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Research Article

Calculation of hydrological features for serving the exploitation and use of surface water of Dakbla Thuong hydropower plant

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Abstract: The construction of hydroelectric power plants to develop electricity sources is one of the critical factors of the economic development in Kon Tum Province. Investing in the construction of hydroelectric work contributes to the national electricity source. It also actively contributes to the local irrigation by providing water in the dry season and reducing floods in the wet season. Dak Bla Thuong hydropower plant is in line with the master plan of the Dak Bla river basin, and will optimally exploit energy for the planned river section without affecting neighboring systems in the Dak Po Co river system. Besides, it will contribute to adding a significant energy source to the national power system with a total installed capacity of 9.0 MW and an annual electricity output of about E_o = 31.85 million KW. This paper used a purely statistical method based on a series of hydrological data from 1977 to 2019 to calculate some hydrological features such as standard volumetric flow rate, the minimum monthly flow, the design of flood discharge maximum, etc to serve the licensing of exploitation and use of surface water, ensuring that the work implements well the task of generating electricity while ensuring the minimum flow to the downstream to diminish the risk which is caused by the operation process of electricity generation.

Keywords: Dakbla Thuong hydroelectricity; Exploitation and use of surface water; Hydrological features.

1. Introduction

According to the report of the World Hydropower Association (IHA) in 2018, the installed capacity of hydropower plants in the world has reached 1,267 GW (accounting for 20% of the world's electricity production). China is a rapidly developing country in the construction technology of hydroelectric dam, especially large hydroelectric dams. The Chinese government has implemented a series of hydropower management solutions such as, using the integrated Meta management approach for large hydropower projects; applying the principle of optimizing water resource allocation, planning in case of flood discharge...

Energy is a critical factor in developing countries for economic growth as well as for social development and human welfare. Hydropower is a renewable source of energy, which is economical, non–polluting and environmentally benign among all renewable sources of energy. For the efficient operation of hydropower plants, the hydro energy is stored either in reservoirs for dam based schemes or settling basins for run–of–river schemes. These reservoirs or settling basins are filled with sediments over a period of time. This problem must be taken care of by sediment settling systems in power plants. However, several unsettled sediment pass through the turbines every year and turbine parts are exposed to severe erosion. The erosion of hydro turbine components is a major problem for the efficient operation of hydropower plants. These problems are more commont in power stations which are of run–of–river types. The problem is exacerbated if the silt contains higher percentage of quartz, which is extremely hard [1].

According to the study [2], a wide range of literature streams and methods were examined for this research, including sustainability, integrated resource planning, and construction of portfolios of electricity generation technologies. The research then focused on current and emerging HPSTs (hydropower generation and storage technologies), and technical, economic, social, and environmental sustainability objectives associated with those technologies in the PNW (Pacific Northwest) region of the United States. Candidate technologies obtained from the literature were examined using the Delphi Method, and then rated according to their perceived impacts using the AHP (Analytical Hierarchy Process). GP (Goal Programming) was then used to determine an optimal mix of technologies to achieve sustainability objectives, and used these weightings and assumptions related to specific scenarios regarding technology development, adoption, and availability. This research is important because few previous studies have systematically considered multiple objectives and criteria from multiple stakeholder experts for creating portfolios of sustainable electricity generation. Previous research has also not comprehensively investigated the manner in which changing scenarios of technology development and availability rates may lead to various technological, economic, environmental, and social impacts with regard to planning of regional electrical generation and storage systems.

Nepal has 83,000 MW (megawatts) of exploitable hydropower resources. Yet the country has tapped less than 650 MW of this potential and hydroelectricity meets less than 1% of total national energy consumption, which is explained through the paper. Using a mixed methods approach consisting of semi–structured research interviews, site visits, and a literature review, it explores the various factors impeding the use of small–scale and medium–sized hydroelectric power stations in Nepal. It begins by laying out the research methods for the study along with a concept known as the social science systems approach, or socio–technical systems theory. This theory supposes that the barriers to any technology from reaching commercialization consists of values, attitudes, regulations, and price signals, as well as technical. The study then evaluates a “seamless web” of these types of barriers facing hydropower systems in Nepal. It concludes lessons for policymakers and scholars concerned about Nepal as well as energy policy more generally [3].

[4] shows that this study examines the climate change impacts on 132 US federal hydropower plants; A runoff–based approach is adopted to associate runoff and annual generation; A series of hydro–climatic models is used to project future runoff and generation; and seasonal runoff changes are projected in the future.

The need to improve Nigeria’s power generation has emphasized the importance of improving the country’s hydropower generation output [5]. However, the development of hydropower resources is currently being hampered by a hydrological data shortage due to large ungauged river channels. Data extension techniques with empirical rainfall–runoff models are used to overcome this challenge [6]. A recent study [7] developed a new hybrid biogeography–based optimization (BBO) technique to achieve a better capability to predict daily stream flow. The study referenced to [8] regression analysis to give excellent results in the data analysis and forecasting of hydrological runoff; the study referenced in [9] also used the regression tree ensemble approach to develop a model with good accuracy for runoff prediction. Ramana confirmed the adequacy of regression analysis for runoff prediction with the formulation of a model with three hydrological modules [10]. The methods of modeling surface runoff involve complex evaluation processes with many interconnecting variables [11] that are not available for most river basins in Nigeria.

[12] presents a model to carry out a short–term flow data extension for a minimum of 30 years using the Gauss–Newton Empirical Regression Algorithm (GNRA) for the

determination of the hydropower generation capacity of rivers in ungauged channels. An averaged 2 years of precipitation, observed experimental discharged data, and 30 years of historical and predictive precipitation data were used to generate a regression model equation after authentication analysis. A minimum, average, and maximum of 30 years of historical discharge data and power characteristics of the river were generated. A discharge predictive accuracy of 96.71% and a Pearson Correlation Coefficient of 0.954 were established between the experimental and model results. The river has minimum, average, and peak power potentials of 5 MW, 10 MW, and 20 MW, respectively, and is capable of yielding power throughout the year.

