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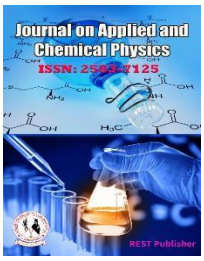

Integration of Environmental Sustainability and Technological Performance in Healthcare Cloud Computing: An ARAS Methodological Study

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Abstract: *This research explores Benefits of Cloud Computing in Healthcare through an In-Depth Evaluation ARAS method. This study evaluates five major cloud computing simulators, Clouds, Cloud Analyst, Green Cloud, Network Cloud Sim, and Ground Sim, across four critical dimensions. Simulator capabilities, underlying platform integration, programming language support, and software compatibility. The study uses a systematic evaluation framework that includes normalized matrices and weighted ratings to determine the most effective Cloud-based solution for healthcare applications. The findings reveal that Green Cloud has proven to be a very effective solution, achieving the highest performance scores (Si: 0.283135, Ki: 0.924851), followed by Network Cloud Sim (Si: 0.177561, Ki: 0.579998). The analysis reveals that environmentally sustainable solutions, represented by the Green Cloud, can deliver optimal performance while maintaining strong technical capabilities. This finding is particularly important as healthcare organizations increasingly prioritize both operational efficiency and environmental responsibility. The study also highlights potential areas for improvement in traditional cloud computing tools, as evidenced by the low rankings of Cloud SIM and Cloud Analyst. These findings provide valuable insights for healthcare organizations looking to implement cloud computing solutions, and suggest that emphasis should be placed on solutions that balance environmental sustainability with strong technical performance. This study further expands the expanding knowledge on the use Cloud computing in healthcare provides valuable insights and practical advice for improving healthcare services and management. Organizations transitioning to cloud-based systems.*

Keywords: *Cloud technology in healthcare, environmentally friendly cloud solutions, and healthcare IT systems, and cloud simulation tools, Sustainable Healthcare Technology, Healthcare Data Management, Cloud Performance Evaluation and Healthcare Infrastructure Optimization.*

1. INTRODUCTION

Cloud computing is a rapidly growing technology that uses computer resources to deliver services over the Internet. In recent times, numerous applications have been developed using this technology. It offers a promising solution to the challenges in healthcare information systems, and its benefits will significantly enhance the development of such systems. Cloud computing offers a wide range of benefits to both healthcare organizations and patients. One significant benefit, especially in the current economic climate, is the ability to reduce costs for healthcare organizations through efficient use of resources [1]. Cloud computing stands out as one of the most revolutionary technologies in recent years. Its applications in various aspects of daily life are growing rapidly, and as it has become so widespread, it is currently widely Healthcare professionals are seeing the rapid advancement healthcare services will soon be moving to the cloud. This shift emphasizes the delivery of cost-effective and efficient healthcare services to people around the world [2]. Healthcare refers to services provided to individuals or populations by healthcare professionals with the aim of improving, maintaining, monitoring or restoring health. Globally, the demand for healthcare It is expected to grow significantly in the future, because various factors including demographic changes in the aging population, increased life expectancy and the prevalence of lifestyle-related diseases [3]. Cloud computing enables healthcare providers to prioritize improving the quality of care delivered rather than focusing on IT management. This is particularly beneficial for small hospitals, community health centres, and medical practices. Furthermore, cloud computing enables seamless The exchange of information between various healthcare institutions participating in patient care, which is essential for efficient healthcare delivery [4]. Cloud computing integrates various components, including technology and software

