# Unraveling the Dynamics of e-Government Digitization, Penetration and User Experience: A Case Study of Greek Municipalities

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*This study examines the user experience (UX) of Greek municipal websites, the first in-depth look at local e-Government services in Greece. Using Lighthouse for technical performance and an Adapted UX Audit, it explores factors beyond digital skills affecting citizen adoption of these platforms. Findings reveal widespread deficiencies, with no municipality scoring above 55%, highlighting significant challenges in usability, functionality, and user satisfaction. Critical issues in Technical Performance and Missing Features, both scoring below 50%, suggest that inherent design flaws hinder user acceptance. The study emphasizes the need for improvements in feedback mechanisms, multilingual support, and accessible help sections to better serve diverse populations. Addressing these gaps could enhance e-democracy by fostering more inclusive, user-friendly services. The results advocate for a strategic overhaul of municipal websites to increase engagement, improve e-Government effectiveness, and strengthen democratic participation. Limitations and recommendations for future research and policy-making are also provided.*

*Keywords: e-democracy, e-municipalities, usability, user experience (UX), system performance*

## INTRODUCTION

In recent years, Digital Transformation and e-Government concepts have become central to public discourse. Numerous national, European, and international institutions have engaged in research, innovation, and financial initiatives to facilitate the public sector's digital transition. The European Commission and the Greek government have prioritized developing sustainable e-Government systems, aiming to digitize public institutions and foster a digitally inclusive society (Ministry of Administrative Reconstruction, 2014). These efforts are fundamentally geared towards creating a transparent, efficient, and non-discriminatory digital interface that promotes social policy and democracy, reconnecting citizens with their government (European Commission, 2010).

Digitization involves transforming traditional, non-digital services, processes, or information into digital formats, making them accessible online (Aslanov & Mirzagayeva, 2022). This transformation is

crucial for modernizing government operations, enhancing service delivery, and improving overall efficiency (United Nations, 2021). It involves adopting technologies to create digital platforms, databases, and systems that facilitate online public services (Vial, 2019). High digitization rates indicate successful technological integration into government processes, resulting in convenient and efficient digital services for the public. Conversely, low digitization rates suggest a reliance on traditional methods, highlighting areas for improvement and the need to accelerate digital transformation to meet citizens' evolving expectations (Schmutz, Sonderegger, & Sauer, 2016, 2017).

Penetration refers to citizens' adoption and utilization of these online channels to access government services (EC, 2020). It serves as a key metric for assessing the success of digital transformation and e-Government initiatives, reflecting the level of engagement and interaction between the public and government agencies through digital platforms (Perez-Morote et al., 2020). A high penetration rate signifies widespread acceptance and use of e-Government services among citizens, highlighting the effectiveness of digital initiatives in reaching the target audience. Conversely, a low penetration rate suggests potential challenges or barriers in adopting digital services, necessitating efforts to promote and enhance the accessibility and user-friendliness of online platforms.

Understanding the factors influencing digitization and penetration is crucial for policymakers and government agencies to tailor strategies and improve the effectiveness of e-government initiatives, ensuring broader citizen participation and fostering a more efficient and inclusive digital public service delivery system.

User-centricity, an essential aspect of digital transformation, refers to designing and implementing digital solutions that focus primarily on the needs, preferences, and experiences of end-users. It involves gathering user feedback and incorporating user insights throughout the development process to ensure that digital services are intuitive, efficient, and user-friendly (Knijnenburg et al., 2012; Schumacher et al., 2010). By prioritizing user needs, organizations can enhance overall user experience, increase user satisfaction, and drive higher adoption rates of digital services, ultimately leading to successful digital transformation (Riedmann-Streitz, 2018; Corrigan & Miller, 2011; Petrovic & Siegmann, 2011).

Greece has made notable strides in the digital transformation of its public sector in recent years. The United Nations reported significant progress, predicting an impressive digitization rate of 86% by 2020 (UN, 2018). The European eGovernment Benchmark of 2020 validated this progress, indicating substantial growth despite Greece's digitization rate being lower than that of the EU27+UK. The same report commended Greece's performance in user-centricity, including online availability, usability, and mobile-friendliness of public systems.

However, Greece faces challenges in penetration, referring to the extent of citizens' utilization of online government services. The European Commission's assessments (EC, 2020, 2021) revealed a persistent deficiency in digitization levels and only a marginal improvement in penetration. Despite transitioning from a "Non-Consolidated eGov" scenario in 2020 to an "Unexploited Scenario" in 2021, Greece still exhibits limited utilization of digital services. Factors contributing to these challenges include insufficient digital skills, moderate quality of government digital services, and inadequate broadband infrastructure.

This research investigates the underlying dynamics between governmental digital services and their successful adoption by citizens. By adopting a human-centered approach, this study focuses on the user experience (UX) of Greek e-Municipalities, emphasizing the factors influencing website acceptance and system effectiveness. It aims to explore the relationship between user-centricity and e-Government penetration, considering how enhancing users' learnability and digital skills can improve system acceptance. The study's objectives are 1. to review Greece's performance in digitization and e-participation, 2. To identify determinants that enhance user acceptance, and 3. pinpoint factors influencing citizens' engagement with e-Government services. This comprehensive understanding will provide valuable guidance for policy formulation and future research in digital transformation within Greek e-Municipalities.

This study aspires to shed light on the critical dimensions of digital transformation in Greek e-Municipalities by addressing these research objectives, offering insights for informed policy-making and contributing to the broader discourse on e-Government development.

## THEORETICAL BACKGROUND

### Enhancing Citizen e-Participation Through Digital Transformation

The integration of Information and Communications Technology (ICT) in public administration aims to enhance citizen empowerment and participation in governance processes. As defined by Macintosh (2004), E-empowerment involves leveraging technology to enable citizens to participate actively in decision-making, thereby influencing the political agenda from the bottom-up. This approach shifts the perception of citizens from mere consumers of public services to active policymakers, fostering a more inclusive and democratic governance structure. According to Wimmer (2007), e-empowerment increases citizens' influence, control, and involvement in policymaking, thus reinforcing democratic principles.

The COVID-19 pandemic has further underscored the necessity of adopting modern digital technologies to advance e-participation and collaborative policy-making. Consequently, various criteria are used to assess e-participation levels globally, at the European level, and locally, providing insights into current statuses and identifying areas for optimization.

### Global and European Assessments of Greece's Digital Performance

The United Nations conducts a biennial e-Government study to monitor the global evolution of e-participation (UN, 2018). This study employs a three-level model of e-participation to transition individuals from passive to active engagement, ultimately leading to genuine empowerment. A key component of this assessment is the E-Participation Index (EPI), which evaluates the availability and relevance of participatory services on government websites. The EPI assesses the use of electronic services for public information provision (e-information), stakeholder contact (e-consultation), and involvement in decision-making processes (e-decision making).

Using the EPI, the UN ranks countries to provide insights into global trends in citizen engagement (UN, 2014; 2016). Greece has shown significant progress in e-participation, climbing from 65th in 2016 to 34th in 2018, with notable improvements across all EPI categories (Costopoulou et al., 2021).

Similarly, the European Community considers User Centricity as one of the fundamental benchmark factors (EC, 2021; 2020). This factor evaluates the degree to which services and information are available online, the level of support provided during the online journey, and whether public websites are optimized for mobile devices. Greece has demonstrated substantial growth in User Centricity, particularly in usability and mobile-friendliness, although challenges remain in online availability.

**TABLE 1**
**COMPARISON OF GREECE'S USER CENTRICITY (UC) PARAMETERS WITH EU27+ FOR 2018-2019 AND CORRESPONDING GROWTH RATES SINCE 2016-2017**

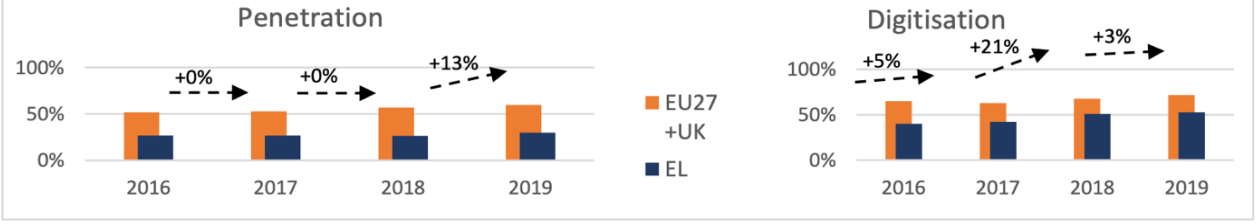
| Assessment Parameters | EU27+ Average Scores (2018-2019) | Greece's Average Scores (2018-2019) | Growth Rate (since 2016-2017) |
|---|---|---|---|
| Online Availability | 86.8% | 84% | +8 |
| Usability | 90.5% | 93% | +7 |
| Mobile Friendliness | 76.3% | 71% | +15 |
| **Overall UC** | **86.5%** | **85%** | **+9** |

EC, 2020

Despite this progress, Greece continues to face challenges in penetration and digitization. The 2020 European Commission report categorized Greece under the "Non-Consolidated eGov" scenario, highlighting its limited utilization of ICT opportunities and lower performance compared to the European average.

**FIGURE 1**
**GREECE'S GROWTH TREND FROM 2016 TO 2019, AS MEASURED AGAINST A EUROPEAN BENCHMARK OF 27+ UK COUNTRIES (2020)**

| | Penetration | Digitisation |
|---|---|---|
| EU27+UK | 60% | 72% |
| EL | 30% | 53% |




EC Report, 2020

**FIGURE 2**
**PENETRATION AND DIGITIZATION MATRIX. GREECE'S POSITION IN TERMS OF PENETRATION AND DIGITIZATION, AS MEASURED AGAINST A EUROPEAN BENCHMARK OF 27+ UK COUNTRIES (2020)**


EC Report, 2020

In 2021, the European Commission report identified Greece in the "Unexploited eGov" scenario, reflecting a medium level of penetration but still lagging in digitization. Despite an increase in penetration levels, Greece's overall digitization processes remain underdeveloped, indicating substantial room for improvement.

