

# Realization of a WebGIS for Remote Control of Biometric Sensors for Facial Recognition of Permanent Staff in an Educational Environment: The Case of the Ministry of National Education in Conakry, Guinea

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## Abstract

Initially focused on the earth sciences and mining resources, remote sensing is now finding increasing applications, notably in human resources management in public administration. This study proposes a WebGIS for real-time tracking using geolocated biometric sensors for facial recognition, with a view to optimizing the attendance management of MENA teachers in Conakry. The system is based on an integrated architecture combining open-source facial recognition sensors, a PostgreSQL/PostGIS database, a QGIS Server, and a Lizmap Web Client interface. Each sensor, installed in a school, automatically detects the teachers initially enrolled and records their clocking-in times. Data is stored locally and then transmitted to the central server via the MQTT protocol, with GSM/GPRS or LoRa relay in the event of failure. This infrastructure enables attendance to be mapped and controlled remotely, promoting transparency and administrative efficiency. Analysis of facial recognition clocking-in data, collected in nine MENA schools in Conakry for a total of 334 teachers, reveals an overall weekly attendance rate of 80.7%, *i.e.*, 1,348 attendances out of 1,670 expected. Of these, 73.5% were on schedule, while 26.5% showed irregularities (late arrivals, early departures, or both). These discrepancies are mainly due to rush-hour traffic jams, aggravated by the fact that, for economic reasons, most teachers live in the suburbs. As for absences (19.3%), the main causes identified are: socio-political problems (70%), social events (22%), health rea-

sons (7%), and 1% unjustified. A notable anomaly was observed on the 2<sup>nd</sup> day of collection with 68% absences, linked to a political demonstration by opposition parties. The integration of these data into a WebGIS system enables dynamic, geographical visualization of teacher presence, promoting better workforce management and decision-making within the Ministry.

## Keywords

WebGIS, Geolocated Biometric Sensors, Facial Recognition, Attendance Management, QGIS Server, Lizmap, PostGIS, MENA, Conakry

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## 1. Introduction

Human resources management in the public sector remains a challenge in Guinea, particularly in education, where the monitoring of teacher attendance in Conakry suffers from structural flaws: lack of reliable systems, red tape, falsified attendance records, and lack of real-time monitoring. In 2015, the government tested the use of biometric fingerprint time clocks in ministries [1] [2], but this initiative failed due to maintenance issues, lack of data centralization, and vulnerability to field realities. The COVID-19 crisis led to the abandonment of the device, which was deemed risky because of the physical contact involved.

Faced with these limitations, contactless technologies such as facial recognition coupled with geolocation in a WebGIS infrastructure are emerging as more resilient alternatives. In the sub-region, several examples confirm their relevance: in Cameroon to combat absenteeism [3], in Côte d'Ivoire to supervise pupils [4], and in Ghana in public schools [5].

Drawing on these sub-regional lessons and the shortcomings of the previous Guinean system, the aim of this study is to develop an interactive WebGIS for real-time monitoring and remote control using biometric facial recognition sensors, with a view to optimizing the management of permanent teaching staff attendance at schools in Conakry. Specifically, this will involve:

- 1) Model the geographic information system by integrating biometric, spatial, and temporal data into a coherent architecture based on a PostgreSQL/PostGIS database;
- 2) Deploy biometric facial recognition sensors interfaced to a WebGIS for automatic teacher attendance registration;
- 3) Remote control and real-time monitoring of teaching staff via geolocated connected sensors.

## 2. Presentation of the Study Area

Guinea (Conakry) is a coastal country in West Africa. It lies between latitudes 7°00'00" and 13°00'00" North and longitude 13°10' West, covering an area of 245,857 km<sup>2</sup>. It is bordered to the east by Côte d'Ivoire and Mali, to the south by Liberia and

Sierra Leone, to the west by the Atlantic Ocean and Guinea-Bissau, and to the north by Senegal and Mali. Its capital, Conakry, the subject of this study, lies between latitudes 9°24'00" and 9°42'00" North and longitudes 13°30'00" and 13°51'00" West (Figure 1).

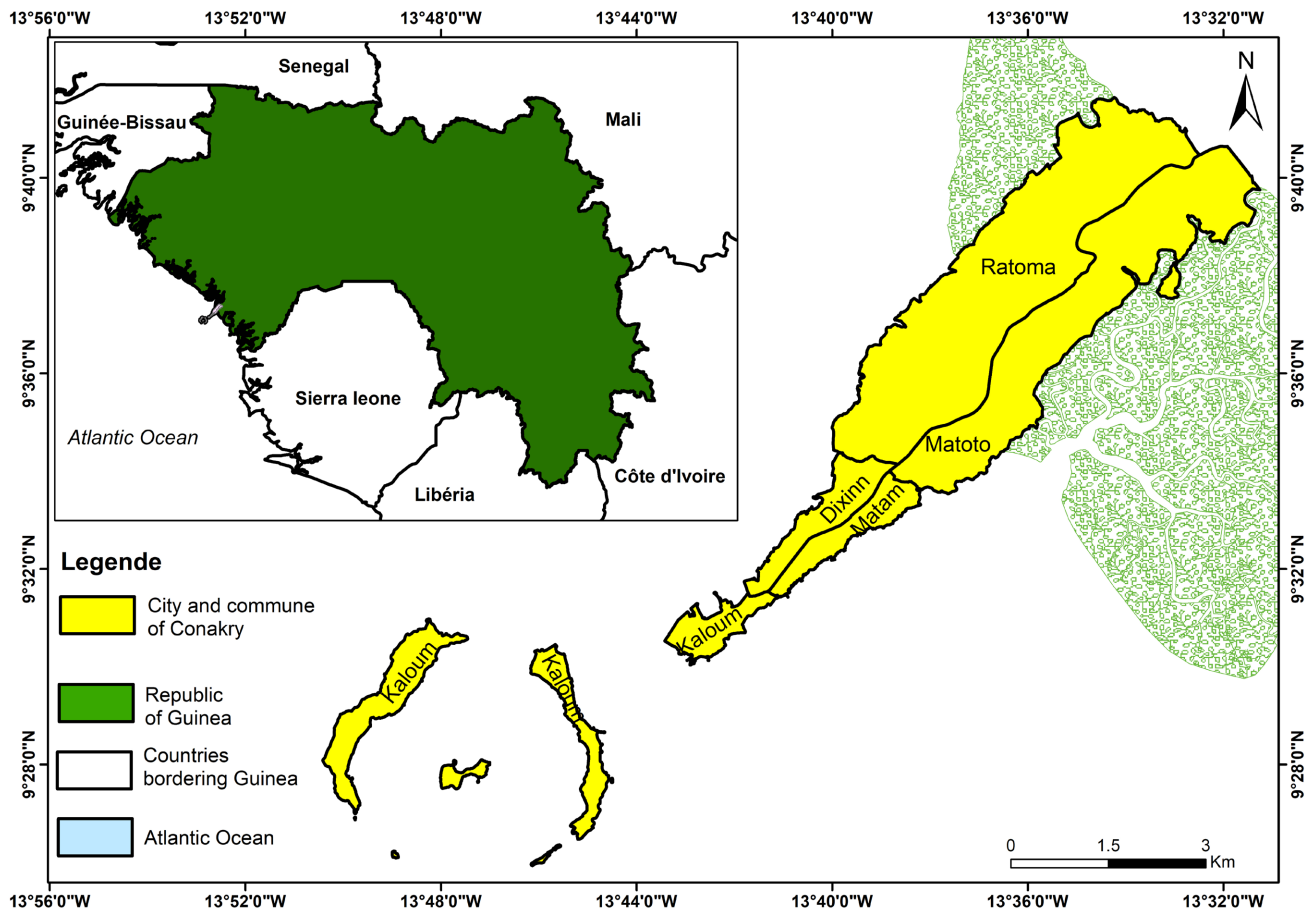


Figure 1. Location of the city of Conakry.

### 3. Equipment and Methods

#### 3.1. Equipment

##### 3.1.1. Digital Data

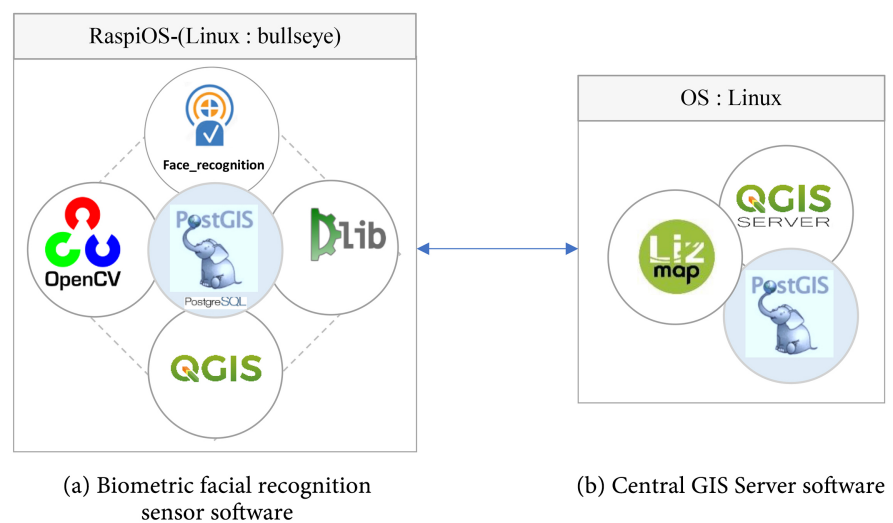
The study was based on a set of materials and data. Vector-based geographic data, in particular shapefiles of administrative boundaries, were supplied by INS (National Institute of Statistics) Guinea. The BSD of the MENA provided an Excel file containing the GPS coordinates of the schools. In addition, administrative documents (decrees, laws) from MENA (Ministry of National Education and Literacy), METFP (Ministry of Technical Education and Vocational Training), MESRS (Ministry of Higher Education and Scientific Research) and MFPREMA (Ministry of the Civil Service, State Reform and Modernization of Administration) were analyzed to understand the institutional framework of human resources management.

