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تقييم إمكانية الوصول الرقمي للمواقع الإلكترونية السودانية: تقييم متعدد الأدوات عبر القطاعات الحكومية والأكاديمية والخدمية

Digital Accessibility Assessment of Sudanese Websites: A Multi-Tool Evaluation Across Governmental, Academic, and Service Sectors

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الملخص:

على الرغم من التقدم العالمي في مجال إمكانية الوصول الرقمي، لا يزال مدى امتثال مواقع الويب في الدول النامية لمعايير إمكانية الوصول الدولية غير مدروس بشكل كافٍ. تقدم هذه الدراسة تقييمًا استكشافيًا أساسيًا لإمكانية الوصول الرقمي عبر سبعة مواقع سودانية مؤثرة تمثل القطاعات الأكاديمية والحكومية والخدمية. يستخدم التقييم منهجية التثليث متعددة الأدوات، بالاعتماد على WAVE وDevTools axe وLighthouse، لتقييم الامتثال لإرشادات WCAG 2.1 AA. تكشف النتائج عن تباين كبير في أداء إمكانية الوصول، حيث تتراوح درجات Lighthouse بين 76 و88. ومع ذلك، يكشف التدقيق المعمق عن عوائق جوهرية في إمكانية الوصول عبر جميع المواقع، بما في ذلك عدم كفاية تباين الألوان، وغياب النصوص البديلة، وغموض عناوين الروابط، وبنية HTML غير دلالية. والجدير بالذكر أن التباينات بين مخرجات الأدوات تُبرز قصور الاعتماد على طريقة تقييم واحدة، حيث حققت بعض المواقع درجات عالية نسبيًا على الرغم من وجود أوجه قصور هيكلية كبيرة. تُرسّخ هذه النتائج أول قاعدة بيانات تجريبية لإمكانية الوصول الرقمي في السودان، وتُبيّن أن العوائق الرئيسية لا تكمن في القيود التقنية، بل في نقص الوعي المؤسسي وضعف التنفيذ. وتختتم الدراسة بتوصيات مُحددة للسياسات والحوكمة المؤسسية وممارسات المطورين بما يتماشى مع معايير WCAG 2.1 AA.

الكلمات المفتاحية: إمكانية الوصول الرقمي، WCAG 2.1، إمكانية الوصول إلى الويب، السودان، التقنيات المساعدة، قارئات الشاشة، التقييم الآلي، WAVE، أدوات مطوري axe، Lighthouse، محتوى الويب العربي.

Abstract

Despite global progress in digital accessibility, the extent to which websites in developing countries comply with international accessibility standards remains largely underexplored. This study presents an exploratory baseline assessment of digital accessibility across seven high-impact Sudanese websites representing academic, governmental, and service sectors. The evaluation employs a multi-tool triangulation approach using WAVE, axe DevTools, and Lighthouse to assess compliance with WCAG 2.1 AA guidelines. The results reveal substantial variability in accessibility performance, with Lighthouse scores ranging from 76 to 88. However, deeper inspection uncovers critical accessibility barriers across all sites, including insufficient color contrast, missing alternative text, ambiguous link labels, and non-semantic HTML structures. Notably, discrepancies between tool outputs highlight the limitations of relying on a single evaluation method,

as some sites achieved relatively high scores despite significant structural deficiencies. The findings establish the first empirical baseline for digital accessibility in Sudan and demonstrate that the primary barriers are not technical limitations but rather institutional awareness and implementation gaps. The study concludes with targeted recommendations for policy, institutional governance, and developer practices aligned with WCAG 2.1 AA.
Keywords: Digital Accessibility, WCAG 2.1, Web Accessibility, Sudan, Assistive Technologies, Screen Readers, Automated Evaluation, WAVE, axe DevTools, Lighthouse, Arabic Web Content.

1. Introduction

Digital accessibility refers to the design and development of web content and digital services in a manner that ensures usability for individuals with disabilities, including those with visual impairments who rely on assistive technologies such as screen readers. As digital services become central to education, governance, and communication, accessibility is no longer a technical enhancement but a fundamental requirement for digital inclusion.

Internationally, accessibility is recognized as a human right, as reflected in the United Nations Convention on the Rights of Persons with Disabilities (CRPD), ratified by Sudan in 2008. Despite this commitment, the accessibility of digital platforms in Sudan remains largely underexplored, with no systematic empirical studies assessing compliance with established standards such as WCAG 2.1.

While high-income countries have advanced through legislative frameworks and enforcement mechanisms, developing contexts continue to face challenges related to limited awareness, lack of enforcement, and constrained resources. In Sudan, ongoing digital transformation initiatives have not been accompanied by formal accessibility assessments or policy frameworks.

To address this gap, this study conducts an exploratory baseline evaluation of selected Sudanese websites across three critical sectors: higher education, government, and telecommunications. These sectors were chosen due to their essential role in delivering services that directly affect citizens' daily lives.

A multi-tool evaluation strategy is employed using WAVE, axe DevTools, and Lighthouse to ensure methodological robustness and reduce tool-specific bias. The analysis focuses on homepage accessibility, recognizing it as the primary entry point and a critical barrier for users relying on assistive technologies.

The study is guided by the following research questions:

1. To what extent do selected Sudanese websites comply with WCAG 2.1 AA standards?

2. What are the most prevalent accessibility barriers across sectors?

3. How do accessibility outcomes differ between public and private institutions?

To the best of our knowledge, this study provides the first empirical baseline of web accessibility in Sudan using a multi-tool approach within an Arabic-language context.

2. Related Work

2.1 Global Studies

Previous research has demonstrated persistent accessibility challenges even in technologically advanced contexts. Lazar et al. (2019) found that a significant proportion of U.S. government websites remained non-compliant with accessibility standards despite legal mandates. Similarly, Brajnik and Vigo (2018) emphasized that no single evaluation tool can comprehensively detect accessibility issues, advocating for multi-tool approaches.