**TABLE 2**
**COMPARISON OF GREECE'S USER CENTRICITY (UC) PARAMETERS WITH 27+ UK FOR 2019-2010 AND CORRESPONDING GROWTH RATES SINCE 2018-2019**

| Assessment Parameters | EU27+ Average Scores (2019-2020) | Greece's Average Scores (2019-2020) | Growth Rate (since 2018-2019) |
|---|---|---|---|
| Online Availability | 87.2% | 79% | -5 |
| User Support | 88.4% | 93% | 0 |
| Mobile Friendliness | 91.2% | 83% | +12 |
| **(Overall) UC** | **88.3%** | **85%** | 0 |

EC, 2021

A paradox arises from these reports: Greece's digitization levels have not kept pace despite increased penetration. This discrepancy suggests that factors beyond digital literacy, such as system usability and user-centric design, play critical roles in effective e-Government service adoption.

Therefore, evaluating and enhancing these factors are crucial for Greece to fully realize the potential of its e-Government initiatives, improving both citizen engagement and the effectiveness of public service delivery.

**Maturity Models and Digital Performance Assessment**

The examination of maturity models and digital performance assessments reveals crucial insights into the adoption and effectiveness of e-participation at both national and local levels in Greece. The differences between global, national, and local assessments underscore the varying degrees of digital maturity and the unique challenges municipalities face in integrating advanced e-Government technologies.

*Global vs. Local Assessments*

The E-Participation Index (EPI) provides a comprehensive overview of e-participation adoption at the national level. While it offers valuable global data, it may not be fully suitable for assessing local government practices due to the unique cultural and operational contexts that exist at the municipal level (Steinbach et al., 2019). Recognizing this limitation, the UN proposed the Local Online Service Index (LOSI), which aims to evaluate local e-government practices by considering these cultural characteristics (UN, 2018). However, the applicability of LOSI across diverse local environments is still under investigation, indicating a need for further refinement and standardization.

*Insights From Local Studies*

Costopoulou et al. (2021) conducted a study using the Citizen Web Empowerment Index (CWEI) to assess e-information, Web 2.0 tools, e-consultation, and e-decision-making processes locally in Greece. Their findings indicated small-to-medium-scale improvements in digital engagement. However, they also highlighted that municipalities' integration of advanced digital technologies is still in its early stages. The study recommended that municipalities explore new technologies such as mobile apps, social media, and big data to enhance citizen participation. This suggests that while there are positive trends, significant work remains to achieve comprehensive digital transformation at the local level.

Similarly, Ntaliani et al. (2017) investigated electronic and mobile participation within 325 Greek municipal governments. Their research revealed substantial room for improvement in developing clear strategies for incorporating mobile technology into civic engagement. Despite some progress, the findings

emphasized the need for more robust and coherent strategies to fully leverage mobile technologies in fostering citizen participation.

Taken together, the findings from these studies highlight the varying levels of maturity and digital performance between national and local government e-participation initiatives. The current state of e-participation maturity models and digital performance assessments underscores a significant disparity between national and local levels. This disparity ranges from providing a broad, global perspective on national e-participation adoption to offering services at the local level that have a slow pace of integrating advanced digital technologies, such as mobile apps, social media, and big data.

**Differences in e-Governmental Sites and Local Government Sites (Municipalities)**

Previous studies (Alexopoulos et l., 2018; Costopoulou et al., 2017; Lappas et al., 2015) have examined e-Government progression within Greek municipalities. Their comprehensive analysis reveals significant differences in citizens' perspectives on e-Governmental sites compared to local government (municipal) sites in Greece. These differences are rooted in the varying levels of interactivity, accessibility, and overall service quality these platforms provide.

*One-Way Information vs. Interactive Capabilities*

Lappas et al. (2015) established a framework for evaluating e-Government based on residents' preferences, revealing that Greek municipalities primarily offered one-way information and limited interaction capabilities. The authors posed the factor that Greek municipalities primarily offer one-way information dissemination. Municipal websites are often limited to providing static content such as municipal information, tourist attractions, council member details, and mayoral information. This one-way flow of information does not facilitate interactive engagement or transactional capabilities, which are crucial for fostering active citizen participation and engagement. The lack of interactive features, such as online forms for feedback, discussion forums, or real-time communication tools, restricts the ability of citizens to engage dynamically with local governments.

In contrast, based on the same report, e-Governmental sites at the national level have shown a greater inclination towards incorporating interactive capabilities. National platforms are more likely to offer comprehensive e-services, including e-consultation, e-decision-making, and other participatory tools that enable citizens to interact more directly with government services and policies. This interactivity is a key factor in enhancing user satisfaction and promoting a sense of involvement among citizens (Lappas et al., 2015)

*Slow Pace of Development in Municipalities*

Costopoulou et al. (2017) highlighted the slow pace of e-Government development within Greek municipalities compared to the progress observed at the national level. While some focus has been on enhancing e-information, local government sites still lack essential features such as online polls and reputation systems. These tools are vital for gauging public opinion and building trust through transparent and responsive governance. The absence of such features indicates a significant gap between the potential of e-Government services and their actual implementation at the municipal level.

On the other hand, national e-Governmental sites have made more strides in integrating advanced features that support comprehensive user engagement and participation. This disparity suggests that while national initiatives may benefit from more resources and centralized policies, local governments struggle with limited capacities and slower adoption rates.

*ICT Infrastructure and Domain-Specific Progress*

Alexopoulos et al. (2018) identified barriers in Smart Cities development, noting improvements in ICT infrastructure but limited progress in health, transportation, and security domains. These authors detected notable improvements in ICT infrastructure within Greek municipalities, such as implementing free Wi-Fi in public areas and upgrading hardware and software in municipal departments. However, significant

barriers remain, particularly in health, transportation, and security sectors. The limited progress in these critical domains further exacerbates the gap between local government capabilities and citizen expectations.

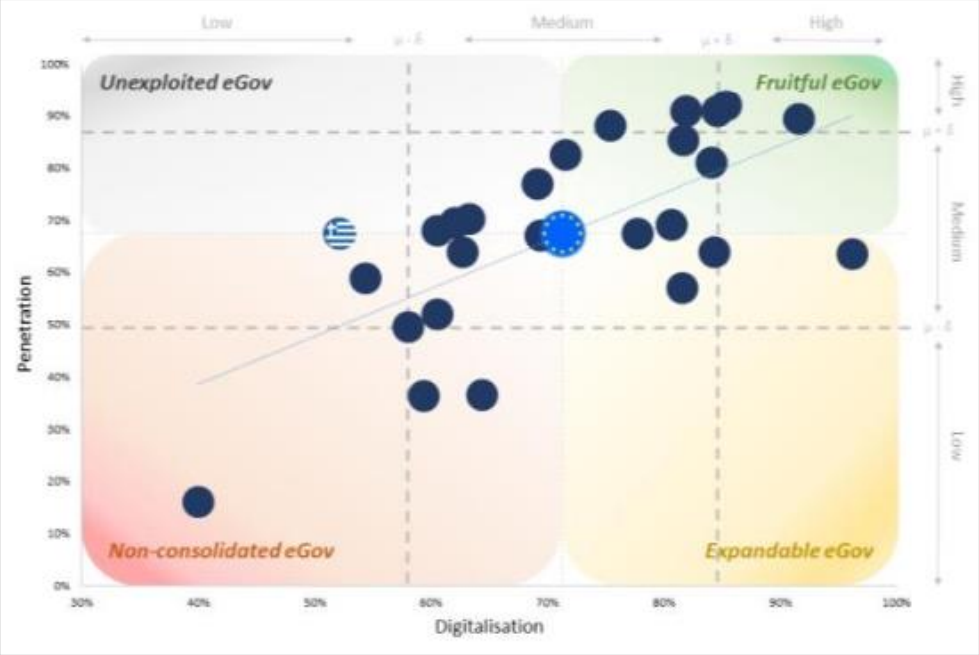
In comparison, national e-Governmental sites tend to have better-developed infrastructure and broader domain coverage, reflecting more holistic digital transformation strategies. This comprehensive approach ensures citizens can access a wider range of services efficiently, enhancing the overall user experience and trust in e-Government initiatives.

Taken together, the differences in citizens' perspectives on local versus e-Governmental sites are largely influenced by the levels of interactivity, the pace of development, and the comprehensiveness of ICT infrastructure. Local government websites often lag behind national platforms in providing interactive, user-friendly, and fully functional e-services. This gap highlights the need for targeted research methods to further elaborate on users' perspectives and evaluate users' adoption of such systems. Understanding these perspectives will enable the development of strategies to enhance the digital capabilities of municipalities, ensuring they can meet the evolving needs and expectations of their citizens.

**Usability and Learnability as Unified Concepts**

Usability is a multifaceted concept encompassing both technical and user perception aspects. It includes how efficiently a system performs tasks, its intuitive interface, and its ability to facilitate user interactions (Hartson & Pyla, 2012; Albert & Tullis, 2017; Bevan, 2008). However, usability also involves the human aspect of design—how comfortable, enjoyable, and meaningful the interaction is for the user. It hinges on factors like aesthetics, clarity of information, and the ability to cater to diverse user needs and preferences. Thus, a system's usability extends beyond technical proficiency to include psychological and emotional dimensions of user satisfaction and engagement (Hassenzahl & Tractinsky, 2006; Hassenzahl & Ullrich, 2007).

