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Digital Momentum and Urban Transformation: Measuring Smart City Readiness in Algeria through Principal Component Analysis.

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Abstract
This study develops a composite Smart City Readiness Index to evaluate Algeria's urban digital transformation from 2017 to 2029. Using Principal Component Analysis, we synthesize a multidimensional dataset comprising technological, infrastructural, demographic, and economic indicators into a single interpretable score. The PCA approach enables dimensionality reduction while preserving the latent structure of the data, effectively handling multicollinearity and revealing dominant readiness patterns. The resulting index is scaled to a 0-100 range to facilitate temporal comparison and policy relevance. Statistical diagnostics, including eigenvalue decomposition, confirm the robustness of the model. The readiness scores show a consistent upward trajectory, with digital access and service penetration emerging as primary drivers. Economic indicators such as GDP and population density contribute to secondary dimensions, highlighting the enabling role of macroeconomic conditions. The study offers a replicable framework for smart city assessment in developing contexts and provides actionable insights for strategic planning and digital policy formulation.

Keywords:
Smart city readiness;
Urban development;
Economic transformation;
Algeria.

JEL Classification Codes: C38 ; O18 ; O33

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1. INTRODUCTION

The global momentum toward Smart Cities reflects a strategic shift in urban development, where digital technologies, data analytics, and citizen-centric design converge to enhance the efficiency, sustainability, and inclusivity of urban life. While much of the innovation has been concentrated in high-income nations, the imperative for smart urban transformation in developing countries is growing rapidly. These regions face mounting pressures from population growth, urban sprawl, and infrastructural deficits making the smart city model not just aspirational but essential.

Algeria, as a representative case of the Global South, presents a compelling context for evaluating Smart City Readiness. With a population exceeding 46 million as of 2023and an urbanization rate of74.7%, the country is experiencing significant demographic and spatial shifts. Its GDP stood at approximately $206 billion USD in 2023, classifying it as a lower-middle-income economy. These macroeconomic and demographic factors form the backdrop against which digital transformation must unfold.

The readiness of Algerian cities to embrace smart technologies is shaped by several interdependent variables. Internet penetration has reached 71%, with over 27 million users online. Mobile internet dominates access, supported by 83% 4G coverage although fixed broadband infrastructure remains underdeveloped. Financial inclusion is advancing, with increasing adoption of online banking and digital payment systems, though disparities persist in rural areas. Education levels and digital literacy are improving, yet gaps in STEM training and innovation capacity remain. These factors technology infrastructure banking and online financial inclusion internet penetration, education

urbanization GDP, and population are central to assessing smart city readiness.

This article introduces a composite scoring framework for Smart City Readiness, tailored to the Algerian context. By applying Principal Component Analysis (PCA) and thematic indexing, the study quantifies readiness across key domains and identifies strategic levers for policy intervention. The goal is to provide a replicable model for other developing nations seeking to navigate the complexities of digital urban transformation.

Research problematic

To what extent has Algeria strengthened its readiness over time to implement smart city initiatives, and how effectively is it building the institutional, technological, and infrastructural foundations required for a successful transition toward smart urban development?

2. Smart Cities and Algeria's Transition Toward Digital and Sustainable Development

2.1. Institutional Support and Entrepreneurial Ecosystems

Algeria has made significant strides in supporting digital entrepreneurship and modernizing its ICT infrastructure. Innovation hubs and incubators across major cities serve as testing grounds for smart city solutions, contributing to job creation and poverty alleviation. These efforts are reinforced by national programs and strategic investments that promote digital literacy and startup growth.

One notable initiative is the Do4Africa Program, which addresses urban challenges through digital tools and citizen-centered design. By improving resource management in areas such as water, transport, and energy, the program exemplifies Algeria's commitment to sustainable urban innovation.

2.2. The Startup Ecosystem: A Catalyst for Smart City Development

The year 2024 marked a turning point for Algeria's startup landscape, with record-breaking funding and sectoral diversification. Total investment reached $650 million, a 60% increase from the previous year, signaling strong investor confidence and policy alignment. Algiers emerged as a leading hub, while secondary cities such as Oran and Constantine showed rapid growth.

