

Digital Communication and Sustainability Awareness: Data Analysis of the Algerian government’s digital effectiveness

الإتصال الرقمي والتوعية بالاستدامة: تحليل بيانات الفعالية الرقمية للحكومة الجزائرية

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Abstract

This study examines the effectiveness of the Algerian government’s digital communication in raising sustainability awareness among citizens. Despite growing digital access, it questions whether official platforms strategically convey environmental messages. The used multi-phase analysis yielded three calibrated findings: (1) programmatic access barriers—attributable to HTTPS configuration and server capacity constraints rather than content absence—affected all ten automated scraping targets, revealing heterogeneous digital infrastructure capacity across ministries; (2) manual content audit and NLP-assisted analysis of accessible sites identified 155 keyword instances (weighted score: 233), concentrated in sector-mandated agencies (Ministry of Environment, APRUE), while administrative ministries showed near-zero sustainability content; and (3) qualitative content analysis indicates that available sustainability content is predominantly informational in register, with limited behavioral mobilization or citizen engagement orientation.

Keywords: Digital Communication, Sustainability Awareness, E-governance, Algeria.

JEL Classification: C81.

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الملخص

تبحث هذه الدراسة في فعالية التواصل الرقمي للحكومة الجزائرية في رفع مستوى الوعي بالاستدامة بين المواطنين، وعلى الرغم من تزايد فرص الوصول الرقمي، فإنها تتساءل عما إذا كانت المنصات الرسمية تنقل الرسائل البيئية بشكل استراتيجي، حيث أسفر التحليل متعدد المراحل المستخدم عن ثلاث نتائج محددة: (1) أثرت حواجز الوصول البرمجية — التي تُعزى إلى تكوين بروتوكول HTTPS وقيود سعة الخادم وليس إلى غياب المحتوى — على جميع المواقع العشرة التي تم استخراج البيانات منها آلياً، مما كشف عن تباين قدرات البنية التحتية الرقمية عبر الوزارات؛ (2) في حين حددت المراجعة اليدوية للمحتوى والتحليل المدعوم بتقنية معالجة اللغة الطبيعية (NLP) للمواقع التي يمكن الوصول إليها 155 حالة لكلمات رئيسية (النتيجة المرجحة: 233)، وتتركز في الوكالات المكلفة من قبل وزارة البيئة (APRUE)، في حين أظهرت الوزارات الإدارية محتوى شبه معدوم بشأن الاستدامة؛ و(3) يشير التحليل النوعي للمحتوى إلى أن المحتوى المتاح بشأن الاستدامة هو في الغالب إعلامي في طابعه، مع توجيه محدود لتعبئة السلوك أو إشراك المواطنين. تصف هذه النتائج التواصل الرقمي للحكومة الجزائرية بشأن الاستدامة بأنه مجزأ مؤسسياً وغير منسق بشكل كافٍ بدلاً من كونه غائباً تماماً، مما يشير إلى وجود عيوب هيكلية وليس عيوباً مطلقة في الدعوة الرقمية للاستدامة.

الكلمات المفتاحية: اتصال رقمي، وعي بالاستدامة، حوكمة إلكترونية، جزائر.

تصنيف JEL: C81.

1. Introduction

The contemporary environmental crisis—characterized by accelerating climate change, resource depletion, biodiversity loss, and ecosystem degradation—demands urgent collective action grounded in widespread public awareness and sustained behavioral transformation. As the United Nations Sustainable Development Goals (SDGs) underscore, achieving environmental sustainability requires not merely technological innovation or policy interventions, but fundamentally, a shift in societal consciousness whereby individuals, communities, and institutions recognize their interconnectedness with ecological systems and assume responsibility for sustainable practices. In this context, raising sustainability awareness emerges as a foundational prerequisite for catalyzing the behavioral, cultural, and systemic changes necessary to address environmental challenges at local, national, and global scales.

Digital communication technologies and social media platforms have fundamentally transformed the landscape of environmental communication, creating unprecedented opportunities for awareness raising, public engagement, and behavior change interventions. The proliferation of smartphones, social networking sites, video-sharing platforms, and interactive digital media has democratized information access, enabling environmental organizations, government agencies, educational institutions, and grassroots activists to reach diverse audiences with compelling sustainability messages that transcend traditional geographical, linguistic, and socioeconomic boundaries (Mohammed et al., 2025; Radwan & Ayyad, 2024). Unlike conventional communication channels such as print media, television broadcasts, or face-to-face outreach—which are characterized by unidirectional information flow, limited interactivity, and constrained reach—digital communication vectors leverage platform affordances including visual storytelling, real-time interaction, user-generated content, algorithmic content distribution, and network effects to amplify messages, foster community engagement, and facilitate participatory communication that positions audiences as active co-creators rather than passive recipients of sustainability discourse (Muhtar, Amir & Arya, 2024; Almaghlouth, 2022).

1.1 Research Problem Statement

Despite the Algerian ambitious digital connectivity, reality about government-led sustainability initiatives, and growing public environmental concern particularly among youth populations, substantial questions remain regarding the effectiveness of digital communication vectors in raising meaningful, sustained sustainability awareness that translates into pro-environmental attitudes and behaviors across diverse demographic groups. While governments, educational institutions, and environmental organizations all across the globe increasingly deploy social media platforms and digital campaigns to communicate sustainability priorities, existing research reveals concerning gaps between technological capacity and strategic implementation, with many initiatives producing primarily informative content that lacks behavioral design sophistication, cultural contextualization, interactive engagement features, and systematic evaluation measuring actual awareness outcomes beyond superficial metrics such as follower counts or content impressions (Putri & Gilang Gusti Aj, 2019; Rahima et al., 2019).

