Use of Artificial Intelligence for Modeling the Flows of the Kalamu River and the Congo River at Boma for Energy Security

[Utilisation de l'intelligence artificielle pour la modélisation des débits du fleuve Kalamu et du fleuve Congo à Boma pour la sécurité énergétique]

André Nzita Mampuya[1,2*], Clément Umba-di-Mbudi N'zau[2,3], Joséphine Kankolongo Ntumba[3] & Guyh Ngoma Dituba[4]

[1]*Regional School of Water (ERE), University of Kinshasa (UNIKIN), Kinshasa, Democratic Republic of the Congo*
[2]*President Joseph Kasa-Vubu University, Faculty of Engineering, Boma, Democratic Republic of the Congo*
[3]*University of Kinshasa, Faculty of science and technology, Kinshasa, Democratic Republic of the Congo*
[4]*University of Quebec in Abitibi-Temiscamingue, School of Engineering, Rouyn-Noranda, Canada*

Résumé

L'évaluation des ressources en eau est cruciale face aux défis croissants en matière de sécurité énergétique et environnementale. Cette étude porte sur la faisabilité de l'installation d'un système hydroélectrique de pompage-turbinage à Boma, en République démocratique du Congo, en réponse aux fréquentes coupures de courant. L'objectif est notamment de modéliser les débits de la rivière Kalamu et Congo afin de déterminer la viabilité du projet. Pour ce faire, les données historiques sur les niveaux d'eau des fleuves, recueillies entre 1960 et 2017, ainsi que les données de précipitations et d'évaporation recueillies entre 1992 et 2023, ont été analysées, compte tenu du manque de données sur les débits du fleuve Kalamu, à l'aide de méthodes d'intelligence artificielle, notamment l'approche Random Forest. Les résultats montrent d'importantes fluctuations des débits, avec des périodes de sécheresse prolongée affectant la disponibilité en eau pour le projet. L'étude met en évidence d'importants défis liés à la gestion des ressources en eau, notamment la variabilité des débits, qui pourrait compromettre l'efficacité du système proposé. Il est recommandé de considérer les débits du fleuve Congo comme une alternative viable, tout en intégrant des stratégies de gestion durable des ressources en eau pour répondre aux besoins locaux.

Mots-clés : Intelligence artificielle, Modélisation des débits, Forêt aléatoire, Sécurité énergétique, Gestion des ressources en eau.

Abstract

Water resource assessment is crucial in the face of growing energy and environmental security challenges. This study focuses on the feasibility of installing a pumped-storage hydroelectric system in Boma, Democratic Republic of Congo, in response to frequent power outages. Objectives include modeling the river of the Kalamu and Congo Rivers to determine the project's viability. To do this, historical data on river levels, collected between 1960 and 2017, as well as precipitation and evaporation data collected between 1992 and 2023, were analyzed, taking into account the lack of flow data on the Kalamu River, using artificial intelligence methods, including the Random Forest approach. The results show significant fluctuations in flow rates, with periods of prolonged drought affecting water availability for the project. The study highlights significant challenges related to water resource management, including flow variability, which may compromise the effectiveness of the proposed system. It is recommended that Congo River flows be considered as a viable alternative while integrating sustainable water resource management strategies to meet local needs.

Keywords: Artificial intelligence, Flow modeling, Random Forest, Energy security, Water resource management.

1. Introduction

This study focuses on evaluating the feasibility of installing a pumped-storage hydroelectric energy system in the town of Boma, Democratic Republic of Congo (DRC). This project is motivated by frequent power outages by the National Electricity Company (SNEL), which increase residents' dependence on charcoal. This fuel is used not only for cooking but also for other domestic needs, including combustion in ovens (Al Hasibi, 2010; Mpanzu et al., 2018; Mbuangi & N'toto, 2021). Boma's precarious energy situation calls for sustainable solutions to meet the population's growing needs while reducing pressure on local forest resources.

The town of Boma is crossed by the Kalamu River, a tributary of the Congo River. Historically, the flow of this river has shown significant fluctuations, with periods of dryness observed since 1904, according to data provided by Regideso, the national water supply company's station of Boma. This lack of flow regularity poses challenges for water resource management, making it difficult to plan water infrastructure projects. Moreover, although data on Congo River water levels, as well as precipitation and evaporation, have been available for over 30 years, the lack of data on the Kalamu River's flow complicates analysis of the current hydrological situation. Previous research has shown that interannual flow variability can be influenced by artificial hydrological regimes, highlighting the importance of accurate modeling to anticipate these fluctuations. For example, Assani (2004) compared flow variability as a function of hydrological regimes, while Ioan et al. (2020) proposed improvements in hydraulic system management through backpedaling techniques in hydropower facilities. Several relevant studies have also been conducted. Pierrefeu et al. (2022) developed an innovative hybrid approach to measuring flow in hydropower pipelines, which can provide useful insights for flow management in Boma. Furthermore, Ago et al. (2005) conducted a flood analysis downstream of the Nangbeto Dam on the Mono River, highlighting the challenges facing hydraulic infrastructure under varying climatic conditions. Kayser et al. (2019) explored the synergies between hydropower generation and flood protection, which is relevant to the Boma context, where such considerations are essential for project sustainability.