**FIGURE 3**
**PENETRATION AND DIGITISATION MATRIX. GREECE'S POSITION IN TERMS OF PENETRATION AND DIGITIZATION, AS MEASURED AGAINST A EUROPEAN BENCHMARK OF 27+ UK COUNTRIES (2021)**




EC Report, 2021

Regarding e-Services, issues related to navigation and information architecture are crucial. An intuitive structure ensures that users can easily access the required services, enhancing the overall user experience. Conversely, a poorly designed layout can deter users, undermining the adoption and success of e-Services (Sönmez et al., 2024).

Usability also includes critical content and features. Missing content can lead to user dissatisfaction and hinder their ability to accomplish tasks efficiently. Trust and credibility are integral components of usability, established through design elements, accurate information, and a transparent user interface (i.e. Elshan et al., 2022). Technical bugs can significantly impact usability, frustrating users and leading to negative perceptions of the e-Services (Van Riel et al., 2001).

In conclusion, evaluating factors such as navigation, information architecture, content completeness, trust, and technical reliability is paramount when investigating the usability and learnability of e-Services. Understanding and improving these elements are essential for designing systems that meet user needs and expectations. Prioritizing these factors ensures that e-Services are functional and user-friendly, promoting higher adoption rates and greater user satisfaction. Therefore, comprehensive evaluations of these factors should be integral to any usability and learnability assessment, guiding the development of more effective and engaging digital services.

**User Centricity, User Acceptance, and Usability Levels**

Scholars emphasize the importance of trust and user experience in effective e-Government utilization (Fernandes et al., 2013; Tan, Benbasat & Cenfetelli, 2008). Vasilikopoulou (2017) conducted a comprehensive assessment of Greek e-Government sites, identifying several usability challenges:

1. Absence of a unified central portal leading to confusion and mental discontinuity.
2. Lack of information about each site's purpose and available e-services.
3. Disconnect between e-Government websites and real-world processes.

Based on these observations, usability issues are anticipated across various aspects of Greek municipal websites. An adapted UX Audit Assessment will identify additional usability challenges that hinder full system utilization.

User-centered design is crucial for addressing usability challenges. Fernandes et al. (2013) found that educational level and technology familiarity do not significantly impact e-Government penetration. Instead, system performance plays a critical role in shaping the overall user experience, influencing factors like speed, visual aesthetics, and ease of use (Hassenzahl & Ullrich, 2007; Tan, Benbasat & Cenfetelli, 2008).

These insights highlight the critical importance of user centricity, user acceptance, and usability levels in the effective implementation of e-Government services. The identified usability challenges, such as the absence of a unified central portal, lack of clear information, and disconnect with real-world processes, underscore the need for a user-centered design approach.

In conclusion, evaluating factors such as system performance, speed, visual aesthetics, and ease of use is essential when investigating user centricity, user acceptance, and usability levels of e-Government services. Addressing these factors through user-centered design can significantly enhance the overall user experience, thereby promoting higher adoption rates and greater user satisfaction. Understanding and improving these elements are crucial for designing e-Government systems that meet user needs and expectations. Therefore, comprehensive evaluations of these factors should be integral to any usability assessment, guiding the development of more effective and engaging e-Government services.

**Quality of System Evaluation**

Evaluating the quality of system performance is crucial for understanding user adoption and overall user experience in e-Government services. This evaluation encompasses emotional and practical aspects such as visual aesthetics, usability, usefulness, and security, which are critical for designing effective and user-friendly digital platforms.

*Performance*

System performance is pivotal in determining user adoption and overall user experience. Performance encompasses both emotional aspects, such as visual aesthetics and attractiveness, and practical considerations, including usability, usefulness, and security (Hassenzahl & Ullrich, 2007; Hassenzahl & Tractinsky, 2006). Technical factors, like speed and system characteristics, are also integral (Hartson & Pyla, 2012; Albert & Tullis, 2017; Bevan, 2008). Research by Tan, et al. (2008) in the United States demonstrated a link between website performance and user satisfaction. Their evaluation encompassed several criteria, including Tangibles (web interface), Reliability (functionality consistency), Responsiveness (accessibility across devices and times), and Empathy (content personalization). Slower websites often led to frustrating user experiences (Tan, et al., 2008) Similarly, Jati and Dominic (2009) found that the speed of e-Government portals significantly influenced perceived quality and usability.

Adhering to Web Content Accessibility Guidelines (WCAG) can enhance user experience by improving perceived usability, ease of use, interaction, and trust (Schmutz, Sonderegger, & Sauer, 2017). The Lighthouse tool assesses adherence to WCAG as well as other critical categories, including search engine optimization (SEO), best practices, and performance, providing an objective assessment of factors impacting e-Government quality, such as perceived ease of use and usefulness, attractiveness, interaction, privacy, and trust (Barnes & Vidgen, 2006; Kaisara & Pather, 2011; Papardomichelaki & Mentzas, 2012; Daştan, 2015; Belanche, et al., 2014; Rasyid & Alfina, 2017; Karunasena & Deng, 2012; Desmal, et al., 2019).

*Search Engine Optimization (SEO)*

SEO metrics are instrumental in assessing website quality, considering factors such as content quality, delivery speed, and cross-device accessibility (Hanlon, 2022). SEO aims to evaluate website usability in terms of design, architecture, and content to enhance search engine visibility and attract quality traffic (Drivas, et al., 2019). Empirical validation of SEO's impact on user experience indicates that optimized websites can prolong user visits, ultimately enhancing the overall user experience (Egri & Bayrak, 2014). Ensuring search engine optimization becomes imperative, as unoptimized e-Government portals impede information access (Kopackova, et al., 2010).

*Best Practices*

The "Best Practices" dimension pertains to adherence to coding and web development standards to ensure a positive user experience (web.dev, 2022). Compliance with these standards ensures technological currency, website speed, and security (web.dev, 2022). Notably, trust in e-Government is multifaceted, encompassing institutional-based trust, trust in stored data, trust in transactions, trust in services, trust in information, and confidence in systems (Papadopoulou, et al., 2010). This trust, often established through the application of cutting-edge technology and security protocols, reinforces the importance of adhering to best practices (Barnes & Vidgen, 2006; Kaisara & Pather, 2011; Belanche, et al., 2014; Papardomichelaki & Mentzas, 2012; Daştan, 2015; Papadopoulou, et al., 2010).

*Accessibility*

Accessibility evaluation in e-Government research involves the application of Web Content Accessibility Guidelines (WCAG) to assess portals, provide an explanation of the country's score on the United Nations Department of Economic and Social Affairs (UN DESA) e-Government development index (EGDI), and offer recommendations for enhancement (Paul, 2022). Automated tools are often employed for this purpose (Al Mourad, et al., 2019; Micheal, 2019; Kuzma, 2010; Paul, 2022). Adhering to accessibility requirements is essential, as it positively impacts task completion time, user perception of usability, aesthetics, workload, and trustworthiness (Schmutz, et al., 2017) Automated tools are advocated for their ability to provide a more comprehensive assessment of website accessibility compared to expert evaluation (Brajnik, et al., 2010).

## METHODS

### Conceptual Framework

This research aims to identify critical factors influencing e-Government penetration by assessing the quality of digital services provided by Greek municipalities. The study employs two primary tools: the Lighthouse open-data tool and an adapted UX Audit Assessment. These tools evaluate the technical performance and usability of municipal websites, respectively, recognizing that both users' digital literacy and the design of the systems play crucial roles in effective e-Government service delivery.

### Study Design

The study utilizes a mixed-methods approach, combining quantitative data from the Lighthouse tool with qualitative insights from the Adapted UX Audit Assessment. This approach allows for a comprehensive evaluation of the municipal websites' technical and user-experience aspects.

### Sample Selection

Ten Greek municipal websites were selected for this study using a simple random sampling method. The selection criterion was a minimum population threshold of 60,000 residents within each municipality. This threshold ensures that the sample represents diverse user demographics and captures a wide range of user experiences. The selected municipalities include Rethimno, Metamorfosi, Thessaloniki, Oropos, Corfu, Limnos, Alexandroupolis, Trikala, Ioannina, and Korinthos.

### Data Collection Tools

*Lighthouse Tool*

The Lighthouse tool, an automated website performance testing application, was used to assess the technical quality of the municipal websites. The evaluation focused on four key indicators:

- **Performance:** This includes metrics such as First Contentful Paint (FCP), Speed Index, Largest Contentful Paint (LCP), Time to Interact (TTI), Total Blocking Time (TBT), and Cumulative Layout Shift (CLS).
- **Accessibility:** Adherence to Web Content Accessibility Guidelines (WCAG) and other critical accessibility criteria.
- **Best Practices:** Compliance with coding and web development standards, user experience considerations, and security protocols.
- **SEO (Search Engine Optimization):** Factors such as mobile friendliness, content quality, and crawling and indexing capabilities.

Each municipal website's homepage was analyzed using the Lighthouse tool, as the homepage serves as a crucial entry point and typically shapes visitors' initial impressions.

*UX Audit Assessment: An Adapted Version*

The UX Audit checklist used in this study is an adapted and shorter version of a usability audit originally developed by Travis (2014). The original checklist comprises 247 statements across eight dimensions, designed to comprehensively evaluate website usability. For this study, which focuses on evaluating municipality websites in Greece, the checklist was shortened to 50 statements grouped into five dimensions: Navigation & Information Architecture, Page Layout & Visual Design, Missing Features, Technical Performance, and Trust & Credibility. Each dimension contains 10 statements, rated on a scale of -1 to 1, where 1 indicates full satisfaction, 0 indicates partial satisfaction, and -1 indicates dissatisfaction.

