

1 Article

2 Closing the Digital Gap in Nigerian Land Records: An Open- 3 Source QGIS Plugin for Cadastral Survey Archiving and 4 Spatial Management

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10 Abstract

11 Secure, retrievable cadastral records are foundational to land tenure security and
12 effective land administration, yet most private cadastral surveying firms in Nigeria
13 maintain survey records exclusively on paper, a structural limitation that prevents
14 spatial querying, concurrent access, and long-term integrity verification across the 50-
15 year archival period required by the Survey Co-ordination Act. This paper presents the
16 Survey Management System, a free and open-source QGIS plugin connected to a
17 PostgreSQL/PostGIS spatial database, which connects the AutoCAD drafting workflow
18 already standard in Nigerian cadastral practice to a structured digital archive without
19 requiring practitioners to change how plans are drawn. The system implements bearing-
20 and-distance traverse computation conforming to the Nigerian Survey Regulations
21 1:5000 precision standard, role-based access control structured around the principal
22 surveyor hierarchy, MD5 cryptographic document integrity verification, and automatic
23 detection of boundary conflicts with neighbouring cadastral records. Its principal
24 contribution to digital land administration adoption is an automated DXF import engine
25 that reads beacon coordinates, boundary polylines, traverse annotations, and plan
26 metadata directly from AutoCAD files, eliminating the manual data re-entry identified
27 as the main barrier to digital uptake in private firms. The engine exploits the finding that
28 the Boundary LWPOLYLINE in Nigerian AutoCAD survey plans encodes the correct
29 traversal order in vertex sequence. Validation on production plans from a licensed firm
30 in Imo State demonstrated sub-centimetre traverse closure accuracy (precision ratio
31 1:16,240 against a regulatory minimum of 1:5000) and complete metadata recovery.
32 Record retrieval time fell from approximately 20 minutes to under 2 seconds; spatial
33 proximity queries, previously impossible under the paper system, complete in under 5
34 seconds. The plugin is freely available with no commercial licensing requirement and
35 exceeded 255 downloads across 20 countries within its first month of release.

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Keywords: cadastral information system; land tenure security; digital land
administration; QGIS plugin; Nigerian survey records; PostGIS; DXF import; open-
source GIS; land records digitisation; West Africa

1. Introduction

41 Land tenure security depends on records—records that are accurate, retrievable, and
42 verifiably unchanged over time. The World Bank Land Governance Assessment
43 Framework [1] and UN-Habitat's work on tenure security [2] both identify reliable land
44 records as foundational infrastructure for development. In Nigeria, the legal framework
45 for cadastral surveying requires survey plans to remain valid and retrievable for 50
46 years under the Survey Co-ordination Act [3], and the Nigerian Institution of Surveyors
47 (NIS) sets professional standards governing archiving obligations [4]. Yet the
48 operational reality in most private cadastral offices is that these obligations are met
49 through physical filing systems: a plan is drawn in AutoCAD, printed, submitted to the
50 State Ministry of Lands, and filed in the office. The statutory archival record exists only
51 on paper.

52 This paper describes the Survey Management System, a free and open-source
53 plugin for the QGIS geographic information platform [6], built specifically around the
54 operational needs of Nigerian cadastral surveying practice. It addresses three structural
55 gaps identified during field practice at a private cadastral firm [5]: giving spatial
56 expression to cadastral records so they can be mapped and queried; preserving them
57 with verifiable integrity across the statutory archival period; and making them accessible
58 to the full office team with appropriate permission controls.

59 A professional evaluation by a Fellow of the Nigerian Institution of Surveyors
60 identified manual data re-entry as the single most significant barrier to digital adoption:
61 survey firms draw their plans in AutoCAD, which is both the professional standard and
62 what the State Ministry expects to receive. The coordinate data is already in the
63 AutoCAD file; re-typing it into a database is slow, error-prone, and the principal reason
64 practitioners do not adopt digital archiving tools [5]. Version 1.2 of the plugin addresses
65 this directly with an automated DXF import engine.

66 The plugin was submitted to the QGIS Plugin Repository in April 2026. More than
67 255 downloads were recorded within the first 30 days across 20 countries, with no
68 advertising and while carrying the experimental flag, suggesting the problem addressed
69 here is recognised beyond Nigerian practice.

