

# Impact of Urbanization on the Tile Watershed in the Urban Commune of N'Zerekore

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## Abstract

Rivers still play an important role in our societies, mainly as a water resource and a place of recreation, but nowadays, human activities have led to a profound modification of the natural environment, particularly in the urban environment. The Tile River has been transformed nowadays as a channel for evacuating and draining waste from the city of N'Zerekore. The objective of this study is to analyze the effects of urbanization on the watershed of the Tile River in the urban commune of N'Zerekore, this area which is experiencing enormous pollution problems linked to uncontrolled urban sprawl. To assess the dynamics of the spatial-temporal occupation of urbanized areas, Landsat satellite image processing was used. Its aim was to produce a map of urbanized areas over three (30) years from 1993 to 2023 in order to compare them to understand the changes induced over time. The methodology for analyzing the quality of surface water in Tile consisted of identifying water sample collection sites, waste dumps, mechanical and brick workshops, markets and habitats around the watercourse. A survey of the local population and an analysis of the physicochemical and bacteriological parameters collected were carried out. The results obtained from the processing of Landsat satellite images showed that the increase in urban areas over the past thirty years has caused disturbances that have led to changes in the quality of surface water in N'Zerekore. Physicochemical and bacteriological analyses of samples from three (3) sampling sites were carried out. The results of the analysis of these water samples show a deterioration in the physicochemical and bacteriological quality of its water according to the 2011 WHO standards, particularly for surface water. These results highlighted potential pollution of the water in Tile due to the socio-economic activities of local residents and especially because of the proxim-

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ity of homes to the riverbed.

## Keywords

Impact, Urbanization, Pollution, River, Residents, Tile, Water Resources, Remote Sensing

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## 1. Introduction

Water resources are essential for the reproduction of aquatic flora and fauna, for consumption, agriculture, industrial production, and for supporting other socio-economic activities of populations. However, water is firstly unevenly distributed throughout the world, but also and above all as a receiving environment it is subject to the impacts of human activities. Today, in Guinea as in African countries, water resources are under increasing pressure from population explosion, socio-economic activities, and its domestic or industrial use leads in some respects to recurring conflicts between the different users. It is therefore essential to ensure sustainable management of this resource if we want to guarantee access for all, preserve the proper functioning of ecosystems and maintain resilience to the effects of climate change.

In a context of rapid global population growth, urbanization, pollution, and climate change, water resources are under significant threat, both in terms of quantity and quality. Water has thus become a major challenge for sustainable development.

Indeed, these human activities associated with certain natural phenomena (soil erosion, water runoff, etc.) contribute in an accelerated way to the degradation of surface water resources. They are at the root of disturbances of the natural balance and the increase in the organic load of water and sediments, eutrophication, asphyxiation of the aquatic environment as well as health problems of the riverside populations.

The protection of aquatic ecosystems is therefore essential to the ecological balance of all fish species and to a healthy diet for local populations living along waterways. This is how work carried out on some waterways in Benin has made it possible to understand the system for assessing water quality by analyzing physicochemical parameters and their ability to ensure certain functions such as maintaining biological balances and producing drinking water (Flavien et al., 2011).

It should be noted that the pollution of waterways leads to the loss of water quality and can not only contribute to the disruption of aquatic ecosystems, but also transform water into a vector of diseases (Servat, 2022). Thus, water, the source of life, can become a danger to the environment and to users if it is not of acceptable quality. Then, riverside residents are the most exposed to waterborne diseases such as typhoid, dermatitis, and parasitosis (Pantha et al., 2021).

In China, the first census on water resource pollution identified 5.9 million

sources of pollution grouped into four main categories (industrial, agricultural, domestic and those concentrated decontamination facilities). According to the study, 26% of surface water is completely unusable, 62% is unfit for fish and 90% of waterways flowing through cities are polluted (Heim et al., 2010).

In Cameroon, a team of researchers has shown that the waters of the town of Bafoussam are loaded with pathogenic germs, high levels of phosphates, chlorides and suspended matter. This disrupts aquatic life by suffocating the environment (Guy-Romain et al., 2006).

