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# Site Selection for Girls Hostel in a University Campus by MCDM based Strategy

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**ABSTRACT**

The area of interest based on girls' hostel site selection is an important topic nowadays. The research directly impacts the well-being, safety, and academic success of female students who are using accommodation facilities while pursuing their academic courses. An efficient hostel location not only supports the physical safety of students but also takes care of their psychological and emotional well-being by providing a suitable and supportive living atmosphere. Different valuable criteria and sub-criteria are considered for evaluating the most suitable site for a girls' hostel. Security and protection, proximity to academic buildings, accessibility, health and safety, and environmental factors are considered as criteria along with their associated sub-criteria in this study. Two decision-makers are given data sets in linguistic terms, which are further converted into crisp numbers. The weights of the criteria and sub-criteria are determined by a well-known multi-criteria decision-making (MCDM) technique called the Entropy-weighted method. Further, the most prioritized location for the girls' hostel on the university campus was evaluated using the Weighted Aggregated Sum Product Assessment (WASPAS)-based ranking MCDM method. Additionally, sensitivity analysis was conducted to check the stability and flexibility of the results.

## 1. Introduction

Hostel is such a residential unit that can encourage community living, provide safety and security, especially for girls students who feel uncomfortable living alone or in small groups. So, choosing a secure and well-monitored area is very important for making a girls' hostel on a university campus. It is essential to find a hostel site that is really peaceful and has a study-friendly environment away

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from noisy avenues. Being near to academic buildings and libraries is also vital for facilitating study and avoiding wasted time. Moreover, the selected location should also provide easy access to real-life necessities like dining halls, medical facilities means hospitals, public transportation, etc and the main thing is that the selected site must contain privacy. Site selection in a scientific manner is essential in constructing any restaurant, hospital, university, etc. Here, we indicate some site selection related research papers that have been published, i.e., [1–8].

Since there are several criteria that go into choosing the ideal site, multi criteria decision making (MCDM) [2, 9–11] can be applied to this procedure. There are several kinds of decision making mathematical tools exist, they are: Analytic Hierarchy Process (AHP) [3, 8, 12], CRiteria Importance Through Inter criteria Correlation (CRITIC) [13], Decision making trial and evaluation laboratory (DEMATEL) [14], Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) [3, 8, 15], Complex Proportional Assessment (COPRAS) [1], Combined Compromise Solution (CoCoSo) [13, 16], Measurement of alternatives and ranking according to COmpromise solution (MARCOS) [17], VIseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) [2, 6], Multi-Objective Optimization by Ratio Analysis plus the Full Multiplicative Form (MULTIMOORA) [5, 18], etc. MCDM is further used in numerous fields, like [19–22]. But, in this paper, the Entropy Method [2, 6, 7] and the Weighted Aggregated Sum Product Assessment Method (WASPAS) [5, 7, 13] are applied to continue the process of site selection problem for Girls Hostel in a University Campus. Here, we use the Entropy method to evaluate the criteria weight and the WASPAS technique to determine the proposed hostel site ranking.

### 1.1 *Structure of this study*

This study is presented as follows: Firstly, the introduction of this girls' hostel site selection is described in Section 1. Then, the literature survey on the site section and MCDM methodologies are discussed in Section 2. The mathematical procedures of proposed MCDM methodologies are mentioned in Section 3. The process of the criteria section and alternatives sorting for girls' hostel in a university campus are discussed in Section 4. The model formulation and data collection process of this study are covered in Section 5. Further, the numerical illustration and discussion process of this proposed research are described in Section 6. Then, the computational complexity and sensitivity analysis of this model are discussed in Section 7 and Section 8, respectively. Finally, the managerial insights, conclusions and future research scope are discussed and analysed in Section 9.

## 2. Literature survey of this study

This section describes the brief literature on different site selection studies and Multi Criteria Decision Making (MCDM) based research in recent times.

### 2.1 *Site selection with MCDM methodology*

Multi Criteria Decision Making (MCDM) plays an important role in site selection or in determining the best location in terms of surroundings. Various MCDM processes can analysis and compute the selected criteria weight and then raking with the alternatives. With the help of this method, MCDM provides a structured approach to making proper and balanced decisions. This guarantees that the selected site complies with the overall objectives and limitations.

Here are some site selection oriented research studies in recent times in the area, such as a women's university site selection in West Bengal, a state in India [1], a sustainable health care centre location selection in Riyadh, Saudi Arabia [2] and shopping mall site selection in different locations in a city namely Kolkata (Calcutta) in India [3]. Further, different MCDM methods are also used in the restaurant location section beside highway [8], charging station site selection of electric vehicles in West Bengal, India [23], an assessment on a project of site selection in New Towns [4], an educational institute location selection [5] and so on.

Ranking of the different states in India based on women's empowerment and ranking of different women empowerment in India using MCDM methods are discussed by Adhikari et al. [6, 12], respectively. Additionally, the most valuable factor for women's empowerment in the sports sector is analysed by DEMATEL based MCDM method by Gazi et al. [14].

Azeem et al. [24] used the MCDM method for hostel site selection in a Complex Fermatean Fuzzy Set (CFFS) environment. Further, Tah [25] applies the geographical information system for the growth of hostels in Ahmadu Bello University, Zaria, in Nigeria. Also, the infrastructure and services of the hostel for postgraduate students' are analysed by Agyekum et al. [26], and the students' gratitude for hostel accommodation is examined by Azeez et al. [27] in detail. Danso et al. [28] evaluate the satisfaction and facilities of hostels among 40 different private hostels in Knust Campus. Jameel [29] determine the sustainability impact of the newly constructed student hostel in the United Arab Emirates University (UAEU). Additionally, various studies have been conducted on hostel facilities and satisfaction; anyone may see [30–32].

### 2.2 *Literature on Entropy and WASPAS methods*

The entropy method is a mathematical process that is used in multi-criteria decision making (MCDM) to compute factor weights. This method was proposed by Shannon [33] in 1948. This approach is flexible and can be used in various complex decision-making scenarios. The entropy technique has been used for research papers in various fields in real life problems. The Entropy based MCDM method is used in numerous fields, including hospital site selection [2], evaluating sustainable women's empowerment [6], selecting material in the engineering sector [34], determining the challenges of adapting edge computing in an educational institute [7] and many more. In addition, the correlation analysis & covariance to confirm the accuracy of the evaluated results [35] and utilizing the generalised distance measure by the fuzzy entropy measure [36], entropy technique applied.

The weighted Aggregated Sum Product Assessment Method (WASPAS) is a significant decision-making method to rank the alternatives considering multiple conflicting criteria-based weighted systems. This method was first established by Zavadskas et al. [37] in 2012. WASPAS is a combined ranking procedure for the MCDM method that considers weighted sum and weighted product models. Now, we discuss real world issues solved by the WASPAS method in various studies, including university location selection problem [5], taking edge computing model in educational institutes [7], illness prediagnosis based on symptoms [13], selecting last-mile delivery model [38], assessment of manufacturing companies [39], etc.

## 3. Methodology

Multi-Criteria Decision Making (MCDM) Methods define the structure of determining the best feasible solution according to recognized differing criteria of real life difficulties. This technique is applied to take verdicts connected to these problems. In this process, the main criteria of alternatives are given more better position than the less significant criteria of an item. Here, we will examine the total phenomenon via two approaches: the entropy method and the weighted aggregated sum product assessment method (WASPAS) method.

## *3.1 Entropy Weighted Method*

A mathematical communication theory was invented by Shannon [33] in 1948, which is also known as the Shannon method or entropy-weighted method. It is an objective weighted method that can assist in computing the significance of several conflicting criteria and how they relate to each other. Gazi et al. [2] and Adhikari et al. [6] applied the entropy weighted method in respective fields to evaluate the weight of the multi criteria based decision problems. The structural framework of the entropy weighted method is depicted in Figure 1 and the mathematical procedure of this weighted calculation technique is described as follows:

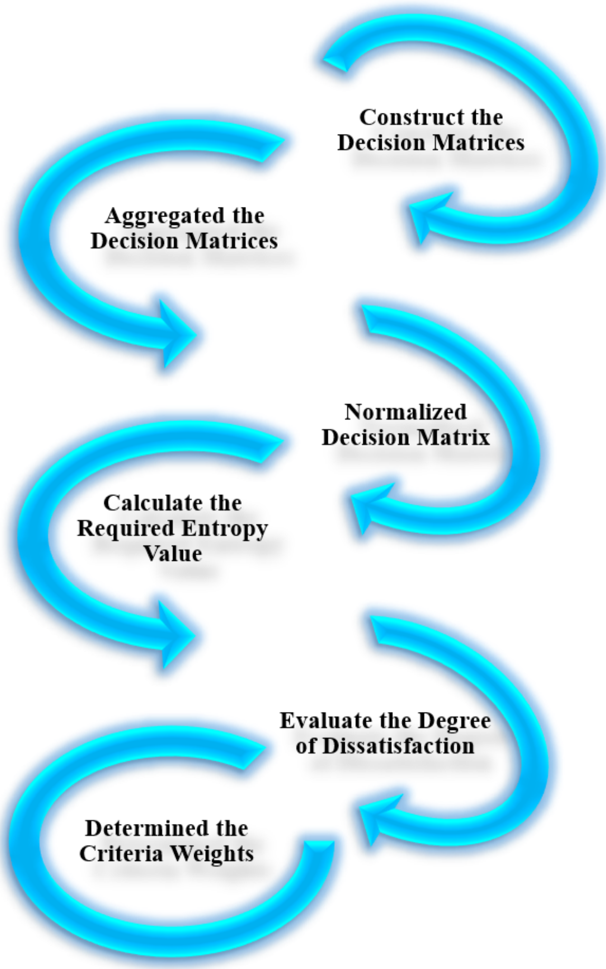


**Fig. 1.** Hierarchical structure of the Entropy method

In this paper, $d'$ number of decision makers (DMs) make opinions based on their skills and knowledge. Also, consider that there is $e$ number of criteria with $b$ number of alternatives associated with this model. For each criteria $\mu$, there exists $m_\mu$ number of sub-criteria connected. The following steps are in the entropy method:

