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Development of a Site Digital Terrain Model (DTM) for the Implementation of a Digital Twin of the Regional Institute of Public Health (IRSP) of Ouidah

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Abstract

The digital transformation of existing infrastructure represents a major lever for improving asset management and public facility maintenance. Within this framework, Scan-to-BIM approaches enable the generation of accurate digital models of existing structures using field-acquired data. However, while these workflows are widely applied to buildings, the integration of their surrounding outdoor environment remains underdeveloped, thereby limiting the implementation of true digital twins at a site scale. This study focuses on the digital representation of the entire Regional Institute of Public Health (IRSP) campus in Ouidah (Benin) through the development of a Digital Terrain Model (DTM). This model serves as the essential geospatial foundation for the institute's future digital twin. The adopted methodology relies on a multi-source data acquisition strategy, combining site contextualization from Google Earth or Google Maps data, a drone-based photogrammetric survey to obtain a high-resolution point cloud, and GNSS surveys to ensure precise georeferencing and altimetric alignment. Following the processing of the collected data, a digital topographic surface was generated using Autodesk Revit to produce an intelligent topographic model compatible with BIM workflows. The results provide an accurate representation of the campus morphology and offer a reliable baseline

for outdoor infrastructure management, surface runoff analysis, maintenance planning, and the progressive georeferenced integration of the site's various buildings into a single digital model. The developed DTM thus represents a fundamental step toward creating the digital twin of the Ouidah IRSP, from a perspective of decision support, sustainable infrastructure management, and the replication of this workflow across other campuses and public facilities in Benin.

Keywords

Digital Terrain Model (DTM), Scan-to-BIM, Digital Twin, Drone Photogrammetry, Leveling Network, RTK NTRIP, GNSS Network

1. Introduction

The sustainable management of large-scale public infrastructure is one of the major challenges facing developing countries, particularly in West Africa, where the rapid growth of the built environment contrasts with the limited availability of monitoring and maintenance tools [1] [2]. University campuses, which combine teaching buildings, sports facilities, green spaces, and a road network within a single footprint, exemplify this issue particularly well: their extent and the diversity of their components make any planning or maintenance operation difficult to manage without an appropriate digital documentation tool. The Institut Régional de Santé Publique (IRSP) of Ouidah, the leading public-health training institution in Benin, has a university campus of this type, including several teaching buildings, sports facilities, green spaces, and an internal road network. However, no unified digital documentation of the site currently exists, making planning, preventive maintenance, and future expansion difficult to manage rigorously. Building Information Modeling (BIM), initially developed for the management of new construction projects, is progressively emerging as a relevant methodological framework for the documentation and management of existing infrastructure, particularly through the *Scan-to-BIM* workflow [3]-[5]. Although this workflow is well documented for individual buildings, its application at the scale of an entire university campus, including the terrain, site infrastructure, and other site features, remains relatively underexplored, particularly in countries with developing BIM maturity [2]. The production of a Digital Terrain Model (DTM) constitutes precisely this indispensable first building block: it provides the geospatial foundation on which the BIM Site Model, and ultimately the IRSP digital twin, can be built [1] [5].

This article addresses this gap by documenting the complete process of developing the DTM of the IRSP Ouidah campus, from multi-source data acquisition to the production of a georeferenced BIM topographic surface in Autodesk Revit, via the photogrammetric processing of the point cloud. To our knowledge, this work constitutes one of the first documented applications of such an approach to a university campus in West Africa.

2. Conceptual Framework and State of the Art

2.1. Digital Elevation Models: Definitions and Terminology

Before addressing the concept of a Digital Terrain Model (DTM), it is necessary to distinguish between the different types of digital elevation models, whose terminology is sometimes used imprecisely in the field.

The generic term Digital Elevation Model (DEM) refers to any digital representation of the elevation of a surface, without specifying the nature of that surface. It is an umbrella term encompassing two distinct models, depending on the surface being represented.

The Digital Terrain Model (DTM) represents the elevation of the bare-earth surface, with vegetation, buildings, and other constructed objects removed. It therefore describes the actual morphology of the terrain and provides the preferred basis for topographic analyses, particularly the study of terrain relief, slopes, and surface runoff.

The Digital Surface Model (DSM), on the other hand, represents the elevation of the first surface encountered by the sensor: treetops, building roofs, power lines. It therefore includes both buildings and vegetation.

