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# DETERMINATION OF MALAYSIAN GOVERNMENT WEBSITE EVALUATION METRICS BASED ON THE ANALYTICAL HIERARCHY PROCESS

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**Abstract:**

Telecommunications technology is constantly changing with more modern hardware, software and even networks, making it viable. Along with the sophistication, the government uses websites known as electronic government (E-Government) to deliver critical information, thus forcing the government to consider good website performance, compliance with the latest standards, user-friendly services, and digital services devices. In setting website evaluation criteria, the government lacks emphasis on the study of website evaluation metrics that can extend to website technology 5.0 and beyond. The website quality concept, consisting of various metrics and criteria, makes it difficult for stakeholders to analyse and set their priorities and importance in implementing web-based services. This study was carried out to develop the priority index of the metrics and criteria through the Analytical Hierarchy Process (AHP) method and confirm the priority of metrics and criteria based on comparing alternative positions obtained with the UN EGDI report for 2020 as a benchmark. The results of this study successfully classified five metrics out of 10 main metrics and 17 criteria out of 89 criteria metrics. The five main metrics for evaluating Government agency websites and their priorities identified in this study are Security, Performance, Content Structure, Technology and Accessibility. The discovery of these metrics and criteria gives exposure to all stakeholders in the website development process and its evaluation.

**Keywords:**

Web Performance, Web Critical Metrics, Web Quality, Web Search Engines, Analytical Hierarchy Process

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## Introduction

The government issued two circular documents related to the management of public sector websites. The first circular is General Circular No. 1 of 2006, entitled Public Sector Website/Portal Management. While, the second circular is the Public Administration Progress Circular No. 2 of 2015, titled Public Sector Agency Website Management, which outlines some of the main components that need to be emphasised, including design, functionality, and page content. Each component outlined in the circular has certain criteria that each Government agency must follow in providing a website, including online services.

In accordance with the guidelines issued by Malaysia Digital Economy Corporation Sdn. Bhd (MDEC, formerly known as Multimedia Development Corporation), several mechanisms for monitoring the government's website and online services are produced as follows:
a. Malaysia Government Portals and Websites Assessment (MGPWA) was introduced in 2005
b. Provider-Based Evaluation (ProBE) was introduced in 2014 to replace MGPWA.
c. Malaysian User Satisfaction Evaluation (MUSE) was introduced in 2015 and implemented with ProBE until 2017.

Government agencies also lack emphasis on the use of mechanisms to measure compliance with best practice values in developing online services in line with current technological advances. In providing services digitally, some functions or digital features need to be paid attention to (Shaheen et al. 2012). In setting the evaluation criteria for Government agency websites, the government lacks emphasis on the study of metrics or website evaluation criteria that can drive to website technology 3.0, 4.0, and so on. The assessment of government websites today is still based on provider-based content or, in other words, only revolves around providing functions and content to users.

The concept of website quality consists of various factors that need to be emphasised, such as service quality perspective, user perspective, content perspective or usability perspective (Ismail et al. 2021). Therefore, the diversity of factors, metrics, perspectives and criteria make it difficult for stakeholders to analyse and set their priorities and importance towards implementing web-based Government services. This prompts efforts to establish priorities for factors or criteria for realising a high-quality, high-tech website.

The government has done very little research on problems involving decision-making based on multiple criteria (MCDM). The government does many priority index studies on website evaluation criteria in prioritising the improvement of public sector agency websites, which results in the workload of web admins or website developers not being managed. Several research questions were put forward to determine the objectives of the study to be achieved, namely (1) What are the metrics for evaluating Government agency websites? (2) What is the classification of criteria for each evaluation metric of Government agency websites? (3) What is the weight or priority index for each metric and evaluation criteria of the Government agency website? (4) How to determine the priority index produced coincides with the landscape of globally ranked website evaluation?

The objective of the study is to (1) identify metrics and evaluation criteria for Government agency websites; (2) classify metrics and evaluation criteria of government agency websites; (3) determine priority metrics and evaluation criteria for government agency websites using

Journal of Information System and Technology Management
EISSN: 0128-1666
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the AHP approach; and (4) confirm the priority of metrics and criteria based on the comparison of alternative positions obtained with the UNEGDI report for the year 2020 as a benchmark.