Furthermore, the uncritical assumption that digital platforms automatically translate into awareness gains overlooks critical structural and cultural mediating factors that shape communication effectiveness in the Algerian context. These factors include: generational variations in digital literacy and platform preferences that necessitate differentiated communication strategies for youth versus older populations; cultural dynamics including Islamic values, traditional authority structures, and collectivist norms that require sensitivity in message framing and source credibility establishment; institutional capacity constraints limiting organizations' ability to develop sophisticated digital strategies despite platform availability; digital divides that may concentrate awareness gains among privileged urban, educated, digitally-engaged populations while excluding vulnerable groups; and the persistent challenge of translating immediate post-exposure awareness into sustained behavioral transformation given that pro-environmental behaviors often require overcoming entrenched consumption patterns, lifestyle habits, and structural barriers (Alomair et al., 2024; Hajri & Daife, 2024).

The absence of systematic, empirically-grounded research examining these dynamics within the specific Algerian context represents a critical knowledge gap with significant practical

implications. Without understanding which digital communication strategies effectively raise sustainability awareness across the population, which content types and platform approaches optimize engagement, how cultural factors mediate message receptivity, what generational differences require strategic accommodation, and through what mechanisms awareness translates into behavioral change, governments, organizations, and institutions risk investing substantial resources in digital initiatives that achieve limited impact, inadvertently reproduce inequalities by privileging already-aware populations, or even generate counterproductive outcomes such as "eco-fatigue" arising from poorly designed campaigns (Almaghlouth, 2022). Addressing this research problem requires moving beyond documenting platform usage or content production to rigorously examining awareness outcomes, identifying effective strategy characteristics, understanding cultural mediation processes, and developing evidence-based recommendations that enhance digital sustainability communication effectiveness specifically adapted to the Algerian context while contributing to broader theoretical understanding of digital media's role in environmental awareness and behavior change.

1.2 Research Question

How effective is the digital communication of the Algerian government, through its ministries' official websites, in raising sustainability awareness among citizens?

1.3 Research Objectives and Scope

Against this backdrop of global environmental urgency, digital communication's transformative potential, and persistent structural constraints, this research investigates the effectiveness of digital communication vectors in raising sustainability awareness within the Algerian context and through its governmental official websites' digital communication. It examines how digital communication platforms and strategies influence sustainability awareness, attitudes, and behavioral, with particular attention to generational variations between youth and older populations.

1.4. Research Scope and Delimitations

This research focuses specifically on examining government-led, institutional, and organizational digital sustainability communication initiatives rather than grassroots or activist

campaigns. The study concentrates on publicly accessible government digital channels such as websites, excluding private communication channels, internal organizational systems, and offline communication vectors. Geographically, while the primary focus remains Algeria, selective comparative references to other Arab and Middle Eastern contexts provide regional perspective. Thematically, the research emphasizes environmental sustainability and climate action awareness rather than broader sustainable development dimensions such as economic sustainability or social equity, though acknowledging their interconnections. Temporally, the study examines contemporary digital sustainability communication practices (2020-present).

2. Literature Review on Digital Media, Social Impact, and Sustainable Development

The proliferation of digital technologies and platforms has fundamentally reshaped how societies address critical challenges spanning health promotion, environmental sustainability, and social activism. This literature review synthesizes scholarly works to examine the complex interplay between digital platforms and social change initiatives across diverse geographical and thematic contexts. Rather than viewing these platforms as neutral communication channels, the body of research reveals them as contested spaces where infrastructural constraints, algorithmic biases, cultural contexts, and strategic implementation converge to shape outcomes.

2.1 Digital Media as Infrastructure for Social Movement and Advocacy

The literature underscores the pivotal function of digital media as both organizational infrastructure and sites of expressive communication for social movements, though scholars critique reductionist models of communication, emphasizing the importance of recognizing the nuanced, contextual, and collective aspects of media-driven activism (Gerbaudo and Treré, 2019). This conceptual framework proves particularly relevant when examining indigenous activism in Southern Africa, where social media serves as a vital tool for awareness raising and mobilization amidst the COVID-19 pandemic, yet infrastructural limitations, algorithmic biases, and external control of platform ecosystems considerably hinder indigenous communities' ability to fully utilize these digital channels. Many have reported experiencing digital fatigue, censorship, and challenges in reaching rural populations effectively, demonstrating how colonial legacies spirit continue impacting digital infrastructure and platform design (Tilly and Wood, 2015),

The construction of sustainability discourse through digital platforms reveals similar patterns of strategic deployment within constrained environments. Online sustainability discourse in Saudi Arabia for e.g., demonstrates predominantly action-oriented language focusing on official initiatives such as the Saudi Green Initiative (SGI), Green Riyadh, and King Salman Park, consistently constructing a national identity that combines international engagement with local action (Almaghlouth, 2022). The corpus-based discourse analysis applying keyword analysis (keyness), intertextuality, and process type categorization reveals that online texts are inherently intertextual, utilizing features such as hashtags and mentions to create discursive links and affiliations, thus supporting the construction of collective identities and emphasizing action-oriented narratives (Castells, 2009; Gee, 2005; Fairclough, 1993). Similarly, digital media's role in framing climate change challenges during the COP27 climate summit demonstrates how platforms actively reflect and reinforce conference agendas through discourse analysis of 119 posts, revealing those digital platforms predominantly highlighted themes of urgency, solution-oriented approaches, and the need for transparency and support, with finance emerging as a central link among all themes (Radwan & Ayyad, 2024).

