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Toward Successful DevOps: A Decision-Making Framework

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ABSTRACT DevOps (development and operations) is a set of collaborative practices that automate delivery of new software updates with the aim to reduce the development life cycle and produce quality software products. Software organizations face several barriers while adopting DevOps practices as the integration of development and operation teams requires merger of different processes, tools, and skill sets. This study aims to develop a prioritization-based framework of the DevOps best practices based on evidence collected from industry experts. To attain the study aims, firstly, a systematic literature review was conducted to identify DevOps best practices reported in the literature. Next, a questionnaire survey study was conducted to receive insight from industry practitioners for the identified best practice. Finally, the fuzzy-AHP technique was applied to prioritize the best practices concerning to the significance for DevOps process. We believe that the identified best practices, their categorization and fuzzy-AHP based framework will help industry experts to revise and improve their strategies to make the DevOps process sustainable.

INDEX TERMS DevOps, best practices, fuzzy AHP analysis.

I. INTRODUCTION

Software industry is always looking for effective and flexible ways to develop quality software within limited time and cost. Recently, DevOps paradigm has gained popularity in software development process [1], [2]. DevOps provides platform for both development and operation teams to work collaboratively to develop software products. DevOps facilities cross functional shared responsibilities and trust between both types of development and operation teams [3]. DevOps substantially extends the continuous development goals of the agile movement by supporting automation of continuous integration and release processes[4], [5]. Leite *et al.* [6] defined DevOps as: a culture effort that automate organization infrastructure and the processing cycle of software development, guaranteeing the reliability of software product. DevOps offer several benefits to software organizations such as more focus on implementation and frequent release. Moreover, DevOps also automate the build, testing and deployment processes [7]. Forsgren [7] stated that automated development process assists to reduce the human effort and enable the automated deployment according to the schedule.

Likewise, it is emphasized that the automatic development environment significantly contributed towards the development and quality of software applications [8]. The sustainable DevOps execution allow software organizations to deliver frequent small releases which helps improve visualization of modules to the end-user [9]. The small and frequent deployment offers the development teams to receive appropriate suggestions from client which assists to modify overall quality of a product [10]. In-spite of several benefits associated with sustainable DevOps, software practitioners face numbers of challenges for the sustainability

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of DevOps process such as ''fear of change'', ''conceptual deficit'', ''blame game'', and ''complex and dynamic environments'' [11]. Similarly, Jabbari *et al.* [12] stated that communication gap and heterogeneous environments are critical challenges for sustainable DevOps implementation in software industry.

Despite challenges associated with DevOps sustainability in software industry, several well-established organizations such as Etsy, IBM, Netflix, and Flickr have successfully adopted it [13]. For example, in Flickr, effective communication and collaboration in both development and operations practitioners have helped the organization to decrease the release time. The implementations of DevOps practices in different organizations revealed that sustainable DevOps implementation enhances the systems quality and delivery process [13], [14]. Erich *et al.* [13] pointed out that practices for sustainable DevOps are rapidly being adopted by software organizations with an aim to gain benefits with them.

CAMS (Culture, Automation, Measurement, Sharing) presents the core areas of DevOps [15], [16]. Rafi *et al.* [17], Akbar *et al.* [18] and Plant *et al.* [19] indicated that to make the DevOps process sustainable the organizations need to focus on CAMS areas. Thus, the importance of sustainable DevOps process in real-world practices motivated us to conduct comprehensive systematic research to investigate and analyses the guidelines reported in the state-of-art and practices. The objectives of this study are: (1) to conduct a systematic literature review and questionnaire survey approach to explore and verify best practices of sustainable DevOps process; (2) to prioritize the investigated best practices using fuzzy-AHP approach; and (3) to develop a decision-making framework based on the rankings of best practices. As, there is no study conducted to prioritize the best practices of DevOps process. We have filled the research gap by applying the fuzzy-AHP method in DevOps process areas. We believe that the deep understanding of the DevOps best practices will assist the practitioners to manage the DevOps activities effectively and efficiently. The prioritization of best practices provides the rank order, which helps the practitioners to consider the most significant practices which are critical for the successful execution of DevOps process. To reach-out the study objectives, the developed research questions are as follow:

- [RQ1] What guidelines for sustainable DevOps implementation in software development organizations are reported in the literature and industry practices?
- [RQ2] How the explored guidelines were prioritized using fuzzy-AHP?
- [RQ3] What would be the prioritization-based framework for sustainable DevOps guidelines?

The paper is organized as: study background is reported in section 2. The used research methodologies are discussed in section 3. The results and analysis are presented in section 4. Summary of the study findings is shown in section 5. Section 6 presents the threats to validity of study findings. The conclusions and future direction of the study are summarized in section 7.

II. BACKGROUND AND MOTIVATION

Software organizations have shown interest in adoption of software development approaches with reduced development and delivery cycle. The basic intention behind the adoption of new development approaches is the rapid change in the customers' requirements and the consideration of requested change in positive manner. Agile development approaches have been adopted by software industry to address the rapid change concern in software development life cycle [20]. The idea and the success of continues delivery comes-up with a new software development strategy known as DevOps. DevOps is a new software development methodology which focuses on collaboration between Developer and Operation teams to work in an environment where they can share goals, processes, and tools [4], [9], [21]–[23]. In software industry, experts treat DevOps as the cultural movement that assists the development environment concerning with effective communication, control, and responsibilities[20], [24]. Various studies have reported that the collaboration, automation, and services are the key aspects of DevOps [9], [25].

Dyck *et al.* [26] mention that the revolution caused by the DevOps significantly contributed to enhance the level of trust among practitioners that assist to transform and change the development environment in software organizations. Furthermore, Smeds *et al.* [23] ''highlighted that the DevOps is not only a culture change it also helps to improve the development process. Literature also reported the limitation and importance of DevOps paradigm [27]–[29]. According to Banica *et al.* [30], the main advantages of DevOps are product quality services and continues bonding. Similarly, Gupta *et al.* [31] mention that the DevOps supports in trust building between Dev and Ops practitioners. Moreover, they explored and ranked DevOps attributes that are critical to evaluate the readiness considering the adoption of DevOps in an organization. Furthermore Gill *et al.* [32] expressed that the DevOps contributed to develop the bridge between Dev and Ops teams that overcome the communication and coordination gape between practitioners. Wiedemann *et al.* [33] argued that, the DevOps provides the roadmap for project management team to support better performance, understandability, integration, relationships among teams. However, there is a need of strong collaboration, trainings, skills and effective automation to adopt DevOps practices in a practical way.'' The organization adopting DevOps also faced several critical challenges [32]. Gill *et al.* [32] highlighted that the process and procedure-related challenges, cultural conflicts, and the problems in operational models.

The existing literature portrays evidence-based research in the context to explore the guidelines for DevOps sustainability in software organizations. Furthermore, no research has been done to analyze the sustainable DevOps guidelines using the fuzzy-AHP approach. This detailed empirical investigations and analysis, will help the teams to understand and develop the methodologies for sustainable implementation of DevOps in software development industry.

III. RESEARCH DESIGN

The research design is outlined in Figure 1. First, a SLR was conducted to identify the best practices associated with DevOps projects. Next, a questionnaire survey study was conducted to get feedback from industry practitioners on the identified DevOps best practices. Finally, the fuzzy-AHP was used to prioritize the identified best practices.

A. SYSTEMATIC LITERATURE REVIEW (SLR)

In this study, we have used the guidelines developed by Kitchenham and Charters [34] to conduct the SLR. The SLR consists of three phases namely, ''planning the review'', ''conducting the review'' and ''reporting the review''.

1) PLANNING THE REVIEW

Planning refers to developing the protocols adopted to collect and analyses the data. The following review protocol steps were carried out to extract and analyses the literature to answer the proposed research question.

a: DATA COLLECTION SOURCE

Selection of appropriate data sources is essential to identify literature related to the research objective of the study. In this study, we followed guidelines of Chen *et al.* [35] and Zheng *et al.* [36]; and following digital repositories were selected to search for related primary studies.

- ''IEEE Xplore (http://ieeexplore.ieee.org)''
- ''ACM Digital Library (http://dl.acm.org)''
- ''Springer Link (http://link.springer.com)''
- ''Wiley Inter-Science (www.wiley.com)''
- ''Science Direct (http://www.sciencedirect.com)''
- ''Google Scholar (http://scholar.google.com)''
- ''IET Software (https://digital-library.theiet.org)''

b: SEARCH STRING

We followed the guidelines presented in [36], [37] to develop search string for the study. First, key terms were identified from relevant studies [1], [13], [30], [32], [38]. Next, we used the ''AND'' and ''OR'' operators to formulate the search string by using key terms and their synonyms as follows:

''''best practices'' OR ''practices'' OR ''motivators'' OR ''activities'' OR ''Concerns'' OR ''techniques'' OR ''tools,'' OR ''methods,'' OR ''process'' OR ''evaluation'') AND (''DevOps'' OR ''Development and Operation,'' OR ''Continues development and operation.''''

c: INITIAL INCLUSION CRITERIA

Study inclusion criteria are as follows: (1) ''The paper should be published in a well-reputed journal, conference, or book chapter''. (2) ''The article should explain the best practices for DevOps implementation''. (3) ''Study results should be based on empirical data''. (4) ''Selected literature should be in English language''.

d: INITIAL EXCLUSION CRITERIA

Study exclusion criteria are as follows: (1) ''If two studies are from a similar research project, only the most completed one was considered''. (2) ''The paper does not provide detail information about DevOps implementation''. (3) ''The study that not related to the study objective''. (4) ''The literature review studies were not considered''.

e: STUDY QUALITY ASSESSMENT (QA)

The quality assessment process was performed to decide suitability of the selected primary studies concerning to the study objective. The QA process is performed based on Kitchemhm and Charctros [34] guidelines. The QA process was performed based on consists of five questions as shown in Table 1. Detailed results of the QA process are presented in Appendix-A.

2) CONDUCTING THE REVIEW

a: FINAL STUDY SELECTION

Primarily, 860 studies were extracted in the response of the search string executed on the selected databases. The collected literature was further refined by applying the tollgate approach developed by Afzal *et al.* [39]. The tollgate approach consists of five phases, and each step is performed carefully, aiming to select the studies for data extraction finally. A total of 71 studies were selected for the final data extraction process as shown in Figure 2. The list of selected studies and their QA score is given in Appendix-A.

b: DATA EXTRACTION AND SYNTHESIS

The selected 71 studies (Figure 2) were carefully reviewed to extract relevant information to answer the research questions of the study. Author one and three of the study were involved in the data extraction phase, while authors two, four and five validated the extracted data. First, main theme concepts and practices were identified from the selected studies. Next, we synthesized the collected data into 48 best practices for implementing DevOps projects.

In order to avoid potential bias in the study, we performed the ''inter-rater reliability'' test [39]. Three external experts randomly selected 12 studies and performed the data extraction process. Next, we compared findings of research team with external experts by applying the non-parametric ''Kendall's coefficient of concordance'' (W)[40]. ''The value of W=1 indicates the complete agreement, and W=0 indicates complete disagreement''. The results of W=0.84 p=0.003 shows a significant agreement between findings of research team and external experts. The used code is given in this link: *https://tinyurl.com/y5fct4ql*.