### 3.1.2. Field Equipment

The facial recognition device consists of a nano-computer (Raspberry Pi) and a camera. There is also a GARMIN 64 GPS receiver, which was used to collect the geographical coordinates of the various sites where the facial recognition surveillance cameras involved in the study were installed. To cope with power cuts, a photovoltaic solar power supply has been installed to ensure the continuous operation of the biometric cameras.

### 3.1.3. Software

Software used includes QGIS Desktop for GIS management, PostgreSQL/PostGIS for spatial data storage, and OpenCV, dlib, and face\_recognition for facial recognition. QGIS Server and Lizmap Web Client were used for online map publication (Figure 2).



**Figure 2.** Central GIS server software and a facial recognition sensor.

## 3.2. Methode

The WebGIS developed integrates several essential modules for effectively managing permanent teaching staff in Conakry, Guinea. It provides user administration, configuration of specific parameters, management of personnel information, biometric enrolment, sensor geolocation, attendance monitoring via facial recognition, and face encoding and learning. The system also tracks staff mobility, manages absence notifications, facilitates face searches, and offers dynamic presence mapping for optimized control and decision-making.

### 3.2.1. WebGIS Information System Modeling

Due to the complexity of the distributed, interactive system in this study, the UML (Unified Modeling Language) method was chosen over the MERISE method, which is considered less suitable for modeling connected architectures [6] [7]. The WebGIS class diagram, taking into account all the modules mentioned, is shown in Figure 3.

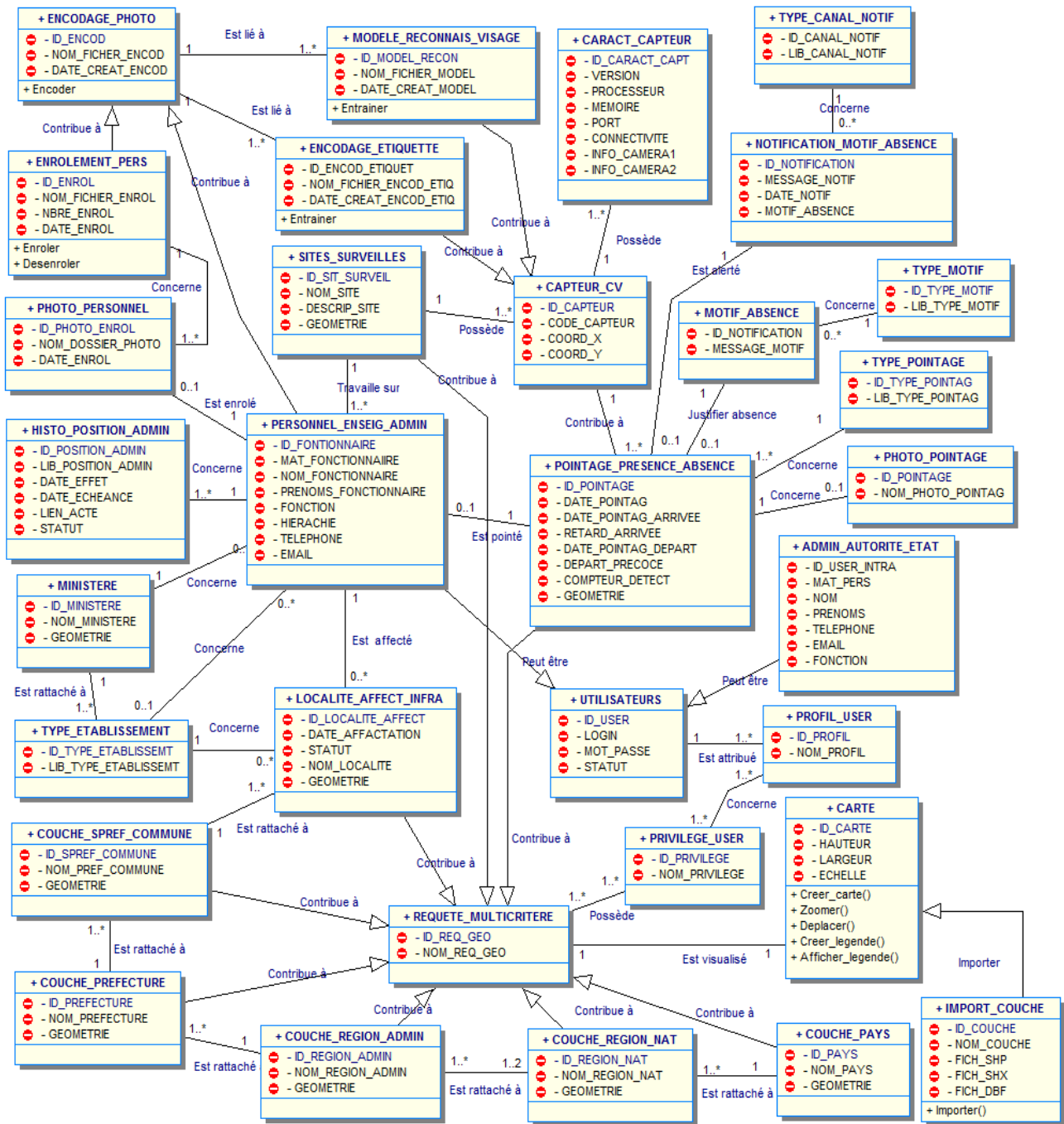
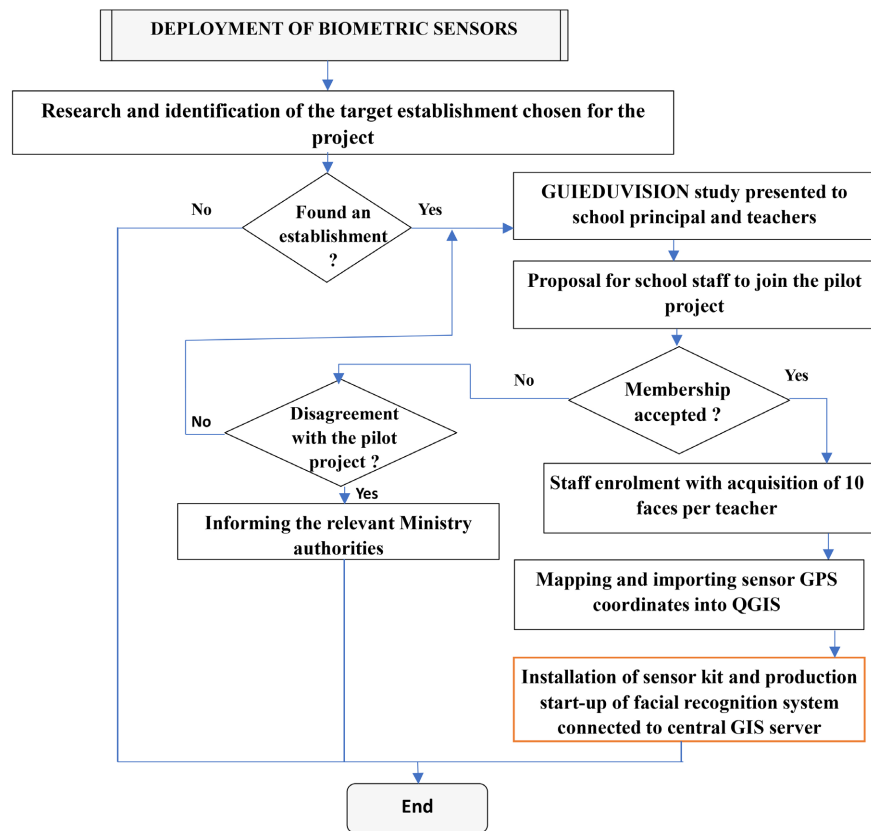


Figure 3. Class diagram of the WebGIS for managing permanent teaching staff numbers.

### 3.2.2. Deployment of Biometric Facial Recognition Sensors

In this context, the “GUI-EDU-VISION” pilot project, called “GUinea EDUCation VISION”, was launched to test the solution in targeted establishments. An awareness-raising phase precedes deployment, to present the objectives, technology, and guarantees concerning personal data. In the event of opposition, the Ministry decides what action to take. Sensor data are then integrated into WebGIS for centralized, real-time spatiotemporal monitoring of teaching staff (Figure 4).



**Figure 4.** Process for integrating biometric sensor information into WebGIS.

### 3.2.3. Remote Control and Monitoring of Teaching Staff via Connected Facial Recognition Sensors

#### 1) Data processing and transmission via IoT network infrastructure

The system integrates Raspberry Pi-based facial recognition sensors with GPS modules and high-resolution 4K cameras, connected via MQTT to a central server running QGIS Server and a PostgreSQL/PostGIS database. Sensor nodes are configured to operate autonomously and send real-time event logs, including timestamp, geolocation, and recognition status.

The facial recognition device communicates with a central GIS server via the Message Queuing Telemetry Transport (MQTT) protocol, ensuring efficient transmission of geospatial data. The process is illustrated in the following functional block diagram (Figure 5).

