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Emergency camps design using analytical hierarchy process to promote the response plan for the natural disasters

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ABSTRACT

The Increase in natural, unpredictable events these days require a rapid action to mitigate ensuing damage. Emergency architecture is the immediate answer to sudden humanitarian needs. Referring to disaster management phases, architectural design considerations should enhance these phases and prioritizing implementation considerations. To address these challenges, disaster management principles and phases were discussed, and urban planning & shelter design considerations for emergency camps were classified into four principles. These principles include site selection, infrastructure, camps zoning, and shelter design principles, which have a set of factors. These principles and factors are ranked according to their importance from (12) experts opinions and by using the analytical hierarchy process (AHP) as an analysis tool. Then, the study examined the effectiveness of the AHP model by applying it to four emergency camps (previous experiences). Finally, an emergency camp was proposed based on the expert's evaluation and the lessons learned from the previous experiences.

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KEYWORDS
Emergency camp urban design; analytical analysis-(AHP); disaster management; safe and healthy

Introduction

Recently, many countries in extremely different regions suffered from the up growing of disasters especially, natural disasters. which have caused tremendous assets and life losses (Bahinipati, Patnaik, & Viswanathan, 2015). In 2021, climate disaster events reached about 18 in the United States (Smith et al., 2020), including two floods, ten severe storms, and four tropical cyclones that caused about 538 deaths. In addition to losses of about $1 billion per event. Europe and many Arab countries also suffered from bad weather events like unprecedented rains, 'floods of death' in Belgium, Germany, Netherlands, and Switzerland claiming many lives (about 150–170 deaths or losses, sinking of cities near river banks). Heavy rains were also recorded in northern Turkey and floods in India, Nepal, and Oman.

At these events, authorities urged thousands of coastal residents to leave their homes, go to emergency shelters, and prepare to cope. Many stakeholders contribute to this field, especially the UNHCR, whether with financial, psychological, or social support.

These facts represent a burden on governments. The omission of adequate decision-making causes the emergence of many risks and security, health, and environmental problems (Anderson, 2003). Therefore, the good design for emergency camps is one of the most important issues at present. Specialists have set standards for disaster management phases (Battistella & Buonocore, 2015). These phases must be implemented within clear strategies. This can be achieved by studying and analyzing urban planning & shelter design considerations for the displaced and using accurate analysis tools help decision-makers to complete the design process successfully.

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Literature review

Literature gaps and research contributions

Most previous studies discussed refugee camps and their planning considerations, with no specific attention to emergency camps. There is a large difference between them, where emergency camps are considered temporary residence communities, designed not for longtime accommodation. So, it's getting mandatory to discuss this type of camp, especially at a time that coincides with the increase in the number of natural disasters in many regions. A literature review starts with disaster definition and classification, the general scope of the disaster management plan, and the role of an emergency camp in this plan was also reviewed. In addition, design considerations for emergency camps including urban planning & shelter design have been discussed. A review of the Analytical Hierarchy Process (AHP) was presented as an analysis chosen tool.

Disaster definition and classification

Disasters can be defined as any event, human-made or natural, sudden or progressive, causing widespread human material or environmental losses, which exceed the ability of the affected community to cope using its own resources (Shen, Zhou, Wu, & Cai, 2018). Natural disasters include climatic and geological disasters, and cosmic, and biological disasters (Amara & Nordell, 2017). The first type is the most common and frequent one includes earthquakes, volcanoes, floods, hurricanes, storms, fires, and others. Biological disasters (Wirasinghe, Caldera, Seneviratne, & Ruwanpura, 2013) include epidemics and agricultural pests. While, cosmic disasters (Kumar, 2020) comprise the falling of celestial bodies or exceeding the limits of natural radiation that come from radioactive materials found in the surroundings. All of them cause severe damage to lives and property and significantly affect the economy of the afflicted areas. Individuals may contribute to increasing the proportion of these losses by neglecting appropriate preventative actions (Markhvida, Walsh, Hallegatte, & Baker, 2019).

The emergency camp role in the success of the disaster management plan

Natural disasters are considered one of the most frequent disasters in recent times (Abiodun, Odunayo, Ayub, & Kumari, 2021). It can be predicted with the help of the local and international authorities which relies on satellite images and aerial surveys to monitor various natural phenomena. It helps reduce disaster risks by giving the needed data to provide early warning and respond to emergencies (Abulnour, 2013). This anticipation process gives the opportunity to prepare a suitable action plan. This action plan is called the 'Disaster Management plan' (Karim, 2021). It is defined as the process of managing resources and arrangement of responsibilities to deal with the crisis at the humanitarian and executive levels (Barua, Mitra, & Eslamian, 2021). In fact, providing safe and healthy emergency camps in the response plan could mitigate the effects of the disaster, and support the transition from the response phase to the recovery phase with a minimum loss of lives as illustrated in (Figure 1), (Juni, Noor, & Arifah, 2019). More specifically, safe and healthy camps play a critical role in the *Scenario-Based Response Plan* for the natural disasters (DMS-Ministry of Home Affairs of Nepal, 2011). Where it was designed based on a group of engines that were classified into before and after disaster occurrence, each engine has a set of affecting drivers. The emergency camp is considered an effective driver, that could lead to a successful chain starting from mitigation and ending with successful recovery as shown in (Figure 2), (IOM, 2020).

Design considerations for emergency camps: urban planning & shelter design

Generally, emergency camps and shelter architectural design considerations are intended to save lives, reduce costs by minimizing the need for later corrective measures, ensuring the most efficient use of land, and providing services. Converting camps into settlements integrated with the host community is also a psychological need.