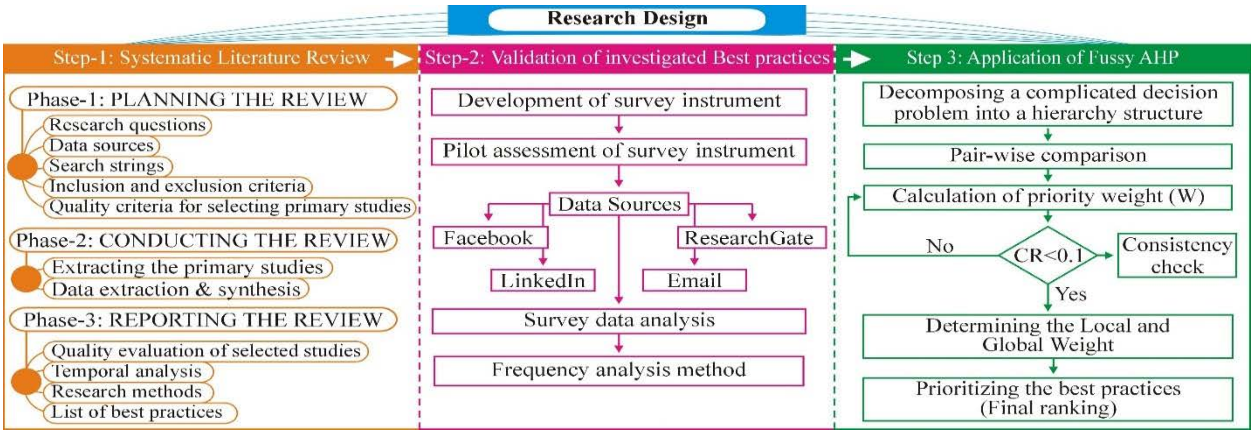

FIGURE 1. Study research design.

TABLE 1. QA criteria.

Checklist Questions	Likert scale
"Does the used research approach address the research questions?"	Yes=1, Partial=0.5, NO=0
"Does the study discuss the best practices of DevOps?"	Yes=1, Partial=0.5, NO=0
"Does the study have a clear motivation for DevOps implementation?"	Yes=1, Partial=0.5, NO=0
"Is the collected data related to DevOps practices execution?"	Yes=1, Partial=0.5, NO=0
"Are the identified results related to the justification of the research questions?"	Yes=1, Partial=0.5, NO=0

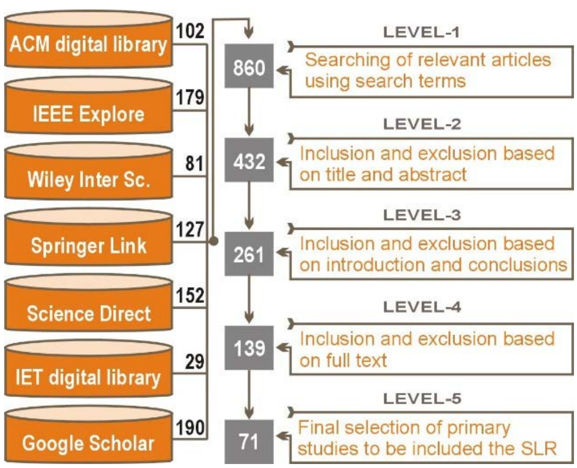

FIGURE 2. Refinement of formal studies.

3) REPORTING THE REVIEW

a: QUALITY OF SELECTED STUDIES

The quality of the selected studies assess using the criteria given in Table 1. According to the results given in appendix-A, 70% of selected studies scored more than 75%; and this shows that the selected studies are potential sample of literature to address the study objective.

b: EXTRACTED DATA

By carefully reviewing the each selected study, 48 best practices were identified. The list of the explored best practices is given in Table 4. The identified best practices gives the guidelines to the practitioners for the successful execution of DevOps process in real-world environment.

B. EMPIRICAL STUDY

1) QUESTIONNAIRE SURVEY

A questionnaire survey was developed to seek feedback from industry practitioners. The survey participants were asked to rank the DevOps best practices identified from the SLR study. First, the questionnaire survey was tested through a pilot study involving one developer from academia (Chongqing University, Chain) and two from industry (Virtual force-Pakistan and QSoft-Vietnam). Next, based on the feedback received from the pilot testing phase, final version of the questionnaire survey was prepared. The survey is divided into three sections. First section collects demographic data, second section seeks feedback on the identified best practices, and the third section included an open-ended question that allowed the participants to include additional best practices or comments. Final version of the survey is presented in Appendix-B.

2) DATA SOURCES

The target population for the survey was software practitioners with experience in DevOps projects. The participants of the study were recruited by using the snow balling techniques [41]–[43]. The data collection process was executed from December-2020 to February-2021. The completed surveys were manually reviewed for completeness and five

TABLE 2. Triangular fuzzy numbers.

Operation Law	Expression
Addition ($V_1 \oplus V_2$)	$(v^l_1, v^m_1, v^u_1) \oplus (v^l_2, v^m_2, v^u_2) = (v^l_1 + v^l_2, v^m_1 + v^m_2, v^u_1 + v^u_2)$
Subtraction ($V_1 \oplus V_2$)	$(v^l_1, v^m_1, v^u_1) \oplus (v^l_2, v^m_2, v^u_2) = (v^l_1 - v^l_2, v^m_1 - v^m_2, v^u_1 - v^u_2)$
Multiplication ($V_1 \oplus V_2$)	$(v^l_1, v^m_1, v^u_1) \oplus (v^l_2, v^m_2, v^u_2) = (v^l_1 * v^l_2, v^m_1 * v^m_2, v^u_1 * v^u_2)$
Division ($V_1 \oplus V_2$)	$(v^l_1, v^m_1, v^u_1) \oplus (v^l_2, v^m_2, v^u_2) = (v^l_1 / v^l_2, v^m_1 / v^m_2, v^u_1 / v^u_2)$
Inverse ($V_1 \oplus V_2$)	$(v^l_1, v^m_1, v^u_1)^{-1} = (1/v^l_1, 1/v^m_1, 1/v^u_1)$
For any real number k (kV_1)	$k(v^l_1, v^m_1, v^u_1) = k\, v^l_1, k\, v^m_1, k\, v^u_1$

incomplete responses were rejected. Finally, 93 responses were used for further data analysis process. The bibliographic information is presented in section-4.2.

3) SURVEY DATA ANALYSIS

In this study, we used the frequency data analysis approach to analyze the collected responses, as it is considered the effective way to compares the responders opinions in between the variables and across the group of variables [44]. The same approach has been adopted in the existing studies [45]–[47].

C. PHASE 3: FUZZY SET THEORY AND AHP

The fuzzy-AHP technique has been adopted in various other research domain for solving the complex decision-making problems in production houses, managerial policies and numerous other areas. For example, for selection of intelligent building systems by Wong and Li [48], prioritizing the key success factors of software projects by Yaghoobi [49], clinical engineering health technology projects assessment by Sloane *et al.* [50], selection and evaluation of the project in mechanical engineering by Palcic and Lalic [51], risk analysis and management of engineering projects by Wen-Ying [52], prioritizing the challenging factors of agile development in distributed software development the context by Shameem *et al.* [53], prioritize the coordination barrios of humanitarian supply chain management by Kabra *et al.* [54], improve the human decision-making problems by Albayrak and Erensal [55]. Thus, to prioritize the identified best practices of DevOps, we applied fuzzy AHP as it is successfully adopted to address the multi-criteria decision-making problem in various engineering domain. The implementation process of fuzzy AHP steps is discussed in this section.

1) FUZZY SET THEORY

The Fuzzy set theory is an extended version of classical set theory that's initially proposed by Zadeh *et al.* [56]. That was oriented to fix the vagueness of uncertainties of ear world practices using multicriteria decision making problems.

The basic input of Fuzzy set theory is to epitomize the vague data. In the fuzzy set, a membership function μF(x) is characterized, which maps an object between 0 and 1. The protocols of fuzzy set theory along with definition are presented in sub-sequent sections:

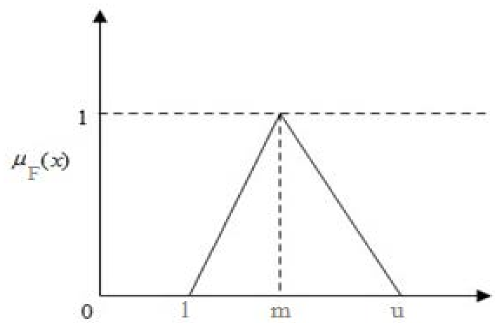

FIGURE 3. Triangular fuzzy number.

Definition: "A triangular fuzzy number (TFN) F is denoted by a set (vl, vm, vu)", as presented in Figure 3. The given equation

Defines the membership function μF(x) of F.

$$\mu_F(x) = \begin{cases} \frac{t-v^l}{v^m-v^l}, & v^l \le t \le v^m \\ \frac{v^u-t}{v^u-v^m}, & v^m \le t \le v^u \\ 0, & Otherwise \end{cases} (1) \quad (1)$$

where v^l, $v^m$and v^u are the crisp numbers denoting the lowest, most promising, and highest possible values respectively.

The "algebraic operational laws using two TFNs, namely (V_1, V_2) are given in Table 2."

2) FUZZY ANALYTICAL HIERARCHY PROCESS (FAHP)

FAHP is the most effective and powerful approach used to solve the multicriteria decision making problems. The key benefit of FAHP is the relative ease with which it manages the multiple criteria, easier to understand, and it can efficiently manage both qualitative and qualitative data. The following primary step of FAHP approach:

"Step1-Decompose the complex decision problem into the hierarchical structure" (Figure 4)."

"Step2-Calculate priority vector at each level of hierarchy with the help of pairwise comparison."

"

"Step3-Compute the consistency ratio of the pairwise comparison."

"Step4- Calculate the final priority weight for the factors and the sub-factors" (Figure 4)."

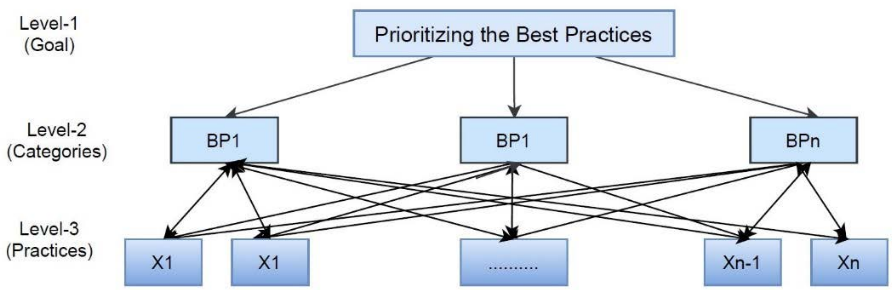

FIGURE 4. FAHP decision hierarchy.

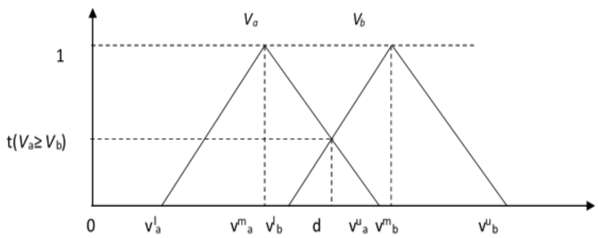

FIGURE 5. Triangular fuzzy number.

However, conventional AHP has numerous advantages [57]–[59], but it also faced some core limitations as it is based on the "Crisp environment", "Judgmental scale is unbalanced", and the "absence of uncertainty", and because of these limitations the selection of judgment is subjective. The FAHP was developed to address these limitations of AHP to get results more effectively and accurately [51]. The FAHP deals with uncertainties, imprecise judgment of different experts by handling the linguistic variables. FAHP approach has been considered in different context [49], [50], [52], [54]. To address the uncertainties and vagueness we have used the FAHP suggested by Chang [60] that provides more appropriate and consistent results compared with other FAHP approaches.

In a prioritization problems, let $X = \{v_1, v_2 \ldots, v_n\}$ signify the "elements of main categories as an object set and $U = \{t_1, t_2 \ldots, t_n\}$ shows the elements of each category as a goal set. Considering the Chang [60] approach, every object is measured, and extent analysis for each goal (gi) is executed, respectively. Thus, for each object, there are (m) extent analysis values that can be obtained with the following Equation" (2) and (3):

$$V^1_{gi}, V^2_{gi}, \ldots, V^m_{gi}, (2) i = 1, 2, \ldots, n\,(3) \tag{2}$$

$$T^1_{gi} T^2_{gi} T^m_{gi}, i = 1, 2, \ldots, n\,(3) \tag{3}$$

where, all $F^j_{gi,}$ (j = 1, 2, ..., m) are fuzzy triangular numbers (TFNs).