## Literature Review

The literature review describes some important aspects such as the International Organization for Standardization (ISO) in the aspect of website quality and performance evaluation; evaluation metrics through several online website evaluation tools; the website evaluation mechanism developed by the Malaysian government, including the evaluation of the E-Government Development Index evaluated by the UN; and an introduction to the AHP method used in assigning weights to crucial metrics and website evaluation criteria.

Various E-government service delivery platforms are being used to foster efficiency in government operations and create good governance. This is through promoting transparency and accountability, reducing corruption, revamping service delivery, improving civil servant performance, empowering citizens and promoting the efficient use of government funds (Almunawar Mohammad Nabil 2015).

The ISO 9126-1 software quality model identifies six key quality characteristics: Functionality, Trustworthiness, Applicability, Efficiency, Maintainability, and Mobile (portability). At least 20 criteria can be considered from this ISO for website evaluation. Although ISO 9126-1 was abolished and replaced by ISO 25010, most of the basis for subsequent ISOs is from this ISO (Devi & Sharma 2016). The product quality model defined in ISO/International Electrotechnical Commission (IEC) 25010 consists of eight quality characteristics: functional suitability, functional efficiency, compatibility, usability, reliability, safety, maintainability and portability. At least 31 criteria can be considered from this ISO for website evaluation (Bäcklund & Hedén 2018; Abduljalil et al. 2019).

According to the definition of the ISO 9241-151 Guide on World Wide Web User Interfaces, one of the sub-standards provides guidelines for user-centred websites that aim to make the interface user-friendly by improving its usability. Five main issues are highlighted in the guidelines: high-level design decisions and design strategies, conceptual content models, content objects and functionality, navigation and search, and content presentation (Çağıltay et al. 2013).

Lighthouse measures six (6) performance metrics often used by the Google search engine and several website evaluation tools such as Dareboost, Gtmetrix and others. The six metrics are Largest Contentful Paint (LCP), First Input Delay (FID), Cumulative Layout Shift (CLS), First Contentful Paint (FCP), Speed Index (SI), and Time to Interactive (TTI). At least 15 online website evaluation tools were explored, and their metrics and criteria information was extracted. The information can be summarised in Table 1.

Journal of Information System and Technology Management
EISSN: 0128-1666
Volume 8 Issue 32 (September 2023) PP. 69-81
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**Table 1: Online Website Evaluation Summary**

| No. | Website Evaluation Tools | No. Metric | No. Criteria | References (if applicable) |
|---|---|---|---|---|
| 1. | Dareboost | 3 | 19 | (Shenoy & Prabhu 2016) |
| 2. | Geekflare | 3 | 25 | (Król & Zdonek 2020) |
| 3. | GTmetrix | 2 | 17 | (Mohammad et al. 2020; Nor Azman et al. 2021; Król Karol 2018) |
| 4. | Nibbler | 4 | 24 | (Bilal et al. 2019; Anon. t.th-a. About Nibbler) |
| 5. | Google PageSpeed Insights (GPI) | 1 | 21 | (Krstić 2021; Anon t.th. About PageSpeed Insights) |
| 6. | Pingdom | 1 | 11 | - |
| 7. | Web.dev | 4 | 20 | - |
| 8. | Grader website | 4 | 15 | (Suliman 2020; Al-Sakran & Alsudairi 2021) |
| 9. | WooRank | 11 | 46 | (Shenoy & Prabhu 2016) |
| 10. | Yellow Lab Tools | 10 | 50 | - |
| 11. | SEOchecker | 8 | 10 | - |
| 12. | SEOreviewtools | 6 | 2 | (Anon. t.th-b. SEO Review Tools) |
| 13. | PWA by Web.dev | 4 | 17 | (Anon. t.th-c. Progressive Web Apps) |
| 14. | PWABuilder | 3 | 24 | (Anon. t.th-d. PWABuilder Suite Documentation) |
| 15. | Google AMP | 5 | - | - |

At least six (6) previous studies were explored, and metric information and criteria were extracted. The information can be summarised in Table 2.