This assessment focused on five critical areas:

a) Navigation & Task Orientation: Evaluating the efficiency of the website's navigation system and the organization of information. This aspect evaluates the efficiency of the website's navigation system and information organization, ensuring that users, regardless of their level of digital maturity, can easily find the relevant content and complete desired tasks. Intuitive

navigation contributes to the learnability of the system, allowing users to quickly adapt to its structure and functionalities.

b) Layout & Visual Design: Assessing the visual appeal and user-friendliness of the design, including typography, color schemes, and imagery. This assessment seeks to create a visually appealing and user-friendly design. Clear and consistent visual cues aid users in understanding the website's layout and interactions, which is especially beneficial for users with lower digital literacy levels.

c) Missing Features: Identifying essential features or functionalities that are absent on the website. By providing all necessary tools and functions, the system becomes more accessible to users of varying levels of experience, enabling
    - Technical Performance: Uncovering and resolving technical difficulties or glitches that users may encounter. The fundamental difference between this metric and the "Performance" dimension measured by the Lighthouse tool is that the features examined here refer mostly to the design and the good system's feedback (i.e. error/success messages, loading and progress indicators), as well as the proactive behavior of the system to prevent user's errors.
    - Trust & Credibility: Evaluating factors that influence user trust, such as the clarity and accuracy of information, privacy assurances, and credibility indicators.

**Ensuring Content Validity & Reliability**

*Content Validity*

To ensure content validity, the adapted checklist was reviewed by a panel of 7 UX experts. Each expert rated the relevance of each statement on a scale from 1 to 4 (1 = not relevant, 4 = highly relevant). The Item Content Validity Index (I-CVI) was calculated for each dimension by determining the proportion of experts who rated the item as 3 or 4. The I-CVI scores for the dimensions were as follows: Navigation & IA (9.29), Page Layout & Visual Design (10), Missing Features (10), Technical Performance (10), and Trust & Credibility (10). The Scale Content Validity Index (S-CVI), representing the average of the I-CVI scores for each dimension, was calculated to be 0.93 for Navigation & IA and 1.00 for the other dimensions. The overall I-CVI and S-CVI for the checklist were 9.858 and 0.986, respectively. These results indicate that the adapted checklist has high content validity, with most items rated as highly relevant by the experts, ensuring that the checklist effectively covers the necessary aspects of usability for evaluating municipality websites in Greece.

**TABLE 3**
**DESCRIPTIVE STATISTICS. MEAN, STANDARD DEVIATION (SD) FOR EACH UX AUDIT DIMENSION**

| | Mean | SD | Min | Max |
|---|---|---|---|---|
| Navigation & Task Orientation | 3.46 | 0.63 | 2 | 4 |
| Page Layout & Visual Design | 3.60 | 0.49 | 3 | 4 |
| Missing Features | 3.60 | 0.49 | 3 | 4 |
| Technical Performance | 3.61 | 0.49 | 3 | 4 |
| Trust & Credibility | 3.63 | 0.49 | 2 | 4 |

*Reliability*

To ensure the reliability of the UX audit tool, an Intraclass Correlation Coefficient (ICC) analysis was conducted using ratings provided by a panel of 7 UX experts. Each expert rated the relevance of 50 items across 5 dimensions. The ICC was calculated using a two-way mixed-effects model for consistency, using IBM SPSS statistics package, version 29.

The results indicated a moderate level of agreement among the experts. The average measures ICC was 0.420, with a 95% confidence interval ranging from 0.136 to 0.635, suggesting moderate reliability when considering the mean ratings of the experts. However, the single measures ICC was low (0.094), indicating substantial variability in individual ratings.

In addition, Cronbach's Alpha for the entire scale was calculated to assess internal consistency. The overall Cronbach's Alpha was 0.420, reflecting moderate consistency across the items. While this value is below the commonly accepted threshold of 0.7, it is considered acceptable for exploratory studies and provides valuable insights for further refinement of the UX audit tool.

**FIGURE 4**
**INTRACLASS CORRELATION COEFFICIENT (ICC), USING SPSS SOFTWARE, INDICATING THE RELIABILITY OF THE ADAPTED UX AUDIT CHECKLIST**

**Intraclass Correlation Coefficient**

| | Intraclass Correlation[b] | 95% Confidence Interval | | F Test with True Value 0 | | | |
|---|---|---|---|---|---|---|---|
| | | Lower Bound | Upper Bound | Value | df1 | df2 | Sig |
| Single Measures | .094[a] | .022 | .199 | 1.723 | 49 | 294 | .003 |
| Average Measures | .420[c] | .136 | .635 | 1.723 | 49 | 294 | .003 |

Two-way mixed effects model where people effects are random and measures effects are fixed.

a. The estimator is the same, whether the interaction effect is present or not.

b. Type C intraclass correlation coefficients using a consistency definition. The between-measure variance is excluded from the denominator variance.

c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

## Data Analysis

*Quantitative Analysis*

Descriptive statistics were used to analyze the data collected from the Lighthouse tool. Mean scores and standard deviations were calculated for each of the four key indicators (Performance, Accessibility, Best Practices, SEO) to identify improvement areas.

*Qualitative Analysis*

The qualitative data from the UX Audit Assessment were analyzed using pattern and classification analysis. This involved cleaning the data, identifying recurring themes, grouping related data, and categorizing them into broader topics. A Response Frequency Analysis was conducted to determine the frequency and severity of identified issues, allowing the researchers to prioritize and address critical usability challenges.

## RESULTS

### System Performance

Descriptive statistics show differences in the mean scores across all dimensions (Table 3). Specifically, Performance Errors exhibit the highest level of difficulty, (M = 5, SD = 0.9), followed by Accessibility (M = 4.7, SD = 2.2), and Best Practices compliance (M = 3.2, SD = 1.7) and SEO (M=1.4, SD=1). These findings emphasize the need for targeted improvements in each area to optimize the examined websites' overall performance and user experience.

**TABLE 3**
**DESCRIPTIVE STATISTICS. MEAN AND STANDARD DEVIATION (SD) FOR EACH LIGHTHOUSE INDICATOR**

| | Mean | SD | Min | Max |
|---|---|---|---|---|
| Performance | 40.60 | 24.35 | 11.00 | 86.00 |
| Accessibility | 80.50 | 11.68 | 62.00 | 98.00 |
| Best Practices | 75.50 | 12.98 | 54.00 | 92.00 |
| SEO | 86.70 | 9.56 | 70.00 | 100.00 |

The initial analysis of Accessibility, SEO, Best Practices, and Performance as shown in Table 4, showed that in terms of accessibility, 20% of the assessed e-Government portals perform well, 80% perform at a medium level, and no website function poorly. Similar findings were made for "Best Practices", where no websites performed poorly, 10% of e-Government portals performed well, and 90% performed at a medium level. Approximately half of the portals examined, namely 50% receive a medium score in terms of "SEO," and the other 50% performs well. The primary problem of the portals appears to be "Performance," as none of the e-Government portals under examination perform well, just 30% perform medium, and 70% perform poorly.

**TABLE 4**
**CLASSIFICATION OF E-GOVERNMENT QUALITY BASED ON LIGHTHOUSE ANALYSIS**

| | **Performance** | | **Accessibility** | | **Best Practices** | | **SEO** | |
|---|---|---|---|---|---|---|---|---|
| | Frequency | Percent | Frequency | Percent | Frequency | Percent | Frequency | Percent |
| Bad | 7 | 70% | 0 | 0% | 0 | 0% | 0 | 0% |
| Medium | 3 | 30% | 8 | 80% | 9 | 90% | 5 | 50% |
| Good | 0 | 0% | 2 | 20% | 1 | 10% | 5 | 50% |
| Total | 10 | 100% | 10 | 100% | 10 | 100% | 10 | 100% |

*Performance*

The initial assessment of e-Government portal performance revealed a diverse landscape. The rendering speed of these portals was measured across six dimensions (Table 5): First Contentful Paint (FCP), Speed Index, Largest Contentful Paint (LCP), Time to Interact (TTI), Total Blocking Time (TBT), and Cumulative Layout Shift (CLS).

Regarding FCP, which gauges the time it takes to render initial images and content after a user's navigation, a mere 10% of the portals performed well, while the majority (60%) exhibited a medium performance level. A similar trend was observed in the Speed Index, where 50% of the portals displayed a suboptimal performance.

Largest Contentful Paint (LCP), a metric assessing perceived load speed and user assurance, revealed that 60% of portals scored a medium rating, while 30% performed poorly. TTI, which measures the time for a page to become fully interactive, witnessed 30% of portals performing poorly, with only 10% achieving a good rating.

Total Blocking Time (TBT), an indicator of user input responsiveness, displayed a mixed landscape with 50% of websites demonstrating medium performance, 20% ranking poorly, and 30% performing well. Cumulative Layout Shift (CLS), evaluating visual stability, showed that 52% of portals scored well, with 40% ranking medium and 40% performing poorly. This metric is particularly crucial for ensuring a satisfying user experience.

**TABLE 5**
**FREQUENCIES OF PERFORMANCE CLASSIFICATION IN THE E-GOVERNMENT PORTALS**

| | | Good | Medium | Bad | Total |
|---|---|---|---|---|---|
| First Contentful Paint | Frequency | 1 | 6 | 3 | 10 |
| | Percent | 10 | 60 | 30 | 100 |
| Speed Index | Frequency | 1 | 4 | 5 | 10 |
| | Percent | 10 | 40 | 50 | 100 |
| Largest Contentful Paint | Frequency | 1 | 6 | 3 | 10 |
| | Percent | 10 | 60 | 30 | 100 |
| Time to Interactive | Frequency | 1 | 6 | 3 | 10 |
| | Percent | 10 | 60 | 30 | 100 |
| Total Blocking Time | Frequency | 3 | 5 | 2 | 10 |
| | Percent | 30 | 50 | 20 | 100 |
| Cumulative Layout Shift | Frequency | 2 | 4 | 4 | 10 |
| | Percent | 20 | 40 | 40 | 100 |

*Accessibility*

Regarding accessibility (Table 6), the assessment unveiled areas of both strength and improvement. Notably, a substantial majority (80%) of e-Government portals exhibited a medium level of performance, while none were found to perform poorly in the category. Areas such as "Tables & Lists" and "Best Practices" displayed robust performance, with 80% and 90% of portals, respectively, showcasing no errors.

