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Analysing factors affecting the success of Information System (IS): An AHP-Based Analysis of Public Service IS in India

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Abstract:
This paper aims to analyse the information systems in the public service segment – banking, revenue department, land records & registrations, electricity supply, water supply, etc., covering 16 segments – on three parameters – installation process, the performance of the IS and the user (the staff operating the IS) satisfaction. The current study presents the blueprint for the IS managers or companies in this segment for the performance evaluation from the user's perspective with the defined AHP Factor Analysis model. Further, the methodology helps the practitioners in shortlisting of information systems for decision-making. The research work has proved that the AHP-based analysis can be one of the better fit methods for analysing the key parameters or criteria for evaluating an information system for the user satisfaction or shortlisting of candidates for the selection process.

Keywords: *Information Systems, Evaluation of IS, AHP-Based Analysis,*

Introduction:
Information systems have become an integral part of organisations in today's digital age. Advancements in technology have made it possible to easily collect, store, process, and analyse large amounts of data. This has led to the emergence of big data analytics, artificial intelligence, and machine learning, among other technologies, that have significantly impacted how businesses operate.
One of the significant benefits of information systems is the ability to provide organisations with real-time data, enabling them to make informed decisions quickly. Data analytics can identify patterns and trends in customer behaviour, allowing businesses to tailor their products and services to meet their customers' needs (Hsu & Chen, 2007).
However, with the proliferation of information systems come risks, such as cybersecurity threats and data breaches. Robust security measures need to be in place to ensure that sensitive information is not compromised. Skilled professionals must manage and maintain these systems to prevent such risks. This demands proper analysis of the information systems with regard to user satisfaction, performance and the upgrading of the current technology.
This paper aims to analyse the information systems in the public service segment – banking, revenue department, land records & registrations, electricity supply, water supply, etc., covering 16 segments – on three parameters – installation process, the performance of the IS and the user (the staff operating the IS) satisfaction. This research will present the blueprint for the IS managers or companies in this segment for the performance evaluation from the user's perspective with the defined AHP Factor Analysis model.

Literature Review:
The author came across a different approach to study user satisfaction in information systems. The approach and the application of methodology varies depending on the technology, level of implementation, industry, service, usage level, etc. However, the author filed specific industry experiences shared as specific study in journals - Health IS (Daniel Ekelund et al., 2021); Public Service IS (Maulany & Loppies, 2018a); e-Government IS (Riahla, 2023); Banking and Accounting IS (Al-Okaily, 2021); and the thesis analyzing data from IS in a construction industry (Prince Boateng et al., 2014) has helped the authors in understanding the approach to study the user satisfaction pertaining to their experience with an information system. The study on the public service IS (Abbas, 2020; Hosseini Teshnizi et al., 2021; Maulany & Loppies, 2018a, 2018b; Vaidya & Kumar, 2006) was a major learning for developing the methodology and the questionnaire for the current study.
One of the core articles traced in this study provides a valuable resource for researchers and practitioners interested in the application of fuzzy AHP methods in decision-making. The authors provide a thorough review of the current state of the field, including both the potential benefits and challenges associated with fuzzy AHP implementation (Liu et al., 2020). Similar learning about the use of AHP methods in decision-making with respect to the information systems are (Prince Boateng et al., 2014), (Saaty, 2008), (Salmeron & Herrero, 2005), (Vaidya & Kumar, 2006).

During the literature study the authors come across the thesis which has used an SDANP model that can be used to assess risks in megaprojects. The thesis has been tested using data and information from various megaprojects drawn from information systems (Prince Boateng et al., 2014).

Methodology:

This study has considered installation, performance, and user satisfaction as the three key parameters for the analysis. However, some general aspects are considered based on the studies traced during the literature study (Liu et al., 2020; Saaty, 2008; Salmeron & Herrero, 2005). Table 1 describes the factors considered for the analysis. However, for the general understanding, the authors have presented the key parameters considered in this study.