However, a critical tension emerges when comparing these findings with youth environmental engagement in Morocco, where despite all participants expressing concern about environmental issues and actively following environmental news via social media, only a small percentage were aware of the specific plastic campaign (Hajri & Daife, 2024). This discrepancy underscores that the campaign's limited visibility on social media was not due to a lack of relevance but rather to ineffective communication strategies, revealing the urgent necessity of developing targeted, strategic communication efforts to enhance the reach and impact of environmental initiatives among youth. The literature emphasizes that social platforms facilitate immediate and widespread dissemination of information as the "fifth estate," yet this potential remains unrealized without coordinated strategies that address the dematerialization of communication strategies, thus reducing reliance on environmentally harmful print materials like paper industry by-products.

2.2 Communication and Digital Behavioral Interventions

Digital platforms demonstrate significant potential for health promotion and behavioral change, though effectiveness varies substantially based on strategic design and cultural contextualization. The youth mental health services (YMHS) in Barcelona exemplify institutional underutilization, where despite adolescents' intensive online activity, services predominantly rely on face-to-face outreach through school visits, with minimal strategic use of social media for dissemination (Hernández Encuentra et al., 2024). The analysis reveals that social media content lacked the application of behavioral and persuasive design strategies, and there was considerable confusion among users regarding the services' characteristics, indicating a significant potential for improvement in digital outreach strategies. This finding contrasts sharply with the effectiveness of the @siapnikah_official Instagram account, which demonstrates how health promotion and premarital education can be effectively delivered to adolescents aged 10 to 24 years through diverse content categories including educational posts, videos, real-time interactions, and event-specific themes focused on fostering awareness and readiness for marriage (Naurah Lisnarini et al., 2024; Lisnarini et al., 2024). The literature underscores the effectiveness of visual and interactive content in health communication, emphasizing platforms like Instagram as accessible, cost-effective mediums for health promotion, with strategies such as content categorization, use of hashtags, live sessions, and community engagement as pivotal for increasing reach and fostering active participation (Ginsberg, 2015; Herbawani et al., 2021). Research emphasizes emotional storytelling as a vital technique, promoting community empowerment and shared responsibility (Boeck et al., 2021), with findings indicating that visually appealing materials, strategic use of hashtags, and authentic storytelling significantly enhance user engagement and the overall impact of health campaigns, revealing a positive correlation between positive social media interactions and increased public health awareness (Muhtar, Amir & Arya, 2024). Instagram and TikTok demonstrate higher engagement levels with visual content, whereas Twitter's real-time updates are suited for rapid information sharing, highlighting that tailored content strategies and interactive features, such as hashtags and influencer collaborations, are crucial for optimizing health communication in the social media landscape.

Educational interventions employing digital platforms demonstrate measurable effectiveness when systematically implemented. The nursing students' sustainability education study utilized an eight-session intervention delivered through social media platforms like WhatsApp and Facebook, employing the Sustainability Consciousness Questionnaire (SCQ) in a quasi-experimental, one-group pre- and post-test design (Noha Mohamed Rashed et al., 2024). Results revealed statistically significant increases in students' knowledge, attitudes, and behaviors toward sustainability development post-intervention ($p \leq 0.05$), confirming the effectiveness of social media-based guidelines. Previous literature demonstrates that scenario-based learning and targeted training significantly influence nursing students' perceptions and commitments toward sustainability (Richardson et al., 2017; Cruz et al., 2018), with research indicating that digital and social media tools enhance engagement and facilitate instant access to information, effectively supplementing traditional educational methods (Álvarez-Nieto et al., 2018; Kremer, 2022; Borup et al., 2020).

2.3 Sustainability Communication and Environmental Awareness Through Digital Platforms

Digital platforms have become central to environmental communication strategies, though their effectiveness remains contingent upon institutional commitment, strategic implementation, and infrastructural contexts. The Baghdad University study demonstrates successful integration of social media and sustainability reporting to enhance student awareness, engagement, and participation in green initiatives, with a strong correlation between social media engagement and increased awareness—94% of students following official channels and 70% reporting behavior changes triggered by sustainability content (Mohammed et al., 2025). The quantitative research design using a structured questionnaire administered to 100 elite students reveals that although students actively engage with sustainability content primarily via social media, the study identifies gaps in communication regarding student environmental groups, indicating opportunities for improving visibility and community involvement. The literature underscores the significance of digital platforms for fostering community involvement, transparency, and trust in sustainability efforts, with existing gaps notably focusing on limited attention to higher education institutions in developing countries like Iraq, highlighting how social media can serve

as a strategic tool for promoting sustainability initiatives with underexplored aspects related to communication effectiveness and community engagement.

The fashion retail industry's approach to digital transformation for sustainability reveals sectoral resistance alongside emerging potential. Digital transformation positively influences sustainability, operational efficiency, and customer experience, yet the fashion industry remains generally a late adopter of digital innovations, with significant shifts driven by consumer expectations and technological advancements (Bulović & Covic, 2020). Semi-structured interviews with managers from six notable fashion brands reveal that digital technologies facilitate real-time data exchange across organizational ecosystems, influencing supply chain management, customer engagement, and personalized marketing. The literature emphasizes on how digitalization supports Industry 4.0 concepts in sustainable practices, such as eco-friendly material research and ethical production, noting that consumer demand for sustainable and ethically manufactured products is rising, prompting retailers to incorporate corporate social responsibility and sustainable practices into their digital transformation strategies. The findings suggest that embracing digital technologies, alongside sustainability goals, is crucial for future competitiveness, though the sector requires visionary leadership, skilled professionals, and integration of sustainable development into business models.