However, challenges emerged in the "Contrast" category, with 90% of portals facing issues related to insufficient color contrast between text and background. This concern can hinder individuals with limited vision from discerning critical elements.

The most prominent accessibility issues surfaced in "Navigation," "ARIA," and "Labels & Names." Navigation challenges encompassed issues like duplicated element IDs and improper tab index values, potentially causing screen readers to skip essential content. ARIA, which aims to enhance screen reader comprehension, revealed lapses in providing accessible button names and alternative attributes for images. "Labels & Names" revealed shortcomings in naming links and frames, impacting screen reader functionality.

**TABLE 6**
**FREQUENCIES OF NUMBER OF ACCESSIBILITY ERRORS OCCURRED IN THE E-GOVERNMENT PORTALS**

| | | No of Errors detected | | | | |
|---|---|---|---|---|---|---|
| | | .00 | 1 | 2 | 3 | Total |
| Contrast | Frequency | 1 | 9 | 0 | 0 | 10 |
| | Percent | 10 | 90 | 0 | 0 | 100 |
| Names & Labels | Frequency | 1 | 1 | 4 | 4 | 10 |
| | Percent | 10 | 10 | 40 | 40.0 | 100 |
| Tables & Lists | Frequency | 8 | 1 | 1 | 0 | 10 |
| | Percent | 80 | 10 | 10 | 0 | 100 |

| | | No of Errors detected | | | | |
|---|---|---|---|---|---|---|
| | | **.00** | **1** | **2** | **3** | **Total** |
| ARIA | Frequency | 6 | 3 | 0 | 1 | 10 |
| | Percent | 60 | 30 | 0 | 10 | 100 |
| Navigation | Frequency | 6 | 3 | 0 | 1 | 10 |
| | Percent | 60 | 30 | 0 | 10 | 100 |
| Best Practices | Frequency | 9 | 1 | 0 | 0 | 10 |
| | Percent | 90 | 10 | 0 | 0 | 100 |

*Best Practices*

The evaluation of best practices showcased a predominance of medium-level performance, with 90% of portals falling into this category. Frequencies of the detected errors as shown in Table 7, reveal that the "General" category, emphasizing user experience and functionality, witnessed the most common issues. Approximately half (50%) of the portals exhibited unresolved problems due to insufficient security controls and browser errors.

Under "User Experience," concerns included low-resolution homepage images and images displayed in incorrect aspect ratios, potentially impacting user perception. In "Trust & Security," issues emerged related to portals linking to unsafe external destinations and the absence of HTTPS, posing potential security risks. Finally, the "Browser Compatibility" category revealed that three portals lacked the HTML doctype, causing unexpected rendering.

**TABLE 7**
**FREQUENCIES OF NUMBER OF BEST PRACTICES ERRORS OCCURRED IN THE E-GOVERNMENT PORTALS**

| | | No of errors detected | | | |
|---|---|---|---|---|---|
| | | **0** | **1** | **2** | **Total** |
| User Experience | Frequency | 6 | 3 | 1 | 10 |
| | Percent | 60 | 30 | 10 | 100 |
| Trust & Security | Frequency | 4 | 3 | 3 | 10 |
| | Percent | 40 | 30 | 30 | 100 |
| General | Frequency | 0 | 5 | 5 | 10 |
| | Percent | 0 | 50 | 50 | 100 |
| Browser Compatibility | Frequency | 7 | 3 | 0 | 10 |
| | Percent | 70 | 30 | 0 | 100 |

*SEO*

In the realm of Search Engine Optimization (SEO), the e-Government portals exhibited a commendable overall performance. Frequencies in Table 8 show that, in terms of Mobile Friendliness, which ensures usability across devices, the majority (70%) of portals were free from faults. However, issues were noted related to sizing adaptability on all devices.

Crawling and indexing, essential for search engine discoverability, encountered minimal problems. The sole identified issue was blocking the homepage from indexing, limiting search engine crawling.

Content-related issues centered on a lack of meta descriptions for documents and missing alternative attributes for images, which can affect search engine optimization.

**TABLE 8**
**FREQUENCIES OF NUMBER OF SEO ERRORS OCCURRED IN THE E-GOVERNMENT PORTALS**

| | | No of Errors detected | | | |
|---|---|---|---|---|---|
| | | **0** | **1** | **2** | **Total** |
| Mobile Friendliness | Frequency | 7 | 3 | 0 | 10 |
| | Percent | 70 | 30 | 0 | 100 |
| Content | Frequency | 2 | 6 | 2 | 10 |
| | Percent | 20 | 60 | 20 | 100 |
| Crawling & Indexing | Frequency | 9 | 1 | 0 | 10 |
| | Percent | 90 | 10 | 0 | 100 |

**System Usability**

Descriptive statistics reveal variations in the mean scores across all evaluated usability dimensions (Table 9). Specifically, the Navigation & Task Orientation dimension showed relatively consistent performance across the municipalities (M = 0.07, SD = 0.2), with scores ranging from -0.4 to 0.5. The Page Layout & Visual Design dimension revealed significant differences and greater variability in the design quality (M = -0.17, SD = 0.4), with scores ranging from -0.8 to 0.8. The Missing Features dimension presented substantial discrepancies in the availability of key features across different municipalities (M = -0.10, SD = 0.6), with scores ranging from -0.8 to 0.7. Technical Performance displays a slightly positive mean score (M = 0.03, SD = 0.6), with scores ranging from -1 to 1, suggesting varied technical execution. Lastly, the Trust & Credibility dimension achieves the highest performance (M = 0.13, SD = 0.6), ranging from -0.6 to 0.8, indicating that trust and credibility are generally well-handled but still show room for improvement.

These findings emphasize the need for targeted enhancements in specific areas to optimize the overall user experience of the evaluated websites.

**TABLE 9**
**DESCRIPTIVE STATISTICS. MEAN AND STANDARD DEVIATION (SD) FOR EACH USABILITY DIMENSION**

| | Mean | SD | Min | Max |
|---|---|---|---|---|
| Navigation & Task Orientation | 0.07 | 0.2 | -0.4 | 0.5 |
| Page Layout & Visual Design | -0.17 | 0.4 | -0.8 | 0.8 |
| Missing Features | -0.10 | 0.6 | -0.8 | 0.7 |
| Technical Performance | 0.03 | 0.6 | -1.0 | 1.0 |
| Trust & Credibility | 0.13 | 0.6 | -0.6 | 0.8 |

*Navigation & Task Orientation*

The Navigation & Task Orientation dimension shows a mixed performance across municipal websites. Negative scores for the logical ordering of navigation choices and tab placement (-0.4) suggest that users find the navigation structure unintuitive. Similarly, challenges in remembering information across sections

(-0.4) and moving between pages (-0.1) may lead to frustration. On the positive side, accurate category labels (0.3) and minimizing screens per task (0.5) enhance efficiency and reduce cognitive load. However, slight positive scores for jargon-free terminology and distinguishing required fields (both 0.1) suggest room for improvement. While some aspects are effective, critical areas need improvement to enhance usability and user experience.

**TABLE 10**
**DESCRIPTIVE STATISTICS. MEAN AND STANDARD DEVIATION (SD) FOR EACH STATEMENT IN THE NAVIGATION & TASK ORIENTATION DIMENSION**

| | Mean | SD | Min | Max |
|---|---|---|---|---|
| There is a convenient and obvious way to move between related pages and sections and it is easy to return to the home page | -0.1 | 0.9 | -1 | 1 |
| The information that users are most likely to need is easy to navigate to from most pages | 0.2 | 1.0 | -1 | 1 |
| Navigation choices are ordered in the most logical or task-oriented manner | -0.4 | 0.8 | -1 | 1 |
| Navigation tabs are located at the top of the page, and look like clickable versions of real-world tabs | -0.4 | 0.8 | -1 | 1 |
| Category labels accurately describe the information in the category | 0.3 | 0.8 | -1 | 1 |
| The terms used for navigation items and hypertext links are unambiguous and jargon-free | 0.1 | 0.9 | -1 | 1 |
| Hypertext links that invoke actions (e.g downloads, new windows) are clearly distinguished from hypertext links that load another page | 0.2 | 0.9 | -1 | 1 |
| The number of screens required per task has been minimized (2-5 clicks) | 0.5 | 0.8 | -1 | 1 |
| Users of the site do not need to remember information from place to place | -0.4 | 1.0 | -1 | 1 |
| There is a clear distinction between “required” and “optional” fields on forms | 0.1 | 0.7 | -1 | 1 |

*Page Layout & Visual Design*

The Page Layout & Visual Design dimension reveals key areas for improvement in municipal websites. The lowest score (-0.8) for layout effectiveness in guiding users highlights a significant design issue. Negative scores for avoiding excessive text and multimedia (-0.5) and for the use of attention-attracting features (-0.3) suggest that many websites overwhelm users with unnecessary elements. On the positive side, consistent font usage and good balance between information density and white space (both 0.1) are handled adequately, and color is effectively used to structure content (0.3). However, mixed feedback on visual appeal (-0.1) and confusion with graphics (-0.1) indicates a need for a more cohesive and intuitive design.