Gnassou (2019) also discussed the challenges of renewable energy in the DRC, highlighting the need for a thorough water resources assessment. Finally, Laraque et al. (2022) study of the Congo River rating curves provides a solid foundation for understanding hydrological dynamics in the region.

The objectives of this research include modeling the flow of the Congo River and simulating the flow of the Kalamu River. We will use artificial intelligence methods, notably the Random Forest approach, which allows for advanced modeling of the relationships between monthly flow, precipitation, and evaporation. This methodology aims to provide reliable and usable results for sustainable water resource management, taking into account the specific climatic and hydrological characteristics of the Boma region. To achieve these objectives, we collected data on river flow, precipitation, and monthly evaporation from 1992 to 2023, as well as on the water level of the Congo River from 1960 to 2017. Using the Python Anaconda software, we will implement machine learning techniques to model and simulate the flow of the Kalamu River. This approach will not only allow for a better understanding of the hydrological dynamics of the region but also assess the possibility of installing a pumped energy storage system, highlighting the challenges and opportunities associated with this project (Kose & Kaya, 2018; Alturki & Awwad, 2021; Blakers et al., 2021).

2. Materials and Methods

2.1. Presentation of the study environment

The study was carried out in the town of Boma, as well as in the Kalamu River watershed, at the Kalamu Dam (latitude: -5.81° S, longitude: 13.08° E, altitude: 100 m), as shown in figure 1. This site is characterized by cascading waterfalls. The town of Boma is home to one of the oldest services of the Water Authority of the Democratic Republic of Congo, established in 1903, that is, 122 years ago. The intake station on the Kalamu River is located in the Kalamu Dam, also built in 1903, and has a capacity of 67 m³/h (Regideso, 1992). Before flowing into the Congo River near the port of Boma, the Kalamu River flows through three communes of the town: Kabondo, Nzadi, and Kalamu (Vuni et al., 2020). The Kalamu River watershed covers an area of 68.84 km² and has a perimeter of 44.36 km.

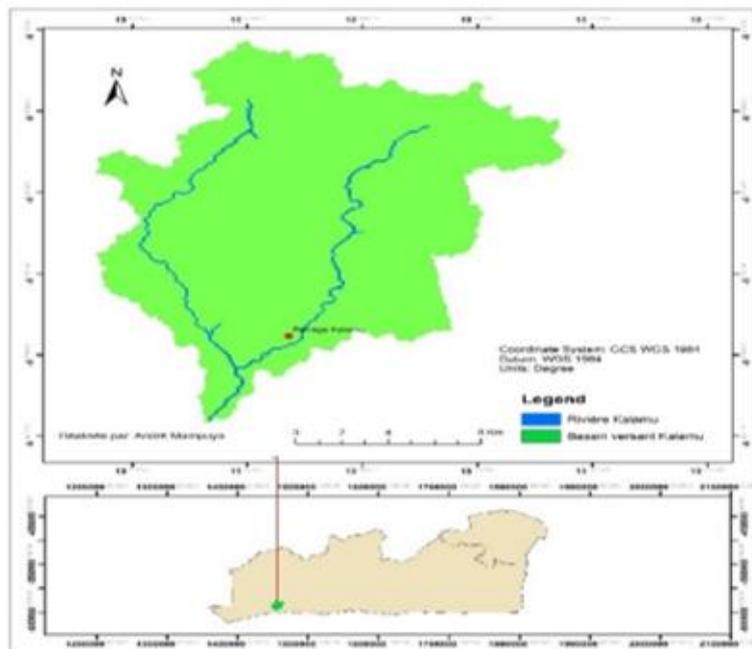_____

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Figure 1. Kalamu River watershed at Boma

2.2 Data collection

Crucial data were collected from various sources. The water level of the Congo River was collected by the Compagnie des Voies Maritimes (CVM) in Boma, covering the period from 1960 to 2017. Monthly precipitation and evaporation data were obtained from the Boma meteorological station, ranging from 1992 to 2023. Historical information on the flow of the Kalamu River was provided by the Regideso in Boma. These data are essential for understanding the hydrological dynamics of the region and for planning an energy storage system (Regideso, 1992).

2.2.1 Taring equation

To model the flow rates of the Congo River, the Lempicka rating equation was used, formulated as follows:

$$Q = 277797.599 + 1595.025h + 3230.865h^2$$
$$(1)$$

Where Q represents the flow rate in m³/s and h is the water height in meters. This equation is crucial to establish a baseline for subsequent analyses (Laraque et al., 2022).

2.3 Data analysis

To carry out this study on the flow rates of the Kalamu River and the Congo River at Boma, several methodological steps were followed.

2.3.1 Tools and Software for Random Forest Modeling and Simulation of Kalamu River Flows

The analysis was performed using Python libraries, including Pandas for data manipulation, Scikit-learn for the Random Forest regression model, and Matplotlib for visualization (Pierrefeu et al., 2022). A DataFrame was created from the collected data, after checking the consistency of the lists of dates, precipitation, and evaporation. A 'Discharge' column was added, estimating the discharges of the Kalamu River.