**Table 2: Summary of Previous Studies**

| No | Name of Author / Model | No. Metric | No. Criteria | Reference |
|---|---|---|---|---|
| 1. | Semerádová & Weinlich (2020) | 10 | - | (Loiacono et. al. 2002; Semerádová & Weinlich 2020) |
| 2. | Loiacono et al. (2002) | 12 | - | (Loiacono et al. 2002) |
| 3. | SERVQUAL | 5 | - | (Semerádová & Weinlich 2020) |
| 4. | Singh et al. (2016) | 7 | 14 | (Singh et al. 2016) |
| 5. | SITEQUAL | 4 | - | (Olaley et al. 2018) |
| 6. | Polillo (2011) | 11 | - | (Polillo 2011) |

In an effort to upgrade the quality of the government's website towards web technology 5.0 and beyond, there are many factors or website evaluation metrics that website providers should emphasise, such as service quality perspective, user perspective, content perspective or usability perspective (Ismail et al. 2021). The features extracted from Web 3.0 to Web 5.0 technology are in Table 3.

Journal of Information System and Technology Management
EISSN: 0128-1666
Volume 8 Issue 32 (September 2023) PP. 69-81
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**Table 3: Summary of Web 3.0, Web 4.0 & Web 5.0 Features**

| No. | Web 3.0 | Web 4.0 | Web 5.0 |
|---|---|---|---|
| 1. | The semantic web | The symbiotic web | Emotional intelligence |
| 2. | 3D web | Always alive | |
| 3. | Social web | Web OS | |
| 4. | Smart web | Self-learning system | |
| 5. | Media centric | Communicate like a human | |
| | | Open, connected and intelligent | |
| | | Fast and reliable | |

The Analytic Hierarchy Process (AHP) is a method for organising and analysing complex decisions using mathematics and psychology. Thomas L. Saaty developed it in the 1970s, and it has been refined since then. It contains three parts: the main goal or problem that is trying to be solved, all possible solutions, called alternatives, and the criteria to evaluate those alternatives (Waris et al. 2019). It stands out from other decision-making techniques because it measures criteria and choices that are traditionally difficult to quantify with numbers (Adepoju et al. 2020). AHP defines a pairwise comparison to determine preference using a matrix to compare pairwise variables of the same level. The inconsistency index should not exceed 10% (Helingo et al. 2017; Asadabadi et al. 2019).

The AHP method has always gained a place among decision-makers, where research projects related to AHP increased from 8.84% to 10.51% every year (Ossadnik et al. 2015). The AHP method is not limited to the ICT field but is also used in the construction industry (Uğura & Baykan 2016; Waris et al. 2019), the automotive industry (Iriadi & Yohana 2016), procurement, the environment (Waris et al. 2019), human resources (Mu & Pereyra-Roja 2017), security awareness (Normandia et al. 2018).

## Research Methodology

The research methodology consists of three phases. The first phase (Phase 1) is the information gathering and identifying metrics and criteria. The second phase (Phase 2) is classifying metrics and evaluation criteria for public sector agency websites. The third phase (Phase 3) is the metric and criteria evaluation phase using the AHP approach.

Phase 1: The collection of information is divided into four things, namely (1) metric information and website evaluation criteria; (2) expert information consisting of the government and industry related to the development and evaluation of websites; (3) alternative information, which is a list of official country websites at the ASEAN level; and (4) information on the level of achievement for certain metrics and criteria against the chosen alternative.

Metric information and criteria are identified through a literature review that includes international standards, website evaluation tools, Government website rating systems, previous studies and current web technology features. The characteristics of high-quality and high-performance websites are extracted and identified as metrics and criteria for public sector agency websites. The selection of metrics and criteria is based on the frequency of their use in previous studies. It has a direct evaluation impact through the use of evaluation tools such as Dareboost, Geekflare, GTmetrix, Nibbler, PageSpeed Insights, Pingdom, Web.dev, Website

Journal of Information System and Technology Management
JISTM
EISSN: 0128-1666
Volume 8 Issue 32 (September 2023) PP. 69-81
DOI: 10.35631/JISTM.832005
Grader, WooRank, Yellow Lab Tools, SEOchecker and SEOreviewtools (Salvio & Palaoag 2020).

