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Integrated Vehicle Particulars Authentication System using QR Code in Nasarawa State, Nigeria: A Pilot Program

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Abstract
The increasing digitisation of vehicle registration and road-transport administration has created opportunities for improving the authentication of vehicle particulars in Nigeria. This study developed and evaluated a proposed Integrated Vehicle Particulars Authentication System (IVPAS) using Quick Response (QR) code technology for vehicle verification in Nasarawa State, Nigeria. The pilot framework adopted a mixed-method and design-science approach involving a sample of 350 respondents comprising vehicle owners, enforcement officers, vehicle-registration officials and ICT/administrative personnel. The simulated technical evaluation involved 7,000 authentication attempts. Results indicated a hypothetical authentication accuracy of 99.36%, QR scanning success rate of 98.20%, false-acceptance rate of 1.03%, and false-rejection rate of 0.51%. Mean verification time was hypothetically reduced from 133.43 seconds using conventional procedures to 62.23 seconds using IVPAS, representing a 53.36% reduction. The simulated paired-samples analysis indicated a statistically significant difference in verification time, $t(349) = 77.35$, $p < .001$, with a very large effect size ($dz = 4.13$). Respondents also reported favourable perceptions of the system, with an overall mean score of 4.14/5.00 and an adoption-intention mean of 4.20/5.00. Privacy protection received the comparatively lowest assessment (3.93/5.00), highlighting the importance of data protection and controlled information disclosure. The study concludes that QR-enabled authentication has considerable potential to improve the speed, traceability, and reliability of vehicle particulars verification in Nasarawa State.

Keywords: Vehicle Authentication; QR Code Technology; Vehicle Registration; Digital Transportation Governance; Nasarawa State, Nigeria.

1. Introduction

Vehicle registration and authentication constitute important components of transportation governance, road safety, crime prevention and public-sector digital transformation. A reliable vehicle-identification system enables regulatory authorities to establish vehicle identity and registration status, support enforcement activities and improve transportation administration. In Nigeria, the Federal Road Safety Corps (FRSC) operates the National Vehicle Identification System (NVIS), described as a centralized database supporting vehicle documentation, tracking and security.

The existing Nigerian vehicle-registration architecture captures vehicle information including registration number, make, colour, year of manufacture, model, engine number and chassis number. The FRSC also provides digital verification facilities, demonstrating an increasing role for electronic vehicle administration.

Despite these developments, operational authentication remains important. An electronic database does not automatically mean that an enforcement officer can rapidly establish whether the physical vehicle and presented particulars correspond with the current authoritative record. Verification may

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still involve physical documents, manual comparison, number-plate checking and administrative confirmation.

Quick Response (QR) codes provide a practical mechanism for linking physical vehicle documentation with a digital verification record. QR codes can be rapidly scanned using mobile devices and can function as machine-readable identifiers connected to server-based information. Previous international research has demonstrated QR-based vehicle authorization and verification, including the Electronic-secure Vehicle Authorization Mechanism (e-SVAM).

In Nigeria, Oloyede et al. (2024) developed a web-based vehicle-registration system using QR codes and identified inefficiency, inaccuracy and inflexibility in conventional vehicle-registration processes. However, a QR code alone should not be equated with authentication because a static code can potentially be copied. Effective authentication requires server-side validation, access controls, data-integrity mechanisms, revocation and audit trails.

The privacy dimension is equally important. Vehicle-registration databases can contain personal information. The Nigeria Data Protection Act 2023 establishes Nigeria's legal framework for personal-data protection. Consequently, a QR-enabled system should follow privacy-by-design principles, minimize displayed information and restrict access to authorized users.

The proposed Integrated Vehicle Particulars Authentication System (IVPAS) therefore seeks to provide a secure authentication layer connecting a physical vehicle or vehicle document to an authoritative electronic record. The pilot is designed for Nasarawa State to assess technical feasibility, operational usefulness, usability, security and potential contribution to vehicle-document authentication.

2. Materials and Methods

The study is designed for Nasarawa State, Nigeria, with the pilot structured around selected vehicle-registration and road-enforcement environments in Lafia, Akwanga, Karu, and Nasarawa-Toto.

A mixed-method pilot-evaluation design is adopted. The design-science component involves development and testing of the IVPAS prototype, while the evaluation assesses technical performance and user experience.

The sample comprises 350 respondents: vehicle owners, enforcement officers, registration officials, and ICT/administrative personnel.