requirement specifications, into a unified system. This integration acts as a comprehensive package, especially beneficial for beginners in this field. These beginners represent the future of progress and innovation in the advanced world. Cloud computing strives to encompass all the ways in which innovation can be transformed into technology. To promote the significant structure with the growth with the rise of cloud computing, a large number of small businesses are adopting this technology. making valuable investments. Without a doubt, cloud computing is rapidly increasing the recognition of its benefits [5]. Healthcare providers generally aim to leverage information technology to achieve the competitive advantage that IT provides. The benefits of adopting IT solutions in healthcare organizations include improving clinical practices, aiding decision-making, and facilitating information sharing. However, existing e-health practices face numerous challenges, including technical issues such Due to challenges such as complexity, compatibility, and lack of adequate IT infrastructure, as well as financial and organizational barriers, high costs associated with implementing HIT programs [6]. Mobile devices provide a variety of services that enhance our lifestyles. They are seamlessly integrated into our daily routines, helping us with tasks as diverse as determining Manage location, time, and image processing, book hotels, make online transactions, and stay in touch with others. Cloud computing relies on a network of shared resources to improve performance, resulting in reduced management and capital costs [7]. Cloud computing is being recognized as a promising solution for improving healthcare, however, it faces several challenges. a robust legal and regulatory framework that oversees the international exchange of patient data. As cross-border data flows are governed by various international, national and regional legal and regulatory frameworks, this issue is gaining increasing importance among policymakers, academics, and health and information technology professionals. Therefore, comparative country studies provide valuable insights for those seeking to understand how cloud computing and other ICT policy is changing can improve health or have other outcomes [8]. Due to its broad applicability across various sectors, the IT industry considers Cloud computing as a growing technology. Cloud computing it plays a key role in providing and distributing various software and services via the Internet. It has become a key Infrastructure for a large number of companies. After more than a decade of development, cloud computing has achieved considerable success, profoundly impacting the economy, society, industries, and science [9]. The integration of mobile computing and cloud computing in healthcare has great potential to transform healthcare delivery and improve patient outcomes. The impact of mobile computing, cloud computing, and AI in healthcare is only just beginning to be fully recognized. Mobile healthcare applications, such as electronic health records, which enable users to access their information from anywhere using mobile devices, have already provided numerous practical benefits. These applications have greatly improved patient safety by enabling real-time data sharing and instant access to medical records and measurements [10]. Recently, cloud computing has received considerable momentum and attention in both academia and industry, where it is recognized as an opportunity that can provide significant benefits and empowerment in certain situations. Its flexibility and pay-per-use cost structure make it particularly advantageous for enterprises. Cloud computing enables widespread and seamless Access to shared resources and common infrastructure, providing on-demand services through the network, to support execution tasks increasing demands of electronic health applications [11]. Cloud computing is considered one of the latest advancements in technology. Its applications are expanding rapidly, and many industries are adopting its use. These resources include tools and applications such as data storage and databases. Cloud computing helps to securely store data and information. Patients with chronic diseases may have to visit the hospital frequently, and their information needs to be stored securely and privately, ensuring minimal changes or unauthorized access [12]. Recent advances in cloud computing and mobile technology have this has resulted in the development of several models for cloud-based healthcare services and devices. In a cloud system, health data can be stored and sent to medical professionals from any location, and responses are sent back to patients via a web services network. This article presents a mobile cloud computing solution using a health web service [13]. The concept of cloud computing traces its origins to Time sharing, introduced in the 1960s, allowed multiple users to access the same computer at the same time at the same time. However, the contemporary concept of cloud computing, which involves the provision of computing resources over the Internet, was first introduced in the late 1990s. Cloud computing is crucial for business innovation. Its flexibility and adaptability open up new ways to work, operate, and manage a business. The service enables users to access files and applications stored in the cloud from anywhere, thus near physical hardware [14]. A suitable solution to meet this requirement is to add an additional layer between the traditional gateway and the remote cloud server. Key Fog computing features include edge space, low latency, location awareness, and defencing. spread, interoperability, and the ability to support real-time analytics [15]. Due to its ability to drive growth, cloud computing offers a solution for many organizations. It is well suited to efficiently manage data and provide Versatile, scalable and cost-effective platform. This solution allows organizations to share data between different systems without the need to manage the underlying infrastructure. As a result, businesses of all sizes, including large corporations, higher education institutions, and Small and medium businesses worldwide are discovering cloud computing allows them to grow and improve efficiency and productivity without increasing capital expenditures. While the benefits of cloud

computing are clear for most industries, the healthcare sector has been slow to embrace it. due to concerns about security and privacy [16].

2. MATERIALS AND METHOD

Cloud Sim: Cloud Sim is a toolkit (library) developed for simulating cloud computing environments. It provides base classes to describe management policies for various system Elements such as data centres, virtual machines, applications, users, computing resources, and scheduling and provisioning.