While there are strengths in specific areas like font usage and color application, the overall layout and visual design require significant improvements to ensure a more user-friendly and visually appealing experience.

**TABLE 11**
**DESRIPTIVE STATISTICS. MEAN AND STANDARD DEVIATION (SD) FOR EACH STATEMENT IN THE PAGE LAYOUT & VISUAL DESIGN DIMENSION**

| | Mean | SD | Min | Max |
|---|---|---|---|---|
| Excessive use of text, scripts, applets, movies, audio files, graphics and images has been avoided | -0.5 | 0.7 | -1 | 1 |
| The layout helps focus attention on what to do next | -0.8 | 0.4 | -1 | 1 |
| Things that are clickable (like buttons) are obviously pressable and do not have characteristics that suggest that they aren't | -0.2 | 0.6 | -1 | 1 |
| Fonts are used consistently and are readable (size, colors) | 0.1 | 1.0 | -1 | 1 |
| There is a good balance between information density and use of white space | 0.1 | 0.7 | -1 | 1 |
| The site avoids extensive use of upper case text | 0.8 | 0.4 | -1 | 1 |
| Graphics will not be confused with banner ads | -0.1 | 0.7 | -1 | 1 |
| Colour is used to structure and group items on the page | 0.3 | 0.8 | -1 | 1 |
| Attention-attracting features (such as animation, bold colours and size differentials) are used sparingly and only where relevant | -0.3 | 0.7 | -1 | 1 |
| The site is pleasant to look at | -0.1 | 0.7 | -1 | 1 |

*Missing Features*

The Missing Features dimension highlights several critical gaps in municipal website functionality. The lowest score (-0.8) for feedback mechanisms indicates that users struggle to report issues or provide suggestions. Other key deficiencies include the lack of accessible help sections, multilingual support, and updated calendars (all scoring -0.6), which are vital for user engagement. However, strengths were noted in the availability of contact information (0.7), functional social media links (0.6), and up-to-date downloadable resources (0.4). Despite these positives, the negative scores for the search bar functionality (-0.3) and form operations (-0.1) suggest inconsistent user experiences. While some aspects are well-handled, significant improvements are needed in feedback mechanisms, multilingual support, and other essential features to enhance usability and functionality.

**TABLE 12**
**DESCRIPTIVE STATISTICS. MEAN AND STANDARD DEVIATION (SD) FOR EACH STATEMENT IN THE MISSING FEATURES DIMENSION**

| | Mean | SD | Min | Max |
|---|---|---|---|---|
| The website includes a functional search bar that provides relevant results. | -0.3 | 0.7 | -1 | 1 |
| The site provides essential contact information (email, phone, address) that is easily accessible and up-to-date. | 0.7 | 0.7 | -1 | 1 |
| The site offers a clear and functional feedback mechanism for users to report issues or provide suggestions. | -0.8 | 0.4 | -1 | 1 |
| All forms and submission processes (e.g., contact forms) are operational and user-friendly. | -0.1 | 0.7 | -1 | 1 |
| The site offers accessible help or FAQ sections to assist users with common issues. | -0.6 | 0.5 | -1 | 1 |
| The site ensures all forms of processes (e.g., accessing PDFs, financial info etc.) are operational and user-friendly. | 0.1 | 0.9 | -1 | 1 |
| The site supports multiple languages, allowing users to switch between different languages seamlessly. | -0.6 | 0.7 | -1 | 1 |
| The site includes social media links that are functional, allowing users to connect with the website on various platforms. | 0.6 | 0.7 | -1 | 1 |
| The site offers downloadable resources (e.g., PDFs, documents) that are up-to-date and relevant. | 0.4 | 0.8 | -1 | 1 |
| The site includes a calendar or event scheduling feature that is relevant to citizens regularly updated and easily accessible. | -0.6 | 0.7 | -1 | 1 |

**Technical Performance**

The Technical Performance dimension reveals both strengths and areas for improvement in municipal websites. As Table 13 shows, the highest score (1.0) indicates that sites effectively avoid horizontal scrolling, and proper line spacing (0.6) enhances usability. However, significant issues include the lack of customized 404 error pages (-1.0), which frustrates users, and insufficient warnings for slow-loading pages and delays (both -0.7). Other negative aspects are inadequate progress indicators and user confirmations (both -0.2), indicating a need for better user support. While some areas like immediate feedback (0.2) and page loading times (0.2) are handled reasonably well, overall, there is a clear need for better error handling and feedback mechanisms to improve the technical performance and user experience.

**TABLE 13**
**DESCRIPTIVE STATISTICS. MEAN AND STANDARD DEVIATION (SD) FOR EACH STATEMENT IN THE TECHNICAL PERFORMANCE DIMENSION**

| | Mean | SD | Min | Max |
|---|---|---|---|---|
| The user is warned about large, slow-loading pages (e.g. "Please wait…"), and the most important information appears first | -0.7 | 0.9 | -1 | 1 |
| The site can be used without scrolling horizontally (design errors & bugs) | 1.0 | 1.0 | -1 | 1 |
| The site uses a customised 404 page, which includes tips on how to find the missing page and links to "Home" and Search | -1.0 | 0.8 | -1 | 1 |
| Pages load quickly (5 seconds or less) | 0.2 | 0.8 | -1 | 1 |
| The site provides immediate feedback on user input or actions | 0.2 | 0.8 | -1 | 1 |
| The site keeps users informed about unavoidable delays in the site's response time (e.g. when opening a heavy file, i.e. municipality's financial statements) | -0.7 | 0.9 | -1 | 1 |
| The site provides good feedback (e.g. progress indicators or messages) when needed | -0.2 | 0.9 | -1 | 1 |
| User confirmation is required before carrying out potentially "dangerous" actions (e.g. deleting something) | -0.2 | 0.8 | -1 | 1 |
| The site provides good system feedback (e.g. success/error messages) | 0.1 | 1.0 | -1 | 1 |
| There is a line space of at least 2 pixels between clickable items and the Fitt's Law is ensured | 0.6 | 0.7 | -1 | 1 |

*Trust & Credibility*

The Trust & Credibility dimension reveals mixed results for municipal websites. The highest score (0.8) indicates strong attention to content quality, with few typographic errors or spelling mistakes. The avoidance of pop-up ads (0.4) and the presence of trustworthy individuals behind the sites (0.4) also positively impact credibility. However, the lowest score (-0.6) for preventing user errors suggests that many websites fail to support users effectively, reducing trust. Issues with visual design alignment and handling duplicate search results (both -0.2) further highlight improvement areas. While some aspects, like clear governmental backing (0.2) and content freshness (0.3), are generally positive, they vary across sites. Contacting someone for assistance scored neutrally (0), indicating inconsistency. Overall, while content quality and ad management are strengths, improvements in user error prevention, design consistency, and search functionality are needed to enhance trust and credibility.

**TABLE 14**
**DESCRIPTIVE STATISTICS. MEAN AND STANDARD DEVIATION (SD) FOR EACH STATEMENT IN THE TRUST & CREDIBILITY DIMENSION**

| | Mean | SD | Min | Max |
|---|---|---|---|---|
| The content is up-to-date, authoritative and trustworthy | 0.2 | 0.9 | -1 | 1 |
| It is clear that there is a real governmental organisation behind the site (e.g. there is a physical address or a photo of the office) | 0.2 | 0.6 | -1 | 1 |
| The site avoids advertisements, especially pop-ups. | 0.4 | 0.8 | -1 | 1 |
| It is easy to contact someone for assistance and a reply is received quickly | 0 | 0.8 | -1 | 1 |
| The content is fresh: it is updated frequently and the site includes recent content | 0.3 | 0.8 | -1 | 1 |
| The site is free of typographic errors and spelling mistakes | 0.8 | 0.4 | -1 | 1 |
| The visual design complements the status of the municipality and any offline communication messages | -0.2 | 0.6 | -1 | 1 |
| There are real people behind the organisation and they are honest and trustworthy (look for bios) | 0.4 | 0.8 | -1 | 1 |
| The search results page does not show duplicate results (either perceived duplicates or actual duplicates) | -0.2 | 0.8 | -1 | 1 |
| The site does a good job of preventing the user from making errors | -0.6 | 0.5 | -1 | 1 |

*Municipalities' Usability Distribution*

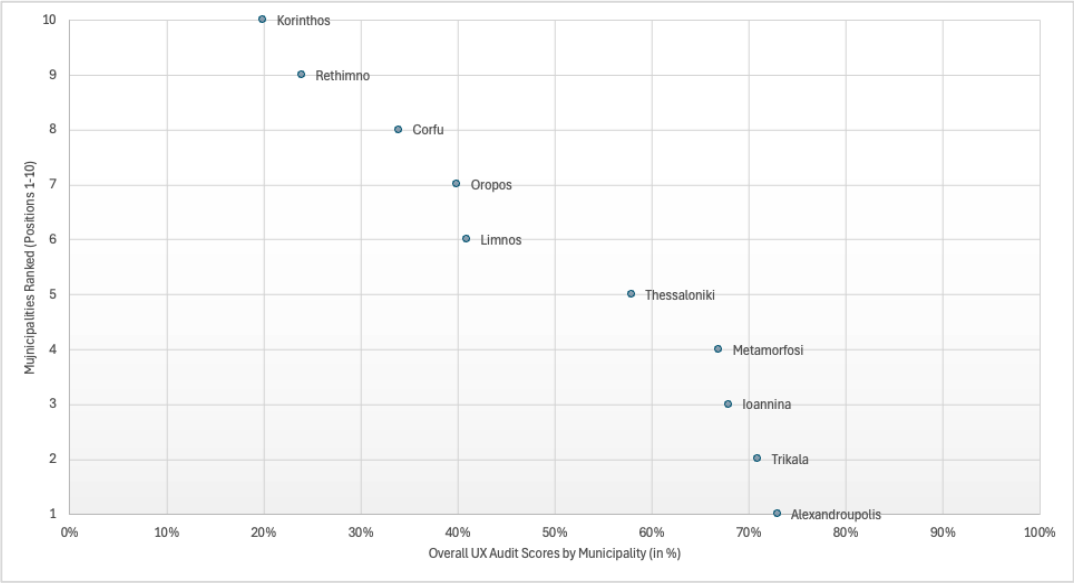
Table 15 presents the overall scores (%) achieved by each municipality in the Adapted UX Audit, along with the Grand Average scores (%) for each dimension of the assessment. Figure 4 shows the overall UX audit scores distribution across the municipalities under investigation. The results indicate that Alexandroupolis (73%) and Trikala (71%) are the top performers, followed by Ioannina (68%), Metamorfosi (67%), and Thessaloniki (58%). On the other end, Limnos (41%), Oropos (40%), Corfu (34%), Rethimno (24%), and Korinthos (20%) show the lowest scores, underperforming across all dimensions.