Each nano-computer (e.g., Raspberry Pi), equipped with a facial recognition camera, acts as an MQTT client. When a teacher is recognized, the score data is encapsulated in an MQTT message in the following format:

Syntax:

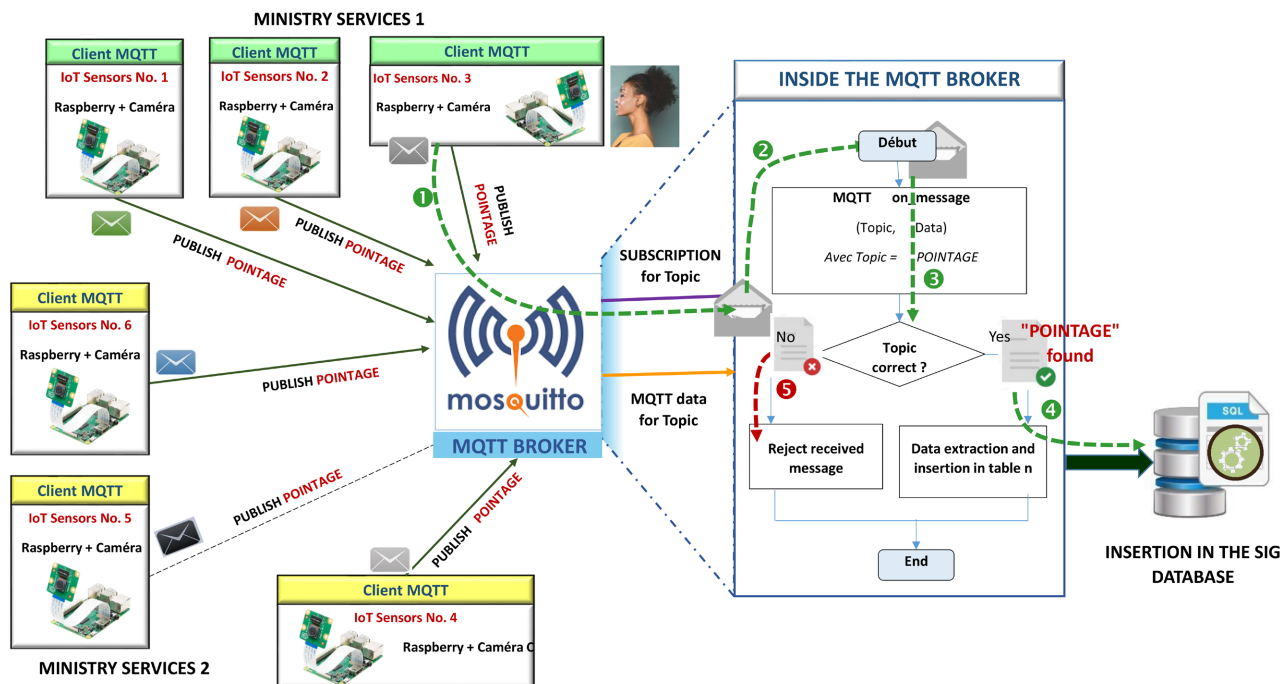
[topic]: [sensor\_code], [user\_id], [timestamp], [latitude], [longitude], [statut]

Example:

POINTAGE: C0002, A012, 2021-05-17 14:30, 13.0451, 7.5202, present

The message, sent via the IoT network to the MQTT broker (Mosquitto), is forwarded to the subscribed GIS server via a Python script. If the Internet is avail-

able, the data is inserted directly into the spatial database; if not, it is stored locally on the Raspberry Pi, then transferred once the connection has been re-established. These data enable geolocalized, real-time monitoring of teaching staff attendance. In addition, a backup transmission system with GSM/GPRS or LoRa relay is provided in the event of failure of the initial data transmission system based on the IoT network.



**Figure 5.** Functional synoptic diagram of geo-data centralization in an IoT network.

Given the sensitivity of the data processed, particularly biometric data, strict personal data protection measures have been integrated into the system. The system applies end-to-end encryption when transmitting biometric data via MQTT. No facial images are stored on the sensors; only anonymized facial vectors are transmitted to the central server for comparison. In addition, access to the supervision interfaces is reserved for authorized Ministry staff, with two-factor authentication. This system complies with the recommendations of the European General Data Protection Regulation (GDPR) on the processing of sensitive data, although it has not yet been officially transposed into Guinean law. A request for an opinion has also been submitted to Guinea's Autorité Nationale de Protection des Données Personnelles (ANPDP), whose recommendations are aligned with those of France's Commission Nationale de l'Informatique et des Libertés (CNIL).

## 2) Analysis and display of WebGIS data

Users interact seamlessly with WebGIS, quickly accessing time and attendance and permanent staff management data in real time. With each spatial query, WebGIS interrogates its database to obtain relevant results for monitoring teaching staff numbers. The various stages are detailed in **Figure 6**.

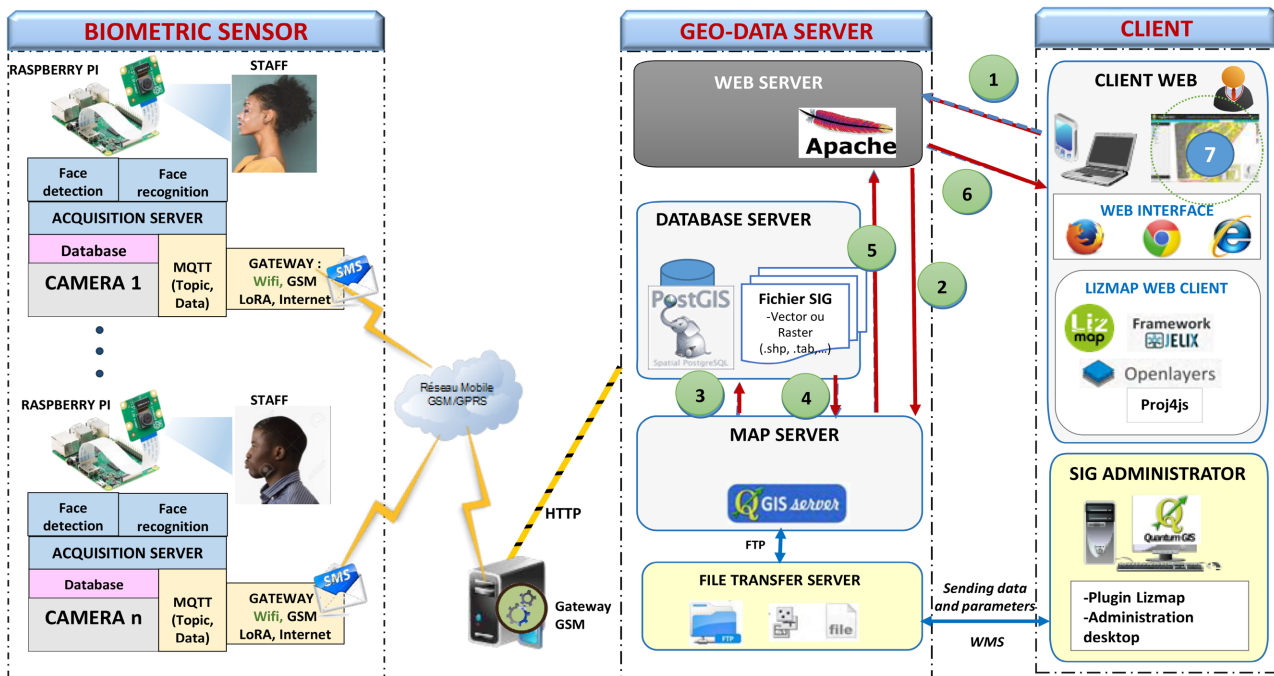


Figure 6. General WebGIS architecture.

When a user makes a spatial query, this is what happens:

- User query;
- The web server receives the request and asks the map server to execute it;
- The map server, in turn, asks the spatial database server to provide the requested data;
- The DBMS extracts useful information from its data warehouse and sends it back to the map server;
- Returns web services files (WMS, WFS, WCS) to the web server;
- The web server receives the files and inserts them into an HTML page;
- The user receives this page and views it in his browser.

## 4. Results and Discussion

### 4.1. Results

#### 4.1.1. Modeling the WebGIS Information System for Managing the Education System’s Workforce

Setting up a WebGIS begins with system modeling, followed by implementation in a database, and culminates in the display of data in a dynamic, interactive interface (Figure 7).

#### 4.1.2. Mapping of Conakry’s Open-Source Biometric Facial Recognition Sensors

As part of the remote control of teaching staff using facial recognition, the first step was to identify and locate educational establishments in Conakry (Table 1). On this basis, a progressive sensor deployment strategy was drawn up, taking into account staff density, geographical coverage, connectivity and the diversity of teaching levels.