2.3. Infrastructure, Global Integration, and Talent Development

Algeria's digital infrastructure saw major upgrades in 2024, including broadband expansion and 5G deployment. Pilot smart city projects in Algiers and Oran emphasize sustainability, cybersecurity, and integrated urban planning.

International collaborations have also accelerated ecosystem growth. Over 50 startups expanded abroad, leveraging global partnerships for funding and market access. The country recorded 15 M&A deals worth $200 million, signaling Algeria's emergence as a regional innovation hub.

2.4. Challenges and Strategic Outlook

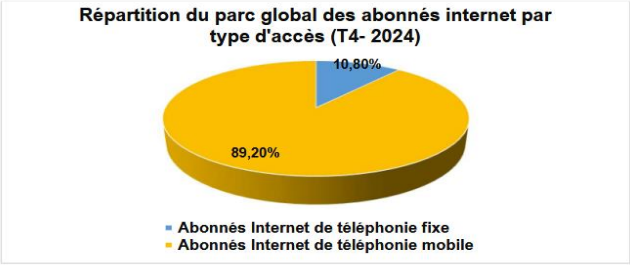
Despite these advances, Algeria's smart city trajectory faces challenges, including regulatory gaps, uneven funding distribution, and infrastructural bottlenecks. However, the country's abundant human capital, strategic geographic location, and growing digital ecosystem present substantial opportunities.

Looking ahead to 2025, Algeria aims to deepen its focus on green tech, fintech, and global partnerships, positioning itself as a leader in regional digital transformation and sustainable urban development. (https://www.arpce.dz/en/, 2025)

3. Data Snapshot: Algeria's Digital infrastructure

This section provides an overview of Algeria's evolving digital infrastructure, highlighting key indicators that reflect the country's progress in connectivity, technological capacity, and digital service deployment. It examines foundational elements such as internet access, mobile networks, and ICT readiness, which collectively shape Algeria's ability to support smart city initiatives and broader digital transformation goals.

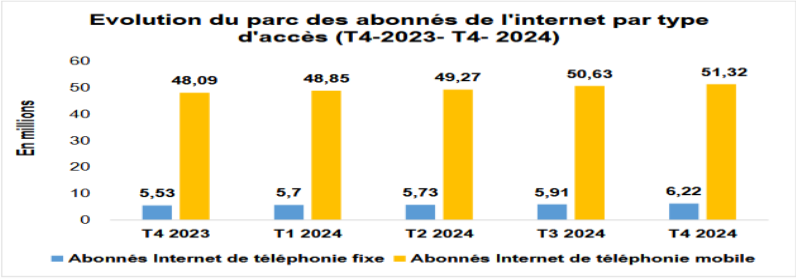
Fig 1. Distribution of the total internet subscriber base by type of access.



Source :(https://www.arpce.dz/en/, 2025)

Key Insight: 89.2% of internet subscribers in Algeria use mobile internet, while only 10.8% rely on fixed-line connections. This highlights the clear dominance of mobile technologies in the country's digital infrastructure, positioning mobile connectivity as a cornerstone of Algeria's evolving digital economy.

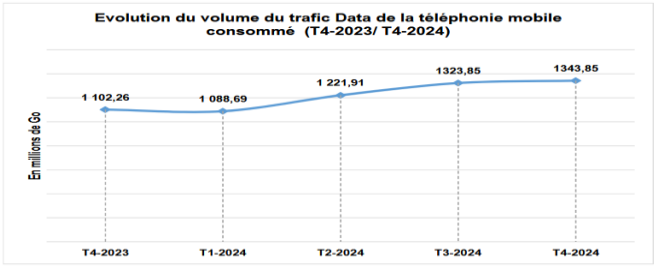
Fig 2. Evolution of Total Internet Subscribers (Fixed + Mobile) Q4 2023 to Q4 2024



Source: (https://www.arpce.dz/en/, 2025)

The total number of internet users in Algeria increased from 53.62 million to 57.54 million between the fourth quarter of 2023 and the same period in 2024, marking a 7.31% annual growth. This steady rise in connectivity reflects strong momentum in digital access and infrastructure development, underscoring its role as a fundamental driver of the country's digital transformation.