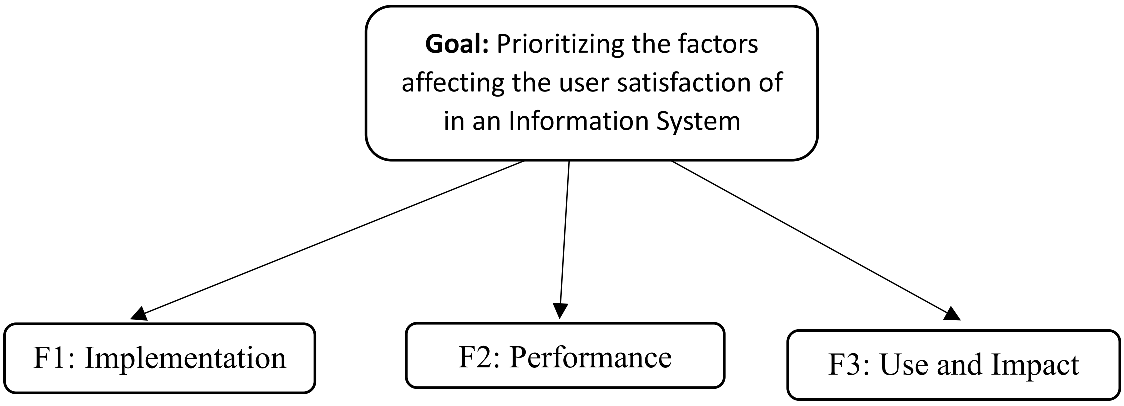
- ***Installation***: includes the technical aspects of developing, deploying and maintaining, such as hardware, software, network, security, interoperability and standards. It may also include the institutional aspects of establishing the legal framework, governance structure, roles and responsibilities, budget and funding sources.
- ***Performance***: This covers the functional aspects of delivering the intended services and data to the users, such as availability, reliability, accuracy, timeliness, completeness and relevance. Further, it covers the impact aspects of achieving the desired outcomes and benefits for the users, such as efficiency, effectiveness, transparency, accountability and inclusion.
- ***User satisfaction***: This factor focuses on the perceptual aspects of measuring the users' feedback and opinions on the IS, such as awareness, accessibility, usability, quality, satisfaction and trust. It may also include the behavioural aspects of observing the users' actions and interactions with the IS, such as adoption, usage frequency, duration and intensity.

The current research paper has adopted the AHP-based methodology to analyse the IS systems in public services. This methodology is adopted based on the study in the area of Health IS (Daniel Ekelund et al., 2021); Public Service IS (Maulany & Loppies, 2018a); e-Government IS (Riahla, 2023); Banking and Accounting IS (Al-Okaily, 2021); and measurement of IS from the usage parameters (Scott, 1995), are the base to design the methodology adopted. The collective opinion of the literature study on AHP-Based methodology says that this decision-making method uses a structured technique for organising and analysing complex problems based on mathematics and psychology. It involves breaking down a problem into a hierarchy of criteria, sub-criteria and alternatives and comparing them pairwise using a ratio scale. This study has used pairwise comparisons to calculate the weights or priorities of each element in the hierarchy and then to aggregate them into a final ranking of the alternatives.

The AHP-based methodology can help decision-makers to handle multiple and conflicting criteria, to incorporate both quantitative and qualitative factors, and to deal with uncertainty and inconsistency. The literature study provides evidence for using AHP-based methodology in various domains, such as project management, resource allocation, strategic planning, risk assessment and vendor selection (Liu et al., 2020; Prince Boateng et al., 2014; Saaty, 2008; Salmeron & Herrero, 2005; Vaidya & Kumar, 2006).

This study used the Analytic Hierarchy Process (AHP) - a multicriteria decision-making technique- to organise and analyse complicated decisions. The Analytic Hierarchy Process (AHP) is a theory of measurement through pairwise comparisons and relies on the judgements of experts to derive priority scales (Saaty,2008). The present study categorises the factors required to select the information system. Table 2 describes the AHP model of this study.