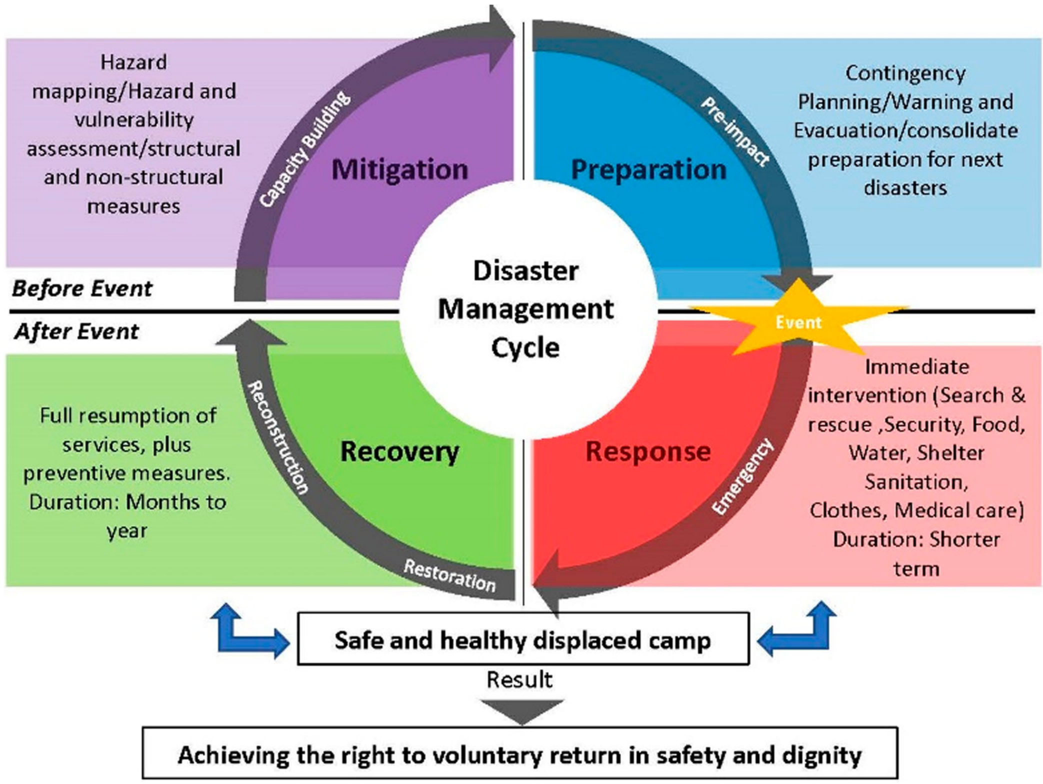


Figure 1. Disaster Management Plan.

Urban planning considerations

Good site selection and planning of emergency camps for displaced affected by natural disasters have a significant impact on the success of the disaster management plan, as it is one of the main pillars in the response and recovery phases. Its successful practical implementation provides the sufferers with a safe and rapid environment that meets basic personal needs, and reduces the possibility of occurrence of any incoming risks such as epidemics, diseases, famines, etc. Experts contributed to adopt these considerations by getting lessons from personal needs and previous accidents. They help in obtaining a planning model, other than spontaneously settling for the displaced. Urban planning considerations can be categorized into three principles, site selection (Huynh, 2015; Ma, Xu, Qin, & Zhao, 2019; UNHCR, 2007), infrastructure (Ahmed, Firoze, & Rahman, 2020; Pascucci, 2019), and camps zoning (Pascucci, 2021) principles, and a set of included factors which can be summarized as illustrated in (Table 1), (Table 2), and (Table 3).

Shelter design considerations

The right to adequate housing is one of the main human rights. Adequacy includes providing security of tenure, availability of services, materials, facilities, and infrastructure, affordability, habitability, accessibility, location, and cultural adequacy. Government authorities must be a part of getting these rights. In this vein, the shelter design factors associated with this principle include the following as illustrated in (Table 4), (European Commission, 2017; Hasgul & Ozsoy, 2017; UNHCR, 2007).

Analytical hierarchy process (AHP)

AHP is a type of analytical analysis explained and developed by Saaty in 1980. It's an effective tool for decision making in multi criteria situations, that need an evaluation of various elements according to

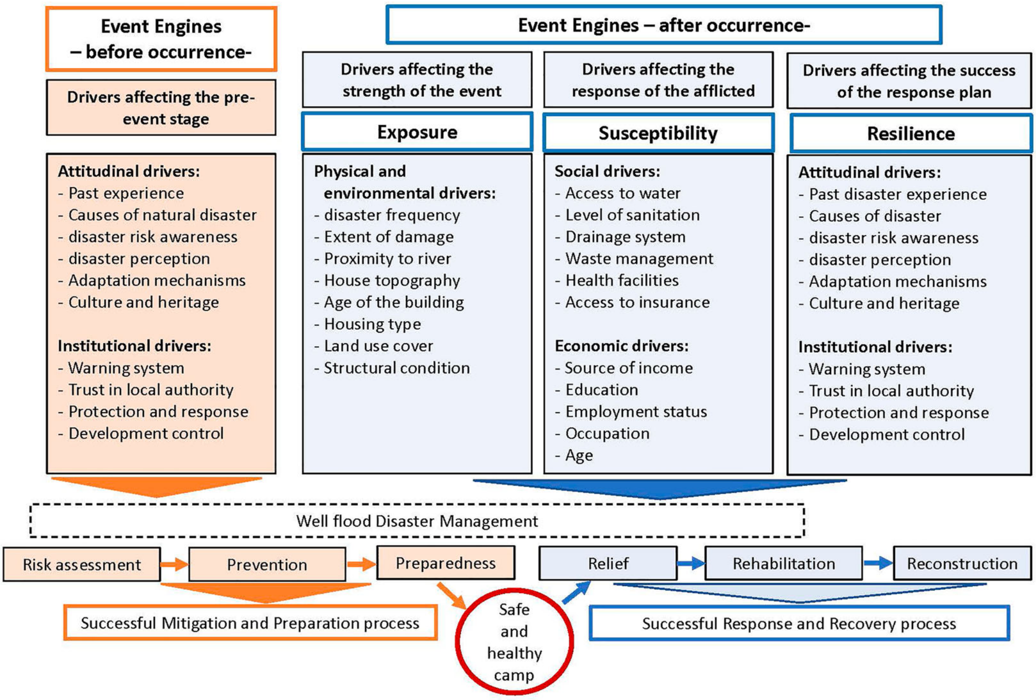


Figure 2. A Scenario Based Response Plan for the natural disasters.

each other using pairwise comparison (Saaty, 1980). This technique is based on experts' opinion, and it deals with a combination of qualitative and quantitative data sources (Saaty & Vargas, 2012). The AHP method is suitable to be adopted with a small size sample, and it could provide a consistent result (Cao et al., 2016). The structure of the AHP evaluation model could support the decision-makers to understand the context of the problem carefully (Taheri, Gutiérrez, Mohseni, Raeisi, & Taheri, 2015). While the judgment of the decision makers is based on the state of mind, feeling situation, learning, and personal experience (Tierno, Puig, Vera, & Verdu, 2013). The AHP method plays a critical role to minimize uncertainty and to quantify the sensitivity of the experts' opinions (Darko et al., 2019). In another hand, the AHP method was involved in the analysis of urban studies. For instance, solid waste management (Abaa, Noor, Yusuf, Din, & Abu Hassan, 2013), flood risk evaluation (Ekmekcioglu, Koc, & Ozger, 2021), industrial site selection (Reisi, Afzali, & Aye, 2018), and land suitability analysis of urban growth (Aburas, Abdullah, Ramli, & Asha'ari, 2017). Therefore, the authors considered AHP as the adequate tool for the analysis of this study.