Cloud Analyst: Cloud analytics, within cloud computing, offers many of the same functionalities as traditional data analytics. However, instead of hosting everything on-premises, cloud analytics provides tools to build, deploy, scale, and manage data analytics on a third-party infrastructure in the cloud. A data analyst collects and analyses data to identify patterns and generate valuable insights that aid in problem solving and decision making. They have skills in data cleaning, visualization, and analysis, and a strong understanding of data ethics and the tools needed for these tasks.

Green Cloud: The practice of making cloud-based workloads as environmentally sustainable as possible includes a variety of activities, such as optimizing applications for performance in the cloud and using renewable energy sources. Implementing green cloud strategies can contribute to sustainability efforts and lead to cost savings.

Network Cloud Sim: Cloud networking refers to an IT infrastructure where some or all of an organization's network capabilities and resources are hosted on a public or private cloud platform, managed either on-premises or by a service provider, and delivered on-demand. NASA is a good example of an organization using hybrid cloud.

Ground Sim: Ground Sim is a simulation tool used to model and analyse various ground operations at airports, including aircraft movements, baggage handling, and passenger flow. It helps improve ground services by simulating different scenarios, identifying inefficiencies, and optimizing operational processes to improve overall airport performance and reduce delays.

Simulator: Simulation is used to assess the effects of process changes, new procedures, and capital investments in equipment. Engineers can use simulation to evaluate the performance of an existing system or to predict the performance of a proposed system in the future, so that they can compare different solutions and design options.

Basic Platform: A computer platform primarily consists a memory unit where one or more CPUs and application data and code are kept. This also includes peripherals such as DVD drives, hard drives, graphics cards, and network interfaces that enable communication with the external environment. For example, you can move around the presentation area while speaking to keep your audience's attention. Using gestures, such as hand gestures, and actively engaging with your listeners are effective ways to ensure they pay attention to your message.

Programming Language: Programming languages are fundamental to software development. They are used to write instructions that computers can understand and execute. These languages are very important because they help developers create software that solves complex problems, automates tasks, and improves performance.

Software: Unlike hardware, which refers to the physical components of a computer, software is a broader term that includes applications, scripts, and programs that run on a device. Software not only helps your computer hardware perform essential tasks, but it also improves the efficiency of your business. The right software can introduce innovative ways of working. As a key business resource, it is important to choose software that aligns with the specific needs of your organization.

Admission Rate Evaluation System: The addition rate rating system was developed to rank Alternatives from best to worst, based on same criteria. However, many case studies, particularly in water resources Management, Public Health Administration, Business Management, Road Safety, and many other fields, require a hierarchical structure of criteria. To implement in the hierarchical ARAS method, we used the terms defined by the multi-criteria hierarchical process method, because MCHP can be applied to any MCDA technique [17]. It is difficult to assess the impact of different problem-solving methods. ARAS method has significant potential for the future of construction engineering because it provides a structured approach to decision support [18]. A typical MCDM problem involves ranking a finite set of decision alternatives, each unique decision criteria that must be evaluated simultaneously. In this approach, a utility function defining the relative performance of a potential alternative is

