Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 15, Issue, 12, pp.26654-26658, December, 2023
DOI: https://doi.org/10.24941/ijcr.46376.12.2023

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

STUDY OF THE VARIABILITY OF THE HYDROLOGICAL REGIME OF THE DIANI RIVER IN THE N'ZEREKORE REGION IN THE REPUBLIC OF GUINEA

Yacouba CAMARA[1*], Oumar KEITA[2], Amadou Lamarana BAH[3] and Nénè Aissata BALDE[4]

[1*,4]Institut Supérieur de Technologie de Mamou, Département Energétique, Mamou, Guinée ; [2]Université de N'Zérékoré, Département Hydrologie, N'Zérékoré, Guinée ; [3]Université Gamal Abdel Nasser de Conakry, Laboratoire d'Enseignement et de Recherche en Energétique Appliquée, Conakry, Guinée

ARTICLE INFO

Article History:
Received 20th September, 2023
Received in revised form
27th October, 2023
Accepted 15th November, 2023
Published online 20th December, 2023

Key words:

Flows, Precipitation, Variability, Hydrological Regime, Climate, Guinea.

***Corresponding author:**
Yacouba CAMARA

ABSTRACT

This present research aims to determine the hydrological parameters from average flows to define the variability of the hydrological regime of the Diani River watershed in N'Zérékoré in the Republic of Guinea. This research allowed us to understand the behavior of the flow in the river bed. During this research, after obtaining the average flow rates from the daily flow rates of the 27-year observation series (1995-2021), we determined; if the number of years of observation chosen is sufficient or not through the calculation of the mean square error whose calculated value is 14% which is in the interval of (10 to 15)%. From there, the rest of the results obtained during this study are as follows: the average interannual flow equal to 144.49 m^3/s, the sum of average precipitation equal to 34184.6 mm/h, the coefficient of variability equal to 0 .44, the flow coefficient equal to 0.1, the minimum average flow rate is 26.48 m^3/s and was observed in 2011 and the maximum average flow rate was observed in 2006 and is equal to 347.05 m^3/s.

Citation: ***Yacouba CAMARA, Oumar KEITA, Amadou Lamarana BAH and Nénè Aissata BALDE,* 2023.** "Clinical placement and clinical skills at Ahfad University for Women Physiotherapy Education.". *International Journal of Current Research*, 15, (12), 26654-26658.

INTRODUCTION

Climate change and its influence on the environment and society are the major problems of the modern world. The consequences of these phenomena on water resources are particularly strong and affect many sectors of activity. Studies on climate variability and change have interested global decision-makers following several large-scale climate events (Omar GHADBANE, 2021; Dezetter, 2008). Climate change has resulted in a succession of periods of drought in North Africa, West and Central Africa and in the Mediterranean region from the end of the 1960s and the beginning of the 1970s (Dezetter, 2008; Paka, 2020). The hydrological regime defines the state and responses of a river system in relation to the climate system and the physico-geographic characteristics of the watershed (DariuszWrzesi, 2020; Wrzesi´nski, 2005). The flow regime of different models can be treated as certain "preferred states" of the runoff system, which are more or less stable. In order to identify a change in any pattern (regardless of the reason), one must first correctly describe its initial state (Krasovskaia, 2002). Multi-year variations in river flow can result from environmental changes at local scales (e.g., caused by human activity) or regional and global scales (caused by climate change). Hydrological data, including river flow, can therefore serve as an indicator of climate change (Wrzesi´nski, 2014). Long-term fluctuations in hydrological and meteorological parameters have been the subject of attention of hydrologists and climatologists since the beginning of the 20th century (Stojkovic, 2015).