**Step 1: Structured the decision matrices**

First of all, we have established a decision matrix based on the wise opinion of DMs in linguistic terms. This is structured by $\mathscr{D}$-th decision makers (DMs) where, $\mathscr{D} = 1, 2, \ldots, \mathscr{D}, \ldots, d'$ and $d'$

be the number of decision matrices.

$$(\tilde{\mathscr{F}}_e)_{\mathscr{D}} = \begin{bmatrix} (\tilde{\mathscr{H}}_{11})_{\mathscr{D}} & (\tilde{\mathscr{H}}_{12})_{\mathscr{D}} & \dots & (\tilde{\mathscr{H}}_{1e})_{\mathscr{D}} \\ (\tilde{\mathscr{H}}_{21})_{\mathscr{D}} & (\tilde{\mathscr{H}}_{22})_{\mathscr{D}} & \dots & (\tilde{\mathscr{H}}_{2e})_{\mathscr{D}} \\ \vdots & \vdots & \ddots & \vdots \\ (\tilde{\mathscr{H}}_{b1})_{\mathscr{D}} & (\tilde{\mathscr{H}}_{b2})_{\mathscr{D}} & \dots & (\tilde{\mathscr{H}}_{be})_{\mathscr{D}} \end{bmatrix} \tag{1}$$

i.e.,

$$(\tilde{\mathscr{F}}_e)_{\mathscr{D}} = [(\tilde{\mathscr{H}}_{\mu\beta})_{\mathscr{D}}]_{bc} \tag{2}$$

where $(\tilde{\mathscr{F}}_e)_{\mathscr{D}}$ is $b \times e$ order matrix ;$\mathscr{D} = 1, 2, \dots, d'$ ; each criteria $\mu$ (when, $\mu = 1, 2, \dots, e$) and each alternatives $\beta$ (when, $\beta = 1, 2, \dots, b$). In a similar way, $\mathscr{D}$-th decision makers (DMs) are also given the decision matrix for the selected sub-criteria, where $\mathscr{D} = 1, 2, \dots, \mathscr{D}, \dots, d'$ and $d'$ is described as follows,

$$(\tilde{\mathscr{F}}_{m\mu})_{\mathscr{D}} = \begin{bmatrix} (\tilde{\mathscr{H}}_{11\mu})_{\mathscr{D}} & (\tilde{\mathscr{H}}_{12\mu})_{\mathscr{D}} & \dots & (\tilde{\mathscr{H}}_{1e\mu})_{\mathscr{D}} \\ (\tilde{\mathscr{H}}_{21\mu})_{\mathscr{D}} & (\tilde{\mathscr{H}}_{22\mu})_{\mathscr{D}} & \dots & (\tilde{\mathscr{H}}_{2e\mu})_{\mathscr{D}} \\ \vdots & \vdots & \ddots & \vdots \\ (\tilde{\mathscr{H}}_{b1\mu})_{\mathscr{D}} & (\tilde{\mathscr{H}}_{b2\mu})_{\mathscr{D}} & \dots & (\tilde{\mathscr{H}}_{bm_\mu})_{\mathscr{D}} \end{bmatrix} \tag{3}$$

i.e.,

$$(\tilde{\mathscr{F}}_{m\mu})_{\mathscr{D}} = [(\tilde{\mathscr{H}}_{\beta\zeta_\mu})_{\mathscr{D}}]_{bm_\mu} \tag{4}$$

Here, $\zeta_\mu = 1_\mu, 2_\mu, \dots, m_\mu$ and for each factor $\mu$, $(\tilde{\mathscr{F}}_{m\mu})_{\mathscr{D}}$ is a $b \times m_\mu$ order matrix.

**Step 2: Aggregation the structured decision matrices**

The above decision matrices aggregate into a decision matrix,

$$\vartheta_{1_{\tilde{\mathscr{H}}_{\mu\beta}}} = \sqrt[d']{\left\{ \prod_{\mathscr{D}=1}^{d'} (\vartheta_{1_{\tilde{\mathscr{H}}_{\mu\beta}}})_{\mathscr{D}} \right\}} \tag{5}$$

For criteria and sub-criteria, the aggregated decision matrix is constructed from Equation (2) and Equation (4) using Equation (5), respectively. The aggregated decision matrix for criteria, denoted as $\tilde{\mathscr{F}}_e$, i.e.,

$$\tilde{\mathscr{F}}_e = [\tilde{\mathscr{H}}_{\mu\beta}]_{be} \tag{6}$$

And, by the similar way, for the sub-criteria, defined as $\tilde{\mathscr{F}}_{m\mu}$, i.e.,

$$\tilde{\mathscr{F}}_{m\mu} = [\tilde{\mathscr{H}}_{\beta\zeta_\mu}]_{bm_\mu} \tag{7}$$

**Step 3: Normalized the decision matrix**

The calculated aggregated decision matrix is normalized as follows,

$$\tilde{\mathscr{H}}^n_{\mu\beta} = \frac{\tilde{\mathscr{H}}_{\mu\beta}}{\sum_{\beta=1}^{b} \tilde{\mathscr{H}}_{\mu\beta}} \tag{8}$$

**Step 4: Calculate the required entropy value**

Evaluate the entropy value of each criteria using Equation (8), we get,

$$\mathscr{E}'_\mu = -\frac{1}{\log b} \times \sum_{\beta=1}^{b} \left\{ \tilde{\mathscr{H}}^n_{\mu\beta} \times \log\left(\tilde{\mathscr{H}}^n_{\mu\beta}\right) \right\} \tag{9}$$

where, $\mu = 1, 2, \dots, e$.

**Step 5: Compute the degree of dissatisfaction**

The degree of dissatisfaction $\mathscr{C}_\mu$ for each criteria $\mu$, s.t.,

$$\mathscr{C}_\mu = (1 - \mathscr{E}'_\mu) \tag{10}$$

where, $\mu = 1, 2, \ldots, e$.

**Step 6: Criteria weight**

The required criteria weight is,

$$\mathscr{W}_\mu = \frac{\mathscr{C}_\mu}{\sum_{\mu=1}^{e} \mathscr{C}_\mu} \tag{11}$$

The evaluated factor weight from equation (11), which is used for further calculation, where $\mu = 1, 2, \ldots, e$. We also find the sub-criteria weight for each criteria by using a similar way. Equation (11) shows the local weight of criteria and sub-criteria.

After that, the global weight ($\tilde{\mathscr{W}}_{\zeta\mu}^{\mathscr{G}}$) of sub-criteria evaluated by using Equation (12), as follows

$$\tilde{\mathscr{W}_\zeta \mu}^{\mathscr{G}} = \mathscr{W}_\mu \times \tilde{\mathscr{W}}_{\zeta\mu} \tag{12}$$

and, the global weight ($\tilde{\mathscr{W}}_{\mu}^{\mathscr{G}}$) of criteria determined by using Equation (13), as follows

$$\tilde{\mathscr{W}}_{\mu}^{\mathscr{G}} = \sum_{\zeta\mu=1\mu}^{m\mu} \tilde{\mathscr{W}}_{\zeta\mu}^{\mathscr{G}} \tag{13}$$

where, $\zeta_\mu = 1_\mu, 2_\mu, \ldots, m_\mu$ and $\mu = 1, 2, \ldots, e$.

## 3.2 *Weighted Aggregated Sum Product Assessment Method (WASPAS)*

Weighted Aggregated Sum Product Assessment (WASPAS) method was developed by Zavadskas et al. [37] in 2012. This is a ranking based MCDM procedure that combines the Weighted Sum Method (WSM) with the Weighted Product Method (WPS). This ranking method is applied in medical diagnosis [13] and adopting edge computing in educational institutes [7] in uncertain environments. The structural flowchart of the WASPAS method is depicted in Figure 2 and the numerical computational frameworks of the WASPAS method are described as follows:

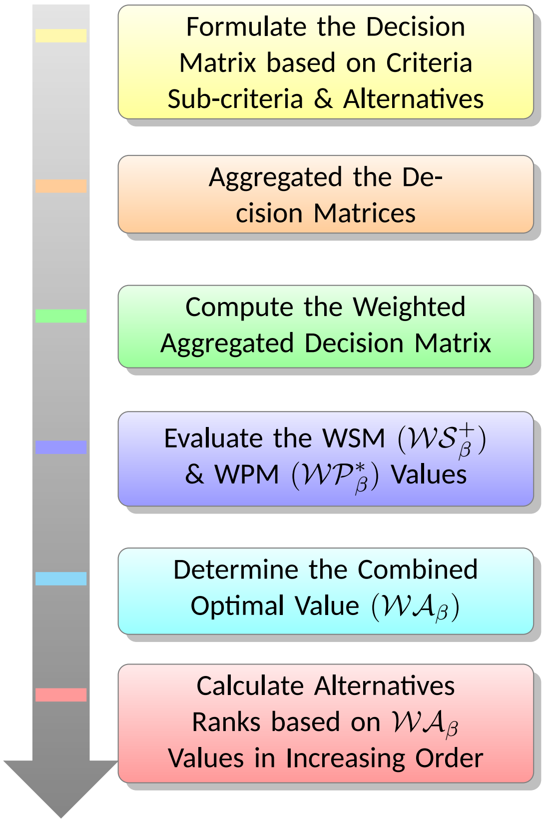


**Fig. 2.** Structure procedure of the WASPAS method

Like the previous section 3.1, we choose that there is $e$ number of criteria with $b$ number of alternatives and $d'$ be the number of decision makers (DMs) for generalised methodology. For each criteria $\mu$, there exists $m_{\mu}$ number of sub-criteria. Then the mathematical procedure step frowned as follows:

**Step 1: Construction of Decision Matrices**

The decision matrices are structured by $\mathscr{D}$-th decision makers (DMs) based on their experiences with linguistic terms. So, the given decision matrices are shown in Equation (1) to Equation (2) for selected criteria.