In the Republic of Guinea, it has been shown that the lack of a collection system along the Tile River in the urban commune of N'Zerekore means that 67.2% of residents throw their household waste into the environment and 30% of residents throw theirs directly into the river (Delamou et al., 2015).

Furthermore, Bilgin (2018) indicates that in Matoto, there are 43 SMEs for 11,133 subscriber households, representing a penetration rate of 10.8% for a total population of 103,597 households. The study shows the existence of 70% of anarchic dumpsites installed in neighborhoods and around markets, of which 8% are served by voluntary contribution, 17% by the door-to-door pre-collection system for informal recovery and 5% by the same system, but intended for burial at the Minière landfill.

## 2. Methodology

The urban commune of N'Zerekore is composed of 22 neighborhoods (located between 07° 42' - 07° 47' north latitude and 008° 46' - 008° 51' west longitude). It is located in the prefecture of N'Zerekore in the southeast of Guinea Conakry. The prefecture of N'Zerekore is the largest city in the Forest Guinea region, the southeastern region of the Republic of Guinea, and the second largest city in the country after Conakry. It is the capital of the prefecture of N'Zerekore.

The town of Zasonon (in Manon) or Zalikwele (in Kpele) was founded between 1800 and 1850. One day, Yakpawolo Goikoya Zogbelemou (one of the descendants of HweleKpe), was struck down with a dermatosis that he had difficulty treating. During a hunting scene, he became very thirsty and hungry. He quenched his thirst in the waters of the stream that rises between the current civil prison and the court of first instance of N'Zerekore. Immediately, he found a cassava plant at the water's edge. He pulled it up and used it to satisfy his hunger. He slept soundly. When he woke up, he found that his scabies had completely disappeared. Surprised, he cried out "Zali ka", it is my medicine. Then, he added: "Ga zalikwele" which means "I am near my medicine, next to my medicine". Hence the name "Zalikwele" distorted by N'Zerekore by the colonist.

The vegetation around N'Zerekore, once impenetrable, has rapidly deteriorated under the pressure of an increasingly rampant and demanding population. Slash-and-burn cultivation of rice, cassava, peanuts, bananas, and taros, along with coffee, cocoa, oil palm, and rubber plantations, has reduced the secondary forest, half a century ago, to a wooded or shrubby savannah in places. From an aerial view,



These two techniques were used not only to identify the sources of pollution in the Tile River's waters, but also the riverside stakeholders responsible for them. This observation allowed us to identify some of the activities carried out along the Tile River and to describe the study area.

## 2.2. Choice of Sites Sampling

Considering the various activities practiced in the study area (rice growing, market gardening, households, markets, livestock, mechanics, welding, brick kiln, entrepreneurship,) and the natural characteristics (distribution of the hydrographic network in the city, topography, etc.), we selected three (3) sites distributed along the watercourse, taking into account their accessibility and the actual characteristics of the waters of the Tile River in the study area. These are: Bellevue upstream, Commercial in the center and Mohomou downstream in the city of N'Zerekore. The name of each site is that of the district in which the site is located.

Three sampling points were strategically selected to represent upstream, mid-stream, and downstream watershed conditions, consistent with EPA (2002) guidance on the importance of spatial replication to capture longitudinal water quality gradients in river systems. This approach ensures adequate representation of spatial variations in environmental pressures along the hydrologic continuum. **Table 1** below shows the contact details geographical of the sites sampling.

Water samples for analysis were collected in plastic bottles provided by the CÉRE laboratory. Samples were taken in the mornings before 12:00 to facilitate the loading, storage and transport of samples to the CÉRE laboratory on the WFP humanitarian flight on 21/08/2024. The bottles intended for deep sampling were attached to a string of sufficient length to reach the required depth [Bilgin \(2018\)](#).

