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Development of a Contextualized Web-Based Calculator Estimating System for Concrete, Masonry, and Steel Materials in the Philippine Construction Industry

Rel Jade L. Saladaga[1], Nicanor F. Branzuela Jr.[2], Adolph Vincent E. Vigor[3]

[1]Instructor, Department of School of Engineering Technology, JH Cerilles State College
[2]Assistant Professor, Department of Technical and Technology Education, University of Science and Technology of Southern Philippines
[3]Associate Professor, Department of Architecture, University of Science and Technology of Southern Philippines

Abstract

This study developed and evaluated a contextualized web-based calculator estimating system for concrete, masonry, and steel materials in the Philippine construction industry. The study was undertaken in response to the limitations of traditional and existing digital estimation methods, such as time consumption, proneness to human error, restricted accessibility, compatibility issues, and limited alignment with local construction standards and practices. Guided by the Waterfall Software Development Methodology, the system was designed to be accessible across various digital devices, user-friendly, geographically accessible, and capable of generating saved and print-ready construction estimates based on local standard materials. The study employed a descriptive quantitative research design to assess the usability of the developed system. Using purposive sampling, a total of 40 respondents participated in the evaluation, consisting of 10 experts in construction estimation from Pagadian City and 30 non-expert respondents from Lakewood, Zamboanga del Sur. Data were gathered through an adopted System Usability Scale (SUS) questionnaire and were analyzed using mean and standard deviation. Findings revealed that the developed system obtained a grand mean of 4.52 and a standard deviation of 0.52, interpreted as Very High Usability. The results further indicated that the system was perceived as intuitive, efficient, accessible, and easy to learn by both expert and non-expert users. Moreover, the system was found to be practical for real-world construction estimation tasks due to its integrated functions, device compatibility, and convenience in both on-site and off-site use. The study concludes that the developed contextualized web-based calculator estimating system is a viable and effective tool for improving construction material estimation within the Philippine context. It is therefore recommended that future enhancements include offline capability, expanded material coverage, customizable reporting tools, and AI-assisted features to further improve the system's functionality and usability.

Keywords: Contextualized web-based calculator, construction estimation, bill of materials, system usab-

ility, Philippine construction industry, concrete materials, masonry materials, steel materials

INTRODUCTION

In building construction, maintaining quality standards is essential. Estimating the costs of construction materials and the project itself correctly is one of the most important steps in making this happen. Construction estimation is very important for all kinds of projects, from small homes to big infrastructure projects. This is because it ensures that resources are used correctly and directly affects the project's success, cost-effectiveness, and overall quality. This process is commonly handled by a Construction Estimator, who determines material quantities and projected costs before or during construction through on-site and off-site assessments. Cheng and Tsai (2009) say that construction estimates often depend a lot on the knowledge and gut feelings of skilled workers. Mendoza (2022) also says that estimating construction costs is a complicated job, and if you guess too high or too low, the project may not work out, and the quality may suffer. Cost overruns are also common worldwide in the construction industry (Bascon et al., 2023). While research on cost overruns in the Philippines is still limited, one identified cause is inaccurate estimated quantities (Payumo Nunag & S. Villaverde, 2021).

Cost estimation is an important part of managing a construction project because it helps ensure the work is completed on time and within budget. However, not all project owners can easily get professional estimating services. In many cases, homeowners, engineers, architects, and draftsmen still need to hire or pay a construction estimator, and the cost varies depending on the size and complexity of the project. For some homeowners, the additional expense of hiring an estimator may be difficult to afford. As a result, some rely solely on laborers' experience to estimate the materials needed. In local practice, this is sometimes done through the visual observation method of estimation, where quantities are not calculated systematically but are only guessed based on remembered experience from previous projects. While practical in appearance, this approach may result in the purchase of insufficient or excessive materials, leading to unnecessary expenses for homeowners and potentially affecting the quality of the construction project.

Historically, manual calculations have been the go-to method for construction estimators, particularly during on-site assessments. Manual methods can support personalized assessment, but they often take a long time and are prone to error (Yousif et al., 2020). Many people in the construction industry have switched to digital tools like Microsoft Excel as Technology has improved. These tools help them get things done faster and keep their information in order (Bidwaik et al., 2024). However, Excel and similar programs also have drawbacks, such as subscription fees, device requirements, and compatibility issues. These limitations are more obvious on-site, where speed, ease of access, and convenience are very important. Also, people have sometimes questioned Excel's reliability as an automated calculator due to bugs, corrupted files, or incorrect formula usage, resulting in only 70% accuracy (Rahardja, 2024).