Expert information from the Government agency sector is obtained through the authoritative party, namely MAMPU, responsible for monitoring the performance and quality of public sector agency websites. While, a list of experts from industry sectors related to website evaluation and development is obtained through social media surveys. The information obtained is filtered based on several criteria: qualifications must be at least a Bachelor's degree and above, more than five years of experience in web programming or website evaluation, and equivalent qualifications.

Alternative information is a list of official websites for the Association of Southeast Asian Nations (ASEAN) countries selected by categorising the online service index (OSI) in the UN EGDI Report 2020 into three levels: high, medium and low. Based on the 2020 UN EGDI Report, the OSI for the country of Singapore (http://www.gov.sg) is categorised as a leader (highest at the ASEAN level). Malaysia (http://www.malaysia.gov.my) is also categorised as having the highest score, followed by Myanmar (http://www.myanmar.gov.mm), which was categorised as getting an intermediate score (moderate) and Laos (http://www.laogov.gov.la) which was categorised as getting the lowest score. These four (alternative) website lists are ranked third in the AHP process to be compared with the benchmark study results.

Information on the criteria achievement level against the alternatives was obtained using 11 automated website evaluation tools. The evaluation of alternative websites (official websites for the countries of Laos, Malaysia, Myanmar and Singapore) is made through the scanning function or review of each such equipment online for all alternative URLs, which is http://laogov.gov.la. For Laos, http://www.malaysia.gov.my for Malaysia, https://myanmar.gov.mm for Myanmar and http://www.gov.sg for Singapore. The reports generated by the equipment were analysed and used in the study for the AHP pairwise comparison evaluation in the third stage.

Phase 2: The method for classifying metrics and criteria is through mapping and reducing the scope to 11 website evaluation tools consisting of Dareboost, Geekflare, GTmetrix, Nibbler, PageSpeed Insights, Pingdom, Website Grader, WooRank, Yellow Lab Tools, SEOchecker and SEOreviewtools. In addition, the definition of a metric and criteria is analysed and re-mapped to a more appropriate metric based on the language terms used. This is because there are linguistically different metrics and criteria, but the functionality is almost the same. For example, some website evaluation tools often translate SEO into the content structure. The classification is certified by the authorities and experts involved so that the AHP approach can be implemented.

Phase 3: AHP consists of three principles: decomposition, comparative consideration, and preference synthesis. Decomposition relates to the construction of the hierarchical structure of the model to define the problem. The highest level represents the overall objective, the middle level represents metrics and evaluation criteria, and the lowest level represents decision alternatives. Comparative consideration is a pairwise comparison of factors at the same level to measure their comparative contribution to the overall objective. A comparison matrix is developed by comparing pairs of criteria or alternatives. Pairwise comparisons help decision-makers independently assess the contribution of each criterion to the objective. Finally, the

Journal of Information System and Technology Management
JISTM
EISSN: 0128-1666
Volume 8 Issue 32 (September 2023) PP. 69-81
DOI: 10.35631/JISTM.832005

preference synthesis calculates the composite weight for each alternative. The study through the AHP approach can be structured into four steps, which are (1) Develop a hierarchy of goals; (2) Perform pairwise comparisons; (3) Calculate the eigenvalue and consistency index; (4) Synthesise the entire assessment.

Step 1: The overall goal of metrics, criteria and alternatives is arranged in a hierarchical structure and establishes relationships for each element. After decomposing the problem into a hierarchy, each element at each layer is compared pairwise to assess relative priority. Three hierarchical levels were established for the study. The first level is the main metric of the website, the second level is the criteria for each metric, and the third level is the alternative, which is the official website for Laos, Malaysia, Myanmar and Singapore. A scale is needed to represent varying levels of preference. Saaty (2008) set a scale where nine (9) is the upper limit, one (1) is the lower limit, and the unit difference between successive scale values is used. This scale is based on psychological experiments, which show that individuals have difficulty comparing more than five to nine objects at a time.