Figure 1: AHP Model



Three factors that are relevant for selecting the system were selected based on the literature, namely a) Implementation(F1), Performance(F2) and use and Impact(F3). Table 3 presents the sub-criteria for each factor.

Table 1:
Factors and Sub-criteria of the AHP Model

Implementation(F1)	1. Overall process involved in the implementation 2. Understanding the needs of the organisation 3. Planning and execution 4. Data migration 5. Training 6. Maintenance and Support 7. Cost-Benefit factor of implementing the IS
Performance(F2)	1. Features and functionality in IS to meet the needs of the organisation 2. Ease of implementation across all the Department 3. Able to meet changes/best practices in the functional aspects of the organisation 4. Digitisation and integration of organisation documents 5. Data and reports for the Decision-making 6. Continuous support from the developer/company/vendor 7. API support/integration with third-party software 8. Software maintenance/repair/system log 9. Upgrades/ introduction of new features 10. Affordability of the upgrades. 11. Availability of the Disaster recovery tool/backup 12. Online customer support 13. Overall satisfaction level
Usage and Impact(F3)	1. For report generation 2. For process management 3. For record management 4. Achieving automation in the organisation 5. Cost implication

The AHP method is an Eigenvalue approach to pairwise comparisons. The AHP technique uses pairwise comparison results of factors concerning the goal and sub-factors for factors. The questionnaire was devised based on Saaty's Rating Scale. The questionnaire considers a rating scale from 1 to 9, with 1 being equal importance or influence and 9 being extreme importance or influence. The AHP model's basic steps are as follows (Vaidya,2006).

1. Emphasising the problem.
2. Expand the objectives of the problem or consider all actors, objectives and its outcome.
3. Identify the criteria that affect the behaviour.
4. Construct the problem in a hierarchy of different levels constituting goals, criteria, sub-criteria and alternatives.
5. Compare each element in the corresponding level and calibrate them on the numerical scale. This requires n(n - 1)/2 comparisons, where n is the number of elements with the consideration that diagonal elements are equal or 1, and the other elements will be the reciprocals of the earlier comparisons.
6. Compute calculations to find the maximum Eigen value, consistency index CI, consistency ratio CR, and normalised values for each criterion/alternative.
7. If the maximum Eigenvalue, CI, and CR are satisfactory, the decision is taken based on the normalised values; the procedure repeats until these values lie in a desired range.

With the learning from the literature and the AHP-based analysis process, the Table 2 presents the pairwise comparisons of factors concerning the goal.

Table 2:
Pairwise comparison matrix of factors for the goal

Selecting an information system	Implementation	Performance	Usage and Impact
Implementation	1	3	1/5
Performance	1/3	1	1/9
Usage and impact	5	9	1
Total	**6.33**	**13.00**	**1.31**

The respondents are asked to compare the factors namely implementation, Performance and Usage and Impact and see which is more important with respect to the goal (Selecting an Information System). When we compare implementation and performance, the respondents were of the opinion that Implementation is 3 times more important than performance while selecting an information system. Similarly, Usage and Impact is 5 times more important than Implementation while selecting the information system.

Table 3:
Normalised Matrix of the factors for the goal

Selecting an information system	Implementation	Performance	Usage and Impact
Implementation	0.16	0.23	0.15
Performance	0.05	0.08	0.08
Usage and impact	0.79	0.69	0.76
Total	1.00	1.00	1.00

Further, the above Table 3 presents the respective normalised weights and weights of factors. The normalised weights are required to calculate the respective weights of the factors. The weights of three factors are obtained by taking the average of the rows related to each factor.