Materials and methods

In the first section, desc-based research, and by using the inductive method, the study discusses the definition of disasters and their characteristics. As well as the definition of disaster management and its main phases, until a *Scenario Based Response Plans (SBRP)* is designed as a map for flood disaster response plan. Then urban planning & shelter design principles for emergency camps derived from the 'Handbook for Emergences' issued by the United Nations and other references, were discussed.

In the second section, from the literature review, (Four) main principles and (Nineteen) factors have been categorized, and by using the Analytical Hierarchy Process (AHP), these factors were ranked according to their importance and experts' evaluation as followed:

Table 1. Site selection principle.

(1)	Site selection factors	The most effective requirements
(1.1)	Land use and land rights (Broeck, 2019; Çetinkaya et al., 2016)	The land must be: • Permitted and licensed by the government. • Having rights to use the land resources. • far away from tourist areas.
(1.2)	Size of camp site and population (Younes, Kotb, Abu Ghazala, & Elkadeem, 2022)	Camp size: • The minimum standards 45 m2 / family (with garden). • The minimum standards 30 m2 / family (without garden). • Large camps of over 20,000 people should be avoided.
(1.3)	Security and Protection (UNHCR, 2007)	The site must be: • Located at a reasonable distance from international borders, sensitive areas. • Far from ecologically or environmentally protected areas. • away from flood, earth quick or landslide hazard zones
(1.4)	Accessibility (Çetinkaya et al., 2016)	The site must be: • Close to sources of necessary living supplies. • Available Roads with short access must be considered. • near to airports or seaports to facilitate international relief.
(1.5)	Water source (Jachimowski, 2017)	The site must have an adequate source of water.
(1.6)	Topography, Drainage and Soil Conditions (UNHCR, 2007) (Sabzevari, Mottaki, Hassani, Zandiyeh, & Aslani, 2022)	The site must: • Be located above flood-prone areas, with weak slope (2–4%). • Not be rocky soil, to facilitate rapid absorption of surface water). • Be easy to establish suitable sewer system. The groundwater level should not be lower than 3 m below the surface.
(1.7)	Climatic Conditions, and Local Health (Younes et al., 2022)	Sites must: • Have reasonable climatic conditions around the year. • Be far from environmental health hazards. • Have distance from high-pressure power tower not less than 100 m.
(1.8)	Vegetation (UNHCR, 2007)	Sites must have a good green ground cover.

Table 2. Infrastructure principle.

(2)	Infrastructure factors	The most effective requirements
(2.1)	Sanitation (Hsan, Naher, Griffiths, Shamol, & Rahman, 2019)	Latrines must be: • Provided for each family. • Located on the family plot, far from the shelter.
(2.2)	Water Supply (Younes et al., 2022)	• Distance between shelter and water distribution point shouldn't be more than 100 m. • Minimum water distribution points are preferable.
(2.3)	Roads (UNHCR, 2007)	Roads should: • Follow the contour lines. • Providing clearance distance between 5–7 m.
(2.4)	Fire protection (UNHCR, 2007)	• Site should have a firebreak of 30 m wide every 300 m between blocks.

- Structure of the evaluation model: Defining the (objective) of the analysis (the main goal of the study) as a first level, determining the *principles* as a (criterion) to achieve the goal as a second level, considering all suggested *factors* as an (alternatives) as a third level. Therefore, the AHP hierarchy diagram was attained as illustrated in (Figure 3) and (Figure 4).

Table 3. Camps zoning principle.

(3)	Camps zoning factors	The most effective requirements
(3.1)	Surrounding natural and infrastructure features (UNHCR, 2007)	• Must be explored and combined.
(3.2)	Zoning components (Hasgul & Ozsoy, 2017)	• Locating all services, utilities in the center of the camp or near the entrance. • Social, recreation, educational areas with bathing and washing areas should be decentralized.
(3.3)	Modular planning (Dalal, Darweesh, Misselwitz, & Steigemann, 2018)	Planning should: • Encourage clustered living arrangements. • Avoid linear or grid layout.

Table 4. Shelter design principle.

(4)	Shelter Design factors	The most effective design requirements
(4.1)	Design Concept (European Commission, 2017)	The shelter must: • provide protection, dignity, and security • Reflects needs and requirements of users traditional and social values • provide space to live and store belongings. • Provide privacy and emotional security. • Provide modification by the occupants. • be culturally and socially appropriate in terms of orientation, design details The shelter area must be: • 3.5 m^2/person (warm climates). • 4.5 m^2–5.5 m^2/person (cold climates) • Facilitate different communication options between users
(4.2)	Construction factors (Bashawri, Garrity, & Moodley, 2014; Ngo & Hansen, 2013)	Shelter construction frame should be: • sustainable and renewable supply sources. • quick to install & disassemble. • cost effective over time. • suitable for different seasons. • energy saving through insulation. • stable and has a life span. • support livelihood • designed with noise insulation, temperature, and weather insulation • Roofs and walls should be covered by UV reflected materials. • Shelter openings must be safe & well sealed.
(4.3)	Environmental issues (Bashawri et al., 2014; UNHCR, 2007)	• fits with most climatic conditions • made of materials that can be recycled, upgraded, and reused • promoting personal and environmental hygiene at infrastructure and facilities • The shelter must have comfortable temperature (15–19°C). • must be shaded with good ventilation • It's best to design shelters so they can be winterized
(4.4)	Shelter operation management (UNHCR, 2007)	• Shelter operational fuel should come from immediate surroundings. • There is a must for alternative outer energy resources.