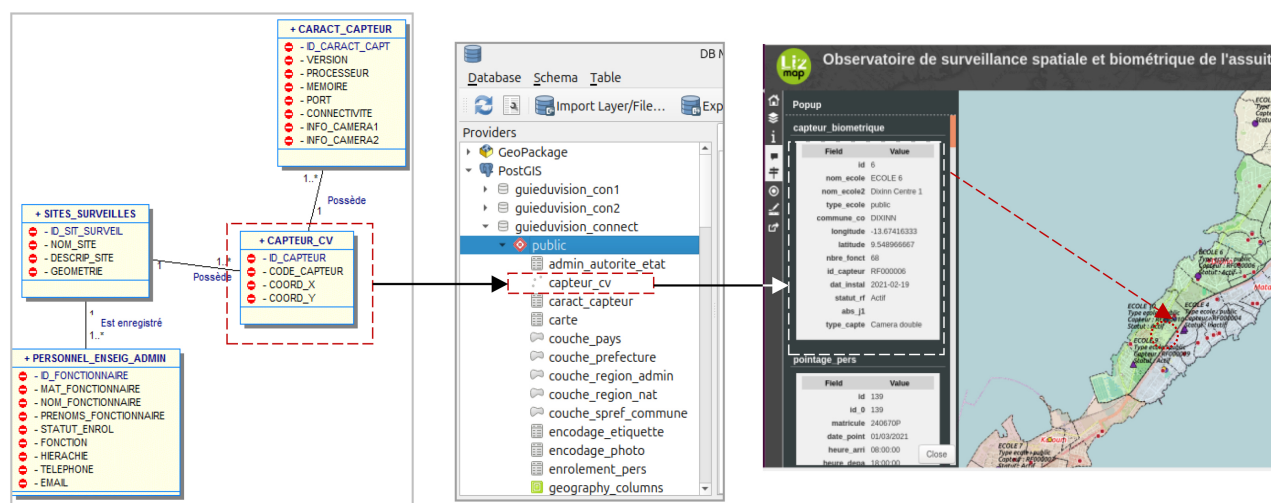


Figure 7. WebGIS modeling result.

Table 1. List of open-source biometric computer vision sensor installations observed.

Sensor ID	School name	School type	Teaching staff	Commune Conakry	Longitude	Latitude	Status
RF000001	ECOLE 1	Primaire	33	RATOMA	-13.662 425	9.578 926 667	Actif
RF000002	ECOLE 2	Primaire	35	RATOMA	-13.629 156 67	9.595 573 333	Actif
RF000003	ECOLE 3	Collège	25	KALOUM	-13.714 498 33	9.507 365	Actif
RF000004	ECOLE 4	Primaire	10	MATAM	-13.677 053 33	9.538 603 333	Inactif
RF000005	ECOLE 5	Primaire	26	MATOTO	-13.600 778 33	9.582 681 667	Actif
RF000006	ECOLE 6	Primaire	68	DIXINN	-13.674 163 33	9.548 966 667	Actif
RF000007	ECOLE 7	Lycée	70	KALOUM	-13.715 568 33	9.510 853	Actif
RF000008	ECOLE 8	Primaire	30	RATOMA	-13.654 128 33	9.604 033 333	Actif
RF000009	ECOLE 9	Primaire	15	DIXINN	-13.687 601 67	9.531 575	Actif
RF000010	ECOLE 10	Primaire	32	MATAM	-13.677 186 67	9.538 341 667	Actif

These nine schools were selected on the basis of three main criteria: 1) geographical distribution across Conakry's five communes, 2) staff size (schools with at least 15 permanent teachers), and 3) technical feasibility (availability of electricity and basic connectivity). While this selection has ensured practical deployment, it limits generalization to remote or small schools.

On this basis, the "GUI-EDU-VISION" project mobilized a total of 334 teachers out of the 344 listed in the ten schools initially identified, representing a 97.1% participation rate. These teachers are spread across the nine schools where the biometric sensors have actually been installed and activated. School 4, with only 10 teachers, was excluded for reasons of size and technical constraints (Figure 8).

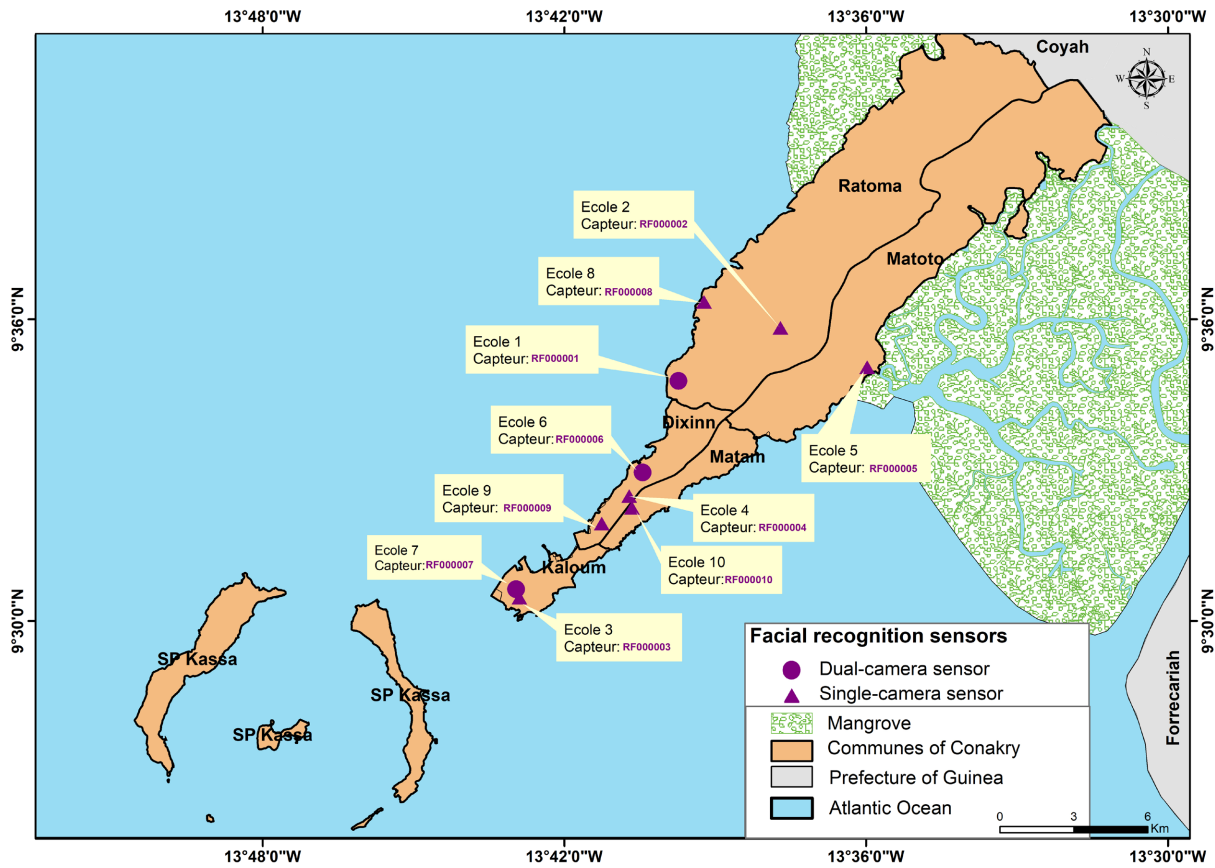


Figure 8. Mapping of open-source biometric facial recognition sensors.

#### 4.1.3. Data Acquired by Biometric Computer Vision Sensors

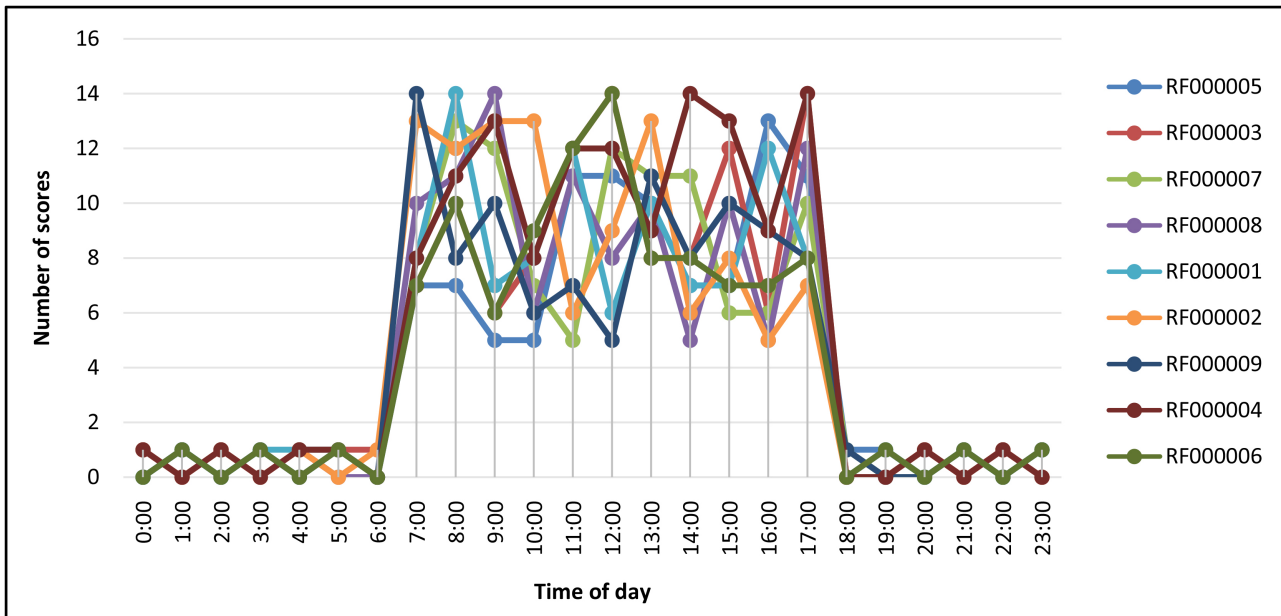
As soon as the open-source biometric facial recognition sensors went into production, the first teacher clocking-in data began to flow into the remote central GIS server. After conclusive tests on the deployment and operation of the computer vision devices, Webmapping was operational for one week, confirming the technical viability of the solution (Table 2).

