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Patron-in-Chief Message

It is with immense admiration and admiration that I express my gratitude for the launch 3rd issue of the Aror University Research Journal (AURJ). As Patron-in-Chief, I believe this journal represents a significant milestone in our journey toward academic excellence, innovative research, and the preservation of our rich cultural heritage.

At Aror University, we are committed to fostering a vibrant culture of research and innovation that addresses contemporary global challenges while recognizing the unique traditions and values of our region. The AURJ is a vital platform for scholars, researchers, and practitioners from diverse fields, including art, design, heritage, and emerging technologies, to share groundbreaking ideas and transformative insights with a global audience.

In today's fast-paced world, interdisciplinary research and collaboration are essential for progress. The AURJ embodies this spirit by encouraging contributions that blend creativity with critical inquiry, ensuring that our research is not only advancing knowledge but also fostering significant social change.

I am particularly pleased to see this initiative align with our wider vision for Aror University, which emphasizes sustainability, inclusivity, and international collaboration. By publishing high-quality, peer-reviewed research, we aim to establish AURJ as a beacon of academic excellence and a catalyst for innovation across disciplines.

I express my gratitude to the editorial team, reviewers, and contributors for their dedication and dedication in making this journal a reality. I am confident that the AURJ will be a key component of scholarly engagement and will enhance Aror University's reputation as a center of academic distinction.

Let us continue to explore new frontiers of knowledge, inspire creativity, and contribute to the advancement of society.

Warm regards,

Prof. Dr. Zahid Hussain Khand
Vice Chancellor
Aror University of Art, Architecture, Design, and Heritage
Patron-in-Chief, AURJ

Editor-in-Chief Message

Dear Colleagues,

It gives me great pleasure to introduce the 3rd issue of Aror University Research Journal (AURJ). AURJ is the inaugural peer-reviewed research publication of Aror University of Art, Architecture, Design and Heritage, located in the heart of the historic Indus Valley, one of the greatest and most ancient centers of culture and civilization in the world.

For more than five thousand years, the Indus Valley and the Sindh region have been both a center of civilizational development and a trading crossroads for diverse cultures, all of which have contributed to the magnificent heritage of the people of Sindh. As inheritors of this millenia-old heritage, our institutional mission at Aror University is focused on reviving traditional values and promoting the cultural and religious diversity of the Sindh region. Accordingly, AURJ has an especial, though not exclusive, interest in research related to art, architecture, archaeology, history, agriculture, and other fields of central relevance to the Indus region and its culture.

More broadly, AURJ aims to serve as a platform to bring together researchers from all disciplines in art, architecture, design, heritage, engineering, technology, and social and natural sciences. AURJ also aspires to be an interdisciplinary forum for sharing problems, solutions, novel ideas, case studies, and technologies in support of the goals of sustainable development.

We welcome submissions and queries for AURJ from academicians, researchers, and practitioners worldwide. At AURJ we are committed to scholarly professionalism. All submissions will be evaluated according to our double-blind peer review process, and all authors will receive prompt notification of editorial decisions.

We are humbly grateful for the opportunity to launch and participate in this new scholarly enterprise, and we welcome both your leadership and your research.

Dr. Steven Bonta
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Comparative Study of Ground Plus One-Story RCC Building with Etabs and Tekla Structure Designer (BIM)

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ABSTRACT

Building Information Modeling (BIM) has dramatically transformed the structural engineering landscape but analytical validation is still a key requirement. This research compares the Ground plus One-Story (G+1) reinforced concrete (RCC) building between ETABS and Tekla Structural Designer (TSD). A "triple-check" validation protocol, using manual load calculations by the Tributary Area Method as a baseline benchmark, was used to ensure the reliability of the computational outputs. Under the same loads and material properties, the structural response was investigated for identical models, including bending moments, shear, and vertical deflections. The results show a high level of analytical convergence between both platforms in the case of low-rise structures, with values for internal forces being almost equal. There was a large disparity, however, in efficiency of workflow; ETABS is very good at detailed finite element analysis but offers no integrated features for detailing and estimating. Unlike that, Tekla Structural Designer offers a better BIM integrated environment which allows for automated reinforcement detailing and full material quantity take-offs in one single application. Based on these results, this study ends up concluding that the use of BIM-based tools such as TSD could be able to streamline considerably the process of structural design to documentation, because it minimizes human error in the project and facilitates the coordination of the project.

1. Introduction

Today the construction industry in Pakistan is at a technological turning point, generating a contribution of just about 2.5% to the national GDP, and using the traditional 2D CAD process, which is still labour intensive [1]. The demand for resilient multi-story reinforced concrete (RCC) structures has risen with increasing urban density, changing the traditional method of manual analysis to integrated Building Information Modeling (BIM) platform [2]. Manual calculations using the Tributary Area Method are the seemingly "gold standard" or traditional method by which structural validation is performed, but are often not adequate for the complex and iterative design process of contemporary engineering projects [3].

In the modern structural engineering market, the most important computer programs for computations are ETABS and Tekla Structural Designer (TSD). ETABS is well known worldwide for its comprehensive finite element analysis (FEA) features, especially seismic and lateral load distribution [4]. In contrast, Tekla Structural Designer is a paradigm shift towards BIM, a physical modeling environment that synchronizes the structural analysis with automated detailing and material quantification. Although BIM has been recognized to offer various benefits such as reduction in rework, better clash detection, yet the use of BIM in Pakistan is minimal, according to recent surveys only 11% is implemented throughout the country as there are no institutional mandates and technical training [5].

To fill this gap, the present research discussed in this paper will be a comparative study of a one-story RCC building with a ground story RCC building. This study will compare manual calculations with those of ETABS and Tekla Structural Designer to validate the analytical consistency and material efficiency of each platform and to achieve a "triple-check" validation. The results give important insights for structural

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engineers to make decisions in the Sindh region as to whether BIM based workflows give a tangible benefit over traditional methods of analysis for small scale residential construction.

2. Literature Review

This shift away from traditional 2D CAD based workflows to integrated Building Information Modelling (BIM) platforms has been a hot topic in today's structural engineering research. The demand for this change is due to the necessity of better coordination, and minimization of human error and error in material estimation in increasingly complex reinforced concrete (RCC) structures.

2.1 Comparative Software Analysis and Structural Behavior

Many studies have been conducted on the analytical convergence of different structural software. For the thermal response of concrete slabs, [6] compared the results of the ACI codes with the results of ETABS and demonstrated the software's reliability in analyzing regular environmental loads. Likewise, in [7] RCC and post tensioned flat slabs were compared in ETABS, which is an efficient software to model complex floor system.

There have been additional comparative research done to investigate the differences among various platforms. The results of [8] on the evaluation of high-rise buildings with ETABS and RSA software showed that the results are generally similar, however the distribution of forces in certain areas can be different as a result of different software algorithms. This is confirmed by [9], who stressed that the choice of structural software is essential for optimal design of reinforced concrete structures. Further, [10] explored the seismic and wind load aspects of 20-storey mixed use buildings, affirming the need for the use of advanced FEA tools to conduct lateral load distribution on multi-storey frames.

2.2 BIM Integration and Material Optimization

The major benefit of contemporary BIM platforms over conventional analytical techniques is that the material quantity calculation and project coordination are performed. A comparative study between manual and BIM procedures for material quantity calculation of high rise buildings has been conducted by [11] and found that there is a great reduction of discrepancies in quantity take-off using BIM. This theme of optimization is also developed by [12] who used BIM to optimize quantities for cost effectiveness in the design of integrated technology laboratory buildings.

In addition to quantity surveying, BIM allows the smooth integration of architectural and structural processes. Regarding the architectural formation of growable light steel structure system, [13] introduced the 3D visualization and BIM integration in construction, and explained how it can enhance the accuracy of the construction process. [14] recently pointed out that BIM technology is emphasizing structural safety; its design approach of integrated modeling for prefabricated steel frame structure helps to bridge the gap between design and physical assembly.

2.3 Structural Systems and Design Processes

For irregular or complex geometries, the design process needs to be optimized, and a robust framework is needed to accomplish this. [15] Understanding of the optimal design process for complex shaped skyscrapers was achieved, with the focus on the need for integrated workflows to ensure structural integrity in non-standard systems. Moreover, [16] investigated the factors affecting the elastic stiffness factor for dual system RCCs, giving technical insights into the stiffness formulations used in modern analytical software, such as ETABS.

3. Methodology

The research takes the three-stage comparative approach to validate the digital structural outputs with the basic manual calculation. This systematic approach allows the performance of a Ground plus One-Story (G+1) RCC structure to be assessed in a very reliable analytical manner, which is the transition between the traditional engineering process and the modern Building Information Modeling (BIM) process.

3.1 Case Study and Material Specifications

The study utilizes a G+1 residential structure located in Nawabshah City, Sindh, Pakistan, as a primary case study. The structure is designed around a structural grid of 23 reinforced concrete columns, with four of these being heavy-load 15" ×15" columns and nineteen being standard 18" ×9" columns. The building is designed around a structural grid of 23 reinforced concrete columns, with four of the columns being heavy-load 15"×15" columns and nineteen

being standard 18"×9" columns. The horizontal structure is a 5" (125 mm) thick two-way slab structure. Materials properties were carefully specified to match the local construction codes, with M25 grade concrete and Fe500 grade reinforcement steel used. For self-weight calculations, the concrete density was assumed as 150 PCF.

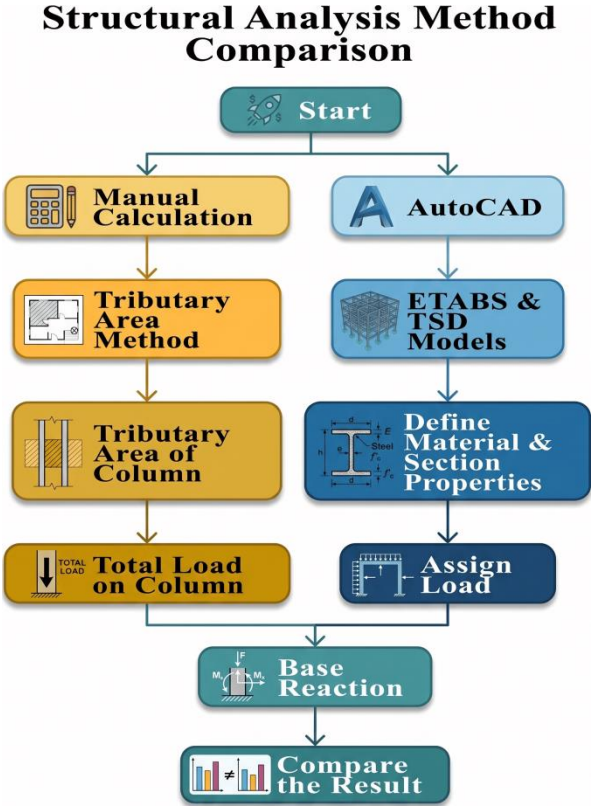

Fig.1 Methodological framework for comparative study, illustrating the parallel workflow between manual validation, ETABS finite element analysis, and Tekla BIM modeling.

Table 1: Design and Material Parameters

Parameter	Specification
Structure Type	Ground Plus One-Story (G+1) RCC
Concrete Grade	M25 (f'c approx 3,625 psi)
Reinforcement Steel	Grade Fe500
Concrete Density	150 lb/ft³ (PCF)
Slab Thickness	5 inches (125 mm)
Beam Section	6" x 18" (Standard)
Column Sections	15" x 15" and 18" x 9"
Design Codes	ACI 318-19 / ASCE 7-10

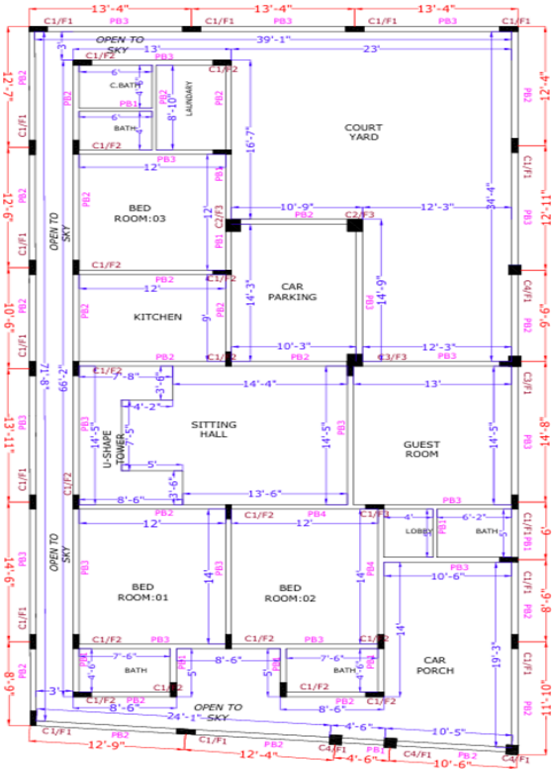

Fig. 2 Architectural floor plan illustrating the residential spatial requirements and column placements.

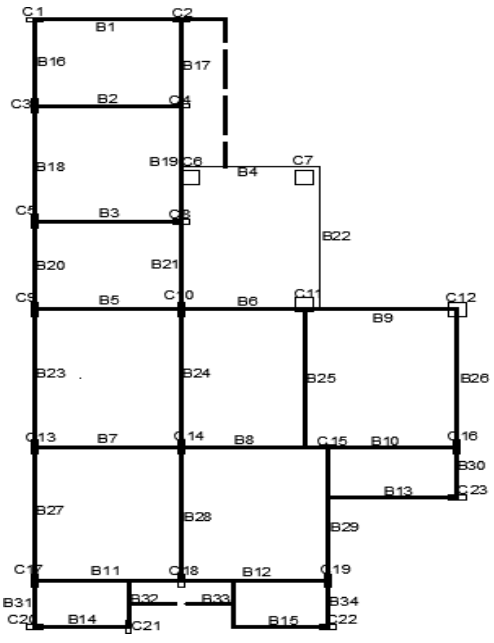

Fig.3 Structural framing plan detailing the beam-column grid (C1-C23) and primary load-bearing members.

3.2 Manual Analytical Validation (Tributary Area Method)

A thorough manual analysis was carried out to provide a baseline for structural behavior. This method, known as the Tributary Area Method, was used to calculate the exact load supported by each column of the grid to determine his or her tributary area. The load path was clearly established: floor loads are carried to the slab, the slab carries loads as Uniformly Distributed Loads (UDL) to the beams, the beams carry loads as point loads to the columns and the total loads carried by the columns are applied to isolated footings. The loads due to total gravity were computed with the ACI factored combination 1.2(DL) + 1.6(LL). The dead load (DL) components consisted of the self-weight of members, a 3" floor finishing load (36.25 PSF), 6" partition walls (0.87 kips/ft), and 6" parapet walls (0.21 kips/ft). A standard live load (LL) was used according to ACI standards; this load was 100 PSF.

3.3 Computational Analysis and BIM Modeling Workflow

Two different computational environments have been used to model the building and evaluated for consistency in analysis and for BIM efficiency.

3.3.1. ETABS Analytical Framework:

The structure was set up as an analytical wireframe to concentrate on Finite Element Analysis (FEA) in the ETABS environment. A shell element model of slabs was used to ensure accurate distribution of the internal forces throughout the frame, such as Shear Forces and Bending Moments. The main task of the ETABS phase was to extract the Joint Reactions as well as unique joint labels (such as Joint 2, Joint 3, Joint 5, Joint 11, Joint 13) to be able to make a direct numerical comparison with the manual results.

3.3.2. Tekla Structural Designer (BIM) Integration:

On the other hand, Tekla Structural Designer (TSD) was used to benefit from its high-fidelity Physical Modeling and BIM functionality. TSD can enable physical members to be directly loaded with architectural loads unlike the traditional analytical software, thereby easing the flow of work. In particular, the TSD phase was used to create detailed Estimate Reports which yielded accurate details of concrete volume (ft3) and reinforcement mass (Tons) for beams, columns and slabs. It enabled the study of the performance of BIM-integrated design in terms of material quantification and construction plan efficiency.

3.4 Evaluation and Comparative Criteria

The last step of the methodology is the multi-metric comparison of the three approaches. The main assessment criteria are:

1. **Reaction Accuracy:** Convergence between Manual Base Reactions and Software-generated Joint Reactions (kips).
2. **Material Optimization:** A comparison of the total volume of concrete and the weight of reinforcement from TSD BIM Reports to the manual method.
3. **Workflow Efficiency:** A qualitative study of the time and complexity needed to produce detailing ready output in a BIM environment vs standalone analytical platform.

4. Results and Discussion

The convergence of the analytical results with computational results obtained from ETABS and Tekla Structural Designer (TSD) of the Ground plus One-Story (G+1) RCC building was analyzed and the material efficiency was evaluated.

4.1 Comparative Analysis of Base Reactions

A comparative analysis of the base reactions is presented. The basic verification of the structural models was accomplished by comparing the factored base reactions at 23 distinct joint locations. This “Triple-Check” protocol is a guideline to help verify interpretation of the gravity load path created in the manual methodology by both ETABS and TSD.

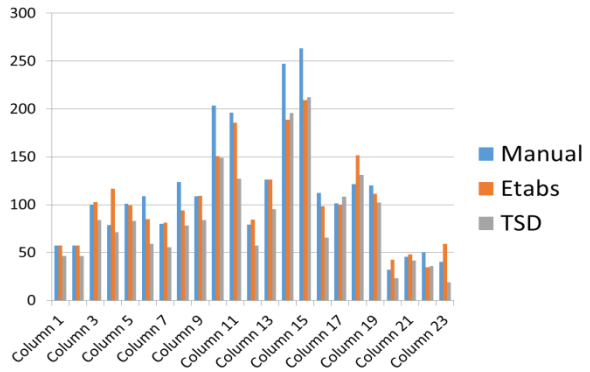

Fig.4 Comparative bar chart of factored base reactions at critical joint locations, validating ETABS and Tekla outputs against manual benchmarks.

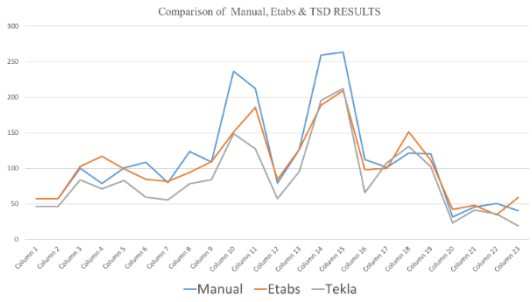

Fig. 5 Comparative line graph of factored base reactions at critical joint locations, validating ETABS and Tekla outputs against manual benchmarks.