The distinction between a DTM and a DSM lies in the processing of the acquired data. Indeed, a raw photogrammetric point cloud initially represents a DSM, as it captures the first visible surface. The DTM of the bare-earth surface is then extracted through data classification and filtering. This distinction structures the methodology presented in Section 3.

2.2. From the DTM to the BIM Site Model: A Conceptual Progression

In this study, the DTM constitutes the reference topographic product obtained through photogrammetric processing. It is generally generated in the form of a Triangulated Irregular Network (TIN), which connects terrain measurement points through linear interpolation and adapts to variations in data density according to the complexity of the terrain [4] [5]. However, from a BIM-based site management perspective, the raw DTM represents only an initial step. Its value is enhanced by developing it into a **BIM Site Model**, which characterizes the different areas of the campus (roads, green spaces, building footprints, and sports facilities) through parametric subregions and incorporates buildings as georeferenced objects linked to the terrain surface. This progression, from the DTM to the BIM Site Model and ultimately to the digital twin, defines the aim of this study [6].

Syed Abdul Rahman *et al.* [7] explicitly establish this connection in their systematic review of digital terrain models and urban digital twins, emphasizing that the DTM provides an essential foundation for developing representative digital twins and that its integration into BIM through IFC conversion tools constitutes a key step in this transition. Clemen *et al.* [5] further developed the IFC Terrain tool specifically to facilitate the conversion of geospatial DTM data into an in-

teroperable BIM object in IFC format.

2.3. UAV Photogrammetry and Campus DTM: Related Work

Drone-based photogrammetry is now a widely used method for the rapid, accurate, and cost-effective acquisition of large-scale topographic data. Nex and Remondino [4] laid the methodological foundations for this approach, demonstrating that UAVs can achieve ground resolutions on the order of centimeters, making the resulting data compatible with the requirements of BIM site modeling. More recently, studies conducted at the scale of entire university campuses have confirmed the feasibility and relevance of this approach for large sites [1] [7].

Berrett *et al.* [8], for example, developed a highly realistic 3D model of the Brigham Young University campus (Utah, USA), covering 1.7 km^2 and more than 75 buildings, by combining UAV aerial photogrammetry with terrestrial surveys and high-precision GNSS positioning. Although the scale of this campus is considerably larger than that of the IRSP of Ouidah, which covers approximately 0.08 km^2 and includes 36 buildings, the study nevertheless demonstrates that the combination of UAV and GNSS technologies is technically feasible and reproducible across different site scales, supporting its relevance for a smaller campus such as the IRSP.

Regarding vertical accuracy, Martínez-Carricondo *et al.* [9] established that the use of ground control points measured using GNSS is critical to the vertical accuracy of a DTM derived from UAV photogrammetry. Their findings show that when an insufficient number of properly distributed ground control points is used, vertical errors can exceed ±10 cm, making the resulting model unsuitable for high-precision BIM applications.

Regarding integration into BIM software, Lim *et al.* [10] provide a detailed workflow for importing a UAV-derived point cloud into Autodesk Revit as a topographic surface, examining the influence of point-cloud density on software performance and the accuracy of the generated surface. Their recommendations regarding point-cloud subsampling correspond closely to the constraints encountered in the present study.

2.4. BIM and Asset Management in West Africa: A Particular Context

While BIM is now common practice in industrialized countries, its adoption in sub-Saharan Africa remains embryonic. Bui *et al.* [1] point out that developing countries face a triple constraint: limited access to survey equipment, a shortage of local BIM skills, and a lack of documented feedback demonstrating the added value of these approaches to public asset owners. In this context, the present study is part of a twofold movement: contributing scientifically to the literature on campus DTM-BIM, and constituting a local empirical reference base that can be mobilized to accelerate the diffusion of these practices in Benin.

3. Study Site and Methodology

3.1. Description of the IRSP of Ouidah

The Regional Institute of Public Health (IRSP) of Ouidah is one of the major public health training institutions in West Africa. Located in the historic city of Ouidah, in southern Benin, its campus covers approximately 8 hectares and comprises 36 buildings serving various functions, including teaching buildings, administrative blocks, laboratories, and accommodation for students, senior staff, and other personnel. The site also includes several sports facilities, a gymnasium, football and basketball courts, as well as green spaces and an internal network of paved roads, as shown in Table 1 and Figure 1(a) and Figure 1(b). The diversity and density of this site make it a representative case study of Beninese public university campuses, while presenting concrete asset-management challenges related to the absence of existing digital documentation.