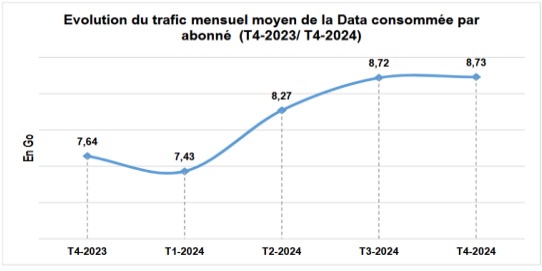
Fig 3. Evolution of Mobile Data Traffic Q4 2023 to Q4 2024



Source:(https://www.arpce.dz/en/, 2025)

Between the fourth quarter of 2023 and the fourth quarter of 2024, mobile data consumption in Algeria rose from 1,102 million GB to 1,344 million GB, marking a significant 21.92% increase. This surge reflects the growing intensity of digital activity and the rising demand for online services, underscoring the rapid expansion of Algeria's mobile-driven digital economy.

Fig 4. Average Monthly Data Consumption Per Subscriber Q4 2023 to Q4 2024



Source:(https://www.arpce.dz/en/, 2025)

The average monthly data usage per mobile subscriber in Algeria increased from 7.64 GB to 8.73 GB between the fourth quarter of 2023 and the fourth quarter of 2024, representing a 14.27% rise. This growth indicates higher user engagement and an increasingly digital lifestyle, highlighting key signs of progress and maturity in Algeria's evolving digital economy.

4. Previous studies

Smart city development has become a strategic imperative for rapidly urbanizing regions, especially in developing countries. (Ait-Yahia[1] et al., 2019) offer a global lens on how smart city concepts are evolving through practical implementations, highlighting both achievements and adoption challenges. Echoing this localized in Algeria, (Boudiaf & Sarra, 2021) analyze Algiers' metropolitan dynamics and the delayed development of Sidi Abdellaha city envisioned as Algeria's first smart urban relay but falling short of sustainable standards due to infrastructure lags. (Antwi-Afari et al., 2021) provide a decision-based framework to measure city smartness across developing contexts, while (Batmetan & Quido, 2022) emphasize a multidimensional strategy built on governance, branding, economy, living, society, and environment, stressing the importance of strategic alignment with local goals. (Bhattacharya et al., 2020) contribute an actionable Smart Sustainable City Development Index (SSCDI) based on layered indicators, showcasing how Indian cities are being assessed across social, cultural, environmental, and economic dimensions. (Indraprahasta & Alamsyah, 2024) challenge the universal application of smart urbanism by mapping the intellectual landscape through bibliometric analysis, calling for context-aware smart city models attuned to local socio-technical realities.

Extending the strategic conversation, (Vu & Hartley, 2018) link e-government maturity to institutional reform and propose a policy framework to guide smart city progress in developing nations. (Tan & Taeihagh, 2020) synthesize 56 studies and conclude that realizing smart cities requires concurrent legal, financial, and human capital reforms, cautioning against overreliance on technology in data-poor environments. (Naoui et al., 2021) introduce a distributed deep learning architecture tailored to smart environments and energy forecasting, showing how intelligent infrastructure can reduce latency and boost analytical performance in urban management. Addressing the challenge of data incompleteness, (Samasti et al., 2025) propose the IVNS-EDAS methodology to classify smart city readiness using both qualitative and quantitative inputs. Their framework supports strategic decision-making despite gaps in urban data. Collectively, these studies underscore that smart cities are more than technological endeavors they demand robust governance, integrated planning, and localized implementation approaches. This contextual foundation frames the investigation into Algeria's evolving readiness for smart city adoption, especially through its clean energy transition and infrastructure modernization. (Fadhel et al., 2024) They define smart cities as cities using intelligent sensors, IoT devices, and data fusion to enhance operations and services. They emphasize how crucial good information fusion is and reflect upon both the advantage it provides in terms of efficiency and how it creates problems in dealing with vast data quantities as well as processing in real-time. Expounding upon this technological platform, (Chen et al., 2024) discuss how Metaverse arrival would further enable smart cities through addition of immersive environments for planning, governance, and citizen engagement. They outline related core technologies

facilitating such convergence though they identify unresolved questions regarding scalability, governance, and security issues that would have to be addressed to realize Metaverse-driven urban system full potential.