The graphical representation

Fig.4 and **Fig. 5** shows an overall trend for most joints for all three methods. The Analytical Convergence of the Software Models is shown visually by the proximity of the bars at Joint 1 and Joint 3. The differences in the larger bars are evident, and the graph is a good indication of the conservative nature of manual calculations compared to the sophisticated load distribution algorithm used in ETABS.

4.2 Structural Behavior and Force Distribution

Structural response of RCC frame has also been analyzed by extracting Bending Moment Diagrams (BMD) and Shear Force Diagrams (SFD) for factored load combination: 1.2(DL) + 1.6(LL).

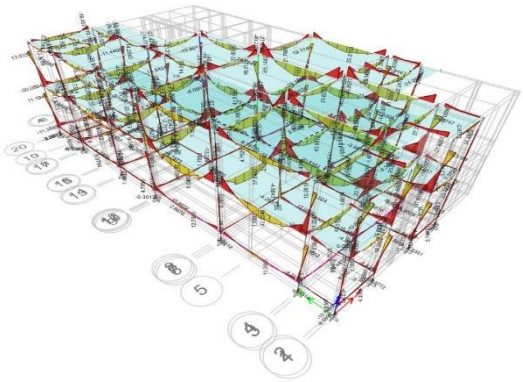

Fig.6 Shear Force & Bending on Etabs

Error! Reference source not found. and **Fig.7** are visual verification of the internal force distribution. The ETABS model includes integrated shear and bending outputs, which also exhibit smooth transitions at the continuous beam-column joints. Likewise, the Tekla Structural Designer (TSD) outputs of "Moment Major" and "Shear Major" show consistent patterns of forces with the maximum moments correctly generated at the mid-spans and supports. This similarity in the force diagrams for both software packages extend the validity of the results generated by the BIM-integrated workflow in Tekla and shows that the analytical outputs are very comparable to those available from a dedicated finite element platform such as ETABS.

Table 2: Comparison of Factored Base Reactions

Sr.no	*Manual*	*Etabs*	*Tekla*
1	*57.12*	*57.42*	*46.5*
2	*57.12*	*57.42*	*46.5*
3	*99.98*	*102.69*	*83.9*
4	*78.54*	*116.82*	*71.2*
5	*100.70*	*99.304*	*82.9*
6	*108.66*	*84.72*	*59.2*
7	*79.82*	*81.47*	*55.6*
8	*123.74*	*94.07*	*78.4*
9	*108.86*	*109.21*	*84*
10	*236.384*	*150.76*	*148.9*
11	*212.384*	*185.76*	*127.2*
12	*79.14*	*84.32*	*57.2*
13	*126.008*	*126.39*	*95.4*
14	*259.216*	*188.69*	*195.6*
15	*263.32*	*209.09*	*212.03*
16	*112.43*	*98.12*	*65.6*
17	*101.49*	*100.09*	*108.12*
18	*121.46*	*151.35*	*130.9*
19	*120.13*	*111.261*	*102.1*
20	*31.78*	*42.38*	*23.2*
21	*45.60*	*48.09*	*41.5*
22	*50.40*	*34.56*	*36*
23	*40.35*	*59.09*	*18.9*

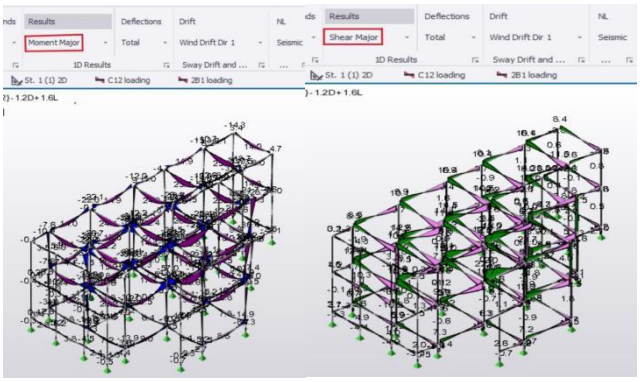

Fig.7 Shear Force & Bending on TSD

4.3 BIM-Based Material Quantification and Efficiency

One of the significant goals of this research was to evaluate the effectiveness of the BIM technology in terms of material estimating, over traditional manual quantity surveying. The physical model was used to automatically produce high fidelity Estimate Reports with Tekla Structural Designer.

The main benefit of TSD workflow in a BIM environment is highlighted in the formulation of **Table 3** and **Table 4**. The research was able to document a total volume of concrete of 2,978.9 ft3 and a total mass of reinforcement of 10.297 Tons (including a 10% detailing allowance). These quantities can be brought directly from the synchronized 3D model which reduces the possibility of human error commonly associated with the manual extraction. This is a useful feature that enables engineering practices in the Sindh region to have a better estimation of the construction cost and plan the work more accurately.

Table 3: Total Concrete Volume

Total Concrete Volume				
Material	**Weight**	**Gross Surface Area**	**Net Surface Area**	**Volume**
	[ton]	**[ft^2]**	**[ft^2]**	**[ft^3]**
Concrete	223.420	9727.3	9727.3	2978.9
Total	**223.420**	**9727.3**	**9727.3**	**2978.9**

Table 4: Total Reinforcement

Total Reinforcement	
Type	**Total Mass**
	[ton]
Beams	2.527
Columns	3.498
Slabs/Mats	3.884
Total + 10.00 % detailing allowance	**10.297**

5. Conclusion

A comparative study of a Ground plus One-Story (G+1) RCC building with manual calculation, ETABS and Tekla Structural Designer (TSD) shows that both the computational platforms are highly reliable in designing low rise structures. The research has successfully tested the accuracy of these digital tools by achieving high analytical consistency with results obtained from the manual tributary area benchmarks for bending moment, shear force and deflection. The software packages yielded very similar answers for basic structural operations, but it is a different paradigm that is illustrated in practical use. While ETABS is still a great option for detailed pure structural analysis, Tekla Structural Designer is an efficient and versatile option for real-world engineering, bringing 3D modeling, analysis, automated detailing and quantity take-off reports together in a single Building Information Modeling (BIM) ecosystem.

In addition, this research highlights the need to choose the structural software according to the project requirements and not solely based on its analytical features. ETABS is adequate for academic studies and/or purely analytical purposes where the objective is only to determine the forces and deflection values. In professional practice, where coordination with architects and contractors is crucial, however, the integrated BIM features of Tekla Structural Designer give an advantage that can be measured. The automatic Generation of quantity take-off and reinforcement detailing by TSD reduces the amount of human effort and errors needed in project documentation and cost estimation.

Future Studies

With the findings of this study, it is recommended that future structural design project be assigned to software according to its desired level of practical output: Firstly, ETABS is recommended to be used for high-precision analytical works, namely in professional works that require detailed BIM coordination in the project, Tekla Structural Designer is suggested to be used. The students and early career engineers are also encouraged to work on both platforms so that they are able to differentiate between an analysis based and BIM based methodology, making them more technically versatile to meet the current market demand for engineering.

The comparative framework is proposed to be used in future academic studies with high-rise and irregular structural configurations to analyze the seismic and torsional performance of the software with complex load scenarios. Furthermore, future research could explore the use of advanced materials and time-dependent thermal effects, including those that are

modelled for hot climates, to improve the overall model of structural behavior in different environmental conditions.

Acknowledgment

Not available

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Cyber K2D: An Uncertainty-Aware Index for Measuring the Knowledge-to-Doing Gap in Cyber Hygiene

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ABSTRACT

Cybersecurity awareness studies often show that students know basic safety rules but do not always apply them in daily digital routines. Existing work has measured awareness, intentions, or training outcomes, yet many studies provide limited item-level uncertainty reporting and do not directly quantify the distance between factual knowledge and recent protective behavior. This paper presents Cyber K2D, a lightweight Knowledge-to-Doing gap measure for cyber hygiene. An anonymous cross-sectional survey was completed by 302 university respondents; after consent-based screening, 272 responses were included. The instrument contained seven knowledge items, five self-efficacy items, and six recent-behavior items. Knowledge was normalized as a knowledge rate, behavior was normalized as a safe-practice rate, and the Cyber K2D Gap was defined as knowledge rate minus behavior rate. Item-level percentages were reported with Wilson 95% confidence intervals, and uncertainty responses were treated as a visible risk signal. The results show moderate knowledge (mean Knowledge Score = 4.01/7) and moderate behavior adoption (mean Behavior Rate = 0.51). The mean Cyber K2D Gap was 0.07, indicating that knowledge slightly exceeded reported safe behavior. Knowledge was positively associated with safe behavior (Spearman rho = 0.40, p = 1.91e-11), while self-efficacy showed a smaller positive association (rho = 0.24, p = 8.56e-05). The weakest areas were deception-cue recognition, password reuse, risky public-Wi-Fi login behavior, and uncertainty about whether protections were active. The main contribution is not another general awareness message, but a reproducible diagnostic method that ranks specific knowledge-behavior gaps with uncertainty estimates so that universities can design focused micro-interventions and evaluate behavior-focused progress over time.

1. Introduction

Cybersecurity incidents often begin with ordinary user actions: clicking a deceptive message, reusing a password, trusting a familiar-looking link preview, approving an unexpected login prompt, or entering credentials on an unsafe network. Large incident reports continue to identify credential misuse, phishing, and human decision-making as important parts of the threat landscape [1]-[3]. For this reason, cybersecurity awareness remains a necessary part of institutional protection, especially in universities where students use many personal and academic services across shared networks and devices.

However, awareness alone is not the same as protection. A person may know that strong passwords, multi-factor authentication, safe updates, and careful link checking are important, but still fail to apply these practices consistently. This difference is the knowledge-to-doing gap. The gap matters because many awareness programs are still judged mainly through quiz scores or general satisfaction measures, even though real risk depends on daily behavior. Training research also shows mixed outcomes, especially when awareness content is generic, delivered only once, or not connected to specific real-world actions [4], [6], [7].

The present study reframes cybersecurity awareness as a measurable movement from knowledge to action. The purpose is not to claim that practical

demonstrations, multi-factor authentication, or password guidance are new by themselves. These practices already exist in many institutions. The new outcome of this work is a compact diagnostic index that shows where knowledge is not becoming behavior, reports confidence intervals for each item, and treats "Not sure" responses as meaningful risk signals. This makes the survey useful for choosing targeted micro-interventions instead of repeating broad awareness messages.

The study is grounded in established behavior theory. Protection Motivation Theory explains that protective behavior depends on perceived threat, response effectiveness, and the belief that the action can be performed [14]. The Theory of Planned Behavior emphasizes attitudes, social norms, and perceived control [13]. Self-efficacy is also central because users may know the correct rule but still avoid action if the task feels confusing or inconvenient [12], [15]. Cyber K2D uses these ideas in a simple measurement structure: knowledge, self-efficacy, recent behavior, and the difference between knowledge and behavior.

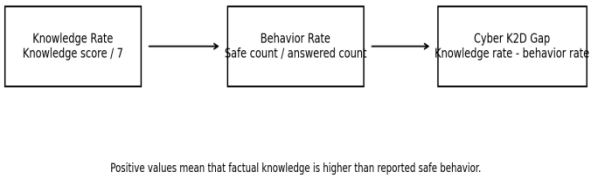

Fig.1 Cyber K2D measurement logic used in this study.

This paper makes three contributions:

- Operationalizes the Cyber K2D Gap as a reproducible Knowledge Rate minus Behavior Rate measure for cyber hygiene, allowing knowledge and recent practice to be compared on the same 0 to 1 scale.
- Quantifies item-level knowledge and safe-practice adoption with Wilson 95% confidence intervals, so weak areas can be ranked with statistical uncertainty rather than reported only as raw percentages.
- Prioritizes behavior-focused micro-interventions by identifying high-risk items where knowledge, behavior, and uncertainty patterns suggest that students may struggle during real security decisions.

2. Related Work and Research Gap

Cybersecurity awareness has been measured through many survey-based approaches. University-focused studies continue to show that students may report moderate to high awareness while still showing weaknesses in password behavior, phishing judgment, and safe technology use [8], [10], [22], [23]. Such studies are useful for describing awareness levels, but instruments and reporting practices often differ, which makes direct comparison difficult.

Table 1: Positioning of Cyber K2D against related approaches.

Approach	Main strength	Typical limitation for local decision-making	How Cyber K2D extends it
Awareness surveys among students [8], [10], [22], [23]	Describe awareness and education levels in student populations.	Often emphasize overall scores and may not quantify the gap between correct answers and recent practice.	Adds a normalized knowledge-to-doing gap and ranks specific weak items.
HAIS-Q and KAB-style measurement [17], [18]	Provide structured and validated measurement of human security dimensions.	Broader and longer instruments may be less convenient for repeated local diagnosis.	Uses a shorter three-block instrument for quick benchmarking and repeated evaluation.
SeBIS and intention scales [19]	Measure security behavior intentions across important domains.	Intentions do not always represent recent behavior.	Uses recent self-reported behavior and safe-practice coding.
Training and phishing intervention studies [6], [7]	Evaluate training methods and real-world training effectiveness.	Intervention results may not show which local behaviors need immediate attention.	Uses item-level gaps to choose micro-interventions before or after training.
Security culture models [9]	Frame security as knowledge, values, risk perception, responsibility, and habits.	Conceptual models may not offer a simple short index for classroom or institutional audits.	Operationalizes the culture-to-behavior idea in a short measurable instrument.

More structured measurement instruments have also been proposed. The Human Aspects of Information Security Questionnaire (HAIS-Q) measures knowledge, attitudes, and behavior across several security domains and has been validated in later studies [17], [18]. The Security Behavior Intentions Scale (SeBIS) measures intentions across passwords, securement, updates, and proactive awareness [19].

These instruments provide important psychometric foundations, but their main purpose is not short diagnostic ranking of item-level knowledge-to-behavior gaps in a local training setting.

Recent literature also emphasizes security behavior, self-efficacy, and information security culture. Studies on MFA adoption, password-manager usability, phishing reporting, and self-efficacy show that behavior is shaped by usability, confidence, perceived value, and social context, not only by factual knowledge [15], [16], [20], [21]. Conceptual work on personal information security culture also supports a wider view in which knowledge, values, risk perception, responsibility, and habits interact [9].

The research gap addressed here is therefore practical and methodological. Many surveys report awareness scores, and many training papers discuss interventions. Fewer short survey studies directly combine: (i) a normalized knowledge-to-behavior gap, (ii) Wilson confidence intervals for item-level priorities, (iii) visible "Not sure" patterns, and (iv) a clear instrument appendix for replication. Table 1 summarizes how the present paper is positioned against related approaches.

3. Methodology

3.1 Study design and participants

A cross-sectional online survey design was used. Respondents completed the survey voluntarily after reading an information sheet and giving consent. The survey was administered in a university context and was analyzed anonymously. After applying the consent-based inclusion rule, 272 responses were included in the final analytical dataset.

The study used available demographic fields only for aggregate description and subgroup planning. No individual respondent was identified in the analysis. The sample should be interpreted as a convenience sample rather than a probability sample of all university students.

3.2 Instrument

The questionnaire was organized into three blocks. The knowledge block included seven True/False/Not sure items about common cyber hygiene concepts. The self-efficacy block included five Likert-scale "I can..." items measuring confidence in performing protective actions. The behavior block included six Yes/No/Not sure items about protective actions during the previous three months. The complete analysis instrument and coding scheme are provided in Appendix A to support replication.

3.3 Scoring model

Knowledge Score. Each correct knowledge answer was coded as 1. Incorrect and "Not sure" answers were coded as 0 because both represent lack of usable knowledge in a real decision. The Knowledge Score ranged from 0 to 7.

Self-Efficacy Score. The five self-efficacy items were scored from 1 (strongly disagree) to 5 (strongly agree). The respondent-level Self-Efficacy Score was calculated as the mean of completed items. The scale reliability reported for SE1-SE5 was Cronbach alpha = 0.715, which is acceptable for a short exploratory scale.

Behavior Rate. Each behavior item was converted into a safe-practice indicator. For protective actions, "Yes" was coded as safe. For risky actions, such as password reuse and risky public-Wi-Fi login, coding was reversed so that higher values always indicated safer behavior. "Not sure" responses were excluded from the denominator in the primary analysis and reported separately. The Behavior Rate was calculated as:

$$\text{Behavior Rate} = \text{Safe Count} / \text{Answered Count}$$

Cyber K2D Gap. To remove the earlier ambiguity between a behavior rate and a gap score, this version uses one canonical definition:

$$\text{Cyber K2D Gap} = (\text{Knowledge Score} / 7) - \text{Behavior Rate}$$

The Cyber K2D Gap ranges approximately from -1 to +1. Positive values mean that knowledge is higher than reported safe behavior. Values near zero mean that knowledge and behavior are aligned. Negative values mean that reported safe behavior is higher than factual knowledge. Respondents with no Yes/No behavior answers were excluded from behavior-rate and gap calculations.

3.4 Statistical analysis

Descriptive statistics were calculated for composite scores. Item-level knowledge and behavior percentages were reported with Wilson 95% confidence intervals because Wilson intervals perform well for binomial proportions, including values near 0 or 1 [26], [27]. Spearman rank correlation was used to examine associations between Knowledge Score,

Self-Efficacy Score, and behavior because the scores are bounded and not assumed to be normally distributed. A Poisson rate model with robust standard errors was used for Safe Count, with log (Answered Count) as an offset, so the coefficients can be interpreted as changes in the rate of safe practice per answered behavior item.

4. Results

4.1 Sample and completeness

The survey received 302 submissions. No duplicate submissions were removed. After consent-based screening, 272 responses were included. Age was available for 257 respondents. The mean age was 22.24 years (SD = 4.30), with a median of 21 years (IQR = 20-23). Reported gender distribution was 151 male, 118 female, and 3 missing. Reported training exposure was 192 with no training, 55 with a short workshop, 23 with a course, and 2 missing.

Table 2: Sample flow and score completeness.

Measure	Value
Raw submissions	302
After de-duplication	302
Duplicates removed	0
Included after consent screening	272
Missing Knowledge Score	0.00%
Missing Self-Efficacy Score	1.84%
Missing Behavior Rate	4.41%

4.2 Composite scores and Cyber K2D Gap

Table 3 presents the cleaned composite results. The mean Knowledge Score was 4.01 out of 7. The mean Self-Efficacy Score was 3.26 out of 5. The mean Behavior Rate was 0.51, which means that respondents reported safe practice for about half of the answered behavior items. The mean Cyber K2D Gap was 0.07, indicating that knowledge was slightly higher than safe behavior in the sample.

Table 3: Composite score summaries after applying the unified K2D definition.