(a)



(b)

Figure 1. (a): Delimitation of the IRSP Ouidah campus area (Google Maps), (b): Oblique aerial view of the IRSP Ouidah campus.

Table 1. Main characteristics of the IRSP Ouidah campus.

Parameters	Description
Location	Ouidah, Atlantique Department, Benin
Campus Area	8 hectares (0.08 km^2)
Number of Buildings	36 buildings
Site Components	Teaching buildings, administrative blocks, laboratories, accommodation for students, staff and personnel
Reference Coordinate System	NGB (elevation)/UTM Zone 31N (planimetry)
Pre-existing Digital Documentation	No digital model or digitized as-built plan

3.2. Overall Data Acquisition and Processing Workflow

The methodology implemented in this study is structured into five successive phases, from field preparation to the production of the BIM Site Model, in accordance with the general framework of the Scan-to-BIM workflow applied at the scale of an outdoor site [2] [10]. The workflow combines two complementary data acquisition technologies, each suited to a specific component of the site: UAV photogrammetry for the terrain and terrestrial LiDAR for the buildings. The complete workflow is summarized in **Table 2**. **Figure 2** shows the site boundaries, buildings, and site features on the orthophoto.

Table 2. Overall workflow for producing the DTM and the BIM Site Model of the IRSP.

Phases	Operations	Tools/Software
Phase 1 Contextualization	Site analysis, delineation of the boundary, identification of constraints, geographic North orientation	Google Earth/Google Maps
Phase 2 Establishment of the reference network and topographic survey	Layout and measurement of ground control points, planimetric (UTM 31N) and elevation (NGB) georeferencing, topographic survey of the site	GNSS receiver, total station, automatic level
Phase 3 UAV photogrammetry (terrain)	Flight planning, acquisition of aerial imagery, generation of the dense terrain point cloud	DJI Mavic 4 Pro drone
Phase 4 Terrestrial LiDAR scan (buildings)	Precision survey of existing buildings using a terrestrial laser scanner	FJDynamics Trion P1 scanner
Phase 5 Processing and BIM modeling	Processing of control-point network data, elevation measurements and footprint surveys. Realignment and cleaning of point clouds, DWG/CSV export, generation of TIN topographic surface, modeling of scanned buildings, zoning into sub-regions, georeferencing and integration into the site	RKT NTRIP, Autodesk ReCap, Autodesk AutoCAD, Autodesk Revit

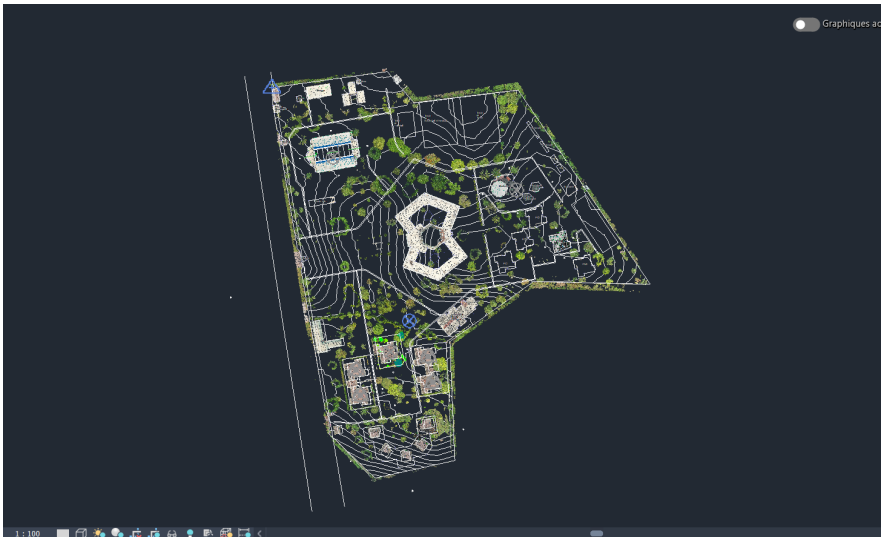

Figure 2. Site plan (boundaries, buildings, and site features) superimposed on the orthophoto and the topographic solid, top view in Autodesk Revit.