**Table 1.** Contact details geographical of the sites sampling.

| Site sampling | Longitude O | Latitude N |
|---------------|-------------|------------|
| Bellevue      | 8°47'58,51  | 7°45'26,19 |
| Commercial    | 8°48'79,54  | 7°44'58,36 |
| Mohomou       | 8°49'29,03  | 7°44'20,19 |

## 3. Measurement of Physicochemical and Bacteriological Parameters

**Table 2** gives the methods of analysis of the different parameters assigned to the study.

### Satellite Image Processing and Diachronic Mapping of Land Use from 1993 to 2023 in the Urban Commune of N'Zerekore

Satellite image processing was used. Its aim was to produce a map of land use over three (30) years from 1993 to 2023 to understand the changes induced over time. This interface allowed us to locate the study area on the world map and generate

**Table 2.** Parameters analyzed and analysis methods.

| No.                                    | Settings                     | Method of analysis                   |
|--|------------------------------|--------------------------------------|
| 1                                      | pH                           | pH meter 70+WATERPOOF                |
| 2                                      | Temperature                  | Multiparameter (Eh, EC, T°, pH)      |
| 3                                      | Conductivity                 | 70+WATERPOOF Conductivity Meter      |
| 4                                      | Total dissolved solids       | 70+WATERPOOF Conductivity Meter      |
| 5                                      | Suspended matter             | DR/850 HACH Spectrophotometry        |
| 6                                      | Turbidity                    | Lovibond Model TB210 IR Turbidimetry |
| 7                                      | Total iron                   | DR/850 HACH Spectrophotometry        |
| 8                                      | Nitrate                      | DR/850 HACH Spectrophotometry        |
| 10                                     | Nitrite                      | Spectrophotometry DR/850HACH         |
| 11                                     | Sulfate                      | Spectrophotometry DR/850HACH         |
| 12                                     | Salinity                     | Spectrophotometry DR/850HACH         |
| 13                                     | Dissolved oxygen             | Oximeter 70+WATERPOOF                |
| 14                                     | DCO                          | Titrimetric                          |
| 15                                     | DBO5                         | Pressure probe manometry             |
| 16                                     | REDOX potential (Eh) mV      | Multiparameter (Eh, EC, T°, pH)      |
| 17                                     | Copper                       | Spectrophotometry DR/1900HACH        |
| 18                                     | Potassium                    | Spectrophotometry DR/1900HACH        |
| 19                                     | Zinc                         | Spectrophotometry DR/1900HACH        |
| 20                                     | Chloride                     | NF EN 196-2                          |
| 22                                     | Phosphates                   | Spectrophotometry DR/850HACH         |
| <b>Bacteriological analysis method</b> |                              |                                      |
| 23                                     | Total coliforms              | Membrane filtration                  |
| 24                                     | Fecal coliforms              | Membrane filtration                  |
| 25                                     | Fecal streptococci           | Membrane filtration                  |
| 26                                     | Escherichia Coli             | Membrane filtration                  |
| 27                                     | BHAA (total microbial flora) | Incorporation into agar              |

land use maps for each of the periods chosen as the reference date for this field study.

This processing was done in two stages namely pre-processing and post-processing. The first stage consisted of downloading the Landsat image scenes from 1993, 2003 and 2023 onto the USGS plate, before sending them, after downloading, into the QGIS software. They were filtered to reduce their atmospheric noise, we used the SAGA raster filter (Aplacian filter) to improve the quality of the extracted images and to do the fusion. After the fusion, we went into (raster various fusion), on LANDSAT5, in order to merge the bands 2; 3; 4 and 5 to obtain a pseudo color band on LANDSAT8, 2, 3, 4 8. Then, a mask for each scene was

created in order to cut our study area according to the different periods chosen for this study.

After the visual evaluation of the images, we did (raster extraction cut) in order to cut these images following the outline of the study area. Afterwards, the cut images were placed in the set band. This is how we created the training and took the ROI (Regions of Interest) after clicking on RUN to launch the spatial-temporal occupation units to be extracted according to the results from the surveys carried out in the field. These focused on: (I) vegetation; (ii) buildings; (iii) bare soils; (iv) water.