The data were prepared for model training by creating a feature matrix and a target vector, followed by splitting the data into training and test sets. The Random Forest model was trained, and predictions were evaluated via the mean squared error (Douches, 2009; Ioan et al., 2020). The results were visualized to identify trends, and a ranked flow curve was plotted to represent excess probabilities (Ago et al., 2005; Kayser et al., 2019).

2.3.2 Tools and Software for Linear Regression Modeling of Congo River Flows

Data analysis began by importing essential libraries such as Pandas, NumPy, Matplotlib, Seaborn, and Scikit-learn for data manipulation and visualization (Pierrefeu et al., 2022). The Congo River discharge data were converted into a DataFrame, with a transformation of the 'Year' column to datetime format to ensure consistency (Laraque et al., 2022). For regression analysis, the independent variables X were defined as a time sequence, while Y represented the discharges. A linear regression model was created and trained with Scikit-learn.

Model evaluation extracted the intercept and slope, and Pearson correlation tests were performed to verify the statistical significance of the coefficients (Magrin and Mugelé, 2020; Nzita et al., 2024). The results were visualized with a scatter plot and a ranked flow curve, illustrating the probabilities of excess (Ago et al., 2005; Kayser et al., 2019).

3. Results

3.1 Climate Data Analysis for Boma: Precipitation and Evaporation

Data collected at the Boma weather station on monthly precipitation and evaporation from 1992 to 2023 are illustrated in figures 1 and 2 using the Python anaconda software.
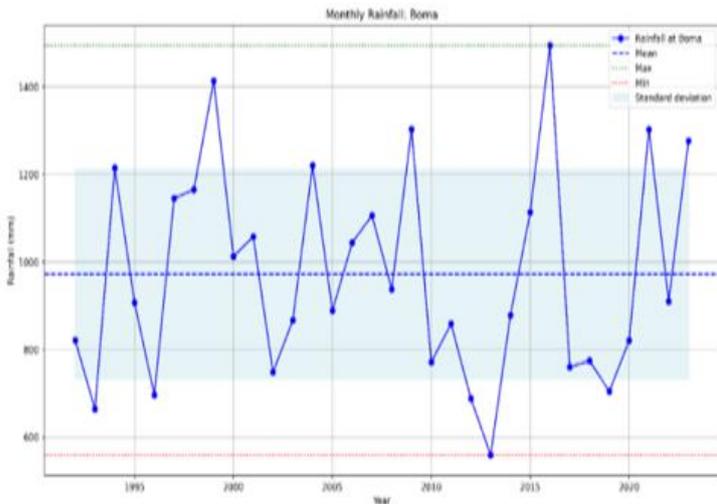
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Figure 2. Monthly precipitation from 1992 to 2023

Interpretation of figure 2 reveals that monthly rainfall in Boma exhibits considerable variability, with an average of approximately 1,200 mm per year. The extremes of rainfall range from 800 mm to 1,400 mm. Furthermore, the shaded area indicates the standard deviation, which reflects the dispersion of the data around the mean. A higher standard deviation would mean greater variability in rainfall, suggesting that some months may experience very high rainfall, while others could be much drier. They highlight the importance of monitoring these fluctuations to effectively manage water resources and anticipate environmental impacts.
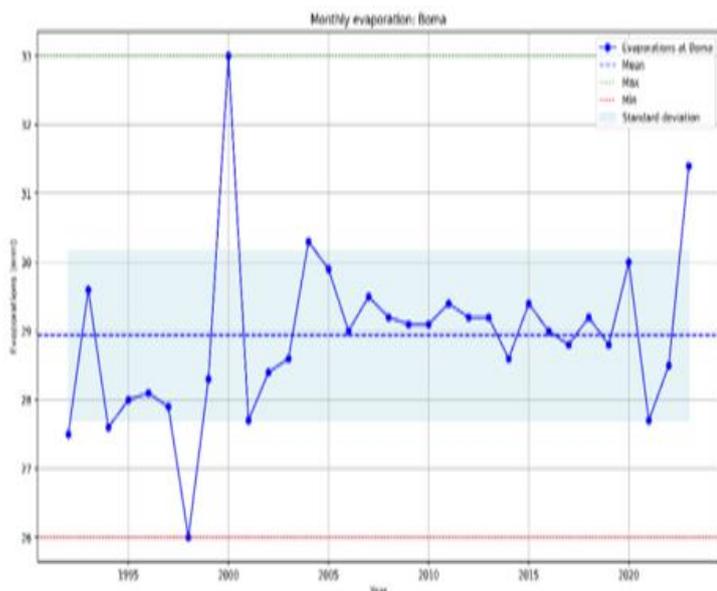

Figure 2. Monthly evaporation from 1992 to 2023

Interpretation of the evaporation figure at Boma highlights an average of approximately 30 mm per month, with maximum values reaching 33 mm and minimums around 26 mm. The shaded area on the graph indicates the standard deviation, which measures the dispersion of the data around the mean. A relatively low standard deviation suggests that evaporation measurements are fairly consistent from month to month. This variability, although moderate, has important implications for water resource management, particularly in the face of fluctuations in precipitation and agricultural needs.