Table 2. Extrait de relevé de pointage de présence des enseignants permanents.

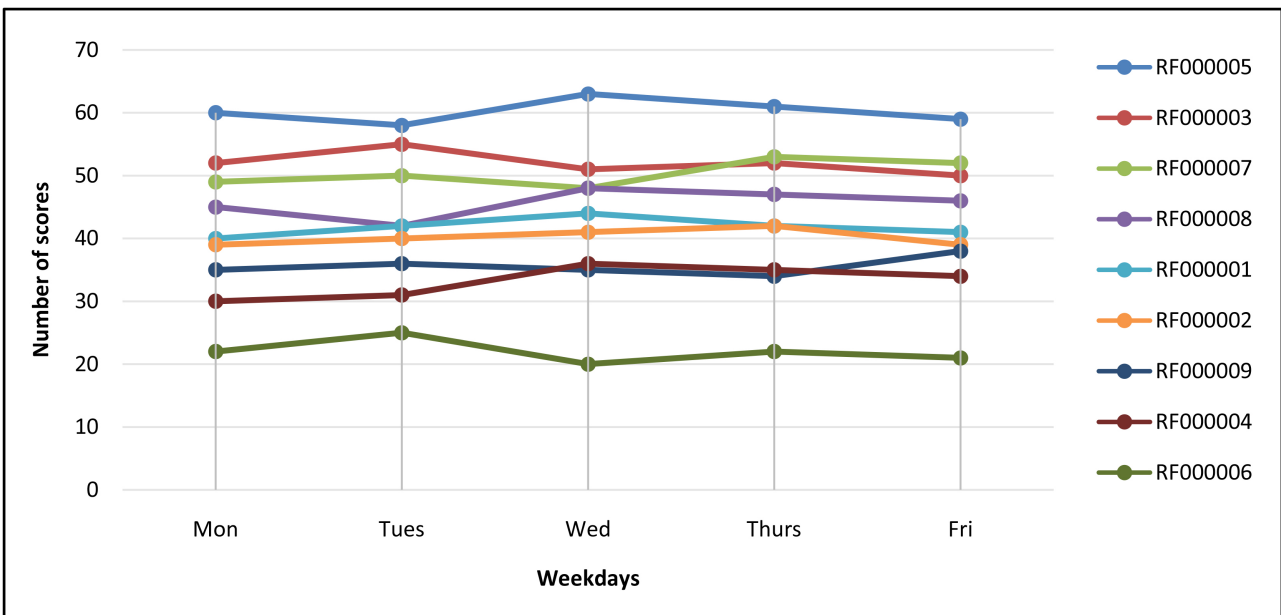
Sensor ID	Matricule	Date of completion	Arrival	Departure	School	Longitude	Latitude
RF000001	A0010	01/03/2021	07:14:00	17:50:00	ECOLE 1	-13.662 425	9.578 926 67
RF000001	A0023	01/03/2021	07:53:00	18:02:00	ECOLE 1	-13.662 425	9.578 926 67
RF000002	A0009	01/03/2021	07:54:00	17:10:00	ECOLE 2	-13.629 156 67	9.595 573 333
RF000001	A0018	01/03/2021	08:00:00	17:51:00	ECOLE 1	-13.662 425	9.578 926 67
RF000007	A0014	01/03/2021	08:04:00	18:10:00	ECOLE 7	-13.715 568 33	9.510 853
RF000006	A0007	01/03/2021	08:07:00	17:51:00	ECOLE 6	-13.674 163 33	9.548 966 667
RF000010	A0015	01/03/2021	08:08:00	17:15:00	ECOLE 10	-13.677 186 67	9.538 341 667
RF000005	A0016	01/03/2021	08:10:00	18:12:00	ECOLE 5	-13.600 778 33	9.582 681 667

#### 4.1.4. Remote Supervision of Biometric Facial Recognition Sensors

Biometric computer vision sensors are connected objects that are monitored in real time by WebGIS. **Figure 9** shows the number of biometric clockings recorded by 9 biometric sensors over the course of a working day and week (Monday to Friday). Each line represents the activity of a specific sensor, making it possible to compare their performance and detect any anomalies in operation or frequency. What's more, each sensor can be stopped or restarted remotely from the control center by SMS.

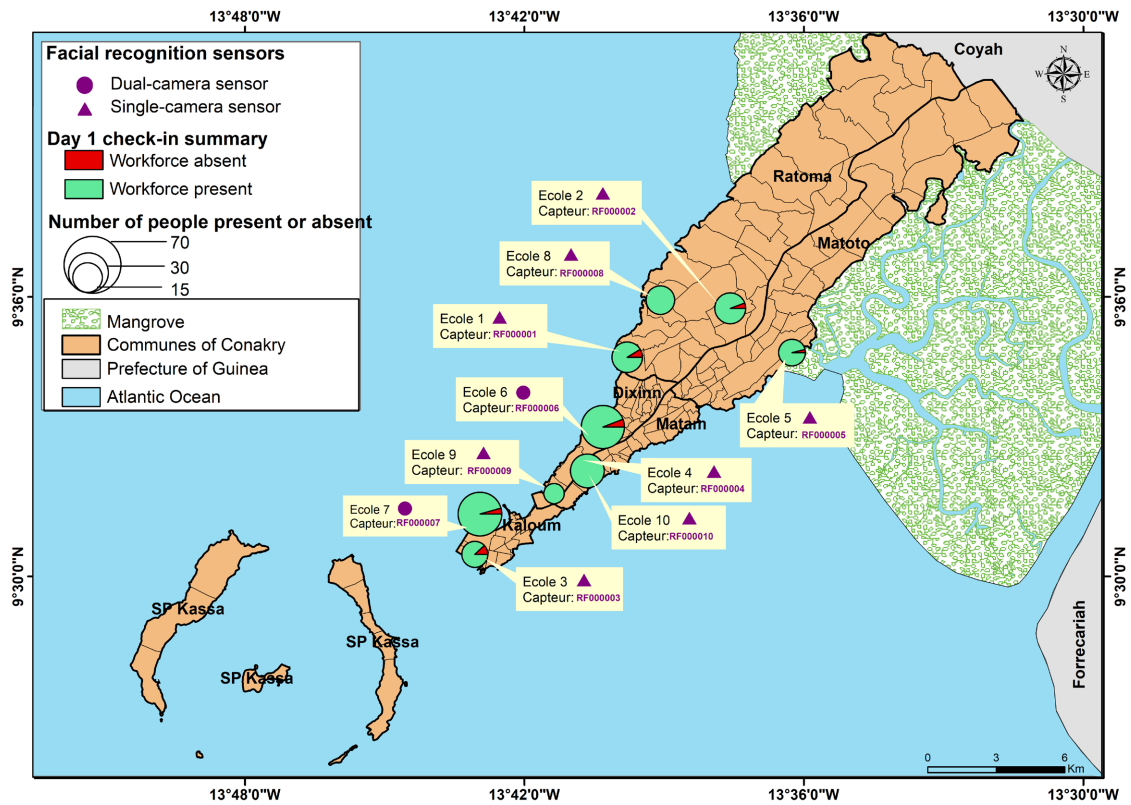


(a) Daily sensor activity

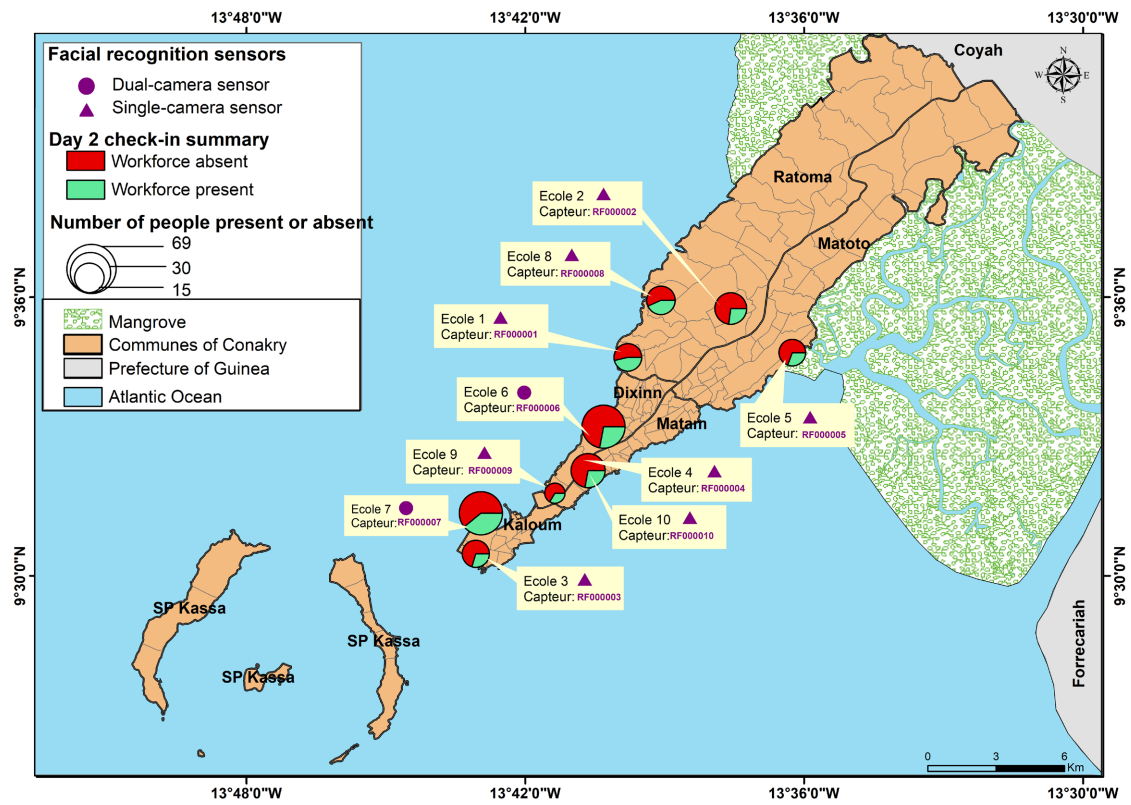


(b) Weekly sensor activities

**Figure 9.** Supervision curves for facial recognition biometric sensors.



(a) Daily attendance card from 01/03/2021 (1<sup>st</sup> day)