- Pair-wise comparison matrices: Creating the matrices, all constructed matrices are square reciprocal matrices $A = [a_{ij}]$ of order ***n*** which the importance of element C_i with respect to C_j is determined by the element a_{ij}, where $a_{ij} = 1/a_{ij}$ for $i \neq j$ and $a_{ii} = 1$ for all of i values, where i is number of raw and j is the number of columns of any element of the matrix. Criterion matrix [P1, P2, P3, P4] and, Alternative matrices [P11, P12, … ., P18], [P21, P22, P23, P24], [P31, P32, P33], [P41, P42, P43, P44] were created.
- Experts interview: the matrices were filled by **(12)** experts including (3) academic stuff in urban planning, (3) from the Ministry of Interior – Civil Defense, (3) Non-Governmental Organizations

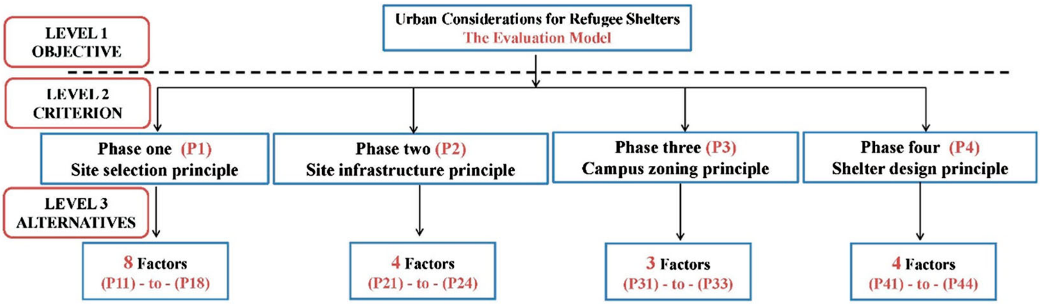


Figure 3. The hierarchy model general scope.

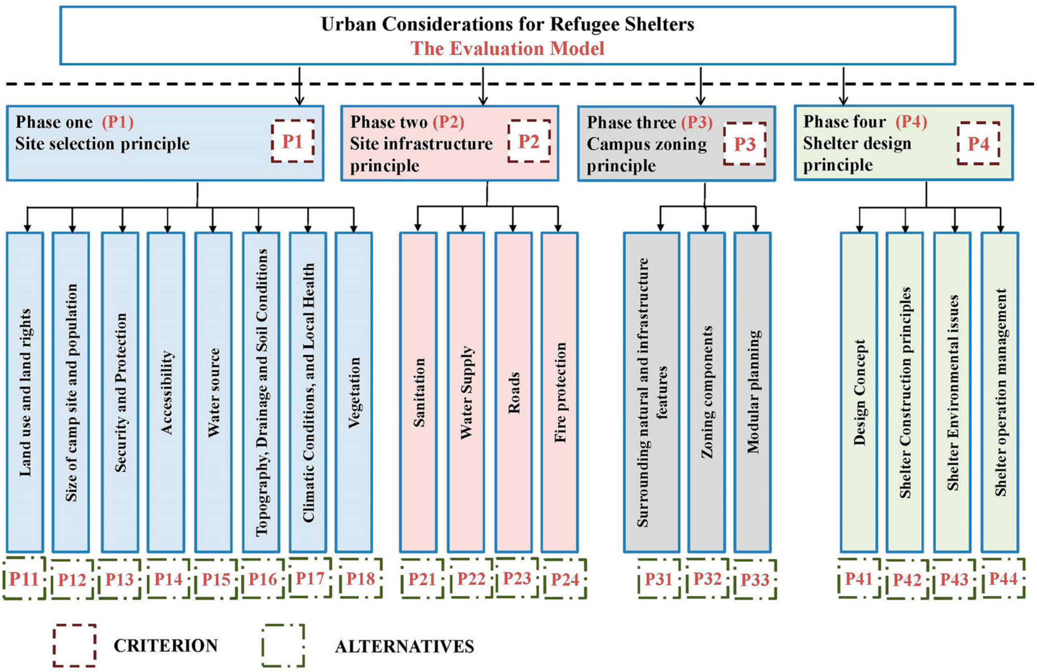


Figure 4. The hierarchy model structure.

(NGOs), and last (3) are considered environmental planning professionals. The pair-wise comparison to determine the relative importance between two compared elements on a scale from 1 to 9 was implemented as shown in (Table 5).

- Calculating the relative weight for the criterion and checking consistency for the matrix: Relative weights of each element is calculated by calculating the Eigen Vector (**ω**) that equal **[***Geometric Mean /Σ (Geometric Means)***].** To check the consistency ratio (CR), consistency Index (CI) was calculated using Equation (1), and then (CR) was calculated using Equation (2) and (Table 6), (Table 7) and Appendix 1. It shouldn't exceed 0.1, Thus, the judgements are accepted, and the matrix is valid. The consistency index (CI) using Equation (1) = **0.071,** the consistency index (CR) using Equation (2) = **0.08**. *C.R. < 0.1 then the criterion matrix is consistent*

$$\mathrm{CI} = \frac{\lambda_{\max} - n}{n - 1} \tag{1}$$

Table 5. Pair-wise comparison matrix for urban planning & shelter design principles (the criterion).

	P1	P2	P3	P4
P1	1.000	1.000	2.000	4.000
P2	1.000	1.000	6.000	3.000
P3	0.500	0.167	1.000	2.000
P4	0.250	0.333	0.500	1.000

Table 6. Eigen Vector Calculation (relative weights for the criterion).

Code	Geometric Mean (n^{th} root of Product) (P1*P2*P3*P4) ^ (1/4)	Eigen Vector (ω) Geometric Mean / Σ (Geometric Means)	(Aω) Matrix A * Eigen Vector	($\lambda_{max)}$ = Aω/ω
P1	1.681792831	**0.348**	1.413	4.059
P2	2.059767144	**0.426**	1.848	4.336
P3	0.638943104	**0.132**	0.564	4.268
P4	0.451801002	**0.093**	0.389	4.157
SUM	**4.83230408**	**1.000**		$\boldsymbol{\lambda_{max}}$ **= 4.204 (Average)**

Table 7. Average random consistency index.

n	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

where, CI is the consistency index, n is the order of the pair-wise comparison matrix and λ_{max} = (multiplying matrix A with the Eigen Vector**)**.

$$CR = \frac{CI}{RI} \tag{2}$$

where, CR is the consistency ratio, CI is the consistency index and RI is the random consistency index obtained from (Table 7).

- Matrices are repeated for each factor (alternatives) for the four main principles (criterions) (site selection, site infrastructure, camps zoning, and shelter design), **(ω)** for each is calculated and checking for the matrices consistency by calculating the (CR) were implemented as showed in (Table 8–11).
- Calculating global weight: to obtain ranking for all the factors (the Nineteen factors). The relative weight for each criterion is multiplied by the relative weight for each alternative, then global rank can be, determined according to the obtained global weight.

In the third section, after ranking the urban planning & shelter design factors, the AHP analytical tool should be examined according to its effectiveness and efficiency in the field of displaced urban

Table 8. Pair-wise comparison matrix for site selection factors.

