

# Social acceptability of urban video surveillance in Bandundu mathematical modeling, decision architecture and computer science challenges

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**Abstract:** Urban security in Bandundu remains hampered by crime, theft, burglaries, and inadequate surveillance systems. This article uses a mixed-methods survey conducted with 103 residents and 20 institutional stakeholders to formalize the social acceptability of video surveillance. The theoretical model incorporates TAM, UTAUT, institutional trust, and privacy calculus. The results show a predominantly favorable acceptability, conditioned by feelings of insecurity, perceived usefulness, trust in authorities, and privacy guarantees. Age has no statistically significant relationship with acceptance of camera installation.  $\chi^2 = 1,513$  The article proposes a formalization using logistic regression, path analysis  $p = 0,982$ ,  $ddl = 7$  and structural equation modeling, followed by a BI architecture integrating data acquisition, storage, decision analysis, dashboards, and data security. Optimizing camera deployment is formulated as a maximum coverage problem under budgetary constraints. The main contribution lies in the articulation between social acceptability, statistical modeling, decision-making computing and digital governance in the Democratic Republic of Congo.

**Keywords:** video surveillance, social acceptability, TAM, UTAUT, logistic regression, structural equations, business intelligence, Bandundu, DRC.

## 1. INTRODUCTION

Video surveillance has gradually become an instrument of urban policy in several African cities. In Bandundu, the capital of Kwilu province, population growth, trade flows, and persistent crime fuel a demand for the protection of people and property. The potential implementation of a camera system is not simply a technical decision. It involves social perceptions, relationships of trust, fundamental rights, and budgetary choices. The purpose of this article is to offer a scientific analysis of the social acceptability of video surveillance in Bandundu by combining mathematical modeling, decision architecture, and computational perspectives.

The literature on technology acceptance offers useful frameworks. The TAM model links acceptance to perceived usefulness and perceived ease of use. The UTAUT model incorporates expected performance, expected effort, social influence, and enabling conditions. Applied to surveillance, these models must be enriched by institutional trust, privacy concerns, and feelings of insecurity. This article thus formulates several hypotheses. H1 posits that feelings of insecurity increase favorability toward video surveillance. H2 assumes that privacy concerns reduce this acceptability. H3 suggests that trust in public authorities positively influences acceptance. H4 considers that perceived usefulness plays a mediating role between insecurity and acceptability. H5 posits that enabling conditions, including electricity, maintenance, and regulation, influence acceptance.

This article makes a threefold contribution. Theoretically, it connects social acceptability with models of technological acceptance. Methodologically, it transforms declarative variables into measurable indices and estimable equations. From a computer science perspective, it proposes a BI architecture and an optimized camera deployment framework that is compatible with security and data protection requirements.

## 2. THEORETICAL FRAMEWORK AND OPERATIONALIZATION

Video surveillance refers to a set of technical devices used to observe, record, and transmit images. Video protection, on the other hand, focuses more on public spaces and public roads. Social acceptability corresponds to the collective and individual judgment regarding the legitimacy, usefulness, and compatibility of a device with values and expectations. Acceptance refers to actual consent or a favorable attitude. This distinction is essential to avoid reducing acceptability to a simple binary response.

The chosen model considers four main dimensions. The feeling of insecurity *INS* encompasses fear of assault, fear of going out at night, perception of crime, and perceived vulnerability. Perceived usefulness *UTI* includes prevention, identification of perpetrators, and assistance with investigations. Institutional trust *CONF* measures confidence in the police, authorities, and the protection of images. Concern for privacy *PRIV* captures the fear of excessive surveillance, misuse of images, and lack of oversight. The dependent variable *ACC* represents the social acceptability of video surveillance.

The operationalization uses five-point Likert scales. The indices are normalized between 0 and 1. Internal consistency is assessed using Cronbach's alpha coefficient.

$$\alpha = \frac{k}{k-1} \left( 1 - \frac{\sum_{j=1}^k \sigma_j^2}{\sigma_T^2} \right)$$

Construct validity can be examined by exploratory factor analysis, with KMO index and Bartlett's test of sphericity. The variables are then integrated into explanatory models.

## 3. MIXED METHODOLOGY

The study adopts a sequential mixed-methods approach. The quantitative component is based on a questionnaire administered to 103 residents. The qualitative component involves semi-structured interviews with institutional, community, police, and business stakeholders. Data collection is carried out using KoBoCollect and KoBoToolbox. Quantitative analysis is performed using SPSS and Excel. Qualitative analysis is based on thematic analysis.