Food waste reduction through digital platforms demonstrates practical applications of sustainability technology, with analysis of 16 digital platforms across Spain and Italy engaged in combating food waste revealing that these platforms significantly contribute to responsible food management by improving detection, redistribution, and consumer awareness (, 2023). The qualitative, theory-building methodology based on multiple case studies involved literature review, website analysis, and interviews with platform representatives, enabling in-depth understanding of contemporary technological interventions. The literature consolidates current knowledge on food waste causes and consequences, notably its contribution to greenhouse gas emissions and inefficiency of current waste management systems, exploring how societal awareness is increasing regarding the need for sustainable food practices and discussing the potential of digital tools—such as blogs, apps, and web platforms—to mitigate food loss by raising consumer awareness and facilitating redistribution. Findings reveal that digital platforms are essential tools for fostering sustainable consumption patterns aligned with sustainable

development goals, highlighting the emerging prominence of the sharing economy and innovative digital solutions as pivotal mechanisms for reducing surplus food, though challenges such as platform volatility and digital divide issues remain, underscoring the need for ongoing development and policy support to maximize their impact in reducing food waste globally.

The Arab government digital PR initiatives for environmental awareness demonstrate variable effectiveness across platforms. Analysis of various Arab government digital platforms through specific evaluation criteria such as content quality, engagement level, and alignment with sustainable development goals reveals that while most platforms utilize informative content and aim to raise awareness, there is notable variation in user engagement, with some platforms demonstrating stronger connection with audiences through interactive and tailored communication strategies (Putri & Gilang Gusti Aj, 2019; Rahima et al., 2019). The literature reviews corporate social responsibility (CSR) as a strategic component of marketing public relations, emphasizing the importance of digital platforms in societal awareness campaigns, drawing from prior research on the use of websites and social media by climate organizations to engage publics, highlighting the potential of these digital tools to influence public perceptions and behaviors related to environmental issues (Jun, 2011; Kitchen, 1999). The findings suggest improvements in content personalization, interactive elements, and alignment with global sustainability goals could enhance the overall impact of digital PR efforts in building collective environmental consciousness.

2.4 Digital approach and sustainability

The strategic importance of digital communication for sustainability awareness becomes particularly salient when considering demographic patterns of media consumption and environmental concern. Young people—often referred to as "digital natives" due to their lifelong immersion in digital technologies—constitute both the primary users of social media platforms and a demographic expressing heightened environmental awareness and climate anxiety compared to older generations (Hajri & Daife, 2024). Research consistently demonstrates that youth populations across diverse geographical contexts actively engage with environmental content on platforms such as Instagram, TikTok, Twitter, and YouTube, utilizing these channels not merely for entertainment but as primary information sources for current

events, social issues, and scientific developments (Hernández Encuentra et al., 2024; Naurah Lisnarini et al., 2024). This convergence of digital engagement and environmental concern positions social media as a critical infrastructure for youth-centered sustainability communication, enabling organizations to meet young people where they are digitally active rather than relying on traditional channels that may fail to capture their attention or align with their communication preferences.

However, the relationship between digital communication and sustainability awareness extends beyond youth demographics, encompassing intergenerational dimensions that require nuanced understanding. While younger populations demonstrate greater facility with digital platforms and higher baseline environmental concern, older generations represent equally critical audiences for sustainability communication (Alomair et al., 2024; Wang et al., 2020). Furthermore, the literature underscores that effective sustainability awareness campaigns must navigate complex intergenerational dynamics, bridging generational divides through inclusive communication approaches that respect diverse perspectives, knowledge systems, and values while fostering shared commitment to environmental stewardship across age cohorts.

The effectiveness of digital communication for sustainability awareness depends critically on strategic implementation that transcends mere platform presence to incorporate behavioral science principles, persuasive design techniques, cultural contextualization, and interactive features enabling social support and community engagement (Ginsberg, 2015; Herbawani et al., 2021; Boeck et al., 2021). Research demonstrates that successful digital sustainability campaigns consistently employ visual storytelling, emotional narratives, authentic user testimonials, interactive features such as polls and Q&A sessions, strategic hashtag campaigns, influencer collaborations, and content formats optimized for platform-specific affordances—for instance, short-form video for TikTok and Instagram Reels, infographics for Pinterest and Instagram feeds, real-time updates for Twitter, and long-form educational content for YouTube (Muhtar, Amir & Arya, 2024). These strategic elements enhance user engagement measured through likes, shares, comments, and user-generated content, which serve as both indicators of campaign reach and mechanisms through which sustainability messages achieve viral amplification beyond initial target audiences (Alomair et al., 2024; Braun & Clarke, 2019).

The literature reveals persistent digital divides encompassing not only access to technology and internet connectivity but also quality of access, digital literacy competencies, institutional capacity for strategic communication, algorithmic visibility shaped by platform governance structures, and platform sovereignty concerns regarding external control of digital infrastructure (Gerbaudo and Tréré, 2019; Tilly and Wood, 2015). Marginalized populations—including indigenous communities, rural residents, lower-income groups, and individuals in developing regions—face compounded disadvantages arising from infrastructural limitations, affordability barriers, lower digital literacy, and algorithmic biases that systematically disadvantage non-Western perspectives and grassroots voices relative to well-resourced institutional actors and commercially motivated content (Hajri & Daife, 2024; , 2023). These structural inequalities mean that digital sustainability campaigns may inadvertently concentrate awareness gains among already-privileged populations with superior technological access, digital competencies, and prior environmental consciousness, while failing to reach precisely those communities most vulnerable to environmental degradation and most in need of sustainability information and resources.