Step 2: The pairwise comparison matrix was evaluated by authorities and experts using the preference scale for pairwise comparison recommended by Saaty (2008). For example, performance and content structure criteria are compared using the question, "How important is the Performance criteria when compared to the content Structure criteria?" and the answer given by the experts is “Moderate Performance Prefers Content Structure”, instead of numerical value. Then, the corresponding numerical values in the relevant comparison matrix cells are substituted.

Step 3: After pairwise comparisons, calculations are made to produce a weighted set of criteria and a consistency index using SuperDecision software. Saaty (2008) recommends that a consistency index of less than 0.1 is acceptable. If the consistency index is higher than 0.1, the pairwise comparison should be repeated with the experts. Consistency index (CI) was calculated for each matrix, criterion and alternative comparison. To calculate the CI, multiply the preference vector by the original matrix. Then, calculate the row sum of the new matrix, divide each row sum in the column by the corresponding entry from the preference vector, and average the results to obtain the principal eigenvalues.

Step 4: Finally, the AHP value is calculated for each website, and the website with a higher value is chosen to be the best. The AHP value is calculated using the following formula:

$$AHP_i = \sum_{j=1}^{N} \alpha_{ij} w_j, \ for\ i = 1,2,3,\dots,M \qquad \text{Equation (1)}$$

where M is the number of alternatives, and N is the number of criteria; αij denotes the ith alternative score related to the jth criterion; wj denotes the weight of the jth criterion.
After obtaining the eigenvalues for the entire matrix, the weights of each metric, criterion and alternative are produced by the eigenvalue normalisation method at each level. For example, for the metric level (first level), the eigenvalue of the Security metric is divided by the sum of the eigenvalues for the first level. Similar to the criterion stage (second stage) and the alternative stage (third stage), the weighted sum of each stage is worth one.

Apart from determining priorities for metrics and criteria using the AHP approach, Phase 3 is also a phase of testing or comparing with the benchmarks of ASEAN country websites

Journal of Information System and Technology Management
JISTM
EISSN: 0128-1666
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DOI: 10.35631/JISTM.832005

evaluated by the UN EGDI, namely Singapore (highest), Malaysia (highest), Myanmar (middle) and Laos ( lowest). The weighted results obtained for each alternative are ranked according to order; the order produced in this study is compared with the order obtained from the UN EGDI Report.

**Result and Discussion**

Based on the classification and mapping made according to the research methodology, a hierarchy of goals can be developed as in Figure 1. Five metrics, namely Performance, Content Structure, Accessibility, Safety and Technology, are on the first level hierarchy. 17 Criteria: FID, LCP, CLS, Minification, <Meta>, <H>, Freshness, Click target, Open graph, Printability, Active link, valid SSL, CSP, Secure centralisation, AMP, Analytics and PWA are on the second level hierarchy. In contrast, the alternative is the node at the lowest hierarchy: Laos, Malaysia, Myanmar and Singapore. Each node with an arrow line connecting to the same parent node will be evaluated in the same cluster. For example, FID, LCP, CLS, and Minification nodes will be evaluated in the same cluster under the Performance metric.