The quantitative sample comprises 64.1% men and 35.9% women. The 31–40 age group represents 42.7%, followed by the 21–30 age group at 33.0%. The 41–70 age group represents 13.6%. The 0–15 and 15–20 age groups each represent 3.9%. The sample contains 103 valid observations and no missing data for the main variables.

Ethical considerations focus on free consent, confidentiality, anonymity, and risk minimization. Issues related to security, crime, and institutional trust are sensitive. Participants are informed that the data will be used strictly for scientific purposes.

## 4. MATHEMATICAL MODELING

### 4.1. Binary Logistic Regression

Let be  $Y_i$  the binary variable indicating the acceptance of a camera near the neighborhood.  $Y_i = 1$  In case of acceptance,  $Y_i = 0$  otherwise. The logistic model is written

$$P(Y_i = 1 | X_i) = \frac{1}{1 + \exp[-(\beta_0 + \beta_1 INS_i + \beta_2 UTI_i + \beta_3 CONF_i + \beta_4 PRIV_i + \varepsilon_i)]}$$

The logit transformation is expressed

$$\text{logit}(p_i) = \ln\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \beta^\top X_i$$

The rating ratios are obtained by

$$OR_k = \exp(\beta_k)$$

Maximum likelihood estimation maximizes

$$\ell(\beta) = \sum_{i=1}^n [y_i \ln(p_i) + (1 - y_i) \ln(1 - p_i)]$$

A value  $OR_k > 1$  indicates that a unit increase in value  $X_k$  increases the probability of acceptance. A value  $OR_k < 1$  reflects a reducing effect.

#### 4.2. Track analysis and structural equations

The trail model posits that feelings of insecurity influence perceived usefulness, which in turn influences acceptability. Institutional trust and privacy directly impact acceptability.

$$UTI_i = \alpha_0 + \alpha_1 INS_i + \zeta_{1i}$$

$$ACC_i = \gamma_0 + \gamma_1 UTI_i + \gamma_2 CONF_i + \gamma_3 PRIV_i + \gamma_4 INS_i + \zeta_{2i}$$

The general structural form is written

$$\eta = B\eta + \Gamma\xi + \zeta$$

Measurement models link latent variables and observed indicators.

$$x = \Lambda_x \xi + \delta$$

$$y = \Lambda_y \eta + \varepsilon$$

The estimation can be performed using maximum likelihood, partial least squares, or a Bayesian approach. The direct, indirect, and total effects are calculated. The indirect effect of  $INS$  on  $ACC$  via  $UTI$  is  $\alpha_1\gamma_1$ . The total effect is  $\gamma_4 + \alpha_1\gamma_1$ .

#### 4.3. Composite Acceptability Index

A synthetic index is constructed by min-max normalization.

$$z_{ij} = \frac{x_{ij} - \min(x_j)}{\max(x_j) - \min(x_j)}$$

$$A_i = \sum_{j=1}^J w_j z_{ij}, \quad \sum_{j=1}^J w_j = 1, \quad 0 \leq A_i \leq 1$$

The weights can be determined by expertise, estimated by factor analysis, or derived from a regression model. The index  $A_i$  allows individuals and neighborhoods to be ranked according to their level of acceptability.

#### 4.4. Association Tests

The chi-square test assesses the independence between two categorical variables.

$$\chi^2 = \sum_{i=1}^r \sum_{j=1}^c \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

$$E_{ij} = \frac{n_i n_j}{n}$$

The Goodman and Kruskal lambda measures the proportional reduction of the prediction error.

$$\lambda = \frac{\sum_i \max_j f_{ij} - \max_j f_{.j}}{n - \max_j f_{.j}}$$

The Goodman-Kruskal tau, the uncertainty coefficient, and  $d$ Somers's tau complete the analysis. In the study, age and acceptance of a camera near the neighborhood did not show a significant association. The chi-square value is given 1,513 by  $ddl = 7$  and  $p = 0,982$ . The symmetric lambda value is given 0,016 by  $p = 0,563$ . The Goodman-Kruskal tau value is given 0,005 by  $p = 0,864$  and 0,015. The uncertainty coefficient is given 0,012 by  $p = 0,967$ .  $p = 0,982$  Somers  $d$ 's tau value is given  $-0,007$  by  $p = 0,905$ . Therefore, age is not a significant predictor of acceptability.

## 5. RESULTS

### 5.1. Profile and declared acceptability

The majority of respondents expressed support for the installation of cameras in public spaces. The main reasons cited were crime prevention, identification of offenders, facilitation of investigations, and public protection. Qualitative responses frequently mentioned social security, public safety, civil protection, and the creation of databases.