Cambodia is a country with a special network system and access to many countries. Cambodia has cooperated with surrounding countries to research and develop hydropower. Cambodia has cooperated with China to build the Sesan II hydropower plant, operating since November 2017 on the Sesan River – a tributary of the Mekong River in Northeastern Cambodia. Facing the current situation of massive hydropower development in the Mekong basin, the International Mekong River Association has implemented the project "Initiative Hydropower (ISH)" with the main tasks of: Strengthening communication and cooperation between member countries and stakeholders in hydropower development in river basin; build a knowledge base (data and information) about hydropower; provide technical assistance to the linkages of member countries and develop measures to enhance the sustainable of projects. In particular, the project provided a quick assessment tool of the hydropower company.

This is also one of the tools that Vietnam is using to appraise and evaluate the sustainable development of hydropower projects. In addition, a number of case studies assess the impact of renewable energy construction including hydropower on the socio–economic environment in France. Research has shown that the environmental impacts of hydropower projects vary widely, depending on site–specific mitigation measures and production strategies: if poorly managed, Hydropower production can reduce biodiversity and can significantly degrade alluvial ecosystems and related services [13].

From 2006 to now is an important development period in the exploitation of hydroelectric power of the country. The largest hydropower projects built and completed during this period are: Son La Hydropower (2400 MW), Lai Chau Hydropower (1200 MW) and Huoi Quang Hydropower (560 MW). Hydropower development began to deepen.

At present, the inter–reservoir operating reservoir for hydropower cascades has been established and signed by the Prime Minister to issue a decision for all river basins with hydropower ladders. As of 2018, a total of 80 large and new hydropower projects have been put into operation with a total installed capacity of 15,999 MW. It can be said that up to now, large hydropower projects with a capacity of over 100 MW have almost been fully exploited. Projects with favorable locations and low investment costs have also been implemented. Some hydropower plants are under construction and expansion and storage hydropower plants will be invested to match the structure of power sources in the national power system.

[14] has determined that the construction of Cam Thuy 1 hydropower plant does not affect the exploitation of Cam Luong fish stream tourism because there is no connection between the water of Cam Thuy 1 hydropower reservoir and the water level of Cam Luong fish spring in the year both the flood season and the dry season. [15] studied on "Research on calculating and regulating reservoirs to improve operation efficiency of A Vuong hydropower plant" with the following objectives: (1) Surveying and studying the current status of reservoir water use in order to provide operational solutions that can be applied and increase the efficiency of water use for power generation for A Vuong Hydropower Plant; (2) The solution to calculate the optimal operation of the reservoir water source, if successfully applied, will contribute to improving the environment, reducing the pressure of electricity shortage, thereby contributing to ensuring the country's energy security.

The study [16] has focused on giving two suitable operating options for daily regulating reservoirs. Therefore, the algorithm is built and applied to the Krong No 2 and 3 hydroelectric ladders on the Krong No river. Simulation results show that both lakes operate under the plan of operating at maximum capacity during peak hours, but when the flow is low, the amount of water from the lake is used to generate electricity until the water level is dead. Thus, in the next day, the water level of the lake may not reach the average lever before 9:30 a.m if the amount of water is small. This option will bring high efficiency to the ladder system than when considering independent lakes. [17] studied "Building algorithms and programs to calculate hydroelectricity, economic efficiency of stored hydroelectric power stations in Vietnam". This paper presents the initial research results on the possibility of building stored hydroelectric power plants in Vietnam, builds algorithms, writes programs to calculate hydroelectricity and analyzing energy economy of hydropower Tay Nguyen projects. The program has been piloted for Phu Yen Dong Hydroelectricity project, Son La province.

[18] studied on "Determined the parameters of small and medium hydropower stations regulating working days in flooded dam". The article used a combination of simulated hydrological calculations for the stairs, and at the same time considered the construction cost factor when other parameters changed, within the scope of the article, it was limited to only two small hydroelectric projects with day–regulating lakes. From there, the calculation is applied to the Thuong Son Tay project on the Dak Dring river in Quang Ngai province. The paper used computational methods to simulate hydroelectricity combined with economic analysis to select the optimal discharge channel bottom elevation and dead water level when these stations work in steps and ladders in flood dam. For downstream hydropower plants, when the upstream reservoirs participate in regulation, the dead water level can be raised to ensure the most efficient operation. For hydropower plants in the upstream where the working mode depends on the upstream water level of the downstream hydropower plant, the bottom elevation of the discharge channel cannot be selected according to the dead water level of the lower lake (when designing). but need to rely on the operating dead water level of the lake below. When being applied to Thuong Son Tay and Son Tay, it shows that the dead water level of Son Tay Lake is about 6 m higher than the dead water level during the engineering design process while the bottom elevation of the Thuong Son Tay hydropower discharge canal (189.5 m) is approximately equal to that of the Thuong Son Tay hydropower plant. Optimal dead water level.