The following are the critical steps of Chang's extent analysis method[60]:

Step 1-The element of fuzzy synthetic extent (S_i) for the i^{th} object using Eq. (4):

$$S_i = \sum_{j=1}^{m} V^j_{gi} \otimes \left[\sum_{i=1}^{n}\sum_{j=1}^{m} V^j_{gi}\right]^{-1} \tag{4}$$

To achieve the expression $\sum_{j=1}^{m} V^j_{gi}$, execute the fuzzy addition operation of m extent analysis using Eq. (5):

$$\sum_{j=1}^{m} V^j_{gi} = \left(\sum_{j=1}^{m} v^l_{gi}, \sum_{j=1}^{m} v^m_{gi}, \sum_{j=1}^{m} v^u_{gi}\right) \tag{5}$$

and to make the expression $\left[\sum_{i=1}^{n}\sum_{j=1}^{m} V^j_{gi}\right]^{-1}$, the fuzzy addition operation is performed on $V^j_{gi}(j = 1, 2, \ldots, m)$ value, as follow using Eq. (6):

$$\sum_{i=1}^{n}\sum_{j=1}^{m} V^j_{gi} = \left(\sum_{i=1}^{n} v^l_i, \sum_{i=1}^{n} v^m_i, \sum_{i=1}^{n} v^u_i\right) \tag{6}$$

Finally, calculate the inverse of the vector with the help of Eq. (7):

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} V^j_{gi}\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} v^u_i}, \frac{1}{\sum_{i=1}^{n} v^m_i}, \frac{1}{\sum_{i=1}^{n} v^l_i}\right) \tag{7}$$

Step 2-As F_a and F_b are two fuzzy triangular numbers, then these fuzzy numbers need to be compared that is knows as Degree of possibility i.e. $V_a = (v^l_{a,} v^m_{a,} v^u_a) \geq V_b = (v^l_{b,} v^m_{b,} v^u_b)$ and is compared as follows using Eq.(8) and Eq. (9).

$$V(V_a \geq V_b) = sup[min(\mu v_a(x), (\mu v_b(x))] \tag{8}$$

$$V(V_a \geq V_b) = hgt(V_a \cap V_b) = \mu_{v_a}(d) = \left\{\begin{array}{cc} 1 & if\ v^m_b \geq v^m_a \\ \frac{v^l_b - v^u_a}{(v^m_b - v^u_a) + (v^m_b - v^l_b)} & Otherwise \\ 0 & v^l_a \leq v^u_b \end{array}\right\} \tag{9}$$

Here, d indicate the highest intersection point between D, $\mu V_{a,}$ and μ_{Vb}(Figure 5). The values of $T_1(V_a \geq V_b)$ and

$T_2(V_a \geq V_b)$ are compulsory for determining the value of P_1 and P_2.

Step 3-Determine the degree of possibility for a convex fuzzy number to be greater than k convex fuzzy numbers Vi ($i = 1, 2, \ldots, k$) can be calculated as follow using Eq. (10) and Eq.(11):

$$T(V \geq V_1, V_2, V_3 \ldots V_k) = \min T(V \geq V_i) \tag{10}$$

Assuming that,

$$d'(V_i) = \min T(V_i \geq V_k) \tag{11}$$

for k = 1,2,...,n; $k \neq i$.

With the help of Eq. 12, calculate the weight vector.

$$W' = (d'(V_1), d'(V_2), d'(V_3), \ldots .d'(V_n)) \tag{12}$$

where, $V_i(i = 1,2,\ldots,n)$ are n distinct elements.

Step 4- The normalized weight vectors are calculated using Equation 13, and the result will be a non-fuzzy number (known as defuzzification) which represents priority weight for the criteria:"

$$W = (d(V_1), d(V_2), d(V_3), \ldots, d(V_n)) \tag{13}$$

where W is a non-fuzzy number.

Step 5- Checking consistency ratio: The pairwise matrices should always be consistent in fuzzy AHP [53]. Therefore, it is necessary to check the consistency ratio of each pairwise comparison matrices [61], [62]. To do so, the graded mean integration approach is utilized for de-fuzzifying the matrix. A triangular fuzzy number, denoted as P = (l, m, u), can be de-fuzzified to a crisp number as follows:

$$P_{crisp} = \frac{(4m + l + u)}{6} \tag{14}$$

After the defuzzification of each value in the matrix, consistency ratio (CR) of the matrix can easily be calculated and checked whether CR is smaller than 0.10 or not. For this, two primary parameters, i.e., consistency index (CI) and consistency ratio (CR) are used, which are defined using Equations 14 and 15, respectively.

$$CI = \frac{I_{\max} - n}{n - 1} \tag{15}$$

$$CR = \frac{CI}{RI} \tag{16}$$

where,

$I_{\max}$: the largest eigenvalue of the comparison matrix,"

n: the number of items being compared in the matrix

RI: the random index and its value can opt from Table 3.

To be a consistent matrix, the computed value of CR should less than 0.10. If the value of CR is found to be higher than 0.10, the decision-maker has to make the pairwise judgments again.

IV. RESULTS AND ANALYSIS

A total of 48 best practices were identified from the literature. We also map the best practices into different categories of CAMS framework (culture, automation, measurement and sharing) [17], [63]. The coding based scheme [64] was used to map the identified DevOps best practices in the core categories of CAMS. The mapping team consist of three authors of this study (Author no.1, 3 and 4). The mapping results are given in Table 4.

A. RESULTS OF EMPIRICAL INVESTIGATIONS

1) RESPONDENTS' BIBLIOGRAPHIC INFORMATION

In the questionnaire survey, we had participants are from 20 different countries, as shown in Figure 6. Moreover, we had 26 (22%) participants from small organizations, 49 (42%) are belongs to medium organizations, and 41 (35%) are from large scale organizations, as shown in Figure 7.

a: RESPONDENTS WORKING EXPERIENCE

The results presented in Figure 8 shows the experience of survey respondents' range between 2 to 20 years. The mean and medium were calculated, and the results (6 and 5.5 respectively) indicate the young pool of the respondents. Thus, there is a good combination of survey participants having different experience levels related to software development activities.

b: RESPONDENT's DESIGNATIONS

Cois *et al.* [38] mention that the responses are varied with respect to the designation of participants. Gupta *et al.* [31] reported that a respondent could only be measured appropriately if the participants deal with it frequently. The analyzed results show that most of the survey participants either project manager or software developers. The detailed results are shown in Figure 9.

2) RESPONDENTS FEEDBACK

Questionnaire survey study aimed to get the feedbacks of experts about the identified best practices and their categories. During the data collection process, a total of 116 complete response were considered for further analysis. The collected responses were summarized into three core categories, i.e., Positive (strongly agree, agree), neutral, Negative (strongly disagree, disagree) Table 5. The results presented in the positive category shows the opinions of those participants who agree with the identified best practices identified via SLR and their categories. The responses presented in the negative category shows the opinions of those respondents who do not agree with identified best practices their categories. The results presented in the neutral category shows the responses of those participants who do not have any idea with the impact of identified factors.

The results of the empirical study presented in Table 5 shows that most of the survey participants agree as

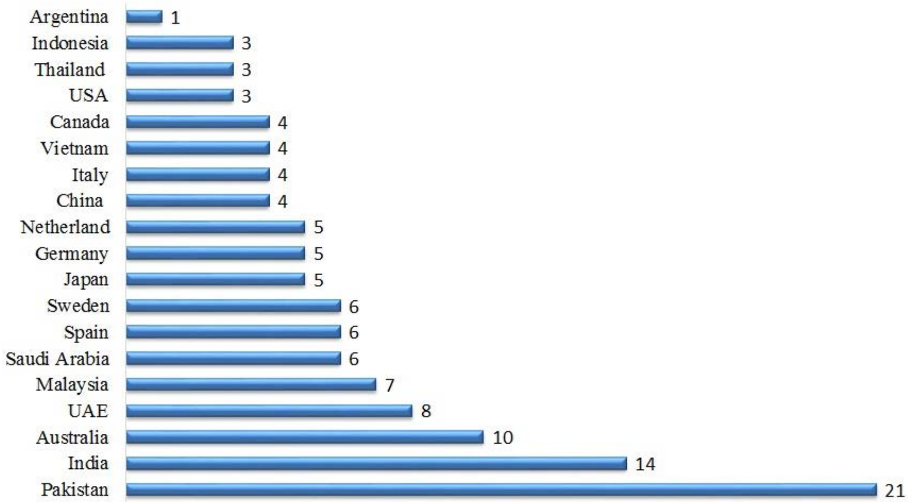

FIGURE 6. Respondent's affiliation countries.

TABLE 3. Random consistency index (RI) with respect to matrix size.

Size of the matrix"	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Random consistency index" (RI)	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

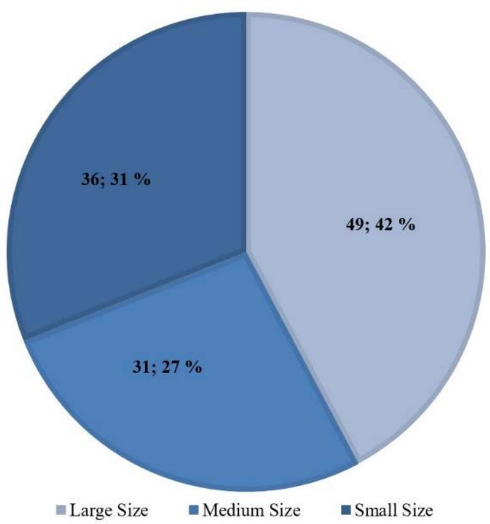

FIGURE 7. Respondents organization size.

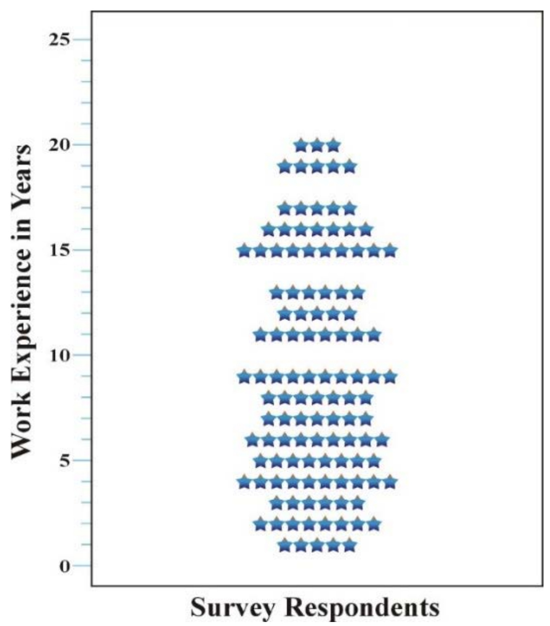

FIGURE 8. Experience of survey respondents.

the reported best practices could positively influence the adoption of DevOps in software organizations. It is observed that BP41 (Enterprises should focus on building a collaborative culture with shared goals, 91%) is reported as the most important best practices from the survey participants. We further noted that BP9 (Emphasize Quality Assurance Early, 88%) and BP40 (Keep All Teams on the Same Page, 88%) are declared as the second highly considered best practices by the survey respondents.

Moreover, it is noted that C4 (Culture, 93%) is the most important category of the investigated best practices as considered by the survey participants. C3 (Sharing, 88%) and C1 (Measurement, 84%) is declared as the second and third highest regarded as categories of the best practices considered by the survey participants.

B. APPLICATION OF FUZZY-AHP

The fuzzy-AHP approach was used to prioritize the investigated best practices with respect to their significance for the

TABLE 4. List of identified best practices and their mapping in CAMS.