One big way smart city tech shows up is in transportation stuff, (Elassy et al., 2024) whose paper looks at Intelligent Transportation Systems (ITS) as key remedies for safer, more efficient, and sustainable urban travel. Their discussion includes vehicle ad-hoc networks, intelligent and virtual traffic signals, and mobility forecast instruments all backed by advanced communications to enable real-time operations. They also cite privacy and security issues and include case studies illustrating ITS advantages in building sustainable cities. Governance is also instrumental equally, with (Kaiser, 2024) They talk about how smart governance, using digital platforms and stuff like ICT adoption plus innovation, really helps push forward the idea of smart cities and even whole nations. It acts as this big enabler. Then they point out the main pillars, things like smart citizens, smart government, smart economy, and smart society. Still, they mention the barriers too, such as needing policy reforms, dealing with budget limits, and worries over data security.

At the micro-level, (Huda et al., 2024) point out how home automation fits as a key piece in smart city setups. They suggest some research paths to help blend smart homes right into bigger urban systems. Sustainability plays a part in all that. (Sharifi et al., 2024) carry out a systematic review that ties smart cities to the United Nations Sustainable Development Goals, the SDGs. Thing is, current studies tend to stick mostly to SDG 6 on water, SDG 7 on energy, and SDG 11 on cities. This piece builds on that kind of work., (Qian et al., 2024) People talk about this framework called humanity-technology-sustainability. It is meant to check out smart

cities now in the post-pandemic period. They look at 20 major cities from around the globe as benchmarks. The main point is to match up those big sustainability ideas with goals that actually get done.

Security concerns remain central, with (Kidmose, 2025) They map out the threat landscape for smart vehicles in smart cities, by spotting vulnerabilities, attack surfaces, and all the potential impacts that could happen. These approaches give structured recommendations, too. They help strengthen safety, privacy, and resilience in connected transport systems. And finally, it tackles traffic congestion. One of the biggest urban challenges out there. (Miftah et al., 2025) show how big data analytics, real-time processing, and machine learning work together to optimize traffic flows, it leads to reductions in travel times by up to 25 percent. Their findings really support adopting AI-driven automation and connected vehicle technologies. That builds adaptive, efficient, sustainable urban mobility systems.

5. Data and Methodology

5.1 Study Scope and Analytical Framework

This study investigates the evolution of smart city readiness in Algeria over the period 2017 to 2029, using a multidimensional dataset that captures technological, infrastructural, demographic, and economic indicators. The analysis employs Principal Component Analysis (PCA) to construct a composite SmartCity Readiness Index, which synthesizes multiple variables into a single interpretable score. The index is then scaled to a 0-100 range to facilitate comparison across years.

The econometric approach is grounded in dimensionality reduction and index construction, allowing us to identify latent patterns in the data and assess readiness trajectories over time.

PCA is particularly suitable for this context, as it handles multicollinearity and reveals the dominant structure in high-dimensional datasets. The resulting index is visualized using animated plots to enhance interpretability and engagement.

5.2 Data collection and processing

Data were collected from reliable official sources including Statista. For the period 2017-2029, projections based on historical growth trends and linear regression models were used. All variables were normalized using Z-score before applying Principal Component Analysis

Table 1. Data descriptive

Code	Variable Name
INU	Internet Users (%)
INP	Internet Penetration
ONB	Online Banking Penetration (%)
DFW	Digital Fitness & Well-Being
ODC	Online Doctor Consultations
DTC	Digital Treatment & Care
SEC	Security Services
CYB	Cyber Solutions
IOT	Industrial IoT
SMC	Smart Cities
SMF	Smart Finance
POP	Population
GDP	Gross Domestic Product

Source: Authors.