In a similar way, for the chosen sub-criteria, the given decision matrix is constructed in Equation (3) to Equation (4).

**Step 2: Aggregation the constructed decision matrices**

Equation (5) is used to aggregate $d'$ decision matrices into one decision matrix. Then, the aggregated matrix is displayed in Equation (6) and Equation (7) for criteria and sub-criteria, respectively.

**Step 3: Compute the criteria weight**

All criteria weights $(\mathscr{W}_{\mu})$, where $\mu = 1, 2, \ldots, e$ are computed by entropy weighted method in the above section (Section 3.1) and Equation (11) gives the weight of the criteria.

**Step 4: Find Weighted Sum model (WSM)**

The weighted sum $\mathcal{WS}^{+}_{\beta}$ is the first relative importance value which is evaluated from the factor weight $(\mathcal{W}_{\phi})$ and the aggregated matrix $\tilde{\mathscr{F}}_{e}$, that is denoted by,

$$\mathcal{WS}^{+}_{\beta} = \sum_{\mu=1}^{e} \left( \tilde{\mathcal{Q}}_{\mu\beta} \times \mathscr{W}_{\mu} \right) \tag{14}$$

where $\tilde{\mathcal{Q}}_{\mu\beta}$ are calculated in Equation (5) and $\mathscr{W}_\mu$ are calculated in Equation (11) with $\mu = 1, 2, \ldots, e$ and $\beta = 1, 2, \ldots, b$.

**Step 5: Determine Weighted Product Model (WPM)**
The weighted product $\mathcal{WP}^*_\beta$ is the second relative importance value computed with the help of aggregated matrix $\tilde{\mathscr{F}}_e$ and the factor weight $(\mathscr{W}_\mu)$ as follows,

$$\mathcal{WP}^*_\beta = \sum_{\mu=1}^{e} \left(\tilde{\mathcal{Q}}_{\mu\beta}\right)^{\mathscr{W}_\mu} \tag{15}$$

where $\mathcal{P}_{\alpha\phi}$ and $\mathcal{W}_\phi$ are calculated in previous with $\mu = 1, 2, \ldots, e$ and $\beta = 1, 2, \ldots, b$.

**Step 6: The required combined optimal value**
In the final step, the WASPAS method is the combination of the Weighted Sum Model (WSM) and Weighted Product Model (WPM), for the ranking of alternatives is defined as,

$$\mathcal{WA}_\beta = \mu\mathcal{WS}^+_\beta + (1-\mu)\mathcal{WP}^*_\beta \tag{16}$$

In this equation, $\mu$ is the coefficient of combined with the optimal value with $\mu \in [0, 1]$. The value of $\mu$ is equal to $0.5$ if the combined optimal factor is similarly affected by WSM and WPM procedures.

Rank the alternatives is given with according to the value of $\mathcal{WA}_\beta$, that determined by Equation (16). The alternatives with higher values from this equation are chosen as optimal, followed by decreasing order.

### 3.3 *Pseudo code of this empirical model*

Establish the framework with $e$ number of criteria, $m_{mu}$ number of sub-criteria for each criteria $\mu$, $b$ number of alternatives and $d'$ number of decision makers (DMs) consider for constructing madel. The decision matrices are built with $b \times e$ order and $b \times m_\mu$ order for criteria and sub-criteria, respectively. The two MCDM techniques, namely entropy and WASPAS, are applied to determine the criteria & sub-criteria weights and rank the alternatives, respectively. The $d'$ number of $b \times e$ order and $b \times m_\mu$ order decision matrices for criteria and sub-criteria are taken as input data. The pseudo code of this model is:

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*INPUT:* $d'$ number of $b \times e$ and $b \times m_\mu$ orders decision matrices for criteria & sub-criteria, respectively
*OUTPUT:* Calculate criteria & sub-criteria weight and rank the alternatives
*COMPUTE:* Local and global weights of the criteria & sub-criteria
*INITIALIZE:* Linguistic terms and crisp numbers
*OPERATION:* Entropy and WASPAS

1. *MERGE* Aggregate the $d'$ number of decision matrices for criteria & sub-criteria
2. *NORMALIZATION* normalize the aggregated decision matrix
3. *FOR Entropy*
4. *FIND* determine the logarithmic value for every entry
5. *THEN* evaluate the logarithmic sum for every criteria and sub-criteria
6. *CALCULATE* find out the entropy value and degree of dissatisfaction value
7. *FIND* determine the weights of the criteria and sub-criteria
8. *END Entropy*

9. *GLOBAL WEIGHT* evaluate the global weight of the criteria & sub-criteria from local weights
10. *BEGIN WASPAS*
11. *COMPUTE* calculate weighted sum and weighted product models
12. *FIND* evaluate $\mathcal{WS}_\beta^+$, $\mathcal{WP}_\beta^*$ and $\mathcal{WA}_\beta$ values for alternatives
13. *RANKING* rank the alternatives based on $\mathcal{WA}_\beta$ value
14. *END WASPAS*

# 4. Criteria and Alternative Selection for Girls Hostel in a University Campus

This section deliberates on the application of the projected model. The two parts of this section are the criteria for a girls' hostel in a university and the different sites (locations) as the alternatives for a girls' hostel. The criteria and alternatives of the proposed model are discussed in the following way,

## 4.1 *Criterion Selection*

The site selection for a girls' hostel in a university campus involves various essential criteria to ensure that the proposed locations are viable for girls' students. Selection of a proper location for a hostel is a very challenging task.

### 4.1.1 *Security and protection ($\mathscr{E}_1$):*

A girls' hostel should have 24 hour surveillance with security guards and CCTV to assure indemnity and protection. It should be also be confirmed that, the entry and exit points are kept secure with restricted access and change the area with dimly-lit environment to ward off any unauthorized activity. We can consider two different sub-criteria of security and protection. They are,

a. **Lighting facility ($\mathscr{E}_{1A}$):**
One of the first things that should be considered while selecting the site for the ladies hostel that directly affects security and safety is adequate lighting. It will elevate the sense of security among the inhabitants and decrease the chances of accidents as well as dissuade potential security threats. Proper lighting system will increase the luminosity in the hallways, entrances and common rooms, required mostly during the dusk proceeding the night-time. Sunlight must be available in the rooms to promote healthy well-being, enhancing physical and mental health, thus improving educational excellence.

b. **Surveillance ($\mathscr{E}_{1B}$):**
Surveillance is another major aspect at the time of choosing the site of female hostels in order to provide a better protection. CCTV cameras need to be placed strategically to ensure a better inspection of the place. Unwarranted access and the possibility of harassment can be decreased with a strict and trustworthy monitoring system. Quick response to the emergency situations needs to be certain. The presence of conventional surveillance methods would induce a sense of comfort and safety to the occupants as well as their family members. Thereafter, it will become a dependable and alluring choice to accommodate.

### 4.1.2 *Proximity to Academic Buildings ($\mathscr{E}_2$):*

Proximity to academic buildings for a girls' hostel guarantees quick and easy access to classes and minimises travel time. It actually reduces the student's fatigue. For this reason, girls are encouraged to participate in campus activities, which enhances the overall academic experience. Here, two sub-criteria are considered, such that,

a. **Distance to Classrooms / Library ($\mathscr{E}_{2A}$):**
A convenient way to ensure the academic improvement of the inhabitants is to consider the distance of hostels from classrooms, libraries and canteens. The commuting time can be decreased with quick access to their classes and study resources. The collaborative learning opportunities can be enhanced with better time management and an inspiring daily presence in the classes. The security of the students is better ensured with lesser distance between hostels and the library or canteens.

b. **Transportation ($\mathscr{E}_{2B}$:)**
Transportation plays an important role in choosing a suitable place for ladies' accommodation. Communication to the off-campus locations such as clinics or markets as well as different of parts of campus with the inclusion of classrooms, canteens, libraries and extracurricular activities can be smooth with a hostel site that is well connected to the networks of transportation or dependable services of the shuttle. Safety during late hours can be enhanced with decreased walking distance in remote areas through an appropriate system of communication. Students are able to manage their time effectively with proper communication systems that provide a steady societal and educational life.