Measure	n	Mean	SD	Median	IQR	Range
Knowledge Score (0-7)	272	4.01	2.11	4.00	2.00-6.00	0-7
Self-Efficacy Score (1-5)	267	3.26	0.80	3.25	2.75-3.75	1-5
Behavior Rate (0-1)	260	0.51	0.28	0.50	0.25-0.75	0-1
Cyber K2D Gap (-1 to +1)	260	0.07	0.36	0.06	-0.17-0.32	-1 to 1
Answered behavior items	272	4.10	1.34	5.00	4.00-5.00	0-5

4.3 Knowledge Accuracy

Knowledge accuracy varied by item (Table 4 and Figure 2). The strongest knowledge item was A7, related to the malware risk of unofficial app stores (71.69%, 95% CI 66.06-76.71). The weakest item was A1, related to spoofed display names or link previews (37.50%, 95% CI 31.96-43.39). The highest "Not sure" rates occurred for A1 (37.13%), A6 (27.57%), and A3 (23.53%), suggesting uncertainty around deception cues, public-network risk, and shortened-link destination risk.

Table 4: Knowledge items: percent correct with Wilson 95% confidence intervals.

Item	Operational topic	Correct (%)	95% CI
A7	Unofficial app stores raise malware risk	71.69	66.06-76.71
A2	MFA helps if a password leaks	63.24	57.36-68.74
A5	Limit app permissions	62.87	56.98-68.39
A4	Strong passwords/passphrases	58.46	52.52-64.15
A3	Shortened links can hide destination	55.88	49.94-61.66
A6	Public Wi-Fi and non-HTTPS risk	51.10	45.19-56.99
A1	Spoofed display name/link preview	37.50	31.96-43.39

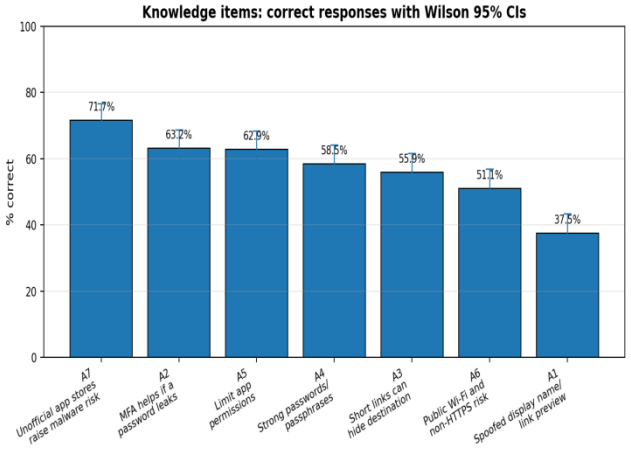

Fig.2 Knowledge item accuracy with Wilson 95% confidence intervals.

4.4 Behavior adoption

Safe behavior adoption also varied across items (Table 5 and Figure 3). The strongest behavior item was reviewing app permissions (B4: 67.14%, 95% CI 60.57-73.09). The weakest behavior item was avoiding password reuse (B3: 39.66%, 95% CI 33.65-46.01), followed by avoiding risky public-Wi-Fi logins (B6: 46.53%, 95% CI 40.39-52.78). These results show that students may understand several

safety concepts but still struggle with practices that require ongoing habits or setup effort.

Uncertainty in behavior items was also meaningful. The highest "Not sure" shares were found for enabled MFA (B1: 24.63%), installed updates within a week (B5: 22.06%), and reviewed app permissions (B4: 21.69%). These responses may indicate that some respondents did not know whether a security setting was active or could not recall recent protective actions.

Table 5: Behavior items: percent safe with Wilson 95% confidence intervals.

Item	Safe behavior topic	Safe (%)	95% CI	Not sure (%)	n (Yes/No)
B4	Reviewed app permissions	67.14	60.57-73.09	21.69	213
B5	Installed updates within a week	64.62	57.98-70.75	22.06	212
B2	Used a password manager	56.94	50.28-63.37	20.59	216
B1	Enabled MFA	52.68	45.86-59.41	24.63	205
B6	Avoided risky public-Wi-Fi logins	46.53	40.39-52.78	9.93	245
B3	Did not reuse passwords	39.66	33.65-46.01	12.87	237

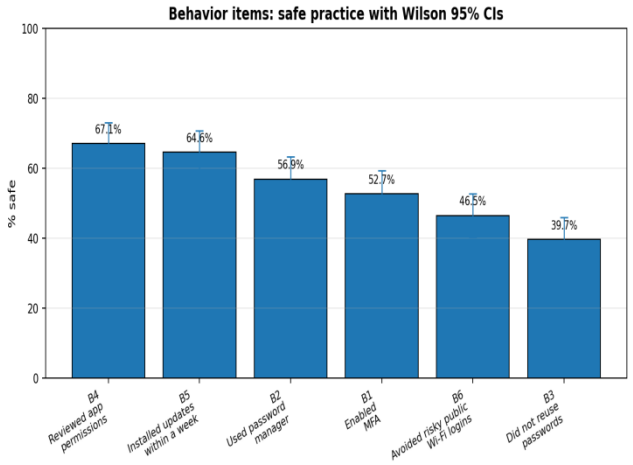

Fig.3 Safe behavior adoption with Wilson 95% confidence intervals.

4.5 Associations and predictors of safe behavior

Knowledge and behavior were positively associated. Spearman rank correlation between Knowledge Score and Behavior Score was rho = 0.40 (p = 1.91e-11, n = 258). Self-efficacy also had a positive but smaller association with behavior (rho = 0.24, p = 8.56e-05, n = 258). These results show that knowledge and confidence matter, but neither fully explains safe behavior.

In the Poisson rate model, Knowledge Score remained a significant predictor of safe behavior. The incidence rate ratio for Knowledge Score was 1.06 (95% CI 1.02-1.10, p = 0.005), meaning that each additional correct knowledge item was associated with approximately 6% higher expected safe-practice rate, holding self-efficacy constant. Self-efficacy had a positive but less precise association (IRR = 1.07, 95% CI 0.98-1.16, p = 0.118).

Table 6: Predictors of safe behavior in the Poisson rate model.

Predictor	IRR	95% CI	p-value	Interpretation
Knowledge Score (per +1 correct item)	1.06	1.02-1.10	0.005	About 6% higher safe-practice rate
Self-Efficacy Score (per +1 point)	1.07	0.98-1.16	0.118	Positive but not statistically precise

5. Discussion

The main finding is straightforward: the sample showed moderate cybersecurity knowledge, but recent safe behavior was only moderate. The positive association between knowledge and behavior confirms that knowledge is useful. The Cyber K2D Gap shows that knowledge is not enough. Safe action also depends on confidence, convenience, habit, and the ability to check whether a protection is actually enabled.

This result helps clarify the novelty of the paper. The recommended actions, such as MFA guidance, password-manager support, update reminders, and link-verification demonstrations, are not new as individual practices. The contribution is the measurement approach that identifies which of these actions should be prioritized for a particular population. For example, the data suggest that password reuse and public-Wi-Fi login behavior require more attention than app-permission review in this sample. A general awareness lecture would not reveal this ordering.

The weakest knowledge item involved spoofed display names and link previews. This is important because phishing attacks often rely on surface trust cues. A student may know the phrase "avoid suspicious links" but still trust a message that looks official. The gap therefore lies in mental models, not only in recall. Training should show how deception works through short live examples, not only through written rules.

The weakest behavior item was password reuse. This is consistent with prior work showing that password-manager adoption and strong password routines involve usability barriers, first-use friction, and habit formation [21]. The practical implication is that "do not reuse passwords" is not enough. The safer behavior becomes more realistic when users are guided through a password-manager setup, recovery-code storage, and account-by-account replacement of reused passwords.

The "Not sure" results are also important. Uncertainty is not simply missing knowledge. In real security decisions, uncertainty can lead to quick unsafe choices. If a respondent does not know whether MFA is enabled, whether updates were installed, or whether a link preview can be trusted, the institution has not created a dependable safety habit. For this reason, training evaluation should measure uncertainty reduction along with knowledge and behavior.

Compared with previous awareness surveys, the present paper gives a more actionable output: a ranked list of weak concepts and weak behaviors with confidence intervals. Compared with broad security culture models, Cyber K2D is narrower but easier to repeat in a classroom, department, or university-wide audit. Its value is strongest as a local diagnostic benchmark rather than as a full psychometric replacement for larger validated instruments.

5.1 Practical Implications

The results support behavior-focused micro-interventions. A suitable program could include: (i) a two-minute demonstration showing how display names, previews, and shortened URLs can mislead users; (ii) a short password-manager onboarding session; (iii) a public-Wi-Fi checklist for avoiding sensitive logins on unsafe networks; and (iv) a guided MFA verification activity where students check whether MFA is enabled and save recovery codes. These actions are practical because friction is reduced and advice becomes a visible task.

For institutions, Cyber K2D can be used before and after such interventions. A useful evaluation would not ask only whether students learned the content. It would ask whether the lowest-ranked behavior items improved, whether the Cyber K2D Gap decreased, and whether "Not sure" responses declined on high-risk items. This connects training design with measurable behavior-oriented outcomes.

5.2 Limitations and Threats to Validity

Self-report bias. The behavior items relied on self-report. Respondents may forget past actions or provide answers that seem socially desirable. This can overestimate safe behavior. Future work should add objective checks where ethical and practical, such as voluntary device-setting verification or controlled security tasks.

Convenience sample. The sample came from a university context and should not be treated as representative of all students or all users. Cyber K2D should be repeated in other institutions, age groups, and professional settings before wider generalization.

Cross-sectional design. The data were collected at one time point. Associations between knowledge, self-efficacy, and behavior should not be interpreted as causal effects. Longitudinal or intervention-based designs are needed to test whether improving a specific knowledge item changes the related behavior.

Short instrument. The instrument was intentionally brief. This reduces respondent burden but limits depth. It does not replace larger validated tools such as HAIS-Q or SeBIS. Its main purpose is practical diagnosis and repeated local benchmarking.

Behavior frequency. Behavior items used Yes/No/Not sure responses. This makes scoring simple but does not capture how often a risky behavior occurs. A future version should test frequency-based behavior items while keeping survey length manageable.

Measurement reliability. The self-efficacy block showed acceptable internal consistency for a short scale. However, additional psychometric work is needed, including exploratory factor analysis, confirmatory factor analysis in a larger sample, and measurement invariance testing across gender, program, and training-exposure groups.

9. Conclusion

This paper presented Cyber K2D as a simple uncertainty-aware method for measuring the knowledge-to-doing gap in cyber hygiene. In a university sample of 272 consented respondents, knowledge was moderate, self-efficacy was moderate, and recent safe behavior was only moderate. The unified Cyber K2D Gap showed that knowledge slightly exceeded behavior, while item-level results identified the clearest priority areas: deception-cue

recognition, password reuse, risky public-Wi-Fi login behavior, and uncertainty about active protections. The findings support a shift from broad awareness delivery to targeted behavior support. Cyber K2D can help universities and organizations decide which safe practices need immediate attention, evaluate whether micro-interventions reduce the gap, and report results with clearer uncertainty estimates.

8. Future Recommendations

First, Cyber K2D should be tested as a pre-post intervention measure. A short intervention can target the weakest items, and the same instrument can be repeated after two to four weeks to assess whether knowledge, behavior, and uncertainty changed.

Second, training-exposure subgroups should be analyzed more deeply. The current dataset includes respondents with no training, a short workshop, and a course. A Kruskal-Wallis test or ordinal/rate model could compare these groups and show whether different training exposure is associated with lower K2D gaps.

Third, future studies should combine Cyber K2D with objective or semi-objective behavior indicators, such as MFA setting checks, password-manager setup confirmation, or simulated link-verification tasks. This would reduce dependence on self-report.

Fourth, the instrument should be refined through cognitive interviews and factor analysis. This would improve item clarity, confirm the structure of self-efficacy items, and support stronger claims about measurement validity.

Finally, the framework can be adapted to other behavior-change domains where knowledge does not reliably become action. Cross-domain comparison may help cybersecurity training borrow stronger behavior-change methods from health and safety research.

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Temporal Dynamics of Vegetation in Hyderabad, Sindh: An NDVI-Based Analysis

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Hyderabad, NDVI, Landsat, Vegetation dynamics, Urban expansion, remote sensing, semi-arid environment

ABSTRACT

Rapid urbanization and climate-related environmental stress have intensified pressure on vegetation resources in semi-arid cities, yet long-term city-scale vegetation assessments remain limited for Hyderabad, Sindh, Pakistan. This study analyses the temporal dynamics of vegetation in Hyderabad over a 20-year period using Landsat-derived Normalized Difference Vegetation Index (NDVI) for 2004, 2014, and 2024. Satellite images from Landsat 7 ETM+ and Landsat 8 OLI were processed to calculate NDVI and classify the study area into four major classes: water bodies, urban/barren land, shrubs/low vegetation, and healthy vegetation. Random Forest classification and accuracy assessment were applied to improve land cover discrimination, achieving an overall accuracy of approximately 85%. The results show a substantial decline in healthy vegetation from 48.33% in 2004 to 21.96% in 2014 and 16.26% in 2024, representing an overall reduction of 32.07 percentage points. In contrast, urban/barren land increased from 19.50% in 2004 to 47.85% in 2014 and 49.20% in 2024, showing an overall increase of 29.70 percentage points. Shrubs/low vegetation showed minor variation, decreasing slightly from 30.79% to 30.04%, while water bodies increased from 1.36% to 4.48% during the study period. The findings indicate a clear transition from vegetation-dominated surfaces toward urban/barren land, particularly in rapidly expanding areas such as Latifabad and Qasimabad. This study highlights the effectiveness of NDVI-based monitoring for detecting vegetation loss and provides evidence to support sustainable urban planning, green infrastructure development, and environmental management in Hyderabad.

1. Introduction

Land use and land cover change is one of the most important indicators of environmental transformation, especially in regions facing rapid population growth, urban expansion, agricultural intensification, and climate variability [1]. Land is a vital component of the natural environment because it supports biodiversity, ecosystem services, agriculture, water resources, and human settlements [2]. However, increasing pressure from population growth and development has accelerated the conversion of natural and semi-natural landscapes into built-up, barren, and degraded surfaces, creating serious challenges for sustainable land management [3]. Climate change has further intensified these challenges by influencing vegetation distribution, ecosystem productivity, water availability, and land surface conditions [4].

Recent studies have emphasized that land surface changes are strongly connected with both human activities and climate-related stresses. For example, land surface changes in the highland environment of Gilgit-Baltistan, Pakistan, have been studied to support sustainable management of fragile mountainous landscapes [5]. Similarly, hydroclimatic research has shown that changes in evapotranspiration, temperature, humidity, wind speed, and precipitation patterns can directly influence vegetation condition, agricultural water demand, and land surface processes [6]. Recent studies on Pakistan's monsoonal precipitation have also highlighted shifting rainfall patterns, which can affect

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water availability, vegetation growth, and regional environmental stability [7]. Hydrological studies have further demonstrated that climate variability and human activities can alter streamflow and water resources, which are closely linked with land cover and vegetation dynamics [8].

Remote sensing has emerged as a powerful tool for detecting and quantifying changes in land cover, vegetation health, and ecosystem dynamics over large spatial and temporal scales [9]. Multi-temporal satellite imagery makes it possible to monitor land surface changes, classify different land cover types, and assess biophysical parameters in a consistent and cost-effective manner [10]. Multispectral remote sensing is particularly useful because it captures spectral differences among vegetation, water bodies, barren land, and built-up areas, allowing researchers to evaluate spatial patterns and temporal changes in the landscape [11].

The Normalized Difference Vegetation Index is one of the most widely used satellite-derived indices for vegetation monitoring because it uses the contrast between red and near-infrared reflectance to indicate vegetation greenness, density, and vigor [12]. Higher values generally represent healthy and dense vegetation, while lower values indicate sparse vegetation, built-up surfaces, barren land, or water bodies [13]. Previous studies have applied vegetation indices for vegetation monitoring, crop condition assessment, drought evaluation, and land cover analysis at local, regional, and global scales [14]. Therefore, this index provides a reliable basis for evaluating vegetation dynamics in semi-arid and rapidly urbanizing regions [15].

Hyderabad, Sindh, is an important urban center in the lower Indus Basin and is in a semi-arid climatic zone where vegetation and water resources are highly sensitive to land use change and climate variability. The city has experienced rapid expansion in recent decades, particularly in areas such as Latifabad, Qasimabad, and the central urban zone. This urban growth has increased pressure on agricultural land, shrubland, water bodies, and natural vegetation. In such environments, vegetation loss can intensify urban heat, reduce ecological stability, affect local biodiversity, and increase stress on already limited water resources [16].

Although several studies have examined land surface change, hydroclimatic variability, evapotranspiration, precipitation shifts, and hydrological responses in Pakistan and other regions, limited attention has been given to long-term vegetation dynamics at the city scale in Hyderabad, Sindh [5] [6] [7] [8]. This represents an important research gap because Hyderabad is undergoing rapid urban development while also being exposed to semi-arid climatic conditions and water-resource limitations. A localized satellite-based vegetation assessment is therefore necessary to understand how vegetation cover has changed over time and how urban/barren land, shrubs, and water bodies have shifted during the last two decades.

The present study aims to analyze the temporal dynamics of vegetation in Hyderabad, Sindh, using Landsat satellite imagery for 2004, 2014, and 2024. The satellite-derived vegetation values were classified into water bodies, urban/barren land, shrubs/low vegetation, and healthy vegetation to quantify land surface changes over time. The specific objectives of this study are to assess spatial and temporal changes in vegetation cover, quantify the increase or decrease in major land cover classes, identify areas affected by urban expansion, and provide scientific evidence for sustainable urban planning, vegetation conservation, and environmental management in Hyderabad.

2. Materials and Methods

2.1 Study Area

The study was conducted in Hyderabad, Sindh, Pakistan, a rapidly urbanizing city located in the lower Indus Basin. The study area lies approximately between 25°10′–25°30′ N latitude and 68°20′–68°30′ E longitude (Fig. 1). Hyderabad is characterized by a semi-arid climate, limited annual rainfall, high summer temperatures, and strong dependence on surface and groundwater resources. The city includes a mixture of built-up land, agricultural fields, shrubland, open/barren surfaces, and water bodies associated with the Indus River system and irrigation channels.

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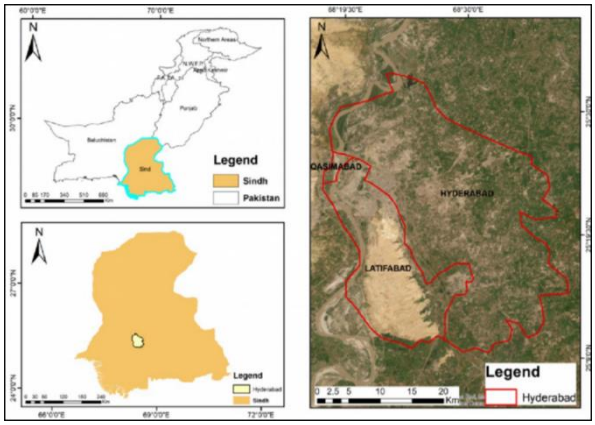

Fig. 1 Location map of the study area

2.2 Data Collection

Multi-temporal Landsat satellite images were used to assess vegetation dynamics in Hyderabad for the years 2004, 2014, and 2024. The satellite images were obtained from the United States Geological Survey (USGS) website (https://earthexplorer.usgs.gov). Landsat imagery was selected because it provides long-term data availability, medium spatial resolution, and reliable spectral information for vegetation and land cover analysis.