3.3. Field Data Acquisition

3.3.1. Topographic Survey

Data collection began with topographic measurements on the site. For the georeferencing of GNSS measurements, RTK NTRIP mode was used. Benin's Permanent Station Network (RSPB) was modernized in 2022, making it possible to receive real-time corrections in the field via an internet connection. This step made it possible to establish planimetric calibration points for the subsequent measurements.

The nearest permanent station of the RSPB network is the Cotonou station (BJCO). It is located approximately 42 km in a straight line from the IRSP site.

Since this study focuses on the Digital Terrain Model, emphasis was placed on elevation surveys. Following the GNSS measurement campaign, an optical level was used to survey the relief of the site.

The specifications of the optical level used are summarized in Table 3.

Table 3. Specifications of the optical (automatic) level used for the elevation survey.

Accuracy	Without micrometer	1.5 mm/km
Telescope	Magnification	28×
	Minimum focusing distance	0.3 m
	Resolution	1˚25'
	Field of view	3.5"
Compensator	Working range	±15'
	Type	Pendulum compensator with magnetic damping
General	Temperature	−20˚C to 50˚C
	Water resistance	IPX6

In order to connect the measurements to Benin's General Leveling Network (RGB), the nearest known elevation benchmark was identified. This is the first-order geodetic benchmark IGN102, located at the Monument Aux Morts. This benchmark is located approximately 1.2 km in a straight line from the site, next to the Monument Aux Morts. A closed circuit was therefore created to establish 14 known altitude markers on the IRSP site. **Figure 3** shows the distribution of the 14 points on the site.



Figure 3. Distribution of points on the site (georeferencing points are in red and independent control points are in blue).

These points serve as the basis for the site's elevation survey and, subsequently, for an interpolation aimed at best representing its relief.

Of the 14 points, 9 were used for georeferencing the photos and 5 were used as independent control points. In **Figure 3**, the 9 points (S1 - S9) are shown in red and the 5 control points (CP1 - CP5) are shown in blue.

3.3.2. Photogrammetric Survey

The drone photogrammetric survey was carried out using a DJI Mavic 4 Pro, following a systematic grid flight plan covering the entire campus. After processing, the acquired images made it possible to reconstruct a three-dimensional point cloud of the terrain, georeferenced using the ground control points measured on site. The prior contextualization of the site via Google Earth and Google Maps made it possible to precisely define the flight footprint, anticipate risk areas, and verify the site's geographic North orientation prior to acquisition.

In addition, the existing campus buildings were surveyed by terrestrial laser scanning using an FJDynamics Trion P1 scanner, providing high-precision point clouds suited to the detailed BIM modeling of the built structures (**Figure 4**).



Figure 4. Orthophotograph and point cloud derived from UAV photogrammetry over the entire IRSP campus.

The PIX4Dmatic quality report indicates a camera geolocation error of X_RMS 1.295 m, Y_RMS 1.170 m, and Z_RMS 3.561 m. The Hasselblad L1D-20c camera report presents the following values (sensor 12.825 × 7.214 mm): average GSD of 2.8 cm; 212 images acquired, 100% calibrated in a single block; 903,037 automatic tie points (ATPs), median of 10,398 matches per image; reconstruction software identified: PIX4Dmatic v1.86.0.

3.4. Processing of Field-Collected Topographic Data

The elevation measurement results collected in the field were processed in the GéoBase module of the Covadis software.

After interpolation, the elevations of the previously selected control points were extracted from the model and compared with the values derived from the photogrammetric data.

The geometric accuracy of the resulting model was calculated using Equations (1) and (2) below [11]:

$$RMSE_{(X,Y)} = \sqrt{\frac{\sum_{i=1}^{n}\left[\left(X_{P,i}-X_{G,i}\right)^2+\left(Y_{P,i}-Y_{G,i}\right)^2\right]}{n}} \quad (1)$$

$$RMSE_Z = \sqrt{\frac{\sum_{i=1}^{n}\left(Z_{P,i}-Z_{G,i}\right)^2}{n}} \quad (2)$$

where:

$RMSE_{(X,Y)}$ —the root mean square error in planimetry,

$RMSE_Z$ —the root mean square error in altimetry,

$(X,Y,Z)_{P,i}$ —represent the coordinates of point i extracted from the model

generated by aerial photographs,

$(X,Y,Z)_{G,i}$ —represent the coordinates of point i obtained by GNSS measurement,

n—represents the number of points taken into account for the calculation.