Categories	Sr. No	Best practices	IDs of selected SLR studies
Measurement	BP1	Organizations start DevOps practices with small projects	PS1, PS3, PS13, PS 16, PS19, PS 21, PS29, PS33, PS37, PS41, PS46, PS47, PS52, PS55, PS58, PS64, PS70
	BP2	nclude modeling for legacy infrastructure and applications in your DevOps plans	PS6, PS15, PS 18, PS25, PS 31, PS39, PS43, PS54, PS67
	BP3	Consider application architecture changes based on on-premises, cloud, and containers early on in the process	PS9, PS17, PS27, PS 36, PS44, PS 55, PS70
	BP4	Avoid fragmented toolset adoption, which can add to your costs	PS2, PS5, PS10, PS 12, PS17, PS 24, PS28, PS34, PS38, PS44, PS45, PS50, PS54, PS57, PS61, PS68
	BP5	Effective and comprehensive measurement and monitoring	PS5, PS10, PS 14, PS18, PS 25, PS27, PS35, PS39, PS43, PS46, PS50, PS55, PS61, PS64, PS66
	BP6	Decide which processes and tests to automate first	PS1, PS7, PS 17, PS26, PS 31, PS43, PS44, PS56, PS61, PS70
	BP7	Monitor the Application's Performance	PS4, PS7, PS11, PS20, PS 22, PS28, PS34, PS38, PS42, PS45, PS49, PS53, PS54, PS56, PS59, PS66, PS70, PS71
	BP8	Integrated Configuration Management	PS11, PS22, PS31, PS 42, PS53, PS59, PS69
	BP9	Emphasize Quality Assurance Early	PS6, PS9, PS 15, PS23, PS 29, PS31, PS37, PS42, PS45, PS54, PS60, PS63, PS67
	BP10	Active Stakeholder Participation	PS5, PS13, PS 19, PS27, PS 30, PS36, PS43, PS49, PS55,
	BP11	Use tools to capture every request	PS8, PS18, PS 25, PS33, PS 45, PS52, PS60, PS61
	BP12	Decide which processes and tests to automate first	PS4, PS8, PS 12, PS16, PS 26, PS30, PS36, PS38, PS40, PS45, PS52, PS56, PS62, PS68
	BP13	Continuous integration and testing	PS4, PS5, PS 19, PS30, PS 41, PS47, PS52, PS65, PS70
	BP14	Implement tracking and version control tools	PS 9, PS14, PS 24, PS28, PS36, PS37, PS42, PS51, PS59, PS62, PS66
Automation	BP15	Have a centralized unit for DevOps	PS5, PS8, PS13, PS 15, PS23, PS 24, PS30, PS35, PS37, PS40, PS44, PS50, PS57, PS64
	BP16	Reduce handoffs	PS3, PS9, PS14, PS 16, PS21, PS 23, PS29, PS36, PS37, PS41, PS46, PS48, PS52, PS57, PS68, PS69
	BP17	Implement Automation in Dashboards	PS2, PS11, PS14, PS30, PS 38, PS45, PS54, PS64, PS66
	BP18	Use the right and advanced tools	PS7, PS15, PS16, PS 22, P25, PS 31, PS34, PS39, PS42, PS47, PS55, PS61, PS69
	BP19	Use tools to capture every request	PS9, PS17, PS 23, PS35, PS 41, PS47, PS53, PS64
	BP20	Use tools to log metrics on both manual and automated processes	PS7, PS8, PS 13, PS24, PS 27, PS32, PS39, PS43, PS46, PS51, PS60
	BP21	Provisioning and change management	PS3, PS6, PS15, PS 17, PS19, PS 25, PS29, PS35, PS39, PS45, PS47, PS51, PS55, PS56, PS62, PS67, PS69, PS70
	BP22	Build Up the Rest of Your CI/CD Pipeline	PS6, PS11, PS18, PS 24, PS28, PS 34, PS35, PS39, PS45, PS52, PS57, PS70
	BP23	Take a 'security first approach'	PS11, PS19, PS 26, PS34, PS 42, PS51, PS59
	BP24	Use on-demand testing environments	PS3, PS10, PS 17, PS20, PS 25, PS32, PS35, PS41, PS46, PS50, PS58, PS60, PS62
	BP25	Develop automated continues deployment environment	PS2, PS7, PS9, PS 11, PS13, PS 16, PS23, PS26, PS29, PS34, PS37, PS41, PS45, PS52, PS58, PS64, PS68, PS70
	BP26	Standardize and automate complex DevOps environments with cloud sandboxes and other tools	PS6, PS11, PS 15, PS22, PS 26, PS31, PS38, PS42, PS44, PS49, PS51, PS53, PS56,PS61, PS65
Sharing	BP27	nsure continuous feedback between the teams to spot gaps, issues, and inefficiencies	PS8, PS13, PS15, PS 23, P26, PS 29, PS35, PS38, PS45, PS49, PS56, PS69
	BP28	Communications and collaboration planning	PS4, PS4, PS8, PS 12, PS15, PS 19, PS22, PS28, PS29, PS31, PS35, PS39, PS43, PS54, PS59, PS65, PS69, PS70, PS71
	BP29	Continuous practice and planning to avoid resistance	PS13, PS17, PS 25, PS36, PS 45, PS53, PS62
	BP30	Create real-time project visibility	PS5, PS 20, PS31, PS37, PS44, PS48, PS52, PS54, , PS66
	BP31	ncrease flow of communication by reducing batch size	PS1, PS7, PS 16, PS21, PS 27, PS33, PS35, PS43, PS48, PS56, PS67
	BP32	Building trust and share values and goals for effective channel	PS3, PS4, PS10, PS 15, PS16, PS 20, PS24, PS27, PS30, PS32, PS36, PS38, PS45, PS46, PS52, PS54, PS62, PS65, PS66, PS68
	BP33	Enterprises should standardized processes and establish common operational procedures	PS9, PS11, PS 17, PS22, PS 25, PS30, PS34, PS41, PS47, PS49, PS51
	BP34	Create a clear plan that includes milestones, project owners, and well-defined deliverables	PS4, PS8, PS 14, PS22, PS 25, PS30, PS34, PS41, PS47, PS49, PS51, PS55, PS56, PS63
	BP35	Teams need training on DevOps	PS5, PS12, PS 21, PS32, PS35, PS42, PS45, PS51, PS55, PS61, PS71
	BP36	Shared code of conduct, a formal roles assignment, and clear and simple processes may help in understanding responsibilities	PS1, PS9, PS 18, PS24, PS32, PS40, PS46, PS52, PS56, PS60, PS62, PS 69, PS71

TABLE 4. *(Continued.)* **List of identified best practices and their mapping in CAMS.**

Culture	BP37	Exercise Patience	PS5, PS7, PS12, PS 13, PS17, PS 21, PS23, PS26, PS31, PS34, PS35, PS40, PS43, PS47, PS50, PS53, PS58, PS64
	BP38	Educate executives at your company about the benefits of DevOps, in order to gain resource and budget support	PS7, PS16, PS 25, PS33, PS39, PS46, PS49, PS54, PS62
	BP39	Cohesive team work to fill gap during Isolation changes	PS2, PS4, PS7, PS 14, PS 18, PS20, PS23, PS32, PS33, PS37, PS42, PS45, PS48, PS49, PS52, PS56, PS59, PS65, PS67
	BP40	Keep All Teams on the Same Page	PS4, PS10, PS 18, PS27, PS31, PS39, PS42, PS49, PS51, PS56, PS63
	BP41	Enterprises should focus on building a collaborative culture with shared goals	PS3, PS6, PS11, PS 17, PS19, PS 23, PS26, PS30, PS33, PS35, PS39, PS41, PS47, PS51, PS53, PS56, PS61, PS68
	BP42	Consider DevOps to be a Cultural Change	PS3, PS9, PS 13, PS21, PS 27, PS33, PS37, PS42, PS45, PS48, PS50, PS56, PS64
	BP43	Select DevOps "Champions"	PS1, PS2, PS11, PS 17, PS22, PS 28, PS34, PS37, PS40, PS42, PS48, PS49, PS55, PS60, PS62
	BP44	Assess your organization's readiness to utilize a microservices architecture	PS2, PS4, PS10, PS 14, PS19, PS 24, PS25, PS30, PS36, PS39, PS43, PS45, PS49, PS54, PS57, PS69
	BP45	Become a Psychologist	PS5, PS11, PS 16, PS24, PS 26, PS32, PS39, PS42, PS48, PS54, PS59, PS65
	BP46	Commit daily, reduce branching	PS8, PS16, PS 26, PS34, PS 39, PS46, PS50, PS58, PS68
	BP47	Understand and address your unique needs	PS7, PS14, PS20, PS 25, PS36, PS 44, PS46, PS51, PS56
	BP48	Start toward Your Business Goals	PS10, PS19, PS 27, PS37, PS45, PS52, PS61, PS62, PS70

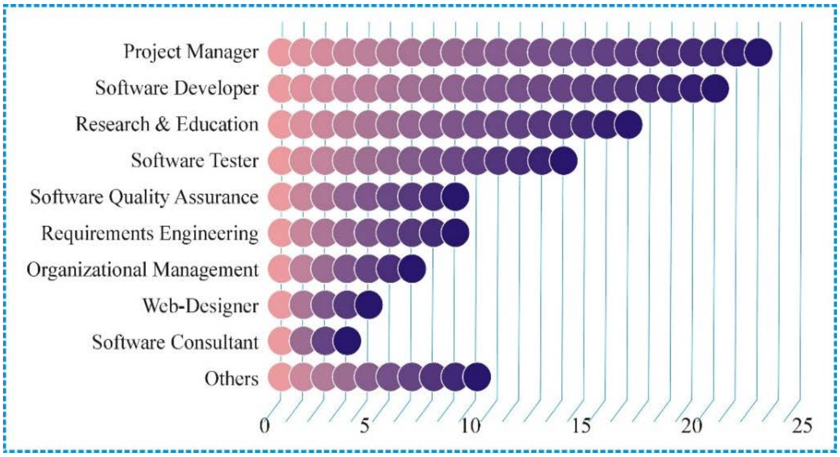

FIGURE 9. Designation of survey participants.

success and progression of DevOps paradigm. To perform the fuzzy-AHP analysis, we used the "MATLAB R2016b programming environment developed by math works is an American privately held corporation", which was executed on a computer with an Intel Corei3, 3.5-GHz processor and 8-GB memory. The adopted phases of Fuzzy-AHP approach are presented in the subsequent sections.

1) STEP-1 PROPOSED HIERARCHY STRUCTURE OF REPORTED BEST PRACTICES AND THEIR CATEGORIES

To apply the fuzzy-AHP, the critical session making problem is arranged in a hierarchy structure (as presented in Figure 4). The proposed hierarchy structure (Figure 10) was developed by considering the investigated best practices and their core categories. The main objective of the study is found on the first levels (i.e., prioritization of DevOps best practices), the categories and their corresponding best practices are given on level-2 and level-3, respectively. The proposed hierarchy structure is presented in Figure 10.

2) STEP-2 CONDUCTING THE PAIRWISE COMPARISON

The purpose of this study is to prioritize the identified best practices and their categories concerning their significance for the successful implementation of DevOps paradigm. To perform the pairwise comparison (for fuzzy-AHP analysis), we have developed a questionnaire and contacted respondents of the first survey. A total of 29 responses were received from the survey participants. All the responses were manually reviewed to check for incomplete data. We found that all the 29 responses were complete. A sample of the pairwise questionnaire survey (second survey) is given in Appendix-C. Small sample size can be one potential issue with the application of fuzzy-AHP analysis. However,

TABLE 5. Results of a questionnaire survey study.