(b) Daily attendance card for 02/03/2021 (2<sup>nd</sup> day)

**Figure 10.** Visualization of some daily WebGIS scores.

#### 4.1.5. Remote Sensing of Teacher Attendance/Absences

##### 1) Analysis of teachers' daily attendance and absences

Figure 10(a) illustrates the low proportion of absences (5%) recorded on the first day of check-in. Figure 10(b) reveals an abnormal rise in the absentee rate, reaching 68% on the second day, due to a political disruption. The following working days show a gradual return to normal, with a marked improvement in attendance.

##### 2) Analysis of weekly teacher attendance and absences

Over the course of a week, 1348 biometric entries were recorded. The WebSIG interface enabled real-time visualization of teacher registrations, late arrivals, and absences. The mapping system highlighted punctuality rates by school and correlated absences with known socio-political protest events.

These initial results show that the biometric time and attendance system has got off to a satisfactory start overall, with an 81% attendance rate recorded at all sites monitored. However, an absence rate of 19% was still observed during this first week of testing (Figure 11).

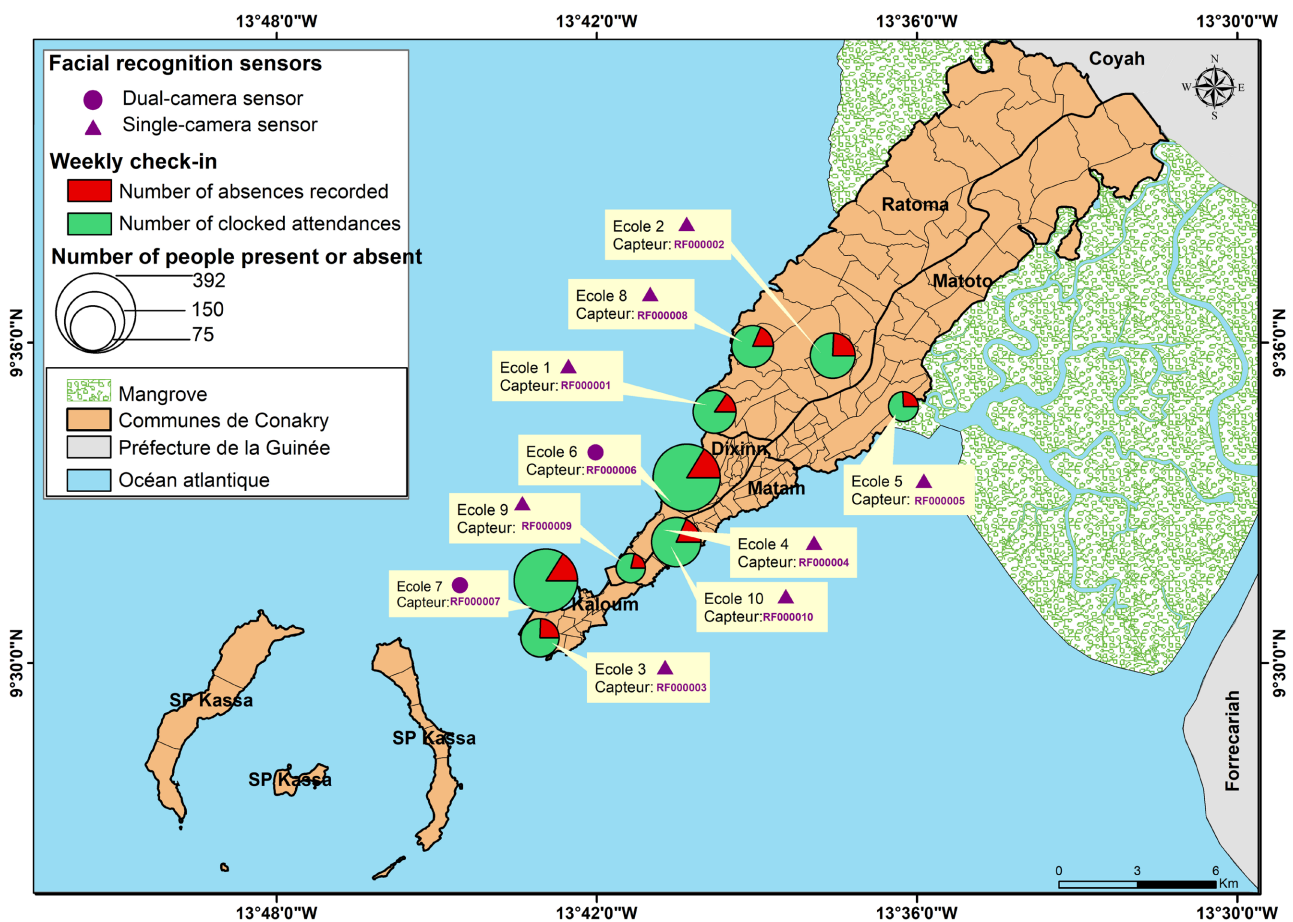


Figure 11. Weekly teacher attendance and absence report card.

#### 4.1.6. Decision Support System for Monitoring Staffing Levels

The integration of GIS into biometric management systems is not limited to simple visualization, but represents a strategic decision-support tool for improving

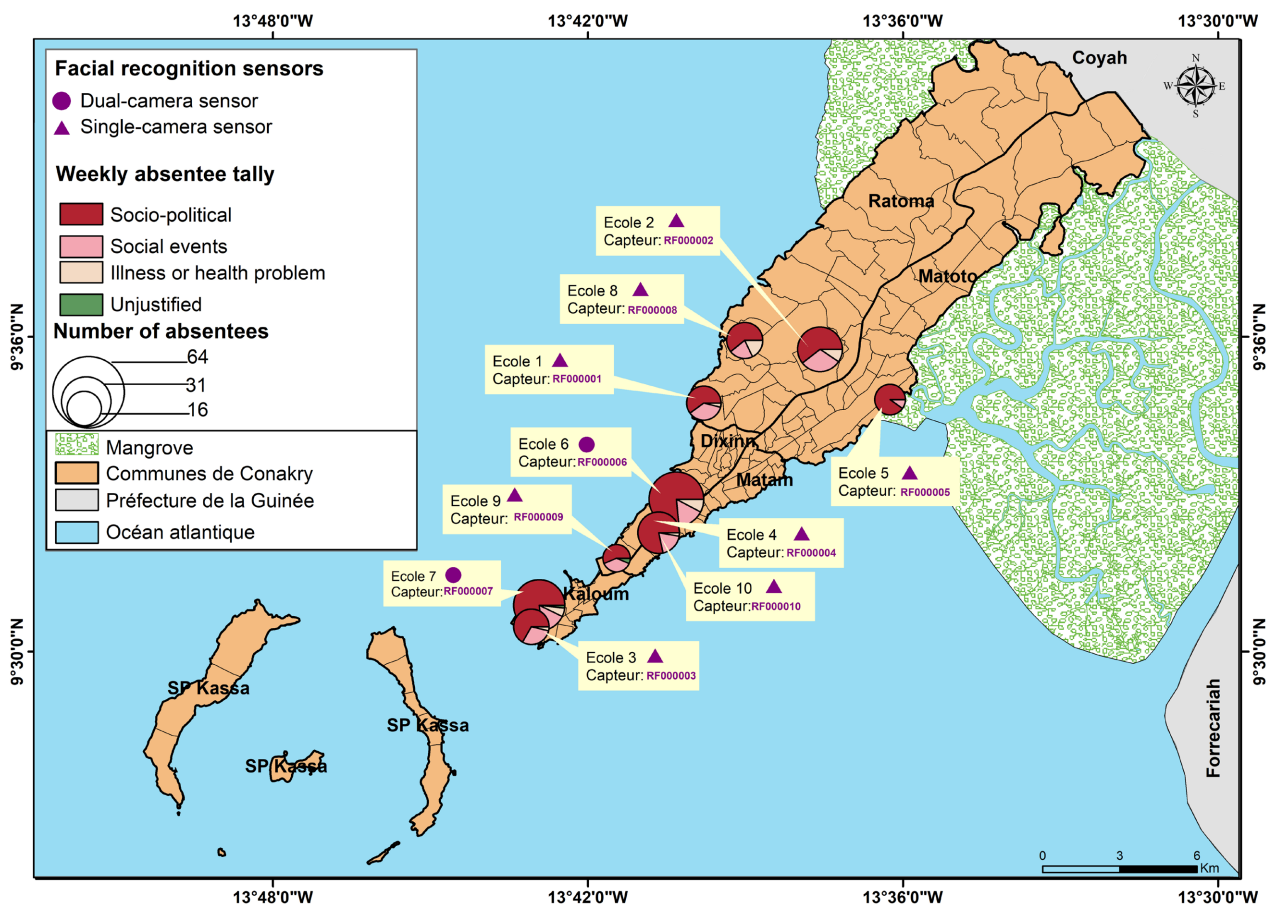
educational governance, reducing territorial inequalities, and enhancing the effectiveness of personnel management policies.