70 **2. Background**

71 *2.1. Land Records and Tenure Security in Nigeria*

72 Nigeria's land administration system operates under the Land Use Act 1978, which vests
73 all land in each state in the Governor, and the Survey Co-ordination Act [3], which
74 governs cadastral surveys and archiving. In practice, most transactions involving private
75 land require a survey plan prepared by a licensed surveyor, submitted to and registered
76 with the State Ministry of Lands. The private firm retains an office copy; the ministry
77 retains a red copy. These two copies are the primary archival record of the parcel. There
78 is no national digital cadastral database for private-sector survey records.

79 Nigeria's NaLIS (National Land Information System) initiative operates at the
80 federal level, but the gap between federal coordination and the operational reality of
81 private district offices remains large. Most digitisation efforts have focused on
82 government-held records at the ministry level, not on the records held by private firms.
83 Yet the private firm archive is, for many parcels, the only record of survey data in
84 sufficient technical detail to reconstruct a boundary.

85 *2.2. Digital Adoption Barriers in Private Cadastral Practice*

86 The standard workflow at Nigerian private cadastral firms follows a consistent pattern
87 [4,5]. A licensed surveyor captures parcel boundaries in the field, processes the data
88 using AutoCAD-based drafting software, and submits both a printed plan and a digital
89 file to the State Ministry of Lands. The same parcel data ends up in four physically

90 separate records, the field book, the office file, the ministry submission, and the client
 91 copy, with no mechanism to keep them consistent. Data enters government systems by
 92 manual re-entry of paper submissions, which introduces transcription errors and can
 93 take months.

94 The most significant gap for digital adoption in private firms is what happens at the
 95 interface between AutoCAD and a database. A firm wishing to archive digitally
 96 immediately faces the problem of re-entering data from plans that already exist as
 97 AutoCAD files, sometimes decades of accumulated records. This re-entry task is the
 98 reason adoption stalls [5], and it is the specific problem the DXF import engine described
 99 in this paper is designed to eliminate.

100 2.3. Open-Source GIS Tools for Land Administration

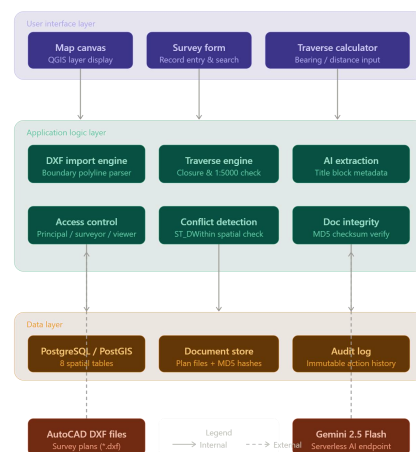
101 QGIS [6] is the leading open-source desktop GIS platform, widely installed among
 102 Nigerian geospatial professionals and freely available without commercial licensing
 103 costs. Its Python plugin framework provides full access to the map canvas, coordinate
 104 reference system handling, and attribute editing. The PostGIS spatial extension to
 105 PostgreSQL [7,8] adds spatial data types and functions, storing point coordinates, line
 106 geometries, and polygon boundaries alongside conventional tabular data, and enables
 107 spatial queries such as finding all survey records within a given distance of a new plot
 108 boundary.

109 Published QGIS plugins for land administration include the Cadastre plugin
 110 developed for France and tools based on the Land Administration Domain Model
 111 (LADM) [12]. None of these address the data conventions or professional standards
 112 specific to Nigerian cadastral practice. AutoCAD DXF [9] is the standard digital output
 113 format from Nigerian survey drafting offices; the ezdxfl Python library [10] provides the
 114 parsing capability used in the import engine described here.

115 3. System Design

116 3.1. Architecture

117 The Survey Management System has three main components: a QGIS Python plugin
 118 providing the user interface and map integration; a PostgreSQL/PostGIS spatial database
 119 holding all survey records; and a serverless AI endpoint for title block metadata
 120 extraction. Figure 1 illustrates the overall system architecture. Table 1 summarises the
 121 individual components.



122
 123 **Figure 1.** Overall system architecture of the Survey Management System showing three layers
 124 (user interface, application logic, data) and external connections to AutoCAD DXF files and the
 125 Gemini AI extraction endpoint.

Table 1. System component overview.