5.3 Principal Component Analysis (PCA)

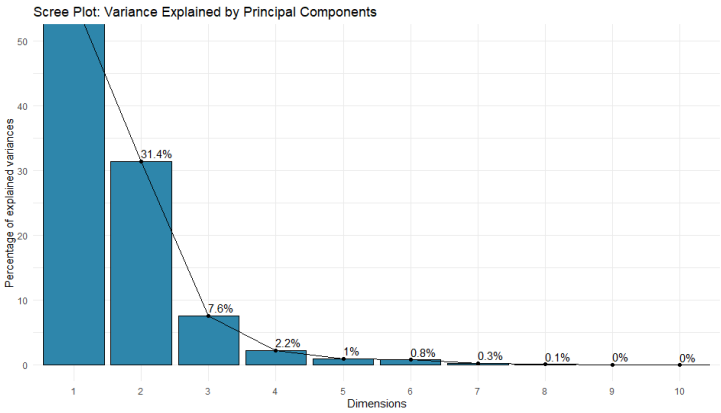
Principal Component Analysis (PCA) is a multivariate statistical technique used to reduce the dimensionality of a dataset while preserving as much variability as possible. It transforms a set of possibly correlated variables into a new set of uncorrelated

variables called principal components, which are linear combinations of the original variables. These components are ordered such that the first component explains the largest possible variance, the second explains the next largest, and so on.
The core idea is to project high-dimensional data onto a lower-dimensional space that captures the most significant patterns. This is achieved through eigenvalue decomposition of the covariance (or correlation) matrix of the standardized data.

5.3 Justification for Using PCA in This Study

PCA was used in this study to build a composite Smart City Readiness Index by reducing numerous indicators (digital infrastructure, health tech, cybersecurity, urban systems) into fewer components while preserving most of the information. It addresses multicollinearity by transforming correlated indicators into independent components, with the first principal component (explaining 56.47% of total variance) representing overall readiness. PCA also provides variable loadings, helping identify key drivers of smart city performance using standardized data from 2017–2029. and was used to construct the SmartCityReadiness Index, later rescaled to a 0–100 range for interpretability.

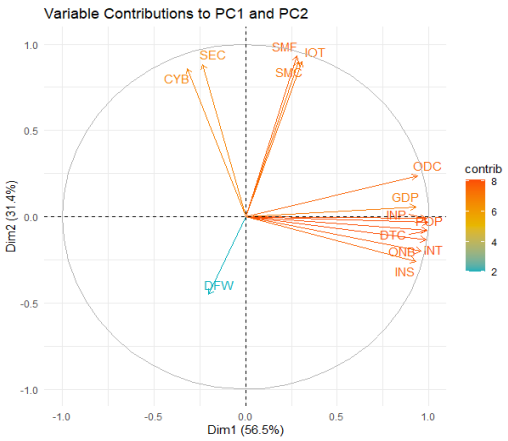
Fig 5. Variance Explanation Plot



Source: Authors.

Figure 6 shows how much variance each principal component picks up. PC1 handles most of the dataset's variability, about 56.47 percent. That pretty much backs up why we use it as the main SmartCity Readiness Index. Then there's this sharp drop in variance after PC2. It really points to how well the dimensionality reduction worked.

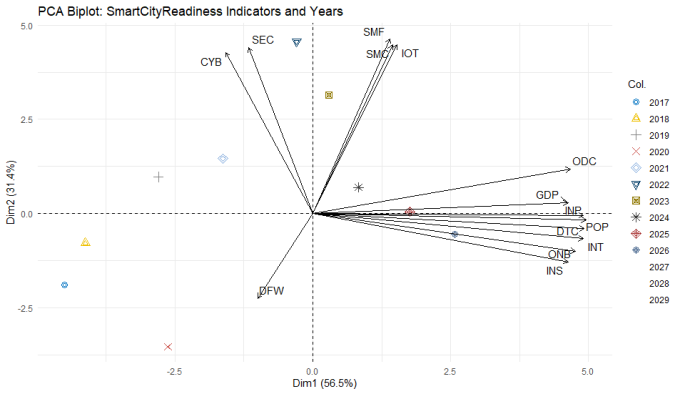
Fig 6. Variable Contributions to PC1 and PC2



Source: Authors.

Figure 7 shows what each variable brings to PC1 and PC2. Digital infrastructure and service adoption, things like INU, ONB, DFW, SMC really highlights their big part in smart city readiness. PC2 deals with demographic and economic stuff, mostly driven by GDP and population.