According to Pekarova *et al*. (2003) who tested the time series of annual discharges of certain major rivers of the world for wet and dry periods identified that the extreme occurrence cycles of these two seasons are respectively 28 to 29 years and 20 to 22 years. It was also found that the temporal shift in the occurrence of extreme flows (maxima and minima) depended on longitude and latitude. Pekarova *et al*. (2006) then analyzed the occurrence of dry and wet periods for 18 major European rivers during the period 1850–1997. Although statistical analysis of the flow series did not confirm a long-term increase or decrease over the past 150 years, drought cycles of approximately 13.5 years and 28 to 29 years have been identified. In Eastern Europe, the occurrence of wet and dry cycles was delayed by a few years compared to Northern and Western/Central Europe. Similar periods have been reported in other rivers around the world (Amazon, Congo) as well as in the Southern Oscillation, North Atlantic Oscillation and Pacific Decadal Oscillation phenomena. The project on the characterization of the water regime of the Danube basin was carried out by the National Committee to study long-term trends in runoff and inter- and intra-annual variability. Bormann (Bormann, 2010) also studied changes in river runoff regimes in Germany in relation to climate change and found that while general runoff regime types (such as pluvial, snow and glacial) had not changed, their detailed characteristics (amplitude, timing of extreme values of the Pardé coefficient) were considerably affected by environmental changes. Khon and Mokhov (Khon, 2012) assessed the future average annual river runoff regime and its distribution within the year for the main Eurasian basins, including the Volga and

Amur basins and the main Siberian rivers: the Ob , the Yenisei and the Lena. The obtained results show that the average annual runoff of Siberian rivers is expected to increase by the end of the 21st century, mainly due to an increase in spring runoff, an increase in winter precipitation and, as a result, the mass of snow, as well as more intense snow melts in spring. Hall *et al*. (2014) assessed the state of the art of changing flood regimes in Europe and highlighted the growing concern that floods are becoming more frequent and severe in Europe. Stojkovic *et al*. (2016) presented a new stochastic model, based on the historical characteristics of annual flow time series, to simulate the average annual flow of large European rivers. Pekarova *et al*. (2002) applied a hydrological series of average daily flows from 20 gauging stations to study spatial and temporal changes in the magnitude, duration and frequency of high flows in the Danube basin. Recent studies have proven that the North Atlantic thermohaline circulation also has an impact on river flow in Poland (Bochiola, Long Term, 2014). The consequences of destabilization of river flow regimes are not only a hydrological problem, but also affect economic and social aspects of human development. For example, Bochiola *et al*. (19), Tahir *et al*. (2011) and Faiz *et al*. (2011) analyzed the hydrological regime of the poorly calibrated high altitude zone of the upper Indus River basin of Pakistan and proved the importance of these studies in planning and management of water resources, design of hydraulic structures and better policies in response to the water needs of agriculture downstream of this area in relation to climate change. Some researchers emphasize the importance of hydrological regime variability in shaping the biophysical attributes and functioning of river ecosystems (Faiz, 2018). Harris *et al*. (2000) proposed a classification of the regimes of four British rivers using multivariate techniques to separate annual flows and temperatures in the context of hydroecology and the importance of flow and temperature as primary variables in the management of flowing water, riparian and floodplain ecosystems. It is within the framework of better understanding the behavior of the flow of the Diani River which extends mainly into Guinea that we have chosen this theme entitled: Study of the variability of the hydrological regime of the Diani River in N'Zérékoré in the Republic from Guinea.

MATERIALS AND METHOD

MATERIALS

PRESENTATION OF THE STUDY AREA: The Diani River Watershed extends mainly in Guinea, with longitudinal continuity from upstream to downstream and reaches an area of 5,200 km2. Its average annual contribution is 4,400mm3 of water on an average slope of 1/1000 (Figure 1). The Diani River which serves as a boundary between the prefecture of Macenta and that of N'Zérékoré has its source in the classified forest which runs along the Milo River, to the east between Kassiadou and Balladou, 4 km from Vasseridou center (Prefecture of Macenta) . It is the most important river in Forestry Guinea and the only one to have a reliable gauging station which is located at the Diani bridge at which hydrological observations were made, 6 km from Koulé (Prefecture of N' Zérékoré) on the national road linking Macenta to N'Zérékoré. The Diani demarcates Guinea from Liberia over a course of 50 km before passing into Liberian territory near Banié, Yomou prefecture where it takes the name of Saint Paul River (Simon Pierre LAMAH, 2020).

TOOLS: The study of the variability of the hydrological regime of the Diani River in the N'Zérékoré region in the Republic of Guinea is based on hydrological analyzes of average annual flows for an observation period of 27 years (1995-2021), in order to better understand the hydrological regime of the said river. This study involves the determination of extreme flows (flood and low flow) which is of capital importance in the field of hydrology in terms of characterizing the hydrological regime and assessing the catastrophic risks of a watercourse. The hydrological data used for this study are recorded in Table 1.