For 2004, Landsat 7 Enhanced Thematic Mapper Plus imagery was used, while Landsat 8 Operational Land Imager/Thermal Infrared Sensor imagery was used for 2014 and 2024. Cloud-free or nearly cloud-free images were selected from the same season, preferably the post-monsoon period, to reduce seasonal differences in vegetation condition and ensure meaningful comparison across the selected years (Table 1).

Table 1: Details of satellite imagery used in the study

Year	Satellite/Sensor	Product level	Spatial resolution	Data source
2004	Landsat 7 ETM+	Collection 2 Level 2	30 m	USGS/GEE
2014	Landsat 8 OLI/TIRS	Collection 2 Level 2	30 m	USGS/GEE
2024	Landsat 8 OLI/TIRS	Collection 2 Level 2	30 m	USGS/GEE

2.3 Data Preprocessing

The satellite images were preprocessed before NDVI calculation and classification. The preprocessing steps included radiometric correction, atmospheric correction, band selection, layer stacking, mosaicking where required, and subsetting according to the boundary of the study area.

Landsat Collection 2 Level 2 surface reflectance products were used to minimize atmospheric effects and improve spectral reliability. The images were clipped to the study area using the Hyderabad boundary shapefile. Cloud-contaminated pixels, cloud shadows, and unwanted background areas were removed where necessary to improve classification accuracy.

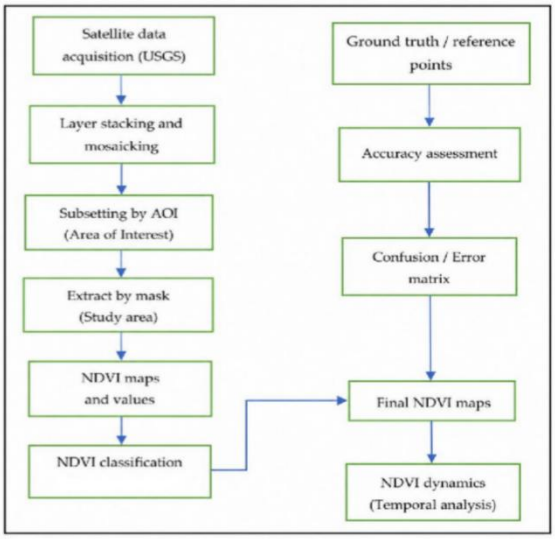

Fig. 2 Flow chart of methodology for current study.

For Landsat 7 ETM+, special attention was given to data quality because images acquired after 2003 may contain scan line corrector gaps. Where required, gap-filling or suitable cloud-free scenes were used to reduce the effect of missing data. All images were projected to a common coordinate system to ensure spatial consistency among the 2004, 2014, and 2024 datasets.

The preprocessing and mapping were carried out using ArcGIS 10.8. The final preprocessed images were then used for NDVI calculation, classification, accuracy assessment, and change detection (Fig. 2).

2.4 Normalized Difference Vegetation Index (NDVI)

The spectral features of vegetation, such as its ability to absorb visible light and photosynthetic energy, are considered in NDVI assessment. NDVI is a plant health assessment based on how the plant absorbs and reflects light at specific frequencies. The NDVI is an excellent indicator of vegetative growth conditions and vegetative cover degree. If a region is vegetated, its NDVI value is a positive number that increases as the vegetation cover improve [17].

Landsat data were obtained in HDF (Hierarchical Data Format). Subsequently, it was reprojected from the original sinusoidal projection to geographic projection (WGS84 datum). Then, stacking, mosaicking, and subsetting to AOI were performed in ArcMap 10.8. Likewise, NDVI matrices were calculated using an ArcMap spatial analysis tool (using a raster calculator) according to Equation (1). After processing all the data, maps for the years 2004, 2014, and 2024 were developed.

$$NDVI = \frac{NIR + RED}{NIR - RED} \qquad (1)$$

Where NIR represents near-infrared band and RED represents red band. These indices have characteristic values between −1 and 1 [18]. NIR is reflected by leaves in plants, while chlorophyll absorbs it. If NDVI is high, it indicates that vegetation is abundant. Alternatively, if NDVI is low, there is little or no vegetation potential. Extremely low NDVI values (below 0.1) correlate to bare rock, sand, or snow regions. High levels imply temperate and tropical rainforests (0.2 to 0.3), whereas moderate values depict shrubs and grasslands (0.6 to 0.8).

For Landsat 7 ETM+, Band 4 was used as the NIR band and Band 3 as the red band. For Landsat 8 OLI, Band 5 was used as the NIR band and Band 4 as the red band. The resulting NDVI values ranged from negative values to positive values. Negative values generally represented water bodies, values close to zero represented built-up or barren surfaces, moderate values represented shrubs or sparse vegetation, and higher values represented healthy vegetation (Table 2).

The NDVI maps were classified into four major classes:

Table 2: NDVI classification scheme

NDVI range	Class	Description
NDVI < 0	Water bodies	Rivers, canals, ponds, or waterlogged areas
0 to 0.15	Urban/barren land	Built-up areas, bare soil, roads, and exposed land
0.15 to 0.30	Shrubs/low vegetation	Sparse vegetation, grassland, and low-density vegetation
NDVI ≥0.30	Healthy vegetation	Dense vegetation, cropland, and relatively healthy green cover

2.4 Data Classification

To improve the reliability of the classified outputs, Random Forest classification was applied using NDVI values and spectral information from Landsat imagery. Training and validation samples were selected for the four NDVI-based classes using visual interpretation of satellite imagery, false-color composites, natural-color composites, and reference/ground truth points. False-color composites helped in distinguishing vegetation, water bodies, and built-up surfaces, while natural-color composites supported the visual identification of urban areas, barren land, and surface water.

The Random Forest classifier was used because it is suitable for remote sensing classification and can handle spectral variability among different surface features. The classified NDVI outputs were further assessed using reference points. An accuracy assessment was performed through a confusion/error matrix to evaluate the reliability of the classification. The overall classification accuracy was approximately 85%, indicating that the classified NDVI maps were suitable for analyzing vegetation dynamics in the study area.

After classification, the area of each NDVI class was calculated for 2004, 2014, and 2024. Since Landsat imagery has a spatial resolution of 30 m, each pixel represents 900 m². The area of each class was calculated by multiplying the number of classified pixels by the pixel area. The area was then converted into hectares and percentages using the following equations:

$$\text{Area (ha)} = \frac{(\text{Counted Pixels}) \times (\text{Pixel size})^2}{10^4} \qquad (2)$$

where the pixel size is 30 m for Landsat imagery.

$$\text{Area (\%)} = \frac{\text{Area of Class}}{\text{Total Area}} \times 100 \qquad (3)$$

These area statistics were used to quantify temporal changes in vegetation and other NDVI-based classes. The resulting classified maps and area percentages were then compared across 2004, 2014, and 2024 to identify changes in water bodies, urban/barren land, shrubs/low vegetation, and healthy vegetation within Hyderabad, Sindh.

2.5 Post-Classification Change Detection

This study used ArcGIS 10.8 and Google Earth Pro tools to analyze and classify satellite images from 2004 to 2024 based on satellite and actual geographical land utilization to detect NDVI changes. For this purpose, we conducted accuracy assessments to evaluate the classified images and NDVI changes.

2.6 Accuracy Assessment

The classification accuracy of satellite images can be assessed by calculating overall accuracy and Kappa Coefficient (K). The overall accuracy can be determined by estimating user and producer accuracy [67,70]. User accuracy is used to quantify the probability that a classified pixel matches the land cover class of its actual geographical position. The classification accuracy of actual land cover types is evaluated by producer accuracy, which is quantified by gap errors. About 50 random ground control points (GCPs) were created for each year, i.e., 2004, 2014, and 2024, and the minimum allowance distance set was 30 m for each class. The total accuracy of the classification of satellite images is determined by comparing how each pixel is classed against the actual land cover produced from their combined baseline data [19]. The coefficient K was utilized as an indicator of consistency between predicted results and actuality or to determine if the numbers included in an input dataset reflect a considerably best improvement.

The overall accuracy and coefficient K were found to be 88% and 85%, respectively. The calculation of accuracy assessment indices for the complete study period (2000–2021) is presented in the Results section.

3. Results and Discussion

3.1 Spatial Distribution of NDVI Classes in 2004

The NDVI-based classification for 2004 indicates that Hyderabad had a relatively higher proportion of healthy vegetation compared with the later study years. The classified map shows that healthy vegetation was mainly distributed in the northern, central, and peri-urban parts of the study area, while water bodies were concentrated along riverine and canal-associated zones. The spatial pattern suggests that, during 2004, agricultural fields, vegetated open spaces, and natural green cover were still dominant in several parts of Hyderabad.

The area statistics further confirm this pattern. In 2004, healthy vegetation covered 48.33% of the study area, making it the dominant NDVI class. Shrubs or low vegetation accounted for 30.79%, while urban/barren land occupied 19.50%. Water bodies represented the smallest class, covering only 1.36% of the total area. These values indicate that nearly half of the study area had relatively high vegetation density in 2004, while built-up and barren surfaces were comparatively limited (**Fig. 3** and **Fig. 4**).

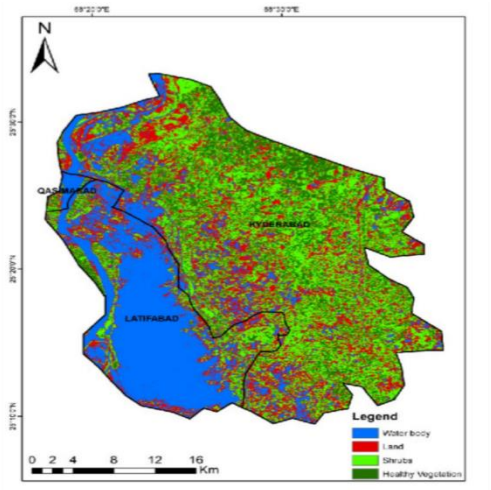

Fig. 3 NDVI map of 2004

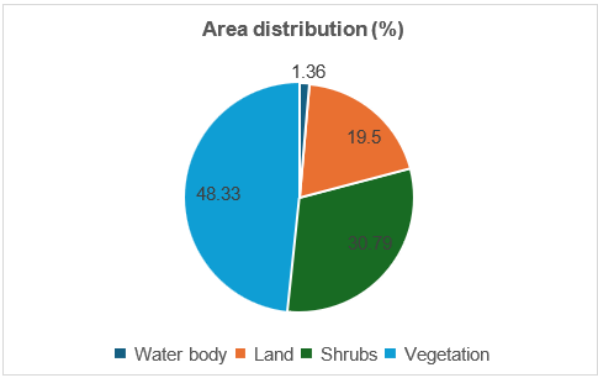

Fig. 4 Pie chart of NDVI map of 2004

3.2 Spatial Distribution of NDVI Classes in 2014

The NDVI classification for 2014 shows a clear shift in land surface conditions compared with 2004. The most prominent change is the expansion of the urban/barren land class, particularly in and around the rapidly developing areas of Latifabad, Qasimabad, and the central urban zone. This increase indicates that built-up surfaces, exposed soil, and non-vegetated land expanded considerably during the first decade of analysis.

In 2014, urban/barren land increased to 47.85%, showing a major rise from 19.50% in 2004. Healthy

vegetation decreased sharply from 48.33% in 2004 to 21.96% in 2014. This represents a decline of 26.37 percentage points within ten years. Shrubs or low vegetation decreased slightly from 30.79% to 28.27%, while water bodies increased marginally from 1.36% to 1.89%.

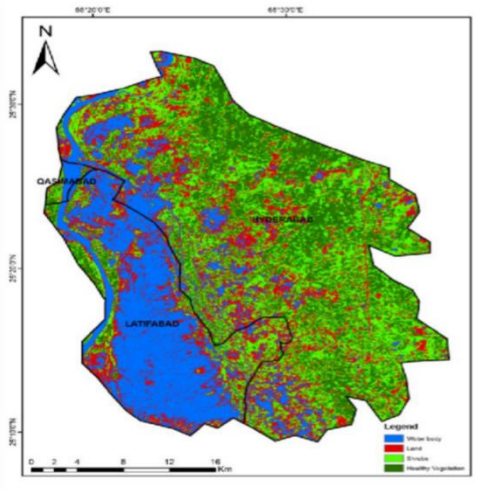

Fig. 5 NDVI map of 2014

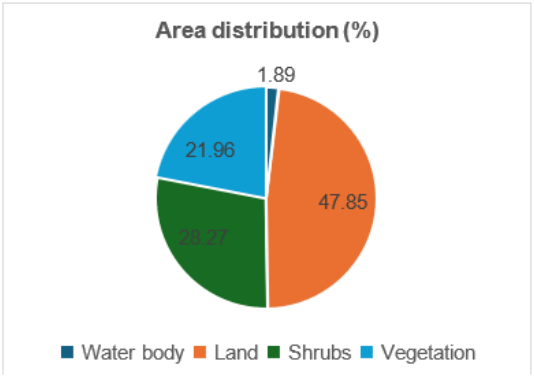

Fig. 6 Pie chart of NDVI map of 2014

The results suggest that the period from 2004 to 2014 was marked by rapid land conversion. The substantial increase in urban/barren land occurred mainly at the expense of healthy vegetation. This pattern is consistent with the expansion of housing schemes, road networks, commercial areas, and other urban infrastructure in Hyderabad. The decline in healthy vegetation also indicates pressure on agricultural and natural vegetated areas located near expanding urban settlements (Figure 5 and 6).

3.3 Spatial Distribution of NDVI Classes in 2024

The NDVI map for 2024 indicates that urban/barren land remained the dominant class in Hyderabad. The spatial distribution shows continued expansion of low-NDVI surfaces, especially in areas affected by urban growth and land development. Healthy vegetation further declined and became more fragmented compared with 2004 and 2014. Vegetated patches were mainly limited to agricultural areas, riverine zones, and scattered green spaces.

In 2024, urban/barren land increased to 49.20%, showing a slight increase from 47.85% in 2014. Healthy vegetation declined further to 16.26%, compared with 21.96% in 2014 and 48.33% in 2004. Shrubs or low vegetation increased slightly to 30.04%, while water bodies increased to 4.48%.

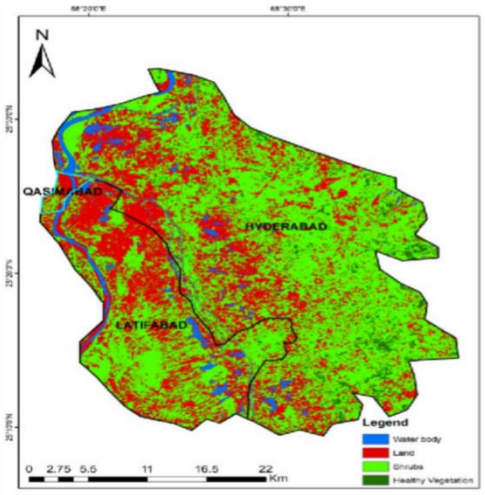

Fig. 7 NDVI map of 2024

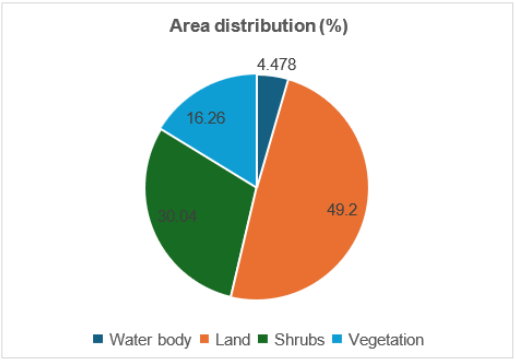

Fig. 8 Pie chart of NDVI map of 2024

The continued reduction in healthy vegetation shows that Hyderabad has experienced persistent pressure on green cover over the last two decades. Although the rate of urban/barren land expansion was much higher between 2004 and 2014 than between 2014 and 2024, the decline in healthy vegetation continued during the second decade. This suggests that even after the major phase of urban expansion, remaining vegetated areas continued to be converted, degraded, or fragmented.

The increase in water bodies from 1.89% in 2014 to 4.48% in 2024 may be associated with seasonal water availability, irrigation activity, waterlogging, surface

water retention, or changes in hydrological conditions during the image acquisition period (Figure 7 and 8).

3.4 Temporal Changes in NDVI Classes from 2004 to 2024

The temporal analysis reveals substantial changes in land surface conditions in Hyderabad between 2004 and 2024. The most significant changes were observed in healthy vegetation and urban/barren land. Healthy vegetation decreased from 48.33% in 2004 to 16.26% in 2024, showing a net decline of 32.07 percentage points. In contrast, urban/barren land increased from 19.50% to 49.20%, showing a net increase of 29.70 percentage points.

Shrubs or low vegetation showed only minor variation over the study period. This class decreased from 30.79% in 2004 to 28.27% in 2014, followed by a slight increase to 30.04% in 2024. Overall, shrubs declined by only 0.75 percentage points between 2004 and 2024. Water bodies increased from 1.36% in 2004 to 4.48% in 2024, showing a net increase of 3.12 percentage points (Table 2).

Table 2: Temporal changes in NDVI-based land cover classes from 2004 to 2024

Class	2004		2014		2024		2004-2024
	Area (km^2)	Area (%)	Area (km^2)	Area (%)	Area (km^2)	Area (%)	Change (%)
Water body	139.19	1.36%	193.302	1.89%	457.18	4.48%	3.12%
Land	4934.13	19.50%	4885.497	47.85%	5022.77	49.20%	29.70%
Shrubs	3143.24	30.79%	2886.66	28.27%	3067.46	30.04%	-0.75%
Vegetation	1991.37	48.33%	2242.485	21.96%	1660.52	16.26%	-32.07%

The results show that the dominant land surface transformation in Hyderabad has been the conversion of healthy vegetation into urban/barren land. The sharpest change occurred between 2004 and 2014, when healthy vegetation declined by 26.37 percentage points and urban/barren land increased by 28.35 percentage points. Between 2014 and 2024, the rate of urban/barren land expansion slowed, increasing by only 1.35 percentage points. However, healthy vegetation still declined by 5.70 percentage points, indicating continued vegetation degradation and fragmentation (Figure 9).