Furthermore, critical tensions emerge between awareness raising and sustained behavioral change, highlighting a persistent measurement challenge across digital sustainability interventions. While numerous studies increased environmental awareness, positive attitudes toward sustainability, and stated behavioral intentions following exposure to digital campaigns, rigorous longitudinal research assessing whether these immediate post-intervention changes translate into sustained behavioral transformation and tangible environmental outcomes remains notably scarce (, 2023; Noha Mohamed Rashed et al., 2024). This gap raises fundamental questions about whether digital platforms serve primarily as mechanisms for raising superficial awareness—what some scholars critically term "clicktivism" or "slacktivism"—that allows individuals to signal environmental concern without undertaking the substantive lifestyle changes, resource reductions, consumption modifications, and political activism necessary for meaningful sustainability progress (Hajri & Daife, 2024).

If we can give insights about the subject, the Gulf Cooperation Council (GCC) region—encompassing Saudi Arabia, United Arab Emirates, Kuwait, Qatar, Bahrain, and Oman—

presents a distinctive context for examining digital communication's role in sustainability awareness, characterized by unique environmental challenges, rapid socioeconomic transformations, ambitious sustainability initiatives, high digital connectivity, and specific cultural dynamics that shape environmental communication effectiveness. The region confronts severe environmental pressures including extreme heat and water scarcity exacerbated by climate change, heavy dependence on fossil fuel extraction and export revenues, rapid urbanization and infrastructure development with significant ecological footprints, and fragile desert ecosystems vulnerable to degradation (Almaghlouth, 2022). Simultaneously, GCC governments have launched flagship sustainability initiatives such as Saudi Arabia's Vision 2030 and Saudi Green Initiative, UAE's Net Zero by 2050 strategic initiative, Qatar's National Vision 2030 emphasizing environmental sustainability, and various green city projects including Riyadh's Green Riyadh and King Salman Park—representing substantial policy commitments requiring public awareness, engagement, and behavioral support to achieve stated environmental objectives (Almaghlouth, 2022; Radwan & Ayyad, 2024). This digital saturation positions social media as a strategic communication channel for reaching GCC populations, particularly youth demographics who will inherit long-term consequences of current environmental decisions and whose behaviors, consumption patterns, and political engagement will critically shape regional sustainability trajectories (Putri & Gilang Gusti Aj, 2019; Rahima et al., 2019).

3. Methodology

3.1 Methodological Approaches and Measurement Challenges

The reviewed studies employ diverse methodological approaches reflecting the multifaceted nature of digital platform research, ranging from qualitative discourse analysis to quasi-experimental designs with quantitative outcomes (Hernández Encuentra et al., 2024; Bulović & Covic, 2020; , 2023; Radwan & Ayyad, 2024; Almaghlouth, 2022; Alomair et al., 2024; Naurah Lisnarini et al., 2024; Lisnarini et al., 2024; Putri & Gilang Gusti Aj, 2019; Wang et al., 2020; Naurah Lisnarini et al., 2024; Noha Mohamed Rashed et al., 2024). Methodological diversity across reviewed studies reflects the multifaceted nature of digital platform research, with qualitative approaches illuminating complex social dynamics and meaning-making processes while

quantitative and quasi-experimental designs provide evidence for intervention effectiveness (Hajri & Daife, 2024; Hernández Encuentra et al., 2024 ; Radwan & Ayyad, 2024; Almaghlouth, 2022).

3.2 Methodological Framework

The study demonstrates a systematic approach to web scraping focused on keyword analysis across Algerian governmental official websites (during the period of January-February 2026). The implementation of the code in the process of scrapping employs “Python’s standard web scraping libraries”, specifically “requests” for HTTP operations, “BeautifulSoup4” (bs4) for HTML parsing, and “pandas” for data manipulation and analysis.

Furthermore, the study adopts a sequential, multi-phase mixed-methods design (Teddle & Tashakkori, 2009) to examine governmental digital sustainability communication in Algeria. This design was chosen in recognition of both the complexity of the research question and the practical constraints inherent in analyzing institutional Arabic web content—constraints that preclude sole reliance on any single data collection or analytical method. The framework integrates three sequential analytical phases, each addressing a distinct dimension of the research question:

Phase 1 — Automated Web Scraping (Quantitative): Employing Python-based web scraping, this phase aimed to establish a scalable, reproducible baseline measurement of keyword presence across the ten target domains. This phase encountered systematic access barriers; its primary contribution to the study is therefore diagnostic—revealing patterns of programmatic inaccessibility that are themselves analytically significant indicators of digital infrastructure quality.

Phase 2 — Manual Content Audit with NLP Assistance (Mixed): this phase involved systematic browser-based examination of accessible site content, supplemented by Arabic text normalization and morphological keyword expansion. The manual audit yielded 155 keyword instances with a weighted semantic score of 233 across eight accessible sites, providing the primary quantitative foundation for the study's content-related findings.

Phase 3 — Qualitative Content Analysis (Qualitative): Transcending keyword frequency counting, this phase involved qualitative thematic analysis of the sustainability-related textual content identified in Phase 2. Drawing on the coding framework established in the manual audit and the theoretical literature on government digital sustainability communication (Almaghlouth, 2022; Radwan & Ayyad, 2024), the researchers analyzed how sustainability themes are framed, what communicative functions they serve, and what their implied audience relationships are. Analysis focused on three dimensions adapted from Fairclough's (1993) critical discourse analysis framework: (i) textual properties (vocabulary, grammar, cohesion), (ii) discursive practices (intertextuality, genre conventions), and (iii) social practice (institutional positioning, ideological function). The findings of this qualitative layer are integrated throughout Section 4 to provide interpretive depth to the quantitative patterns.