### 1) Classification of absences and identification of absence factors for teaching staff

The sudden change in attendance required an investigation to identify the causes, whether technical, organizational, or contextual, in order to ensure the reliability of the biometric system. An analysis of the accumulated data enabled us to detect recurring absences and draw out avenues for improvement.

An SMS notification system was set up to inform absent teachers and collect their justifications. The reasons for absence were analyzed on the basis of the responses obtained.

In 9 MENA schools in Conakry, out of 1670 expected clockings for 334 teachers, 322 absences were recorded (*i.e.*, 19.3%). Of these, 70% were due to socio-political factors (strikes, demonstrations, etc.), 22% to social events (weddings, christenings, funerals, etc.), 7% to health problems, and 1% were unjustified (**Figure 12**).



**Figure 12.** Classification map of weekly absence factors for teaching staff.

### 2) Attendance classification and identification of factors causing teachers to be late or leave early

**Figure 13** shows the weekly attendance figures recorded by facial recognition

in 9 MENA schools in Conakry, for 334 teachers. Of 1670 expected clockings, 1348 were recorded (80.7% attendance). Of these, 73.5% were on time, 10.4% arrived late, 9.1% left early, and 7% had both. These results illustrate a good overall attendance record and a fine-tuned ability to track time thanks to biometrics.

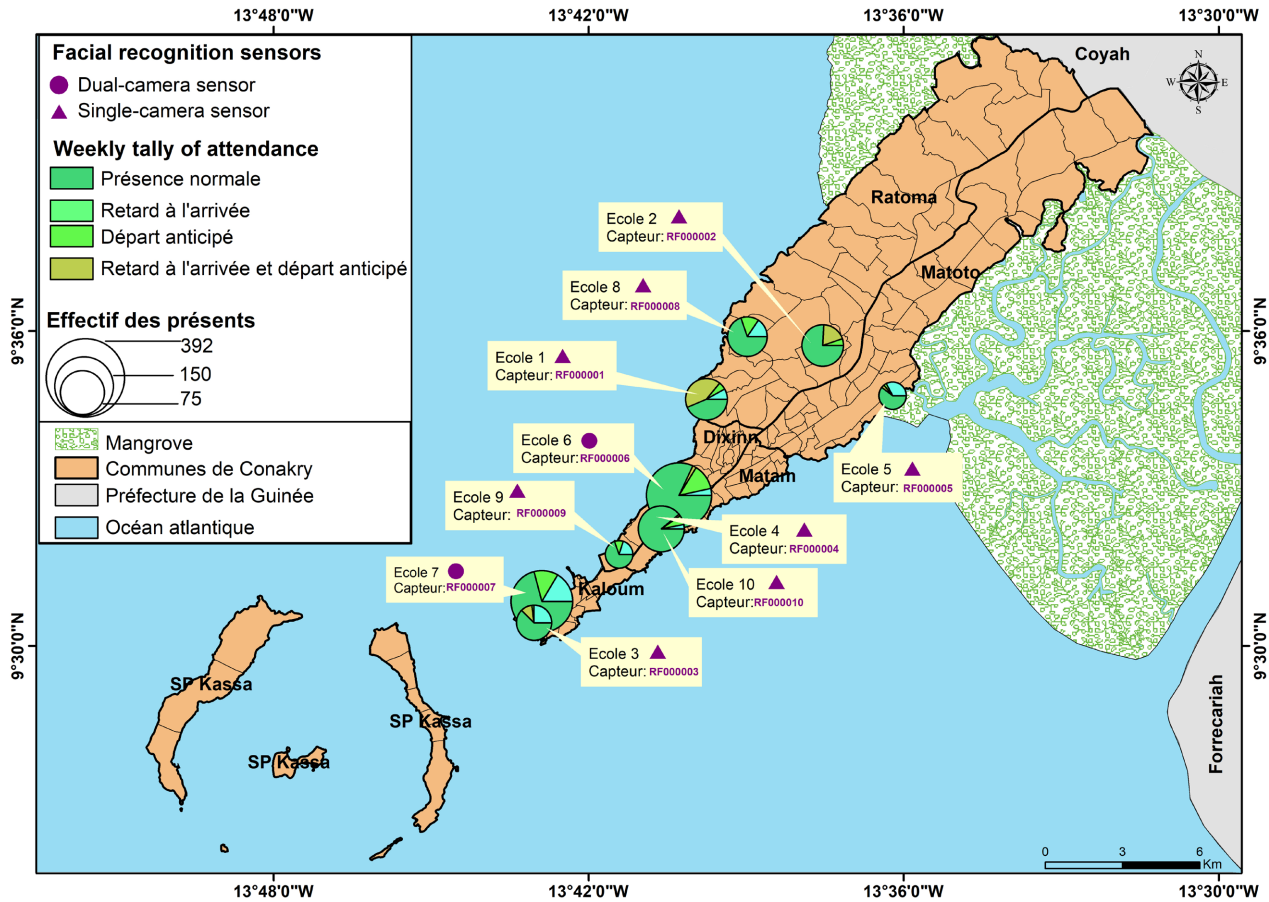


Figure 13. Teacher weekly attendance classification chart.

### 3) Technical performance of biometric sensors and identification of spatial patterns of absenteeism

#### • Technical performance of biometric sensors

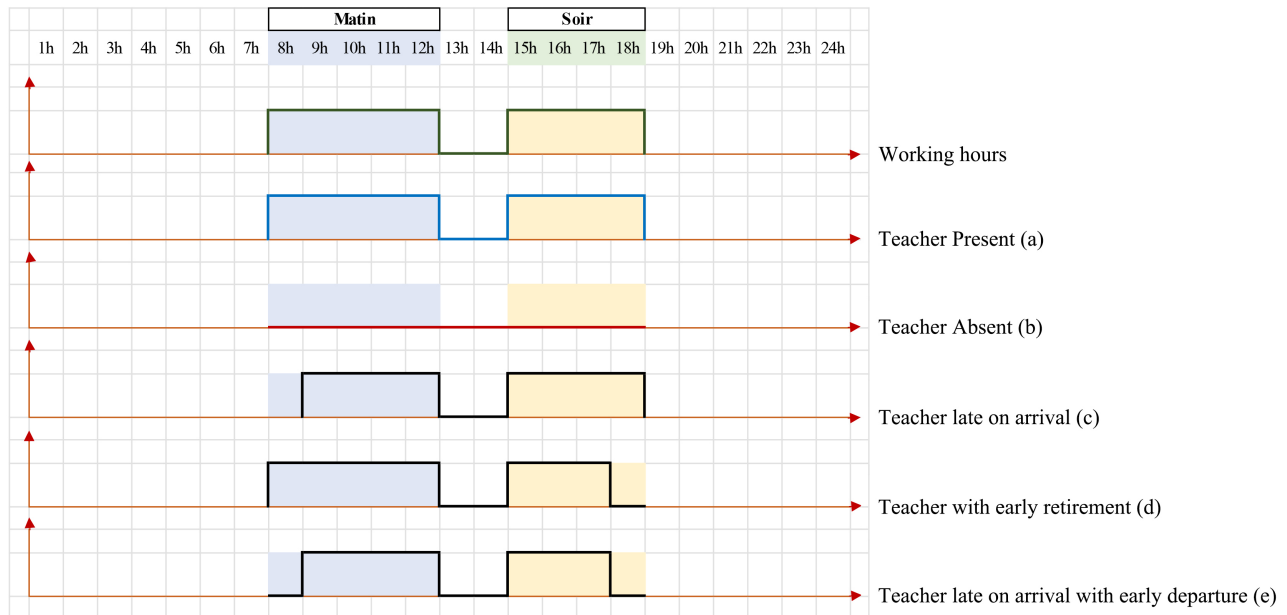
The biometric sensors used are based on the OpenCV facial recognition engine coupled with the Dlib library. In tests prior to the pilot phase, the false acceptance rate (FAR) was estimated at 1.3%, while the false rejection rate (FRR) was 3.7%, which is still acceptable for an educational context. However, performance was slightly degraded by excessive light interference or partially masked faces (scarves, glasses, hats, etc.). These limitations have been pointed out and taken into account in the project's technical documentation.

#### • Identification of spatial patterns of absenteeism

Over and above their technical performance, these sensors have also enabled us to identify spatial patterns of absenteeism through automated detection of anomalies in clocking-in patterns. Two configurations were tested for this purpose:

○ **Detecting anomalies with a fixed biometric sensor and a single camera**

A single camera is installed in a secure area of the school. Teachers must go there to register their presence. This system is suitable for schools with several entrances and exits, but centralizes the clocking-in process in a single location. This type of clocking in and out allows us to detect the following spatial patterns of absenteeism (**Figure 14**).



