumecs of additional discharge could be achieved with the help of such minimum storage. It might enhance the potentiality of power production from 10.098MW to 30.394 MW in the first location and from 4.783 MW to 14.397 MW in the second location.

VIII. CONCLUSION

The study of the Desang River with 19 years discharge data establishes that it is a perennial River

Fig 7 - Nagaland Border Intake Namrup discharge

with 36.140 cumecs discharge at 90% exceedence level. The river course has shown different head conditions before reaching the low elevation land. Two potential combinations of intake and power house were assessed and found to have 38 metre head in one combination and 18 metre head in another. The first combination has the potentiality of generating 10.098 MW power without any storage

Fig 8 – Elevation Profile on BC Cross section and the second combination has the potentiality of 4.783 MW of electrical energy without any storage. Further field level investigation and ground truthing might provide more options for establishing economically viable hydropower plants in this river. There are various geologically conducive locations in the river course for building reservoirs to meet the peak load demand and increase the head further.

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