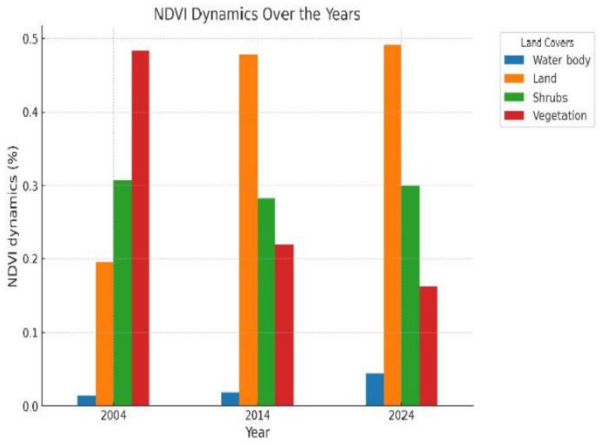

Fig. 9 Comparative area distribution of NDVI-based classes for 2004, 2014, and 2024.

The line graph (Figure 10) illustrates the percentage change in different land cover classes—Water body, Land, Shrubs, and Vegetation—over 20 years from 2004 to 2024. The graph shows that land area (red) has experienced a significant increase of 29.70%, indicating extensive urbanization. In contrast, vegetation (dark green) has declined sharply by 32.07%, highlighting a substantial reduction in healthy vegetation. Water bodies (blue) show a modest increase of 3.12%, reflecting slight growth in water resources or management. Shrubs (light green) have decreased slightly by 0.75%, suggesting some loss of shrubland due to land conversion.

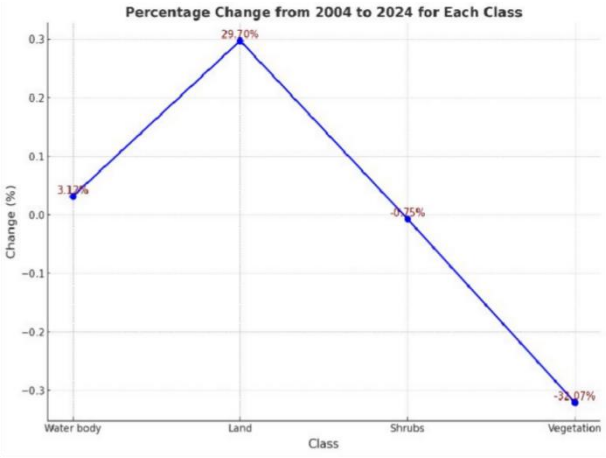

Fig. 10 Change in percentage from 2004 to 2024

The graph (Figure 11) reveals a dramatic increase in land cover (red), which rises from 2004 to 2024, underscoring the impact of urban expansion. Conversely, the vegetation area (dark green) shows a significant decline, indicating a loss of green cover over time—shrubs (light green) exhibit minor variations, with a slight decrease followed by stabilization. Water bodies (blue) maintain a small but

gradually increasing trend, reflecting some improvements in water availability or management efforts.

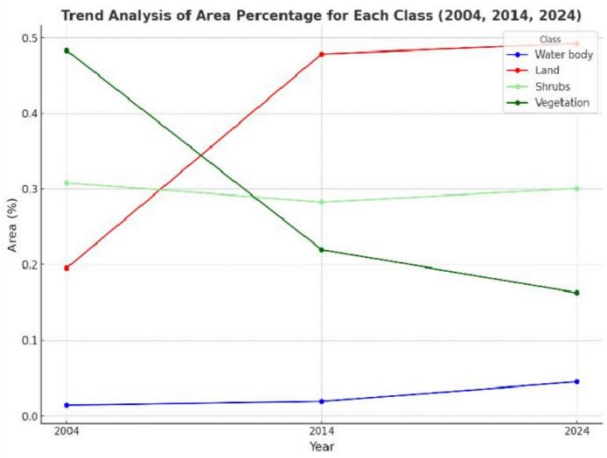

Fig. 11 Trend analysis of area (%)

3.5 Accuracy Measurement

Accuracy assessment was carried out to evaluate the reliability of the classified NDVI maps for the years 2004, 2014, and 2024. For each classified image, reference points were compared with the classified output using a confusion/error matrix. The accuracy assessment included overall accuracy, producer's accuracy, user's accuracy, and the Kappa coefficient (Table 3).

The classified maps showed acceptable accuracy for vegetation change analysis. The overall accuracy was 86.00% for 2004, 84.00% for 2014, and 85.00% for 2024. The average overall accuracy for the three classified maps was approximately 85.00%, indicating that the classification results were reliable for identifying major temporal changes in vegetation, urban/barren land, shrubs/low vegetation, and water bodies.

Table 3: Accuracy assessment results of the LULC classification

Year	Validation points	Correctly classified points	Overall accuracy (%)	Kappa coefficient
2004	50	43	86.00	0.82
2014	50	42	84.00	0.79
2024	50	43	85.00	0.81
Average	—	—	85.00	0.80

The 2004 classified map achieved the highest overall accuracy of 86.00%, with a Kappa coefficient of 0.82. This indicates strong agreement between the classified map and reference data. The 2014 classified map showed an overall accuracy of 84.00% and a Kappa coefficient of 0.79, while the 2024 map achieved an overall accuracy of 85.00% and a Kappa coefficient of 0.81. These values show that the classification results were generally consistent and suitable for temporal vegetation analysis (Table 4).

Table 4: Producer's and user's accuracy (%) for each LULC class

Year	Class	Producer's accuracy (%)	User's accuracy (%)
2004	Water bodies	90.00	90.00
2004	Urban/barren land	84.00	82.00
2004	Shrubs/low vegetation	82.00	80.00
2004	Healthy vegetation	88.00	90.00
2014	Water bodies	88.00	86.00
2014	Urban/barren land	84.00	85.00
2014	Shrubs/low vegetation	80.00	78.00
2014	Healthy vegetation	84.00	86.00
2024	Water bodies	90.00	88.00
2024	Urban/barren land	85.00	86.00
2024	Shrubs/low vegetation	81.00	79.00
2024	Healthy vegetation	84.00	87.00

The class-wise accuracy results indicate that water bodies and healthy vegetation were classified with relatively higher accuracy. Water bodies were easier to identify because they generally showed negative NDVI values. Healthy vegetation also showed higher classification reliability because of its strong NDVI response. The highest user's accuracy for healthy vegetation was 90.00% in 2004, while water bodies showed producer's accuracy values ranging from 88.00% to 90.00%.

Comparatively lower accuracy was observed for shrubs/low vegetation, with producer's accuracy ranging from 80.00% to 82.00% and user's accuracy ranging from 78.00% to 80.00%. This lower accuracy may be due to spectral similarity between sparse vegetation, dry vegetation, exposed soil, and barren land. In semi-arid environments such as Hyderabad, shrubs and low vegetation often mix with bare soil, making them more difficult to classify using medium-resolution Landsat imagery.

3.5 Discussion of Vegetation Decline and Urban Expansion

The results demonstrate that Hyderabad has undergone a major land surface transformation during the last two decades. The decline in healthy vegetation from 48.33% to 16.26% is the most important finding of this study. This change indicates a substantial

reduction in dense and productive vegetation, which may include agricultural fields, natural vegetation, and urban green spaces. The simultaneous increase in urban/barren land from 19.50% to 49.20% suggests that urban development has been one of the main drivers of vegetation loss.

The spatial pattern of change is especially important in areas such as Latifabad and Qasimabad, where rapid urban development has expanded residential, commercial, and transport infrastructure. As these areas grow, vegetated and agricultural lands are often converted into built-up surfaces. Such conversion reduces vegetation cover, increases impervious surfaces, and can contribute to higher land surface temperature, reduced groundwater recharge, and increased pressure on drainage systems.

The slight recovery or stability of shrubs/low vegetation in 2024 may indicate the presence of sparse vegetation, seasonal vegetation, abandoned fields, or transitional land surfaces. However, this class does not provide the same ecological value as healthy vegetation. Therefore, the increase in shrubs cannot compensate for the sharp decline in dense vegetation. Similarly, the increase in water bodies should be interpreted with caution because NDVI-based water classification can be influenced by seasonal conditions, rainfall, irrigation, waterlogging, and image acquisition date.

Overall, the findings suggest that Hyderabad is shifting from a vegetation-dominated landscape toward an urban/barren land-dominated landscape. This transition has important environmental implications. Reduction in green cover can weaken local ecosystem services, reduce biodiversity, increase surface heating, and create additional stress on water resources. In a semi-arid city such as Hyderabad, maintaining vegetation cover is particularly important because vegetation helps regulate microclimate, reduce dust, support soil stability, and improve urban environmental quality.

3.6 Implications for Urban and Environmental Planning

The observed decline in vegetation highlights the need for sustainable urban planning in Hyderabad. Urban expansion should be managed in a way that protects existing green spaces, agricultural land, and ecologically sensitive zones. Planning authorities should prioritize urban greening, roadside plantation, restoration of degraded land, protection of water bodies, and development of green belts around rapidly expanding urban areas.

The results also demonstrate the usefulness of NDVI as a monitoring tool for semi-arid urban environments. By using consistent satellite imagery and classification thresholds, NDVI can provide a cost-effective method for tracking vegetation loss and identifying areas where restoration or conservation measures are needed. Regular monitoring using Landsat, Sentinel-2, or other high-resolution satellite data can support better decision-making for urban growth, water management, and environmental protection.

4. Conclusion

This study assessed the temporal dynamics of vegetation in Hyderabad, Sindh, using Landsat-derived NDVI for the years 2004, 2014, and 2024. The results reveal a clear transformation of the study area from a vegetation-dominated landscape toward an urban/barren land-dominated landscape over the last two decades. Healthy vegetation declined substantially from 48.33% in 2004 to 21.96% in 2014 and further to 16.26% in 2024, showing an overall reduction of 32.07 percentage points. In contrast, urban/barren land increased from 19.50% in 2004 to 47.85% in 2014 and 49.20% in 2024, indicating an overall increase of 29.70 percentage points. This inverse relationship between vegetation decline and land expansion highlights the strong influence of urban growth on the ecological condition of Hyderabad.

The most significant vegetation loss occurred between 2004 and 2014, suggesting rapid conversion of vegetated and agricultural areas into built-up and barren surfaces during this period. Areas such as Latifabad, Qasimabad, and the central urban zone appear to be major zones of land transformation due to residential, commercial, and infrastructure expansion. Shrubs or low vegetation showed minor fluctuation, decreasing slightly from 30.79% in 2004 to 30.04% in 2024, while water bodies increased from 1.36% to 4.48% during the same period. However, the increase in water bodies should be interpreted carefully because it may be influenced by seasonal conditions, irrigation patterns, waterlogging, or image acquisition timing.

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Overall, the findings demonstrate that NDVI is an effective and reliable tool for monitoring vegetation dynamics in semi-arid urban environments. The decline in healthy vegetation has important implications for local biodiversity, urban heat regulation, soil stability, groundwater recharge, and environmental quality. For Hyderabad, where climatic stress and rapid urbanization interact, the continuous reduction of green cover may increase environmental vulnerability if not addressed through sustainable planning.

The study emphasizes the need for regular satellite-based monitoring, protection of remaining green spaces, restoration of degraded vegetation, and integration of green infrastructure into urban development plans. Future research should include additional variables such as land surface temperature, rainfall, soil moisture, groundwater conditions, and socio-economic drivers to better understand the causes and consequences of vegetation change. The findings provide useful evidence for policymakers, urban planners, and environmental managers to support sustainable land use planning and vegetation conservation in Hyderabad, Sindh.

5. Recommendations

This study on vegetation dynamics in Hyderabad, Sindh, using NDVI-based analysis leads to several key recommendations:

- **Sustainable Urban Planning:** Incorporate green spaces in urban development to preserve biodiversity and mitigate environmental degradation. Policies should focus on preventing urban sprawl from encroaching upon vital ecological areas.
- **Water Resource Management:** Enhance water conservation practices and restore water bodies to improve water availability. Urban planning should include strategies for efficient water use and natural resource management.
- **Climate Resilience and Biodiversity Conservation:** Promote reforestation, protect native species, and develop climate adaptation plans to mitigate the effects of climate change and preserve vegetation.
- **Integrate Socio-Economic Factors:** Involve local communities in land-use planning and adopt sustainable agricultural practices to align development with environmental needs.
- **Strengthen Remote Sensing and Monitoring:** Invest in regular satellite data collection and integrate NDVI with other environmental variables to better monitor vegetation changes and inform decision-making.
- **Policy Integration for Sustainable Development:** Policymakers should adopt green development frameworks and cross-sectoral policies, promoting data-driven decision-making to balance urban growth with environmental sustainability.

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A Lightweight Black Hole Detection Scheme for AODV+ in a Hybrid MANET Internet Environment

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ABSTRACT

Mobile Ad hoc Networks are vulnerable to several routing attacks because of their open and dynamic nature. Among these attacks, the black hole(BH) attack is one of the most harmful, as a malicious node falsely responds to route requests and then drops the received data packets. In a hybrid MANET Internet environment, this problem becomes more critical because mobile nodes communicate not only within the wireless mobile ad-hoc domain but also with external wired hosts through a gateway. In this paper, a lightweight detection and isolation scheme is presented to handle black hole behavior in a hybrid MANET Internet scenario. The proposed scheme plays an important role in improving packet delivery, reducing packet loss, and enhancing routing reliability under malicious conditions. Through lightweight probing and staged suspicion-based isolation, the proposed approach improves routing resilience and strengthens cybersecurity in the considered hybrid MANET Internet environment. The implementation is carried out in NS2 by modifying the AODV+ routing code in C++. The simulation results demonstrate that the proposed detection scheme achieved lower packet loss rate and lower normalized routing load than the attack case, where the packet loss rate decreased from about 99.0% to 70.0% and the normalized routing load dropped from about 327% to 42% under higher flow conditions.

1. Introduction

In the last few decades, wireless communication has become an essential part of modern life. The use of mobile phones, Wi-Fi, portable devices, and wireless data services has increased rapidly in homes, offices, industries, and public environments [1]. Most of these communications are carried out through infrastructure-based wireless networks, where fixed stations, routers, or access points provide connectivity to mobile users. Such networks are widely used because they support organized communication and relatively stable connectivity over a large area [2].

In an infrastructure-based wireless network, communication usually depends on pre-installed devices such as base stations, access points, and fixed routers. Mobile users communicate through these devices, and the backbone network is generally supported by wired or fixed wireless links [3]. This communication model is suitable for many urban and commercial applications. However, in several practical situations, the deployment of fixed infrastructure is difficult, costly, or not possible at all. This issue becomes important in remote areas, temporary deployments, emergency conditions, military environments, and disaster recovery scenarios.

On the other hand, a Mobile Ad hoc Network (MANET) provides a communication model in which mobile nodes communicate without a fixed infrastructure. In MANET, each node can act both as a host and as a router. Nodes may communicate directly if they are within transmission range, while communication between distant nodes is achieved through intermediate mobile nodes in a multihop manner [4][5]. Since the network topology changes dynamically due to node movement, the establishment and maintenance of communication routes become

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challenging tasks. However, in many practical cases, MANET is not required to operate as an isolated island only. Mobile nodes may also need communication with external fixed hosts, servers, or infrastructure networks. In such cases, an integrated or hybrid wireless network can be formed by combining an ad hoc wireless domain with an infrastructure or wired domain through gateway nodes.

A hybrid MANET Internet environment can therefore be considered as a useful extension of ordinary MANET [6]. In this type of architecture, mobile nodes in the wireless domain are able to communicate with external wired hosts through a gateway or access point. This arrangement extends the communication range of the MANET and allows interaction between mobile nodes and fixed network entities. In this type of network, the gateway node plays an important role in connecting the MANET side with the wired side. Fig.1 shows the type of network where mobile nodes communicate with wired hosts through a gateway node.

Although MANET routing protocols (e.g., AODV and DSDV) provide useful support for route establishment [7], they remain vulnerable to routing attacks because of the open and distributed nature of MANET. One of the well-known attacks is the black hole (BH) attack, in which a malicious node falsely advertises a favorable route and then drops the data packets after attracting the traffic [8]. This attack can severely affect communication reliability, especially in a hybrid MANET Internet scenario where the impact is not limited to wireless nodes only but may also disturb traffic forwarded through the gateway toward external wired hosts. Therefore, attack handling and secure routing behavior are important issues in such integrated environments.

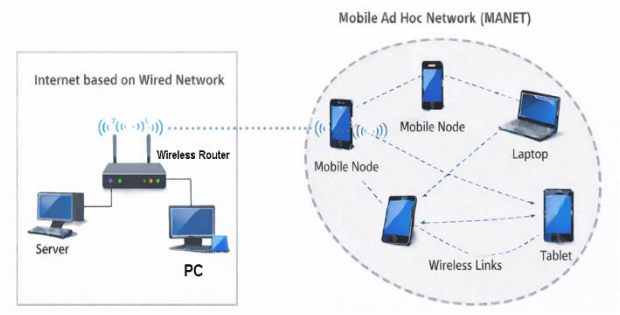

Fig.1 A hybrid MANET Internet Network

2. Literature Review

The Ad hoc On-Demand Distance Vector (AODV) routing protocol is one of the most widely studied reactive routing protocols in mobile ad hoc networks. It establishes routes on demand and uses routing control packets such as Route Request (RREQ), Route Reply (RREP), and Route Error (RERR) to maintain communication between source and destination nodes. Due to its adaptive nature, AODV has been widely used in simulation studies for performance evaluation under different traffic and mobility conditions [9]. In addition to ordinary MANET environments, researchers have also extended AODV for integrated and hybrid communication scenarios. Hamidian and coauthors studied Internet connectivity for mobile ad hoc networks and introduced AODV+ as an extension of AODV for gateway-assisted communication between MANET and external wired networks. In such an approach, one or more gateway nodes allow communication between the ad hoc wireless domain and the wired Internet side. This makes AODV+ an important protocol for hybrid MANET Internet environments [10].

In MANET routing, security has remained an important issue because the open and decentralized nature of the network makes routing vulnerable to malicious behavior. One of the most common routing attacks is the black hole attack. In this attack, the malicious node falsely advertises a fresh or shortest path and then drops the packets after attracting the traffic. A large number of studies have addressed black hole attack in AODV-based MANETs. Some researchers proposed detection through route reply verification, while others used trust-based methods, sequence number checking, or intrusion detection systems. Recent studies also show that black hole attack still causes severe degradation in packet delivery, throughput, and overall communication reliability if it is not handled properly. Therefore, black hole detection in AODV and related protocols continues to be an active topic of study [11], [12], [13].