Web-based solutions have become useful alternatives over the last few years because they are easy to use and work across many platforms. Revano (2019, p. 166) says that web-based systems make things easier for people. Even though these benefits exist, the construction industry in the Philippines has not yet fully embraced web-based estimating solutions because there are few systems specifically designed for local building codes and practices. Most web-based estimators available are designed for construction projects in other countries, which makes them less useful for this one. For instance, Yousif et al. (2020) developed a web-based Automated Quantity Survey that estimated only concrete and performed calculations for sand and cement, omitting gravel mixtures. In addition, it is based on cement estimates on 50 kg bags, whereas

40 kg bags are more commonly used in the Philippines, making it less adaptable for local contractors. Similarly, Sexton (2013) developed a construction estimation tool that incorporated non-hollow concrete blocks, which are less widely used in the Philippines, where Concrete Hollow Blocks (CHBs) are more commonly used for wall construction. Because of these differences, such systems are not entirely suitable for use by local construction contractors.

Given these limitations, construction workers and project owners in the Philippines need a more localized, easy-to-use estimating tool that meets their real needs. Because of this, the goal of this study is to create a Web-based Construction Bill of Materials Estimator tailored for the Philippines. The proposed tool is intended to be adaptable across various digital devices, provide user-friendly features, and ensure geographic accessibility. It utilizes mathematical formulas based on local standard construction materials, stores estimate for future reference and generates print-ready results when needed. Through this innovation, construction professionals, students, and even homeowners may be empowered to perform more accurate on-site and off-site material and cost estimates aligned with local market practices, using any internet-enabled device.

OBJECTIVE OF THE STUDY

To develop a Web-based System calculator for Construction Estimate that is compatible with any digital device, offers user-friendly features, ensures geographic accessibility, computes based on the local standard materials, saves estimates for future reference, and provides print-ready results when needed. Specifically, this paper aims to answer the question:

1. What is the level of usability of the developed web-based estimating system using the System Usability Scale (SUS)?

METHODOLOGY

The study used a descriptive research design to evaluate the system's usability. It employed a quantitative approach consistent with descriptive research. As noted by Creswell (2003), descriptive research is an approach in which the researcher makes knowledge claims primarily grounded in constructivist and participatory perspectives, supported by quantitative data analysis.

Participants in the study were selected through purposive sampling. The study involved a total of 40 participants, composed of 10 experts from Pagadian City and 30 non-experts from Poblacion, Lakewood, Zamboanga del Sur.

Based on the demographic profile, most of the participants were aged 25 to 34, comprising 36.36% of the total respondents, followed by those aged 35 to 44, at 27.27%. Participants aged 18 to 24 and 45 to 54 each accounted for 18.18%, while no participant belonged to the 55 to 60 years old age group.

In terms of respondent classification, 25% were experts, 32.50% were homeowners or future homeowners, and 42.50% were homeowners with ongoing renovations or house construction. The experts were chosen based on the criterion that they were professional Engineers or Architects actively engaged in construction estimation. On the other hand, the non-experts were selected because they were individuals who either planned to construct a house in the future, were undertaking an ongoing house renovation, or were undertaking full house construction.

Moreover, the demographic profile indicated that smartphones or mobile phones were the most used devices during system testing, accounting for 45.76% of responses, followed by laptops (32.20%), desktop computers (16.95%), and tablets (5.08%). Regarding internet connectivity, most participants accessed the

system via wifi hotspots (53.23%) and mobile data (40.32%), while only a few used broadband or cable connections, each at 3.23%. No participant reported using dial-up or DSL connections.

The instruments utilized in this study included an adopted survey questionnaire based on the System Usability Scale (SUS). The SUS is a reliable, cost-effective tool for global assessment of the usability of electronic systems (Brooke, 1995). According to ISO 9241, the usability of a system can only be measured by considering the context in which it is used. Furthermore, usability measurement encompasses several aspects, namely effectiveness, efficiency, and satisfaction. The participants' perceptions and suggestions for improving the system were likewise considered in the evaluation of the developed system. Additionally, a laptop was utilized in the Development of the system.