Component	Technology	Purpose
QGIS Plugin	Python 3.12, PyQt5	User interface, map integration, traverse computation
Database	PostgreSQL 12+, PostGIS 3.0+	Survey records, spatial geometries, documents
DXF Engine	Python, ezdxf 1.4	AutoCAD DXF parsing and traverse extraction
AI Server	Python, Vercel, Gemini 2.5 Flash	Hosted title block metadata extraction
Authentication	SHA-256 + salt hashing	Login, role enforcement, audit trail

3.2. Database Schema and Spatial Storage

The database uses eight tables. The surveys table holds plan-level metadata. survey_points stores beacon coordinates as PostGIS Point geometries with the original projected Easting and Northing values alongside WGS84 representations. survey_boundaries holds the plot outline as a polygon, enabling spatial indexing. survey_traverses and traverse_legs hold the traverse computation record. survey_documents stores file references with MD5 checksums. app_users holds credentials and roles. audit_log is an immutable record of every action taken in the system.

Storing boundaries as PostGIS polygons means that every cadastral record can participate in spatial queries: finding all records overlapping a given area, identifying surveys within a specified distance of a new boundary, or generating a map of all surveys completed in a given period. These queries are impossible against a paper archive regardless of how carefully the paper records are maintained.

3.3. Access Control and Audit Trail

Three user roles reflect the professional hierarchy of Nigerian cadastral practice. Superusers (principal surveyors) have full system control: record creation and deletion, user management, and audit log review. Surveyors can create and edit all survey data. Viewers—pupil surveyors, drafters, or client representatives—can search and display records but cannot make changes. Every login, record modification, and management action is recorded in the audit log with a timestamp and username, providing the traceability that regulatory oversight of professional land records requires.

3.4. Document Integrity Across the 50-Year Archival Period

When a plan file is uploaded, the system computes its MD5 hash and stores it alongside the file reference. A verification function recomputes the hash at any subsequent time and flags any discrepancy. The 50-year statutory archival period mandated by the Survey Co-ordination Act [3] means that digital plan files will pass through multiple operating system migrations, hardware replacements, and software changes. The MD5 checksum provides a lightweight but verifiable record of document integrity across this period—a function previously supplied only by the physical red copy held in a ministry archive.

3.5. Boundary Conflict Detection

When a new survey boundary is saved to the database, PostGIS runs an automatic spatial check using ST_DWithin against all existing boundaries, flagging any record within 1 metre of the new plot outline. This replicates at the firm level a validation step

currently available only at the State Ministry of Lands, catching potential boundary overlaps before plan submission rather than during ministry review. Early detection reduces the cost of correction and the time lost to re-measurement and plan revision.

4. DXF Import Engine

4.1. The Boundary Polyline Convention

The key insight behind the DXF import engine is that the Boundary LWPOLYLINE on Nigerian AutoCAD survey plans already encodes the complete traverse sequence in vertex order. The vertices are the beacon coordinates in traversal order, with the first vertex corresponding to the P1 starting beacon. This is a convention of Nigerian survey drafting practice, the boundary outline is drawn as a continuous closed polyline starting from P1, moving clockwise through each beacon, rather than anything specified in the DXF format itself [9]. It proved consistent across every plan tested.

Earlier approaches to automated DXF import attempted to extract traverse data from bearing and distance text annotations alone, matching each annotation to its nearest computed segment midpoint and reconstructing the leg sequence. This approach was unreliable: annotation placement varies between drafting offices and AutoCAD versions, and heuristic sorting produced incorrect sequences on non-standard plans. The boundary polyline approach eliminates the need for heuristic sorting entirely.

4.2. Extraction Algorithm

The extraction algorithm proceeds in ten steps (Table 2). For each segment between consecutive Boundary vertices, the algorithm computes the expected bearing and distance and searches the annotation layers for a text value agreeing within 1 degree and 1 m. Where a matching annotation exists, its value is used in preference to the computed value, preserving the surveyor's original DMS entry. The AI-assisted title block extraction endpoint handles the variable layout of plan metadata across different drafting offices, using Google Gemini 2.5 Flash [11] to return structured JSON from the raw DXF text entities.

Table 2. DXF traverse extraction algorithm.

Step	Operation	Source Layer
1	Locate the closed LWPOLYLINE on the Boundary layer	Boundary
2	Remove the closing duplicate vertex if present	—
3	Compute bearing and distance for each consecutive vertex pair	—
4	Parse all TEXT entities on the BEARING layer; convert %%D to degrees	BEARING
5	Parse all TEXT entities on the DISTANCE layer	DISTANCE
6	Match nearest bearing annotation to each segment midpoint (tolerance: 1 degree)	—
7	Match nearest distance annotation to each segment midpoint (tolerance: 1 m)	—
8	Set vertex[0] as the P1 traverse starting point	—
9	Match PILLAR_NAMES labels to nearest beacon point (tolerance: ≤ 5 m)	PILLAR_NAME S

10 Extract grid control coordinate from MTEXT
Easting/Northing annotations 0

190 4.3. Bearing Parsing

191 Nigerian survey plan DXF files present bearing text in several formats. The parser
192 handles six: whole-circle bearing in degrees, minutes, and seconds; whole-circle bearing
193 in degrees and minutes only (common in Imo State plans); quadrant bearing (e.g., N42
194 degrees 18 minutes E); degrees only; decimal degrees; and any of the above with the
195 AutoCAD %%D escape code substituted for the degree symbol. The %%D conversion
196 runs before pattern matching. Regular expressions permit variable whitespace between
197 degree and minute fields.