directly proportional to the impact of the values and weights of the key criteria in the problem [19]. The results of this study show a strong alignment between the two methods. Belgium emerged as the most successful team in both methods, followed by Croatia. According to the ARAS method, the title-winning France is in third place, and according to the SAW method, England is in third place [20]. When laboratory subjects are replaced by real residents living in their own homes, the value of the information increases, making it possible to deploy smart health surveillance systems globally. To support this, we present publicly available ARAS datasets collected from two real homes with multiple residents. Most previous studies have focused on single-dwelling situations. However, when collecting the ARAS dataset, we relaxed this assumption and collected data from multi-dwelling homes [21]. The SAFERIDER team analysed five essential ARAS functions: speed warnings, curve warnings, forward collision warnings, intersection support, and lane change support. However, research on ARAS for two-wheelers is limited, and this area is not as active as studies focusing on four-wheeler safety. Although Vehicle dynamics and injury severity in collision accidents differ significantly from four-wheelers, ARAS assessment methods for two-wheelers remain unexplored [22]. In this study, we quantitatively assess the impact of ARAS, not only in terms of the accident-reduction effects, but also in terms of the social benefits of implementing ARAS in society, RS is based on experiments and computer simulation methods. To assess the practicality and benefits of this system in society, we propose an evaluation method for ARAS that combines riding simulator experiments and computer simulations within a cost-benefit analysis framework. The aim of this study was to measure This refers not only to the collision-reduction effect achieved through the use of ARAS, but also to the overall reduction in accidents, taking into account collisions caused by both human errors and system errors [23]. This the model was developed by integrating the fuzzy ARAS method with a scoring system and factor analysis. technique goal of this study is to develop a practical fuzzy ARAS method using. factor analysis in the manufacturing sector and integrate it with the scoring system of the job evaluation system. This study seeks to design a versatile model that is applicable to various fields of human resource management. Job evaluation is strongly linked for Employee satisfaction in companies and organizations. This study incorporates the fuzzy ARAS method with scores and factor analysis to improve job evaluation processes and provide a comprehensive definition of job roles [24]. The literature suggests that scoring and factor analysis are very important in improving Work productivity. This integrated framework was investigated by combining scoring and factor analysis techniques with the fuzzy ARAS method. This study provides a detailed implementation of the proposed Modell, based on findings derived from the literature, the integration of scoring and factor analysis methods is particularly emphasized with MCDM techniques has not been explored together, revealing a gap in the existing literature [25]. For example, the power plants, airplanes, ships, cars, and motorcycles. Effective management of energy conversion systems requires assessment from energetic, economic, and environmental perspectives. One of the most useful methods for assessing the performance of these systems includes fitness-based analysis [26]. Operations research provides government agencies and large companies with the tools they need to make well-informed decisions, reduce risks, and improve their performance. Technological advances and the challenges posed by the global economy have made the business environment is becoming increasingly complex. [27]. Retinal surgery is a procedure performed on the retina and the retina. During this operation, surgeons must have very precise manipulation skills and maintain proper control over the contact the contact the. In general, Due to human limitations, vitreoretinal eye surgery is considered one of the most complex procedures, leading to the development of assistive devices designed to support this process [28]. This application can help schools in making decisions related to selecting the best students. The problem of selecting the best students can be solved by building a decision support system based on the ARAS method. The ARAS method primarily focuses on comparing and ranking alternatives, which involves physical systems, decision systems, and information systems to obtain better and better results [29]. Many researchers have used the ARAS method, including processes that help simplify and expedite the determination of eligibility for non-cash food assistance through the complex calculations of the ARAS method. By using the ARAS method in selecting security personnel candidates, the HR department can be assisted in quickly and accurately determining which candidates to accept. The ARAS method uses the highest utility value (Ki) to identify the best option in the in-house selection process [30].

3. ANALYSIS AND DISCUSSION

TABLE 1. Cloud computing benefits in healthcare

	Simulator	Basic Platform	Programming Language	Software
Cloud SIM	10	6	14	13
Cloud Analyst	20	15	15	2
Green Cloud	40	57	57	35
Network Cloud SIM	30	22	14	50
Ground SIM	15	10	22	13

Table 1 illustrates Benefits of Cloud Computing in Healthcare by evaluating various simulators and platforms based on key criteria, using the ARAS methodology. For example, Green Cloud stands out with high scores across all categories, especially excelling in software and platform considerations. Cloud Sim and Network Cloud Sim show strong performance, although each has a unique focus. This comparison highlights the different contributions of these tools to improving healthcare solutions using cloud computing.