3.2 Hydrological Modeling and Flow Analysis of the Kalamu River

Figure 3 illustrates the Kalamu River flows from 1992 to 2023 using the random forest machine learning approach to model and simulate the Kalamu River flows from monthly rainfall, monthly evaporation, and some flow data of this river.
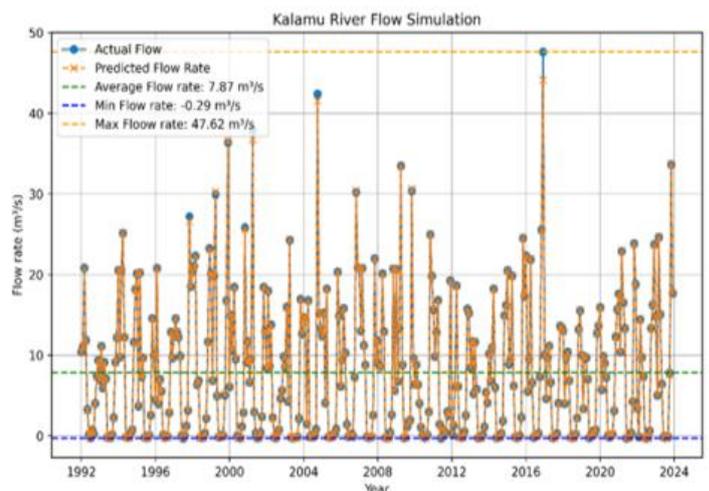

Figure 3. Modeling and Simulation of Kalamu River Flows at Boma

The blue dots represent observed flows, while the orange line indicates predicted flows, with a green line showing the average flow of approximately 7.87 m³/s. The blue and red dotted lines mark the minimum and maximum flows, at -0.29 m³/s and 47.62 m³/s, respectively. These data highlight the significant variations in flows over the years, with a minimum below zero signaling possible drought periods and a maximum suggesting flood risks. The discrepancies between actual and predicted flows show that the model does not always capture the complexity of hydrological events. Systemic variability highlights unmodeled factors influencing flows. The root mean square error (RMSE) is 0.003, indicating that the model is generally accurate. Understa

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nding these dynamics is crucial for water resource management, protecting riparian ecosystems, and preventing risks from floods and droughts.

The graph in figure 4 illustrates the relationship between classified flows of the Kalamu River at Boma and exceedance probability, which is necessary for water resources management.
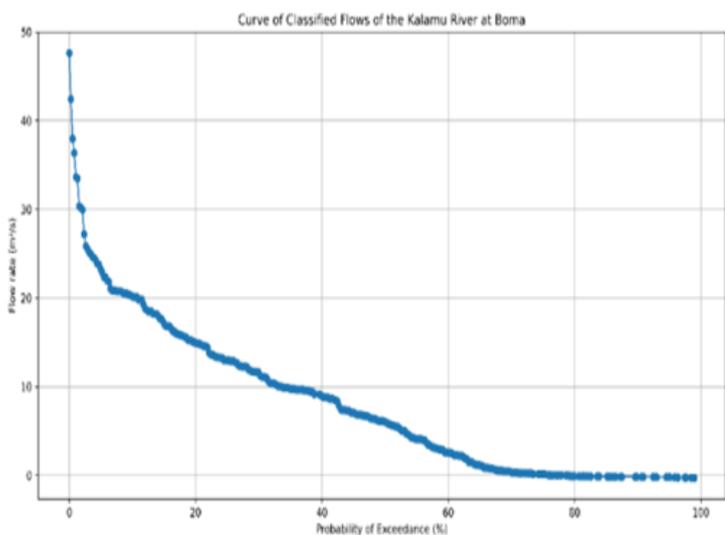

Figure 4. Classified flow curve of the Kalamu River at Boma

To assess the feasibility of installing a pumped hydroelectric energy storage system on the Kalamu River, it is essential to analyze the river's flow rates based on the data provided.

With a 0.00% probability of exceedance, the flow rate reaches 47.62 m³/s, but this level is observed only 0 days per year. With a 10.16% probability, the flow rate decreases slightly to 20.12 m³/s, which corresponds to approximately 37 days per year. Continuing to examine the values, we see that a flow rate of 14.92 m³/s is reached with a 20.05% probability, which corresponds to 73 days per year. With a 30% probability, the flow rate is 11.23 m³/s, observed for 110 days. With a probability of 50%, the flow rate is 5.80 m³/s, which corresponds to 183 days per year. When the probability reaches 68.75%, the flow rate is 0.43 m³/s, observed for 251 days. The values continue to decrease with a probability of 77.86%, where the flow rate is 0.00 m³/s for 284 days per year. At 78.65%, the flow rate is -0.01 m³/s, which represents 287 days. On the other hand, at a probability of 98.96%, the flow rate drops to -0.29 m³/s, which corresponds to approximately 344 days per year. This last figure indicates extreme conditions where the flow rate would be insufficient for the operation of the proposed system.