Table 4:
Weights of factors for the goal

Selecting an information system	Implementation	Performance	Usage and Impact	Weights
Implementation	0.16	0.23	0.15	0.1804
Performance	0.05	0.08	0.08	0.0714
Usage and impact	0.79	0.69	0.76	0.7482
Total	1.00	1.00	1.00	

Here the weight of implementation is obtained by computing the average of values 0.16, 0.23 and 0.15, which is 0.1804. Similarly weights of other factors are also calculated and presented in the 4^{th} column of the above table 4 to presents the weights of the factors for the goal.
In order to find out the consistencies of the expert's judgements, this study has used the following formula to calculate the consistency ratios (CR) of the comparison matrices.

$$CI = (\lambda_{max} - n)/(n-1)$$

Where CI = consistency index,
λ_{max} is the principal eigenvalue
n = the order of the Matrix or the number of criteria considered
If CI =0, means the expert's judgement satisfies consistency
If CI > 0, means the experts have conflicting judgements
If CI ≤ 0.1, means there is a reasonable level of consistency (Boateng,2014)
CR = CI/RI

Table5 below presents the RI - the random consistency index.

Table 5:
Random consistency table

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

When CR ≤ 0.1(10 %), it indicates the expert's judgment satisfies consistency.
First, we find the consistency ratio for pairwise comparison Matrix
The principal eigenvalue λ_{max} for the criteria is derived by using the formula :

$$\lambda_{max} = \sum_{j=1}^{n} TjPVj$$

Where n = Number of criteria (n =3)(Table)
Tj = Total of the relative importance values in the column corresponding to the j^{th} criterion
PVj = Priority index of the j^{th} criterion in the priority vector of the criteria.
So, the principal eigenvalue λ_{max} for the criteria is computed as follows.
λ_{max} = 6.33×0.1804+ 13×0.0704+1.31×0.7482 =3.052

The formula for the consistency index is given as
Consistency index (CI) = (λ_{max} – n)/(n-1) = (3.052-3)/2= 0.01453

Random consistency index(R) when n = 3 is 0.58
Consistency ratio (CR) =CI/RI = 0.01453/0.58 = 0.02502 =2.502 %

Since the consistency ratio is less than 10 %, the values in the eigenvector are acceptable.

Similarly, pairwise comparisons of factors and subcriteria are also computed. The final results are presented in the following table 6.

Table 6:
Calculated Weights of the Criteria and Sub-criteria

Main Cause	Weights of Main Causes	Sub-Cause	Weights of Sub-causes
Implementation	0.1804	The overall process involved in the implementation	0.0177
		Understanding the needs of the organisation	0.0358
		Planning and execution	0.0177
		Data migration	0.0178
		Training	0.0219
		Maintenance and Support	0.0353
		Cost - Benefit factor of implementing the IS	0.0342
Performance	0.0714	Features and functionality in IS to meet the needs of the organisation	0.0000464
		Ease of implementation across all the Department	0.0001007
		Able to meet changes/best practices in the functional aspects of the organisation	0.0000129
		Digitisation and integration of organisation documents	0.0000271
		Data and reports for the Decision-making	0.0000207
		Continuous support from the developer/company/vendor	0.0000100
		API support/integration with third-party software	0.0001299
		Software maintenance/repair/system log	0.0000778
		Upgrades/ introduction of new features	0.0000357
		Affordability of the upgrades	0.0000164

		Availability of the Disaster recovery tool/backup	0.0001678
		Online customer support	0.0000614
		Overall satisfaction level	0.0000079
Usage and Impact	0.7482	For report generation	0.450385
		For process management	0.028717
		For record management	0.095178
		Achieving automation in the organisation	0.048904
		Cost implication	0.12498

By analysing the results, the respondents feel that usage and impact are the most crucial factors for selecting an information system (Highest rank= 0.7482); implementation comes next with a rank of 0.1804, followed by a performance of 0.0714. Though performance is a factor that is most important in the case of selecting an information system, the respondents felt that comfort in using the system was the top priority in selecting an information system.