S. No.	Best practices and their categories	Number of responses =116							
		Positive			Negative			Neutral	
		S.A	A	%	D	S.D	%	F	%
C1	Measurement	40	57	84	2	6	7	11	9
BP1	Organizations start DevOps practices with small projects	40	56	83	4	1	4	15	13
BP2	Include modeling for legacy infrastructure and applications in your DevOps plans	51	42	80	5	5	9	13	11
BP3	Consider application architecture changes based on on-premises, cloud, and containers early on in the process	46	39	73	9	3	10	19	16
BP4	Avoid fragmented toolset adoption, which can add to your costs	40	57	84	2	6	7	11	9
BP5	Effective and comprehensive measurement and monitoring	37	51	76	6	4	9	18	16
BP6	Decide which processes and tests to automate first	49	34	72	7	6	11	20	17
BP7	Monitor the Application's Performance	37	48	73	6	7	11	18	16
BP8	Integrated Configuration Management	31	61	79	3	6	8	15	13
BP9	Emphasize Quality Assurance Early	58	44	88	0	3	3	11	9
BP10	Active Stakeholder Participation	41	47	76	7	6	11	15	13
BP11	Use tools to capture every request	30	64	81	2	6	7	14	12
C2	Automation	41	54	82	3	6	8	12	10
BP12	Decide which processes and tests to automate first	39	46	73	8	7	13	16	14
BP13	Continuous integration and testing	39	48	75	6	8	12	15	13
BP14	Implement tracking and version control tools	30	51	70	10	5	13	20	17
BP15	Have a centralized unit for DevOps	39	44	72	14	7	18	12	10
BP16	Reduce handoffs	33	40	63	16	5	18	22	19
BP17	Implement Automation in Dashboards	42	53	82	6	2	7	13	11
BP18	Use the right and advanced tools	39	56	82	8	3	9	10	9
BP19	Use tools to capture every request	51	47	84	2	3	4	13	11
BP20	Use tools to log metrics on both manual and automated processes	45	48	80	4	4	7	15	13
BP21	Provisioning and change management	33	56	77	8	4	10	15	13
BP22	Build Up the Rest of Your CI/CD Pipeline	39	53	79	9	5	12	10	9
BP23	Take a 'security first approach'	41	55	83	7	6	11	7	6
BP24	Use on-demand testing environments	35	50	73	7	9	14	15	13
BP25	Develop automated continues deployment environment	43	44	75	9	4	11	16	14
BP26	Standardize and automate complex DevOps environments with cloud sandboxes and other tools	31	61	79	3	6	8	15	13
C3	Sharing	58	44	88	0	3	3	11	9
BP27	Ensure continuous feedback between the teams to spot gaps, issues, and inefficiencies	41	47	76	6	7	11	15	13
BP28	Communications and collaboration planning	30	64	81	2	6	7	14	12
BP29	Continuous practice and planning to avoid resistance	41	47	76	6	7	11	15	13
BP30	Create real-time project visibility	39	46	73	8	7	13	16	14
BP31	Increase flow of communication by reducing batch size	39	48	75	7	7	12	15	13
BP32	Building trust and share values and goals for effective channel	37	55	79	7	4	9	13	11
BP33	Enterprises should standardized processes and establish common operational procedures	39	49	76	5	7	10	16	14
BP34	Create a clear plan that includes milestones, project owners, and well-defined deliverables	40	47	75	6	4	9	19	16

TABLE 5. *(Continued.)* **Results of a questionnaire survey study.**

BP35	Teams need training on DevOps	46	39	73	8	4	10	19	16
BP36	Shared code of conduct, a formal roles assignment, and clear and simple processes may help in understanding responsibilities	40	57	84	2	6	7	11	9
C4	Culture	47	61	93	0	0	-	8	7
BP37	Exercise Patience	49	34	72	7	6	11	20	17
BP38	Educate executives at your company about the benefits of DevOps, in order to gain resource and budget support	37	48	73	6	7	11	18	16
BP39	Cohesive team work to fill gap during Isolation changes	31	61	79	3	6	8	15	13
BP40	Keep All Teams on the Same Page	58	44	88	0	3	3	11	9
BP41	Enterprises should focus on building a collaborative culture with shared goals	47	59	91	0	4	3	6	5
BP42	Consider DevOps to be a Cultural Change	39	48	75	6	8	12	15	13
BP43	Select DevOps "Champions"	39	44	72	6	14	17	13	11
BP44	Assess your organization's readiness to utilize a microservices architecture	39	50	77	9	7	14	11	9
BP45	Become a Psychologist	36	52	76	6	4	9	18	16
BP46	Commit daily, reduce branching	46	39	73	8	4	10	19	16
BP47	Understand and address your unique needs	40	57	84	2	6	7	11	9
BP48	Start toward Your Business Goals	37	51	76	6	4	9	18	16

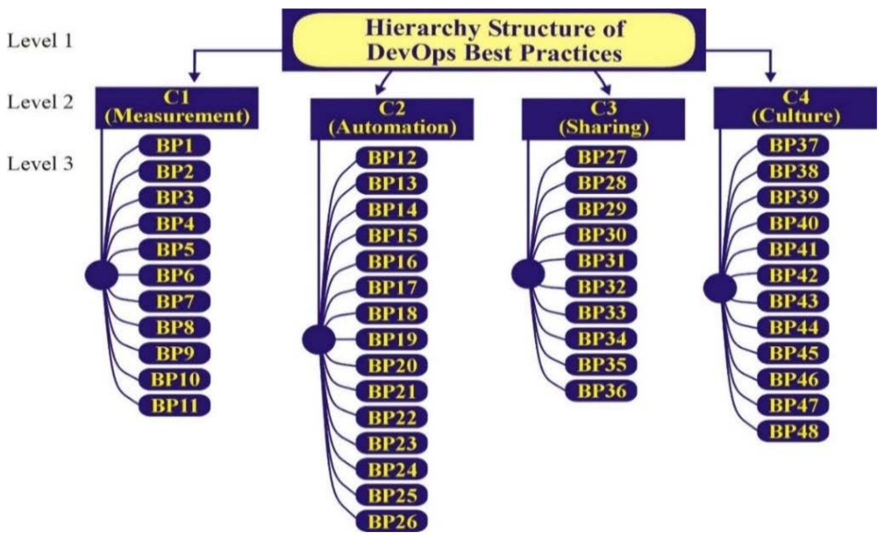

FIGURE 10. Proposed hierarchy structure.

several existing studies have used a similar size of the dataset to perform the AHP analysis [48], [65]–[67]. For example, Shameem *et al.* [53] conducted an AHP analysis to prioritize the influencing factors of distributed agile software development based on the responses collected from five experts.

Similarly, Cheng and Li [66] prioritize the success factors of construction partnering by considering the data collected from nine experts. Lam and Zhao [67] conducted a survey study with eight experts to investigate the influencing factors of teaching quality. Moreover, Cheng and Li [66] conducted an AHP analysis for the selection of intelligent buildings system by considering the responses collected from nine experts. Therefore, we have performed a fuzzy AHP analysis by considering the data collected from 29 experts which is an acceptable sample size for generalizing the results of this study.

The data collected via the fuzzy AHP survey were transformed in geometric mean to evaluate the pairwise comparison of the DevOps best practices and their respective categories. The geometric mean is useful to transform the expert's judgments into TFN numbers; the formula used to

TABLE 6. Triangular fuzzy conversion Scale [68].

"Linguistic Scale"	"Triangular Fuzzy scale"	"Triangular Fuzzy Reciprocal scale"
Just equal (JE)	(1,1,1)	(1,1,1)
Equally important (EI)	(1/2,1,3/2)	(2/3,1,2)
Weakly important (WI)	(1,3/2,2)	(1/2,2/3,1)
Strong more important (SMI)	(3/2,2,5/2)	(2/5,1/2,2/3)
Very strong more important (VSMI)	(2,5/2,3)	(1/3,2/5,1/2)
Absolutely more important (AMI)	(5/2,3,7/2)	(2/7,1/3,2/5)

apply the geometric mean is given below:

$$\text{Geometricmean} = n\sqrt{a1xa2 \times a3 \ldots\ldots\ldots .an} \quad (17)$$

a=Weight of each response
n=Number of responses.

Linguistic variable against their triangular fuzzy Likert scales is given in Table 6. To develop the pairwise comparison matrixes of the reported best practices and their respective categories; the triangular fuzzy conversion scale (Table 6), proposed by Bozbura *et al.* [68] was adopted.

3) STEP-3 CALCULATING THE LOCAL PRIORITY WEIGHT OF EACH BEST PRACTICE AND THEIR RESPECTIVE CATEGORIES: A NUMERICAL EXAMPLE

The priority vector is calculated using the pairwise comparison matrix. The pairwise comparisons of the best practices' categories are presented in Table 7 and the priority vector of the categories of best practices presented in Table 10. Local Priority Weight (LPW) of all the main categories of the best practices were calculated using Equation 3. First, the synthetic extent values of four categories, i.e. measurement, automation, sharing and culture, were determined, and the priority weight of each category was calculated using Equation 4. We have provided the calculation of priority weight for all the categories of the best practices as follows the equation can be derived, as shown at the bottom of next page. The "Measurement" (M), "Automation" (A), "Sharing" (S) and "Culture" (C) represent the synthesis values of main categories which were calculated using Equation 4 as follow:

$$A = \sum_{j}^{m} F_{g1}^{j} \otimes \left[\sum_{i}^{n} \sum_{j}^{m} F_{gi}^{j} \right]^{-1}$$
$$= (5, 7, 8.5) \otimes (0.04386, 0.054945, 0.070922)$$
$$= (0.219298, 0.384615, 0.602837)$$

The degree of possibility using Equation 6 is determined. The minimum degree of possibility (priority weight) for each pairwise comparison was calculated using Equation 8.

Therefore, the weight vector was determined as W' = (1, 0.030019, 0.69836, 0.36405) (Table 8). When these values were normalized, the importance of attributes was calculated as W = (0.4789, 0.01435, 0.3337). The given results reveal that "culture" is the most significant category as it has highest priority weight as compared to the other categories of the best practices.

4) STEP-4 TEST THE CONSISTENCY OF THE PAIRWISE MATRIX

In "this section, we presented a step-by-step calculation of the procedure followed to check whether a given pairwise matrix is consistent or not. For this, we have considered the Table of Categories (Table 9). A triangular fuzzy number of the pairwise comparison matrix of the main categories is defuzzified to crisp number using Equation 14 and obtained the corresponding Fuzzy Crisp Matrix (FCM) as shown in Table 9:

The largest Eigenvector ($\lambda_{\max}$) value of the FCM matrix is calculated by calculating the column sum of each column of FCM matrix (Table 9) and then divide each element of FCM matrix by column sum. Moreover, the priority weight is calculated by taking the average of each row", as shown in Table 10.

$$\lambda_{\max} = \sum([\sum Cj] \times \{W) \quad (18)$$

where, $\sum$ Cj= sum of the columns of Matrix [C] (Table 7), W= weight vector (Table 10), therefore

$\lambda_{\max}$ = 2.7∗0.11591+ 7.0∗0.29500+ 3.7∗0.17028+ 5.2∗0.41882= 4.1067

Based on the calculation, the largest Eigenvalue ($\lambda_{\max}$) of the matrix FCM is 4.1067. The dimension of FCM is 4. Therefore n=4 and the Random Consistency Index (RI) is 0.9 for n=4 (Table 3). Therefore, equation 15 and 16 are used to calculate the consistency index and consistency ration as follows:

$$CI = \frac{\lambda_{\max} - n}{n-1} = \frac{4.1067 - 4}{4-1} = 0.035553$$
$$CR = \frac{CI}{RI} = \frac{0.035553}{0.9} = 0.039503$$

The calculated value of CR is 0.039503<0.10; therefore, the pairwise comparison matrix developed for the categories of best practices is consistent and acceptable. Similarly, the consistency ratio for all the categories of the best practices is checked, and the results along with a pairwise comparison of

TABLE 7. Pairwise comparing between the categories.

	Measurement	Automation	Sharing	Culture
Measurement	(1,1,1)	(0.3, 0.4, 0.5)	(1, 1.5, 2)	(0.5, 0.6, 0.1)
Automation	(2, 2.5, 3)	(1,1,1)	(0.4, 0.5, 0.6)	(0.5, 0.6, 0.1)
Sharing	(0.5, 0.6, 0.1)	(1.5, 2, 2.5)	(1,1,1)	(0.5, 0.6, 0.1)
Culture	(1, 1.5, 2)	(1, 1.5, 2)	(1, 1.5, 2)	(1,1,1)

TABLE 8. Results of V values for criteria.

	M	A	S	C	d (Priority Weight)
V (M≥….)	-	1	1	1	1
V (A≥….)	0.030018	-	0.26503	0.62273	0.030018
V (S≥….)	0.69837	1	-	1	0.69837
V (C ≥….)	0.36406	1	0.64662	-	0.36406

TABLE 9. Fuzzy crisp Matrix (FCM) for best practices categories.