	P11	P12	P13	P14	P15	P16	P17	P18
P11	1.000	2.000	3.000	4.000	5.000	2.000	4.000	6.000
P12	0.500	1.000	4.000	2.000	2.000	3.000	2.000	3.000
P13	0.333	0.250	1.000	3.000	1.000	1.000	4.000	4.000
P14	0.250	0.500	0.333	1.000	3.000	3.000	3.000	5.000
P15	0.200	0.500	1.000	0.333	1.000	2.000	1.000	3.000
P16	0.500	0.333	0.333	0.333	0.500	1.000	2.000	1.000
P17	0.250	0.500	0.500	0.500	1.000	0.500	1.000	2.000
P18	0.167	0.333	0.250	0.200	0.333	1.000	0.500	1.000

(CR) = 0.0931.
C.R. < 0.1 then the criterion matrix is consistent.

Table 9. Pair-wise comparison matrix for camps' zoning factors.

	P21	P22	P23	P24
P21	1.000	2.000	3.000	5.000
P22	0.500	1.000	3.000	7.000
P23	0.333	0.333	1.000	4.000
P24	0.200	0.143	0.250	1.000

(*CR*) = 0.0633.
C.R. < 0.1** then **the criterion matrix is consistent.

Table 10. Pair-wise comparison matrix for camps' infrastructure factors.

	P31	P32	P33
P31	1.000	4.000	5.000
P32	0.250	1.000	3.000
P33	0.200	0.333	1.000

(*CR*) = 0.0824.
C.R. < 0.1 then the criterion matrix is consistent.

Table 11. Pair-wise comparison matrix for shelter design factors.

	P41	P42	P43	P44
P41	1.000	3.000	1.000	5.000
P42	0.333	1.000	1.000	3.000
P43	1.000	1.000	1.000	2.000
P44	0.200	0.333	0.500	1.000

(*CR*) = 0.0688.
C.R. < 0.1 then the criterion matrix is consistent.

planning. This is achieved by applying it to four previous experiences in emergency camps and measuring the percentage of achievement of the four main principles and their factors.

Results

Regarding the statistical analysis of the AHP model to evaluate the (Four) principles and the (Nineteen) factors of the urban planning & shelter design considerations for displaced, and after the verification of the matrices via (C.R) calculation. Where all the (C.R) values for the matrices were < 0.1, so, it was consistent. The relative weight of the design principles (criterion), the relative weight, and the global weight of factors (alternatives) were calculated as shown in (Table 12) and (Table 13).

In the same context, and from (Table 12) for the criterion evaluation (the Four principles). The infrastructure phase (P2) was ranked the highest weight (0.426). Consequently, it was the most important phase. The site selection phase (P1) was ranked at the second in hierarchy (0.348). Phase (P3) was the third, and phase (P4) was the fourth in hierarchy. Additionally, (Table 13) clarified that the land use and land rights (P11), water supply (P21), surround natural and infrastructure features (P31), and design concept (P41) were ranked the priority within the principles

Table 12. Weight of urban planning & shelter design principles (LEVEL2- CRITERION).

Code	Phase	W/Level 2
Phase 1 (P1)	Site selection	0.348
Phase 2 (P2)	Infrastructure	0.426
Phase 3 (P3)	Campus zoning	0.132
Phase 4 (P4)	Shelter design	0.093

Source: by the author.

Table 13. Relative and global weight priority (LEVEL3- ALTERNATIVES).

Code	Factors	W/L3	R. RANK	W/L1	G. RANK
Site selection factors					
P11	Land use and land rights	**0.304**	**1**	**0.1058**	**3**
P12	Size of camp site and population	**0.192**	**2**	**0.0668**	**5**
P13	Security and Protection	**0.123**	**4**	**0.0428**	**8**
P14	Water Source	**0.128**	**3**	**0.0445**	**7**
P15	Accessibility	**0.084**	**5**	**0.0292**	**11**
P16	Topography, Drainage and Soil Conditions	**0.063**	**7**	**0.0219**	**15**
P17	Climatic Conditions, and Local Health	**0.067**	**6**	**0.0233**	**14**
P18	Vegetation	**0.039**	**8**	**0.0136**	**17**
Site infrastructure factors					
P21	Water Supply	**0.446**	**1**	**0.1900**	**1**
P22	Sanitation	**0.343**	**2**	**0.1461**	**2**
P23	Fire protection	**0.156**	**3**	**0.0665**	**6**
P24	Roads	**0.055**	**4**	**0.0234**	**13**
Campus zoning factors					
P31	Surrounding natural and infrastructure features	**0.674**	**1**	**0.0890**	**4**
P32	Zoning components	**0.226**	**2**	**0.0298**	**10**
P33	Modular planning	**0.101**	**3**	**0.0133**	**18**
Shelter design factors					
P41	Design Concept	**0.429**	**1**	**0.0399**	**9**
P42	Shelter Environmental issues	**0.218**	**3**	**0.0203**	**16**
P43	Shelter Construction principles	**0.259**	**2**	**0.0241**	**12**
P44	Shelter operation management	**0.093**	**4**	**0.0086**	**19**

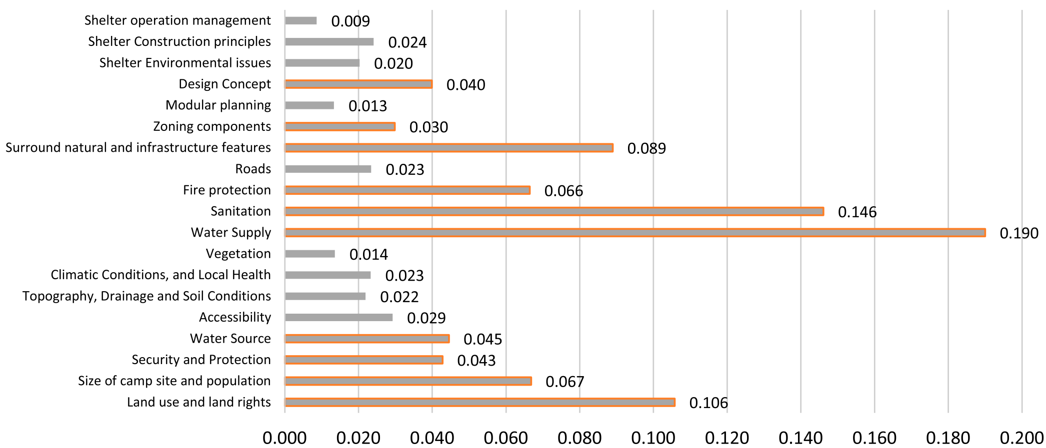


Figure 5. Factors global weights.