The above studies have shown different approaches in the process of calculating hydrological characteristics such as discharge, water level, serving different stages before and after the plant construction and put into operation. However, new studies only focus on calculations for plant operation. On the basis of analysis of studies related to hydroelectricity and methods of calculating hydroelectricity for design and construction of hydropower projects. Thereby, the researches mostly calculate related issues such as calculation of lake regulation to improve operational efficiency or calculate to improve economic efficiency... These studies mainly focus on the calculation of hydropower to improve the operating efficiency of the hydropower plant. In other ways, the calculation is done at the stage after the plant has been put into operation. The calculation of hydroelectricity for the design at the pre–feasibility stage has not been mentioned much. In fact, the calculation of the initial hydrological characteristics is an indispensable step for the calculation and design of hydropower plants. Thus, the main purpose of the paper is to calculate hydroelectricity to determine the basic hydrological characteristics of flow, water column... and propose some solutions to minimize negative impacts on the environment when building DakBla Thuong hydropower plant.

2. Materials and Methods

2.1. Description of study site

Dak Bla Thuong hydropower plant is located in the territory of two communes Dak Ruong and Tan Lap in Kon Ray district, Kon Tum province. The construction of the Dak Bla Thuong hydropower plant aims to exploit the energy source on the Dak Bla River to generate electricity, contributes to increasing more power to the regional power netwok, and taking the initiative in power when a problem occurs with the national grid. Dak Bla Thuong hydropower work is a transverse dam–type hydroelectric work. River basin to dam route Dak Bla Thuong hydroelectric is located in the upper and middle areas of the Dak Bla river. The topography of the studied basin is a high mountainous area and the basin tends to tilt from North to South. The watershed of the West and Southwest basins (passing through the 1600–2066 m high mountains) is slightly higher than the East and the Northeast (passing the 1500–1800 m high mountains). The highest point of the basin is the Ngoc Linh Mountain at 2066 m, the lowest point in the dam route is the river bed with an elevation of about 585 m. Regarding hydrological measurement: In the DakBla river basin, there are two basic hydrological measurement stations, namely the Kon Tum hydrological station that fully monitors all factors (Q, X, flood extraction, Mud and sand) from 1977 to 2019 and Kon Plong station from 1994 to 2019. The measurement stations of related hydro–meteorological factors are listed in Table 1.

Table 1. Network of hydrometeorological stations related to the study area.

No.	Station	Measurement factors	Times	
			From	To
I		Meteorological Station		
1	Dak To	Rainfall	1977	2019
		Evaporation	1977	2019
		Average wind	1977	2019
		Wind max 8 directions, no direction	1977	2019
		Sunshine hours	1977	2019
		Humidity	1977	2019
		Temperature	1977	2019
2	Kon Tum	Rainfall	1977	2019
		Evaporation	1977	2019
		Average wind	1977	2019
		Wind max 8 directions, no direction	1977	2019
		Sunshine hours	1977	2019
		Humidity	1977	2019
		Temperature	1977	2019
3	Dak Glei	Rainfall	1977	2019
4	Tra My	Rainfall	1960	2019
5	Kham Duc	Rainfall	1978	2019
6	Po Re Me	Rainfall	1977	2019
7	Gia Vuc	Rainfall	1977	2019
8	Pleiku	Rainfall	1977	2019
9	Sa Thay	Rainfall	1982	2019
10	Son Ha	Rainfall	1977	2019
II		Hydrology stations		
1	Trung Nghia	Discharge, water level, alluvium	1978	1998
2	Dak Mot	Discharge, water level, alluvium	1994	2019
3	Kon Tum	Discharge, water level, alluvium	1960	2019
4	KonPlong	Discharge, water level	1994	2019
5	Dak To	Discharge, water level	1978	1978

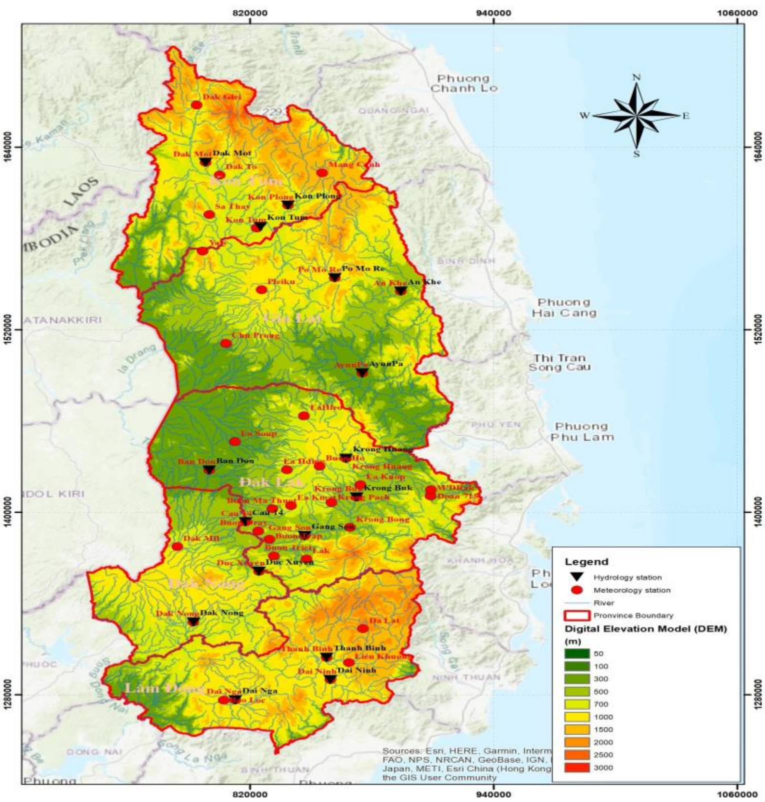

Figure 1. Network of hydrometeorological stations related to the works.