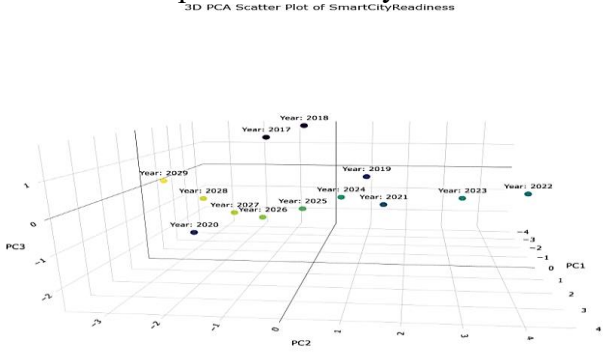
Fig 7. PCA Biplot: Indicators and Years



Source: Authors.

Figure 8 shows the PCA biplot pretty clearly. You can see how those indicator vectors point out their pull on the readiness scores. Years kind of group together over time, and it points to Algeria's smart city progress going up. Later ones match closer to the strong digital indicators.

Fig 8. 3D PCA scatter plot of smart city readiness



Source: Authors.

Figure 9 shows this 3D PCA scatter plot for SmartCity Readiness over the years. You can see the way things spread out in space. It really points to Algeria making steady progress in digital infrastructure. Same with health tech. And urban innovation as well. Later years bunch up closer to those higher readiness spots.

5.4 PCA results

We assessed Algeria's smart city readiness using PCA on data covering digital, infrastructure, demographic, and economic factors. PCA reduced the data into key components, with tables showing eigenvalues, loadings, contributions, and readiness scores (0-100). These results reveal underlying patterns, justify dimensionality reduction, and provide a clear basis for tracking Algeria's smart city progress over time.

Table 2. Smart City Readiness Scores

Year	Readiness-Score	Readiness-Index
2017	-4.510	0.000
2018	-4.126	4.545
2019	-2.802	20.238
2020	-2.630	22.274
2021	-1.629	34.127
2022	-0.293	49.953
2023	0.291	56.884
2024	0.827	63.234
2025	1.760	74.285
2026	2.578	83.982
2027	3.084	89.974
2028	3.520	95.144
2029	3.930	100.000

Source: Authors.

Table 1 shows the yearly Smart City Readiness Scores for Algeria. These go from 2017 up to 2029. They come from Principal Component Analysis, or PCA. The first column is called Readiness-Score. It gives the raw PCA output. That captures where Algeria stands in this whole multidimensional smart city setup. Then the scores get turned into a normalized Readiness-Index. This one ranges from 0 to 100. It makes things easier to understand. You can compare year to year pretty straight forward. The data points to a steady climb in readiness. It starts at a baseline of minus 4.51 back in 2017. That matches up to an index of 0. By 2029 it hits 3.93. Scaled that to 100. This whole progression hints at consistent improvements. They are accelerating even. Think digital infrastructure. Service penetration also. And urban innovation capacity. The biggest jumps happen between 2021 and 2026. That period shows intensified development. Policy impacts as well.

Table 3. Eigenvalues Table

Eigenvalue	Percentage of variance	Cumulative % of variance
7.905	56.464	56.464
4.400	31.433	87.898
1.064	7.604	95.502
0.312	2.235	97.737
0.139	0.993	98.730
0.114	0.817	99.548
0.041	0.298	99.846
0.017	0.121	99.967
0.002	0.018	99.986
0.001	0.011	99.997
0.000	0.001	99.999
0.000	0.000	100.00

Source: Authors.

The eigenvalues table breaks down how much variance each principal component from the PCA explains. PC1 comes in with about 7.91 as its eigenvalue. That covers 56.46 percent of the total variance in the data. It grabs most of the main patterns in Algeria's smart city readiness stuff. Then PC2 adds another 31.43 percent. So, by the second one at almost 88 percent cumulative. PC3 only throws in 7.60 percent more. That gets the total to 95.5 percent. After that, things drop off quick. Each next component handles less than 2.3 percent. It shows the real action happens in those first two or three. Makes sense for cutting down dimensions. And yeah, it backs using PC1 for the overall SmartCity Readiness Index.