Discussion on the findings

The current research paper has adopted the AHP-based methodology to analyse the IS systems in public services. The methodology is based on the study in Health IS, Public Service IS, e-Government IS, Banking and Accounting IS, and measurement of IS from the usage parameters identified through literature review. The AHP model of this study consists of three factors (Implementation, Performance and Usage and Impact) and several sub-criteria for each factor. The AHP method uses pairwise comparisons of factors and sub-factors concerning the goal and a questionnaire based on Saaty's Rating Scale. The AHP method is an Eigenvalue approach to pairwise comparisons that calculates the weights or priorities of each element in the hierarchy and then aggregates them into a final ranking of the alternatives. Following 4 key steps are adopted to present this discussion -

1. Identify the decision, options, and criteria.
2. Conduct pairwise comparisons of options and criteria using a ratio scale.
3. Calculate the importance weight of each criterion and sub-criterion using an Eigenvalue approach.
4. Identify the best option by calculating something called utility, which is the sum of the products of the weights and scores of each option.

Table 6 is the cumulative result of the entire exercise in this research. The table shows the weights of the main causes and sub-causes for selecting an information system. The weights are derived from the pairwise comparisons of the alternatives and criteria made by the evaluators. The weights indicate the relative importance or influence of each cause or sub-cause on the decision. The higher the weight, the more important or influential the cause or sub-cause is.

The causes and sub-causes have the highest weights and how they affect the ranking of the alternatives. For example, you can see that Usage and Impact (F3) has the highest weight among the main causes (0.7482), which means that it is the most important factor for towards the overall user satisfaction in an information system. Within this factor, for report generation has the highest weight among the sub-causes (0.450385), which means that it is the most important aspect of Usage and Impact. Therefore, it is expected that the alternative that performs best in terms of report generation will have a high utility score and a high chance of being selected as the best option will shortlisting the IS in an Indian public service organizations.

While comparing the weights of different causes and sub-causes to study the difference in importance or influence. For example, Implementation (F1) has a much lower weight than Usage and Impact (F3) (0.1804 vs 0.7482), which means that Implementation is much less important than Usage and Impact for selecting an information system in Indian Public Service Organization and while studying the user satisfaction. Within Implementation, Cost - Benefit factor of implementing the IS has the highest weight among the sub-causes (0.0342), which means that it is the most important aspect of Implementation. However, this weight is still much lower than for report generation (0.450385), which means that Cost - Benefit factor of implementing the IS, is much less important than for report generation for selecting an information system and towards the overall user satisfaction in the Indian Public Service Organization.

The consistency ratio (CR) of each matrix measures how much deviation there is from a perfectly consistent matrix, where all pairwise comparisons are transitive and consistent. A CR value close to zero indicates a high level of consistency, while a CR value close to or above 0.1 indicates a low level of consistency or a high level of inconsistency.

This research study has proved that the AHP-based analysis can be one of the better fit methods for analysing the key parameters or criteria for evaluating an information system for the user satisfaction or shortlisting of candidates for the selection process. Further, this study has demonstrated that the methodology adopted can be adopted to evaluate the IS candidate in a Public Service sector.

Conclusion:

In conclusion, information systems have revolutionized the way businesses operate, providing real-time data, automation, and increased efficiency. Organizations need to be aware of the risks associated with these systems and take appropriate measures to mitigate them. Skilled professionals in information technology are in high demand to manage and maintain these systems, making it a promising field for those seeking a career in this area. Further, it demands an evaluation framework and defined model to meet the expectations of the contemporary world.

The authors felt that more intensive research with the detailed criteria and sub-criteria/factors drawn from the earlier research will result in the comprehensive evaluation parameter or matrix to study the information systems. Further, a defined model to evaluate the IS for the selection process and user satisfaction evaluation process will help the corporate and the software developers. This is true with the latest development with respect to the emerging technologies like Artificial Intelligence (AI) and Analytical layers which is super imposed on the existing IS systems.

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