	Measurement	Automation	Sharing	Culture
Measurement	1.0	2.5	1.5	2.0
Automation	0.5	1.0	0.5	0.7
Sharing	0.7	2.0	1.0	1.5
Culture	0.5	1.5	0.7	1.0
Column Sum	2.7	7.0	3.7	5.2

measurement, automation, sharing and culture categories are presented in Table 11, 12,13 and 14.

5) STEP 5- CALCULATING THE GLOBAL WEIGHTS

The local weigh (LW) is used to determine the ranking of a particular best practices within their specific category, and the global weight (GW) presents the impact of the best practices on overall study objective (i.e., prioritization of DevOps success factors). The GW is used to determine the final ranking of the best practices compared with all the investigated 48 best practices beyond their categories. The GW is calculated by

$$S = (4, 5.1, 6.5) \otimes (0.04386, 0.054945,\ 0.070922) = (0.175439, 0.280220, 0.460993)$$

$$M = (2.2, 2.5, 3.2) \otimes (0.04386, 0.054945,\ 0.070922) = (0.096491, 0.137363, 0.226950)$$

$$C = (2.9, 3.6, 4.6) \otimes (0.04386, 0.054945,\ 0.070922) = (0.127193, 0.197802, 0.326241)$$

$$\sum_{i}^{n}\sum_{j}^{m} F_{gi}^{j} = (1, 1, 1) + (1.5, 2, 2.5) + (1, 1.5, 2) \ldots + (0.5, 0.6, 1) + (1, 1, 1) = (14.1, 18.2, 22.8)$$

$$\left[\sum_{i}^{n}\sum_{j}^{m} F_{gi}^{j}\right]^{-1} = (\frac{1}{22.8}, \frac{1}{18.2}, \frac{1}{14.1}) = (0.04386, 0.054945, 0.070922)$$

$$\sum_{j=1}^{m} F_{g1}^{j} = (1, 1, 1) + (1.5, 2.5, 3) + (1, 1.5, 2) + (1.5, 2.0, 2.5) = (5, 7, 8.5)$$

$$\sum_{j=1}^{m} F_{g2}^{j} = (0.3, 0.4, 0.6) + (1, 1, 1) + (0.4, 0.5, 0.6) + (0.5, 0.6, 1) = (2.2, 2.5, 3.2)$$

$$\sum_{j=1}^{m} F_{g3}^{j} = (0.5, 0.6, 1) + (1.5, 2, 2.5) + (1, 1, 1) + (1, 1.5, 2) = (4, 5.1, 6.5)$$

$$\sum_{j=1}^{m} F_{g4}^{j} = (0.4, 0.5, 0.6) + (1, 1.5, 2) + (0.5, 0.6, 1) + (1, 1, 1) = (2.9, 3.6, 4.6)$$

TABLE 10. Normalized matrix of best practices categories.

	Measurement	Automation	Sharing	Culture	Priority
Measurement	(1,1,1)	(0.3, 0.4, 0.5)	(1, 1.5, 2)	(0.5, 0.6, 0.1)	0.11591
Automation	(2, 2.5, 3)	(1,1,1)	(0.4, 0.5, 0.6)	(0.5, 0.6, 0.1)	0.29500
Sharing	(0.5, 0.6, 0.1)	(1.5, 2, 2.5)	(1,1,1)	(0.5, 0.6, 0.1)	0.17028
Culture	(1, 1.5, 2)	(1, 1.5, 2)	(1, 1.5, 2)	(1,1,1)	0.41882

TABLE 11. Pairwise comparison of best practices of "Measurement" category.

	BP1	BP2	BP3	BP4	BP5	BP6	BP7	BP8	BP9	BP10	BP11	Priority
BP1	(1,1,1)	(1, 1.5, 2)	0.4, 0.5, 0.6)	(1, 1.5, 2)	(0.5, 0.6, 1)	(1.5, 2, 2.5)	(1, 1.5, 2)	(0.5, 0.6, 1)	(1.5, 2, 2.5)	(1, 1.5, 2)	0.5, 0.6, 1)	0.099531
BP2	(0.5, 0.6, 1)	(1,1,1)	(1.5, 2, 2.5)	(0.5, 0.6, 1)	0.4, 0.5, 0.6)	(1, 1.5, 2)	(1.5, 2, 2.5)	(0.5, 0.6, 1)	(1, 1.5, 2)	0.4, 0.5, 0.6)	1.5, 2, 2.5)	0.095757
BP3	(1.5, 2, 2.5)	(0.4, 0.5, 0.6)	(1,1,1)	0.4, 0.5, 0.6)	(0.5, 0.6, 1)	(1.5, 2, 2.5)	(0.5, 0.6, 1)	(1.5, 2, 2.5)	(0.5, 0.6, 1)	(1, 1.5, 2)	0.5, 0.6, 1)	0.089031
BP4	(0.5, 0.6, 1)	(1, 1.5, 2)	(0.5, 0.6, 1)	(1,1,1)	(1, 1.5, 2)	(0.5, 0.6, 1)	(0.5, 0.6, 1)	(1, 1.5, 2)	(0.5, 0.6, 1)	(2, 2.5, 3)	(1, 1.5, 2)	0.094217
BP5	(1, 1.5, 2)	(1.5, 2, 2.5)	(1, 1.5, 2)	(0.5, 0.6, 1)	(1,1,1)	0.4, 0.5, 0.6)	(1.5, 2, 2.5)	(1.5, 2, 2.5)	(0.5, 0.6, 1)	(0.5, 0.6, 1)	1.5, 2, 2.5)	0.106180
BP6	(0.4, 0.5, 0.6)	(0.5, 0.6, 1)	0.4, 0.5, 0.6)	(1, 1.5, 2)	(1, 1.5, 2)	(1,1,1)	0.4, 0.5, 0.6)	(1, 1.5, 2)	0.4, 0.5, 0.6)	(1, 1.5, 2)	0.5, 0.6, 1)	0.073984
BP7	(0.5, 0.6, 1)	(0.4, 0.5, 0.6)	(1, 1.5, 2)	(1, 1.5, 2)	(0.5, 0.6, 1)	(1.5, 2, 2.5)	(1,1,1)	0.4, 0.5, 0.6)	(0.5, 0.6, 1)	(1.5, 2, 2.5)	0.5, 0.6, 1)	0.085232
BP8	(1, 1.5, 2)	(1, 1.5, 2)	0.4, 0.5, 0.6)	(0.5, 0.6, 1)	0.4, 0.5, 0.6)	(0.5, 0.6, 1)	(1.5, 2, 2.5)	(1,1,1)	(1.5, 2, 2.5)	(1, 1.5, 2)	(1, 1.5, 2)	0.098665
BP9	(0.4, 0.5, 0.6)	(0.4, 0.5, 0.6)	(1, 1.5, 2)	(1, 1.5, 2)	(1, 1.5, 2)	(1.5, 2, 2.5)	(1, 1.5, 2)	0.4, 0.5, 0.6)	(1,1,1)	0.4, 0.5, 0.6)	0.5, 0.6, 1)	0.085852
BP10	(0.5, 0.6, 1)	(1.5, 2, 2.5)	(0.5, 0.6, 1)	0.3, 0.4, 0.5)	(1, 1.5, 2)	(0.5, 0.6, 1)	0.4, 0.5, 0.6)	(0.5, 0.6, 1)	(1.5, 2, 2.5)	(1,1,1)	1.5, 2, 2.5)	0.088277
BP11	(1, 1.5, 2)	(0.4, 0.5, 0.6)	(1, 1.5, 2)	(0.5, 0.6, 1)	0.4, 0.5, 0.6)	(1, 1.5, 2)	(1, 1.5, 2)	(0.5, 0.6, 1)	(1, 1.5, 2)	0.4, 0.5, 0.6)	(1,1,1)	0.083275

λ= 12.249, CI = 0.12485, CR = 0.082685

TABLE 12. Pairwise comparison of best practices of automation category.

	BP12	BP13	BP14	BP15	BP16	BP17	BP18	BP19	BP20	BP21	B22	BP23	BP24	BP25	BP26	Priority
BP12	(1,1,1)	(0.5, 0.6, 1)	0.4, 0.5, 0.6)	(1.5, 2, 2.5)	0.4, 0.5, 0.6)	(0.4, 0.5, 0.6)	(1.5, 2, 2.5)	(1.5, 2, 2.5)	(0.4, 0.5, 0.6)	1.5, 2, 2.5)	(2.5, 3, 3.5)	1, 1.5, 2)	(1.5, 2, 2.5)	0.4, 0.5, 0.6)	1, 1.5, 2)	0.078232
BP13	(1, 1.5, 2)	(1,1,1)	(1.5, 2, 2.5)	0.5, 0.6, 1)	0.4, 0.5, 0.6)	1.5, 2, 2.5)	0.5, 0.6, 1)	(1.5, 2, 2.5)	0.5, 0.6, 1)	2.5, 3, 3.5)	(1.5, 2, 2.5)	0.4, 0.5, 0.6)	1, 1.5, 2)	0.4, 0.5, 0.6)	1, 1.5, 2)	0.077156
BP14	(1, 1.5, 2)	0.4, 0.5, 0.6)	(1,1,1)	0.4, 0.5, 0.6)	1, 1.5, 2)	(0.4, 0.5, 0.6)	1, 1.5, 2)	0.2, 0.3, 0.4)	(0.4, 0.5, 0.6)	(1, 1.5, 2)	(1.5, 2, 2.5)	0.5, 0.6, 1)	(1.5, 2, 2.5)	0.4, 0.5, 0.6)	1, 1.5, 2)	0.061135
BP15	(0.4, 0.5, 0.6)	(1, 1.5, 2)	(1.5, 2, 2.5)	(1,1,1)	1, 1.5, 2)	(0.4, 0.5, 0.6)	(1.5, 2, 2.5)	0.5, 0.6, 1)	1.5, 2, 2.5)	(1, 1.5, 2)	0.5, 0.6, 1)	(1.5, 2, 2.5)	1, 1.5, 2)	0.5, 0.6, 1)	0.5, 0.6, 1)	0.072116
BP16	1.5, 2, 2.5)	(1.5, 2, 2.5)	0.4, 0.5, 0.6)	0.5, 0.6, 1)	(1,1,1)	1.5, 2, 2.5)	0.5, 0.6, 1)	0.4, 0.5, 0.6)	(1, 1.5, 2)	1.5, 2, 2.5)	0.5, 0.6, 1)	1, 1.5, 2)	0.5, 0.6, 1)	(1.5, 2, 2.5)	(1.5, 2, 2.5)	0.075751
BP17	1.5, 2, 2.5)	0.4, 0.5, 0.6)	(1.5, 2, 2.5)	(1.5, 2, 2.5)	0.4, 0.5, 0.6)	(1,1,1)	1, 1.5, 2)	0.4, 0.5, 0.6)	(1, 1.5, 2)	0.5, 0.6, 1)	1, 1.5, 2)	1, 1.5, 2)	0.5, 0.6, 1)	(1.5, 2, 2.5)	1, 1.5, 2)	0.074993
BP18	(0.4, 0.5, 0.6)	(1, 1.5, 2)	0.4, 0.5, 0.6)	0.4, 0.5, 0.6)	1, 1.5, 2)	0.5, 0.6, 1)	(1,1,1)	1, 1.5, 2)	(0.4, 0.5, 0.6)	1.5, 2, 2.5)	0.5, 0.6, 1)	(1.5, 2, 2.5)	1, 1.5, 2)	0.5, 0.6, 1)	(1.5, 2, 2.5)	0.065516
BP19	(0.4, 0.5, 0.6)	0.4, 0.5, 0.6)	(2.5, 3, 3.5)	, 1.5, 2)	(1.5, 2, 2.5)	1.5, 2, 2.5)	0.5, 0.6, 1)	(1,1,1)	1.5, 2, 2.5)	0.5, 0.6, 1)	0.4, 0.5, 0.6)	1, 1.5, 2)	(1.5, 2, 2.5)	0.5, 0.6, 1)	1, 1.5, 2)	0.077156
BP20	1.5, 2, 2.5)	(1, 1.5, 2)	(1.5, 2, 2.5)	0.4, 0.5, 0.6)	0.5, 0.6, 1)	0.5, 0.6, 1)	(1.5, 2, 2.5)	0.4, 0.5, 0.6)	(1,1,1)	(1, 1.5, 2)	0.4, 0.5, 0.6)	1, 1.5, 2)	0.5, 0.6, 1)	1, 1.5, 2)	1, 1.5, 2)	0.069726
BP21	(0.4, 0.5, 0.6)	0.2, 0.3, 0.4)	0.4, 0.5, 0.6)	0.5, 0.6, 1)	0.4, 0.5, 0.6)	(1, 1.5, 2)	0.4, 0.5, 0.6)	1, 1.5, 2)	0.5, 0.6, 1)	(1,1,1)	1, 1.5, 2)	0.4, 0.5, 0.6)	(1.5, 2, 2.5)	0.5, 0.6, 1)	(1.5, 2, 2.5)	0.052684
BP22	(0.2, 0.3, 0.4)	0.4, 0.5, 0.6)	0.4, 0.5, 0.6)	, 1.5, 2)	1, 1.5, 2)	0.5, 0.6, 1)	1, 1.5, 2)	(1.5, 2, 2.5)	1.5, 2, 2.5)	0.5, 0.6, 1)	(1,1,1)	1, 1.5, 2)	0.4, 0.5, 0.6)	1, 1.5, 2)	0.5, 0.6, 1)	0.06264
BP23	0.5, 0.6, 1)	(1.5, 2, 2.5)	1, 1.5, 2)	0.4, 0.5, 0.6)	0.4, 0.5, 0.6)	0.5, 0.6, 1)	0.4, 0.5, 0.6)	0.5, 0.6, 1)	0.5, 0.6, 1)	1.5, 2, 2.5)	0.5, 0.6, 1)	(1,1,1)	(1.5, 2, 2.5)	0.4, 0.5, 0.6)	0.4, 0.5, 0.6)	0.052583
BP24	(0.4, 0.5, 0.6)	(0.5, 0.6, 1)	0.4, 0.5, 0.6)	0.5, 0.6, 1)	1, 1.5, 2)	(1, 1.5, 2)	0.5, 0.6, 1)	0.4, 0.5, 0.6)	(1, 1.5, 2)	(0.4, 0.5, 0.6)	(1.5, 2, 2.5)	0.4, 0.5, 0.6)	(1,1,1)	(1.5, 2, 2.5)	0.5, 0.6, 1)	0.054597
BP25	1.5, 2, 2.5)	(1.5, 2, 2.5)	(1.5, 2, 2.5)	, 1.5, 2)	0.4, 0.5, 0.6)	(0.4, 0.5, 0.6)	1, 1.5, 2)	1, 1.5, 2)	0.5, 0.6, 1)	(1, 1.5, 2)	0.5, 0.6, 1)	(1.5, 2, 2.5)	0.4, 0.5, 0.6)	(1,1,1)	0.4, 0.5, 0.6)	0.071115
BP26	0.5, 0.6, 1)	(0.5, 0.6, 1)	0.4, 0.5, 0.6)	, 1.5, 2)	0.4, 0.5, 0.6)	0.5, 0.6, 1)	0.4, 0.5, 0.6)	0.4, 0.5, 0.6)	0.5, 0.6, 1)	(0.4, 0.5, 0.6)	1, 1.5, 2)	(1.5, 2, 2.5)	1, 1.5, 2)	(1.5, 2, 2.5)	(1,1,1)	0.054597