2.2. Flow regime to DakBla Thuong construction line

2.2.1. Average annual rainfall

Dak Bla River Basin belongs to a rainy area, the distribution of rain in the study basin is uneven, tends to increase gradually in the direction of southwest and northeast (increasing towards upstream), the average annual rainfall is the area fluctuates with a fairly large amplitude from 2800÷3800 mm in the northern region adjacent to Quang Nam province, while the average rainfall in Kon Tum–Trung Nghia valley is only about 1700÷1900 mm. A year is divided into 2 seasons, the rainy season from May to October and the dry season from November to April in which the rainfall in the rainy season accounts for 80÷90% of the annual rainfall. The number of rainy days in the year is about 160 days in the regions with heavy rainfall, about 110 days in small rain areas, and about 90% of rainy days fall in the months affected by the southwest and west monsoons.

- Determining the average rainfall in the basin for the hydrological station Kon Tum: Using rainfall data from Son Ha, Dak Glei, Dak To, KonPlong, Kon Tum, Gia Vuc, Pleiku, Po Mo Re, Sa Thay stations, calculated is $X_{0tvKonPlong}$ = 2487.1 mm.
- Determining the average rainfall in the basin for the basin between Dak Bla Thuong – Thuong Kon Tum: Using rainfall data from Dak To, KonPlong, Kon Tum, Gia Vuc, Po Mo Re stations, calculated is $X_{0\text{Dak Bla Thuong – TKT}}$ = 2417.0 mm.
- Using the maximum daily rainfall of 4 stations Kon Tum, KonPlong, Dak To and Dak Glei to calculate the rainfall causing floods for the construction route. Calculation results of rainfall causing floods according to design frequencies are shown in Table 2.

Table 2. Rainfall causes floods according to the frequency at the construction route (mm).

P%	0.1%	0.2%	0.5%	1%	1.5%	2%	5%	10%
X(mm)	456	417	364	325	302	286	234	196

2.2.2. Annual flow

a) Calculation method

The study basin includes the basin of the Thuong Kon Tum dam (374 km^2) and the part from the Thuong Kon Tum dam to the DakBla 2 dam (1098.5 km^2). Because the Upper Kon Tum reservoir was built with the task of transferring water to another basin, the problem of calculating annual flow is mainly related to the area (F = 1098.5 km^2).

To calculate the annual flow for the DakBla Thuong hydropower work, hydrological calculation methods are used for the basin, then the results are analyzed and compared to choose the appropriate method.

In hydrological calculations, the following methods are commonly used to calculate annual flows.

Method 1: Using the formula in the norm to determine the average annual discharge of the basin from daily rainfall, potential evaporation of the basin and research parameters on the morphology of each hydrological region, this method is usually used in case there is no hydrographic data in the basin. However, using this method means only the average annual discharge can be calculated (Q_0). The simulation of the daily and monthly average flow of the study route must be based on several hydrological stations in the vicinity of the study area.

Method 2: Using the same hydrological station (same or located on the same river system), this method when calculating will use correction factors such as area ratio, and rainfall rate to determine the Q_0. To determine the average daily and monthly discharge, it is possible to use the average daily and monthly discharge of the same catchment as zoomed in for the study route. This method has the disadvantage of the dependency on the quality and length of the same hydrological station.

Method 3: Using mathematical models such as NAM, TANK, etc the common feature of these models is to find a hydrological station with a moderate area, with a measurement time of about 7 years or more. Determine the average rainfall in that basin and the distribution of rain from a relatively typical rain station, suitable for the basin, then detect the coefficients included in the program to simulate the incoming flow of the hydrological station to suit reality (detecting the set of parameters). After completing the model's set of parameters, borrow the model's parameters to calculate the daily, monthly and yearly flow for the study basin. The characteristic of this method is that it can be applied to small watersheds (only one rain station is affected) and can extend the document to only the length of the rain monitoring document. However, the limitations of this method are: (i) the calculated coefficients for the hydrological station are not necessarily suitable for the study route without 3–5 years of testing with real measured data of the river the study area (program test) and (ii) it is not possible to adjust the diurnal flow in the dry season when there are long periods of no or negligible daily rainfall. This results in the dry season months; the average daily discharge is almost unchanged and is taken as a fixed value from the point of view of the programmer. With the above analysis and arguments, the study basin has an area of 1098.5 km^2; there are hydrological stations like KonPlong, Kon Tum also has a moderate area (approximately the study basin) and have long and continuous measurement documents, especially belonging to the system of hydrological stations managed by the State, so data ensures reliability for calculation. It is recommended to use method 2 only to calculate incoming flow for the route of the DakBla Thuong hydropower plant.

b) Determine the annual flow to the construction route from the same catchment method

The flow chain of the construction route is calculated from the KonPlong station according to the ratio of the area with the correction factor: K_F = 1.16 (1098.5/943). The flow sequence of the construction route is calculated from KonPlong station according to the ratio of the area with correction factor: K_F = 1.16 (1098.5/943) and calibration according to the average rainfall of the basin etween DakBla Thuong basin and KonPlong hydrological station with coefficient K_X = 2417.0/2487.1 = 0.97.

Discharge conversion calculation formula:

$$Q_{Work} = Q_{KonPlong} \times K_X \times K_F \quad (1)$$

Calculation results of hydrological features at specific construction routes as shown in Table 3.

Table 3. The hydrological features of the DakBla Thuong dam route by the same method.

Basin	F (km^2)	X_0 (mm)	α_0	Y_0 (mm)	W_0 (10^6m^3)	Q_0 (m^3/s)	M_0 (l/s.km^2)
Dakbla Thuong	1098.5	2417	0.603	1457	1601.4	50.8	46.2

Annual flow of the construction route taking into account the environmental flow discharged from the Thuong Kon Tum reservoir

According to the Decision No. 1182/QD–TTg dated July 17, 2014 of the Prime Minister on promulgating the process of inter–reservoir operation in the Se San River Basin [19], Thuong Kon Tum reservoir must discharge water continuously to the downstream of Dak Nghe river not less than 5.8 m^3/s for the months of February, March and April; not less than 3.3 m^3/s for the months of December, January, May and June. In other months, there are no specific regulations on the amount of water required to be discharged through the dam into the Dak Nghe River, but only on unscheduled requests of the People's Committee of Kon Tum province. Thus, the average discharge water volume (environmental flow) from Thuong Kon Tum reservoir for the whole year is addition to the DakBla Thuong hydropower plant as shown in Table 4.