### 4.1.3 *Accessibility ($\mathscr{E}_3$):*

A girls' hostel should be accessible to all students which comprises have ramps and barrier-free passageways for differently abled students. Additionally, ensuring easy access to public or campus transportation and close proximity to important services such as medical facilities and stores. Below are the sub-criteria of accessibility. These are,

a. **Disabled Access ($\mathscr{E}_{3A}$):**
Proper accessibility to disabled students is a vital asset while considering the site as it eliminates discrimination and contributes to equality irrespective of physical activities. Elevators, ramps and doorways, along with adequately equipped bathrooms ensure the protection of physically challenged students as well. Here, the vicinity to approachable pathways, classes and other available facilities to certify ease of movement is another major factor. The commitment of the institution to organise inclusive and supportive surroundings by prioritising physically disabled students encourages them to concentrate on their academic and individual growth without any boundaries.

b. **Ease of Navigation ($\mathscr{E}_{3B}$:)**
Ease of navigation is an unavoidable issue that involves comfort in daily life for students. A suitably designed route with approachable and supportive layouts helps the students to roam around the campus swiftly with decreased chances of meeting resistance or getting lost. Feasibly created pathways can cause a spontaneous evacuation at the time of emergencies. Stress-free surroundings and can be acclimated by the new occupants easily, enabling them to concentrate on social life and their studies, eliminating unwanted disruptions.

### 4.1.4 Health and Safety ($\mathscr{E}_4$):

Health and safety is paramount in a girls' hostel. Because of this, safe access control, emergency preparedness and regular health checks need to be ensured. Well-lit locations, surveillance, and constant security reduce risks. Well and hygienic facilities develop overall well-being. Here are two several sub-criteria of health and safety. Such as,

a. **Health Centres ($\mathscr{E}_{4A}$):**
Health care Centres are an important consideration at the time of choosing the site for a ladies' hostel as it ensures day to day medical needs as well as in emergency situations. A health care centre near the hostel elevates swift access to the health facilities during emergencies. It is a vital part, especially for the female student's clinical needs from time to time. The presence of nearby clinics will concrete the health care safety of the students and give satisfaction to the guardians and parents and therefore the site of the hostel becomes much safer and alluring to the residents.

b. **Nearby Fire Safety service ($\mathscr{E}_{4B}$):**
Fire safety services directly impact the security of the occupants, making it a vital part during the planning of the site of female accommodations. A feasible fire stations certain spontaneous reaction to the fire emergencies, reducing possible risks and damages. The liability for the campus can be deducted along with the fact that it complies with safety regulations and provides a peaceful residence for the students. The whole safety infrastructure can be elevated, making it a more permissible and liable option for accommodation sites with proximity to the fire stations.

### 4.1.5 Environmental Factors ($\mathscr{E}_5$):

Environmental factors for a girls' hostel include choosing a site with less pollution, natural ventilation and fresh air quality. Water conservation and garbage disposal systems must be implemented perfectly. Access to green spaces enhances the healthy living atmosphere. There are three individual sub-criteria of environmental factors. They are,

a. **Noise Levels ($\mathscr{E}_{5A}$):**
Noise levels around the hostels are a major consideration while planning for female hostels as it affects both the mental and physical well-being of the students. A site with fewer levels of noise is important for making serene and conducive surroundings for homework, breaks and relaxation. An extended noise level causes disturbances in sleep, reducing levels of academic results, leading them to opt for a residence far from distractions such as noisy roads, railways, construction sites or other noisy areas. Consider a quiet environment that provides overall comfort and quality of life for the students, making it a demanding and utilitarian space for living.

b. **Air Quality ($\mathscr{E}_{5B}$):**
The condition of the air directly affects the overall health of the students. The quality of life and academic performances get disrupted by polluted air, causing respiratory problems, allergies and many more. A healthy environment for living reduces the chances of health related absences with the promotion of an enhanced health system. A place with fresh air provides a comfortable and more pleasant experience for living, with making it an attractive and desirable place for a hostel.

c. **Water Quality ($\mathscr{E}_{5C}$):**
Quality of water is another major factor that needs to be considered while opting for the site of

ladies' hostels as it directly impacts the health and daily needs of students. The availability of fresh and pure water is important for cooking, drinking, and maintaining private cleanliness. On the other hand, poor water quality can increase the chances of water-borne diseases, gastrointestinal diseases, and infections. Effective water treatment is a necessity to ensure an overall healthy lifestyle for the occupants. This will not only ensure health and security compliances but also provide a space of tranquillity for the girls and their families.

## 4.2 *Alternative selection*

In this paper, we take a few alternatives to show the adaptability of proposed approaches. For this, as a real life location selection problem, we consider a campus of the institute Maulana Abul Kalam Azad University of Technology, West Bengal. The institute is located in the district of Nadia, the state of West Bengal in India.

We took three sites, namely, Site 1: South-West Corner, Site 2: North-East Corner and Site 3: Adjacent to Girls' Hostel (the sites are mentioned in Figure 3). The description of the sites with respect to the criteria are as follows:

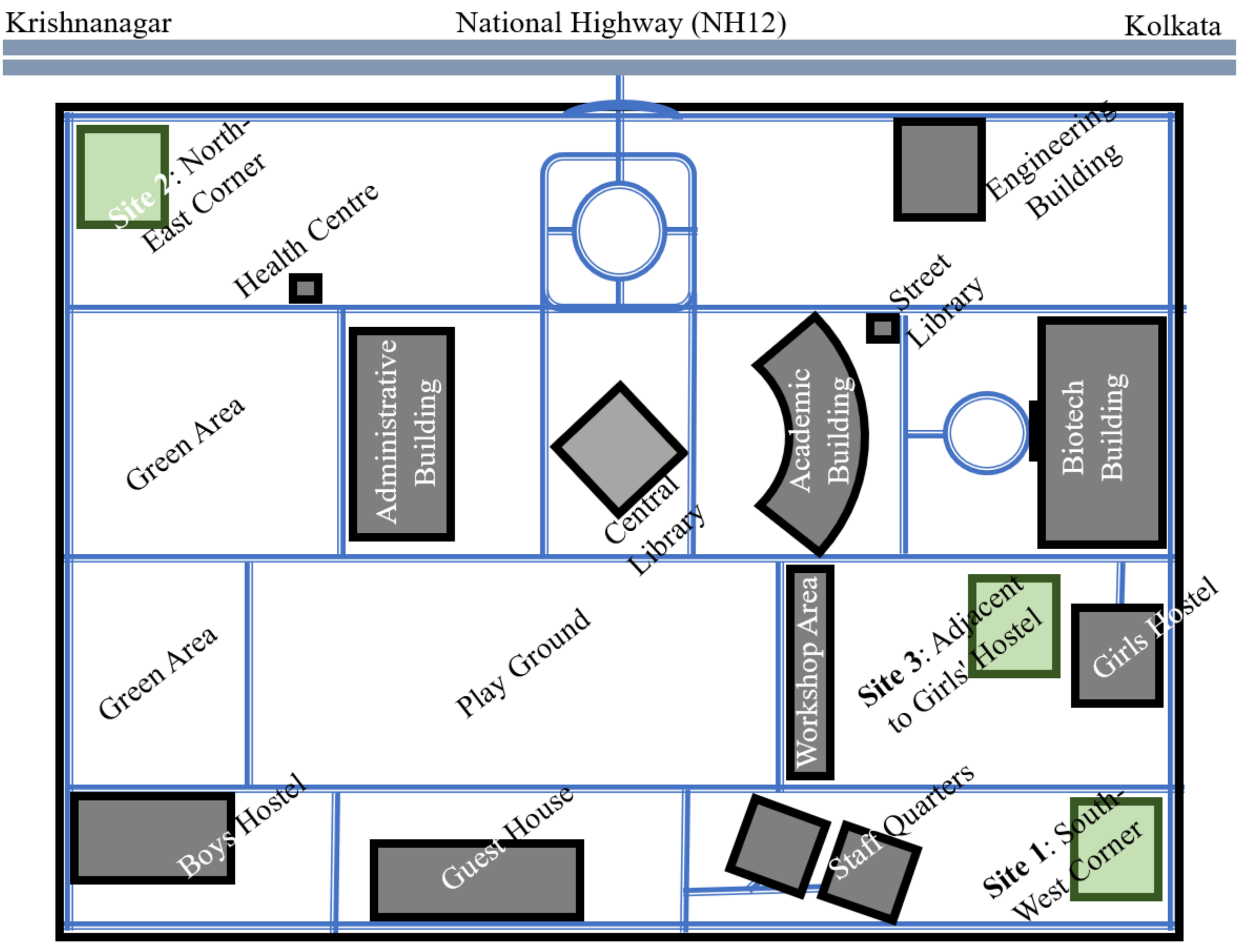


**Fig. 3.** Proposed girls' hostel locations on university campus

### 4.2.1 *Site 1: South-West Corner ($\mathscr{B}_1$):*

This corner is located at the South-West corner of the university campus. It is quite far from the academic building, library and health center. There is no highway adjacent to the location (like NH12).

The strong point of the site is that it is noise-free and surrounded by greenery.

#### 4.2.2 *Site 2: North-East Corner ($\mathscr{B}_2$):*

This site is located at the North-East corner of the university campus. This site is close to the academic building, library and health center. The NH12 is just beside the site. So, it is quite noisy and polluted. There is a poultry farm nearby outside the campus.