198 4.4. Traverse Quality Control

199 The traverse calculator uses the standard angular-linear method. For each leg, departure
200 (delta-E) and latitude (delta-N) are computed as $\text{delta-E} = D \times \sin(\text{theta})$ and $\text{delta-N} = D$
201 $\times \cos(\text{theta})$, where D is horizontal distance in metres and theta is whole-circle bearing in
202 decimal degrees. For a closed traverse, misclosure is expressed as a precision ratio 1:K
203 where K = perimeter divided by misclosure. The NIS cadastral standard requires 1:5000
204 [4]. The system classifies every traverse result into one of three categories and either
205 enables or blocks saving accordingly (Table 3).

206 **Table 3.** Traverse precision classification against the NIS 1:5000 standard.

Precision Ratio	Classification	System Response
$\geq 1:5000$	Meets the cadastral standard	Save enabled; green indicator displayed
1:2000 to 1:4999	Below the cadastral standard	Warning displayed; principal surveyor review required
$< 1:2000$	Fails the standard	Save blocked; re-measurement required

207 5. Validation and Results

208 5.1. Test Data

209 Validation used DXF plans drawn at Datamat Nigeria Limited, Owerri, Imo State,
210 evaluated by a Fellow of the Nigerian Institution of Surveyors [5]. The primary plan,
211 OKUKU_222.dxf, covers a parcel at Amapuokuku, Umuoma I, Imo State, plotted in the
212 Minna/Nigeria East coordinate system (EPSG:26333). It has four beacon points, four
213 traverse legs, and a populated title block. Additional plans from the same practice were
214 imported to confirm behaviour under variation in annotation placement and title block
215 layout.

216 5.2. Coordinate and Traverse Extraction

217 Table 4 shows the four beacon coordinates extracted from OKUKU_222.dxf. Every value
218 matches the original plan exactly. Table 5 shows the four traverse legs and Table 6 the
219 closure residuals.

220 **Table 4.** Beacon coordinates extracted from OKUKU_222.dxf (EPSG:26333).

Label	Easting (m)	Northing (m)	Source Layer
P1	499,124.692	164,684.329	Beacon_Peg

P2	499,131.000	164,655.000	Beacon_Peg
P3 (grid control)	499,120.400	164,650.289	Beacon_Peg
P4	499,117.484	164,682.256	Beacon_Peg

Table 5. Traverse legs extracted from the Boundary polyline vertex sequence.

Leg	From	To	Bearing	Distance (m)	Source
1	P1	P2	167°52'00"	30.000	Annotated
2	P2	P3	246°02'00"	11.600	Annotated
3	P3	P4	354°47'00"	32.100	Annotated
4	P4	P1	73°57'00"	7.500	Annotated

Table 6. Traverse closure residuals. Precision ratio 1:16,240 (regulatory minimum: \geq 1:5000).

After Leg	Computed E (m)	Computed N (m)	Actual E (m)	Actual N (m)	Residual (m)
P2	499,130.998	164,654.999	499,131.000	164,655.000	0.002
P3	499,120.398	164,650.287	499,120.400	164,650.289	0.003
P4	499,117.479	164,682.254	499,117.484	164,682.256	0.006
P1 (close)	499,124.687	164,684.328	499,124.692	164,684.329	0.005

5.3. Metadata Extraction

Table 7 compares metadata extracted by the regex engine and the AI server against the original plan. The AI server identified the LGA from descriptive location text that the regex engine did not capture, the typical case when an LGA name appears in a sentence rather than a labelled field.

Table 7. Metadata extraction comparison. LGA was identified by the AI server from descriptive text; the regex engine did not capture it.