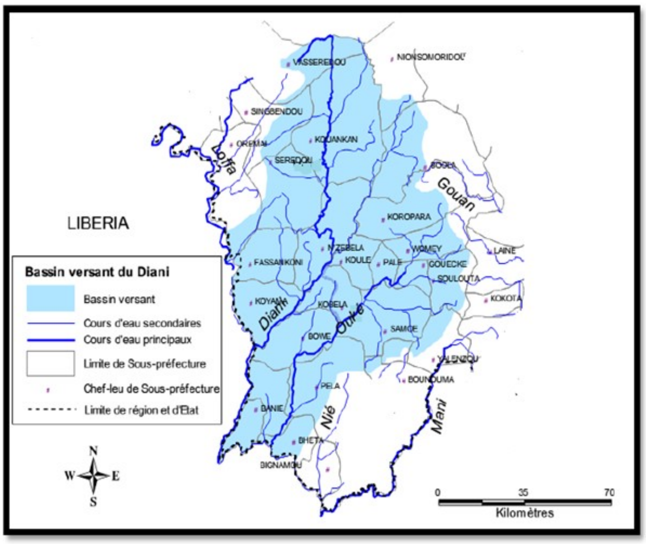

Figure 1. Location map of the Dianiwatershed (Simon Pierre LAMAH, 2020)

METHOD

The methodology adopted in this research for the study of the variability of the hydrological regime of the Diani River is based on: the determination of flood and low flow rates through a graphical representation over an observation period of 27 years and analyze the hydro-climatic parameters of the study site.

Evaluation of the parameters characterizing the hydrological regime of a watercourse

A-Interannual average flow: The interannual average flow Q_moy^int is calculated for the entire observation period (42 years) by the following relationship:

$$Q_{moy}^{int} = \frac{\sum_{i=1}^{n} Q_i^{an}}{N} \quad (1)$$

Where is the sum of the average annual flows, N is the number of years of observation (27 years).

B- Flow module coefficients (Ki) for the entire period: These coefficients determine the variability of flow in the area per year. They are calculated by the following relationship:

$$K_i = \frac{Q_i^{an}}{Q_{moy}^{int}} \quad (2)$$

Where is the average flow for each year.

C- Spacing of arithmetic mean values (Ki-1): The values of the spacing, as well as those of the squared standard deviation and the probability of exceedance P, are calculated and recorded in Table 2 in the results and discussion section, where m is the order number.

D- Coefficient of variability (Cv): The coefficient of variability Cv makes it possible to determine whether the number of years of the observation series is sufficient. It is determined by the following relation (Yacouba CAMARA, 2021):

$$C_v = \sqrt{\frac{\sum(K_i - 1)^2}{N-1}} \quad (3)$$

E- Arithmetic mean square error: The mean square error defined if the number of years of observation is sufficient or not in a hydrological study. It is expressed by the relationship:

$$\delta_q = \sqrt{\frac{1+{C_v}^2}{2N}} \text{x}100 \quad (4)$$

Table 1. Average annual flows of the Diani River (1995-2021)

Years	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Flow rates	88,40	186,60	127,11	138,02	120,22	137,44	126,14	129,14	168,19	131,04	206,03	347,05	275,32	203,63	131,94	60,09	26,48	222,80	136,01	137,43	136,82	140,07	123,87	99,36	88,40	186,60	127,11

Table 2. Averageannual flows, standard deviation and probability of the Diani River

Years classified	Q_i^{moy} Classées	$K_i = \frac{Q_i}{Q_{moy}}$	$(K_i - 1)$	$(K_i - 1)^2$	P=$\frac{m}{n+1} \times 100$
2006	347,05	2,402	1,402	1,965	3,57
2007	275,32	1,905	0,905	0,820	7,14
2012	222,8	1,542	0,542	0,294	10,71
2005	206,03	1,426	0,426	0,181	14,29
2008	203,63	1,409	0,409	0,168	17,86
1996	186,6	1,291	0,291	0,085	17,86
2020	186,6	1,291	0,291	0,085	21,43
2003	168,19	1,164	0,164	0,027	25,00
2007	140,07	0,969	-0,031	0,001	28,57
1998	138,02	0,955	-0,045	0,002	32,14
2000	137,44	0,951	-0,049	0,002	35,71
2014	137,43	0,951	-0,049	0,002	39,29
2015	136,82	0,947	-0,053	0,003	42,86
2013	136,01	0,941	-0,059	0,003	46,43
2009	131,94	0,913	-0,087	0,008	50,00
2004	131,04	0,907	-0,093	0,009	53,57
2002	129,14	0,894	-0,106	0,011	57,14
1997	127,11	0,880	-0,120	0,014	60,71
2021	127,11	0,880	-0,120	0,014	64,29
2001	126,14	0,873	-0,127	0,016	67,86
2017	123,87	0,857	-0,143	0,020	71,43
1999	120,22	0,832	-0,168	0,028	75,00
2018	99,36	0,688	-0,312	0,098	82,14
1995	88,4	0,612	-0,388	0,151	85,71
2019	88,4	0,612	-0,388	0,151	89,29
2010	60,09	0,416	-0,584	0,341	92,86
2011	26,48	0,183	-0,817	0,667	96,43