#### 4.2.3 *Site 3: Adjacent to Girls' Hostel ($\mathscr{B}_3$):*

This site is very much close to the academic and library building and also a little bit close to the health center. The main problem with the site is that a hostel is already near it, and a mechanical workshop is just beside the proposed site. So, it is situated in a crowded place.

**Remark 1.** *It is need not necessary that we only take the above mentioned three sites and the sites are geometrically presented in Figure 3. Anyone may take more sites as per necessary requirements. Here, we take all the sites arbitrarily.*

## 5. Model structured and Data collection

The formulation of this proposed model is discussed in this section. Further, the data source and data collection procedure are also mentioned in this section.

### 5.1 *Model structured*

Section 4.1 lists the five criteria that were taken into consideration for this girls' hostel site selection research in a university campus. Also, we noticed that out of the five criteria, the first four criteria have two sub-criteria and the last criteria have three sub-criteria. This particular portion elaborately narrates the main structure of this work. We choose the three proposed locations as alternatives, which is discussed in Section 4.2.

Then, the decision matrix is constructed with $3 \times 5$ orders for criteria vs alternatives. Since each of the first four criteria has two sub-criteria, it has $3 \times 2$ order decision matrices and the last decision matrix for the sub-criteria of the fifth criteria has $3 \times 3$ order, respectively. The structural flowchart of this proposed site selection research work of a girls' hostel is shown in Figure 4.

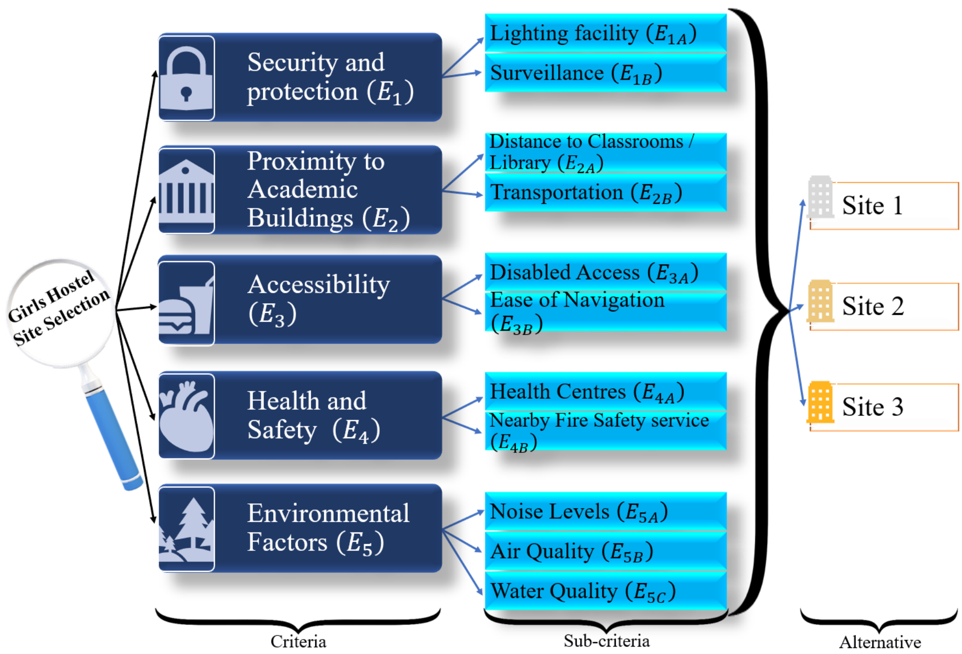


**Fig. 4.** Hierarchical structure of the proposed girls' hostel site selection model

## 5.2 Data collection

This section addresses the data sources of this paper. All the required data was gathered from two DMs in linguistic terms form and after that, it was converted into a crisp number by Table 1. The decision matrix among criteria vs alternatives is presented in Table 2 in linguistic terms with the help of Table 1. Therefore, Table 3, Table 4, Table 5, Table 6 and Table 7 represent the decision matrices of each criterion's sub-criteria vs alternative, respectively using Table 1.

Informative and important data are collected by two decision makers (DMs). These DMs are all professionals and unbiased, with more than 15 years of experience in this field. The DMs are

**DM 1:** A professor in the civil engineering department.

**DM 2:** A university nominated official person with 15 years of experience in hostel management.

For the method Entropy, the decision matrices as data sources were applied to determine the criteria and sub-criteria weights. Then, these decision matrices with evaluated criteria and sub-criteria weights help to find the rank of alternatives using the WASPAS procedure. Additionally, Table 1 represents the conversation table between linguistic terms and crisp numbers. The decision matrix between criteria and alternatives is presented in Table 2. Further, the decision matrix between sub-criteria of Security and protection ($\mathscr{E}_1$) and alternatives is shown in Table 3 and the decision matrix between sub-criteria of Proximity to Academic Buildings ($\mathscr{E}_2$) and alternatives is depicted in Table 4. Then, the decision matrix between sub-criteria of Accessibility ($\mathscr{E}_3$) and alternatives is shown in Table 5 and the decision matrix between sub-criteria of Health and Safety ($\mathscr{E}_4$) and alternatives given in Table 6. Additionally, the decision matrix between sub-criteria of Environmental Factors ($\mathscr{E}_5$) and alternatives is shown in Table 7.

**Remark 2.** *The two wise DMs give the decisions in linguistic terms in the above tables. It makes the further solution easier of this site selection problem.*

**Table 1**
Comparison table between linguistic terms and the set of considered numbers

| **Linguistic Terms** | **The set of considered numbers** |
|---|---|
| Absolutely Important Inference (AII) | $13$ |
| Strongly Important Inference (SII) | $11$ |
| Mostly Important Inference (MII) | $9$ |
| Equally Important Inference (EII) | $7$ |
| Little Important Inference (LII) | $5$ |
| Below Important Inference (BII) | $3$ |
| Poorly Important Inference (PII) | $1$ |

**Table 2**
Decision matrix in linguistic terms of criteria and alternatives given by two DMs

| | **Criteria vs Alternative** | **Security and protection ($\mathscr{E}_1$)** | **Proximity to Academic Buildings ($\mathscr{E}_2$)** | **Accessibility ($\mathscr{E}_3$)** | **Health and Safety ($\mathscr{E}_4$)** | **Environmental Factors ($\mathscr{E}_5$)** |
|---|---|---|---|---|---|---|
| **DM 1** | Site 1: South-West Corner ($\mathscr{B}_1$) | AII | PII | BII | PII | BII |
| | Site 2: North- East Corner ($\mathscr{B}_2$) | BII | AII | AII | SII | AII |
| | Site 3: Adjacent to Girls' Hostel ($\mathscr{B}_3$) | PII | AII | MII | MII | SII |
| | **Criteria vs Alternative** | **Security and protection ($\mathscr{E}_1$)** | **Proximity to Academic Buildings ($\mathscr{E}_2$)** | **Accessibility ($\mathscr{E}_3$)** | **Health and Safety ($\mathscr{E}_4$)** | **Environmental Factors ($\mathscr{E}_5$)** |
| **DM 2** | Site 1: South-West Corner ($\mathscr{B}_1$) | AII | BII | LII | PII | PII |
| | Site 2: North- East Corner ($\mathscr{B}_2$) | PII | AII | SII | AII | SII |
| | Site 3: Adjacent to Girls' Hostel ($\mathscr{B}_3$) | BII | AII | EII | AII | MII |

**Table 3**
Decision matrix between sub-criteria of Security and protection ($\mathscr{E}_1$) and alternatives by DMs

| | **Sub-criteria vs Alternative** | **Lighting facility ($\mathscr{E}_{1A}$)** | **Surveillance ($\mathscr{E}_{1B}$)** |
|---|---|---|---|
| **DM 1** | Site 1: South-West Corner ($\mathscr{B}_1$) | EII | EII |
| | Site 2: North- East Corner ($\mathscr{B}_2$) | MII | MII |
| | Site 3: Adjacent to Girls' Hostel ($\mathscr{B}_3$) | AII | AII |
| | **Sub-criteria vs Alternative** | **Lighting facility ($\mathscr{E}_{1A}$)** | **Surveillance ($\mathscr{E}_{1B}$)** |
| **DM 2** | Site 1: South-West Corner ($\mathscr{B}_1$) | MII | LII |
| | Site 2: North- East Corner ($\mathscr{B}_2$) | SII | MII |
| | Site 3: Adjacent to Girls' Hostel ($\mathscr{B}_3$) | SII | SII |

# 6. Numerical Illustration and Discussion

This section describes the required numerical results of the girls' hostel site selection problem by MCDM based methodology and how it differs with three different locations by numerical way. In this decision making process, to find factor weights of the criteria & sub-criteria and the rank of alternatives, we use the Entropy and WASPAS methodologies, respectively.

First of all, we evaluated the weight of the criteria in Table 8 and the local and global weight of the sub-criteria in Table 9 applying the Entropy method discussed in Section 3.1. The data sets from Section 5.2 is used to do this.