Specifically, Alexandroupolis leads with a 73% overall score, excelling in Page Layout & Visual Design (85%) and Technical Performance (75%), indicating a well-rounded UX. Trikala follows with 71%, performing exceptionally in Navigation & Task Orientation (95%) and Trust & Credibility (85%), though it is held back by low Technical Performance (25%). Ioannina (68%) and Metamorfosi (67%) demonstrate balanced but unremarkable performance, with Ioannina being strong in Navigation & Trust but weaker in Technical Performance (40%). Thessaloniki (58%) shows moderate, consistent scores across all dimensions. Limnos (41%), Oropos (40%), Corfu (34%), and Rethimno (24%) struggle, particularly in Page Layout & Visual Design and Missing Features, contributing to their low UX scores. Korinthos ranks the lowest at 20%, underperforming across all dimensions.

**TABLE 15**
**OVERALL SCORES (%) ACHIEVED BY EACH MUNICIPALITY, ALONG WITH THE GRAND AVERAGE SCORES (%) FOR EACH DIMENSION OF THE AAPTED UX AUDIT**

| Municipality | Navigation & Task Orientation | Page Layout &Visual Design | Missing Features | Technical Performance | Trust & Credibility | Overall Score |
|---|---|---|---|---|---|---|
| Alexandroupolis | 75% | 85% | 60% | 75% | 70% | 73% |
| Trikala | 95% | 85% | 65% | 25% | 85% | 71% |
| Ioannina | 85% | 65% | 65% | 40% | 85% | 68% |
| Metamorfosi | 70% | 75% | 60% | 65% | 65% | 67% |
| Thessaloniki | 65% | 45% | 65% | 50% | 65% | 58% |
| Limnos | 50% | 30% | 30% | 50% | 45% | 41% |
| Oropos | 45% | 60% | 30% | 30% | 35% | 40% |
| Corfu | 20% | 45% | 25% | 50% | 30% | 34% |
| Rethimno | 25% | 10% | 20% | 55% | 10% | 24% |
| Korinthos | 15% | 20% | 20% | 20% | 25% | 20% |
| Grand Average (dimension) | 55% | 52% | 44% | 46% | 52% | |

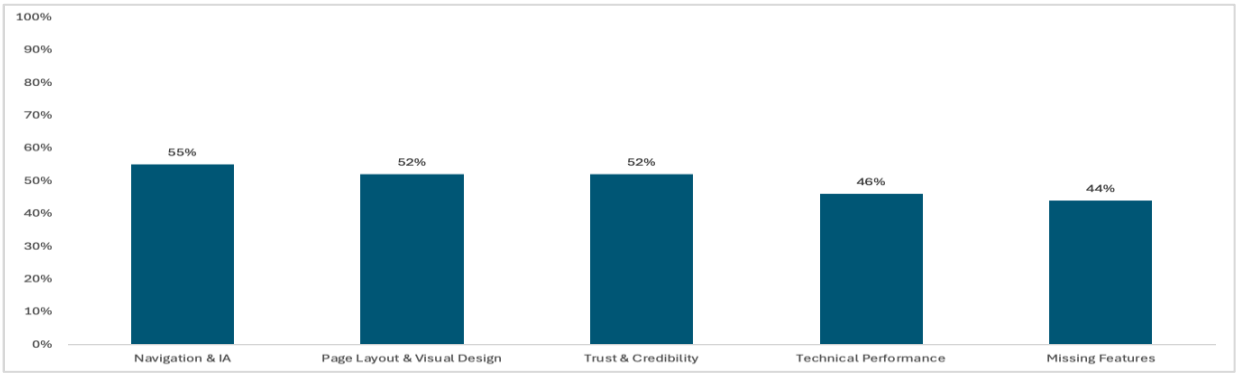
**FIGURE 4**
**DISTRIBUTION OF OVERALL UX AUDIT SCORES ACROSS MUNICIPALITIES UNDER INVESTIGATION**



*Dimension-Specific Results*

Continuing with the dimensions of the Adapted UX Audit Assessment, the Navigation & Task Orientation dimension shows significant variation, with Trikala scoring 95% and Korinthos only 15%. Technical Performance is particularly low, averaging 46%, with Trikala's score of 25% being notably poor. Page Layout & Visual Design also requires improvement, with an average score of 52%. Overall, the highest averages are in Navigation & Task Orientation (55%) and Trust & Credibility (52%), while Missing Features (44%) and Technical Performance (46%) lag behind, highlighting significant gaps in features and reliability (Figure 5).

**FIGURE 5**
**AVERAGE SCORES FOR EACH DIMENSION ACHIEVED BY GREEK MUNICIPALITIES**




## DISCUSSION

Previous assessments by the European Commission (EC, 2021; 2020) have consistently highlighted significant deficiencies in Greece's digitization efforts, with only marginal improvements in digital penetration or citizens' successful adoption of these systems. These reports primarily attribute the challenges to insufficient digital skills among Greek citizens, moderate quality of government digital services, and inadequate broadband infrastructure.

This study aimed to further explore the factors influencing the adoption of governmental digital services, focusing specifically on the user experience (UX) of Greek e-Municipalities. The objective was to build on the EU findings by investigating additional factors beyond digital skills that might limit system adoption. To achieve this, the study employed two key tools: the Lighthouse tool, for assessing technical performance, and the Adapted UX Audit Assessment, which evaluated broader aspects of user experience. This dual approach allowed for a comprehensive examination of digital penetration from both technical and UX perspectives.

The investigation sought to understand how user-centricity and enhancements in user learnability and digital skills could drive greater system acceptance. The study's objectives were to review Greece's digitization performance, identify user acceptance determinants, and pinpoint factors influencing citizen engagement with e-Government services.

### Systems Performance – Lighthouse

The findings from the Lighthouse tool directly correlate with the broader issue of user acceptance in e-Government services. User acceptance is highly dependent on the quality of the user experience (references), which is shaped by various factors, including performance, accessibility, adherence to best practices, and search engine optimization (SEO).

1. **Performance as a Barrier to Acceptance:** The significant performance issues identified, such as slow load times and poor responsiveness, will likely impede user acceptance. Users expect fast and reliable interactions with digital services, and frustration ensues when these

expectations are not met. This frustration can lead to users abandoning the service, thereby reducing overall acceptance and penetration of e-Government services (i.e. Kelly et al., 2023; Bansah, & Darko Agyei, 2022; Wang et al., 2020, Venkatesh et al., 2016; Venkatesh et al., 2012)

2. **Accessibility and Inclusivity:** While the accessibility scores are relatively strong, issues such as poor contrast can alienate users with visual impairments, impacting their ability to engage with the service. Ensuring that all citizens can access these services regardless of their abilities is crucial for broad user acceptance. The medium-level performance in accessibility indicates that there is still work to be done to ensure these portals are truly inclusive (i.e. Chau & Lai, 2003).
3. **Best Practices and User Trust:** The adherence to best practices, particularly in areas like user experience and security, directly impacts user trust and, by extension, user acceptance. When users encounter low-resolution images, browser compatibility issues, or insecure connections, their trust in the service diminishes. A lack of trust can be a significant barrier to acceptance, as users are less likely to engage with or return to a service they perceive as unreliable or unsafe (i.e. Taherdoost, 2018; Al-Omari et al., 2012).
4. **SEO and Discoverability:** Good SEO practices ensure that users easily discover these services, which is the first step in user engagement. The mixed performance in SEO highlights that while some portals are easily found, others may not be as accessible through search engines, limiting their reach and user acceptance (i.e. Schilhan et al., 2021).

In summary, the technical deficiencies identified by the Lighthouse tool—especially in performance and adherence to best practices—pose significant challenges to user acceptance. To foster greater acceptance and penetration of e-Government services, these technical issues must be addressed. Enhancing performance, ensuring robust accessibility, adhering to best practices, and improving SEO will improve the user experience and build the trust and reliability necessary for users to fully embrace and regularly use these digital services.

**System Usability - Adapted UX Audit Assessment**

The Adapted UX Audit Assessment reveals several critical insights into the usability and overall user experience of Greek municipal websites, directly influencing user acceptance.