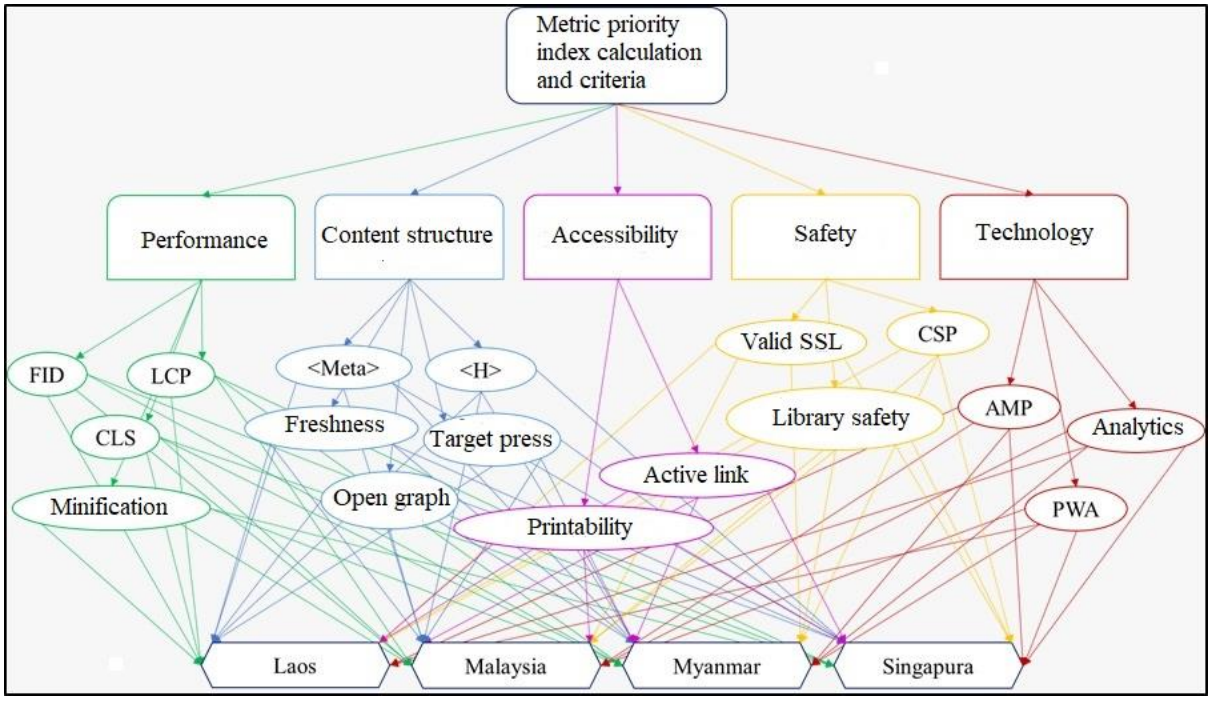


**Figure 1: Hierarchal Structure of Goals**

There are three (3) levels of pairwise comparison. The first stage is a pairwise comparison to evaluate the priority of metrics consisting of Accessibility (A), Safety (S), Performance (P), Content Structure (CK) and Technology (T). The assessment made can be detailed in Table 4.

Journal of Information System and Technology Management
JISTM
EISSN: 0128-1666
Volume 8 Issue 32 (September 2023) PP. 69-81
DOI: 10.35631/JISTM.832005

**Table 4: Evaluation of Key Metrics**

| Key Metrics | Accessibility (A) | Safety (S) | Performance (P) | Content Structure (CS) | Technology (T) |
|---|---|---|---|---|---|
| Accessibility (A) | 1 | 1/9 | 1/8 | 1/7 | 1/6 |
| Safety (S) | 9 | 1 | 4 | 5 | 3 |
| Performance (P) | 8 | 1/4 | 1 | 3 | 3 |
| Content Structure (CS) | 7 | 1/5 | 1/3 | 1 | 2 |
| Technology (T) | 6 | 1/3 | 1/3 | 1/2 | 1 |

The second stage is a pairwise comparison of each criterion under the respective metric. For example, the Accessibility metric has two (2) criteria: Printability and Active Links. The active Link criterion is "Highly preferred" (scale 9) compared to the Printability criterion, and the comparison value is 9. While, the opposite comparison is the reciprocal value of the comparison value of 9, which is 1/9. An example of a pairwise comparison evaluation of the Accessibility metric is in Table 5. This comparison is repeated until all the criteria in the other four (4) complete metrics are compared in pairs.

**Table 5: Criterion Pairwise Comparison Evaluation of Accessibility Metrics**

| Accessibility Metrics | Printability | Active Link |
|---|---|---|
| Printability | 1 | 1/9 |
| Active Link | 9 | 1 |

The third stage of pairwise comparison is to evaluate all alternatives against all 17 criteria that have been classified. Based on the results of the automatic website evaluation tool performed on the alternative websites, the alternative websites are ranked for each criterion. For example, for the Target criteria (Content Structure metric), Myanmar's website is rated "highly preferred" (scale 9) when compared to Laos. Myanmar is also rated "moderately to strongly preferred" (scale 4) compared to Malaysia, and Myanmar is also rated "almost equal to moderately preferred" (scale 2) compared to Singapore. An example of the 3rd-level paired comparison evaluation for the Press Target criteria is as in Table 6.