**Table 4**
Decision matrix between sub-criteria of Proximity to Academic Buildings ($\mathscr{E}_2$) and alternatives by DMs

| | Sub-criteria vs Alternative | Distance to Classrooms / Library $(\mathscr{E}_{2A})$ | Transportation $(\mathscr{E}_{2B})$ |
|---|---|---|---|
| DM 1 | Site 1: South-West Corner ($\mathscr{B}_1$) | PII | PII |
| | Site 2: North- East Corner ($\mathscr{B}_2$) | MII | AII |
| | Site 3: Adjacent to Girls' Hostel ($\mathscr{B}_3$) | AII | SII |
| | **Sub-criteria vs Alternative** | **Distance to Classrooms / Library $(\mathscr{E}_{2A})$** | **Transportation $(\mathscr{E}_{2B})$** |
| DM 2 | Site 1: South-West Corner ($\mathscr{B}_1$) | PII | BII |
| | Site 2: North- East Corner ($\mathscr{B}_2$) | EII | AII |
| | Site 3: Adjacent to Girls' Hostel ($\mathscr{B}_3$) | AII | MII |

**Table 5**
Decision matrix between sub-criteria of Accessibility ($\mathscr{E}_3$) and alternatives given by two DMs

| | Sub-criteria vs Alternative | Disabled Access $(\mathscr{E}_{3A})$ | Ease of Navigation $(\mathscr{E}_{3B})$ |
|---|---|---|---|
| DM 1 | Site 1: South-West Corner ($\mathscr{B}_1$) | PII | LII |
| | Site 2: North- East Corner ($\mathscr{B}_2$) | AII | AII |
| | Site 3: Adjacent to Girls' Hostel ($\mathscr{B}_3$) | EII | SII |
| | **Sub-criteria vs Alternative** | **Disabled Access $(\mathscr{E}_{3A})$** | **Ease of Navigation $(\mathscr{E}_{3B})$** |
| DM 2 | Site 1: South-West Corner ($\mathscr{B}_1$) | SII | LII |
| | Site 2: North- East Corner ($\mathscr{B}_2$) | AII | SII |
| | Site 3: Adjacent to Girls' Hostel ($\mathscr{B}_3$) | MII | MII |

**Table 6**
Decision matrix between sub-criteria of Health and Safety ($\mathscr{E}_4$) and alternatives given by two DMs

| | Sub-criteria vs Alternative | Health Centres $(\mathscr{E}_{4A})$ | Nearby Fire Safety service $(\mathscr{E}_{4B})$ |
|---|---|---|---|
| DM 1 | Site 1: South-West Corner ($\mathscr{B}_1$) | PII | PII |
| | Site 2: North- East Corner ($\mathscr{B}_2$) | SII | AII |
| | Site 3: Adjacent to Girls' Hostel ($\mathscr{B}_3$) | SII | SII |
| | **Sub-criteria vs Alternative** | **Health Centres $(\mathscr{E}_{4A})$** | **Nearby Fire Safety service $(\mathscr{E}_{4B})$** |
| DM 2 | Site 1: South-West Corner ($\mathscr{B}_1$) | BII | BII |
| | Site 2: North- East Corner ($\mathscr{B}_2$) | AII | AII |
| | Site 3: Adjacent to Girls' Hostel ($\mathscr{B}_3$) | MII | LII |

**Table 7**
Decision matrix between sub-criteria of Environmental Factors ($\mathscr{E}_5$) and alternatives by DMs

| | Sub-Criteria vs Alternative | Noise Levels $(\mathscr{E}_{5A})$ | Air Quality $(\mathscr{E}_{5B})$ | Water Quality $(\mathscr{E}_{5C})$ |
|---|---|---|---|---|
| DM 1 | Site 1: South-West Corner ($\mathscr{B}_1$) | AII | AII | SII |
| | Site 2: North- East Corner ($\mathscr{B}_2$) | PII | PII | EII |
| | Site 3: Adjacent to Girls' Hostel ($\mathscr{B}_3$) | PII | MII | MII |
| | **Sub-Criteria vs Alternative** | **Noise Levels $(\mathscr{E}_{5A})$** | **Air Quality $(\mathscr{E}_{5B})$** | **Water Quality $(\mathscr{E}_{5C})$** |
| DM 2 | Site 1: South-West Corner ($\mathscr{B}_1$) | AII | SII | MII |
| | Site 2: North- East Corner ($\mathscr{B}_2$) | BII | PII | EII |
| | Site 3: Adjacent to Girls' Hostel ($\mathscr{B}_3$) | PII | EII | EII |

**Table 8**
Criteria weight evaluated by Entropy method

| Factor of the Edge computing | Weight |
|---|---|
| Security and protection $(\mathscr{E}_1)$ | 0.3640 |
| Proximity to Academic Buildings $(\mathscr{E}_2)$ | 0.1786 |
| Accessibility $(\mathscr{E}_3)$ | 0.0757 |
| Health and Safety $(\mathscr{E}_4)$ | 0.2171 |
| Environmental Factors $(\mathscr{E}_5)$ | 0.1646 |

Table 8 describes the criteria weight of this problem. Therefore, Figure 5 reveals Table 8 more clearly with the Pi diagram.

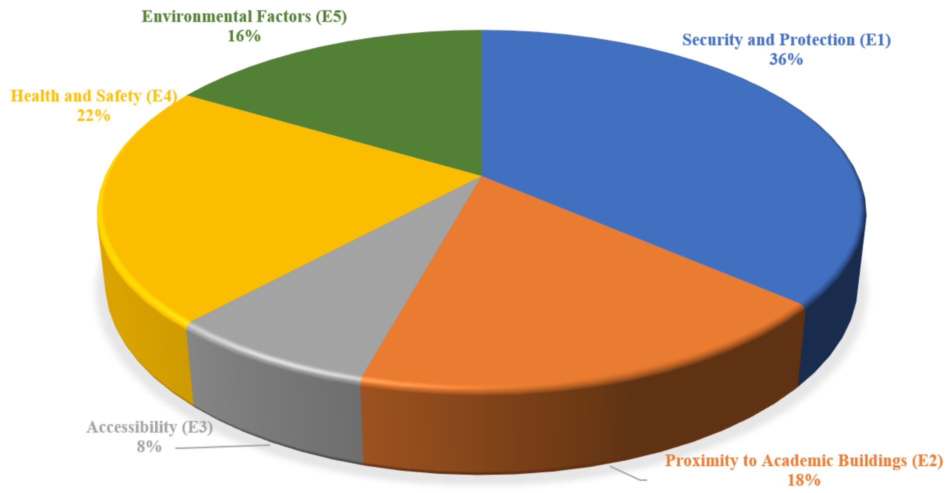


**Fig. 5.** Criteria weight evaluated by entropy weighted method

**Remark 3.** *This is obvious, Table 8 and Figure 5 explain that, Security and protection* $(\mathscr{E}_1)$ *be the most and Accessibility* $(\mathscr{E}_3)$ *be the less weighted criteria. And, Health and Safety* $(\mathscr{E}_4)$*, Proximity to Academic Buildings* $(\mathscr{E}_2)$ *and Environmental Factors* $(\mathscr{E}_5)$ *are the second, third and forth weight individually.*

**Table 9**
Weight of the sub-criteria determined by ENTROPY technique

| Sub-criteria | Local Weight | Global Weight |
|---|---|---|
| Security and protection $(\mathscr{E}_1)$ | | |
| Lighting facility $(\mathscr{E}_{1A})$ | 0.2613 | 0.0951 |
| Surveillance $(\mathscr{E}_{1B})$ | 0.7387 | 0.2689 |
| Proximity to Academic Buildings $(\mathscr{E}_2)$ | | |
| Distance to Classrooms / Library $(\mathscr{E}_{2A})$ | 0.5734 | 0.1024 |
| Transportation $(\mathscr{E}_{2B})$ | 0.4266 | 0.0762 |
| Accessibility $(\mathscr{E}_3)$ | | |
| Disabled Access $(\mathscr{E}_{3A})$ | 0.6876 | 0.0520 |
| Ease of Navigation $(\mathscr{E}_{3B})$ | 0.3124 | 0.0236 |
| Health and Safety $(\mathscr{E}_4)$ | | |
| Health Centres $(\mathscr{E}_{4A})$ | 0.4736 | 0.1028 |
| Nearby Fire Safety service $(\mathscr{E}_{4B})$ | 0.5264 | 0.1143 |
| Environmental Factors $(\mathscr{E}_5)$ | | |
| Noise Levels $(\mathscr{E}_{5A})$ | 0.6538 | 0.1076 |
| Air Quality $(\mathscr{E}_{5B})$ | 0.3327 | 0.0547 |
| Water Quality $(\mathscr{E}_{5C})$ | 0.0135 | 0.0022 |

Now, Table 9 represents the sub-criteria local and global weight with the Entropy process of the MCDM technique and Figure 6 shows this more clearly.