In the data collection process, the data were gathered in Pagadian City and Lakewood, Zamboanga del Sur. After the Development of the web-based system, the experts examined its accuracy and reliability. Following the experts' evaluation, the researcher prepared letters for both expert and non-expert participants, requesting their evaluation of the system. They were also assured that they had the right to withdraw from the study at any time without any penalty or consequences. The researcher then distributed the survey questionnaires to the participants to assess the usability of the web-based system. Furthermore, the researcher collected the participants' written feedback, including their perceptions and suggestions for improving the developed web-based system.

Descriptive statistics, such as the mean and standard deviation, were used to analyze the data and assess how usable the developed web-based system was after participants tried it out. The mean was used to find the average response for each usability criterion, and the standard deviation was used to indicate how much the participants' answers varied or were consistent. It was appropriate to use these statistical tools, as descriptive statistics are meant to summarize and describe the main features of a dataset, such as measures of central tendency and dispersion (Blbas, 2024). Recent usability research has shown that descriptive statistics, especially the mean and standard deviation, can be used to look at System Usability Scale (SUS) results (Formicola et al., 2023). The data were scored and interpreted using the table below:

Table 1: Variables and Scoring Guidelines

Scale	Range	Interpretation (Usability Level)
5	4.21 – 5.00	Very High Usability (VHU)
4	3.41 – 4.20	High Usability (HU)
3	2.61 – 3.40	Moderate Usability (MU)
2	1.81 – 2.60	Low Usability (LU)
1	1.00 – 1.80	Very Low Usability (VLU)

RESULTS AND DISCUSSION

Usability is how well intended users can use a system to achieve their goals in a given context of use, with ease, speed, and satisfaction. This means that usability is not only about whether a system works; it is also about whether users can learn it quickly, do activities with little effort, and feel good about using it. ISO 9241-11 states that usability should always be evaluated in terms of users, the tasks they perform, and the context in which the system is used. Sharma & Tripathi (2023) state that in web-based contexts, websites that are easy to use, well-organized, easy to navigate, and compatible with mobile devices provide better user experience. The evaluation results demonstrate a Very High Usability (VHU) score for the developed web-based estimating system (M = 4.52, SD = 0.52), as presented in Table 3, indicating that users found

the system convenient and satisfactory in its practical application across various devices and connectivity conditions.

Table 2: Assessment of the usability of the web-based estimating system.

Questions for Items for usability	Mean	SD	Interpretation
1. I think I would like to use this tool frequently	4.20	0.63	HU
2. I found the tool unnecessarily complex.	4.50	0.68	VHU
3. I thought the tool was easy to use.	4.70	0.46	VHU
4. I think I would need the support of a technical person to use this system.	4.40	0.74	VHU
5. I found the various functions in this tool were well integrated.	4.53	0.64	VHU
6. I thought there was too much inconsistency in this tool	4.45	0.78	VHU
7. I would imagine that most people would learn to use this tool very quickly.	4.70	0.56	VHU
8. I found the tool very cumbersome to use.	4.50	0.68	VHU
9. I felt very confident using the tool.	4.65	0.53	VHU
10. I needed to learn a lot of things before I could get going with the tool.	4.55	0.60	VHU
Grand Mean:	4.52	0.52	VHU

It is evident that the respondents primarily perceived the system as very usable, user-friendly, and easy to learn. The high average ratings for "I thought the tool was easy to use" (4.70), "I would imagine that most people would learn to use this tool very quickly" (4.70), and "I found the various functions in this tool were well integrated" (4.53) show that the system was easy to use and understand. The modified SUS scoring method shows that the positive responses to the reverse-worded statements mean that the people who answered the questions did not think the system was too complicated, inconsistent, or hard to use, and they did not think they needed a lot of technical support to use it well. This result aligns with ISO 9241-11:2018, which states that usability must be measured in a specific context of use, focusing on effectiveness, efficiency, and satisfaction. The present study demonstrates that high usability ratings indicate that users effectively performed estimation tasks, engaged with the system with low exertion, and experienced satisfaction and confidence during its use. The developed web-based estimating system is considered usable not only for its appropriate functionality but also for its alignment with the genuine needs and operational contexts of its target users (ISO 9241-11:2018). The results support Sharma's (2023) argument n "The Importance of Website Usability in Digital Marketing: A Review" that a website that is easy to use, well-organized, and works well on mobile devices is more likely to keep users engaged and encourage them to use it for longer. The research indicated that websites need to be adaptable across various devices and function effectively on wireless connections, as uninterrupted access significantly influences the user experience. This study is pertinent, as a significant number of respondents used cellphones to assess the system, primarily via Wi-Fi hotspots or mobile data. The suggested solution is made for smartphones, laptops, and tablets and has a save-and-print feature to make things easier. The very high usability score indicates that the system built was easy to use, responsive, and enjoyable, as the literature states (Sharma & Tripathi, 2023).