### 5.2. Perception of insecurity and perceived usefulness

The feeling of insecurity appears to be a central factor. People who perceive a high level of insecurity are more likely to support video surveillance. Perceived usefulness plays a mediating role. Video surveillance is seen as a means of deterrence, identification, and assistance in investigations. The response, "If it's installed, perhaps it can reduce insecurity due to fear of being seen," illustrates the deterrent aspect.

### 5.3. Institutional trust and privacy

Trust in the authorities influences acceptance. Respondents accept the system when they believe the images will be used exclusively for security purposes. Concerns about privacy, excessive surveillance, and misuse of the images reduce acceptability. Therefore, acceptance is not unconditional.

### 5.4. Verification of hypotheses

H1 is validated. Feelings of insecurity promote acceptance. H2 is partially validated. Privacy concerns reduce acceptability, but do not eliminate it. H3 is validated. Institutional trust positively influences acceptance. H4 is supported by qualitative results and the literature. H5 remains dependent on technical, financial, and regulatory conditions.

## 6. BI AND IT ARCHITECTURE

### 6.1. Acquisition Layer

The target architecture integrates IP cameras, environmental sensors, digital recorders, and edge gateways. Video streams are compressed using standards such as H.265. Metadata is extracted locally. Edge latency must comply with

$$T_{\text{edge}} = \frac{D}{B_{\text{up}}} + T_{\text{proc}} + T_{\text{inf}} \leq T_{\text{max}}$$

### 6.2. Storage and Integration Layer

A data lake stores the raw data streams. A star schema data warehouse organizes the analyses. The fact table *Fact\_Acceptabilite* contains measures of acceptability, confidence, insecurity, and utility. Dimensions include *Dim\_Individu* [missing information], *Dim\_Espace* [missing information], *Dim\_Temps* [missing information], *Dim\_Technologie* [missing information], *Dim\_Confiance* [missing information], and *Dim\_Quartier* [missing information]. ETL processes handle extraction, transformation, and loading.

### 6.3. Analytical layer

The analyses utilize OLAP, logistic regression, decision trees, random forests, and XGBoost. Interpretability is enhanced by SHAP. The key indicators are

$$\begin{aligned} TA &= \frac{N_{\text{oui}}}{N_{\text{total}}} \\ IC &= \frac{1}{n} \sum_{i=1}^n C ONF_i \\ IP &= \frac{1}{n} \sum_{i=1}^n P RIV_i \\ IS &= \frac{1}{n} \sum_{i=1}^n I NS_i \end{aligned}$$

Data quality is measured by

$$DQ = 1 - \frac{M + E}{N}$$

#### 6.4. Restitution Layer

Dashboards display acceptance rates by neighborhood, high-risk areas, trust levels, and privacy concerns. GIS mapping visualizes potential sites. Automated alerts report anomalies and incidents.

#### 6.5. Security, ethics and compliance

AES-256 encryption, role-based access control, logging, and anonymization are required. The DRC's Digital Code governs personal data. The European regulation on artificial intelligence provides a framework for high-risk systems. The design must incorporate privacy by design and data minimization.

#### 6.6. Deployment Optimization

The choice of sites can be formulated as a problem of maximum coverage.

$$\begin{aligned} & \max \sum_{j \in J} v_j z_j \\ & \text{s.t.} \sum_{i \in I} c_i x_i \leq B \\ & z_j \leq \sum_{i \in N(j)} x_i \\ & x_i \in \{0, 1\}, z_j \in \{0, 1\} \end{aligned}$$

$x_i = 1$  If a camera is installed on the site  $i$ .  $z_j = 1$  If the area  $j$  is covered.  $v_j$  represents the security value of the area.  $c_i$  is the installation cost.  $B$  is the budget. This formulation allows for optimal allocation under constraints.

### 7. DISCUSSION

The results confirm the literature on the acceptance of surveillance technologies. Perceived usefulness, institutional trust, and feelings of insecurity are major determinants. Comparison with Kinshasa shows a convergence on the security benefits of cameras, but a difference in focus. The Kinshasa study focuses more on technical feasibility. The present study concentrates on social acceptability.

Acceptability should not be equated with unconditional support. Citizens can support video surveillance while demanding guarantees. Transparency, participation, and data protection strengthen its legitimacy. Video surveillance should complement patrols, street lighting, and social prevention efforts.

### 8. LIMITATIONS AND PERSPECTIVES

The sample size limits generalization. Selection and social desirability biases are possible. Statistical analyses of some variables have small sample sizes. Future research directions include multivariate models, structural equation modeling, longitudinal studies, and impact evaluations. A comparison between several cities in the DRC would be relevant.