Although many black hole detection methods have been proposed for AODV, comparatively fewer practical simulation studies have focused on black hole handling in a hybrid MANET Internet environment. In such networks, the impact of malicious routing is not limited to communication among mobile nodes only, but also affects traffic

exchanged with external wired hosts through the gateway. A related study on Integrated Internet MANET investigated black hole attack under AODV+ and proposed a detection approach based on promiscuous monitoring and secure knowledge table maintenance [14]. In that work, neighboring nodes observe forwarding behavior and compare packet-related information stored in the knowledge table, while additional checks, such as TTL, residual energy, and packet drop threshold, are also considered before declaring a node malicious. The detected malicious node is then avoided during the routing process. Such a study is closely related to the present topic and confirms that black hole handling in integrated MANET Internet communication is an important problem. However, such methods often rely on continuous neighbor monitoring, trusted table maintenance, or additional trust-related decision logic. Some studies have also discussed secure gateway discovery and trusted gateway selection in integrated MANET Internet environments [15], but such methods often involve more complex trust or authentication frameworks.

Based on the above discussion, the research gap can be identified clearly. Although black hole detection in AODV-based MANET has been widely studied, lightweight routing-level black hole handling in a hybrid MANET Internet environment remains less explored. Therefore, this work focuses on implementing a lightweight detection and isolation mechanism for black hole behavior in hybrid AODV+ communication using NS2.

Table 1: Comparative Summary of Existing Studies and the Proposed Work

Ref.	Network	Protocol	Focus	Method	Limitation
[9]	MANET	AODV	Routing eval.	Reactive routing	Not hybrid-focused
[10]	Hybrid MANET Internet	AODV+	Internet connectivity	AODV Extension	No black hole focus
[11], 12], [13]	MANET	AODV	BH handling	RREP check, trust, IDS	MANET-only focus
[14]	Hybrid MANET Internet	AODV+	BH detection	Monitoring and knowledge table	High monitoring overhead
[15]	Hybrid MANET Internet	Gateway-based	Secure gateway	Trust/ authentication	Complex framework
Proposed Work	Hybrid MANET Internet	AODV+	Lightweight BH detection and isolation	Dummy probing, suspicion count, isolation	Lightweight routing approach

The motivation of this work comes from the need to improve routing reliability in hybrid MANET Internet communication under malicious conditions. In practical integrated environments, mobile nodes may need to communicate not only with other wireless nodes but also with external wired hosts through a gateway. If a black hole attacker is present in the MANET side, its effect may extend beyond the wireless domain and degrade the complete end-to-end communication path. Therefore, it becomes important to develop a lightweight method that can detect suspicious behavior and isolate malicious nodes without introducing unnecessary routing overhead.

In this paper, a lightweight detection and isolation scheme is implemented to handle black hole behavior in a hybrid MANET Internet scenario using NS2. The proposed method is incorporated into AODV+ and is based on dummy route request probing, repeated suspicious reply observation, local suspicion counting, and attacker isolation after threshold confirmation. The main objective of this work is to study, through simulation, how a lightweight routing-level mechanism can improve communication reliability under black hole attack in a hybrid MANET Internet environment.

The novelty of this work lies in applying a lightweight black hole detection and isolation approach in a hybrid AODV+ communication environment instead of a conventional MANET-only setting. In addition, the proposed approach uses dummy route request probing and staged suspicion-based confirmation to identify malicious behavior and isolate the attacker in a simple and distributed manner.

The main contributions of this work are summarized as follows:

1. A hybrid MANET Internet scenario is implemented using AODV+ with gateway-assisted communication.
2. A black hole attacker is introduced into the modified AODV+ routing behavior in NS2.
3. A lightweight detection and isolation mechanism is implemented using dummy probing and staged suspicion-based confirmation.
4. The network performance is evaluated under normal, attack, and detection cases for an increasing number of communication flows.
5. The results show that the proposed method significantly improves the network performance

under attack and restores the communication behavior close to the normal case.

3. PropDosed Network Scenario and Methodology

3.1 Hybrid MANET Internet Scenario and Blackhole Attacker

In this work, a hybrid MANET Internet scenario is considered. The network consists of two communication domains. The first domain is a wired network containing a fixed wired host, a router, and a gateway node. The second domain is a wireless MANET domain consisting of mobile nodes communicating in an ad hoc manner. The gateway node acts as a bridge between the wired side and the wireless side, allowing communication between wired hosts and mobile nodes.

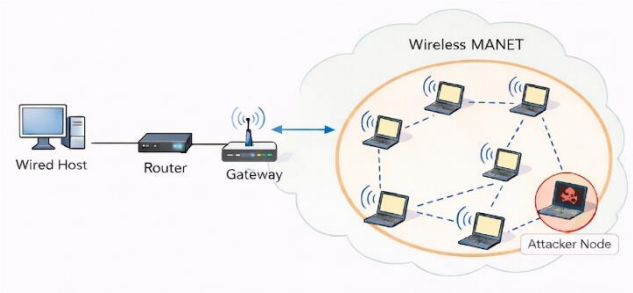

Fig.2 A hybrid MANET Internet with an Attacker Node

In the considered scenario, the wired host communicates with the wireless MANET through the router and gateway. On the wireless side, multiple mobile nodes are deployed, and one malicious node is introduced as an attacker. The communication path is therefore established in the sequence of wired host, router, gateway, and wireless MANET. This arrangement makes the scenario suitable for studying routing AODV+ behavior in hybrid communication environments, where the routing process involves both gateway-assisted communication and multihop wireless forwarding.

Fig.2 shows the hybrid MANET Internet scenario considered in this work. The figure illustrates the wired host connected to the router, the router connected to the gateway, and the gateway connected to the wireless MANET. It also shows the malicious attacker node inside the wireless domain.

3.2 Blackhole Attacker Model

To evaluate the effect of malicious routing behavior, a black hole attacker is introduced into the wireless MANET. In a black hole attack, the malicious node responds to route requests (RREQ) by advertising itself as a favorable route toward the destination using a fake route reply (FRREP). When the source node selects the route through the attacker, the malicious node drops the packets instead of forwarding them.

In the present implementation, the attacker behavior is added to the AODV+ routing code in NS2. Once the attacker mode is activated, the malicious node generates FRREP and attracts the traffic. After receiving the packets, it does not forward them toward the next hop. As a result, the normal routing process is disturbed, and communication performance degrades.

This attacker behavior is particularly important in a hybrid network because the dropped packets may belong not only to wireless node communication, but also to the communication between the wired host and the wireless MANET through the gateway. Therefore, the attack directly affects end-to-end data delivery in the considered hybrid MANET Internet environment.

2.3 Overview of the Proposed Detection and Isolation Method

To handle the black hole behavior, a lightweight detection and isolation mechanism is proposed. The main idea of the proposed method is that suspicious route replies should not be trusted immediately. Instead, the network nodes perform lightweight probing and observe the reply to behavior of suspected nodes before confirming them as attackers.

The proposed mechanism is based on three main steps: dummy route request probing, staged suspicion counting, and local attacker isolation. First, detector-enabled nodes generate dummy route request messages (DRREQ) toward a predefined dummy destination. These dummy route requests are not intended for real data communication but are used to observe suspicious route reply to behavior. If a node replies to the dummy route request in a suspicious way, it is marked as a suspect, and its suspicion count is increased.

In the improved version of the implementation, the suspicion count is maintained separately for each suspected node instead of using a single global counter. This makes the detection logic cleaner and

more suitable for distributed MANET operation. When the suspicious behavior is repeated, and the suspicion count reaches the isolation threshold, the suspected node is marked as an attacker. After that, further route replies from that node are ignored, and the route through that attacker is isolated locally.

The working logic of the proposed method is straightforward. During route discovery, if the attacker is active, it may generate a false reply to attract the route. At the same time, detector-enabled nodes periodically send dummy route requests to test suspicious reply behavior. When a suspicious reply is observed, the corresponding previous hop is treated as a suspect, and its suspicion count is increased. Once the count reaches the defined threshold, that node is isolated as an attacker. In this way, future route replies from the same malicious node are ignored, and communication is restored through safer routes.

The use of delayed detection in the simulation is also important. If the detector starts too early, the attacker may be isolated before real traffic is affected, which leads to unrealistically perfect recovery. In the present work, delayed activation is used so that some traffic is affected first, and then the detector isolates the attacker. This makes the result more realistic and better reflects practical network behavior.

The proposed method is intentionally lightweight. It does not require any external trust manager, centralized monitor, or complex cryptographic framework. The method works directly at the routing level and can therefore be integrated into AODV+ with limited modification. It is simple to implement in NS2, supports hybrid MANET Internet communication, uses per-node suspicion counting, and performs staged isolation instead of immediate hard decision. Therefore, the proposed method is suitable for practical simulation-based evaluation in hybrid MANET Internet scenarios and can also serve as a basic platform for future work on stronger routing security mechanisms.

4. Simulation Setup

The simulation setup consists of a wired domain and a wireless mobile ad hoc domain connected through a gateway node. On the wired side, a fixed wired host communicates through a router and gateway. On the wireless side, multiple mobile nodes communicate in ad hoc mode. One of the wireless nodes is configured as a malicious black hole attacker. The communication between the wired side and the wireless side is therefore established through gateway-assisted routing in the hybrid environment. Fig.3 shows the simulation environment of a hybrid MANET Internet.

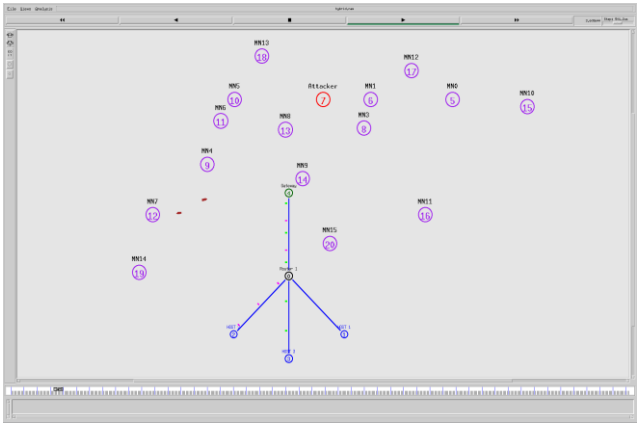

Fig.3 NS2 Simulation Environment of hybrid MANET Internet.

In order to study the behavior of the proposed method under increasing communication demand, the number of active traffic flows is varied. Bidirectional UDP/CBR communication is generated between the wired side and the mobile nodes. The experiments are conducted for five different flow levels, namely 3, 6, 9, 12, and 15 communication flows. For each flow level, three cases are considered: normal AODV+ without an attacker, AODV+ under black hole attack, and AODV+ with black hole attack and detection enabled. In the detection case, delayed activation is used so that the network experiences some attack effect before the attacker is detected and isolated. The main simulation parameters used in this work are listed in Table 1.

Table 1: Simulation Parameters

Parameter	**Value**
Routing protocol	AODV+
Network type	Hybrid wired wireless MANET Internet
Channel type	WirelessChannel
Propagation model	TwoRayGround
MAC type	IEEE 802.11
Simulation area	700 m × 700 m
Simulation time	60 s
Wired host nodes	3
Router nodes	1
Gateway nodes	1
Wireless Mobile nodes	16

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Parameter	Value
Traffic type	UDP/CBR
Packet size	512 bytes
Flow levels	3, 6, 9,12,15
Mobility type	Slow mobility
Cases considered	Normal, Attack, Detection

To evaluate the performance of the network, several standard metrics are considered. Packet Delivery Ratio (PDR) is used to measure the ratio of successfully received packets to the total transmitted packets. Packet loss rate indicates the fraction of packets lost during communication. Normalized routing load is used to measure the routing overhead generated by the routing process relative to successful data delivery.

5. Results and Discussion

This section evaluates the performance of the proposed work and compares it with the normal case and the black hole attack case. The behavior is observed for an increasing number of communication flows. The performance is discussed in terms of packet delivery ratio (%), packet loss ratio (%), and normalized routing load (%). We further discuss the following results separately for each of these quality of service (QoS) performance metrics.

Fig. 4 shows the packet delivery ratio (%) for normal, attack, and detection cases. It can be observed that in the normal case, the packet delivery remains very high at 3 and 6 flows, while in the attack case, it drops sharply. The detection case also maintains high delivery at lower flows and performs much better than the attack case. At 9, 12, and 15 flows, packet delivery decreases in all cases due to higher traffic load, but the attack case shows the worst behavior. The detection case remains close to the normal case and even shows slightly better performance than the normal case at 15 flows. This may be due to heavier congestion in the normal case, where traffic continues to use the same active routes under high load. In the detection case, attacker isolation triggers route rediscovery and rerouting, which in this particular case appears to direct traffic through slightly less congested paths. Therefore, a small PDR advantage is observed in the detection case. However, this should be considered a case-specific result rather than a general trend. These results show that the black hole attacker severely affects packet delivery in the hybrid network. After enabling the proposed detection mechanism, packet delivery improves significantly. It can be concluded that the proposed method successfully restores communication behavior toward the normal condition.

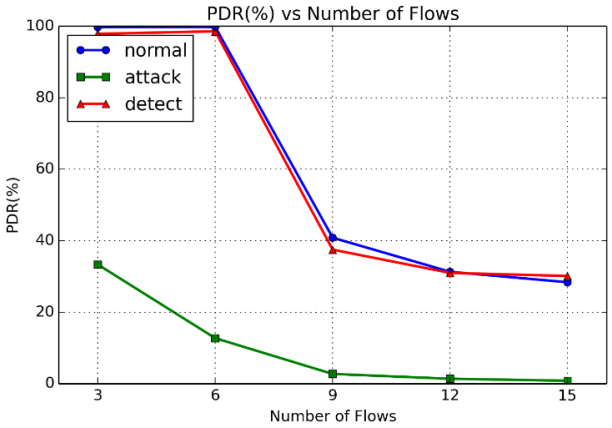

Fig.4. Packet Deliver Ratio (%) vs Number of Flows

Fig. 5 presents the packet loss ratio (%) under normal, attack, and detection cases. It is observed that the attack case produces the highest packet loss for all flow levels. At lower flows, normal and detection cases show very low packet loss, while the attack case already shows high loss.

As the number of flows increases, packet loss increases in all cases, but the increase is much more severe in the attack case. At higher flows, the attack case approaches almost complete packet loss, whereas the detection case remains much closer to the normal case.

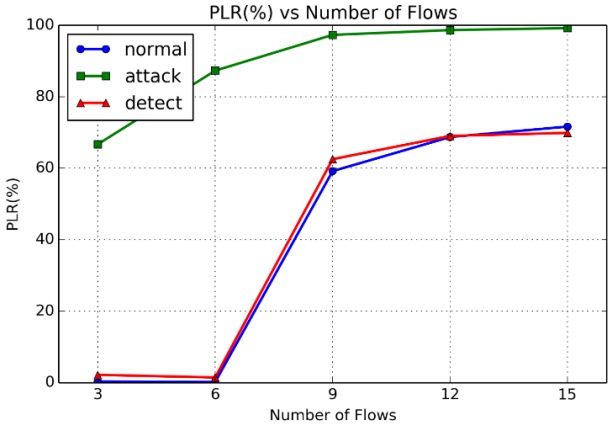

Fig.5 Packet Loss Ratio (%) vs Number of Flows

As the number of flows increases, packet loss increases in all cases, but the increase is much more severe in the attack case. At higher flows, the attack case approaches almost complete packet loss, whereas

the detection case remains much closer to the normal case. These results indicate that the black hole node drops a large fraction of the packets and degrades communication reliability. The proposed detection mechanism reduces packet loss significantly compared with the attack case. Although packet loss increases at higher flows due to traffic stress, the detection case still avoids the very poor behavior of the attack case.

Fig. 6 shows the normalized routing load (%) for the three cases. It is observed that the detection case has a higher routing load than the normal case at all flow levels. This is because the proposed scheme introduces additional routing activity due to probing, suspicion counting, and isolation-related actions. At low flows, the attack case has a small routing load, but at higher flows, it increases sharply and becomes the highest among all cases. The normal case increases gradually with the increase in traffic flows. These results show that the proposed detection method improves communication performance at the cost of additional routing overhead. This tradeoff is acceptable because the attack case causes severe packet loss and very poor packet delivery. The results indicate that the proposed method improves reliability with a lightweight additional routing effort.

In addition to communication-level performance metrics, the proposed scheme is also analyzed using detection and isolation indicators. These include detection count, first isolation time, and isolation count, which help to show the response behavior of the proposed method under different flow levels.

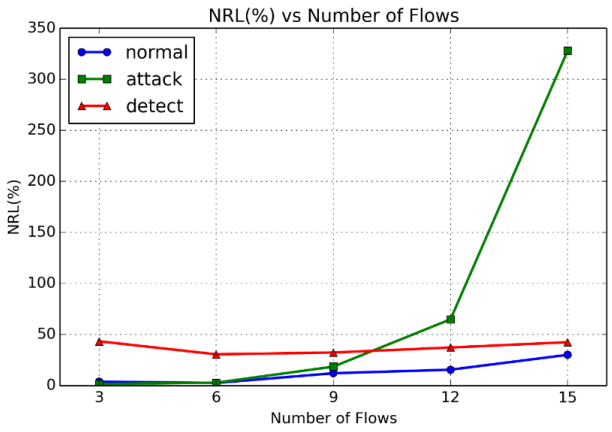

Fig.6 Normalized Routing Load (%) vs Number of Flows

Figure 7(a) shows the detection count under different flow levels. The results indicate that the number of detection events remains nearly stable, varying from 34 to 35 across all considered flows. This behavior shows that the proposed method continues to identify suspicious black hole activity even when the communication load increases.

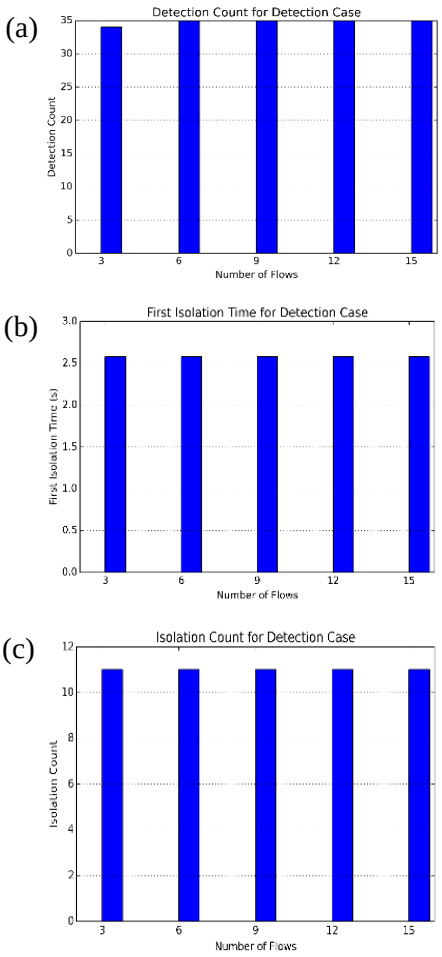

Fig. 7 Detection and isolation behavior of the proposed scheme under different flow levels: (a) detection count, (b) first isolation time, and (c) isolation count.