In summary, the results showed that the contextualized web-based calculator estimation system had a grand mean of 4.52 and a standard deviation of 0.52, which means it was very easy to use. Most

respondents who answered the survey said the system was very easy to use, understand, and effective for estimating construction jobs. The system's ease of use and the fact that most people could learn it quickly were the most highly recommended features, with each getting a score of 4.70. The results indicate that the system's functionalities were well integrated, users felt confident when using it, and did not perceive the tool as challenging or cumbersome. The designed system offered a convenient, accessible, and pleasant experience for users across various devices and internet connectivity conditions.

Respondents, both professional and non-expert, highlighted the system's accessibility, simplicity, convenience, and user-friendliness as its most favorable features. Experts stated that the system makes it easy to find and identify the estimated costs and quantities of materials used, has a simple design that makes it easy for everyone to learn and use, is convenient and saves time, and guarantees quick, accurate, and organized project cost estimates. Non-expert respondents, on the other hand, said that the system was easy to use and that the cons were easy to see, making it easier to navigate. The system is deemed beneficial and highly recommended for engineering and construction students, enabling them to select individual components of a building for estimation and to identify estimated prices and material amounts. These comments corroborate the quantitative findings, indicating that the system is not only highly usable but also practical and advantageous for both professionals and non-experts.

CONCLUSIONS

Based on the findings of the study, the following conclusions were drawn:

1. The contextualized web-based calculator estimation system was very easy to use, according to the results. The system had a grand mean of 4.52 and a standard deviation of 0.52, indicating Very High Usability. This means that most people who answered the survey thought the system was useful, efficient, and good for estimating construction costs.
2. Technology was easy to use and learn. The highest-rated indicators were "I found the tool easy to use" and "I think most people would quickly learn to use this tool," both of which got a mean score of 4.70. This means that users can easily use and understand the system that was designed.
3. It was found that the system's functions were well integrated, logically ordered, and useful in the real world. The results show that people thought the system was easy to use, not hard, inconsistent, or burdensome. This suggests that it makes it easy and certain to estimate activities.
4. The proposed system successfully met the study's goal of providing an easy-to-use, accessible, and device-compatible estimation tool for concrete, masonry, and steel materials. You can use this web-based solution on smartphones, tablets, laptops, and other devices that can connect to the internet. This makes it easy for users to make construction estimates both on-site and off-site. Users can save and print results whenever they need to.
5. The views of both expert and non-expert respondents support the system's usefulness. Experts acknowledged that the approach enables the straightforward identification of predicted prices and material quantities, is easy to learn, convenient, and time efficient. Non-expert respondents appreciated its simple design, well-defined icons, and the capacity to estimate components of construction tasks. These comments suggest that the method is advantageous for both experts and students, as well as for other non-expert users who require a practical estimate tool.

RECOMMENDATIONS

The developed web-based estimating system received a Very High Usability rating. Since the study's ma-

intenance phase lets respondents give feedback and suggestions to make the system better, the following suggestions are:

1. To keep the developed contextualized web-based calculator-estimating system usable and better meet the needs of both expert and non-expert users, it should be improved and maintained regularly.
2. Future versions of the system should include customizable reporting tools and the ability to integrate with other tools, making users more productive and giving them greater control over their workflow based on the needs of their projects.
3. The web-based estimation tool currently requires an internet connection, which may be difficult for people in rural areas. The developers should consider adding offline support or a mode that works both online and offline. In this way, the system may be used more effectively both on-site and off-site, even in areas with unstable internet connections.
4. The system should include more icons, labels, tooltips, and short descriptions to help users, especially those unfamiliar with technical construction terms. A glossary or help section may also be added to make the application easier for first-time users to understand.
5. Users, especially regular people, homeowners, and other non-expert users, should get an orientation or short training session to help them understand the system's features and construction terms better. This recommendation aligns with the study's goal of providing a user-friendly, accessible estimating tool across digital devices.
6. The system's design should be more responsive across smartphones, tablets, laptops, and other digital devices, since the study intended it to be compatible with any device, and many respondents evaluated it on mobile phones and via wireless or mobile-data connections.
7. A feature should be added that automatically displays the overall total of materials and, if possible, the corresponding estimated cost, so users can immediately view a complete summary of their computation results.
8. For future Development, the system may also explore AI-assisted features that can provide smarter guidance, easier interpretation of results, and automated support for users, provided that these features remain aligned with local construction standards and the user-friendly nature of the application.
9. Future researchers are encouraged to expand the present study by including a wider range of construction materials, additional system functions, and a larger group of respondents and locations. Since the current study focused only on concrete, masonry, and steel reinforcements, future studies may further validate and enhance the system in broader settings. They may also explore additional improvements, such as offline capability, AI-assisted features, integrated reporting tools, and automated overall totals for materials and costs. Such efforts would further strengthen the system and support its continuous improvement based on user feedback and recommendations.