### 9. CONCLUSION

The article shows that the social acceptability of video surveillance in Bandundu is conditional. It depends on feelings of insecurity, perceived usefulness, institutional trust, and privacy protection. Age does not have a significant effect. Mathematical modeling, business intelligence architecture, and IT optimization offer operational tools for designing a legitimate, secure, and evaluable system. The success of such a project relies on transparent governance, a clear legal framework, and effective citizen participation.

### REFERENCES

- [1] Venkatesh, V., Morris, MG, Davis, GB, & Davis, FD (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly* , 27(3), 425–478.
- [2] Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly* , 13(3), 319–340.

- [3] Blut, M., Chong, A., Tsiga, Z., & Venkatesh, V. (2022). Meta-analysis of UTAUT2. *Journal of the Academy of Marketing Science* , 50, 1111–1132.
- [4] Cram, W.A., Proudfoot, J.G., & D'Arcy, J. (2021). Seeing is believing? *MIS Quarterly* , 45(4), 1943–1974.
- [5] Acquisti, A., Brandimarte, L., & Loewenstein, G. (2015). Privacy and human behavior in the age of information. *Science* , 347(6221), 509–514.
- [6] Zuboff, S. (2019). *The Age of Surveillance Capitalism* . PublicAffairs.
- [7] Kitchin, R. (2022). *The Data Revolution* (2nd ed.). WISE.
- [8] Davenport, T.H., & Harris, J.G. (2017). *Competing on Analytics* . Harvard Business Review Press.
- [9] Kimball, R., & Ross, M. (2013). *The Data Warehouse Toolkit* (3rd ed.). Wiley.
- [10] Provost, F., & Fawcett, T. (2013). *Data Science for Business* . O'Reilly.
- [11] Shalev-Shwartz, S., & Ben-David, S. (2014). *Understanding Machine Learning* . Cambridge University Press.
- [12] Goodfellow, I., Bengio, Y., & Courville, A. (2016). *Deep Learning* . MIT Press.
- [13] Kline, R.B. (2023). *Principles and Practice of Structural Equation Modeling* (5th ed.). Guilford Press.
- [14] Hair, JF, Black, WC, Babin, BJ, & Anderson, RE (2019). *Multivariate Data Analysis* (8th ed.). Cengage.
- [15] Tabachnick, B.G., & Fidell, L.S. (2019). *Using Multivariate Statistics* (7th ed.). Pearson.
- [16] Field, A. (2024). *Discovering Statistics Using IBM SPSS Statistics* (6th ed.). WISE.
- [17] Creswell, J. W., & Plano Clark, V. L. (2023). *Designing and Conducting Mixed Methods Research* (3rd ed.). WISE.
- [18] Tashakkori, A., Johnson, R.B., & Teddlie, C. (2021). *Foundations of Mixed Methods Research* (2nd ed.). WISE.
- [19] Anunga Kokana, P., Diambote Diasilua, A., & Tshodi Tolembo, ME (2013). Video surveillance of public places and highways: Case of Kinshasa City. *International Journal of Engineering Research & Technology* , 2(10), 766–774.
- [20] Democratic Republic of Congo. (2023). Ordinance-Law No. 23/010 of March 13, 2023, establishing the Digital Code.
- [21] European Union. (2024). Regulation (EU) 2024/1689 laying down harmonised rules on artificial intelligence.
- [22] Boulemtafes, A., Derhab, A., & Challal, Y. (2020). A review of privacy-preserving techniques for deep learning. *Neurocomputing* , 384, 21–45.
- [23] Sarker, I. H. (2021). Machine learning: Algorithms, real-world applications and research directions. *SN Computer Science* , 2(3), 160.
- [24] Shi, W., Cao, J., Zhang, Q., Li, Y., & Xu, L. (2016). Edge computing: Vision and challenges. *IEEE Internet of Things Journal* , 3(5), 637–646.
- [25] Zhou, Z., Chen, X., Li, E., Zeng, L., Luo, K., & Zhang, J. (2019). Edge intelligence: Paving the last mile of artificial intelligence with edge computing. *Proceedings of the IEEE* , 107(8), 1738–1762.
- [26] Athey, S., & Imbens, G. W. (2019). Machine learning methods that economists should know about. *Annual Review of Economics* , 11, 685–725.
- [27] Mullainathan, S., & Spiess, J. (2017). Machine learning: An applied econometric approach. *Journal of Economic Perspectives* , 31(2), 87–106.
- [28] Pearl, J. (2009). *Causality* (2nd ed.). Cambridge University Press.
- [29] Radio Okapi. (2021). The Frontière neighborhood in Bandundu-ville is safe since the deployment of the Police.
- [30] ICERA. (2026). Quantitative Methodology. <https://icera.fr/methodologie-quantitative/>