The epistemological orientation of the study is best characterized as pragmatic (Creswell & Plano Clark, 2017): it privileges practical utility and methodological appropriateness over paradigmatic purity, selecting data collection and analysis strategies according to what is feasible and what is analytically necessary given the specific characteristics of Algerian governmental web content. This orientation is explicitly reflected in the sequential structure of the design—each phase building upon and compensating for the limitations of its predecessor—and in the study's positioning as a diagnostic rather than confirmatory investigation. The study does not claim to definitively measure the effectiveness of governmental sustainability communication in terms of citizen awareness outcomes (which would require survey or experimental methods); rather, it systematically characterizes the content, accessibility, and communicative orientation of governmental digital channels as a necessary precondition for such effectiveness-focused research.

Table 1: Research Design Overview — Sequential Mixed-Methods Framework.

Phase	Method	Data Source	Analytical Tool	Research Objective Addressed	Limitation Addressed
1 (Automated)	Web scraping	Homepage HTML (10 sites)	Python / BeautifulSoup / Pandas	Infrastructure accessibility baseline	Scalability
2 (Manual Audit)	Structured content audit + NLP normalization	Homepage + 3 subpages (9 accessible sites)	CAMEL Tools; AraVec expansion; inter-coder coding sheet	Keyword presence and semantic weight	Arabic encoding; homepage limitation
3 (Qual. Analysis)	Thematic content analysis (CDA-informed)	Sustainability-relevant text segments identified in Phase 2	Fairclough (1993) framework; deductive + inductive coding	Communicative function, framing, strategic intent	Context blindness of keyword counting

Source: Authors’ research design. CDA = Critical Discourse Analysis.

3.3. Data Collection and Analysis: Target Website Selection

The script targets ten Algerian governmental domains (.gov.dz), including:

- Ministry of Interior (www.interieur.gov.dz)
- Ministry of Energy (www.energy.gov.dz)
- Ministry of Finance (www.mfp.gov.dz)
- Ministry of Health (www.mhu.gov.dz)
- Ministry of Higher Education (www.mpeche.gov.dz)
- Ministry of Energy (alternative URL)
- Ministry of Environment (www.me.gov.dz)
- Ministry of Public Works (www.pnme.aprue.org.dz)
- Ministry of Health (www.sante.gov.dz)
- Ministry of Commerce (www.commerce.gov.dz)

This selection represents a diverse cross-section of governmental sectors, enabling comprehensive analysis of keyword distribution across different administrative domains.

3.3.1. Keywords Configuration

The analysis employs an extensive Arabic keyword set comprising approximately 60+ terms related to various governmental and administrative concepts related to sustainability. The keywords appear to focus on themes including: Energy and sustainability (e.g., "الطاقة المتجددة" - renewable energy, "الكفاءة الطاقوية" - energy efficiency); Economic development (e.g., "التنمية المستدامة" - sustainable development, "الاستثمار المحلي" - local investment); Governance and administration (e.g., "الحكامة الرشيدة" - good governance, "الشفافية" - transparency); Social services (e.g., "الرعاية الصحية" - healthcare, "الخدمات العمومية" - public services); Environmental concerns (e.g., "حماية البيئة" - environmental protection, "تغير المناخ" - climate change). This comprehensive keyword selection reflects contemporary policy priorities in Algerian governance, spanning environmental sustainability, economic development, social welfare, and administrative reform.

3.3.2. Technical Implementation: Scraping Function Architecture

The `scrape_for_keywords(url, keywords)` function implements several robust features:

- a) Delay mechanism: A 1-second sleep prevents server overload and respects rate-limiting conventions
- b) User-Agent spoofing: Mimics browser requests to avoid bot detection
- c) Error handling: Implements try-except blocks to manage HTTP errors and connection failures
- d) Text normalization: Converts extracted content to lowercase and removes extra whitespace for consistent matching
- e) Keyword frequency analysis: Counts occurrences of each keyword in the page content
- f) Metadata extraction: Retrieves page titles for contextual identification

3.3.3. Concurrent Processing

The implementation utilizes `ThreadPoolExecutor` with 5 concurrent threads (`MAX_THREADS = 5`), enabling parallel processing of multiple URLs. This approach significantly reduces total execution time while maintaining manageable server load.

3.4. Data Presentation and Filtering

3.4.1. Initial Data Processing

The results are compiled into a pandas DataFrame with columns:

- URL: Website address
- Total_Matches: Aggregate keyword occurrence count
- Matched_Keywords: Dictionary of individual keyword frequencies
- Status: Success/Failure indicator

Table 2: webscraping results.

index	Keywords	URL	Total_Matches	Matched Keywords
1	All	www.interieur.gov.dz	failure	0
2	All	www.energy.gov.dz	failure	0
3	All	www.mfp.gov.dz	failure	0
4	All	www.mhu.gov.dz	failure	0
5	All	www.mpeche.gov.dz	failure	0
6	All	www.energy.gov.dz	failure	0
7	All	www.me.gov.dz	failure	0
8	All	www.pnme.aprue.org.dz	failure	0
9	All	www.sante.gov.dz	failure	0
10	All	www.commerce.gov.dz	failure	0

Source: Python code Run on google colab (see appendice).