As for the second step, it consisted of determining the confusion matrix. To do this, we went into SCP accuracy to sift the images. To achieve this, we did (raster conversion sift) which allowed us to vectorize the sifted images. Vectorization, which is the last step in image processing, consisted of converting the classified images from raster mode to vector mode (polygons) in order to facilitate the management of these images in the GIS analysis software, Arc GIS 10 and to remove the overflow, before calculating the surface.

In this study, we chose supervised classification. The supervised classification used is the Maximum Likelihood algorithm. It was used by several authors because it provides detailed information on land use maps. Its choice is motivated by the good knowledge of the study area. Furthermore, authors such as [Rifal \(2018\)](#) and [Alouche \(2020\)](#) agree that the algorithm, by maximum, is widely used in supervised classifications and is considered the most efficient algorithm in the production of thematic maps in the field of land use.

The quality of the classification was assessed using the confusion matrix through the calculation of the overall accuracy and the Kappa index. The overall accuracy obtained is respectively 95.50 with a Kappa coefficient of 0.85% for the 2000 and 2020 images. The classification is evaluated by the confusion matrix. In the diagonal, the well-classified pixels and the poorly placed pixels are off-diagonal. As for the Kappa index, it expresses the proportional reduction of the error obtained by a classification compared to the error obtained by a completely random classification. Their values, according to ([Kouadio et al., 2020](#)) are presented as follows in [Table 3](#) below.

**Table 3.** Assessment of the Kappa coefficient.

| VALUES       | CATEGORIES               |
|--------------|--------------------------|
| 0 TO 0.20    | VERY WEAK AGREEMENT      |
| 0.21 TO 0.40 | WEAK AGREEMENT           |
| 0.41 TO 0.60 | MODERATE AGREEMENT       |
| 0.61 TO 0.80 | SUBSTANTIAL AGREEMENT    |
| 0.81 TO 1    | ALMOST PERFECT AGREEMENT |

The table above shows the appreciation of the Kappa coefficient.

After establishing the land use maps for 1993 (T1), 2003 (T2) and 2023 (T3), we calculated the variation in surface areas in hectares and the annual rate of change of the land use classes or units used in this study.

The calculation of the variation in surface areas in hectares made it possible to determine, on a global scale (1993-2003-2023), the changes that occurred in the surface areas of the different class units for these different dates.

To perform this calculation, we subtracted the final area from the initial area relative to the study interval of the chosen dates as indicated by the formula of Soro et al. (2014), presented below.

$$R = Vf - Vi \text{ (ha) Or:}$$

- R = Represents the variation in the area of a stratum between the interval of two times (T1, T2 and T3);
- Vf = Represents the value of the area at time T2 (final);
- Vi = Represents the value of the area at time T1 (initial).

As for the calculation of the annual rate of change in land use as a percentage, it allowed us to determine the changes that occurred in the interval of observation periods (30 years) from 1993 to 2023. To carry out this calculation, we divided the value of the result from the subtraction between the final value (Vf) and the initial value (Vi) of each land use unit by one hundred multiplied by the observation period which is thirty (30) years, as established by the formula of Soro et al. (2014) below.

$$\text{Annual T} = Vf - Vi / 100 \times P \text{ (\%)}$$

In short, this work allowed us, firstly, to deduce that the positive values resulting from these calculations represent a progression; the negative values a regression and those close to Zero show that the class remains relatively stable between the three (3) dates. Secondly, it also allowed us to conclude the changes induced by urbanization in N'Zerekore.

## 4. Results

### Evolution of the population of the prefecture of N'Zerekore

Figure 2 shows the population growth of the prefecture of N'Zerekore from 1980 to 2025.