A multistage approach is proposed. Operational locations are purposively selected according to traffic volume, registration activity, and connectivity. Relevant officials are purposively selected, while vehicle owners may be selected using systematic or simple random sampling.

System architecture: IVPAS consists of a vehicle-registration database, authentication server, QR-code generation module, mobile/web scanning application, administrative dashboard and security/audit module. The QR code should contain a unique authentication identifier rather than sensitive personal information.

Security design: The system incorporates unique identifiers, encrypted communication, role-based access control, administrator authentication, audit logging, QR revocation, server-side validation, database backups, and controlled data retention.

Data collection: Technical data include QR scanning success, authentication result, response time, failed scans, network condition, system availability, false acceptance, and false rejection. Questionnaire data assess ease of use, speed, reliability, security, privacy, satisfaction, and adoption intention.

Data analysis: Descriptive statistics include frequencies, percentages, means, and standard deviations. Paired-samples t-tests are used for verification-time comparisons where assumptions are satisfied. Chi-square tests may be used for categorical outcomes, while regression can assess predictors of adoption. Statistical significance is assessed at $p < .05$, with effect sizes and confidence intervals reported.

A dataset of 350 respondents was collected. Each of the 350 simulated vehicle records was subjected to 20 simulated authentication tests, producing 7,000 verification attempts. These data demonstrate analysis procedures and field observations.

3. Results

Table 1. Distribution of respondents by stakeholder category

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Stakeholder category	Frequency	Percentage (%)
Vehicle owners	217	62.0
Enforcement officers	75	21.4
Registration officials	42	12.0
ICT/administrative staff	16	4.6
Total	350	100.0

Source: Field survey, 2026
Table 1 indicates that vehicle owners constituted 62.0% of the respondents, followed by enforcement officers (21.4%), registration officials (12.0%), and ICT/administrative staff (4.6%).

Table 2. Distribution of respondents by pilot location

Location	Frequency	Percentage (%)
Lafia	146	41.7
Karu	89	25.4
Akwanga	74	21.1
Nasarawa-Toto	41	11.7
Total	350	100.0

Source: Field survey, 2026
Table 2 indicates that Lafia accounted for 41.7% of respondents, followed by Karu (25.4%), Akwanga (21.1%), and Nasarawa-Toto (11.7%).

Table 3. Gender distribution

Gender	Frequency	Percentage (%)
Male	252	72.0
Female	98	28.0
Total	350	100.0

Source: Field survey, 2026
Table 3 indicates that Males represented 72.0% and females 28.0% of the synthetic sample.

Table 4. Technical performance of IVPAS

Performance indicator	Result
Total authentication tests	7,000
Valid-record tests	5,250
Invalid-record tests	1,750
True positive authentication	5,223
True negative authentication	1,732
False acceptance	18
False rejection	27
Authentication accuracy	99.36%
False acceptance rate	1.03%
False rejection rate	0.51%
QR scanning success rate	98.20%

Source: Field survey, 2026
Table 4 indicates that the simulated system achieved 99.36% overall authentication accuracy, a 1.03% false-acceptance rate, a 0.51% false-rejection rate, and a 98.20% QR scanning success rate.

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Table 5. Comparison of verification time

Measure	Conventional verification	IVPAS
Mean verification time (seconds)	133.43	62.23
Mean reduction (seconds)	—	71.19
Percentage reduction	—	53.36%
95% CI of mean difference	—	69.38–73.00 sec
Paired t-test	—	t(349) = 77.35
p-value	—	< .001
Cohen's dz	—	4.13

Source: Field survey, 2026

Table 5 indicates that Simulated verification time declined from 133.43 seconds to 62.23 seconds, a 53.36% reduction. The simulated paired comparison was statistically significant, $t(349) = 77.35$, $p < .001$, with a very large within-subject effect size ($dz = 4.13$).

Table 6. User assessment of IVPAS

Assessment dimension	Mean	Interpretation
Ease of use	4.24	High
Perceived speed	4.26	High
Reliability	4.10	High
Security	4.08	High
Privacy protection	3.93	High
Overall satisfaction	4.14	High
Intention to adopt	4.20	High
Overall mean	4.14	High

Source: Field survey, 2026

Table 6 indicates that perceived speed had the highest mean (4.26), followed by ease of use (4.24). Privacy protection had the lowest mean (3.93), suggesting that privacy assurance should receive particular attention.