Field	Plan Original	Regex Engine	AI Server	Match
Plan Number	MFP.J/1442/IM/2018	MFP.J/1442/IM/2018	MFP.J/1442/IM/2018	Yes
Owner	Mr Ferdinand Ugokwe	Mr Ferdinand Ugokwe	Mr Ferdinand Ugokwe	Yes
Surveyor	Surv. Joe A. Odeh	Joe A. Odeh	Surv. Joe A. Odeh	Yes
Survey Date	13/06/2018	13/06/2018	13 June 2018	Yes
State	Imo	Imo	Imo	Yes
Description	Nwogweime Farm Land	Nwogweime Farm Land	Nwogweime Farm Land	Yes
LGA	Owerri West	Not captured	Owerri West	AI only

5.4. Operational Performance

Table 8 compares operation times between the analogue workflow and the Survey Management System. The 20-minute manual record retrieval time is reduced to under 2 seconds, a reduction of more than 99%. Spatial proximity queries that were simply impossible under the paper system complete in under 5 seconds.

Table 8. Performance comparison: analogue workflow vs. Survey Management System.

Operation	Analogue System	Survey Management System
Locate record by plan number	~20 min (manual register)	<2 s (database query)
Find all surveys within 500 m	Not possible	<5 s (PostGIS ST_DWithin)
Verify document integrity	Not possible	Instant (MD5 comparison)
Import coordinates from DXF	~30 min manual re-entry	<30 s (automated engine)
Compute traverse closure	~10 min manual	Instantaneous

5.5. QGIS Plugin Map Canvas Output

Figure 2 shows the beacon coordinates and traverse legs from OKUKU_222.dxf as displayed on the QGIS map canvas, overlaid on Google Hybrid satellite imagery.

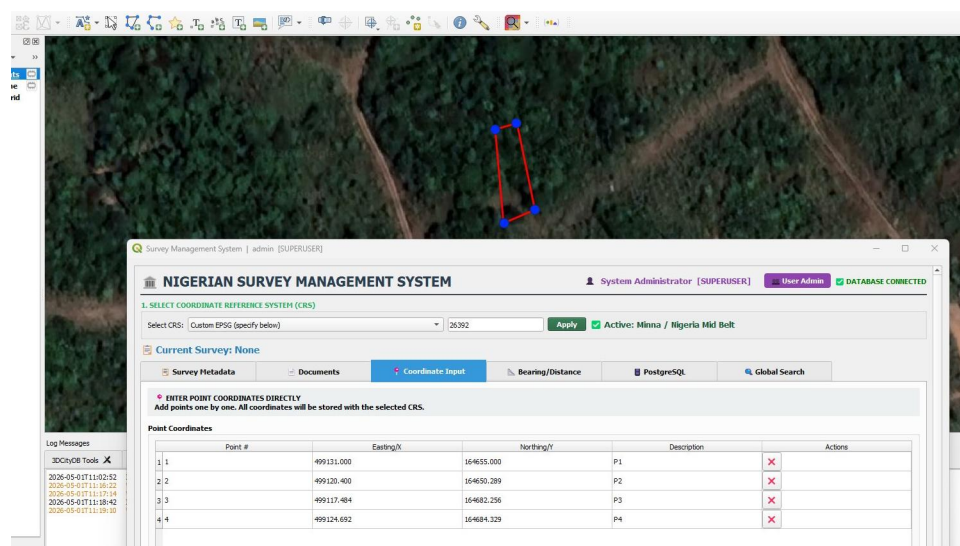


Figure 2. Beacon coordinates and traverse legs from OKUKU_222.dxf plotted on the QGIS map canvas in the Minna/Nigeria East coordinate system (EPSG:26392), overlaid on Google Hybrid satellite imagery. Blue markers indicate beacon points P1-P4; red lines trace the traverse legs. The Survey Management System plugin dialog shows the four extracted coordinate pairs.

5.6. Repository Uptake

The plugin was submitted to the QGIS Plugin Repository in April 2026. More than 255 downloads were recorded within the first 30 days across 20 countries, with no advertising and while carrying the experimental flag, which suppresses it from the default plugin search view. This uptake, on a tool built specifically for Nigerian cadastral practice, indicates that the digital adoption challenge it addresses is more widely shared than the literature on Sub-Saharan land administration might suggest.

6. Discussion

6.1. Land Governance Implications

253 The ability to perform spatial queries against cadastral records has direct implications
254 for land governance. Under the paper system, boundary conflict detection depends on
255 the expertise and memory of the principal surveyor and on the accuracy of ministry
256 records, neither of which provides systematic coverage. The automated conflict
257 detection implemented in this system replicates at the firm level a validation step that
258 currently happens only at ministry review, catching problems earlier in the workflow
259 when correction is less costly.