### Analysis of the Dynamics of Land Use Induced by Urbanization in the Tile Basin from 1993 to 2023 in the Urban Commune of N'Zerekore

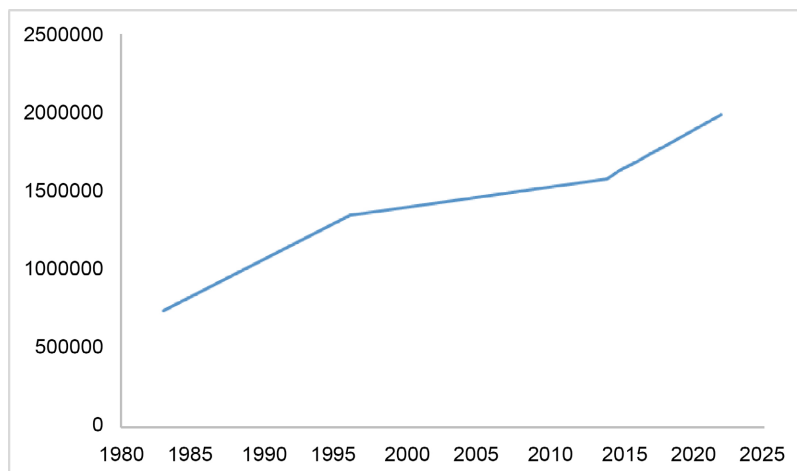
Land use map of the N'Zerekore. Figure 3 below shows Land use of the CU of N'Zerekore for the year 1993.

#### Land use map of the urban commune of N'Zerekore in 2003

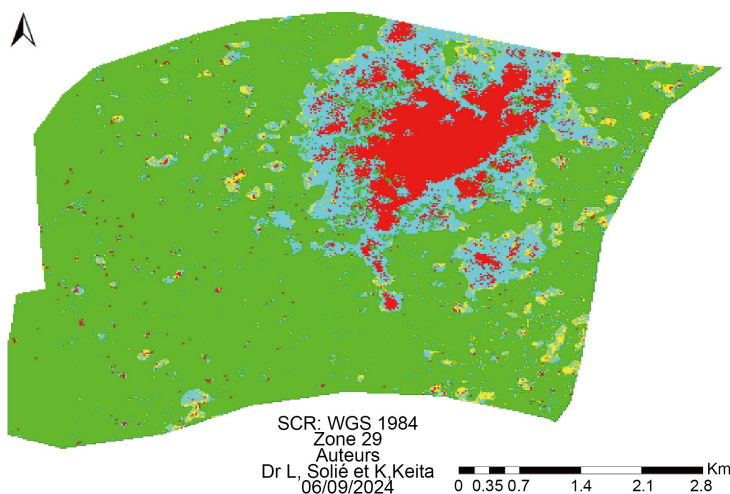
Figure 4 below shows Land use of the CU of N'Zerekore for the year 2003.

Figure 5 below shows Land use of the CU of N'Zerekore for the year 2013.

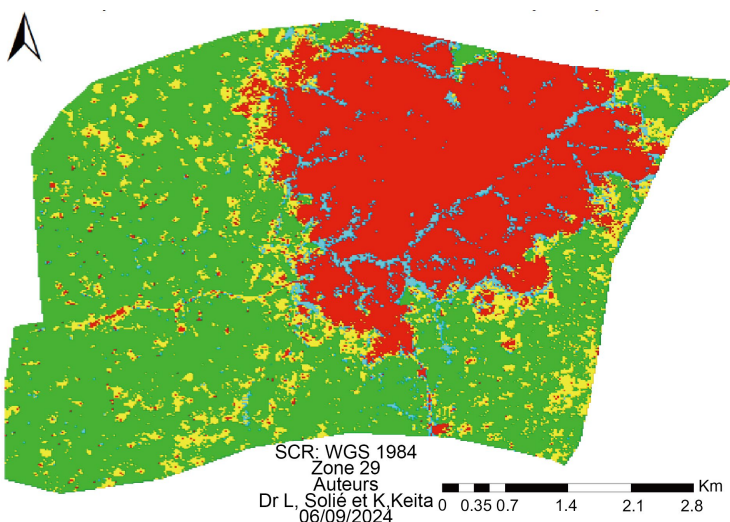
Figure 6 below shows Land use of the CU of N'Zerekore for the year 2023.