Table 4. Discharge water volume from Thuong Kon Tum hydropower plant.

Months	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Average
$Q_{discharge}$ (m^3/s)	3.3	5.8	5.8	5.8	3.3	3.3	0.0	0.0	0.0	0.0	0.0	3.3	2.55

Consequently, the features of annual flow and design annual flow to the construction route should be taken into account, and the environmental flow entering from the Thuong Kon Tum reservoir are determined as in Tables 5 and 6.

Table 5. Hydrological features to the Dak Bla Thuong dam route.

Catchment	F (km^2)	X_0 (mm)	α_0	Y_0 (mm)	W_0 (10^6m^3)	Q_0 (m^3/s)	M_0 (l/s.km^2)
Dak Bla Thuong	1098.5	2417	0.633	1530	1681.8	53.3	48.5

Table 6. Annual flow rate corresponding to design frequencies.

Route	Statistical features			Flow for design frequency				
	Q_0	C_v	C_s	75%	80%	85%	90%	95%
DakBla Thuong	53.3	0.18	0.43	46.5	45.09	43.5	41.6	38.9

2.3. The discharge–frequency curve

This study used observed data to measure the average daily and monthly flow of the KonPlong hydrological station (1977–2019) according to the following steps:

+ Build flow retention curve average daily and monthly of KonPlong hydrological station;

+ Build flow retention curve average daily and monthly at DakBla Thuong route;

+ Calculate to convert flow retention curve average monthly of DakBla Thuong route become flow retention curve average daily of the route according to the ratio between the coordinates of the daily average flow and the monthly average of the KonLong hydrological station.

Coordinates of the daily discharge and probability curve and the daily discharge and probability curve in the wet season at the constructions as shown in Figures 2a–2b.

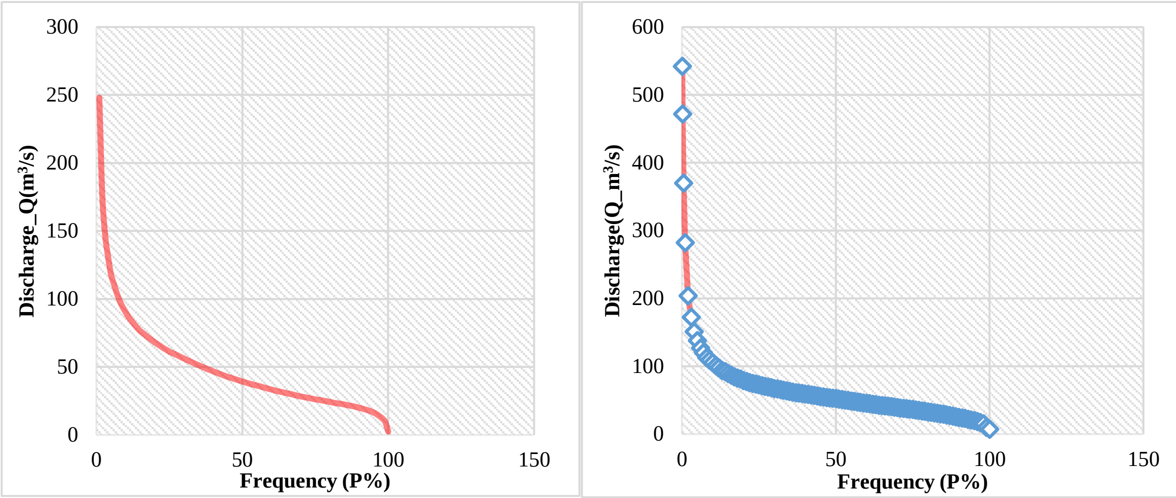

Figure 2. (a) The discharge–frequency curve daily; (b) The discharge–frequency curve wet season at the constructions.

3. Results and discussion

3.1. Design flood flow

To calculate the design flood peak flow for the Dak Bla Thuong construction route, two cases need to be considered: under natural conditions; and when there is Thuong Kon Tum reservoir in the upstream flood discharge.

3.1.1. Calculation of design flood peaks according to real documents measured according to natural conditions

From the actual flow data of the KonPlong station, the flood flows corresponding to the design frequencies can be calculated. The results of flood calculation from the KonPlong hydrological station are shown in Table 7.

Table 7. Floods by frequency at KonPlong and Kon Tum hydrological stations (m^3/s).

Flood frequency at KonPlong station (m^3/s)								
P%	0.1%	0.2%	0.5%	1%	1.5%	2%	5%	10%
Q(m^3/s)	7269	6369	5202	4342	3850	3507	2458	1728
Flood frequency at Kon Tum hydrological station from 1995 to present (m^3/s)								
P%	0.1%	0.2%	0.5%	1%	1.5%	2%	5%	10%
Q(m^3/s)	15876	13940	11425	9565	8500	7755	5470	3864
Calculation of design flood peak according to actual data of Kon Tum station (long series from 1977 to present)								
P%	0.1%	0.2%	0.5%	1%	1.5%	2%	5%	10%
Q(m^3/s)	8980	8049	6828	5913	5383	5009	3836	2974

3.1.2. Calculating the design flood peak at the construction route

Using the reduction formula to determine the design flood at the construction route

$$Q_{CT} = Q_{TP} \times (F_{CT}/F_{TP})^{1-n} \quad (2)$$

where Q_{CT} is the flow calculation for the construction; Q_{TP} is the flow calculation at the zoom station; F_{CT} is the basin area of calculation construction; F_{TP} is the basin area of zoom station; nis the reduction coefficient.