$$X_{max} = Max\,(X_1 \ldots\ldots X_n) \quad \textbf{(1)}$$

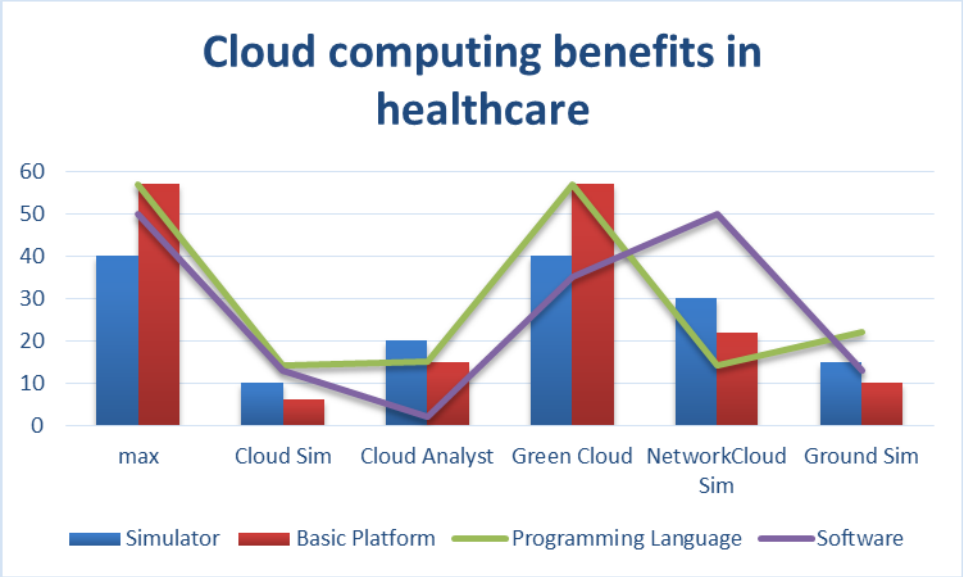

FIGURE 1

Figure 1 illustrates, as estimated ARAS methodology. The table compares various simulators, platforms, programming languages, and software tools. For example, Green Cloud excels in all categories, receiving high scores in Simulator (40), Platform (57), and Software (35). Cloud Sim and Cloud Analyst show contrasting strengths, with Cloud Sim ranking high in Software (14) and Cloud Analyst leading in Platform (20).

TABLE 2. Calculation of maximum value

	Simulator	Basic Platform	Programming Language	Software
Max	40	57	57	50
Cloud Sim	10	6	14	13
Cloud Analyst	20	15	15	2
Green Cloud	40	57	57	35
Network Cloud Sim	30	22	14	50
Ground Sim	15	10	22	13

Table 2 provides the calculation of the maximum values for each category (simulator, base platform, programming language and software) using the ARAS method. The maximum values are 40 for simulator, 57 for both base platform and programming language and 50 for software. The Green Cloud Simulator matches the maximum values for both base platform and programming language, with scores of 40, 57 and 57 respectively, lagging behind software (35). Cloud Sim and Ground Sim consistently show low scores in all categories, with Cloud Sim reaching the lowest values for simulator (10) and base platform (6).

$$X_{1nor} = \frac{X_1}{\sum(X_1 + X_2 \ldots\ldots X_n)} \qquad (2)$$

TABLE 3. Normalized Matrix

	Simulator	Basic Platform	Programming Language	Software
	0.258065	0.341317	0.318436	0.306748
Cloud Sim	0.064516	0.035928	0.078212	0.079755
Cloud Analyst	0.129032	0.08982	0.083799	0.01227
Green Cloud	0.258065	0.341317	0.318436	0.214724
Network Cloud Sim	0.193548	0.131737	0.078212	0.306748
Ground Sim	0.096774	0.05988	0.122905	0.079755

Table 3 shows the normalized matrix for each category (simulator, base platform, programming language, and software) Using the ARAS method, normalized values represent relative performance. each simulator, platform, and software in proportion to their maximum values. For example, Green Cloud receives high normalized scores of 0.258065 for simulator, 0.341317 for base platform, and 0.318436 for programming language, demonstrating its overall performance. Cloud Sim and Ground Sim score low across the board, with Cloud Sim having the lowest normalized values for simulator (0.064516) and base platform (0.035928), highlighting its limited performance in these areas.