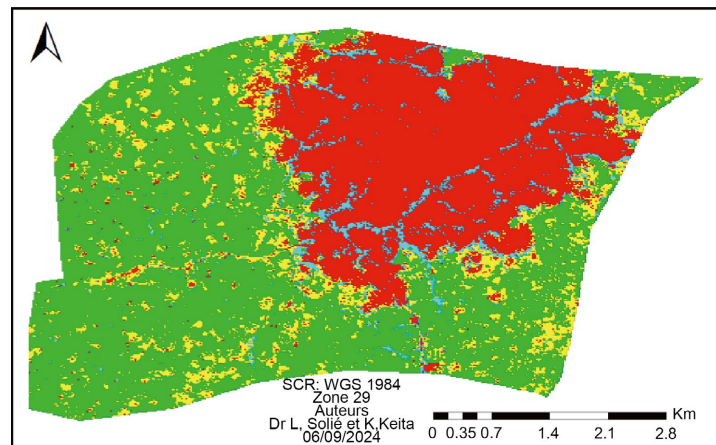
**Figure 2.** Evolution of the population of the Prefecture of N’Zerekore from 1980 to 2025 (National Institute of Statistics/RGPH: 1983; RGPH 1996 and RGPH 2014).



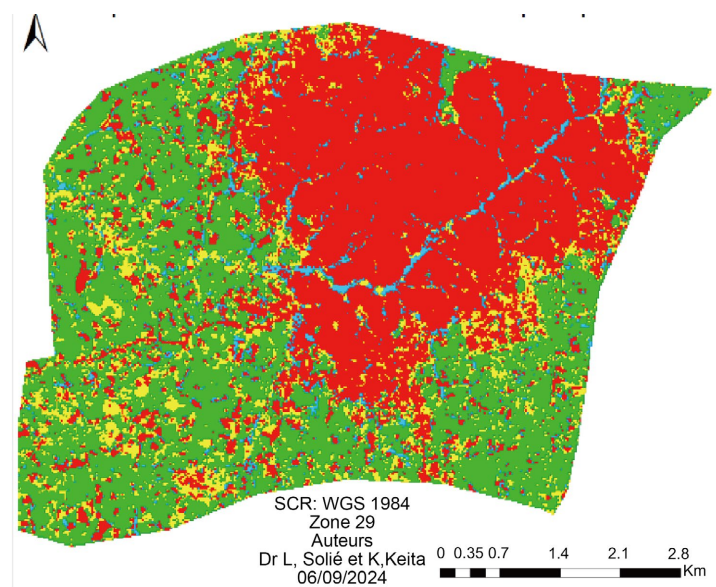
**Figure 3.** Land use of the CU of N’Zerekore for the year 1993



**Figure 4.** Land use of the CU of N’Zerekore for the year 2013.



**Figure 5.** Variation in occupancy classes 2013.



**Figure 6.** Land use of the CU of N'Zerekore for the year 2023.

## 5. Conclusion

This research has helped us understand the interactions between land use and water quality, confirming the importance of an integrated approach to land use planning. It also confirms that without appropriate measures, increasing urbanization directly threatens aquatic ecosystems and freshwater resources.

For urban planners, these results underscore the urgent need to design mitigation strategies that combine urban development with the preservation of natural resources. Adopting nature-based solutions (NBS), limiting impervious surfaces, and implementing green infrastructure represent effective levers for reconciling urbanization and protecting the water environment.

## 6. Discussion

The results of this study highlight a significant correlation between land use pat-

terns and surface water quality in the study area. More specifically, the intensification of urban, industrial, and agricultural areas is accompanied by an increase in nutrient concentrations (nitrates, phosphates), suspended solids, and organic pollutants. These effects are particularly pronounced in urban areas where soil sealing reduces stormwater infiltration, thus increasing pollutant-laden surface runoff.

In contrast, areas with dense forest cover or vegetated riparian buffers demonstrate a better ability to maintain water quality thanks to their role as natural filters. These buffer zones contribute to reducing nutrient and sediment inputs into waterways. The implications for land use planning are therefore major: unplanned or uncontrolled urbanization risks lastingly altering the quality of water resources, with impacts on public health, agriculture and aquatic biodiversity.