Calculated results of flood discharge for the construction route as shown in Table 8.

Table 8. The results of design flood at the construction route according to the reduction formula (m^3/s).

Design flood at the construction route according to the reduction formula from KonPlong station (m^3/s)								
Catchment	0.1%	0.2%	0.5%	1%	1.5%	2%	5%	10%
Dak Bla Thuong	8130	7124	5819	4856	4306	3922	2749	1932
Design flood at the construction route according to the reduction formula from Kon Tum station from 1995 to present (m^3/s)								
P%	0.1%	0.2%	0.5%	1%	1.5%	2%	5%	10%
Q(m^3/s)	7996	7021	5754	4818	4281	3906	2755	1946
Design flood at the construction route according to the reduction formula from Kon Tum station for a long period from 1977 to present (m^3/s)								
P%	0.1%	0.2%	0.5%	1%	1.5%	2%	5%	10%
Q(m^3/s)	4523	4054	3439	2978	2711	2523	1932	1498

Analyze and select the results: The design flood calculation results from KonPlong station and Kon Tum station in the same period (from 1995 to the present) are not much different. However, the results of flood calculation in 2 short and long periods from Kon Tum station are not much different. This calculation result is also consistent with the analysis results of rain causing floods between short and long periods of stations related to the study area. The results of the short–term design flood calculation does not fully reflect the flood situation of the study area. The Central Highlands region in general and Kon Tum province in particular usually do not have large floods (only the 2009 flood) has occurred. This flood is considered particularly large, which dramatically changes the flood regime in the Se-san River Basin.

3.1.3. Calculation of the design flood peak to the construction route in the condition of flood discharge from the Thuong Kon Tum hydropower plant

According to the National Technical Regulation of Irrigation Works – Major Design Regulations (QCVN 04–05: 2012/BNNPTNT): in the ladder operation diagram, if the grade of the reservoir work is under consideration investment is lower than the level of the work being exploited at the upper level, the design calculation must ensure that the flood discharge capacity of the lower level works is equal to the flood discharge volume (design flood flow and check flood flow) of the upper–level systems and the flood volume in the middle area according to the grade of the lower level works.

Dak Bla Thuong hydropower construction is located at the downstream of Thuong Kon Tum hydropower plant, so when this hydropower plant comes into operation, the flood flow to Dak Bla Thuong dam will be discharged from Thuong Kon Tum lake and midstream flood flow.

Therefore, this study used the design flood discharge already issued in the inter–reservoir operation process in the Sesan river basin with the design and check flood peak flow as follows:

- The peak flood flow corresponding to the design frequency is: $Q_{tk(0,1\%)} = 2172\ m^3/s$;
- The peak flood flow corresponding to the check frequency is: $Q_{kt(0,02\%)} = 3320\ m^3/s$,

The design and check flood process to the Thuong Kon Tum dam route and the area between Thuong Kon Tum–Dak Bla Thuong was calculated by the same frequency method according to the actual flood model measured at Kon Tum station. Through the study of many actual flood models of the Kon Tum hydrological station, it was determined that the 2009 flood was likely to cause the most adverse effects to the construction. The results of the calculation of the flood process to the Thuong Kon Tum dam line are shown in Figure 3, and the results of the calculation of the middle area flood processes of the Thuong Kon Tum – Dak Bla dam route are shown in Figure 4.

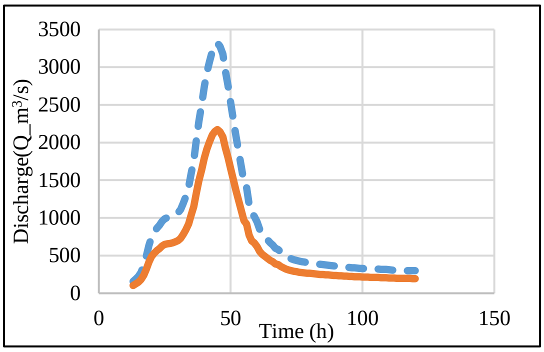

Figure 3. Design flood process according to frequency P = 0.02% (dashed line) and P = 0.1% (solid line) at Thuong Kon Tum dam route.

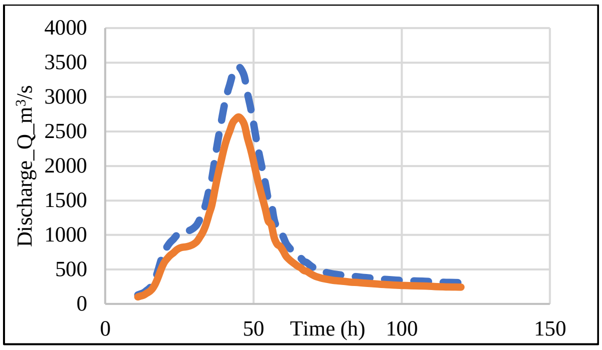

Figure 4. Design flood process according to frequency P = 0.5% (dashed line) and P = 1.5% (solid line) at Thuong Kon Tum dam route.

From the flood process curve to Thuong Kon Tum lake, considering the transmission flow time combined with the flood process curve in the middle zone, the flood process curve to the Dak Bla Thuong dam route can be determined. The results of the calculation of the check flood process to dam route is shown in Table 9 (Thuong Kon Tum check flood combination P = 0.02%; Middle area P = 0.5%) and Table 10 (Thuong Kon Tum design flood complex P = 0.1%; Middle area P = 1.5%).