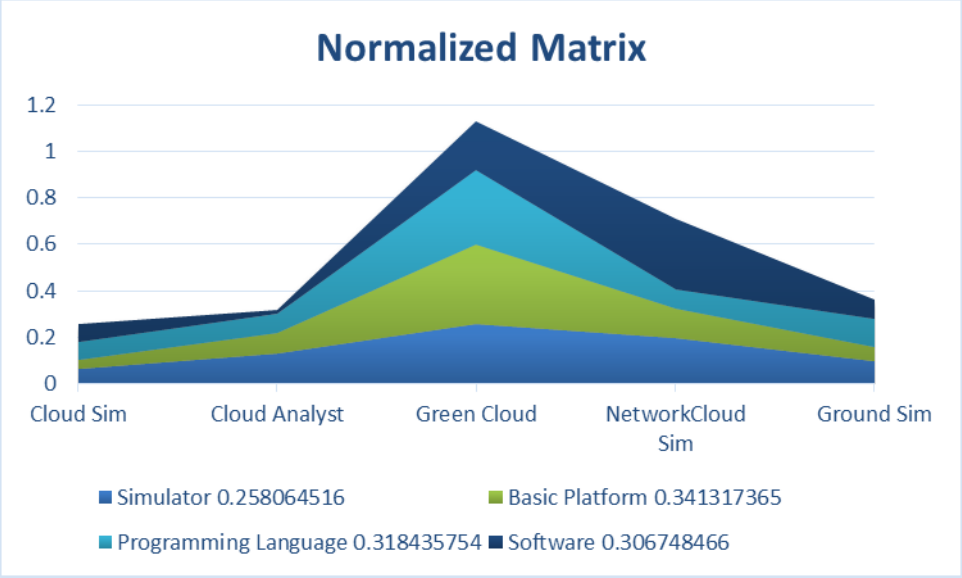

FIGURE 2. Normalized matrix

Figure 2 presents a normalized matrix generated using the ARAS method, in which each value represents the normalized performance of simulators, platforms, programming languages, and software. Green Cloud stands out with the highest normalized scores across simulator, underlying platform, and programming language, while Cloud Sim and Ground Sim show lower values, indicating weaker performance in these categories.

$$X_{wnormal1} = X_{n1} \times w_1 \qquad (3)$$

TABLE 4

	Simulator	Basic Platform	Programming Language	Software
Max	0.064516	0.085329	0.079609	0.076687
Cloud Sim	0.016129	0.008982	0.019553	0.019939
Cloud Analyst	0.032258	0.022455	0.02095	0.003067
Green Cloud	0.064516	0.085329	0.079609	0.053681
Network Cloud Sim	0.048387	0.032934	0.019553	0.076687
Ground Sim	0.024194	0.01497	0.030726	0.019939

Table 4 presents the weighted normalized matrix obtained using ARAS method. Each value represents the performance of the simulators, platforms, programming languages, and software after applying weights to the normalized values. Green Cloud, with the highest weighted scores of 0.064516 for simulator, 0.085329 for base platform, and 0.079609 for programming language, demonstrates its overall superiority. Cloud Sim and Ground Sim indicate their relatively poor performance in all categories. Although Network Cloud Sim outperforms Cloud Sim and Ground Sim in software, it lags behind Green Cloud in most areas.