3.3 Hydrological Analysis of the Congo River at Boma

Figure 5 represents the visualization and histogram of the descriptive statistical analysis of the water height data of the Congo River at Boma from 1960 to 2017 using the Python Anaconda software.
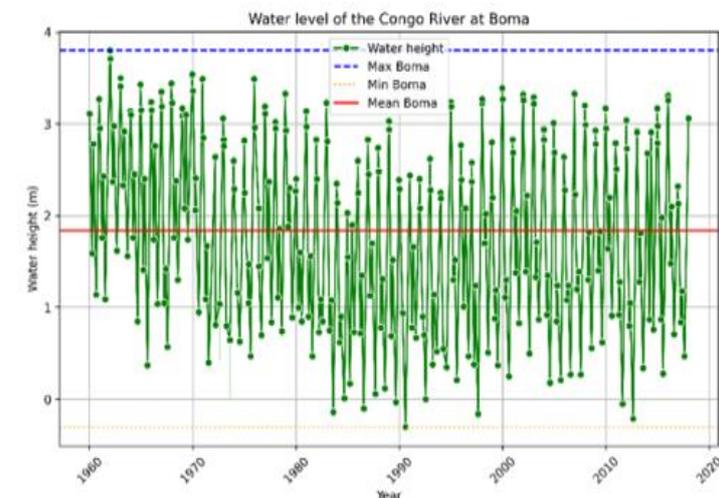
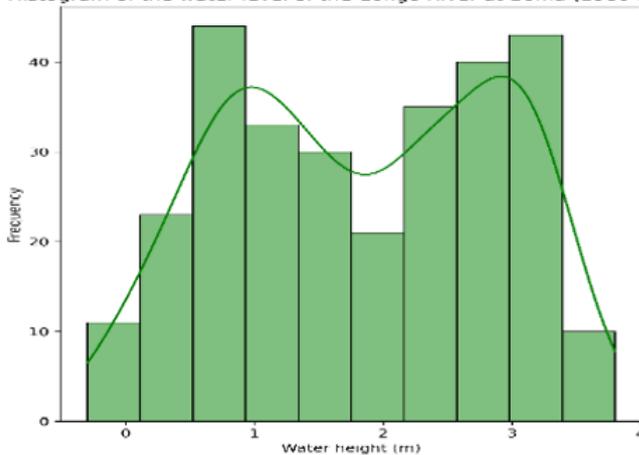*a) Visualization of water height data of the Congo River at Boma*

Figure 5. Visualization and histogram of water height data from the Congo River at Boma

b)   Histograms of river water height data at Boma

The water level of the Congo River at Boma is a key indicator of the state of the river and its impact on the ecosystem and human activities. With 290 recorded measurements, the average is 1.84 meters, indicating general stability, although the standard deviation of 1.04 meters reveals significant fluctuations due to seasonal factors. Extreme values range from -0.30 meters to 3.80 meters, signaling potential flood management problems. Quartiles show that 50% of measurements fall between 0.90 and 2.82 meters,

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essential for biodiversity, agriculture, and navigation. Analysis of a histogram of water levels from 1960 to 2017 reveals that depths around 2 to 3 meters are the most frequent, favorable for the ecosystem and human activities. These data are crucial for water resource management and the protection of the riparian environment.

Figure 6 represents the visualization and histogram of the descriptive statistical analysis of the calculated flows of the Congo River at Boma from 1960 to 2017 using the Python Anaconda software.
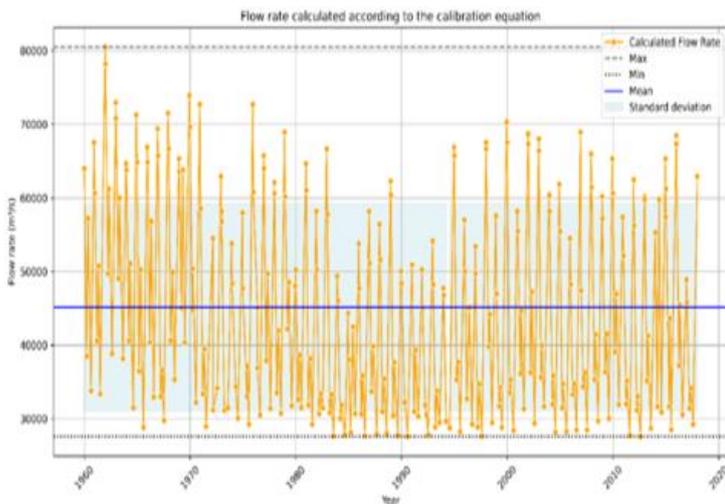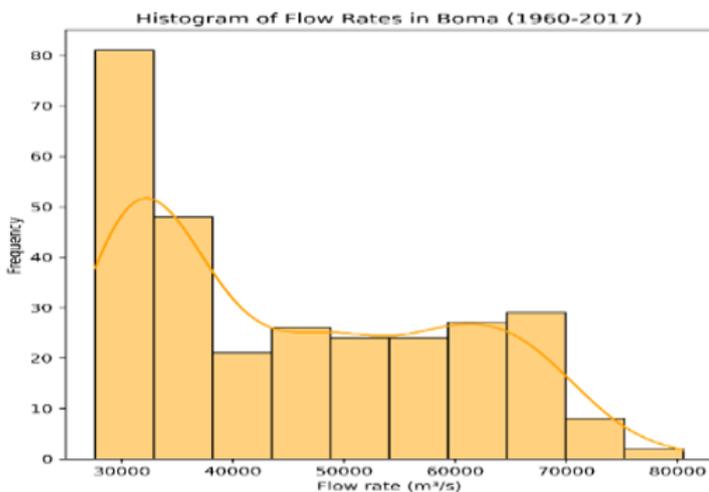