1. **Navigation & Task Orientation**: The mixed performance in this dimension, with mean scores ranging from -0.4 to 0.5, highlights significant variability in how effectively users can navigate municipal websites. Negative scores for the logical ordering of navigation choices and tab placement indicate that many users might struggle to find their way through these websites. Such issues can lead to frustration, reducing the likelihood of users accepting and regularly using these digital services. The slight positive scores in areas like minimizing screens per task suggest that some municipalities are managing to reduce cognitive load, but these successes are not widespread.
2. **Page Layout & Visual Design**: This dimension showed substantial variability, with scores ranging from -0.8 to 0.8. The lowest scores in layout effectiveness suggest that many websites fail to guide users intuitively, which is a significant barrier to user acceptance. Overwhelming users with excessive text and multimedia content detracts from the user experience, making the websites less appealing and harder to use. Although there are some strengths in consistent font usage and color application, the overall design often lacks cohesion, which is necessary to make the website visually engaging and easy to navigate.
3. **Missing Features**: The most critical gaps identified in this dimension include the lack of feedback mechanisms, accessible help sections, and multilingual support, particularly in regions that consistently host many tourists or refugees, such as Limnos, Corfu, and Rethimno. These deficiencies are significant barriers to user acceptance, as they directly impact the user's ability to interact effectively with the website. Users are likely to become frustrated if they cannot easily find help or provide feedback. The inconsistent availability of key features across

different municipalities suggests that while some websites may handle these aspects well, others fall short, leading to a fragmented user experience across the country.

4. **Technical Performance**: Despite some strengths in this dimension, such as avoiding horizontal scrolling and maintaining proper line spacing, significant issues remain. The lack of customized 404 pages and insufficient warnings for slow-loading pages are major pain points that can lead to user frustration. If users encounter broken links or slow-loading pages without adequate feedback, they are less likely to view the service as reliable, which negatively impacts their overall acceptance (Kingsnorth, 2022).
5. **Trust & Credibility**: This dimension shows that while content quality is generally well-handled, there are areas where trust could be improved. Issues like the failure to prevent user errors and inconsistencies in visual design undermine the credibility of these websites. Trust is a crucial factor in user acceptance; if users do not trust the website to function correctly or to keep their data secure, they are unlikely to use it consistently (i.e. Taherdoost, 2018; Al-Omari et al., 2012).

The findings from the Adapted UX Audit Assessment suggest that while some dimensions of user experience are managed adequately, significant areas need improvement. User acceptance is heavily influenced by the ability of a website to provide a seamless, intuitive, and trustworthy experience. The variability in performance across municipalities indicates that not all Greek municipal websites offer a consistent level of service, which can lead to uneven adoption rates. To increase user acceptance, municipalities need to focus on enhancing navigation, improving visual design, ensuring the availability of critical features, and addressing technical performance issues. These improvements will make the websites more user-friendly and build the trust and reliability necessary for users to fully engage with and accept these digital services.

**Dimension-Specific Insights**

The findings from the evaluation of Greek municipal websites suggest a significant disconnect between the design of these digital platforms and the principles that drive user acceptance. The consistently low scores across all dimensions, with no municipality exceeding 55% in any category, reflect a broader issue with how these websites are structured and maintained. Despite Navigation & Task Orientation emerging as the best-performing dimension, the fact that it only averages 55% highlights a serious deficiency in meeting even the most basic usability standards crucial for user satisfaction and acceptance.

This poor performance in critical dimensions such as Technical Performance and Missing Features, which both scored below 50%, is particularly concerning. These dimensions directly relate to the practical and functional aspects of user interaction with the websites. For users to accept and regularly engage with e-Government services, they need to experience seamless navigation, reliable technical performance, and access to all necessary features, including multilingual support and feedback mechanisms. The absence or poor execution of these elements can significantly hinder user acceptance, as citizens may find these platforms frustrating, unreliable, and ultimately unusable.

Moreover, the lack of accessible help sections and feedback mechanisms—especially in regions like Limnos, Corfu, and Rethimno that host many tourists and refugees—further complicates user engagement. These gaps not only reduce the effectiveness of the websites but also alienate users who may require additional support due to language barriers or unfamiliarity with digital platforms. Without addressing these issues, user acceptance will likely remain low, as citizens will be less inclined to utilize systems that do not adequately meet their needs.

In conclusion, the low performance across all dimensions of the Adapted UX Audit underscores the necessity for a comprehensive overhaul of Greek municipal websites. Improving usability, technical reliability, and the inclusion of critical features is essential for increasing user acceptance. If citizens are to fully embrace e-Government services, these platforms must be designed with their needs and experiences at the forefront. Therefore, addressing these deficiencies should be a priority for policymakers and web developers alike, aiming to create a more user-centric digital government that fosters higher user engagement and satisfaction.

## RECOMMENDATIONS

Taken together, several recommendations for policymakers, government entities, and digital agencies can be concluded to improve the user experience and acceptance of local Greek municipal websites:

1. **Conduct Comprehensive UX Audits:** Regularly perform user experience audits using tools like the Adapted UX Audit and Lighthouse to identify and address usability issues. This should be a continuous process to ensure that municipal websites meet evolving user needs and expectations.
2. **Prioritize Usability Enhancements:** Focus on improving Navigation & Task Orientation, as even this best-performing dimension scored only 55%. Ensure that navigation is intuitive, logical, and designed to minimize user frustration. Clear categorization and easy access to essential information should be prioritized.
3. **Enhance Technical Performance:** Address the critical gaps in technical performance by ensuring faster loading times, reducing errors, and improving system feedback mechanisms. Implement robust testing protocols to catch and fix issues such as slow-loading pages, poor system feedback, and the absence of customized error pages.
4. **Improve Accessibility and Inclusivity:** Develop and enforce guidelines to make municipal websites more accessible, particularly in regions with diverse populations like Limnos, Corfu, and Rethimno. This includes adding multilingual support, accessible help sections, and easy-to-find contact information.
5. **Incorporate Feedback Mechanisms:** Establish effective feedback channels on municipal websites to allow users to report issues, suggest improvements, and receive timely responses. These mechanisms are crucial for ongoing improvement and user satisfaction.
6. **Update and Maintain Content:** Ensure that content on municipal websites is regularly updated, accurate, and free from typographical errors. This is essential for building and maintaining trust with users.
7. **Invest in User-Centric Design:** Collaborate with UX professionals to design websites that prioritize user needs. This includes creating visually appealing layouts that are free from unnecessary distractions, using consistent and readable fonts, and balancing information density with white space.
8. **Train and Educate Municipal Staff:** Provide training for municipal staff on the importance of digital literacy and UX principles. Staff should be equipped to maintain and update websites effectively, ensuring they remain user-friendly and functional.
9. **Engage with Citizens:** Involve citizens in the design and testing phases of municipal website development. This could include user testing sessions, surveys, and focus groups to gather feedback directly from the end-users.
10. **Set Benchmarks and Monitor Progress:** Establish clear benchmarks for website performance across all dimensions of UX, including navigation, technical performance, and accessibility. Regularly monitor progress against these benchmarks and make necessary adjustments to meet or exceed them.
11. **Foster Collaboration Across Municipalities:** Encourage knowledge-sharing and collaboration between municipalities to adopt best practices and learn from each other's successes and challenges in website development and maintenance.
12. **Allocate Sufficient Resources:** Ensure that sufficient budget and resources are allocated to the development and maintenance of municipal websites. Investing in high-quality digital infrastructure is crucial for providing citizens with reliable and effective e-Government services.

By implementing these recommendations, policymakers and digital agencies can significantly improve the user experience of Greek municipal websites, leading to higher user acceptance and greater engagement with e-Government services.

## LIMITATIONS & FUTURE STUDIES

Since this study represents a first step in evaluating the user experience and technical performance of local government websites in Greece, it is important to acknowledge several limitations that may impact the generalizability and comprehensiveness of the findings.

1. **Sample Size and Scope:** The study focused on a limited number of Greek municipal websites, which may not fully represent the broader landscape of e-Government services across the entire country. A more extensive sample could provide a more comprehensive understanding of the user experience in different regions.
2. **Lack of Longitudinal Data:** The study provides a snapshot of the current state of municipal websites but does not track changes or improvements over time. A longitudinal approach could offer insights into how these websites evolve and whether implemented changes lead to better user acceptance.
3. **User-Centric Perspective:** While the study emphasizes user experience, it may not fully capture the perspectives and challenges faced by the municipalities themselves, such as resource constraints, administrative priorities, or technical limitations. A more balanced approach that considers both user and provider perspectives could provide a more holistic view.
4. **Focus on Website Evaluation:** The study primarily evaluates the user experience of municipal websites without considering other digital channels or platforms that municipalities may use to engage with citizens (e.g., mobile apps, social media, or offline services). As a result, the conclusions may overlook important aspects of the overall digital experience the municipalities offer.
5. **Potential Subjectivity in UX Audit:** The Adapted UX Audit Assessment, despite its structured approach, may introduce some subjectivity in evaluating certain dimensions, particularly those related to visual design and user interface elements. Since different evaluators might interpret design quality and usability differently, reliability analyses suggest the need for refining the checklist to improve rater consistency. Future research should consider increasing the number of items or revising the existing ones to enhance the tool's reliability and ensure more robust and accurate evaluations.

## CONCLUSION

This study represents a foundational effort to examine the user experience and digital adoption challenges of local e-government services in Greece, focusing on municipal websites. The findings reveal significant shortcomings across all dimensions of user experience, particularly in Technical Performance and Missing Features, which are critical to fostering user acceptance and engagement. Despite some strengths in areas like Navigation & Task Orientation, the overall low scores indicate that fundamental usability principles are not adequately applied. To bridge these gaps and foster e-democracy, there is a clear need for a comprehensive redesign of these digital platforms, ensuring they meet the diverse needs of citizens. Future research should explore these issues across all Greek municipalities to provide a more detailed understanding of the broader landscape and to guide the development of more user-centric e-government services. Addressing these issues will be vital for achieving greater digital penetration, enhancing citizen engagement, and supporting the democratic process in the digital age.

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