3.5. Processing in Autodesk ReCap and Generation of Export Files

The raw point cloud derived from photogrammetry was imported and processed in Autodesk ReCap, which successively performed: the alignment of all data within a common geometric reference frame, cleaning by removal of outlier points, vegetation, and spurious elements, and export to formats usable by Revit. Three types of files were produced at the end of this phase:

- A .DWG file containing the site boundaries and building footprints, used as a reference base plan in Revit;
- CSV/.XYZ/.TXT files containing the X, Y, Z coordinates of the survey points, used for constructing the TIN surface in Revit, referenced to the UTM 31N system in planimetry and the NGB system in elevation;
- An .RCP file (ReCap Project), enabling 3D visualization of the cleaned point cloud and serving as a visual reference during modeling.

3.6. BIM Modeling in Autodesk Revit: From the DTM to the Site Model

Integration into Autodesk Revit constitutes the core of this study's methodological contribution. It was carried out in several successive stages, corresponding to a progression from the raw DTM to the BIM Site Model.

Generation of the TIN topographic surface (BIM DTM). The DWG file was imported via Revit's Link CAD function, providing the site boundaries and building footprints. The .CSV files derived from photogrammetric processing were then imported via the "Specify Points File" function of the topographic-surface tool, automatically generating the TIN surface from the X, Y, Z points. The resulting surface faithfully restitutes the terrain morphology, including its elevation variations, slopes, depressions, and paved areas. This surface constitutes the DTM in the strict sense, the central object of the present study.

Georeferencing of the model. Revit's Survey Point was positioned at the actual coordinates derived from the GNSS survey, with planimetric calibration ensured in the UTM 31N system and elevation calibration in the NGB system. The geographic North orientation, previously verified via Google Earth or Google Maps, was transferred into Revit to ensure consistency between the model's orientation and the actual terrain.

The geoid model used is GGB18V1 in combination with EGM08. The GGB18V1 model was produced in 2018 by IGN Benin in collaboration with IGN France. This model best describes Benin's territory; however, it should be noted that the absence of validated data in certain areas of the country requires the use of the EGM08 model.

Qualification of site features: toward the BIM Site Model. Beyond the raw DTM, the topographic surface was enriched through the creation of parametric sub-regions (the "Split Surface" or "Sub-regions" tool), qualifying the different zones of the campus according to their functional nature and surface material. This step transforms the topographic surface into a genuine BIM Site Model, usable for asset management, maintenance-intervention planning, and the progressive integration of buildings. Building footprints were accounted for using Building Pads, cleanly cutting the topographic surface beneath them. Table 2 summarizes the zoning carried out.

Integration of scanned buildings. In parallel with the production of the DTM, several campus buildings were modeled from point clouds derived from the terrestrial LiDAR scan (FJDynamics Trion P1). Among these modeled buildings, three have already been georeferenced and integrated into the site model, by calibration on the shared coordinates of the site's Revit file. This progressive integration concretely illustrates the transition from the DTM to an operational BIM Site Model, combining terrain and buildings within a single geospatial reference frame.

Figure 5 and Figure 6 show georeferenced TIN topographic surface and building of the IRSP campus generated.

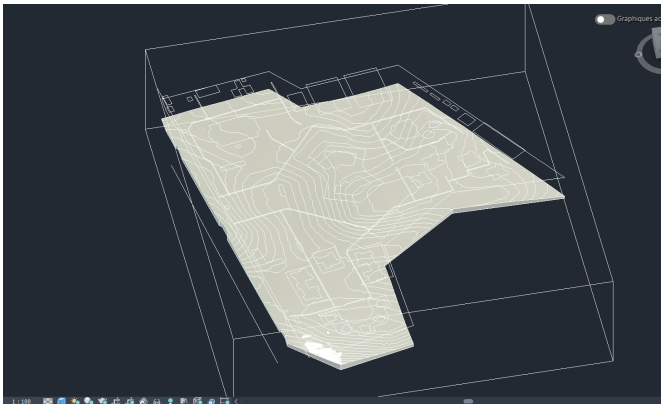

Figure 5. Georeferenced TIN topographic surface (topographic solid) of the IRSP campus generated in Autodesk Revit.