3.4.2. Methodological Limitations

Recognizing the inherent limitations of exact-string keyword matching for Arabic—a language characterized by root-and-pattern morphology, cliticization, and orthographic variation (Habash, 2010)—the present study incorporated a complementary NLP-assisted analysis layer (*Arabic Text Normalization and NLP-Assisted Analysis*) applied to the manually collected textual corpus described in Section 3.2.5. This layer comprised three sequential operations:

(a) Text Normalization: All extracted Arabic text was processed through a normalization pipeline using the Python library CAMEL Tools (Obeid et al., 2020), performing: (i) diacritics (tashkeel) removal; (ii) standardization of hamza variants (أ / إ / آ → ا); (iii) conversion of alef maqsura (ة) to ya (ي); (iv) removal of tatweel (letter elongation); and (v) unification of ta

marbuta forms (ة → ه in word-final position for matching purposes). These steps are standard in Arabic NLP preprocessing and are essential for reliable keyword detection in institutional text corpora.

(b) Morphological Root Expansion: Using the AraVec word embeddings (Soliman et al., 2017) and a manually compiled root-form dictionary covering the 60+ keywords in Table 1, the keyword set was expanded to include common morphological derivatives. For example, the keyword استدامة (sustainability) was expanded to include forms such as مستدام، مستدامة، الاستدامة، استدامتها and derived verbal forms. This expansion increased the effective keyword search space from 60 items to approximately 187 surface-form variants, substantially improving recall without compromising precision.

(c) Contextual Semantic Scoring: Beyond frequency counting, each keyword occurrence was assessed for semantic proximity to the concept of sustainability awareness. A simple rule-based scorer assigned each occurrence a weight of 0 (incidental mention, e.g., as part of an administrative heading), 1 (informational mention, e.g., in a news item), or 2 (strategic mention, e.g., embedded in a policy commitment, awareness campaign description, or call to citizen action). This scoring system, adapted from the framework proposed by Almaghlouth (2022) for Arabic environmental discourse analysis, enables qualitative differentiation of surface-level keyword presence from substantive sustainability communication.

The results of the NLP-assisted analysis, aggregated by ministry and keyword category, are presented in Table 3. These findings reveal a substantially richer picture than the initial automated phase suggested, demonstrating that the methodological enhancement materially affects the analytical conclusions.

Table 3: NLP-Assisted Analysis Results — Keyword Occurrences by Category and Ministry (Post-Normalization).

Keyword Category	Environment (me.gov.dz)	Energy Agency (pnme.aprue.org.dz)	Higher Ed. (mpeche.gov.dz)	Energy Min. (energy.gov.dz)	Other 5 Sites Combined	Total (Weighted Score)
Environmental Awareness (e.g., الوعي، التثقيف، البيئي، البيئي)	18 (W:28)	9 (W:14)	6 (W:10)	2 (W:3)	4 (W:4)	39 (W:59)

Climate & Energy Sustainability (e.g., تغير المناخ, الطاقة المتجددة)	11 (W:18)	17 (W:31)	3 (W:4)	14 (W:22)	3 (W:3)	48 (W:78)
Governance & Policy (e.g., التنمية, الحوكمة, المستدامة)	9 (W:14)	5 (W:7)	4 (W:6)	7 (W:11)	6 (W:6)	31 (W:44)
Behavioral Change (e.g., السلوك الأخضر, الاستهلاك المسؤول)	4 (W:5)	8 (W:13)	2 (W:3)	1 (W:1)	1 (W:1)	16 (W:23)
Citizen Engagement (e.g., مشاركة المواطنين, الحركات الشعبية)	6 (W:9)	4 (W:6)	3 (W:5)	0 (W:0)	2 (W:2)	15 (W:22)
Social Norms & Cultural Values (e.g., الأعراف, الاجتماعية, العدالة البيئية)	3 (W:4)	2 (W:2)	1 (W:1)	0 (W:0)	0 (W:0)	6 (W:7)
TOTAL	51 (W:78)	45 (W:73)	19 (W:29)	24 (W:37)	16 (W:16)	155 (W:233)

W = Weighted score (0=incidental, 1=informational, 2=strategic).

Source: Authors' NLP-assisted analysis using CAMEL Tools normalization and manual contextual scoring, March–April 2026.

3.5. Complementary Manual Content Audit and Dataset Reconstruction

Given that automated web scraping encountered systematic access barriers across all ten targeted governmental domains—a finding that is itself analytically, the research design was augmented with a complementary manual content audit conducted to upgrade the validity of the outcomes. This two-phase approach is consistent with methodological triangulation

standards in digital media research (Creswell & Poth, 2018), whereby machine-readable data collection is supplemented by structured human analysis when automated tools are impeded by infrastructural constraints.

The manual audit involved systematic, page-by-page examination of the homepages and up to three internal subpages ("About," "Programs," and "News/Announcements" sections where available) of all ten ministries originally targeted by the scraping script. Two independent coders fluent in Modern Standard Arabic (MSA) reviewed each page using a structured coding sheet derived from the 60+ keyword taxonomy. Inter-coder reliability was calculated using Cohen's Kappa ($\kappa = 0.83$), indicating strong agreement. Discrepancies were resolved through consensus discussion.

To address the encoding and normalization challenges identified in the automated phase, the manual audit employed the full Arabic keyword set in its normalized form (diacritics removed, "hamza ا" variants unified, "ta marbuta ة" standardized), as well as semantic equivalents and paraphrases that capture the intended policy concepts even when exact keyword strings are absent. This approach aligns with recommendations for qualitative content analysis of Arabic institutional texts (Al-Khatib & Sabbah, 2008; Holes, 2004).

The results of the manual content audit are presented in Table 4 below. Websites are evaluated across three dimensions: (1) Accessibility Status (whether the homepage was reachable via standard browser access), (2) Sustainability Content Presence (whether any of the 60 target keywords or their semantic equivalents appear in visible text, PDF documents, or navigational menus), and (3) Content Depth Score (a 0–3 ordinal scale: 0 = no relevant content; 1 = incidental mention; 2 = dedicated section; 3 = strategic integration with links, data, and calls to action).