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Avoid the stilted expression, “One of us (R. B. G.) thanks...” Instead, try “R. B. G. thanks”. Do NOT put sponsor acknowledgements in the unnumbered footnote on the first page, but at here.

Recommended mitigation measures for urban planners:

1. Integration of vegetated buffer zones (riparian strips) around bodies of water and streams to limit polluting runoff.
2. Promotion of green infrastructure (green roofs, permeable pavements, retention basins) in new urban development areas to promote stormwater infiltration.
3. Rational planning of urban expansion by maintaining a minimum proportion of green spaces and permeable soils to limit excessive sealing.
4. Strict regulation of industrial and agricultural discharges, with regular monitoring of water quality in at-risk areas.
5. Awareness-raising and involvement of local stakeholders (communities, real estate developers, farmers) in the implementation of good land-use practices.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

## References

- Alouche, F. (2020). Comparative Study of Supervised Classification Algorithms for Land Use Mapping: Application to Satellite Imagery. *Journal of Geographic Information and Decision Analysis*, 14, 45-59.
- Bilgin, A. (2018). Surface Water Quality Assessment Using the Canadian Council of Ministers of the Environment (CCO) Water Quality Index and Discriminant Analysis Method: A Case Study on the Coruh River Basin. *Environmental Monitoring and Assessment*, 190, 1-11.
- Delamou, A., Samandari, G., Camara, B. S., Traoré, P., Diallo, F. G., Millimono, S., Verani, F. et al. (2015). Prevalence and Correlates of Domestic Violence among Family Planning Clients in Conakry, Guinea. *BMC Research Notes*, 8, Article No. 814.
- Flavien, L. et al. (2011). *Importance of Spatial Discontinuity in the Case of Restoring the*

*Connectivity of the Forest Network in Lorraine.*

- Guy-Romain, K. K., Mpakam, H. G., Ndonwy, S. A., Bopda, S. L. D., & Ekodeck, G. E. (2006). Integrated Water Resources Management and Millennium Development Goals in Africa: Case of Cameroon. *Vertigo-la revue électronique en sciences de l'environnement*, vol. 7. <https://doi.org/10.4000/vertigo.1803>
- Heim, C., Shugart, M., Craighead, W. E., & Nemeroff, C. B. (2010). Neurobiological and Psychiatric Consequences of Child Abuse and Neglect. *Developmental Psychobiology*, 52, 671-690. <https://doi.org/10.1002/dev.20494>
- Kouadio, K. K., Soro, G. E., Kouadio, L. Y., & Soro, N. (2020). Évaluation de la dynamique spatio-temporelle de l'occupation du sol dans le bassin versant du fleuve Bandama à l'aide de la télédétection et des SIG. *European Scientific Journal, ESJ*, 16, 185-202. <https://doi.org/10.19044/esj.2020.v16n3p185>
- Pantha, K., Acharya, K., Mohapatra, S., Khanal, S., Amatya, N., Ospina-Betancourth, C. et al. (2021). Faecal Pollution Source Tracking in the Holy Bagmati River by Portable 16S rRNA Gene Sequencing. *NPJ Clean Water*, 4, Article No. 12. <https://doi.org/10.1038/s41545-021-00099-1>
- Rifal, A. (2018). Application of Supervised Classification Using Maximum Likelihood for Land Use and Land Cover Mapping. *International Journal of Remote Sensing and GIS*, 7, 1-8.
- Servat, E. (2022). Water, the Urban Challenge. *LUM Magazine-University of Montpellier*.
- Soro, G. E., Kouadio, K. K., Soro, N., & Kouadio, L. Y. (2014). Analyse de la dynamique de l'occupation du sol dans le bassin versant du fleuve Agnéby (sud de la Côte d'Ivoire) par télédétection et SIG. *European Scientific Journal, ESJ*, 10, 379-394.