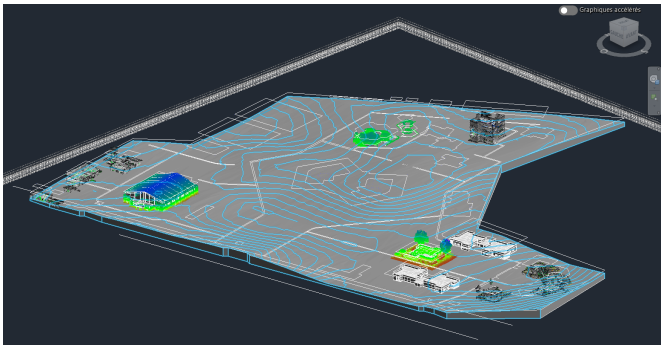

Figure 6. BIM Site Model: topographic surface with contour lines and the first georeferenced buildings integrated into the site.

4. Results and Analysis

4.1. Overview of Results

The implementation of the workflow described in Section 3 resulted in the production of several complementary and interconnected digital deliverables (see Figures 1-6):

- The georeferenced TIN topographic surface, constituting the DTM proper: it restitutes the complete morphology of the IRSP campus, including its elevation variations, access points, and the site's overall relief, derived from the UAV photogrammetric point cloud;
- The BIM Site Model, an enrichment of the DTM through zoning into parametric sub-regions: it qualifies the roads, green spaces, sports fields, and building footprints, transforming the raw surface into an operational asset-management tool;
- Three buildings modeled from the terrestrial LiDAR scan, georeferenced and integrated into the site model by calibration on the shared coordinates of the Revit file, constituting a first concrete demonstration of terrain/building integration within a single geospatial reference frame;
- The processed orthophotographs and point clouds, ancillary products of the UAV photogrammetry and LiDAR scan, which serve as visual references enabling verification and updating of the model.

4.2. Analysis and Discussion

The quality of the generated topographic surface is directly dependent on the density and distribution of the control points established during the setup of the reference point network. The results obtained confirm the findings of Martínez-Carricondo *et al.* [9]: a well-distributed network of control points across the entire footprint ensures high-quality elevation calibration, while the combination of drone and GNSS achieves a resolution and accuracy suited to the requirements of site BIM modeling. This confirms the appropriateness of combining a GNSS receiver with UAV photogrammetry for producing the terrain DTM.

Comparing the coordinates of the control points in the generated model with those obtained by GNSS measurement reveals the following discrepancies:

Number of independent control points: 5

Standard deviation: 0.0537 m

$RMSE_{(X,Y)}$ = 0.129 m

$RMSE_{(Z)}$ = 0.153 m

The added value of this approach lies in the transition from the raw DTM to the BIM Site Model. By qualifying each campus zone through parametric sub-regions, the topographic surface becomes a usable BIM object: each zone is identifiable, measurable, and can be linked to management information. This logic is consistent with the asset-management perspectives described by Bui *et al.* [6] in the context of developing countries, where digital documentation represents the first step toward planned rather than reactive maintenance.

The integration of the first three georeferenced buildings, derived from the terrestrial LiDAR scan, represents a significant advance beyond the DTM alone: it demonstrates the technical feasibility of jointly calibrating an aerial survey (terrain) and a high-precision terrestrial survey (buildings, utility networks, and other features) within the same geospatial reference frame in Revit. This methodological complementarity UAV photogrammetry for large open areas, terrestrial LiDAR for the millimeter-level precision required for built structures concretely illustrates the relevance of a multi-sensor acquisition chain adapted to each component of a complex site, in line with the practices recommended by Tang *et al.* [1] for Scan-to-BIM approaches applied to existing built heritage.

Compared with campus studies conducted in more developed contexts notably Berrett *et al.* [8] on the Brigham Young University campus, or the work of Lim *et al.* [10] in Singapore the present approach stands out for its implementation in a resource-constrained context typical of public university campuses in West Africa. It demonstrates that a processing chain combining accessible tools is capable of producing BIM deliverables of sufficient quality for the management needs of a university campus.

The UAV point density can be calculated from the reported figures: 13,268,858 dense points over 22.483 ha, *i.e.*, approximately 59 points/m^2. Partial documented processing times were 6 min 7 s for calibration and 9 min 16 s for dense point-cloud generation (workstation: i5-11400H, RTX 3050 Ti, 15.7 GB RAM).