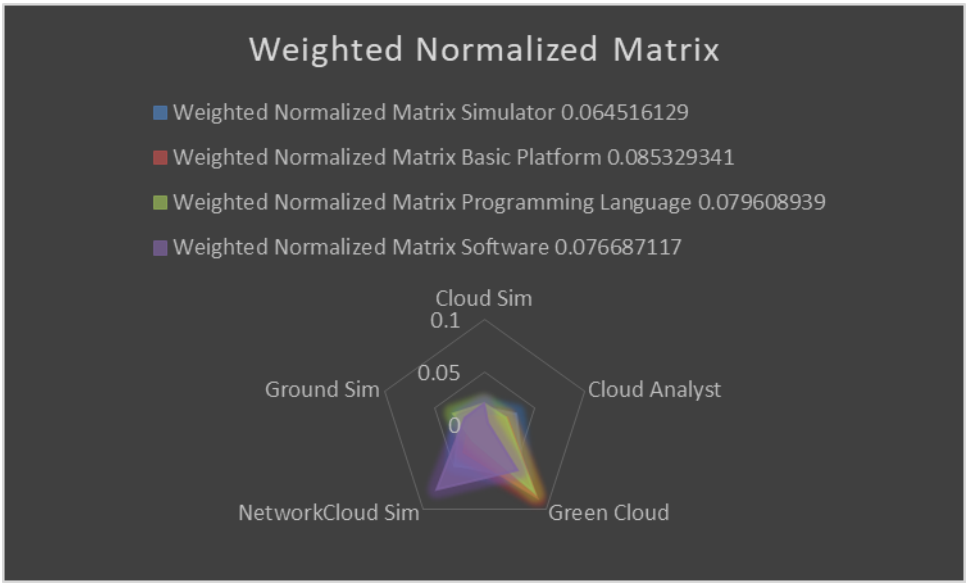

FIGURE 3

Figure 3 illustrates the weighted normalized matrix generated using the ARAS method, which highlights the performance different systems across four categories. Green Cloud Simulator receives the highest weighted scores for the underlying platform and programming language, reflecting its superior performance. Cloud Sim and Ground Sim show the lowest weighted scores, indicating their relatively weak performance.

$$Si = \sum(\boldsymbol{X_1} + \boldsymbol{Y_1} \ldots\ldots \boldsymbol{Z_n}) \quad (4)$$

$$Ki = \frac{\boldsymbol{X_{wnor1}}}{\sum(\boldsymbol{X_{wnor1}} + \boldsymbol{X_{wnor2}} \ldots\ldots \boldsymbol{X_{wnorn}})} \quad (5)$$

TABLE 5. Final Result

	Si	Ki	Rank
	0.306142	1	
Cloud Sim	0.064603	0.211023	5
Cloud Analyst	0.07873	0.25717	4
Green Cloud	0.283135	0.924851	1
Network Cloud Sim	0.177561	0.579998	2
Ground Sim	0.089829	0.293422	3

Table 5 presents the final results using the ARAS method, showing the calculated values of Si (performance score) and Ki (relative importance) for each system. Green Cloud ranks first with the highest Si (0.283135) and Ki (0.924851), indicating its best overall performance. Network Cloud SIM ranks second with a Si of 0.177561 and a Ki of 0.579998. Ground SIM, Cloud Analyst, and Cloud SIM rank third to fifth with the lowest Si and Ki values,

respectively. This ranking highlights Green Cloud as the most effective option, while Cloud SIM performs poorly in comparison.

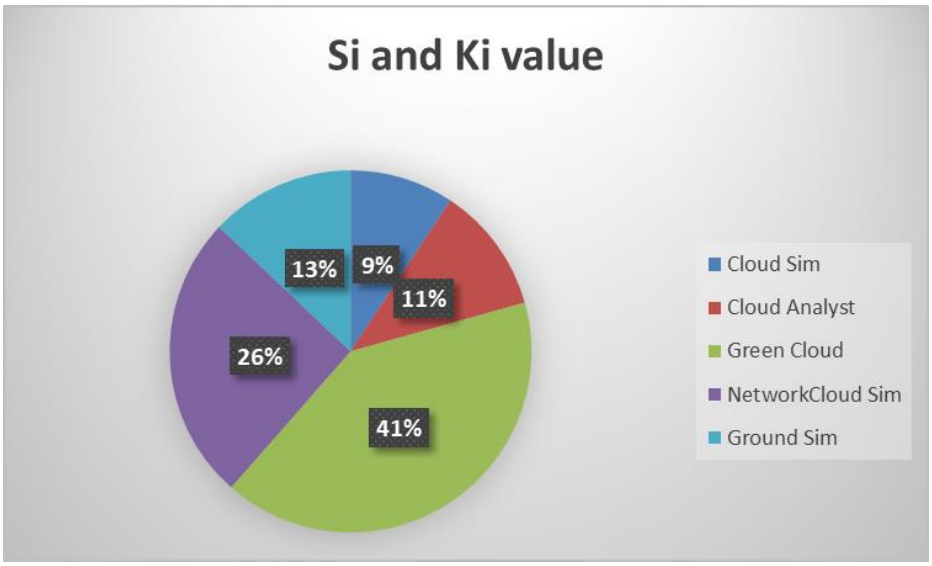

FIGURE 4. Si and Ki

Figure 4 shows the Si and Ki values for each system using the ARAS method. Green Cloud stands out with the highest Si (0.283135) and Ki (0.924851), indicating its high performance and significance. Cloud Sim has the lowest values, reflecting its weak performance compared to the other systems.