Figure 6. Visualization and histogram of the descriptive statistical analysis of the calculated flows of the Congo River at Boma from
a) Visualization of the calculated flow rates of the Congo River at Boma

b) Histograms of river flows at Boma
Figure 6. Visualization and histogram of the calculated flow rates of the Congo River at Boma Descriptive statistics of flow rates at Boma, with 290

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observations, indicate complete data collection. The mean flow rate is 45,145.07 m³/s, essential for assessing the river's capacity to meet ecological and human needs. The standard deviation of 14,111.36 m³/s reveals significant variability, with minimum flows of 27,605.12 m³/s and maximum flows of 80,512.41 m³/s, highlighting water management challenges. The quartiles show that 25% of flows are below 31,850.12 m³/s, while the median is 41,335.85 m³/s. Seasonal fluctuations are also noted in the flow graph. The histogram shows a concentration of flows between 40,000 m³/s and 60,000 m³/s, indicating greater stability. The density curve shows a central trend around 45,000 m³/s, suggesting better water resource management in Boma, essential for hydraulic infrastructure planning.

The graph in figure 7 illustrates the relationship between the classified flows of the Congo River at Boma and the probability of exceedance.
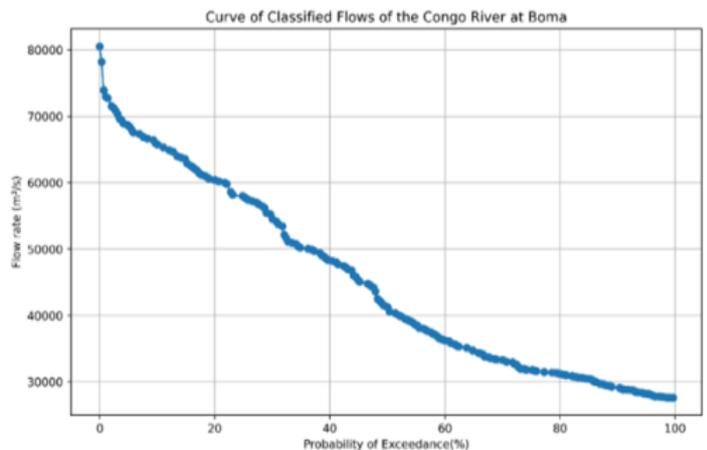
Figure 7. Curve of classified flows of the Congo River at Boma

Managing the Congo River's flow at Boma is essential for the sustainability of ecosystems and human activities. Classified flows vary considerably depending on the probability of excess flow, directly impacting water use. At a probability of 0.00%, the flow reaches 80,512.41 m³/s, observed for 0 days per year. At 5.17%, it is 68,474.83 m³/s, corresponding to 19 days, while at 50%, it drops to 41,269.24 m³/s, sufficient for 183 days. Lower flows, such as 31,209.34 m³/s at 80%, are necessary to preserve aquatic habitats, observed for 292 days. For navigation, a flow of 29,080.85 m³/s is required for 330 days. Flow management is crucial to meeting agricultural, housing, and energy needs. Stable flow

s promote biodiversity while supporting human activities, ensuring a balance between ecological and economic demands.

3.4. Statistical analysis and modeling of the flow rates of the Congo River at Boma

Table I shows Pearson correlation of Congo River discharges at Boma.

Table I. Pearson two-way correlation test of Congo River discharges at Boma from 1960 to 2017

Variable	Correlation	t	df	p-value
Flow rates and time	0.883	4.213	5	0.008**

Analysis of the Pearson correlation test results for Congo River discharges at Boma, from 1960 to 2017, shows a correlation coefficient of 0.883, indicating a strong positive correlation. This suggests that the discharges increase significantly together. The t-value of 4.213 indicates a statistically significant correlation, with 5 degrees of freedom. The p-value of 0.008, less than 0.05, confirms that the observed relationship is robust. Finally, the confidence interval for the discharges, ranging from -7,225.14 to 11,273.59, helps assess the precision of the results.

Table II presents the t-test of the Congo River flows at Boma from the linear regression model.