Table 9. Design flood process by check frequency combination to Dak Bla Thuong dam.

T (hours)	Thuong Kon Tum	Middle area	Total	T (hours)	Thuong Kon Tum	Middle area	Total
1	0	97.2	97.2	61	1472	879	2350
2	0	95.6	95.6	62	1410	820	2231
….	….	….	….	….	….	….	….
59	1888	1059	2947	119	305	309	614
60	1691	978	2668	120	303	308	611
Max	3320	3439	6215				

Table 10. Design flood process by design frequency combination to Dak Bla Thuong Dam.

T (hours)	Thuong Kon Tum	Middle area	Total	T (hours)	Thuong Kon Tum	Middle area	Total
1	0	76.6	76.6	61	963	693	1656
2	0	75.4	75.4	62	922	647	1569
….	….	….	….	….	….	….	….
59	1235	835	2070	119	199	244	443
60	1106	771	1877	120	198	243	441
Max	2172	2711	4507				

3.2. Determine the minimum flow downstream of the work

In order to limit the impact due to the decrease in flow after the downstream of the hydroelectric dam and after the plant, the Law on Water Resources No. 17/2012/QH13 was approved by the National Assembly of the Socialist Republic of Vietnam on June 21. /2012 [20] and Decree No. 201/2013/ND–CP dated November 27, 2013 of the Government detailing the implementation of a number of articles of the Law on Water Resources stipulated, DakBa Thuong hydropower works must be discharged downstream to maintain the minimum flow.

The minimum flow that needs to be maintained downstream of the work is analyzed and determined on the basis of an assessment of the current situation of water sources, the demand for water use and consideration of the possibility of flow fluctuations downstream of the work. At the same time, the selection of the minimum discharge volume should be consistent with the actual conditions, harmonizing the exploitation of resources for socio–economic development, environmental protection and investment efficiency of the work.

The determination of the location and minimum flow value is carried out according to the guidance in Circular No. 64/2017/TT–BTNMT dated December 22, 2017 of the Ministry of Natural Resources and Environment [10] regulating the determination of minimum flow on rivers, streams and downstream of reservoirs and dams. According to the provisions of Article 6, Circular No. 64/2017/TT–BTNMT, the location to determine the flow ensures downstream of the DakBa Thuong hydropower work is right after the dam.

Analysis of the basis for choosing the minimum flow value to maintain the Dakla Thuong hydropower work: In order to have a basis for determining the minimum flow that needs to be maintained downstream, it is necessary to know the information about the current status nature, flow regime, ecosystem characteristics, as well as demand for water use in DakBla river downstream of DakBla Thuong hydropower work.

- About the current status and demand for water exploitation and use on both sides of the DakBla river from the downstream of the DakBla Thuong dam to the DakBla 1 hydropower work.

+ About water demand for domestic and agriculture: the area from downstream of the DakBla Thuong dam to DakBla 1 hydroelectric work has a terrain of rocky mountains, the vegetation here is mainly shrubs and do not have economic value, poor ecosystem, sparse population. Currently, in the planning, there are in no exploitation works and water used on the main river Ma for domestic and industrial purposes and the water source for people's daily life is not taken directly from the DakBla river but is supplied by from rain and water from small creeks.

+ On the section of DakBla river in the downstream area of DakBla Thuong hydropower work, there are no aquaculture and water transportation activities;

+ The aquatic ecosystem is poor, there are no rare and valuable aquatic species, only a few fish species of low economic value live.

- Regarding the regulation of the minimum flow value according to Circular 64/2017/TT–BTNMT dated December 22, 2017, of the Ministry of Natural Resources and Environment [21]: According to Clause 2, Article 4 of Circular 64/2017/TT–BTNMT (stipulating objectives, requirements and bases for determining minimum flow) "Minimum flow in rivers, streams and downstream of reservoirs is determined must be in the range from the minimum monthly discharge to the average discharge of the smallest 3 months (m^3/s)".

From the series of monthly average flow data to the DakBla Thuong hydropower dam route, the flow characteristics are determined:

+ Minimum monthly flow: $Q_{month\ min}$= 5.29 m^3/s (III/2016);

+ Minimum 3–month average flow: $Q_{averge\ 3\ tháng\ min}$ = 6.83 m^3/s;

According to the Circular, the minimum flow value can be determined within the range of:

$Q_{month\ min}$= 5.29 m^3/s $\leq Q_{minimum} \leq Q_{average\ 3–month\ min}$ = 6.83 m^3/s

- Recommendation: As analyzed above, there is no need to exploit and use water from the DakBla river downstream. Demand for water for drinking and domestic, people often use water from small streams. Therefore, the purpose of maintaining a minimum flow downstream of the dam is to ensure the continuity of the flow, the environment of the stream and the normal development of the aquatic ecosystem. However, in order to match the capacity of the water source to the lake and harmonize the benefits of power generation and other benefits, it is recommended to maintain the minimum flow after the DakBla Thuong dam equal to 50% of the minimum monthly flow value. Therefore, the minimum flow value is: Q_{tt} = 2.65 m^3/s.

3.3. Calculation of sediment flow to the construction route

The determination of suspended sediment with Dak Bla Thuong route in this period is based on the suspended turbidity at Kon Tum and Kon Plong stations: $\rho_o = 145$ (g/m^3),

The amount of suspended sediment to the dam is calculated by the formula: $M_1 = \rho_0 \times Q_0 \times T$

With the density of suspended sediment taken as 1,182 tons/ m^3, the annual volume of suspended sediment to the construction route is: $W_1 = M_1/1{,}182$.