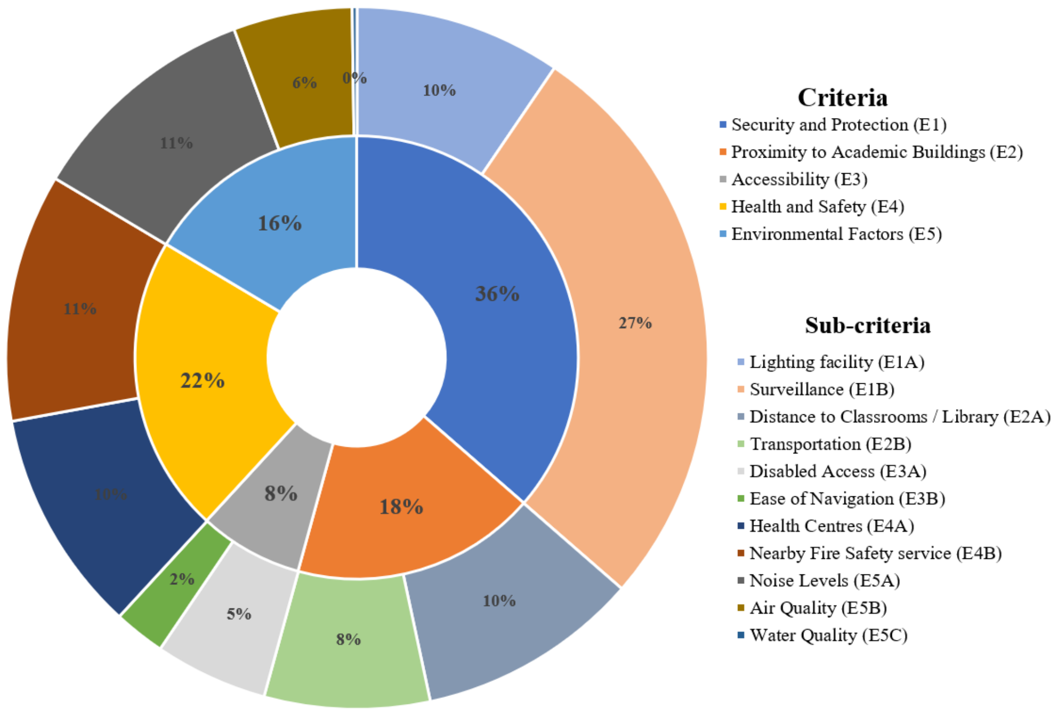


**Fig. 6.** Criteria and sub-criteria's global weights

**Remark 4.** *Table 9 shows the weight of the sub-criteria on the basis of local and global. Surveillance* $(\mathscr{E}_{1A})$, *Distance to Classrooms / Library* $(\mathscr{E}_{2A})$ , *Disabled Access* $(\mathscr{E}_{3A})$, *Nearby Fire Safety service* $(\mathscr{E}_{4B})$, *Noise Levels* $(\mathscr{E}_{5A})$ *are the highest sub-criteria among the sub-criteria of the criteria Security and protection* $(\mathscr{E}_1)$, *Proximity to Academic Buildings* $(\mathscr{E}_2)$, *Accessibility* $(\mathscr{E}_3)$, *Health and Safety* $(\mathscr{E}_4)$, *Environmental Factors* $(\mathscr{E}_5)$ *respectively. The Pi diagram of the global weight of sub-criteria is graphically presented in Figure 6 for easy visualization.*

In order to confirm and choose the ideal location for a ladies' hostel, three different locations are taken as alternatives. Here, we apply the WASPAS process of MCDM methodology, that already discussed in Section 3.2. We represent the ranking of alternatives in Table 10 with the WASPAS method to understand the difference between best and worst place for the girls' hostel which depends on the weighting of several criteria and sub-criteria in Table 8 and Table 9, respectively.

**Table 10**
Alternatives ranking by WASPAS methods and the adjacent data

| Alternative | WSM | WPM | WASPAS | Ranking |
|---|---|---|---|---|
| Site 1: South-West Corner $(\mathscr{B}_1)$ | 11.1595 | 19.4174 | 15.2885 | 3 |
| Site 2: North- East Corner $(\mathscr{B}_2)$ | 17.5230 | 20.6290 | 19.0760 | 1 |
| Site 3: Adjacent to Girls' Hostel $(\mathscr{B}_3)$ | 17.0607 | 20.6338 | 18.8472 | 2 |

Table 10 shows which place is most appropriate for constructing the girls' hostel on a university campus and Figure 7 represents the bar diagram of these three location rankings.

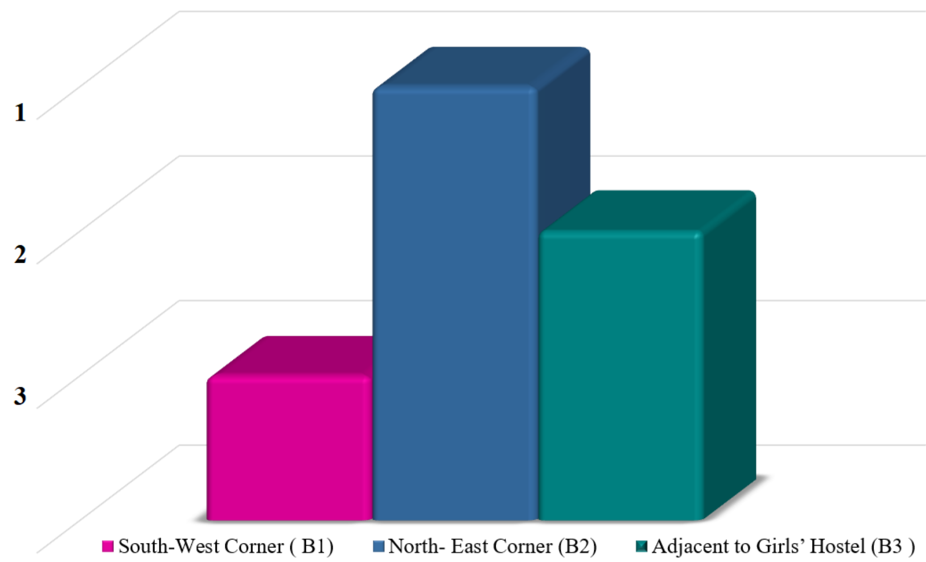


**Fig. 7.** Ranking of the different proposed girls' hostel sites using WASPAS method

**Remark 5.** *According to the two DMs aspects, it is easy to say that Site 2: North- East Corne ($\mathscr{B}_2$) is the most ideal and Site 1: South-West Corner ($\mathscr{B}_1$) is less ideal location for this site selection problem. And, Site 3: Adjacent to the Girls' Hostel ($\mathscr{B}_3$) be the medium/ average place for structuring it.*

# 7. Computational complexity

This section describes the computational complexity, i.e., the number of numerical computations conducted to find out the required result by the MCDM framework. The computational complexity has been calculated in numerous studies, including Mostafa [40] and Ghaleb et al. [41]. Total mathematical calculations operated to evaluate the required result are called computational complexity and are denoted by $T_c$. In this study, $e$ numbers of criteria with every criteria $\mu$ there are $m_\mu$ numbers of sub-criteria considered. Further, $b$ number of alternatives evaluated for best sites for girls hostel and there are $d'$ number of DMs gives opinions for numerical evaluation. All data is taken in linguistic terms and converted into crisp numbers in Table 1. The decision matrices are constructed by $b \times e$ order for criteria and $b \times m_\mu$ order for sub-criteria for the criteria $m_\mu$. Then, the computational complexity $(T_c)$ of this system is calculated by following steps to reach the solutions are as follows:

1. For entropy weighted method for criteria, the $d'$ DMs give $d'$ number of decision matrices of $b \times e$ order. To aggregate those $d'$ numbers of decision matrices into one decision matrix by $b \times e$ number of mathematical calculations. Then, the aggregated decision matrix is normalised by $b \times e + e$ numbers of numerical operations. Further, evaluated the logarithmic value of every coefficient by an additional $b \times e$ number of operations and determined their sum by $e$ number of operations. Then, calculate the entropy value and degree of dissatisfaction for every criteria by $e$ number and $e$ number of mathematical calculations, respectively. Finally, determine the criteria weight of every criteria using $e$ number of numerical operations. Therefore, total operations performed for the entropy weighted method for criteria are $b \times e + b \times e + e + b \times e + e + e + e + e = 3b \times e + 5e$.

2. For entropy weighted method for sub-criteria, the $d'$ DMs gives $d'$ number of decision matrices of $b \times m_\mu$ order for the criteria $\mu$. Then, similar to the entropy weighted method, there are $3b \times m_\mu + 5m_\mu$ mathematical operations conducted for the criteria $\mu$. Then there are total

$(3b \times m_1 + 5m_1) + (3b \times m_2 + 5m_2) + \cdots + (3b \times m_\mu + 5m_\mu) + \cdots + (3b \times m_e + 5m_e)$ numbers of numerical operation conducted for all the criteria.

3. To calculate the global weights of the sub-criteria, there are $m_1 + m_2 + \cdots + m_\mu + \cdots + m_e$ number of mathematical operations performed.

4. For the WASPAS ranking method, aggregated decision matrix and weights are calculated in previous sections. Further, the weighted sum and weighted product models were calculated using $2b \times (e + \sum_{\mu=1}^{e} m_\mu)$ numerical operations. Then, the sum of the weighted sum and weighted product is determined by $2b$ mathematical operations. Additionally, the optimal value is calculated by $b$ operations and the rank of the alternatives is determined by $b$ number of mathematical calculations. The total number of numerical operations conducted is $2b \times (e + \sum_{\mu=1}^{e} m_\mu) + 2b + b + b = 2b \times (e + \sum_{\mu=1}^{e} m_\mu) + 4b$.