λ = 17.140, CI = 0.15286, CR = 0.09613

multiplying the LW of a best practice with their category weight.

For example, the LW of BP1 (Organizations start DevOps practices with small projects, 0.099531) and the category weight is C1 (Measurement, 0.11591); so, the GW of BP1= (0.099531) × (0.11591) = 0.011537. By comparing the local rank of BP1 within their category, it is ranked as the second-highest priority best practices.

While comparing its GW with all other 48 best practices, it stands out 39th most important best practice for the successful implementation of DevOps paradigm. The results presented in Table 15 shows that the GW of BP41

TABLE 13. Pairwise comparison of best practices of 'Sharing' category.

	BP27	BP28	BP29	BP30	BP31	BP32	BP33	BP34	BP35	BP36	Priority
BP27	(1,1,1)	(1, 1.5, 2)	(0.4, 0.5, 0.6)	(1, 1.5, 2)	(0.5, 0.6, 1)	(1, 1.5, 2)	(1, 1.5, 2)	(0.5, 0.6, 1)	(1.5, 2, 2.5)	(1, 1.5, 2)	0.110115
BP28	(0.5, 0.6, 1)	(1,1,1)	(1.5, 2, 2.5)	(0.5, 0.6, 1)	(0.4, 0.5, 0.6)	(1, 1.5, 2)	(1.5, 2, 2.5)	(0.5, 0.6, 1)	(1, 1.5, 2)	(0.5, 0.6, 1)	0.098379
BP29	(1.5, 2, 2.5)	(0.4, 0.5, 0.6)	(1,1,1)	(0.4, 0.5, 0.6)	(0.5, 0.6, 1)	(1, 1.5, 2)	(0.4, 0.5, 0.6)	(1.5, 2, 2.5)	(0.5, 0.6, 1)	(1, 1.5, 2)	0.095144
BP30	(0.5, 0.6, 1)	(1, 1.5, 2)	(0.5, 0.6, 1)	(1,1,1)	(1.5, 2, 2.5)	(0.5, 0.6, 1)	(0.4, 0.5, 0.6)	(1.5, 2, 2.5)	(0.5, 0.6, 1)	(0.5, 0.6, 1)	0.089664
BP31	(1, 1.5, 2)	(1.5, 2, 2.5)	(1, 1.5, 2)	(0.4, 0.5, 0.6)	(1,1,1)	(0.4, 0.5, 0.6)	(1.5, 2, 2.5)	(1.5, 2, 2.5)	(0.5, 0.6, 1)	(0.5, 0.6, 1)	0.109770
BP32	(0.5, 0.6, 1)	(0.5, 0.6, 1)	(0.5, 0.6, 1)	(1, 1.5, 2)	(1, 1.5, 2)	(1,1,1)	(0.4, 0.5, 0.6)	(1, 1.5, 2)	(0.4, 0.5, 0.6)	(1, 1.5, 2)	0.087082
BP33	(0.5, 0.6, 1)	(0.4, 0.5, 0.6)	(1.5, 2, 2.5)	(1.5, 2, 2.5)	(1.5, 2, 2.5)	(1.5, 2, 2.5)	(1,1,1)	(0.5, 0.6, 1)	(0.5, 0.6, 1)	(1.5, 2, 2.5)	0.119216
BP34	(1, 1.5, 2)	(1, 1.5, 2)	(0.4, 0.5, 0.6)	(0.4, 0.5, 0.6)	(0.4, 0.5, 0.6)	(0.5, 0.6, 1)	(1, 1.5, 2)	(1,1,1)	(1.5, 2, 2.5)	(1, 1.5, 2)	0.099249
BP35	(0.4, 0.5, 0.6)	(0.4, 0.5, 0.6)	(1, 1.5, 2)	(1, 1.5, 2)	(1, 1.5, 2)	(1.5, 2, 2.5)	(1, 1.5, 2)	(0.4, 0.5, 0.6)	(1,1,1)	(0.4, 0.5, 0.6)	0.097639
BP36	(0.5, 0.6, 1)	(1, 1.5, 2)	(0.5, 0.6, 1)	(1, 1.5, 2)	(1, 1.5, 2)	(0.5, 0.6, 1)	(0.4, 0.5, 0.6)	(0.5, 0.6, 1)	(1.5, 2, 2.5)	(1,1,1)	0.093742

$\lambda = 11.278$, CI = 0.14197, CR = 0.095285

TABLE 14. Pairwise comparison of best practices of culture category.

	BP37	BP38	BP39	BP40	BP41	BP42	BP43	BP44	BP45	BP46	BP47	BP48	Priority
BP37	(1,1,1)	, 1.5, 2)	.4, 0.5, 0.6)	(1.5, 2, 2.5)	(0.5, 0.6, 1)	(1.5, 2, 2.5)	(1, 1.5, 2)	.5, 0.6, 1)	.5, 2, 2.5)	, 1.5, 2)	.5, 0.6, 1)	.5, 0.6, 1)	089771
BP38	.5, 0.6, 1)	(1,1,1)	(1.5, 2, 2.5)	(0.5, 0.6, 1)	.4, 0.5, 0.6)	(1, 1.5, 2)	(1.5, 2, 2.5)	(0.5, 0.6, 1)	(1, 1.5, 2)	(0.5, 0.6, 1)	.5, 2, 2.5)	(1.5, 2, 2.5)	0.092637
BP39	.5, 2, 2.5)	(0.4, 0.5, 0.6)	(1,1,1)	.4, 0.5, 0.6)	(0.5, 0.6, 1)	(1.5, 2, 2.5)	0.4, 0.5, 0.6)	(1.5, 2, 2.5)	(0.5, 0.6, 1)	(1, 1.5, 2)	.5, 0.6, 1)	(1, 1.5, 2)	0.082375
BP40	(0.4, 0.5, 0.6)	(1, 1.5, 2)	(0.5, 0.6, 1)	(1,1,1)	(1.5, 2, 2.5)	(0.5, 0.6, 1)	(0.5, 0.6, 1)	(1.5, 2, 2.5)	(0.5, 0.6, 1)	(0.4, 0.5, 0.6)	(1, 1.5, 2)	(0.5, 0.6, 1)	0.074275
BP41	(1, 1.5, 2)	.5, 2, 2.5)	(1, 1.5, 2)	.4, 0.5, 0.6)	(1,1,1)	0.4, 0.5, 0.6)	(1.5, 2, 2.5)	(1.5, 2, 2.5)	(0.5, 0.6, 1)	(0.4, 0.5, 0.6)	.5, 2, 2.5)	(1.5, 2, 2.5)	0.099306
BP42	(0.4, 0.5, 0.6)	.5, 0.6, 1)	.4, 0.5, 0.6)	(1, 1.5, 2)	(1, 1.5, 2)	(1,1,1)	(0.5, 0.6, 1)	(1, 1.5, 2)	.4, 0.5, 0.6)	(1, 1.5, 2)	.5, 0.6, 1)	(1, 1.5, 2)	0.072511
BP43	.5, 0.6, 1)	(0.4, 0.5, 0.6)	(1.5, 2, 2.5)	(1, 1.5, 2)	(1.5, 2, 2.5)	(1, 1.5, 2)	(1,1,1)	.4, 0.5, 0.6)	(0.5, 0.6, 1)	(1.5, 2, 2.5)	.5, 0.6, 1)	(0.5, 0.6, 1)	0.083396
BP44	(1, 1.5, 2)	(1, 1.5, 2)	.4, 0.5, 0.6)	.4, 0.5, 0.6)	.4, 0.5, 0.6)	(0.5, 0.6, 1)	(1.5, 2, 2.5)	(1,1,1)	(1.5, 2, 2.5)	(1, 1.5, 2)	.5, 2, 2.5)	(1, 1.5, 2)	0.093556
BP45	(0.4, 0.5, 0.6)	(0.4, 0.5, 0.6)	(1, 1.5, 2)	(1, 1.5, 2)	(1, 1.5, 2)	(1.5, 2, 2.5)	(1, 1.5, 2)	.4, 0.5, 0.6)	(1,1,1)	(0.4, 0.5, 0.6)	.5, 0.6, 1)	(0.5, 0.6, 1)	0.074588
BP46	.5, 0.6, 1)	(1, 1.5, 2)	(0.5, 0.6, 1)	(1.5, 2, 2.5)	(1.5, 2, 2.5)	(0.5, 0.6, 1)	0.4, 0.5, 0.6)	(0.5, 0.6, 1)	(1.5, 2, 2.5)	(1,1,1)	.5, 2, 2.5)	(1, 1.5, 2)	0.092637
BP47	(1, 1.5, 2)	(0.4, 0.5, 0.6)	(1, 1.5, 2)	(0.5, 0.6, 1)	.4, 0.5, 0.6)	(1, 1.5, 2)	(1, 1.5, 2)	.4, 0.5, 0.6)	(1, 1.5, 2)	(0.4, 0.5, 0.6)	(1,1,1)	(0.5, 0.6, 1)	0.071128
BP48	(1, 1.5, 2)	(0.4, 0.5, 0.6)	(0.5, 0.6, 1)	(1, 1.5, 2)	.4, 0.5, 0.6)	(0.5, 0.6, 1)	(1, 1.5, 2)	(0.5, 0.6, 1)	(1, 1.5, 2)	(0.5, 0.6, 1)	(1, 1.5, 2)	(1,1,1)	0.073821

$\lambda = 13.542$, CI = 0.14017, CR = 0.094709

(Enterprises should focus on building a collaborative culture with shared goals, GW=0.041591) is the highest priority best practice for DevOps adoption and its progression in software organizations. Moreover, BP44 (Assess your organization's readiness to utilize a microservices architecture, GW=0.039183) and BP 38 (Educate executives at your company about the benefits of DevOps, to gain resource and budget support, GW=0.038798) are declared as the second and third most significant best practices for DevOps paradigm. The final ranking of all the other best practices is presented in Table 15.