REFERENCES

1. Adobe. (2025). *Illustrator vs. Photoshop: When to use each application.* https://www.adobe.com/creativecloud/design/illustrator-vs-photoshop.html
2. Aljohani, Abd l., Dominic Ahiaga-Dagbui, M. D. (2017). Construction Projects Cost Overrun: What Does the Literature Tell Us? *International Journal of Innovation, Management and Technology*, *8*(2), 137–143. https://doi.org/10.18178/ jimt.2017.8.2.717
3. Adobe. (2025). *Illustrator vs. Photoshop: When to use each application.* https://www.adobe.com/creativecloud/design/illustrator-vs-photoshop.html

4. Aljohani, Abd l., Dominic Ahiaga-Dagbui, M. D. (2017). Construction Projects Cost Overrun: What Does the Literature Tell Us? *International Journal of Innovation, Management and Technology*, *8*(2), 137–143. https://doi.org/10.18178/ jimt.2017.8.2.717
5. Anireddy, A. R. (2024). *Comparative Analysis of Traditional vs Modern Estimating Methods : Pros and Cons of Different Approaches in Construction*. *13*(11), 1–5.
6. Bascon, R., Gangcuangco R., Carreon, A., Morales, M., Alejandrino, A., Nuqui, N., Coronel, J. C., & T ngol, J. V. (2023). Investigation on the Factors Influencing Time and Cost Overrun in Vertical Construction in Pampanga. *IRE Journals*, *6*(12), 730–752. https://www.irejournals.com/formatedpaper/1704711.pdf
7. Bidwaik, P. C. S., Niwane, R., Rathod, D., Biradar, V., Thakare, H., & Deshmukh, V. (2024). *The role of Microsoft Excel in estimating and costing in construction projects*. *06*(03), 2129–2136. https://www.irjmets.com/uploadfiles/paper//issue_3_march_24/50596/final/fin_irjmets1710667082.pdf
8. Blbas, H. T. A. (2024). Descriptive Statistics. In B. S. Kumar (Ed.), *Recent Advances in Biostatistics*. ntechOpen. https://doi.org/10.5772/intechopen.1002179
9. Borrmann, A., König, M., och, C., & Beetz, . (2018). Building Information Modeling: Why? What? How? In A. Borrmann, M. König, C. Koch, & J. Beetz (Eds.), *Building Information Modeling: Technology Foundations and Industry Practice* (pp. 1–24). Spring r International Publishing. https://doi.org/10.1007/978-3-319-92862-3_1
10. Brooke, J. (1995). SUS: A quick and dirty usability scale. *Usability Eval* Ind. *189*.
11. Cheng, M., & Tsai, H. (2009). *Web-based conceptual cost estimates for construction projects using Evolutionary Fuzzy Neural Inference Model*. *18*(March 2009), 164–172. https://doi.org/10.1016/j.autcon.2008.07.001
12. Denver, U. of. (2023). *Adobe Dreamweaver*. University of Denver. https://www.du.edu/it/services/software/software-catalog/395 71a01b1ea850689210e58d4bcbd6
13. Formicola, R., Amici, C., Mor, M., Bissolotti, L., & Borboni, A. (2023). Design of Medical Devices with Usability in Mind: A Theoretical Proposal and Experimental Case Study using the LEPRE Device. *Designs*, *7*(1). https://doi.org/10.3390/designs7010009
14. Ghosh, A., Edwards, D. J., & Hosseini, M. R. (2021). Patterns and trends in Internet of Things (IoT) research: future applications in the construction industry. *Engineering, Construction and Architectural Management*, *28*(2), 457–481. https://doi.org/10 1108/ECAM-04-2020-0271
15. Hosamo, H. H., Imran, A., Cardenas-cartagena, J., Svennevig, P. R., Svidt, K., & Ni lsen, H. K. (2022). *A Review of the Digital Twin Technology in the AEC-FM Industry*. *2022*. https://doi.org/1 .1155/2022/2185170
16. Hu, M., & Skibniewski, M. (2021). Green building construction cost surcharge: An overview—*Journal of Architectural Engineering*, *27*(4), 4021034.
17. Lampawog, H., & Pomperada, J. (2021). *Web Programming using PHP & MySQL*—unlimited Books Library Services & Publishing Inc.
18. Aqbool, R., Saiba, M. R., & Ashfaq, S. (2023). Emerging Industry 4.0 and Internet of Things (IoT) technologies in the Ghanaian construction industry: sustainability, implementation challenges, and benefits. *Environmental Science and Pollution Research*, *30*(13), 37076–37091. https://doi.org/10.1007/s11356-022-24764-1