Table 4. Variable Loadings

Dim.1	Dim.2	Dim.3	Dim.4	Dim.5
0.98	-0.13	0.063	-0.010	-0.021
0.98	-0.009	-0.096	0.071	-0.049
0.958	-0.200	0.136	-0.028	0.13
-0.201	-0.451	0.858	-0.125	-0.034
0.938	0.237	-0.100	0.197	-0.091
0.989	-0.080	-0.073	0.049	0.047
-0.233	0.883	0.301	0.238	0.043
-0.317	0.859	0.273	0.256	0.066
0.307	0.898	0.011	-0.185	-0.162
0.290	0.899	-0.020	-0.223	0.076
0.280	0.932	-0.022	-0.193	0.071
0.931	-0.258	0.190	-0.046	0.154
0.996	-0.033	-0.026	0.049	0.042
0.930	0.057	0.276	0.015	-0.190

Source: Authors.

The table on variable loadings shows these correlation numbers between the original variables and the first five principal components, from Dim.1 up to Dim.5. It gives a good look at how each indicator ties into those hidden dimensions from the PCA. Thing is, Dim.1 forms the base for the SmartCity Readiness Index. It gets a lot of its shape from digital and tech indicators. Stuff like Internet Users, which is INU, Internet Penetration or INP, Online Banking as ONB, then Digital Fitness and Well-Being called DFW, Online Doctor Consultations or ODC, Digital Treatment and Care that's DTC, and Cyber Solutions known as CYB. All of them have loadings over 0.93 on Dim.1. That means they really drive Algeria's readiness profile. It backs up the idea that digital access and how services spread out are the main things pushing smart city growth there in Algeria.

Dim.2 seems to pick up on urban infrastructure and security kind of stuff. It has strong positive loadings from Security Services,

SEC, Industrial IoT which is IOT, Smart Cities as SMC, Smart Finance or SMF, and Population, POP. Dim.3 gets influenced by DFW and GDP. So, it mixes health tech involvement with the size of the economy. The other ones, Dim.4 and Dim.5, they have more spread out and smaller contributions. Probably just leftover variance or some specific links between variables.

Table 5. Variable Contributions

Dim.1	Dim.2	Dim.3	Dim.4	Dim.5
12.3167	0.410	0.373	0.035	0.330
12.329	0.002	0.875	1.627	1.759
11.622	0.909	1.747	0.256	13.399
0.511	4.630	69.242	5.031	0.857
11.134	1.284	0.953	12.473	5.979
12.391	0.146	0.5125	0.788	1.640
0.688	17.754	8.533	18.186	1.359
1.273	16.775	7.006	21.035	3.213
1.193	18.362	0.012	11.022	18.918
1.065	18.367	0.037	16.007	4.251
0.996	19.739	0.046	11.973	3.717
10.968	1.515	3.397	0.691	17.217
12.562	0.025	0.066	0.793	1.288
10.945	0.075	7.193	0.0766	26.067

Source: Authors.

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6. DISCUSSION

This study looks at Algeria’s smart city readiness in a bunch of different ways from 2017 right up to 2029. It pulls in Principal Component Analysis, or PCA, to mix together all these complicated indicators on digital stuff, infrastructure, people, and the economy into one index that’s pretty straightforward to get. the results point to this steady climb in how ready things are. The Smart City Readiness Index starts at zero back in 2017. Then it heads up to a full 100 by 2029, or that the projection anyway. This whole shift shows more than just picking up new tech. It ties into larger changes in the urban setup and economic side of things in Algeria.

The PCA outcomes point to the importance of digital access and service penetration in determining the readiness index. Internet Users (INT), Internet Penetration (INP), Online Banking (ONB), and Digital Treatment & Care (DTC) stand out on the first principal component which accounts for over 56% of the total

variance. This means that the digital infrastructure and Algiers's population's use of online services are the most important drivers of the potential smart city. The correlation matrix also illustrates the correlation among these variables and reinforces the idea of a more cohesive digital layer that has pulsed and expanded over the period in question.

There are economic reasons for the propensity economic readiness scores to rise. This is due to Algeria's gradual efforts to diversify the economy and set up digital modernisation. Including the GDP and Population (POP) in the PCA model indicates that the economy and population size being factors are helpful in developing smart cities. Although these variables are principal to the first constituent in a lesser amount, they are more substantial in the subsequent dimensions, indicating that for a smart transformation, economic power and city size are necessary but not sufficient.