Figure 7(b) presents the first isolation time under different flow levels. It can be observed that the first isolation occurs at almost the same time, around 2.57 s, for all considered cases. This indicates that the proposed scheme responds to suspicious behavior in a consistent manner and is able to start attacker isolation without significant variation under different traffic loads.

Figure 7(c) shows the isolation count under different flow levels. The results remain almost constant, with the isolation count equal to 11 for all tested cases. This indicates that once the suspicious behavior reaches the confirmation threshold, the proposed method performs isolation in a stable and consistent way across different communication loads.

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6. Conclusion

In this paper, a lightweight black hole detection and isolation scheme for a hybrid MANET Internet scenario has been presented. The work focused on a practical NS2-based implementation in which a black hole attacker was introduced into the AODV+ routing behavior, and a lightweight probing-based detector was developed using suspicion counting and local isolation. The simulation results show that the black hole attack severely degrades packet delivery ratio, packet loss, and normalized routing load performance. After enabling the proposed detection mechanism, the network performance improves significantly and approaches the normal case, although with some additional routing overhead. This shows that the method is able to restore the network behavior to a large extent while maintaining a simple implementation structure.

In future work, the proposed scheme can be extended to handle multiple malicious nodes, cooperative black hole attacks, and larger hybrid MANET-Internet scenarios. It can also be evaluated under different mobility patterns and traffic conditions. In addition, the proposed scheme will be compared with representative black hole detection methods from the literature to analyze its relative performance in terms of PDR, PLR, NRL, routing overhead, and implementation complexity.

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Socio-Economic Determinants of Malnutrition: An Empirical Study

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ABSTRACT

Health is a complex condition of physical, mental, and social well-being, and nutrition is one of the main determinants of the overall level of health and human development. This empirical research reviewed the available literature to analyze the relationship between nutritional status and child health outcomes with a special focus on malnutrition as a continuing global public health issue. The results of numerous studies have shown that poor nutrition, in particular, in early childhood, can severely affect physical development, cognitive development, and immunological functions, which often lead to a high level of morbidity and mortality. The review indicates that brain development is a critical factor in the first three years of a child to influence the cognitive and behavioral lifelong outcomes. The results of various studies indicate that malnutrition is one of the most widespread in developing countries, especially in South Asia where the rates of underweight children under five years of age are among the highest in the world. Among the key contributing factors, socioeconomic disparities, the nutrition status of the mother, inadequate feeding practices, infectious diseases, and inaccessibility of healthcare services are identified. Additionally, environmental and demographic factors including sanitation, household income, parental education, and immunization status have a significant impact on child nutritional outcomes. The intergenerational effects of malnutrition, in which poor maternal nutrition influences fetal development and birth rates, contributing to the cycles of malnutrition, are also highlighted in the study. In general, the results highlight the fact that child malnutrition is a health challenge, but also a socio-economic threat that impedes the development of the nation. The research concludes that to decrease malnutrition and increase human capital development, there is a strong need to improve the maternal and child nutrition through targeted interventions, improved access to healthcare, and improved socioeconomic status.

1. Introduction

Health refers to a complete state of social, mental, and physical well-being, and it is not only the lack of diseases. However, the health of a human is the basic human right that organizes the world as an important goal. Health also resembles an essential human property [1]. The basic component of health is nutrition, and without it, human health does not stabilize, and human health decreases to the worst situation that leads to inadequate growth and development of the body; therefore, nutrition seems highly essential. Nutrition is the basic and prime pillar of human life that starts from life. From the earliest stages of development, birth to infancy, childhood to adolescence, and adulthood, complete food and nutrition are essential for survival, physical and mental development, performance of activities, and general health. The nutrition and health of a child and mother are largely associated and closely dependent on care practices. However, unhealthy and malnourished children born to mothers largely die as infants, but fortunately, they survive with low growth and developmental damage in early life [2].

The development of a child's brain happens before reaching the age of three years. Historically, people cannot understand the cognitive and psychological functioning of the brain that it takes rapid growth and changes at the stage of the first three years of life. However, the first three years of the life of a child develop the abilities of learning, speaking, and

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thinking that lay the foundation for social behaviors as adults. In this stage, a child detects new things that are helpful to each waking moment. At birth, a child possesses more than 100 billion brain cells, and they are not connected to each other. These connections seem like wonders of the human body. Various experiences can affect the development of a young brain, but importantly, early nutrition and care are essential and vital for growth [3].

The current situation analyzes that children's nutritional status shows an unclear picture, while malnutrition among children seems to be a big issue at a worldwide level in both developed and underdeveloped nations [4]. Bellay defines in the study that the situation of malnutrition from 1995 to 2003, in developing countries, the rate of underweight among children who are at the ages of five years looks high in some regions. In South Asia, the situation of malnutrition is the highest among five-year-olds from the entire world. Malnutrition is 46% in South Asia, 29% in Sub-Saharan Africa, 17% in East Asia or the Pacific, 17% in the Middle East and North Africa, and 7% in Latin America and the Caribbean countries [5].

The study shows that improved feeding practices help in the prevention and treatment of malnutrition, which saves the lives of about 800000 in a year [6]. The mother's nutritional status before and during pregnancy can influence the development and growth of the fetus and its birth weight, which affects more chances of survival in delivery. Mother’s nutritional well-being is highly essential for keeping care and rearing of a child; that also helps in performing economic and household tasks as well as her subsequent recovery [2].

Child malnutrition is the most highlighted global issue, and it mostly happens in the poorest communities, leading to high mortality and morbidity. Various studies indicated the relationship between the nutritional status and the socioeconomic well-being of parents has unfavorable impacts on the health of children.

Moreover, malnutrition is the fundamental cause of huge diseases among both children and adults that continuously contributes to the disabilities. It is largely dominated in the less developed nations, which affects 1 out of every 3 preschool-age children [4]. A well-nourished child with adequate access to food intake, care, and health has well-weighted and -height measurements compared to the standard normal distribution of weight and height of healthy children of the same age. The well-nourished child associates with proper growth [2].

Additionally, malnutrition is an extensive problem for children—about 200 million, particularly in developing nations, who are at the age of five years are malnourished. The prevalence of malnutrition weakens the immune system, and rises of illness happen as leading shocking consequences; it results in more than half of all children's deaths [2]. Malnutrition among children is not only the cause of lack of access to food owing to inadequate feeding practices and devious infection. The frequent infections of diarrhea, measles, malaria, and pneumonia destabilize the nutritional status of children. The poor feeding practices of improper breastfeeding and giving insufficient qualities that do not ensure children are getting enough food contribute to childhood malnutrition [4].

Malnutrition has many impacts, and it mainly affects the physical well-being and the socio-economic condition of a nation. The cases of malnutrition are highly prevailing in developing countries owing to poverty, misuse of resources, and social isolation [7]. According to Khan [8], the health factor of malnutrition is associated with various factors such as no proper intake of diet and a reduction in the use of micro- and macronutrients.

Based on some existing research evidence, a few factors are at risk for causing malnutrition among one-month- to five-year-old children. The major factors are demographic, socioeconomic, dietary intake, environmental, immunization, and health care. However, the demographic factors are related to the sex of children, the number of children in a household, mothers’ age at birth of a first child, birth order, previous birth interval, age of the child, size of child at birth, and mothers’ bodies’ mass index [9]. The socio-economic factors are residential place, parental education, parental occupation, housing type, religious belief, household positions, and media exposure. The dietary factor consists of breastfeeding status. The environmental factors show drinking water methods and sources and toilet facilities. Finally, immunization and health care factors are largely associated with place of delivery, antenatal care, vaccination, and supplement of vitamins [10].

Nutrition assessments among children are an essential indicator of socio-economic growth of a community. Nutritional status is a highly important public health indicator that assists in measuring the general health situation of the masses. However, nutrition determines factors for both mental and physical development in childhood. No supply of sufficient food to a child seems to adjustment in its physical state according to availability of food that results inappropriate poor health and physical growth to a child [4]. The height and weight of children are measurable factors to examine their nutrition status. The body mass index (BMI) is also under consideration as a standard method for examining malnutrition as a symptom [11]. The existing study is mainly focusing on social and economic aspects and inequalities that result in more risk of malnutrition in children, pregnant women, and elders [10]. The nutrition level of children who belong to low socioeconomic status is compared to their counterparts of upper-class socioeconomic status [12]. Precisely, malnutrition has other various determinants such as poverty, conflicts, gender inequality and illiteracy.

Several major reasons emphasize the researcher's choice of the study of malnutrition and its core causes, such as the social factors of the parents and its effects on children's nourishment. The major aim of this study is to explain the social status of parents and its impacts on the malnutrition of children. However, malnutrition is the main highlighted social and medical problem that is counted on the red-alert list of the country's problems. The researcher has to explain the rationale to conduct the study while justifying all aspects of the research problems. Furthermore, every government has taken a major step to give relief to the population by the various nutritious-related supplies of items and also focuses to address the concerns of under-nutrition. In this aspect, the Pakistani government, with the collaboration of the provincial official setup, is giving more importance to the basic needs of the marginalized segments of the society. Therefore, some measures are taken with the association of local stockholders, civil society, and nonprofit organizations to intervene with the holistic approach of providing food supply, nutrition, and healthcare while the child healthcare and nutrition are primarily put under consideration. These measures are also mentioned as the main goals of the UN's sustainable development goals. The effects of malnutrition are further assigned importance to concentrate on the improper supply of nutrition to the human body that leads to various infections.

From the source of previous studies, some significant causes of malnutrition are associated with less income of a household, low education in mothers, the age of a child, low body mass index of a mother, poor health level, and no proper use of injections by a mother. Some of the studies define that female children are not highly deprived of nutrition compared to male children, but the cultural and socio-economic factors are largely contributing to the favor of male children over the female children in Pakistan. The higher chances of being malnourished are found among both female and male children, but more impacts have seemed to be in male children compared to female children. Precisely, the study highlights the relationships between the social status of parents and its impacts on the malnutrition of children [10].

2. Literature Review

2.1 Malnutrition Among Children A Global Perspective

According to the global hunger index report of 2022, undernourishment means lack of regular sufficient calories for people, and the report shows about 828 million people were affected by undernourishment in the year of 2021 [13]. The situation is worsening at a global level due to crises of conflicts; economic recession due to the covid-19 pandemic; and climate change, and these all are driving forces of hunger. However, the report highlights that the war in Ukraine is the major cause of food shortages, fertilizer prices, and increasing fuel prices globally, which also may create food shortages further [13].

The crisis develops various other factors like inequality, poverty, poor infrastructure, low productivity, and poor governance that lead to more hunger and vulnerability. At a worldwide level, the current food systems at regional or country levels are unable to address the challenges and to end the situation of hunger [13]. The report stated that African countries and Asian countries have high levels of hunger, and these regions are in vulnerable situations for upcoming crises and shocks. The progress against hunger has deteriorated in these regions, which is creating troubles for the need of improvement [13].

The Global Hunger Index indicates the reality that progress comes to an end after the reduction of global

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hunger in the last decades. The report gave a score of 18.2 for the world, which is moderate, and it shows a lower score from 2014, which was 19. 1. The study compares the previous period of 2000, when there was a score of 28.0 for the GHI for the world, and it became less in 2007, at 24. 3. A study pointed out four indicators of the undernourishment prevalence with reference to GHI scores during 2000 to 2007, but in 2021, as reported, 828 million people were facing the issue of undernourishment, which is going back compared to the progress of a decade [14].

The GHI indicators show results that the child wasting rate has festered in the current years at a global level, while the rates of stunting and child mortality are in the process of declining [15]. The study highlights facts and figures that undernourishment at a global level was 13% in the year of 2000 and it was 7.6% in the year of 2017. During this period the prevalence of undernourishment increased at a small level. However, from 2017 to 2021, the prevalence of undernourishment has increased at the global level by 7.6% to 9.8% [13]. The entire countries of the world face a series of acute crises that expose the vulnerability conditions in the food system. [16]. estimation that 46 countries in the world are about to fail to reach the target of low hunger in 2030. However, the study defines three key driving forces, such as climate, economic recessions, and violent conflicts, along with the pandemic covid-19, that are developing the worst situations. The war in Ukraine developed the complexity, food shortage, and disruption in the energy and fertilizer markets at global levels. The entire nations of the world are vulnerable already because of deep-rooted inequality, poverty, and weak governance and institutions, which bear the high burden of the catastrophes.

The current analysis shows that climate change is the major determinant that prevents the acquisition of the second goal of SDG at the global level of zero hunger by 2030 (WHO, 2021). Malnutrition. WHO Report. According to the report of the global hunger index of 2019 about climate change and hunger, human actions are solely responsible for the becoming more adverse situation of sustainable food and nourishment at the global level of the human population [17]. The report of 2020 explains the causes of inequalities with various factors such as injustice, unfairness, political exclusion, and imbalances in power. However, the causes of inequalities are seen as complex with various social determinates. The social injustice refers discrimination to any person or group on the basis of social norms and cultural values that lead them or treated unequal. This type of discrimination shows failure of policy to recognize the damage or effects of inequalities. It also explains a social position of individual in the society such as an infant and young children who are dependent to others, disable boys, low income or caste women, and they are treated unfairness across their lives and generations hence their health, nutrition and education are affected and no access of these basic necessities to them [18].

Child malnutrition is a big problem for public health at a global level with significance to individuals and societies. The study defines that 555 million children under the age of five years are residing in developing countries [19]. Malnutrition signifies various causes of mortality of children under the age of five years that trigger 35% to 50% of deaths among children of 0 to 5 years [20 & 21]. The study states that severe acute malnutrition is a less dominant form of malnutrition but has a high risk of mortality, which is the cause of about 1 to 2 million deaths in a year [22]. According to Black, Morris, and Bryce (2003), malnourished children have prolong consequences of physical and health in their lives. It blocks the cognitive and physical development as well as lower intellectual quotient, behavioural problems and low social skills among children [23]. A study conducted by De Onis, Blossner, borghi, Frongillo and Moriis in 2004 that a huge number of deaths due to malnutrition, and about half of childhood deaths happen in developing countries which are attributed to moderate and mild malnutrition. The study shows 45% of deaths are related measles and 61% of deaths are owing to diarrhea [24].

Siddiqi, Haque, and Goni conducted a study in 2011 in Bangladesh on malnutrition among children, and the study reveals that the prevalence of underweight and stunting among five-year-old children are 40% to 42%, respectively [25]. Edris was done studying the Gumbrit area of Ethiopia in 2006; malnutrition prevails among children in the forms of underweight, stunting, and wasting, and the ratio of the prevalence is 28.5%, 24%, and 17.7%, respectively [26]. A study was done by the National Institute of Statistics of Rwanda in 2005 that chronic malnutrition delays growth that affects about 45% of children under 5 years [27]. The report of the WHO (2008) narrated

malnutrition as the major public health issue mostly of the less developed nations of the world. The study narrated factors of malnutrition, which are no proper pure drinking water and lack of adequate sanitation and hygiene systems, and these factors leave direct effects of various infectious diseases, particularly diarrhea. The report states that malnutrition and all its forms develop the risk of various diseases and deaths [28].

2.2 Malnutrition Among Children in South Asia

A lot of research studies are evidence that the cases of malnutrition among children are largely found in the less developed nations. In this regard, Marcelline reported in their study of 2014 that 925 million people are facing the issue of being undernourished at a global level, while 98% of the cases of undernourishment are from developing countries. The study defines that about 20 million children are facing the situation of severe acute malnutrition, and the highest cases of them are from Sub-Saharan Africa and South Asia [29]. According to de Onis, Frongillo, and Blossner (2000), the burden of malnutrition is mostly seen in South Asia rather than in Africa and other countries. The study supports that the situation of stunting and underweight in South Asia is reported as 44% and 46%, respectively [30].

Regionally, South Asian and African countries have high levels of hunger, which are measured as 27.4% and 27% by the GHI of 2022. The hunger in these two regions is serious. The progress for declining hunger is widely stopped in both regions compared to 2014, while the scores were 28% and 28.1% in South Asia and Sub-Saharan Africa, and their progress is needed to achieve the second goal of zero hunger of SDG by 2030 [13]. The issue of food insecurity is also related to the undernutrition of children of five years in Bihar, India. It is because a large number of people's livelihoods depend on agriculture. In this way, frequent destructions happen due to floods and other calamities that affect the access and availability of supplementary food in terms of money as well; this leads to more stunting and food insecurity for the children [31]. The study shows that stunting rates are high among Afghanistan, Pakistan, and India, with 35% to 38%, while Afghanistan has the highest rate of stunting in the region. Afghanistan experienced the situation of drought, poverty, economic and political instability in 2022, and the consequences of rising food and fuel prices at the global level made the situation worse due to the war of Ukraine, which resulted in a high rate of stunting [32].

The study shows that Yemen has the highest hunger level in 2022. The undernourishment in West Asia and North Africa is high compared to 2010 to 2021 such as 6.1% to 8.6%. The report illustrates that prevalence of undernourishment in Jordan is seemed high as 6% in 2013-15 to 16.9% in the year of 2019-2021, while Prevalence of undernourishment in Lebanon, Yemen and Oman are observed as increasing [33]. However, various countries in the Southeast Asia are observed as the highest child stunting rates particularly in Indonesia as 30.8%, Timor-Leste as 46.7% and Lao PDR as 33.1%. Some countries in the same region also have the high or medium wasting rates among children such as Indonesia 10.2%, Malaysia 9.7% and Cambodia 9.5% [13].

Good health services, environment and proper sanitation and safe water are essential for growth and development of children. Unavailability of these factors have direct impact over the childhood diseases. The increasing of stunting, wasting and underweight is seen among children at Bihar, and the immediate causes were found that influences undernutrition which inclined to the prevalence of various childhood diseases and poor infant feeding practices. Diarrhoea is high among children at the area which cause to poor nutritional status to them. The breast-feeding practices seems poor. These poor practices and childhood diseases have effect to the nutritional status of children of five years ages at Bihar [31]. However, poor maternal nutritional status and poor caring practices for children result in poor nutritional status for the babies, respectively [31]. Moreover, no proper health service owing to inadequate and poor infrastructure and health manpower has a worse impact on general masses in the state. Precisely, the basic and main causes of undernutrition are poor attention to and investment in nutritional programs. Poor management and investment in the public health domain are mainly responsible for the impact of undernutrition [34].