**Table 6: Pairwise Comparison Evaluation of Target Criteria Against Alternatives**

| Country | Laos | Malaysia | Myanmar | Singapore |
|---|---|---|---|---|
| Laos | 1 | 1/5 | 1/9 | 1/8 |
| Malaysia | 5 | 1 | 1/4 | 1/5 |
| Myanmar | 9 | 4 | 1 | 2 |
| Singapore | 8 | 5 | 1/2 | 1 |

The eigenvalue and consistency index calculated for the pairwise comparison of the main metrics through the SuperDecision software for the evaluation of this pairwise comparison are shown in Table 7. The consistency index obtained is less than 0.1. This indicates that pairwise comparisons of key metrics are consistent and acceptable in AHP evaluation. The eigenvalues obtained for the comparison show that the Safety metric is first, followed by the Performance, Content Structure, Technology and Accessibility metrics.

Journal of Information System and Technology Management
JISTM
EISSN: 0128-1666
Volume 8 Issue 32 (September 2023) PP. 69-81
DOI: 10.35631/JISTM.832005

**Table 7: Eigenvalues and Consistency Indices for Pairwise Metric Evaluation**

| Metric | Eigenvalue |
|---|---|
| Accessibility (A) | 0.02744 |
| Safety (S) | 0.49373 |
| Performance (P) | 0.23950 |
| Content Structure (SK) | 0.13209 |
| Technology (T) | 0.10725 |
| Consistency Index | 0.09594 |

The objective of the study is to confirm the priority of metrics and criteria based on the comparison of alternative positions obtained with the UN EGDI report for the year 2020 as a benchmark. Table 8 shows the comparing results. Based on the ranking of these four countries, there are similarities in the UN EGDI Evaluation Report 2020. Under the UN EGDI online service index (OSI), Singapore obtained 0.9647, Malaysia obtained 0.8529, Myanmar obtained 0.2588, and Laos obtained 0.1941, as in Table 4.28. This finding is supported by a study by Dominic et al. (2011) using the AHP method, which also demonstrates that the official website of Singapore surpasses that of Malaysia. Hence, this shows that the weights obtained through the AHP method are consistent with the standards at the global level.

**Table 8: Decision of Alternatives**

| Country | Eigenvalues | Weighted | Position | OSI UN EGDI | Position |
|---|---|---|---|---|---|
| Singapore | 0.10048 | 0.30143 | 1 | 0.9647 | 1 |
| Malaysia | 0.10032 | 0.30095 | 2 | 0.8529 | 2 |
| Myanmar | 0.08321 | 0.24963 | 3 | 0.2588 | 3 |
| Laos | 0.04933 | 0.14799 | 4 | 0.1941 | 4 |

## Conclusion

The study found that many factors affect the quality and performance of websites in achieving best practice standards. The objectives of the study were successfully achieved through the methodology used in the study. The goal of developing a priority list of website evaluation criteria can help public sector agencies prioritise the intervention of web-based service providers by public sector agencies. The inclusion of these suggested metrics or criteria represents a ground-breaking expansion of the body of knowledge on website evaluation, demonstrating their originality in this field. By departing from traditional methods, these cutting-edge criteria and metrics give the subject of website evaluation a new perspective.

The identification metrics and criteria for evaluating website performance and quality can guide stakeholders in providing web-based materials or services. Website developers or providers can take proactive measures to ensure that their websites' performance and quality consistently remain satisfactory.

The AHP method successfully generates accurate priority values to address MCDM problems in various fields. This is evidenced by its alignment with each benchmark employed in the study. The priority values of metrics and criteria generated through this method assist stakeholders in judiciously utilising each metric and criterion in the web development and evaluation process. Indirectly, the workload on webmasters or website providers can be

Journal of Information System and Technology Management
EISSN: 0128-1666
JISTM
Volume 8 Issue 32 (September 2023) PP. 69-81
DOI: 10.35631/JISTM.832005

managed more efficiently by distributing the workload to web developers based on the generated priorities.

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