This calculated square error must be within the interval of (10 to 15)%.

Flow coefficient: The flow coefficient (α) is the ratio between the amount of rain elapsed () and the quantity of water precipitated () during a given period in a given basin. It is defined by the relation (25):

$$\alpha = \frac{Q_{moy}^{int}}{P_{moy}^{an}} \quad (5)$$

This value is generally in the range 0 to 1.

RESULTS AND DISCUSSION

Based on hydrological data over 27 years of observations (table 1), we determined the maximum and minimum average flow rates through a graphical representation shown in Figure 2.

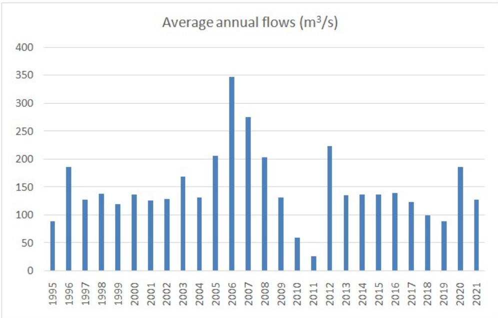

Figure 2. Average annual flows (1995-2021)

In this figure, we see that the maximum average flow was observed in 2006 and corresponds to 347.05 m3/s while the minimum average flow was observed in 2011 and corresponds to 26.48 m3/s. In this table below, the annual average flows are classified in decreasing order of magnitude following the 27 years of observations, in order to calculate the values of the separation, as well as those of the squared standard deviation and the probability of exceeding P. These different calculated parameters make it possible to determine the coefficient of variability, the arithmetic mean square error as well as the flow coefficient. Figure 3 shows the classified average annual flow rates of the Diani River in decreasing order of magnitude. In this figure, we see that the greatest flow was observed in 2006 and the lowest flow in 2011.

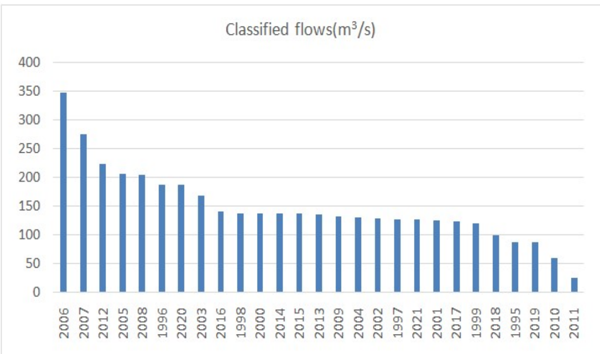

Figure 3. Classified average flows of the Diani River

The average interannual flow (amount of water flowed) and the average precipitation (amount of water precipitated) following the 27 years of observations that we obtained during this study are respectively 3064, 72 m3/s and 34184.6 mm/h. The coefficient of variability which enters into the determination of the sufficiency or insufficiency of the number of years of observations calculated is 0.44, the mean square error calculated is 14% as well as the flow coefficient which is of 0.1.

Based on these different calculated parameters, we can say that the value of the calculated mean square error is in the range of (10 to 15)%, this proves that the number of years of observations is sufficient for this research. . As for the flow coefficient, its value must generally be in the interval from 0 to 1 (Yacouba CAMARA, 2021), for our case the calculated flow coefficient is equal to 0.1, this demonstrates that this value of the flow coefficient calculated flow is within standards. This further justifies that the calculated coefficient is doing well despite the various attacks to which the Diani River is a victim, in particular the effect of climate change, deforestation along the banks of the watercourse and at the head of the source, the production of ordinary bricks which contribute to the siltation of the river bed.