According to a study, 77% of children are physically stunted at the age of one month to six years in Bangladesh [35]. The different types of malnutrition among children are investigated based on some specific demographic, dietary, socio-economic, health, and environmental aspects [35]. The study reveals that in Bangladesh the male cigarette smokers do not spend much on health, housing, clothing, and

education, but their expenditure is more on cigarettes [36]. It is hypothesized that people of less developed countries face income limitations for food, and the spending on tobacco products creates a shortage of food intake that can leave bad impacts on the nutritional status of their children. The study shows that cigarette purchasing reduces the food expenditure that leaves negative impacts on the nutrition of children [37].

Afghanistan is considered at high risk of acute malnutrition and the nutrition reports show that stunting reached the alert stage and also suggested quick intervention. The global experience indicates that the most vulnerable conditions of malnutrition are the suffering of children, pregnant women and elder people. The high rates of malnutrition have portrayed risks of low resistance to various diseases, high mortality, less cognitive abilities and affected physical activities. However, examiners have different views on the major causes of malnutrition in Afghanistan. Some of them argued that lack of access to healthcare services, no proper supply of drinking water quality and no diversity in the diet patterns caused high malnutrition cases occurred in the country. While some experts acknowledged the proposed and mentioned causes of malnutrition but yet they highly emphasized the low supply of caloric intake food [32]. Bangladesh is considered to suffer a high level of malnutrition and several problems are cited. In less developed nation countries, poverty and inequality are largely highlighted as the prominent driving force of malnutrition [38]. The deficiency of nutrition is widely connected with poverty in Bangladesh and India which highly affect the wealth. People have limited affordability of supply of food also among the middle class of society [39].

2.3 Malnutrition Among Children in the Case of Pakistan

In Pakistani society, women are not strong financially and the studies examined that if women are empowered economically, then they spend much money on food, medication and other necessities. The financially strong women are largely spending more amount the health, food and other necessities of children compared to those women who do not have enough economic empowerment. “The positive and significant association of mother’s employment status in male child model shows that the mothers belong to poor families, where their incomes are spent in meeting other household expenditures rather than on their children nutritional requirements.”[10]. The analysis illustrates that females possess no power of income and assets acquisitions to suffer more from malnutrition. The urban resident is mostly highlighting more cases of suffering from malnutrition in male children [40]. Higher birth order is the leading factors of malnutrition among female children. The studies conclude that both female and male children have more chances of malnutrition, but some effects are found higher among male children than female counterparts [10].

The mental and physical health status of children provides malnutrition status. Children who have adequate diet supply do not have to issue with repeated illness and develop a potential growth. Insufficient family earnings, large family size and maternal illiteracy are the substantial cause of the high rate of morbidity and mortality below the five years of age of children in Pakistan. Malnutrition is the main cause of developing a vicious cycle of poverty and deficiency of nutrition [10]. A boy child is always preferred by family members so his probability of being more consumption of nutritious food compared to a female counterpart child but yet why some historical statistics give a horrible picture that boys are suffering more from wasting, stunting and underweight rates than the girls [10].

The food intake process in Pakistan is frequently three times in a day such as breakfast, lunch and dinner. However, most of the people have no proper access of food but whatever is available to them to eat and no importance is highly given to the acquiring highly nutrient or caloric food. A research study portrays that the food habits of the masses depend on their agricultural products that they produce and also determined by their economic and social status. However, the major nutritional problems are low birth weight owing to adverse material nutrition and other micronutrient deficiencies. The adverse nutritional conditions can be examined with massive poverty and unequal distribution of income among the masses and at some extent other behavioural aspects are related to gender based attitudes [41]. The above discussion gives clear cut that need of improvement among nutritional status of the people in Pakistan, and numerous factors are required such as reduction of poverty by various programs, raise food supply, increase awareness of hygiene by community health

programs, make access of clean water, provision of health facilities and plan the universal education to wipe-out illiteracy [41].

Different researchers gave different causes of malnutrition such as population growth, unawareness, poverty, political instability, droughts and improper food stock, and some other important factors are also discussed but these above mentioned are generally seen by various articles. However, large family size and low family income are the main dynamics of malnutrition among children [42]. Malnutrition is the main public medical problem mostly in the less developed nations which results in a high mortality rate among children who are the age of fewer than five years. Malnutrition is also a widely prevailing and highlighted issue in Pakistan. A study prevails that the consequences of malnutrition are higher among young children who have aged 6 to 23 months than the older children from 2 to 5 years [43].

The proper supply of nutrition is vital for the early days of childhood which makes the immune system strong and also helps out in the development of physical and mental aspects of the body [43]. UN report narrates that at the flood battered areas in Pakistan one out of nine children who suffer from acute malnutrition, and they are admitted to health facility centers [44].In case of Sindh and Baluchistan, UNICEF warned about alarming situation of severe acute malnutrition to children who are at five years of ages. The two areas are abruptly worst hit regions of devastating floods. The health professionals screened about 22000 children at health facility centers of the hit regions, and more than 2600 of them were diagnosed by critical condition of malnutrition [44]. Severe acute malnutrition seems a life threating situation whereas children look very thin for their height that results weak immune systems [44].

The study reveals that about 25 million of children and women across Pakistan, and about 7 million of them are form flood hit-regions, need quick attention of providing essential nutrition services [44].The appropriate nutrition is important for children survival and growth as well as health. Well-nourished children need more equipped to learn and grow, and they respond well to tackle diseases. However, poor nutrition affect the education, health and wellbeing across generations [45]. Poor nutrition to mothers during their pregnancy lead to various reasons of malnutrition such as stunting and wasting among children. In Pakistan, nearly 10 million children affected from stunting. The wasting among children in Pakistan is high, and it considered to be emergency level. The case of Pakistan seems that 8 out of 10 children have not proper diet and quality based food to them [45]. A study conducted on the effects of malnutrition with reference to academic performance shows that underweight students have problems with writing and reading skills. The research explains that well-nourished students have adequate skills in both reading and writing [4].

The prime socio-economic problem exists in the developing countries like Pakistan is malnutrition. This issue caused by insufficient nourishment and lack of sanitation and hygiene facilities, and it associates with poor education and health outcomes that hinders in human and economic development [46]. The major nutritional problems in the country are stunting and wasting owing to poor maternal nutrition [4]. The author pays attention to the state responsibility to fight malnutrition and stunting by focusing the stakeholders and officials to work at the single platform as well as mobilize resources from domestic, national and international sources [46]. Stunting means inactivity of physical and mental growth owing to malnutrition, and it involves deficiency of nutrients that are essential for growth and development. Unfortunately, stunting is high among children in Pakistan, and it is reported about 38% children in the country are malnourished. However, huge segments of masses are at danger of the malnutrition due to less availability of nutrient and insufficient food [47]. A research study defines that about 4 out of 10 children are underweight in the country, and this situation shows a serious health concerns such as weak immune system, no proper physical growth, skin diseases, poor mental health and functional disabilities [47].

Ali (2020) reported that stunting among children in Pakistan is declined, and the reduction rate is slow. It is due to low attention for appropriate intervention programs, and the programs only address the issue but there is no use of multiple approach to highlight the determinants of stunting. It is essential to take effective initiative approaches to implement them in pre-conception for preventing the stunting and malnutrition among children in the country [48]. Malik (2016) reported that about a half children in Pakistan are stunted while 11% are wasted. The situation is largely contributing morbidity and

mortality among children of five years age, and it impacts the mental and physical growth of children that leads to economic impacts over the prosperity and development of the country [41].

The study indicates that maternal nutrition is chiefly important in developing countries like Pakistan. A significant part of women faces undernutrition, overweight and deficiency of micronutrient problem in the country. The facts and figures are mentioned in the study that about 177000 annual deaths are associated with maternal and child malnutrition in Pakistan. The issue if coupled with lack of food insecurity and no adequate sanitation and hygiene services that create intensification in female nutrition which prone to infectious diseases among women. The factors of maternal malnutrition have multifaceted in nature that is also include lack of access to good healthcare services, no food security and dietary diversification, early marriage, no proper childbearing norms, limitation to female educations and lack of employment accesses and availabilities. The study also defines that rural households in Pakistan are highly facing food insecurity that creates vulnerable situations of malnutrition among women and children [49]. The previous studies illustrate that mothers' working statuses and no ownership of having assets are originating and main contributors to the increasing malnutrition of children [10].

Malnutrition is mainly known for deficiency of nutrition or under-nutrition which accounted for most of the deaths of children at the global level [19]. The main cause of mortality and morbidity among infants is malnutrition [50]. Moreover, malnutrition mainly stands for the risk to children's health of mental and physical development that results in bad outcomes in later life achievements. Malnutrition leaves negative effects on socio-economic development and the future health of children [42 & 12].

3.4 Social Status of Parents and Malnutrition Among Children Column and Contest Debate

According to Abell, malnutrition is recognized with multiple causes, and clearer causes refer to insufficient intake of quality-based food, no availability of resources, and no capacity of purchasing power. These causes are still creating malnutrition at a global level, and the international organizations are struggling to correct the causes of malnutrition. However, there are other various causes that are associated with malnutrition, which are irrational but have deep effects on human lives [51]. Malnutrition is associated with causes and consequences to both individuals and their social environment. It is also called as hidden hunger [52]. Lack of minerals and vitamin are the major cause of this form of hunger hence it is called as hidden because individuals who are suffering from it has not any kind of information, and they are unknown its results or effects because the consequences seem invisible at initial [53]. Therefore, the whole population can be exaggerated by the hidden malnutrition.

The study defines that the deficiency of minerals leaves the effect of diseases and sufferings on over a billion people. Moreover, deficiency of minerals leads to malnutrition that imposes economic and social costs by obstructing human productivity and economic growth. The malnutrition has an economic rationale to control the illness and diseases that are caused by malnutrition. The economic notion refers to the fact that it is not un-wealthy people who are trapped by hunger but the hungry people who are poor people, so there is a kind of vicious circle of reinforcing hunger and poverty [54]. Ward and Sanders reported in their study of 1980 that high income has positive impacts on adequate food intakes, and better nutrition also increases the productivity of an individual. On the other hand, chronic malnutrition is seen as having negative effects on market-based wages, but Thomas framed a hypothesis that there is no such effect of income over health, but low-income settings portray a causal effect of health on both productivity and wages. In the case of developing countries with eruptive food shortages, a population effect is seen. [55].

Fogel defines in his study of 2004 that about 30% of growth is examined in the per capita income of British in the last 2 centuries because of better nutrition. A similar study was done by the World Bank in 1994 that showed deficiencies of iron, iodine, and vitamins are the cause of wastage of gross domestic products at 5%. However, the study of Fogel [56] shows a successful story that better nutrition leads to high income today and tomorrow for the new generations. "In as far as mineral malnutrition increases mortality, morbidity, and susceptibility to infectious diseases; reduces cognitive abilities and physical performance and earning potential; and disproportionately affects children and (young and pregnant) women." [54].

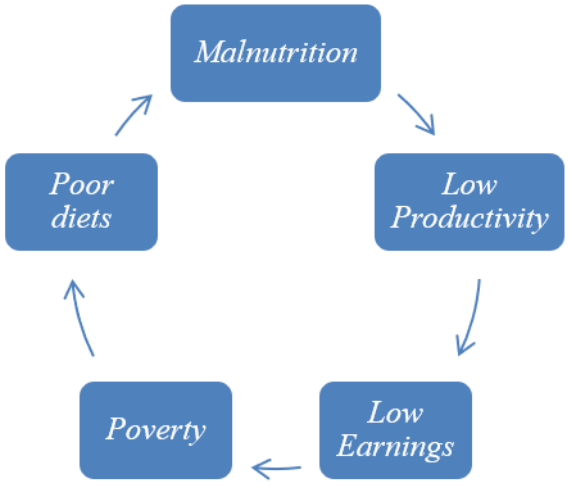

Fig.1 Malnutrition-Poverty Trap (Stein, 2006).

Hunger in general, as a result of food insecurity, has four main causes: (1) unavailability of food, (2) lack of access to food, and (3) its poor utilization (due to a person's inability to select, take in, and absorb the nutrients in the food). Moreover, these causes can be affected by the (4) vulnerability of an individual (i.e., by physical, environmental, economic, social, and health risks)" [54]. Particularly, loss of nutrients is another cause of hunger. The consequence of disasters at the regional level (both natural and man-made) creates unavailability of food and also reduces the food supply. The seasonal changes are also creating a shortage in food supply at the local level that contributes to hunger [57].

A study shows that there are about 20 essential elements for the human body to function adequately. If these elements do not properly intake an adequate amount, then the negative consequences happen to the health of those individuals who use a little amount. A study reports at a global level and emphasizes in less developed nations that the deficiencies of iron, zinc, and iodine are identified and leave bad impacts on public health [58]. A study conducted by De Benoist et al. in 2008 estimated that about 25 percent, which is 1.6 million, of the entire population suffers from the diseases of anemia; the report of the WHO of 2009 explains that about 2 million people at the world level are facing the issue of anemia. The study also portrays that deficiency of iron is largely a nutritional disorder at a global level, which affects both women and children in industrialized and developing nations. Similarly, Brown's study in 2004 estimates that 20% of the population is at risk of deficiency of zinc. However, various researchers explain that there is no exact data available about the deficiencies of micronutrients; hence, there is a need for a survey to fill the gaps [59].

The study shows that the children of educated parents have less malnutrition than the non-educated parents. The parents with low income whose professions are associated with labor work observed high malnutrition in their children. The mothers' education and wealth conditions have a relationship with stunting, and the stunting is seen to be higher in the children of poor families and households compared to the children of rich family backgrounds. The malnutrition proportion is higher for the children whose mothers have no education [29]. The study defines that low time for the child's breastfeeding practices leads to more malnutrition among children. The study also highlights that family resources have great effects on the malnutrition of children; that is, the parents who have income from businesses and monthly salaries and their children are less malnourished. The study also paid attention to the relationship between malnutrition and parents' conflicts. The conflicts lead to more malnutrition among the children.

Some literature defines that poor living standards of families, large family size, food insecurity, and low consumption levels are the causes of malnutrition among children. However, males are largely affected by malnutrition compared to females, and children from rural areas have more effects of malnutrition than urban children. The study also explains that age does not show any kind of difference, such as the situation of "malnutrition increases as the age of a child increases." The study highlights that the children of parents (with a low number of children) who have monthly salary-based income are less affected by malnutrition. The study also shows that uneducated parents have a large number of children with high malnutrition compared to the educated parents. The results of the study found that family size keeps mattering in the situation of malnutrition in the sense that more family members have high levels of malnutrition cases [29]. Gender discrimination has a correlation between social well-being and the development of women. According to a UN report of 2011, it explains that in various parts of Africa there is a huge difference existing, and women have low access to their rights of education, right of inheritance, and resources.

The trade policies at the global level have negative impacts; the unsustainable price hike in the world market obstructs opportunities for the farmers of Africa and others. The report of the UN defines that lack of employment opportunities leads to a high portion of unemployment, and about 300 million people have no such amount for survival, and they have less than one US dollar a day to sustain their lives [32]. The political exclusion and imbalance of power are one of the major inequalities for weak segments of the society. The marginalized class of people have no representatives across all institutions of economic and educational opportunities [60].

The most dangerous happening of malnutrition is during early childhood and pregnancy. Under-nourished children have weak immune systems; hence, they are more prone to illness and infections. Long-term improper nutrition supply can harm stunting that may largely affect cognitive development. The common childhood diseases and high levels of food scarcity can cause acute malnutrition that also leads to the death of infants [61]. The nutrition deficiencies among women and girls who reach the age of reproduction give birth to smaller babies of low weight and height, which happens, furthermore, to the next generations. Stunting leaves adverse consequences on education dramatically. The previous studies define that child stunting has impacts on the brain and other skills, and the stunted children have less education-oriented results in adult lives [61].

3. Discussion and Conclusion

The healthy children symbolize the health status of a country. Adequate nutrition is highly important for the promotion and development of health and prevention of diseases in the nation. However, it is the fundamental right of a child to remain healthy in his/her life; therefore, he/she needs good food, shelter, clothes, education, adequate health, love and affection, and entertainment. Every year, a huge number of children die in the entire world owing to malnutrition, but the number is high in the undeveloped and less developed countries, particularly in the South Asian countries. While the nutritional status of a child is based on numerous factors such as the care practices of the mother, health-related knowledge, feeding practices, mother's education, diseases, socio-economic status of parents, etc. However, socio-economic status is largely associated with determining the nutritional status of a child, especially at the age of growing, and can easily be affected by the lack of nutrition and malnutrition. Malnutrition seems to be responsible not only for the barrier to the development and growth of children but also for creating serious health concern complications that ultimately lead to deaths. The health of children in Pakistan is relatively connected to various factors from socio-cultural, geographical, economic, food availability, care practices, education, and climate, and these factors exist in the country. Malnutrition is largely a public health concern in Pakistan, and several nutritional problems largely disturb a huge segment of the population. However, malnutrition and undernutrition are main obstacles for the promotion and development of the nutritional status of many Pakistani people. The main cause of malnutrition is highly associated with lack of food security at the household level, poverty, unequal distribution of resources, lack of health facilities at the national and local levels, and illiteracy. Besides these major reasons, low levels of education and poor hygiene and sanitation situations are the basic complications for development in Pakistan. In our country, the nutritional status among rural women and children is an extremely alarming condition. In some areas, the wealthy families have standard nutrition status, and they intake proper and good nutrition; hence, they bear less of the burden and complications of malnutrition. Generally, children are largely dependent on mothers and their nutritional access and intake, and their access to good nutrition definitely has great effects on the children's development and growth. The prevalence of malnutrition develops high rates of deaths and diseases among children, and it also slows the mental and physical development and growth among children. The nutrition statuses of mothers and children are abruptly poor in Pakistan; this problem is largely determined in the less and disadvantaged poor. However, the situation varies from region to region and community to community as well as from individual to household. Children are largely affected by the lack of vitamin A, weak immunization, diarrhea, anemia, and goiter because of malnutrition. So, it needs attention to explain and find out the nutrition status among children and the socio-economic status of parents, and then the problem of malnutrition is an easy way to tackle. Hence, this study is selected for extensive research. The main purpose of this study is to examine the social status of parents

and malnutrition level, and the research will also illustrate how social aspects of parents affect the nutrition of children. Moreover, malnutrition has numerous effects on health due to an insufficient supply of nutritious food, age and birth interval, and parents' education and occupation as well as income. All these features of malnutrition will be vastly under consideration in this research. Further, malnutrition is the main issue in the subject of the lack of resources and public expenditure. The cost is calculated currently as developed countries largely utilize the malnutrition-related diseases compared to the less developed countries, whereas the problem is widely existing in the third-world countries. The developing countries are less sparse and spend the amount on public expenditure and are indebted to many causes that give way to various social and medical issues like malnutrition. The issue of improper utilization of public funds is also under debate in the health departments and among the general public to analyze the problem of corruption along with malnutrition.

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