(P1, P2, P3, P4). whilst, and regarding the estimated global weights, the top ten factors, in order, were; water supply, sanitation, land use and land rights, surrounding natural and infrastructure features, size of campsite and population, fire protection, water source, security and protection, design concept, and zoning components as illustrated in (Figure 5.)

Discussion

As shown in (Table 12), the infrastructure phase (P2) was ranked the highest weight. *Three* factors as; water supply, sanitation, and fire protection under this phase were globally ranked among the top ten priorities. That reflects the experts' opinion on the importance of providing a healthy and safe environment for the displaced. In the same context, the site selection phase (P1) was ranked the second in importance. *Four* factors as; land use and land rights, size of campsite and population, water source, and security and protection under this phase were globally ranked among the top ten priorities. The experts' evaluation indicates the importance of providing a Permitted and licensed land by the government, achieving a balance between the site area and the expected number of the displaced to avoid spreading diseases and pandemics, and the site must have an adequate source of water, and the site must be located at a reasonable distance from international borders and sensitive areas. From this point of view, it can be noted that the experts' evaluation was concentrated on the site urban planning than the shelter design itself, where seven of the top ten sub-considerations were regarding site planning as discussed above.

Previous experience for emergency camps' design

From the AHP model evaluation, and the concluded weights for the principles and factors. This part of the study examined the effectiveness and efficiency of the AHP model by applying it to four emergency camps (previous experiences) in South Sudan, Ethiopia, and Southern Bangladesh. It was noted that most of the emergency camps were planned with a fixed grid design which makes it difficult to recognize and identify the places, and difficult for services entries. There is a central public area (communal area) for services gatherings in which communities' areas are distributed around, with a public water source (tank), separate isolated toilets for both sexes, and a source of energy. The evaluation of the four emergency camps was measured according to the relative weights for the alternatives concluded from the AHP analyses. Where it was considered that while the factors of the principles were achieved, it was given a complete relative weight. For each experience, the summation of all weights for each principle was multiplied by 100 to present it as a percentage. The results are summarized as shown in (Table 14), (Figure 6), and Appendix 2.

More specifically, in terms of evaluating models, Bangladesh camp recorded the highest score in all urban planning considerations, where the percent of achievement reached 89% in site selection issues, and 100% in camps zoning. In contrast, the percentage of interest in infrastructure principles increased to reach 90% in the South Sudan model. Other than that, they all have weak points in most remaining principles.

Emergency camp proposal

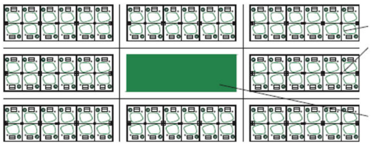
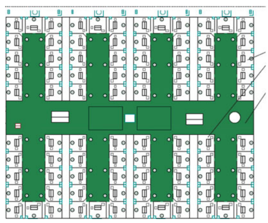
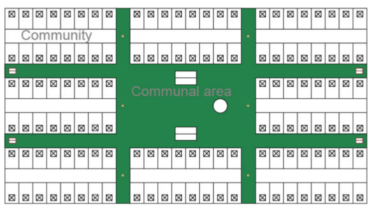
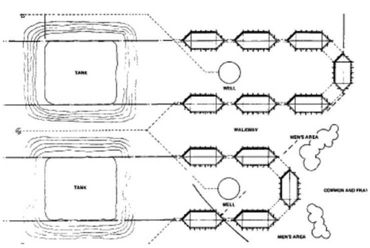
With regard to the evaluation of the AHP model for the emergency camps considerations by the experts, and the examined previous experiences. The study proposes an emergency camp urban model. The design is based on the smallest scale (4*9 m with an area of 36 m^2) for one family (5–6 people), 16 families generate one community as shown in (Figure 7(a)). Two models for assembling the shelters were created, the first consists of four shelters, and the second consists of two shelters, with a private latrine for each shelter. The shelter dimension is (3*6 m with an area of 18 m^2) as shown in (Figure 7(b)). The two models were gathered to make up one community as shown in (Figure 7(c)). A combination of two communities was arranged as illustrated in (Figure 7(d)). Sixteen communities create one block as shown in (Figure 7(e)), four blocks create one sector, and four sectors complete a camp with 20,000 people.

Furthermore, the camp must be provided with services and infrastructure, where, two water taps were placed inside each community, and two refuse drums were placed outside in the front of it. Additionally, each camp (20,000 people) must include one referral hospital, a market, and four distribution points.

In the light of the proposed model, the arrangement of the shelters can provide a safe, and healthy environment for each community, therefore for the camp. More specifically, the advantages of the proposed model can be summarized as:

- The design achieves UNHCR standards.

Table 14. Previous experience for emergency camps design (UNHCR, 2016).

Experience	Camp design			Description
South Sudan				This community was established according to movement of Nubian refugees because of instability in Southern Kordofan region and prospect of flooding. The design concept depends on the 'modular' zone- block- compound- plot.
Achievement of principles	Achieved	Partly achvieved	Not achieved	Design weak points
Site selection		64%		• Poor public health conditions
Site infrastructure	78.90%			• Vegetation areas are very small
Camp zoning	90%			• Lack of fire protection considerations
Shelter design			25.90%	• No paying attention to thermal comfort
Dollo Ado, Ethiopia				This community was structured for Somalian refugees who were forced to leave their country because of, 'the 2011 resurgent of conflict compounded by severe drought'. Its site was selected by Ethiopian government. The design concept based on 'mixed design settlement solution'.
Achievement of principles	Achieved	Partly achvieved	Not achieved	Design weak points
Site selection		50%		• Poor public health conditions
Site infrastructure			44.60%	• Vegetation areas are very small
Camp zoning	90%			• No paying attention to thermal comfort
Shelter design			25.90%	• Roads aren't clear, unpaved
Gambelia, Ethiopia				This community was structured to relocate the South Sudanese refugees because of rains and floods in 2014. The design concept depends on the conservation of 'natural environment'. It was designed into units/communities of 16 plots, average 8 units in each plot to make larger blocks.
Achievement of principles	Achieved	Partly achieved	Not achieved	Design weak points
Site selection	70.80%			• Poor public health conditions
Site infrastructure			44.60%	• Lack of fire protection considerations
Camp zoning			22.60%	• No paying attention to thermal comfort
Shelter design			25.90%	• Roads aren't clear, unpaved
				• Missing privacy, security, protection from out effect
Southern Bangladesh (Kennedy, 2008)				This community was established to displace people after rains and floods. The design depends on clusters, each cluster formed in U-shaped with closed end.
Achievement of considerations	Achieved	Partly achieved	Not achieved	Design weak points
Site selection	89.40%			• Absence of vegetation
Site infrastructure	78.90%			• No paying attention to thermal comfort
Camp zoning	100%			• Roads aren't clear, unpaved
Shelter design.	78.10%			

Note**:** Achieved: **>** 70% Partly achieved: from 70% to 50% Not achieved: <50%.