Table II. Student's test for modeling flow rates at Boma with linear regression

	Estimator	Error	t	p-value
Interception	49106.119	819.369	59.932	0.000***
Slope	-27.183	817.951	-0.033	0.975

Table II presents the results of a linear regression analysis. The intercept of 49106.119 indicates the expected flow rate when the predictor variable (X) is zero, and it is statistically significant with a t-value of 59.932 and a p-value of 0.000. In contrast, the slope of -27.183 suggests that a one-unit increase in the predictor variable results in a 27.183-unit decrease in flow rate, but with a p-value of 0.975, it is not significant, indicating that changes in the predictor variable do not significantly affect flow rates at Boma.

Table III presents the t-Student test of Congo River flows at Boma from linear regression model residuals.

Table III. Residuals of the Student's test of modeling flow rates at Boma with linear regression

Residuals	Min	Quartile 1	Median	Quartile 3	Max
	-19514.945	-12637.055	-3207.309	12723.549	31650.937

Table III presents the residuals, which are the differences between the observed values and those predicted by the model. The minimum residual is -19514.945, and the maximum is 31650.937. The median of the residuals, at -3207.309, indicates that the model tends to underestimate the flows. This information is crucial for evaluating the model's performance, as it allows us to identify its limitations and improve future adjustments.

The modeling flow rates at Boma with linear regression equation is written in the form (figure 8) :

$$Y = -27.18X + 49106.12$$
(2)

Where Y represents the predicted flow rates at Boma and X is the time that influences the flow rate. The graph in figure 8 illustrates the relationship between flow rates and time, with a red line representing the model.
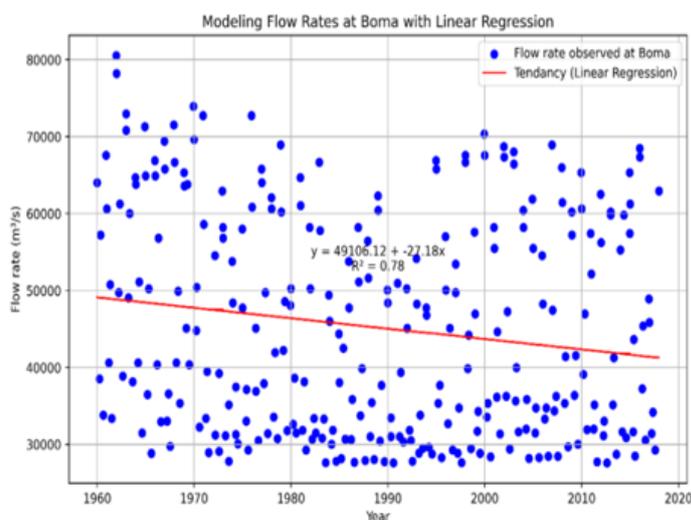
Figure 8. Modeling of the flow rates of the Congo River at Boma

The analysis of the Congo River discharge pattern at Boma examines the blue dots representing observed flows from 1960 to 2020, showing some variability around the mean, influenced by environmental factors. The red trend line, derived from a linear regression, has a negative slope, indicating an average annual decrease of 27.18 m³/s. The coefficient of determination R² of 0.78 underlines a good fit of the model to the data,

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explaining nearly 78% of the flow variations. This trend raises concerns for water resource management if it continues.

4. Discussion

4.1 Climate Data Analysis for Boma: Precipitation and Evaporation

An artificial intelligence modeling study of the flow rates of the Kalamu and Congo rivers confirms several studies. Analysis of rainfall in Boma indicates considerable variability, with an annual average of approximately 1,200 mm and extremes between 800 mm and 1,400 mm. The standard deviation reflects the dispersion of the data, suggesting that some months may be very rainy while others are dry. This highlights the importance of monitoring these fluctuations for effective water resource management (Ago & Ozer, 2005). Regarding evaporation, the average is approximately 30 mm per month, with maximum values of 33 mm and minimums around 26 mm. The relatively low standard deviation indicates monthly consistency in measurements. This variability, although moderate, is important for water resource management, especially in the face of rainfall fluctuations and agricultural needs (Alturki & Awwad, 2021). In summary, these results show significant rainfall variability and evaporation stability, essential for water resource management in the region.

4.2 Hydrological Modeling and Flow Analysis of the Kalamu River

The observed flow rates show an average of 7.87 m³/s, with extremes ranging from -0.29 m³/s to 47.62 m³/s. These significant variations highlight the risks of flooding and drought, requiring sustainable water resource management. (Assani 2004). To evaluate the installation of a pumped hydroelectric energy storage system on the Kalamu River, a classified flow analysis was carried out. At an exceedance probability of 0.00%, the flow reaches 47.62 m³/s, but this level is only observed for 0 days per year. The flow decreases to 5.80 m³/s at 50%, corresponding to approximately 183 days per year. At 78.65%, the flow drops to -0.01 m³/s, observed for 287 days. The flow of the Kalamu River is very limited, given the small size of its basin and climatic conditions characterized by a long dry season. These factors cause this resource to dry up even during several months of the year when capture is therefore impossible (Regideso, 1992).