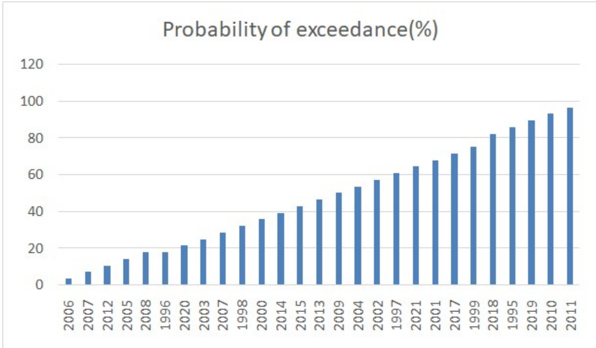

Figure 4. Probability of exceeding observation series

Figure 4 determines the graph of the probability of exceedance of the series of flow observations. In this figure, we see that the greatest flow rate was observed in 2006 and the probability of reaching or exceeding this flow rate is of the order of nearly 4%. On the other hand, the lowest flow rate was observed in 2011 and the probability of exceeding this value is around 96.43%. This demonstrates that the highest flow rate occurs fewer times in the observation series than the lowest flow rate. This irregularity is due to climatic disturbance phenomena. In this case, to contribute to the mitigation of these phenomena, we must restore the banks of watercourses and promote renewable energies to the detriment of fossil fuels.

CONCLUSION

It is with the aim of better understanding the behavior of the flow of the water blade of the watershed of the Diani River in N'Zérékoré which is considered one of the most important rivers of this locality that we interested in this research topic. This research led us to analyze the flow rates of the observation series over 27 years (1995-2021). Based on these flow rates, we were able to determine the parameters involved in the characterization of the hydrological regime of the Diani River in N'Zérékoré in the Republic of Guinea. These parameters are essentially composed of the mean square error which determines whether the number of years of observation chosen is sufficient or not, the modulus coefficient and the flow coefficient which in turn determines whether the flow is within the standards. Then according to the analyses, we found that the maximum average flow was observed in 2006 and the minimum average flow was observed in 2011.

REFERENCES

Omar GHADBANE, Mohamed EL GHACHI et Mohamed CHAKIR, 2021. Étude de la variabilité climatique et de ses impacts sur le régime hydrologique de l'Oued Srou, affluent de rive gauche de l'Oued Oum Er Rbia, Afrique SCIENCE 18(2), pp.69 – 80, 2021

Dezetter, A. J. E. Paturel, D. Ruelland, S. Ardoin-Bardin, L. Ferry, G. Mahe, C. Dieulin, E. Servat, 2008. Modélisation semi-spatialisée des ressources en eau du fleuve Niger à Koulikoro. Prise en compte des variabilités spatio-temporelles. World

Water Congress, 1-4 septembre, Montpellier, France, pp.111 – 126.

Dezetter, A. J. E. Paturel, D. Ruelland, S. Ardoin-Bardin, L. FERRY, G. Mahe, C. Dieulin, E. Servat, Modélisation semi-spatialisée des ressources en eau du fleuve Niger à Koulikoro. Prise en compte des variabilités spatio-temporelles. World Water Congress, 1-4 septembre, Montpellier, France, pp.111 – 126, 2008

Paka, J. A. J. B. Dinga, D. V. Kombyla, L. S. Nkamdjou, M. J. SAMBA, Étude de la variabilité climatique et de ses impacts sur le régime hydrologique de la rivière Lefini, affluent de rive droite du fleuve Congo. Afrique SCIENCE, 17 (6), p.178, 2020

Dariusz Wrzesi´nski and Leszek Sobkowiak, Transformation of the Flow Regime of a Large Allochthonous River in Central Europe—An Example of the Vistula River in Poland, Journal Water, N°12, 507, (2020) pp.1-20

D. Wrzesi´nski, Changes of the hydrological regime of rivers of Northern and Central Europe in various periods of the North Atlantic Oscillation, Quaest. Geogr, (2005) pp.97-109

Krasovskaia, I. L. Gottschalk, River flow regime in a changing climate, Hydrology Science Journal, N° 47, (2002) pages 597

Wrzesi´nski, D. Stability of high and low flow periods on European rivers. *Badania Fizjograficzne Series A–Phys. Geog*, N°A66, (2014) pp.183–194