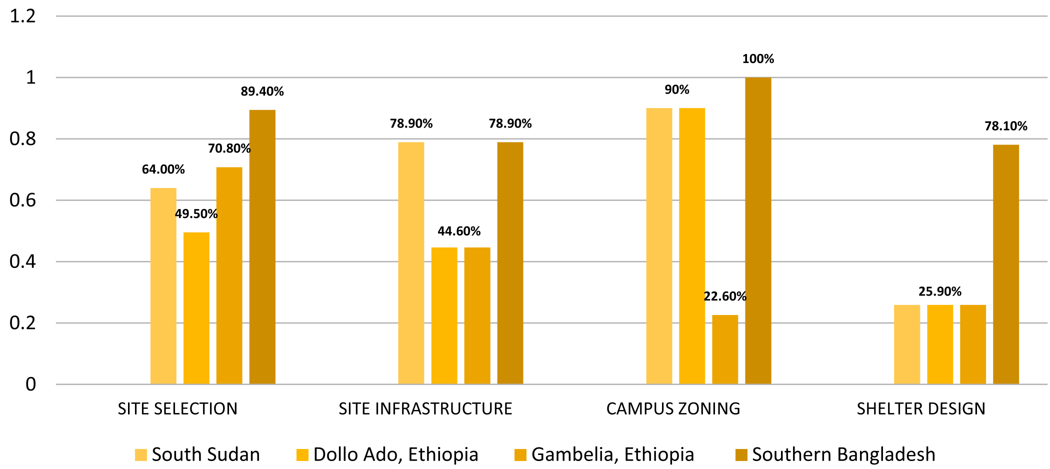


Figure 6. The rates of achieving the principles of previous experience for emergency camps' design.

- The arrangement of the shelters avoided the linear grade layout.
- The community urban design accomplishes a healthy environment where, the assembly of the models provides good air circulation.
- Availability to rearrange the models in the community according to the site circumstances.
- Easy and fast installation for the combined models.
- Each shelter has a private latrine, which provide privacy for each family.
- The combination of the latrines facilitates the maintenance and the sanitation.
- All the services (water taps, refuse drums) are located in or near each community.
- Each community has a good green ground cover.
- Safety and fire protection are achieved, where each community has a main entrance and two emergency exits, also, six fire hydrants were distributed around each block and connected with a water fire tank of 60 m^3.
- Secondary roads width 5 m, and main roads width 8 m.
- The designed models achieve the availability of the extension for the shelter.

Conclusion

A good design for the displaced camps is extremely important in the success of the management plan. The study classified the design considerations for the emergency camps into four main principles, including site selection, infrastructure, camps zoning, and shelter design principles. Nineteen factors associated with these principles were categorized. The Analytical Hierarchy Process (AHP) was applied. The results obtained by the model analysis illustrate that the infrastructure principle is the most important phase in camps' design. *Three* factors; water supply, sanitation, and fire protection under this phase were globally ranked among the top ten priorities. This finding reflects how the experts concentrated on providing healthy and safe displaced camps. In the same context, the global ranks of the other factors showed that the experts tended to provide a healthy and safe environment for the camps through successful urban planning design than the design of the shelter itself. In addition, four previous experiences for emergency camps design were examined. The result illustrates that there are common weak points in its designs, including the absence of vegetation, no paying attention to thermal comfort, and roads are unpaved. Finally, the study proposed an emergency camp based on the expert's opinion and the lessons learned from the previous experiences. This model achieves the UNHCR requirements, as well as accomplishes a safe and healthy environment for the displaced. Noteworthy,