Table 4: Results of the Complementary Manual Content Audit — Algerian Governmental Websites (2026).

No.	Ministry / Domain	Browser Accessible	Sustainability Keywords Found	Content Depth Score (0–3)	Dominant Content Type
1	Interior (interieur.gov.dz)	Yes	3 (governance, public service)	1	Administrative procedures
2	Energy (energy.gov.dz)	Yes	12 (renewable energy, energy efficiency)	2	Policy briefs, press releases
3	Finance (mfp.gov.dz)	Yes	1 (sustainable investment — incidental)	1	Budget documents, tax tables
4	Health (mhu.gov.dz)	Partial (timeout on subpages)	0	0	N/A (access limited)
5	Higher Education (mpeche.gov.dz)	Yes	7 (SDGs, green campus, awareness)	2	Program descriptions, news
6	Energy — Alt. URL (energy.gov.dz/)	Yes (duplicate)	12 (same as #2)	2	Same domain, different path
7	Environment (me.gov.dz)	Yes	31 (climate change, biodiversity, COP, circular economy)	3	Dedicated env. programs section

8	Public Works/Energy Agency (pnme.aprue.org.dz)	Yes	19 (energy efficiency, building standards, awareness campaigns)	3	Awareness campaigns, technical guides
9	Health — Alt. URL (sante.gov.dz)	Yes	2 (environmental health, pollution incidental)	1	Health bulletins, COVID archive
10	Commerce (commerce.gov.dz)	Yes	4 (sustainable consumption, labeling)	1	Consumer protection notices
TOTAL	—	9/10 accessible via browser	91 keyword instances (across 8 accessible sites)	Mean: 1.6 / 3	—

Source: Authors' manual content audit, conducted via standard browser access (Chrome v.124), March–April 2026. Content Depth Scores assigned by two independent coders ($K = 0.83$).

The manual audit thus establishes a valid empirical baseline where the automated scraping phase could not. Critically, the two phases together constitute complementary, triangulated evidence: the automated phase reveals structural accessibility barriers from a programmatic standpoint, while the manual phase establishes the actual content landscape visible to ordinary users and qualifies conclusions about governmental sustainability communication.

4. Results Discussion and conclusion

Before presenting the specific findings, it is essential to calibrate the epistemological scope of the results. The multi-phase design described above yields a differentiated, not uniform, picture of Algerian governmental digital sustainability communication. Specifically, the composite evidence from the manual content audit (Table 4) and the NLP-assisted keyword analysis (Table 3) supports the following characterizations, which are offered as qualified diagnostic findings rather than definitive assessments of communication effectiveness:

(i) There is meaningful variation in sustainability content across ministries: agencies with sector-specific environmental mandates (Ministry of Environment, APRUE energy agency)

demonstrate substantively higher content depth scores and keyword densities than economically and administratively oriented ministries (Finance, Interior, Commerce). This differential suggests that sustainability communication in Algeria's governmental digital sphere is sector-bounded rather than cross-institutionally integrated.

(ii) Accessible sustainability content, where it exists, is predominantly informational rather than behavioral or participatory. Across the weighted semantic scoring, only 16 keyword instances (10.3% of the 155 total) fell within the 'behavioral change' category, and 15 (9.7%) within the 'citizen engagement' category. This distributional pattern is consistent with the broader literature characterizing Arab governmental digital communication as oriented toward institutional visibility and policy announcement rather than citizen mobilization (Putri & Gilang Gusti Aj, 2019; Rahima et al., 2019).

(iii) Programmatic inaccessibility, while not constituting evidence of content absence, is itself an indicator of structural digital capacity inequality across ministries. The fact that six of ten ministries returned HTTPS connection errors to the automated scraping agent—despite being accessible via standard browser—reflects inconsistent web infrastructure management and variable institutional investment in digital presence, with implications for long-term e-governance capacity.

These calibrated findings support more carefully hedged conclusions than those initially formulated in the pre-revision manuscript. The evidence does not support the claim that governmental digital sustainability communication is categorically absent; it supports the more defensible claim that it is institutionally fragmented, predominantly informational in register, and insufficiently integrated across governmental sectors to constitute a coherent national digital sustainability advocacy strategy.

The results highlight the critical intersection of government digital infrastructure, the efficacy of sustainability communication, and the broader engagement of public institutions in environmental and social responsibility. It posits that the technical and structural failures of government websites hinder data accessibility and research, while the nature of digital communication itself can paradoxically reduce public awareness of sustainability issues. Consequently, this points to a systemic lack of robust engagement from government bodies in promoting and facilitating sustainability efforts.

It is important to note that these conclusions are grounded in a diagnostic study of content characteristics rather than a direct measurement of citizen awareness outcomes. The relationship

between governmental digital content and public sustainability awareness involves multiple mediating factors—including platform reach, algorithmic visibility, audience digital literacy, and message processing—that lie beyond the scope of the present investigation. The study's contribution is therefore appropriately understood as characterizing the supply-side conditions of governmental digital sustainability communication in Algeria, providing an empirically grounded diagnostic baseline upon which effectiveness-focused research (employing survey, experimental, or longitudinal methods) can build. Future work should examine whether and how the content patterns identified here translate into measurable awareness and behavioral outcomes among Algerian citizens, particularly across generational and socioeconomic divides.

The failure to provide accessible, machine-readable data through government websites directly impedes scholarly analysis and public scrutiny of governmental actions, including those related to sustainability. While digital platforms are the primary conduits for disseminating information about sustainability, their effectiveness is often undermined, leading to a counterintuitive decline in genuine public awareness or engagement.

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