This study considered, $e = 5$ number of criteria and $m_\mu = 2, 2, 2, 2, 3$ numbers of sub-criteria for the criteria $m_\mu$ where $\mu = 1, 2, \ldots, 5$. Also, $b = 3$ number of alternatives and $d' = 2$ number of decision makers (DMs) are taken for the data collection process. Then the computational complexity or time complexity $(T_c)$ is

- For the entropy weighted method for criteria, the number of calculations conducted are $3 \times 3 \times 5 + 5 \times 5 = 70$.
- For entropy weighted method for sub-criteria, the number of calculations conducted are $(3 \times 3 \times 2 + 5 \times 2) + (3 \times 3 \times 2 + 5 \times 2) + (3 \times 3 \times 2 + 5 \times 2) + (3 \times 3 \times 2 + 5 \times 2) + (3 \times 3 \times 3 + 5 \times 3) = 154$.
- For calculated global weights, the number of calculations conducted are $2 + 2 + 2 + 2 + 3 = 11$.
- For the WASPAS ranking method, the number of calculations conducted are $2 \times 3 \times (5 + 11) + 4 \times 3 = 108$.

The computational complexity or time complexity $(T_c)$ is $70 + 154 + 11 + 108 = 343$.

# 8. Sensitivity analysis

In this section, we describe the analysis of the sensitivity of this study. Four cases are considered on sensitivity analysis, based on the WASPAS [7] based decision based MCDM process.

## *8.1 Case 1: Interchange the criteria and sub-criteria weights of the criteria Security and protection ($\mathscr{E}_1$) and Health and Safety ($\mathscr{E}_4$)*

By analysing this case, we interchange the weights of criteria and it's sub-criteria of Security and protection ($\mathscr{E}_1$) and Health and Safety ($\mathscr{E}_4$). Actually, these two criteria are most significant criteria for the site selection problem of girls' hostels on a university campus. For that reason, these two factors are exchanged and it is found that Site 2: North-East Corner($\mathscr{B}_2$) is most suitable place for this and this is done by the WASPAS method.

**Remark 6.** *We notice that, $\mathscr{B}_2$ holds Rank 1 and $\mathscr{B}_1$ holds Rank 3, it is shown in Table 11. Therefore, Figure 8 explains this case more easily.*

### 8.2 Case2: Remove the criteria and associated sub-criteria of Proximity to Academic Buildings ($\mathscr{E}_2$)

In this case, to compute the sensitivity analysis of this site selection problem, we remove the factor and sub-factor of proximity to academic buildings ($\mathscr{E}_2$). Then, considering 2Dms' perspective and considering the rest categories, we show that, Site 2: North-East Corner($\mathscr{B}_2$) is the best place for this problem and ranking result is same as our main model.

**Remark 7.** *Here, $\mathscr{B}_2$, $\mathscr{B}_3$, $\mathscr{B}_1$ hold Rank 1,2 and 3 respectively, this is shown in Table 11. And, Figure 8 describes this case more clearly.*

### 8.3 Case 3: Remove the criteria and associated sub-criteria of Accessibility ($\mathscr{E}_3$)

We execute this case without the factor and sub-factor of $\mathscr{E}_3$, i.e., accessibility. So, the two DMs give their decision by evaluating the remaining categories. Here, Site 3: Adjacent to Girls' Hostel ($\mathscr{B}_3$) is the best and Site 1: South-West Corner ($\mathscr{B}_1$) is the worst place for this problem.

**Remark 8.** *$\mathscr{B}_3$, $\mathscr{B}_2$, $\mathscr{B}_1$ grab the Rank 1,2 and 3 separately in Table 11. And, Figure 8 interprets this case for more clear visualization.*

### 8.4 Case 4: Remove two criteria with their associated sub-criteria of Accessibility ($\mathscr{E}_3$) and Environmental Factors ($\mathscr{E}_5$)

We already notice that accessibility ($\mathscr{E}_3$) and environmental factors ($\mathscr{E}_5$) are the less important criteria in this site selection problem. So, we omit these two factors in this case. After evaluation, it is noticed that Site 3: Adjacent to Girls' Hostel ($\mathscr{B}_3$) is the ideal location for constructing a girls' hostel and it's not so much different from the main model.

**Remark 9.** *In this case, $\mathscr{B}_3$, $\mathscr{B}_2$, $\mathscr{B}_1$ occupy the Rank 1,2 and 3 individually in Table 11 and Figure 8 explains this.*

**Table 11**
Ranking of the alternatives by different sensitivity analysis cases

| Alternative | Case 1 | Case 2 | Case 3 | Case 4 | Main Model |
|---|---|---|---|---|---|
| Site 1: South-West Corner ($\mathscr{B}_1$) | 3 | 3 | 3 | 3 | 3 |
| Site 2: North- East Corner ($\mathscr{B}_2$) | 1 | 1 | 2 | 2 | 1 |
| Site 3: Adjacent to Girls' Hostel ($\mathscr{B}_3$) | 2 | 2 | 1 | 1 | 2 |

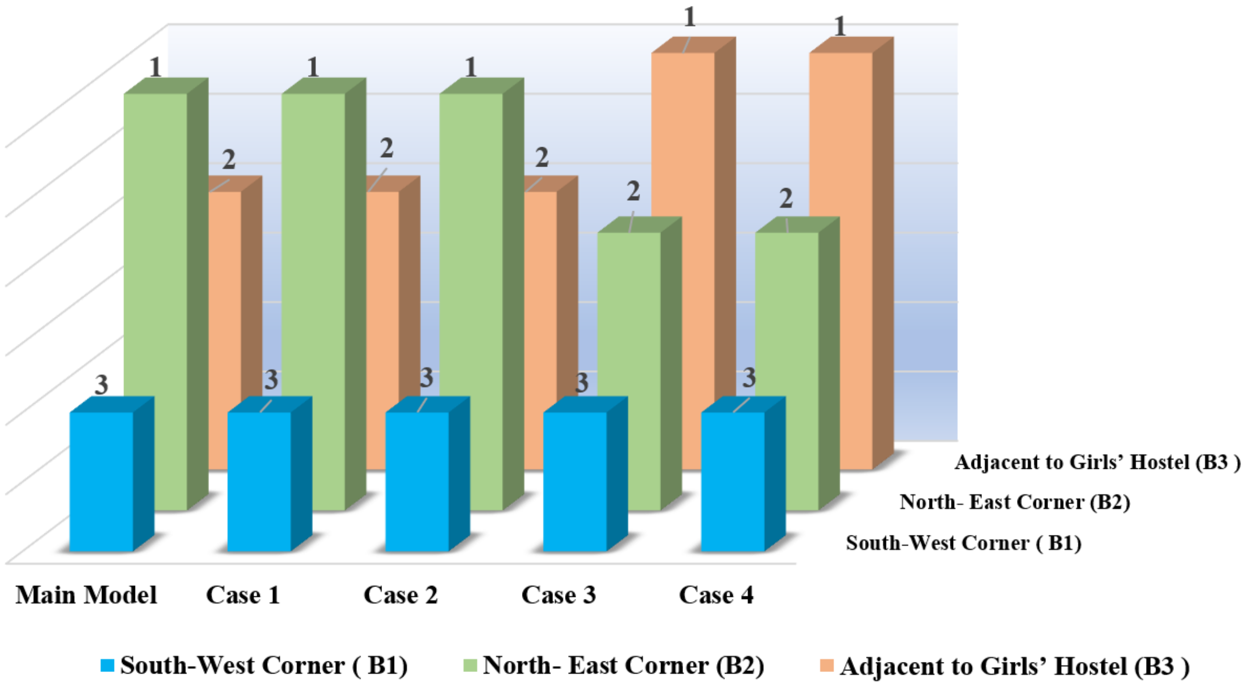


**Fig. 8.** Sensitivity analysis in different cases

## 9. Managerial insights, conclusions and future research scope

When considering an ideal location for a girls' hostel/ residence on the property of an academic institute, managerial skills should focus on main factors such as safety, accessibility, and student well-being. To provide a comfortable and safe living atmosphere, give importance to the strong security infrastructure added areas, such as, surveillance systems with campus security. The location should be placed for suitable access to academic buildings, dining amenities, hospitals and many healthcare facilities. It can diminish travel time and enhance the comfort for students. Meanwhile, choose the environmental aspects such as noise levels and natural sunlight, which contribute to a favorable environment for studying and relaxation. By identifying these objects, managers can create a supportive, protective and secure residential space that indorses institutional academic victory and student gratification.

In conclusion, choosing a suitable site/place for a girls' hostel on a university campus is vital for generating and ensuring proper security, academic facilities and a cosy living orbit. A well-chosen spot boosts the entire student experience, enhances academic success, and expands the well-being of its residents. It is very important in the overall development of a university. Furthermore, careful consideration and planning in site selection for girls' hostel are crucial for delivering a supportive and perfect living space. By giving secure and convenient accommodations, the hostel encourages more women to pursue higher studies and most importantly, it contributes to gender equality on campus. As a result of this, it increases the institution's reputation for inclusivity and diversity.

This site selection study has some limitations and it's an extension of future research work as follows:

1. In this paper, we consider five different criteria and each criteria of the first four has two several sub-criteria and the fifth criteria has three sub-criteria. In future, we can choose many more criteria and sub-criteria for this MCDM model formulation.

2. In future works, we can decide on other different sites/locations as alternatives were taken for computation and different sites in the university shall be considered. To ensure that the results are more accurate, we may extend our giving data set.

3. To determine the criteria weight and rank the alternatives, many other MCDM procedures can be used.

4. For the proposed model's sensitivity analysis, more cases may be taken into consideration.

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**Conflicts of Interest**

The authors declare that they have no known conflicts of interest or personal relationships that could have appeared to influence the work reported in this paper. There are no conflicts of interest between authors.

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