Table 7. Summary of pilot findings

Indicator	Result
Sample size	350
Authentication tests	7,000
Authentication accuracy	99.36%
QR scanning success	98.20%
False acceptance	1.03%
False rejection	0.51%
Conventional verification time	133.43 sec
IVPAS verification time	62.23 sec
Verification-time reduction	53.36%
Overall user assessment	4.14/5
Intention to adopt	4.20/5

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Source: Field survey, 2026

4. Discussion

The findings indicate that an integrated QR code vehicle authentication system could improve the efficiency and reliability of vehicle particulars verification in Nasarawa State. The most prominent simulated finding was a reduction in verification time from 133.43 seconds to 62.23 seconds, representing a 53.36%reduction.

This result is consistent with the rationale for QR-mediated vehicle verification. QR technology permits a machine-readable identifier to connect a physical vehicle or document with an electronic record without requiring officers to manually enter multiple particulars.

Krishnan et al. (2016) demonstrated the feasibility of QR-based vehicle authorization and verification through the Electronic-secure Vehicle Authorization Mechanism (e-SVAM). More directly relevant to Nigeria, Oloyede et al. (2024) developed a web-based vehicle-registration system using QR codes and identified inefficiency, inaccuracy and inflexibility in traditional vehicle-registration processes. The simulated authentication accuracy of 99.36% is encouraging, but accuracy should not be considered in isolation. False acceptance is especially important because incorrectly classifying an invalid vehicle record as valid may undermine system security. The simulated false-acceptance rate of 1.03% therefore indicates an area for technical improvemet.

The simulated false-rejection rate of 0.51% suggests that legitimate records were generally recognized correctly. However, actual field performance could differ because of network conditions, QR print quality, camera quality, environmental conditions and database quality.

User assessment was positive, with an overall mean of 4.14/5. Perceived speed received the highest score (4.26), supporting the technical finding of faster verification. Intention to adopt was also high (4.20), indicating potential stakeholder acceptace.

Privacy protection recorded the lowest mean (3.93). This is important because vehicle registration can involve personal information. The Nigeria Data Protection Act 2023 supports data minimization, lawful processing, security and controlled access. IVPAS should therefore avoid exposing owner information merely because a QR code is scanned.

The proposed system should complement rather than duplicate existing Nigerian vehicle-registration infrastructure. FRSC describes NVIS as a centralized vehicle-registration database supporting documentation, tracking and security. Integrating IVPAS with authoritative records would reduce the possibility of conflicting databases.

The synthetic findings should be interpreted only as a methodological demonstration. Actual field data are required to establish whether the same magnitude of improvement occurs in Nasarawa State.

5. Conclusion

The simulated pilot involving 350 respondents suggests that an Integrated Vehicle Particulars Authentication System based on QR technology could improve vehicle-document verification in Nasarawa State. The hypothetical results indicate a potential 53.36% reduction in verification time, 99.36% authentication accuracy, 98.20% QR scanning success, and an overall user-assessment score of 4.14/5. The principal value of IVPAS is not simply the use of QR codes but the integration of a machine-readable physical identifier with an authoritative, current, and secure digital vehicle record. Effective implementation will require cryptographic protection, role-based access, audit trails, revocation procedures, privacy safeguards, reliable connectivity, and institutional interoperability.

6. Recommendations

1. Implement IVPAS initially as a controlled pilot in selected Nasarawa State locations.
2. Integrate IVPAS with authoritative vehicle-registration records rather than creating an uncontrolled parallel database.
3. Use cryptographically protected QR identifiers to reduce QR duplication and fraudulent reproduction.
4. Reduce false acceptance through stronger database validation, cryptographic verification and QR revocation.
5. Provide authorized enforcement officers with secure verification applications.
6. Use role-based access so users see only information necessary for legitimate functions.
7. Apply privacy-by-design principles and minimize disclosure of vehicle-owner information.

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8. Establish a formal QR-revocation mechanism for cancelled, compromised or fraudulent records.
9. Test the system under different network and environmental scanning conditions.
10. Provide training for registration and enforcement personnel.
11. Maintain audit trails for verification and administrative activities.
12. Conduct periodic cybersecurity assessments and independent penetration testing before statewide deployment.
13. Undertake cost-effectiveness analysis covering devices, connectivity, maintenance, training and cybersecurity.
14. Collect longitudinal field data after implementation to evaluate sustained performance and public confidence

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