The content of bottom sediment transport in the lake is taken empirically by 40% of the suspended sediment volume, with the density of bottom sediment transport taken as 1,554 tons/m^3 of the bottom sediment transport capacity is determined: $W_2 = M_1 \times 40\% /1{,}554$.

The deposition capacity of the work: $W = W_1 + W_2$

The annual volume of sediment deposited to the work route is shown in the following Table 11.

Table 11. Annual amount of sediment to the dam site.

Factors	Unit	Dam route
Average annual flow	m^3/s	51.6
Suspended sediment content	kg	0.145
Annual volume of suspended sediment to the dam route	tons	235952
The density of suspended sediment	tons/m^3	1,182
Mass of bottom sediment transport (40% suspended)	tons	94381
The density of bottom sediment transport	tons/m^3	1,554
The volume of sediment suspended	10^{3}m^3	199,621
The volume of bottom sediment transport	10^{3}m^3	60,734
The total volume of sediment to the lake annually	10^{3}m^3	260,355

3.4. Flow–water level relationship downstream of the dam route

Calculation results of the flow, and water level downstream of the factory route are shown in Table 12.

Table 12. Z~Q relationship downstream of the factory route.

Z (m)	**0**	**19.65**	**118.70**	**331.75**	**626.30**	**586.20**	**586.70**	**587.20**	**587.70**
Q (m^3/s)	583.50	584.54	584.70	585.20	585.70	992.36	1425.47	1920.9	2472.0
Z (m)	588.20	588.70	589.20	589.70	590.20	590.70	591.20	591.70	592.20
Q (m^3/s)	3084.6	3689.4	4352.0	5113.7	6013.9	6968.3	7875.1	8828.2	9790.9

3.5. The impact assessment of the work on the environment–society

3.5.1. Migration and resettlement work

The investor commits to the households that are obligated to the arable land of the households to be compensated in cash at the price prescribed by the State. Because there are no households in the lake bed and the work area, there is no resettlement. On the basis of actual survey measurements with the witness of households, commune authorities, measurement data and self–declaration of damage and collecting opinions of households on compensation for damage when the State recovers land for construction, the investor will coordinate with the district's compensation and site clearance board to implement.

3.5.2. Impact of the construction on the environment and mitigation measures

Treatment of domestic and production waste: Domestic waste is generated mainly from workers' housing quarters. To treat this amount of waste, it is necessary to build landfills in the work area. The locations of these dumps need to be located outside the lake bed and flood–affected areas to avoid becoming a source of pollution after the reservoir is formed. Solutions for collection and treatment of domestic wastewater: workers' quarters need to have a standard domestic waste collection and treatment system before discharging into rivers and streams. For toilet areas, septic tanks should be used to settle solid waste before discharging water into the treatment system.

Solution for material storage yards: One of the main causes of increasing turbidity in river water is rainwater washing away the concentrated soil in the storage yard. To reduce turbidity from this source, it is possible to apply the method of digging ditches to gather around the landfill to collect rainwater that overflows on the surface of the landfill, and then settle it before discharging into the river.

Measures to reduce air pollution: To reduce air pollution around the construction site, the following measures should be applied: all vehicles transporting construction materials must be covered when shipping; apply moisture spray during the levelling process in the time of strong sunshine and wind; spraying water on roads near residential areas where motorbikes often pass through, spray cycle at least once a day; there is a suitable vehicle regulation mode to avoid increasing the vehicle density too high; levelling of materials right after pouring into the dump and spraying with moisture to reduce dust diffusion due to the effect of wind; equip hats for workers operating machines that cause loud noise.

Ecological protection measures: Educating people and workers to build awareness of ecological protection. In order to minimize the adverse impacts of project construction on wildlife, some additional measures should be applied: manage construction workers, completely ban hunting wild animals and indiscriminate deforestation; Regulations for contractors to standardize machines used in construction to ensure that they do not cause noise as well as discharge dust and smoke in excess of the permitted standards of Vietnam; Search and organize mines for mining construction materials far from the less affected forests in the area.

Measures to protect the health of workers and people in the project area: Build a water treatment station to provide clean water for workers; Build at least 1 medical station (separately for construction workers) in the area; Training and guidance for workers on occupational safety measures and common disease prevention.

Measures to minimize negative impacts during water storage and reservoir operation

Clearing the reservoir: To minimize the pollution of reservoir water, it is necessary to clean up the lake bed before blocking the flow.

Plants and trees in the lake bed need to be cleaned and cut down. The rest of the plant should not be more than 50 cm tall. The cut stems and branches are used as fuel, and the leaves are spread evenly on the ground. For existing toilets and barns in the area to be demolished, it is recommended to fill them with clean soil before filling the lake with water.

To clean up the lake, according to the above standards, the investor can apply some solutions commonly used in other reservoirs such as: financial support for households to clean up their own gardens and residences before moving out of the lakebed area. This is a practical measure because people also want to take advantage of the trunks and branches to make wood and firewood. Contract with local authorities (such as Forest Protection Department, Forest Enterprises, etc.) to clean up on public land.

4. Conclusion

The paper research overviews about the construction area and study problems related to the calculation of hydrological characteristics for the DakBla Thuong hydropower. The paper also calculates of some hydrological characteristics such as: average annual flow rate, peak flow corresponding to the design flood, check flood... and especially the determination of the minimum flow value to discharge after the DakBla Thuong hydropower is one of the important bases for considering the operation, exploitation and use of surface water on the

DakBla river in the area of construction of the work route. In addition, the paper assessed the impact of hydropower projects to the environment, economic and society in the vicinity or the project and proposed mitigation solutions. However, the study has not evaluated the hydro–hydraulic interaction of hydropower project in the system river. This will be content that needs to be studied in the next paper.

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