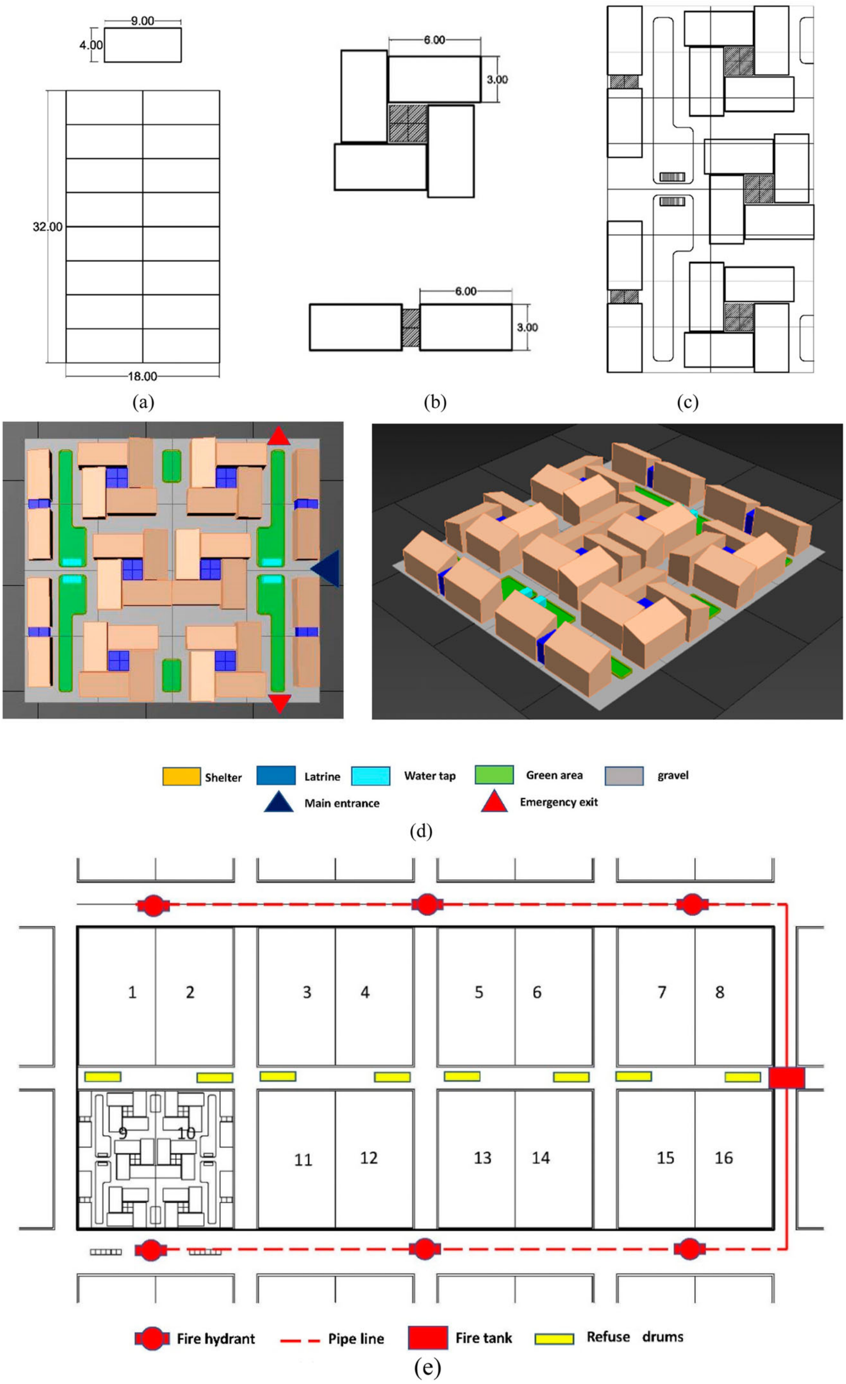


Figure 7. Emergency camp proposal.

The proposed community urban design, the shelter models, and the community grid can be adjusted according to the topographical nature of the site and the climate conditions.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Appendix 1

Eigen Vector Calculation for site selection factors (relative weights for the alternatives)

Code	Geometric Mean (n^{th} root of Product) (P11*P12*P13*P14* P15*P16*P17*P18) ^ (1/8)	Eigen Vector (ω) Geometric Mean / Σ (Geometric Means)	(Aω) Matrix A * Eigen Vector	(λ_{max}) = Aω/ω
P11	2.951568117	**0.304**	2.619	8.606
P12	1.861209718	**0.192**	1.699	8.854
P13	1.189207115	**0.123**	1.228	10.017
P14	1.240981524	**0.128**	1.180	9.220
P15	0.817765434	**0.084**	0.717	8.503
P16	0.607366424	**0.063**	0.578	9.224
P17	0.648419777	**0.067**	0.559	8.358
P18	0.382995156	**0.039**	0.335	8.473
SUM	**9.699513266**	**1.000**		**λ_{max} = 8.906 (Average)**

Eigen Vector Calculation for infrastructure factors (relative weights for the alternatives).

Code	Geometric Mean (n^{th} root of Product) (P21*P22*P23*P24) ^ (1/4)	Eigen Vector (ω) Geometric Mean / Σ (Geometric Means)	(Aω) Matrix A * Eigen Vector	(λ_{max}) = Aω/ω
P21	2.340347319	0.446	1.876	4.206
P22	1.800102872	0.343	1.421	4.141
P23	0.816496581	0.156	0.640	4.115
P24	0.290715368	0.055	0.232	4.197
SUM	5.247662141	1.000		λ_{max} = 4.165(Average)

Eigen Vector Calculation for campus zoning factors (relative weights for the alternatives).

Code	Geometric Mean (n^{th} root of Product) (P31*P32*P33) ^ (1/3)	Eigen Vector (ω) Geometric Mean / Σ (Geometric Means)	(Aω) Matrix A * Eigen Vector	(λ_{max}) = Aω/ω
P31	2.714417617	0.674	2.079	3.086
P32	0.908560296	0.226	0.696	3.086
P33	0.405480133	0.101	0.311	3.086
SUM	4.028458046	1.000		λ_{max} = 3.086(Average)

Eigen Vector Calculation for site selection factors (relative weights for the alternatives).

Code	Geometric Mean (n^{th} root of Product) (P41*P42*P43*P44) ^ (1/4)	Eigen Vector (ω) Geometric Mean / Σ (Geometric Means)	(Aω) Matrix A * Eigen Vector	(λ_{max}) = Aω/ω
P41	1.967989671	0.429	1.809	4.214
P42	1	0.218	0.900	4.127
P43	1.189207115	0.259	1.093	4.214
P44	0.427287006	0.093	0.381	4.093
SUM	4.584483793	1.000		λ_{max} = 4.162(Average)

Appendix 2

FACTORS OF FOUR MAIN PRINCIPLES			South Sudan		Dollo Ado, Ethiopia		Gambelia, Ethiopia		Southern Bangladesh	
SITE SELECTION FACTORS		W/L3	A/N	W	A/N	W	A/N	W	A/N	W
P11	Land use and land rights	0.304	A	0.304	A	0.304	A	0.304	A	0.304
P12	Size of camp site and population	0.192	N	0	N	0	A	0.192	A	0.192
P13	Security and Protection	0.123	A	0.123	N	0	N	0	A	0.123
P14	Water Source	0.128	A	0.128	A	0.128	A	0.128	A	0.128
P15	Accessibility	0.084	A	0.084	N	0	A	0.084	A	0.084
P16	Topography, Drainage and Soil Conditions	0.063	N	0	A	0.063	N	0	A	0.063
P17	Climatic Conditions, and Local Health	0.067	N	0	N	0	N	0	N	0
P18	Vegetation	0.039	N	0	N	0	N	0	N	0
Achievement percentage %			64.00%		49.50%		70.80%		89.40%	
SITE INFRASTRUCTURE FACTORS										
P21	Water Supply	0.446	A	0.446	A	0.446	A	0.446	A	0.446
P22	Sanitation	0.343	A	0.343	N	0	N	0	A	0.343
P23	Fire protection	0.156	N	0	N	0	N	0	N	0
P24	Roads	0.055	N	0	N	0	N	0	N	0
Achievement percentage %			78.90%		44.60%		44.60%		78.90%	
CAMPUS ZONING FACTORS										
P31	Surround natural and infrastructure features	0.674	A	0.674	A	0.674	N	0	A	0.674
P32	Zoning components	0.226	A	0.226	N	0.226	A	0.226	A	0.226
P33	Modular planning	0.101	N	0	N	0	N	0	A	0.101
Achievement percentage %			90%		90%		22.60%		100%	
SHELTER DESIGN FACTORS										
P41	Design Concept	0.429	N	0	N	0	N	0	A	0.429
P42	Shelter Environmental issues	0.218	N	0	N	0	N	0	N	0
P43	Shelter Construction principles	0.259	A	0.259	A	0.259	A	0.259	A	0.259
P44	Shelter operation management	0.093	N	0	N	0	N	0	A	0.093
Achievement percentage %			25.90%		25.90%		25.90%		78.10%	

Note: **A**: Achieved, **N**: Not achieved.
(The presented achievement percentage for each experience factor calculated by adding all above relative weights and multiply it by 100, these percentages were used in Table 14).