19. Marques, S. M., Planas-Iglesias, J. & Damborsky, J. (2021). Web-based tools for computational enzyme design. *Current Opinion in Structural Biology*, *69*, 19–34. https://doi.org/10.1016/j.sbi.2021.1.010
20. McManus, S. (2014). *Web design in easy steps*. In Easy Steps.
21. Mendoza, J. (2022). *Cost Estimating in Construction*. JCVA. https://www.jcvassociates.ph/post/cost-estimating-in-construction
22. Payumo Nunag, M., & S. Vill Verde, B. (2021). Construction Worker Headcount S-STEM for Cost-Efficient Planning of Residential Buildings in Ampanga, Philippines. *Proceedings of the 5th International Conference on Algorithms, Computing and Systems*, 80–87.
23. Qualitative, D. S. (2025). *No Title*. Deakin University Library. https://deakin.libguides.com/qualitative-study-designs/interviews
24. Raček, T., Schindler, O., Toušek, D., Horský, V., Berka, K., Koča, J., & Svobodová R. (2021). Atomic charge calculator II: Web-based tool for the calculation of partial atomic charges. *Nucleic Acids Research*, *48* W1), W591–W596. https://do .org/10.1093/NAR/GKAA367
25. Rahardja, D. (2024). Advantages and disadvantages of time-series forecast computation via Microsoft Excel and three different SAS products, Dewi Rahardja. *Journal of Statistics & Management Systems*, *27*(4), 769–784. htt s://doi.org/10.47974
26. Revano, T. (2019). *Living in the Information Technology Era*. Mindshapers Co., Inc.
27. Revolti, A., Gualtieri, L., Pauwels, P., & Dallasega, P. (2024). From building information modeling to construction digital twin: a conceptual framework. *Production and Manufacturing Research*, *12*(1. https://doi.org/10.1080/21693277.2024.238 679
28. Senarath, U. S. (2021). Waterfall methodology, prototyping, and agile Development. *Tech. Rep.*, 1–16.
29. Sexton, J. (2013). *Construction Calculators and Estimation Tools*. https://www.inchcalculator.com/about-us/
30. Sharma, H., & Tripathi, K. (2023). The Importance of Website Usability in Digital Marketing- A Review. *International Journal of Innovative Research in Computer Science and Technology*, *11* 3), 27–31. https://doi.org/10. 5524/ijircst. 2023.11.3.5
31. Solutions, A. B. (n.d). *No Title*. Retrieved February 12, 2025, from https://images.autodesk.com/pac_grtrchina_main/files/aec_bim.pdf
32. Srivastava, A., Khadke, L., & Hinnasamy, P. (2022). Developing a web application-based water budget calculator: attaining water security in rural-Nashik, India. *Climate Change and Water Security: Select Proceedings of VCDRR 2021*, 473–492.
33. Tayefeh Hashemi, S., Ebadati, O. M., & Kaur, H. (2020). Cost estimation and prediction in construction projects: a systematic review on machine learning techniques. *SN Applied Sciences*, *2*(10), 1–27. https://doi.org/10.1007/s424 2-020-03497-1
34. Wang, Z., Ouyang, B., & Sacks, R. (2023). CBIM: Object-Level Cloud Collaboration Platform for Supporting Across-Domain synchronous Design. *Proceedings of the European Conference on Computing in Construction*. https://doi.org/10. 5490/EC3.2023.189
35. Yousif, J. H., ajeed, S. N. A., & Azzawi, F. J. I. Al. (2020). *Web-Based Architecture for Automatin Quantity Surveying Construction Cost Calculation*. 1–20. https://doi.org/doi:10.3390/infrastructures5060045