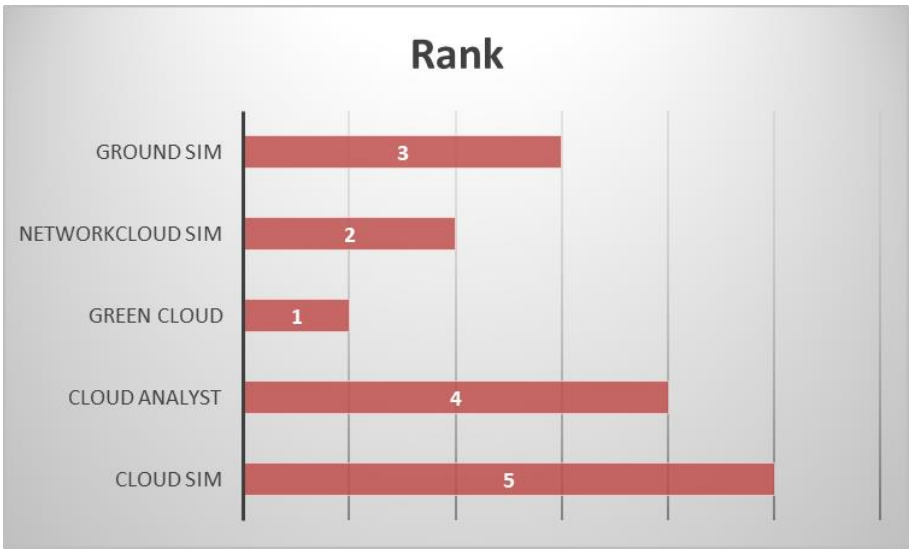

FIGURE 5. Shows the Rank

Figure 5 Shows the final ranking of organizations according to the ARAS method. Green Cloud is ranked first, indicating its overall performance. Network Cloud SIM and Ground SIM are ranked second and third, respectively, while Cloud Analyst and Cloud SIM are ranked fourth and fifth, indicating their relatively low performance.

4. CONCLUSION

Cloud computing has become a transformative force in healthcare, which significant benefits across multiple dimensions. Through a comprehensive ARAS methodology analysis of various cloud computing tools and platforms, several key findings emerge that will help guide future implementations in healthcare settings. The

study's findings clearly show that Green Cloud has emerged as the best solution, ranking first with the highest performance scores (Si: 0.283135, Ki: 0.924851). This indicates that Green Cloud's environmental sustainability focus, combined with its strong technical capabilities, makes it a good fit for healthcare applications. Network Cloud SIM ranked second (Si: 0.177561, Ki: 0.579998), highlighting its strong networking capabilities that are critical for healthcare data management and exchange. The analysis also revealed that Cloud SIM and Cloud Analyst, despite being widely used tools, ranked low in the overall rating. This suggests that traditional cloud computing solutions may need to be improved to meet the specific needs of modern healthcare organizations, especially in the areas of platform integration and software compatibility. Research underscores the importance of considering multiple criteria when selecting cloud computing solutions for healthcare applications. The assessment, conducted across four key dimensions: simulator, underlying platform, programming language, and software, provides a comprehensive framework for healthcare organizations to evaluate and implement cloud solutions that best suit their needs. Looking ahead, the findings suggest that healthcare organizations should prioritize solutions that offer strong environmental sustainability features while maintaining high performance in key technology areas. Green Cloud's success in this analysis reflects a growing trend toward environmentally friendly solutions that improve overall system performance without compromising on technical capabilities. These results are particularly relevant as healthcare continues to digitize and migrate to cloud-based solutions. The insights this analysis provides will help healthcare organizations make informed decisions about cloud computing implementations, ultimately leading to more efficient, sustainable, and effective healthcare delivery systems.

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