2.2 Regional Studies in the Arab World

Studies in the Arab region have reported low compliance levels with accessibility standards. For instance, evaluations of Saudi and Jordanian websites revealed widespread issues such as missing alternative text and poor structural organization. Additionally, research focusing on Arabic web content highlights unique challenges related to right-to-left text handling and improper language tagging, which significantly affect screen reader performance.

2.3 African Context

Research conducted in African countries such as Nigeria, Kenya, and South Africa identifies systemic barriers, including lack of awareness, absence of enforcement, and limited technical capacity. These studies consistently indicate that accessibility challenges are often institutional rather than purely technical.

2.4 Research Gap

Despite growing global and regional interest, no prior study has systematically evaluated web accessibility in the Sudanese context. Furthermore, most existing studies focus solely on diagnostic evaluation without proposing actionable insights.

Unlike prior work, this study combines a multi-tool evaluation framework with a focus on Arabic-language web environments to establish a Sudan-specific accessibility baseline.

3. Methodology

3.1 Study Design

This study adopts a descriptive-analytical approach combining quantitative metrics and qualitative interpretation of accessibility issues. The evaluation is conducted using automated tools to ensure reproducibility and scalability.

3.2 Sample Selection

A purposive sample of seven high-impact websites was selected to represent key service sectors:

- Academic: University of Khartoum, Sudan University of Science and Technology, Nile Valley University
- Government: Ministry of Telecommunications, Ministry of Culture

• Telecommunications: Sudani, Zain Sudan

The selection criteria include functional importance, user interaction frequency, and sector diversity.

3.3 Evaluation Tools

Three widely used accessibility evaluation tools were employed:

• **WAVE**: Provides visual and structural analysis, including error detection and contrast evaluation

• **axe DevTools**: Identifies WCAG violations categorized by severity

• **Lighthouse**: Generates a quantitative accessibility score based on automated audits

The use of multiple tools ensures comprehensive coverage and aligns with best practices in accessibility evaluation.

3.4 Scope and Justification

The analysis focuses on homepage accessibility for the following reasons:

• It represents the primary entry point for users

• Failure at this level prevents further navigation, especially for screen reader users

• It provides a consistent basis for cross-site comparison

3.5 Limitations

• Evaluation limited to homepage only

• Reliance on automated tools without manual validation

• No user testing with assistive technology users

• No mobile accessibility assessment

4. Results

4.1 Overview

The evaluation results indicate substantial variation across websites, with Lighthouse scores ranging from 76 to 88. However, quantitative scores do not fully reflect underlying accessibility issues.

4.2 Key Findings

The analysis revealed several recurring accessibility barriers:

1. **Insufficient Color Contrast (WCAG 1.4.3)**
   Observed across all evaluated websites, affecting readability for low-vision users.

2. **Missing Alternative Text (WCAG 1.1.1)**
   Images without descriptive text prevent screen reader interpretation.

3. **Ambiguous Link Labels (WCAG 2.4.4)**
   Generic labels such as “Read more” hinder navigation for assistive technology users.

4. **Non-Semantic HTML Structures**
   Lack of proper heading hierarchy disrupts logical content navigation.

5. **Keyboard Inaccessibility (WCAG 2.1.1)**
   Interactive elements that require mouse input limit accessibility.

4.3 Tool Discrepancies

Significant discrepancies were observed between tool outputs. For example, some websites achieved relatively high Lighthouse scores despite exhibiting numerous structural issues in WAVE analysis. This highlights the limitations of relying solely on aggregate scoring systems.

5. Discussion

The findings indicate that accessibility challenges in Sudanese websites are widespread and consistent with trends observed in other developing regions. However, the underlying causes appear to be primarily institutional rather than technical.

Academic institutions demonstrated relatively better performance, which may be attributed to greater exposure to international standards and access to technical expertise. In contrast, government and telecommunications websites exhibited structural deficiencies despite providing essential services.

The observed discrepancies between evaluation tools reinforce the importance of multi-tool assessment strategies. While Lighthouse provides a useful quantitative indicator, it may overlook critical issues that affect real user experience.

Furthermore, the prevalence of common issues such as missing alternative text and poor contrast suggests a lack of awareness of basic accessibility practices rather than complex technical barriers.

6. Recommendations

6.1 Policy Level

- Adoption of WCAG 2.1 AA as a national standard
- Integration of accessibility requirements into digital transformation strategies

6.2 Institutional Level

- Establishment of accessibility roles within organizations
- Regular accessibility audits and compliance monitoring

6.3 Technical Level

- Training developers on semantic HTML and ARIA roles
- Use of accessibility testing tools during development
- Implementation of contrast validation and content labeling practices

7. Threats to Validity

Internal Validity

Reliance on automated tools may not capture all usability-related issues.

External Validity

The limited sample size may not represent the entire Sudanese web ecosystem.

Construct Validity

Differences in tool evaluation criteria may lead to inconsistent results.

Tool Limitations

Automated tools detect only a subset of WCAG violations, requiring complementary evaluation methods.

8. Conclusion

This study provides the first empirical assessment of web accessibility in Sudan using a multi-tool evaluation framework. The findings reveal that accessibility barriers are widespread across critical service sectors, with common issues affecting usability for visually impaired users.

The results demonstrate that the primary challenges are not technical limitations but rather gaps in awareness, policy, and implementation. Addressing these challenges requires coordinated efforts at policy, institutional, and technical levels.

Future work should extend the analysis to internal pages, incorporate user testing with assistive technologies, and explore mobile accessibility to provide a more comprehensive assessment.

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