The increase in readiness between 2021 and 2026 fits the global and regional digital policy changes and the rapid expansion of policies driven by the recovery from the pandemic. During this period, and in particular the last two years of the phase, Algeria radically strengthened efforts to extend the reach of the internet and e-Health, and digitizing the financial services. The role of Online Doctor Consultations (ODC) and Digital Fitness & Well-Being (DFW) in the later components demonstrates the emphasis on health tech and behavioral engagement, most likely the result of health policy but also driven by shifts in consumer behavior.

Negatively correlated with the core digital dimensions, yet highly correlated with each other, the PCA also shows a separate latent dimension constituted by Security Services (SEC) and Cyber Solutions (CYB). This could point to a possible friction between digital growth and institutional control, as higher degrees of

connectivity bring with them the need for enhanced cyber security and control frameworks at the governance level. The emergence of this dimension could signify that, beyond the mere adoption of technology, the managerial dimension of digital risk and resilience must also be considered to ascertain Algeria's smart city readiness.

Algeria's trajectory in the PCA space is also depicted in 3D scatter plot and biplot, with an evident movement toward higher readiness zones. A clear strategic conformism toward international smart city standards is confirmed by the clustering around high-impact digital indicators in subsequent years. The gap in secondary ingredients, however, also serves as an indicator of disparities in progress with place-based differences particularly manifested through heath technology uptake and economic integration.

In conclusion, the PCA-derived SmartCity Readiness index offers an effective tool for benchmarking Algeria's cities digitalization. The results point to digital infrastructure as the dominant determinant of readiness, but to realize sustained gains, we will also need corresponding investments in economic capacity, institutional strength, and inclusive service delivery. These findings provide useful implications for policymakers to harmonize innovation, equity and sustainability within the context of smart cities in Algeria.

7. CONCLUSION

A multidimensional model for evaluating Algeria's smart city readiness from 2017 to 2029 is proposed and applied in this study by using Principal Component Analysis (PCA) to integrate different indicators into a single index. The SmartCity Readiness Index based on technology, infrastructure, demography and

economy is a statistically reliable and conceptually coherent indicator of Algeria's journey in digital transformation.

The PCA findings suggest that the first principal component, representing the main pharmacy service index which is rampant with weight of digital access and service usage indicators (Internet Users, Online Banking, Digital Treatment & Care and Internet Penetration). These results highlight the role of digital infrastructure in colouring smart city trajectories. Overall, the high inter-variable correlations and strong communalities indicate that the application of PCA is indeed justified, and suggest that the chosen indicators reflect a latent readiness dimension with a marginal degree of explanation.

The readiness index, in terms of the economy, also sits well with the overall narrative of Algerian development. The constantly improving scores from the starting 0 in 2017 to an estimated 100 in 2029 is evidence that the country is holding onto its commitment to digital modernization and is backed up by macroeconomy stability and population growth. With GDP and population data being incorporated into the model, economic size and urban agglomeration have been the focus as the key facilitators, while the appearance of secondary factors such as cybersecurity and institutional resilience signal the sophistication of smart city governance within an emerging context.

The time course of the index is particularly insightful. Most improvements occur from 2021 to 2026, a time of global digital momentum and recovery from the pandemic. This suggests that Algeria has surfed international waves capitalized on the smart city agenda, used digital health, financial platforms, and urban connectivity. However, even the observed dispersion in secondary components indicates uneven areas of progress, such as behavioral participation and economic integration, that may call for

intervention through targeted policy interventions.

Methodologically, the study demonstrates the applicability of PCA as a dimension reduction method and as a policy tool for index-construction and policy analysis. Scaled scores enhance interpretability, and visualizations scree plots, biplots, and 3D scatter plots provide graphically intuitive insights into Algeria's preparedness trajectory. The model is open to replication and adaptation, offering comparative analysis by region or under alternative policy futures.

In conclusion, Algeria's smart city preparation has progressed steadily over the past decade based on digital infrastructure and supported by economic and demographic drives. The Smart City Readiness Index provides an open, evidence-based framework for monitoring this evolution. With Algeria continuing to invest in urban innovation, the findings of this research can inform planning strategy, resource deployment, and international benchmarking. Future research might extend this model to other developing countries, estimate causal impacts, or use dynamic simulation to forecast future readiness with various development paths.

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