260 The 50-year statutory archival period means that cadastral records outlast the
261 professional careers of the surveyors who create them, the office buildings in which they
262 are stored, and multiple generations of computing hardware. The MD5 integrity
263 verification implemented in this system provides a lightweight mechanism for
264 establishing that a stored digital plan has not been altered since archiving, a property
265 that is particularly important in land dispute resolution, where the provenance of a plan
266 can be contested.

267 **6.2. The Boundary Polyline Finding and Its Transferability**

268 The finding that the Boundary LWPOLYLINE in Nigerian AutoCAD survey plans
269 encodes the correct traverse sequence in vertex order is the key technical result enabling
270 the import engine. Whether this convention holds for AutoCAD-based survey drafting
271 in Ghana, Kenya, South Africa, or other jurisdictions with similar drafting workflows is
272 not yet established, it is a reasonable hypothesis, since the drafting workflow that
273 produces it is not Nigeria-specific, but it requires systematic testing on plans from other
274 countries before the claim can be extended.

275 **6.3. Shared AI Infrastructure for Low-Resource Adoption**

276 The decision to host the AI extraction endpoint centrally rather than require per-user
277 API configuration was motivated by a specific observation about the target adopter:
278 private cadastral firms in Nigerian cities and towns typically have limited IT
279 infrastructure and no staff with cloud computing expertise. A shared endpoint removes
280 a barrier that would otherwise prevent adoption entirely among the practitioners who
281 would benefit most. The planned improvement is a fallback mode allowing institutional
282 adopters to supply their own API key while the shared endpoint continues to serve
283 individual practitioners.

284 **6.4. Limitations and Next Steps**

285 The validation in this paper comes from plans produced by a single firm in Imo State.
286 Systematic testing across the three Minna coordinate zones (Nigeria West, Nigeria East,
287 and Nigeria Mid-Belt), across different periods of AutoCAD software, and across firms
288 with varying drafting conventions is required before production-scale deployment
289 without manual review. The system requires PostgreSQL to be pre-installed, and a
290 SQLite-based offline mode for single-user operation is planned for a subsequent release.

291 **7. Conclusions**

292 This paper presented the Survey Management System, an open-source QGIS plugin that
293 addresses the digital adoption gap in Nigerian cadastral surveying practice. Its principal
294 contributions to digital land administration are: (i) an automated DXF import engine
295 that reads traverse sequences directly from the Boundary polyline, eliminating the
296 manual data re-entry that was the primary adoption barrier; (ii) cryptographic
297 document integrity verification appropriate to the 50-year statutory archival period; (iii)
298 role-based access control aligned to the professional hierarchy of Nigerian cadastral
299 practice; and (iv) firm-level boundary conflict detection that previously required
300 ministry-level review.

Validation confirms sub-centimetre traverse closure accuracy (1:16,240) and complete metadata extraction on plans drawn in the Minna/Nigeria East coordinate system. The operational shift from 20-minute manual retrieval to under 2 seconds, and from no spatial query capability to sub-5-second spatial search, represents a qualitative change in what the cadastral archive can do, not merely in how fast it does it. The 255-download first-month adoption rate across 20 countries with no advertising indicates the problem addressed here is real and recognised in land administration contexts beyond Nigeria.

The source code is available at github.com/Sochukwumaobim/surveymanagement under the GNU General Public Licence v2. The plugin can be installed from the QGIS Plugin Manager by searching for Survey Management System.

Supplementary Materials: Supplementary Materials: Not applicable.

Author Contributions: Conceptualization, U.C. and J.O.; methodology, U.C.; software, U.C.; validation, U.C. and J.O.; formal analysis, U.C.; investigation, U.C.; resources, J.O.; data curation, J.O.; writing—original draft preparation, U.C.; writing—review and editing, J.O.; supervision, J.O. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement: The source code and example DXF validation datasets are available at <https://github.com/Sochukwumaobim/surveymanagement> under the GNU General Public Licence v2. The datasets are openly accessible without restriction.

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Abbreviations

The following abbreviations are used in this manuscript:

DXF	Drawing Exchange Format (AutoCAD)
GIS	Geographic Information System
LGA	Local Government Area
LIS	Land Information System
MDPI	Multidisciplinary Digital Publishing Institute
MD5	Message Digest 5
NaLIS	National Land Information System (Nigeria)
NIS	Nigerian Institution of Surveyors
PostGIS	Spatial database extension to PostgreSQL
QGIS	Quantum Geographic Information System

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