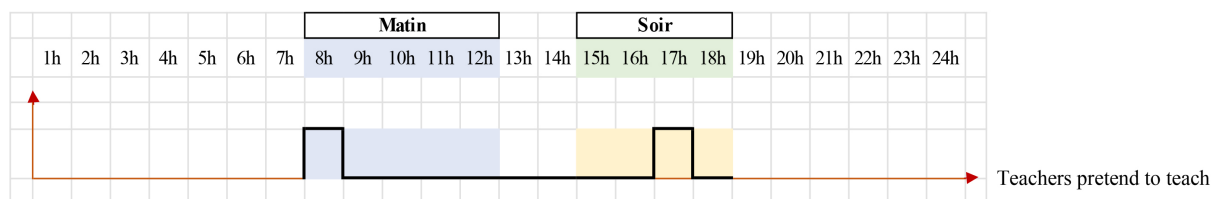
**Figure 14.** Spatial patterns of absenteeism are based on a single point at a fixed sensor.

In this case, the unjustified repetition of the absence model (b) over several consecutive days, in the absence of an administrative act of authorization, makes it possible to detect several anomalies, in particular fictitious teachers, teachers who have died but are still paid, teachers who have abandoned their posts, or cases of substitution.

• **Anomaly detection with a fixed biometric sensor equipped with a single camera**

Two cameras have been installed: one at the entrance and the other at the exit of the school. This system monitors both the arrival and departure of teachers, providing a more complete picture of their actual presence. In addition to the spatial patterns of absenteeism derived from single clocking in and out in front of a fixed sensor, this sensor configuration also detects teachers pretending to teach (**Figure 15**).

In this scenario, a teacher arrives at the school only to register his arrival, then leaves to attend to other business outside the school, returning at the end of the day to register his departure. From a technical point of view, he is considered present. This strategy is often used by teachers who also work in the private sector. It can also involve a teacher not officially assigned to a post, who comes to mark his or her presence in order to avoid administrative sanctions.



**Figure 15.** Spatial absenteeism model based on double clocking in and out.

#### 4) Feedback from users

Qualitative feedback was given to 12 teachers and 4 headteachers, as well as certain authorities from the Guinean civil service and Ministry of Education, at the end of the test week. Overall, the teachers expressed a positive appreciation of the system, underlining its deterrent effect against systematic lateness.

Post-pilot interviews with 12 teachers and 4 school principals revealed a generally positive reception. Teachers appreciated the fairness and automaticity of the system, although some expressed initial concerns that surveillance would interfere with their freedom, which were allayed by awareness-raising sessions and explanations of the non-intrusive nature of the system. Administrators have found real-time reporting useful for resolving attendance conflicts linked to unjustified absences and enforcing accountability.

#### 4.2. Discussion

Accurate monitoring of staff attendance remains a major challenge in African public education systems. Manual attendance registers are often subject to manipulation, delays, and inaccuracies. To address these limitations, this project proposes a low-cost, open-source WebGIS system for remote, real-time supervision of facial recognition sensors installed in schools. It enables data centralization and geospatial visualization for rapid analysis and targeted interventions.

This problem of attendance monitoring is part of a wider dynamic in which the private sector focuses on efficiency, while public administration aims for effectiveness, often to the detriment of optimized human resources management. In Africa, this dichotomy contributes to administrative waste that is detrimental to the performance of basic services, particularly in the field of education.

In this context, digital technologies such as facial recognition, biometrics (fingerprints, iris) and integrated HR management software offer innovative alternatives. Facial recognition enables rapid, reliable identification based on facial morphological characteristics, considerably reducing identity fraud [8]. Nevertheless, it raises legitimate questions about personal data and infrastructure costs [9]. The system adopts end-to-end encryption without retaining raw facial images; only anonymized feature vectors are compared locally before results are transmitted. Data access is secured by defined roles and two-factor authentication. Although no specific legislation yet exists in Guinea, the solution aligns with the principles of the RGPD and the recommendations of the ANPDP.

Biometric systems, such as fingerprint or iris scans, are recognized for their re-

liability in terms of time and attendance, but may give rise to cultural or health concerns [10]. For their part, integrated human resources management (HRM) systems enable HR functions to be centralized and planning to be optimized through cross-analysis [11], although their implementation requires technical skills and ongoing maintenance.

These technologies have proven their effectiveness in reducing absenteeism by empowering agents and facilitating reassignment to underserved areas. In India, the adoption of facial recognition has helped reduce school absenteeism [12], while in Malaysia, biometrics has helped improve educational performance [13].

However, in African public administrations, the effective availability of these biometric systems is often compromised by power cuts, Internet outages, and mobile network failures. In Guinea, despite the commissioning of the 240 MW Kaléta hydroelectric dam, the population's energy needs remain insufficiently covered. Recurrent power cuts have led to the widespread use of generators as a back-up solution, but their cost and environmental impact limit their viability. As part of the GUI-EDU-VISION project, solar energy has been chosen as a sustainable alternative.

Several technical challenges were encountered during the pilot phase. To ensure continuous data transmission, Raspberry Pi devices coupled to a Kannel-controlled GSM dongle were installed, notably on sites 1 and 7, with satisfactory results. In the event of an Internet outage, these devices automatically transmitted data to the central GIS server via the mobile network. An experimental alternative using LoRa modules was also tested in the event of failure of the Internet connection and mobile networks on site: these communicated at low bit rates in a 10 to 16 km local radio loop, connected to a relay point with an Internet connection. Finally, each sensor was equipped with a back-up power supply system based on batteries rechargeable by solar panels, guaranteeing 8 hours' autonomy in the event of a prolonged outage.

Pilot projects in West Africa, supported by the World Bank and UNESCO, combine GIS and biometrics for territorialized management of the teaching workforce [14] [15]. The integration of geographic information systems (GIS) with biometric technologies represents a major step forward in optimizing workforce management within the civil service. While GIS facilitates the visualization, spatial analysis, and tracking of agents throughout the territory, biometric devices enable the reliable, rapid, and secure identification of individuals [16].

This technological complementarity paves the way for the implementation of automated geolocation clocking systems, which are particularly useful in environments characterized by low administrative transparency and high staff mobility, as is often the case in several African countries [17]. Geolocated biometric devices not only ensure the agent's actual physical presence at his or her duty station, but also centralize this data in databases that can be consulted remotely via mapping platforms (GNSS/GIS), offering multi-level supervision (local, regional, national).

The combination of GIS and biometrics also facilitates the generation of statis-

tical and spatial indicators on absenteeism, punctuality, and irregular staff movements [18]. It enables the production of dynamic dashboards and the modeling of prospective scenarios for better allocation of human resources. This approach is also compatible with the imperatives of results-based management (RBM) and good public governance [17] [19], as it makes data relating to the presence or absence of agents easily auditable and verifiable.

What's more, the adoption of this technological synergy strengthens the fight against structural dysfunctions, such as duplicate assignments, fictitious jobs, or prolonged unjustified absences [16]. The geospatial dimension enables cross-checks to be made between the agent's declared location and his or her actual position at the time of clocking in, considerably reducing the possibility of fraud or proxy representation. In short, interoperability between GIS tools and biometrics is not simply a technological feat, but a strategic lever for modernizing public administration. It enables evidence-based workforce management, improves transparency, and promotes a more equitable distribution of human resources across territories [17] [19].

The integration of remote sensing, GIS, and computer vision biometrics in these fields offers considerable potential for solving a variety of problems, improving security, and facilitating resource management, particularly when spatial and biometric data are combined for more in-depth analysis. However, it is crucial to comply with personal privacy and data security standards when implementing these systems. While the pilot project has demonstrated its feasibility in an urban environment, replicating it in rural areas requires a number of adaptations, particularly in terms of energy sources and data transmission. However, the WebGIS platform is scalable, modular, and adaptable to various educational contexts.

## 5. Conclusions

This study designs and tests a WebGIS linking open-source facial recognition sensors installed in nine schools in Conakry to a central PostGIS/QGIS-Server platform via MQTT. In just one week of operation, the system recorded 1348 teacher clockings and produced dynamic real-time maps and dashboards on punctuality, absences, and sensor status. The analysis attributed the majority of absences to socio-political disruptions and delays, mainly to traffic jams. The authors argue that the platform enhances transparency and promotes data-driven human resources management within the Guinean Ministry of National Education.

This WebGIS is a strategic decision-support tool for locating, monitoring, and managing the biometric facial recognition sensors deployed in schools in the Conakry region. It enables efficient remote monitoring of time and attendance devices, rigorous tracking of teaching staff attendance, and detailed analysis of absenteeism dynamics. Thanks to a secure interface, authorized users can consult, edit, and update information on sensors and teacher numbers in real time.

The implementation of an automated attendance control system based on facial recognition, resilient to contagious diseases transmitted by physical contact (such

as COVID-19), represents a major step forward in the modernization of human resources management in Guinea's education sector. By reducing cases of unjustified absenteeism and promoting a more equitable distribution of staff, this system not only reinforces administrative transparency, but also the effectiveness of public action in the field of education.

The development of a WebGIS-based system for remote monitoring of biometric attendance offers a promising solution to long-standing challenges in public education workforce management. The system not only supports transparency and accountability, but also enables geospatial analysis for policy and planning. Future work will focus on extending coverage to rural areas and improving robustness in the face of infrastructure constraints. However, to guarantee its success, it is imperative to put in place strict personal data protection mechanisms, as well as an appropriate training program for system users.

Finally, from a broader perspective, this system could be complemented by a pedagogical monitoring system, to check that each teacher is not only present, but also actually fulfilling his or her teaching obligations. By integrating WebGIS with a module for tracking courses and progress in relation to official syllabuses, decision-makers will have a comprehensive tool for educational governance, combining enrolment management, teaching quality, and accountability.

### Conflicts of Interest

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

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