Finally, continuing the integration of the remaining buildings already modeled from the LiDAR scan but not yet georeferenced constitutes the immediate next step of this work, ahead of connecting the model to dynamic data streams that will prefigure the IRSP digital twin, as conceptualized by Syed Abdul Rahman *et al.* [7] and Pan & Zhang [5].

Certain limitations of the study should nonetheless be highlighted. The actual elevation accuracy of the DTM has not yet been formally validated through comparison with independent control points. In addition, the zoning into BIM subregions relies on visual identification of site features during the survey and modeling process, without a systematic technical inventory of materials and surface conditions.

5. Conclusions

This study documented the development of a Digital Terrain Model (DTM) of the campus of the Regional Institute of Public Health (IRSP) of Ouidah (Benin), the essential first building block for establishing a digital twin of this institution. The methodology implemented combining topographic survey (GNSS, total station, automatic level), UAV photogrammetry for the terrain, terrestrial LiDAR scanning for the buildings, and BIM modeling in Autodesk Revit demonstrated its feasibility in a resource-constrained context, characteristic of public university campuses in West Africa.

Beyond the DTM in the strict sense, the work carried out produced a BIM Site

Model qualifying all components of the campus roads, green spaces, sports facilities, and building footprints through zoning into parametric sub-regions, and already integrating three georeferenced buildings derived from the LiDAR survey. This progression from the raw DTM to the BIM Site Model, combining the terrain and the first built elements within a single geospatial reference frame, constitutes the main original contribution of this work: it transforms a simple topographic survey into an operational asset-management tool that can be used by IRSP administrators to plan maintenance, analyze surface runoff, and manage site interventions.

The limitations identified the absence of formal metrological validation of the DTM, and zoning based on visual identification point directly toward avenues for methodological strengthening. Two perspectives are opened: in the short term, continuing the integration of buildings already modeled but not yet georeferenced into the unified site model; and in the medium term, connecting this model to dynamic data to form the IRSP's operational digital twin. This approach is, moreover, directly transposable to other campuses and public facilities in Benin, thereby contributing to the establishment of a national reference base of BIM practices applied to public infrastructure.

Author Contributions

Conceptualization: all. Formal analysis: Joslin Moukadamou YESSOUFOU, Ernesto Cabral HOUEHANOU and Briac Kevin Patrick KOSSOUGBETO. Funding acquisition: Ernesto Cabral HOUEHANOU and Joslin Moukadamou YESSOUFOU. Investigation: Mensanh Arthur Amédéo TETE and Yolaine GLELE AHANHANZO, Methodology: Ernesto Cabral HOUEHANOU, and Briac Kevin Patrick KOSSOUGBETO. Software: Mensanh Arthur Amédéo TETE and Ernesto Cabral HOUEHANOU, Supervision: Ernesto Cabral HOUEHANOU, Briac Kevin Patrick KOSSOUGBETO, and Yolaine GLELE AHANHANZO. Validation: all Writing (original draft preparation): Mensanh Arthur Amédéo TETE, Ernesto Cabral HOUEHANOU, Joslin Moukadamou YESSOUFOU and Briac Kevin Patrick KOSSOUGBETO Writing (review and editing): all.

Declaration of AI-Assisted Technology Use

During the preparation of this manuscript, the authors utilized artificial intelligence (AI)-assisted tools (specifically, large language models) for the purposes of language refinement, grammar correction, and enhancing the clarity and readability of the text. All AI-generated suggestions were critically reviewed, edited, and approved by the authors to ensure accuracy, scientific integrity, and originality. The authors take full responsibility for the final content, interpretation of data, and conclusions presented in this paper. No AI tools were used to generate core scientific data, conduct analyses, or replace author intellectual contributions. The use of these tools was strictly limited to the writing and editing phase to improve the presentation of the paper.

Conflicts of Interest

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

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Abbreviations

IRSP	Regional Institute of Public Health
DTM	Digital Terrain Model
GNSS	Global Navigation Satellite System
RTK	Real Time Kinematic
NTRIP	Network and Transport of RTCM via Internet Protocol
BIM	Building Information Modeling
TIN	Triangulated Irregular Network
UAV	Unmanned Aerial Vehicle