This study demonstrated the impact of environmental factors on fish migration, which is relevant to understanding how flow fluctuations can affect aquatic ecosystems. It reinforces the idea that hydrological variations must be taken into account for water resource management (Gosset et al., 1992). These results show that the river's flow varies considerably. Negative flows, especially at high probabilities, indicate periods when the river may not provide sufficient water for the system to operate. This suggests that the Kalamu River may not be a viable site for a pumped hydroelectric system, especially during periods of prolonged drought following its operating time of 1800 hours per year (Ioan et al., 2020). Flood analysis highlights the need to consider extreme events in water management planning. This corroborates the importance of anticipating flow variations to protect ecosystems and human activities (Ago et al., 2005), and water resource management in the Congo River Basin must take into account ecological needs to preserve aquatic biodiversity (Laraque et al., 2020).

4.3. Hydrological Analysis of the Congo River at Boma

Analysis of water height data from the Congo River flows at Boma reveals an average of 1.84 meters with a standard deviation of 1.04 meters. The extreme values range from -0.30 meters to 3.80 meters. The relative stability of water levels is crucial for activities such as flooding, navigation, and irrigation. However, significant variability highlights that periods of very low flow can occur, affecting ecosystems and human uses. Effective water resource management is therefore essential. This flood analysis confirms that extreme events must be considered in water management planning (Ago et al., 2005).

The Congo River water level histogram shows that most measurements are between 2 and 3 meters, while extreme levels are rare. Flow rates at Boma have a mean of 45,145.07 m³/s and a standard deviation of 14,111.36 m³/s. This study of interannual flow variability highlights the importance of hydrological regimes for water resource management. Although extreme flow events are infrequent, they require special attention to prevent flooding risks. This flood analysis confirms that extreme events must be considered in water management planning Ago et al. (2005). The flow analysis for the installation of a hydroelectric energy storage system in Boma reveals that at a probability of excess of 0.00%, the flow reaches

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80,512.41 m³/s, observed 0 days per year. At 50%, it is 41,269.24 m³/s, observed 183 days, while at 80%, it is 31,209.34 m³/s, observed 292 days. This is sufficient for hydroelectric pumping system installations that operate at a time of 6000 hours per year (Ioan et al., 2020).

4.4 Statistical analysis and modeling of the flow rates of the Congo River at Boma

The Pearson correlation test for Congo River discharges at Boma showed a coefficient of 0.883, indicating a strong positive correlation. The linear regression shows a negative slope of -27.18, but it is not significant, highlighting the complexity of hydrological systems and the need for advanced methods for modeling. A strong correlation between measured flows, as indicated by the correlation coefficient, is essential for modeling and effective resource management (Pierrefeu et al., 2022).

This study highlighted the challenges associated with installing a pumped energy storage system on the Kalamu River, which cannot be installed because these flows are often negative over the years. Thus, using the flows of the Congo River at Boma, which are sufficiently large for this proposed system, is important. This study is significant for policymakers, researchers, and water resource managers, providing essential data for the development of sustainable strategies and the protection of aquatic ecosystems. The information presented here serves as a basis for future studies and for planning hydraulic projects in the region.

5. Conclusion

This study highlighted the importance of assessing water resources in Boma, Democratic Republic of Congo, in the face of growing energy and environmental security challenges. The results reveal significant variability in the Kalamu River flows, with prolonged droughts compromising the viability of pumped storage energy projects. By integrating advanced artificial intelligence methods, such as the random forest approach, we were able to model flows taking into account precipitation and evaporation. It is recommended to consider the Congo River flows as a viable alternative for energy storage while adopting sustainable water resource management strategies. Anticipating hydrological fluctuations is essential to ensure adequate water supply, not only for energy needs but also for agriculture and the daily lives of residents. This study highlights the need for collaboration between local stakeholders and researchers to develop solutions adapted to the hydrological realities of the region, thus contributing to sustainable and resilient development.

Conflict of Interest

The authors declare no conflict of interest in the publication process of the research article.

Ethical Considerations

This article was prepared in accordance with ethical research principles, ensuring compliance with current standards. It is important to note that no human or animal data were used in this study, ensuring full compliance with ethical requirements. The authors also declare that they have no conflicts of interest regarding this research, which reinforces the study's credibility.

The data used for this analysis were obtained ethically and legally, complying with all relevant regulations. Finally, the study results were presented honestly and transparently, without any data manipulation, to ensure the scientific integrity of the entire work.

Authors contributions

Each author played a key role in the development and finalization of the research article.

A.M.N. was responsible for drafting and preparing the original version. He also focused on data collection and analysis and validated the final version.

C.N.U.-D.-M. was responsible for reviewing the survey, helped improve the quality of the original version, and performed the final revision, ensuring the article was ready for publication. Finally,

J.N.K. and G.D.N. oversaw the entire process, ensuring that all steps were followed correctly.

All authors have read and approved the final version of the manuscript.

ORCID of the Authors

André N.M. : https://orcid.org/0009-0007-6092-145X

Clément U-di-M.N: https://orcid.org/0009-0007-3515-1588

Josephine K.N.: https://orcid.org/0000-0003-1914-3741

Guyh N.D.: https://orcid.org/0000-0002-9671-3819

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