V. SUMMARY AND DISCUSSION

Summary of the findings for each question is presented as follows:

RQ1 (What guidelines for sustainable DevOps implementation in software development organizations are reported in the literature and industry practices?)

As a result of the SLR, a total of 71 studies were identified. The primary studies were carefully reviewed, and a total of 48 DevOps best practise were identified. The best practices were further categorized in the core categories of CAMS model (i.e., Culture, automation, measurement and sharing). The mapping of the best practices into CAMS is used to develop the hierarchy structure required for the fuzzy-AHP.

RQ2 (How the explored guidelines were prioritized using fuzzy-AHP?)

A questionnaire survey was also conducted to seek feedback from practitioners on the identified best practices and their respective categorization. The survey results indicate that industry practitioners agree with the identified best practices and their respective categorization.

RQ3 (What would be the prioritization-based framework for sustainable DevOps guidelines?)

The step-by-step protocols of fuzzy-AHP was applied to prioritize investigate the DevOps best practice. To perform the fuzzy-AHP analysis, the pairwise matrixes of the best practices of each category were developed based on the expert's opinions. All the steps of fuzzy-AHP were carefully applied and the priority weights of each best practice were determined. By applying the fuzzy-AHP analysis, the prioritization weight (global weight) of each best practice was determined. The results show that BP41 (Enterprises should focus on building a collaborative culture with shared goals, GW=0.041591) is the highest priority best practice for DevOps adoption and its progression in software organizations. Leite *et al.* [6] highlighted that DevOps required a cultural change in the software development organization, as it offers continues and a collaborative work environment between the developers and operators. Gupta *et al.* [31] and Marijan *et al.* [69] also highlighted the importance of collaborative culture for the successful adoption of DevOps paradigm. Moreover, BP44 (Assess your organization's readiness to utilize a microservices architecture, GW= 0.039183) and BP38 (Educate executives at your company

TABLE 15. Determining global weights.

Category	Category Weight	Best Practices	Local Weight	Local Rank	Global Weight	Global Rank
C1 (Measurement)	0.11591	BP1	0.099531	2	0.011537	39
		BP2	0.095757	4	0.011099	41
		BP3	0.089031	6	0.01032	43
		BP4	0.094217	5	0.010921	42
		BP5	0.106180	1	0.012307	38
		BP6	0.073984	11	0.008575	48
		BP7	0.085232	9	0.009879	46
		BP8	0.098665	3	0.011436	40
		BP9	0.085852	8	0.009951	45
		BP10	0.088277	7	0.010232	44
		BP11	0.083275	10	0.009652	47
C2 (Automation)	0.29500	BP12	0.078232	1	0.023078	13
		BP13	0.077156	2	0.022761	14
		BP14	0.061135	11	0.018035	26
		BP15	0.072116	6	0.021274	18
		BP16	0.075751	4	0.022347	16
		BP17	0.074993	5	0.022123	17
		BP18	0.065516	9	0.019327	22
		BP19	0.077156	3	0.022761	15
		BP20	0.069726	8	0.020569	20
		BP21	0.052684	14	0.015542	34
		BP22	0.06264	10	0.018479	25
		BP23	0.052583	15	0.015512	35
		BP24	0.054597	12	0.016106	31
		BP25	0.071115	7	0.020979	19
		BP26	0.054597	13	0.016106	32
C3 (Sharing)	0.17028	BP27	0.110115	2	0.01875	23
		BP28	0.098379	5	0.016752	28
		BP29	0.095144	7	0.016201	30
		BP30	0.089664	9	0.015268	36
		BP31	0.10977	3	0.018692	24
		BP32	0.087082	10	0.014828	37
		BP33	0.119216	1	0.0203	21
		BP34	0.099249	4	0.0169	27
		BP35	0.097639	6	0.016626	29
		BP36	0.093742	8	0.015962	33
C4 (Culture)	0.41882	BP37	0.089771	5	0.037598	5
		BP38	0.092637	3	0.038798	3
		BP39	0.082375	7	0.0345	7
		BP40	0.074275	9	0.031108	9
		BP41	0.099306	1	0.041591	1
		BP42	0.072511	11	0.030369	11
		BP43	0.083396	6	0.034928	6
		BP44	0.093556	2	0.039183	2
		BP45	0.074588	8	0.031239	8
		BP46	0.092637	4	0.038798	4
		BP47	0.071128	12	0.02979	12
		BP48	0.073821	10	0.030918	10

about the benefits of DevOps, in order to gain resource and budget support, GW=0.038798) are ranked as three most priority best practise of DevOps paradigm.

The framework of the investigated best practices was developed by using both global and local ranks (Table 15). The objective of framework development is to show the impact of each best practice in their own category and for overall DevOps paradigm. For example, BP1 (Organizations start DevOps practices with small projects) is locally ranked as the 2nd most important best practice for the successful implementation execution of DevOps paradigm. An interesting observation is that BP1 is ranked as the 39th.

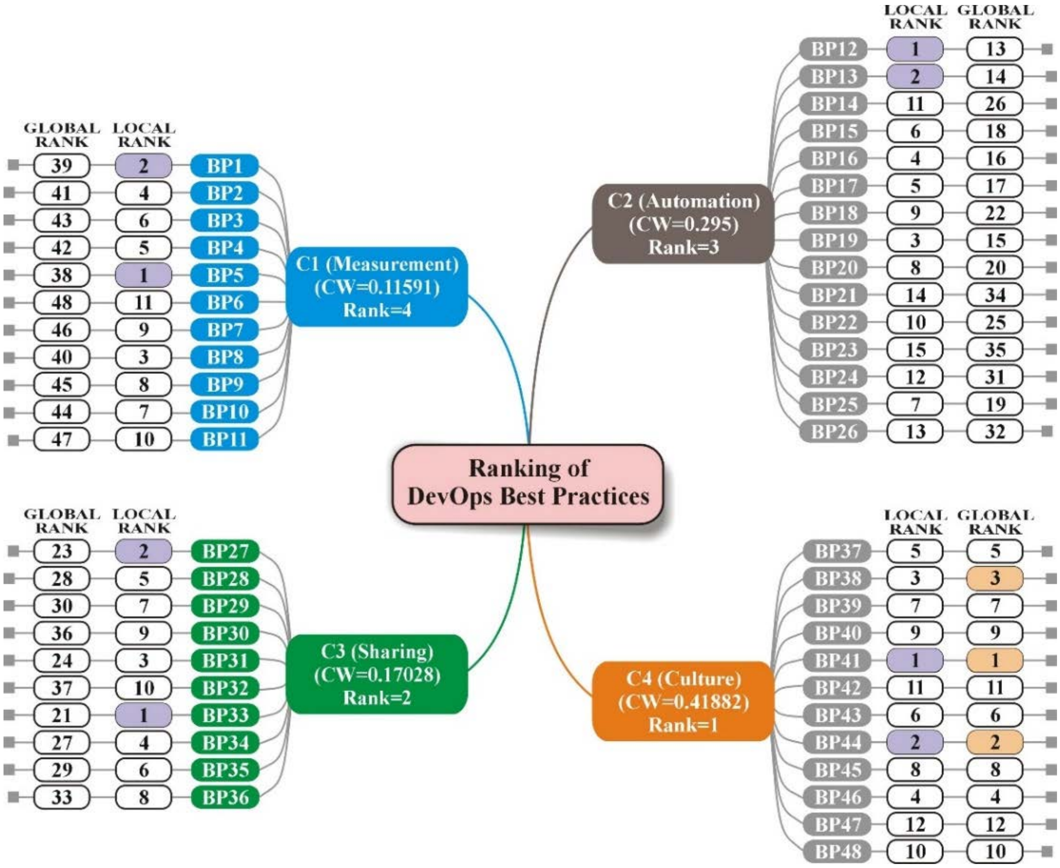

FIGURE 11. Prioritization based framework of the investigated best practices.

Similarly, BP2 (Include modelling for legacy infrastructure and applications in your DevOps plans) is declared as the 4th most important best practices in 'Management category' and ranked as the 42ndwith respect to global rankings.

The local and global ranks of each best practice are presented in Figure 11, which renders the impact of a particular best practices within their respective category and for overall project compared with all the identified 48 best practices. Moreover, C1 (Measurement, CW=0.41882) is ranked as the most significant category of the motivators. Furthermore, it is observed that C2 (Automation=0.295), C3 (Sharing, CW= 0.17028) is ranked as the second and third most significant categories of the best practices. Hence, the critical focus on these areas could assist the organization in the successful execution of the DevOps paradigm.

VI. THREATS TO VALIDITY

One of the limitations of the study is potential researcher's bias in the investigated best practices using a literature review study. To address this comment, the "inter-rater reliability test" was performed, and the results shows no significant biasness in the literature study findings. Another potential threat to validity is the potential to generalize the study results. The best practices are identified by applying a well-established SLR method. Moreover, the identified best practices were further validated by seeking input from 116 industry practitioners. the generalization of the questionnaire survey is the small size of the data set. Moreover, the fuzzy-AHP was performed to rank the investigated best practices and their respective categories considering the experts opinions. The consistency ratio of pairwise comparison matrixes was determined and the results presents the acceptable internal validity of fuzzy AHP analysis results.

VII. CONCLUSION AND FUTURE DIRECTIONS

DevOps is an approach which combines development and operations to enable agility during software development process. The implementation of DevOps practices is complex, and this motivates us to explore the best practices that are important for success of DevOps paradigm in software organizations. As a result of the systematic literature study, a total of 48 best practices were identified. The identified best practices were further mapped in the core categories of CAMS model. Moreover, the questionnaire survey study was conducted to get the insight of experts on the identified best practices. The results of the questionnaire survey study indicated that the identified best practices are in line with real-world practices. Finally, the investigated best practices were further prioritized with respect to their significance for DevOps practices using fuzzy-AHP. The prioritization results show that 'enterprises should focus on building a collaborative culture with shared goals', 'assess your organization's readiness to utilize a microservices architecture' and 'educate executives at your company about the benefits of DevOps' are important best practices. The categorization of investigated best practices and their rankings provides a framework that could assist the academic researchers and industry practitioners in revising and developing the new effective strategies for the sustainable DevOps process in software organizations.

As part of future work, we plan to conduct multivocal literature review and case studies to explore the additional best practices associated with DevOps paradigm. In addition, we plan to identify the critical challenges and success factors that need to be addressed for the successful execution of DevOps practices in software organizations. Ultimately, we plan to develop a readiness model which will assist the practitioners in assessing and improving their DevOps implementation strategies.

APPENDIXES

Appendix-A: Selected studies along with quality assessment score https://tinyurl.com/y9 × 3fg3z

Appendix-B: "Sample of questionnaire survey https://tinyurl.com/y832q5jy

Appendix-C: "Sample of pairwise comparison questionnaire https://tinyurl.com/y97k7jp9

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