Stojkovic, M. S. Prohaska, J. Plavsic, Stochastic structure of annual discharges of large European rivers, *J. Hydrol. Hydromech,* N°63, *(2015) pp.*63–70

Pekarova, P. P. Miklanek, J. Pekar, Spatial and temporal runoff oscillation analysis of the main rivers of the world during the 19th–20th centuries, *J. Hydrol,* N°274, *(2003) pp.*62–79

Pekarova. P, Miklanek. P, Pekar. J, Long-term trends and runoff fluctuations of European rivers, Climate Variability and Change—Hydrological Impacts. In Proceedings of the 5th FRIEND World Conference, Havana, Cuba, (2006)

National Committee of the Slovak Republic for IHP. In Proceedings of the PROJECT 9 Flood Regime of Rivers in the Danube River Basin, Proposal submitted at 21st Working Meeting, Novi Sad, Serbia, 26 June (2007)

Bormann, H. Runoff regime changes in German rivers due to climate change. *Erdkunde,* N°64, (2010) pp.257–279

Khon, V.C. I.I. Mokhov, The Hydrological Regime of Large River Basins in Northern Eurasia in the XX–XXI Centuries, Water Ressource. Regime Water Bodies, (2012) pp.1-10

Hall, J. B. Arheimer, M. Borga, R. Brázdil, P. Claps, A. Kiss, T.R. Kjeldsen, J. Kriauciuniene, Z.W. Kundzewicz, M. Lang, *et al*., Understanding flood regime changes in Europe: A state-of-the-art assessment, Hydrology Earth System Science, (2014) pp.2735-2772

Pekarova. P, Pramuk. B, Halmova. D, Miklanek. P, Prohaska. S, Pekar. J, Identification of long-term high-flow regime changes in selected stations along the Danube River. J. Hydrol. Hydromech, N°64, (2016) pp.393-403

Bower. D, Hannah. D.M, Spatial and temporal variability of UK river flow regimes. In FRIEND 2002—Regional Hydrology: Bridging the Gap between Research and Practice, Proceedings of the Fourth International FRIEND Conference, Cape Town, IAHS Publ. 274: Wallingford, Oxfordshire, South Africa, 18–22 March (2002)

Bochiola, D. Long term (1921–2011) hydrological regime of Alpine catchments in Northern Italy, Advances in Water Ressource, N°70, (2014) pp.51-64

Wrzesi´nski. D, Marsz. A.A, Styszy´nska. A, Sobkowiak. A, Effect of the North Atlantic Thermohaline Circulation on Changes in Climatic Conditions and River Flow in Poland, Water, N°11, (2019) pages 1622

Bocchiola. D, Diolaiuti. G, Soncini. A, Mihalcea. C, D'Agata. C, Mayer. C, Lambrecht. A, Rosso. R, Smiraglia. C, Prediction of future hydrological regimes in poorly gauged high altitude basins: The case study of the upper Indus, Pakistan, Hydrology Earth System Science, N°15, (2011) pp.2059-2075

Tahir. A.A, Chevallier. P, Arnaud. Y, Ahmad. B, Snow cover dynamics and hydrological regime of the Hunza River basin, Karakoram Range, Northern Pakistan, Hydrology Earth System Science, N°11, (2011) pp.2275-2290

Faiz, M.A. D.F. Liu, M.I. Khan, T.X. Li, S. Cui, Assessment of characteristics and distinguished hydrological periods of a river regime, Environ. Earth Science, (2018), p.729

Harris, N.M. A.M. Gurnell, D.M. Hannah, G.E. Petts, Classification of river regimes: A context for hydroecology, Hydrology Process, N°14, (2000) pp.2831-2848

Simon Pierre LAMAH, Koly BEAVOGUI et Koly Prospère GUILAVOGUI, Évaluation du Régime Hydrique du Bassin Versant du Fleuve Diani, République de Guinée, Rev. Ivoir. Sci. Technol., 35, pp.433 – 445, 2020

Yacouba CAMARA, Oumar KEITA, Amadou Bailo CAMARA, Mory TRAORE et Drissa OUEDRAOGO, Étude du Régime Hydrologique à Partir des Pluies du Fleuve Tinkisso à Dabola en République de Guinée, Rev. Ivoir. Sci. Technol., 38, pp.471 – 484, 2021