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Research Article

A 2-stage fuzzy ANP approach for selection procedure of the optimum variant of office plan

Şahika ÖZDEMİR[1,*]

[1]*Department of Interior Architecture and Environmental Design, Istanbul Sabahattin Zaim University, Istanbul, 34303 Türkiye*

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ABSTRACT

To perform the tasks undertaken by the employees in the business life as desired; motivation, work in a comfortable environment and work efficiency. The physical order of working environments; It is essential because of its effect on employee health, psychology and work efficiency. However, the office tools and office design used also significantly impact employee performance and productivity. As a result of the Industrial Revolution and the advancement of technology, the developments achieved have ceased to be a mere housing element. They have been used as office spaces with the expansion of the business areas. This expansion led to an increase in the need for space in time and the increase in the number of employees, which caused the problem of not using the space efficiently. This problem brought about a decrease in work efficiency and led people to seek solutions. As a result, many office types have emerged.
Selecting office types effectively for work efficiency and employee health is crucial in today's world. Weighting office plan types and prioritizing the alternative offices using the weights of office plan types were chosen for this study and a 2-Stage fuzzy ANP methodology was used. The results were compared by using fuzzy AHP. 22 sector experts (namely architect, interior architect, and civil engineer) were asked with the same important value about determining the best office plan type and alternative. This is the first study in the literature to apply the 2-Stage Fuzzy ANP methodology, and also the MCDM methods for office plan types.

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INTRODUCTION

The human being at the center of working life is the most essential part of the enterprises. Defined as an internal customer in the literature, people have many duties and responsibilities in business life. Many factors are necessary for the employees in enterprises to perform their duties efficiently. Since the offices are the service areas of the institutions or organizations and where the employee spends most of their time, the working environment and conditions should be arranged in a suitable way for the employees and that they can do their jobs easily [1].

One of the most critical factors affecting productivity in the working environment is the ergonomic arrangement

*Corresponding author.
*E-mail address: sahika.ozdemir@izu.edu.tr

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of the workplaces. As it directly affects the health, psychology, and work efficiency of the employee, the physical conditions in the work areas should be arranged according to ergonomic elements and efficient and comfortable environments should be created. Creating healthy working environments can be achieved with ergonomic design and ergonomic products. In enterprises where these conditions are not fulfilled, there is a risk that the expected work efficiency and personal productivity will not be realized and that employees' health status will deteriorate [1].

Rather than being large or small, office space is essential to ensure organizational organization among employees. The fact that the manager can easily transfer information and data with other employees is of great importance for the functioning of the offices. Plan organizations where employees can easily reach each other and communicate easily should be considered [2].

Another essential factor to consider when creating office spaces is maximum efficiency from working people. Ensuring appropriate standards for employees also increases office efficiency. Ensuring appropriate standards for employees also increases office efficiency. Providing adequate light, correct temperature and humidity, proper sound levels, selecting material and materials, positioning equipment in the right places, and placing the goods in an appropriate organization are essential factors to increase productivity. Although it is impossible to provide satisfactory standards for every employee, it is necessary to have an organizational chart appealing to the majority. In addition, the positions and duties of the employees should be taken into consideration when preparing this scheme [2].

Selecting or prioritizing alternatives from a set of available solutions concerning multiple criteria is often referred to as multi-criteria decision-making (MCDM). MCDM is a well-known branch of a general class of operation research models that deal with decision problems in the presence of many decision criteria [3].

In the literature, the fuzzy ANP method has been used to solve so kind of problems like research and development project selection [4], performance evaluation [5], tourism type prioritization [6] prioritizing design requirements [7], construction project problem [8], evaluation of store plan alternatives [9], etc.

Hemmati et al. [10] constructed the FANP model and applied it to a sulfuric acid production facility for selecting the maintenance policy. Danai et al. [11] proposed an FANP method for selecting the best supplier in the supply chain. Alilou et al. [12] developed a novel framework to assess watershed health using the FANP method considering topo-hydrological and geo-environmental criteria. Galankashi et al. [13] developed specific criteria and an FANP method to prioritize and select portfolios on the Tehran Stock Exchange (TSE). Many studies use MCDM methods in the literature [14-21].

In this paper, the 2-Stage fuzzy ANP methodology applied, firstly to weighting the office plan types, and secondly to prioritize the alternative offices using the weights of office plan types. Then the results are compared with fuzzy AHP results. This is the first study in the literature to apply the 2-Stage Fuzzy ANP methodology and the MCDM methods for office plan types.

REVIEW OF OFFICE DESIGN CONCEPT

Offices are rooms or spaces on a larger scale where people work together or individually. The concept of the office is an architectural and sociological phenomenon that contains many meanings. According to the Turkish Language Institution, the dictionary meanings of the bureau and office words are similar in terms of importance but can be considered different. The definition of bureau word as the 1st meaning; study room, office; 2nd as meaning; the workplace where the consultancy and editorial works are carried out; 3rd meaning section, branch, and see that the 4th meaning is made in the form of a desk. Its origin is the French Bureau [22].

The meaning of the office is primarily a service. Next, come the organization and the room or building where the service is performed. Therefore, it is wrong to accept the original meaning of the office as a place. Nevertheless, generally achieving a service requires protection from natural elements, a place to sit, and a storage area, that is, a working space [2].

The emergence of the office concept dates back to ancient times. Sometimes it consisted of a large room in the kings' palaces, sometimes cathedrals, and sometimes a part of the houses of trade men. However, with the development of needs, industry, trade and technology, the requirements for office spaces started to increase [23].

When designing an office, the structure of that company is examined i.e. number of departments, number of employers, the characteristics of the departments, what the company does, how it works, whether it has logistics outside, and whether any other branches are checked. Space analysis is done in the so-called offices. In this analysis, area per person, the air circulation areas, the most efficient circulation area, and the relations of the departments are examined. In extensive offices, some departments do not know each other and do not know what each other does. Public spaces such as coffee areas, book reading areas are created to establish relationships between people. People want to be in contact with nature. To bring the employee to nature, it is necessary to either get in some character or show spirit. It is required to move the elements of nature (such as greenery, trees, etc.) from the outside. Daylight should be taken in as much as possible. Gaps that meet the standards should be provided. Because people work more in very confined spaces, their performance decreases. Raising the ceilings as much as possible, using low-reflection material, and creating social spaces are important factors [24].

As a workplace, offices occupy an important place in terms of being an environment that enables product development efficiently and continuously under the intensive time conditions of daily life. While working action and working life are so important, office buildings should be

designed with no function deficits to meet all functions of users. In this way, negativities such as physical and mental fatigue and burnout on employees can be prevented [25].

User Requirements

The user is defined as an individual or group performing a particular action, and equipment is defined as an article used to increase the effectiveness of executing a specific activity [26].

To utilize human talents optimally and to maximize his / her job performance level, first, to know human as user, to know human natural abilities, physiological, psychological, sociological characteristics, desires, expectations and needs; then, it is necessary to create a working environment, a motivating working environment in which he can make the best use of his physical and intellectual abilities [27].

User requirements are defined as environmental conditions that allow the user to continue his or her life in a place without social, psychological and physiological disturbances and help him/her be productive in his/her works [28].

The user needs to depend on the anthropometric, sensory, and perceptual dimensions of human beings. In this context, the user's need is defined as the conditions required for the actions and actions of the human being in a suitable environment for the anthropometric, sensory, and perceptual dimensions of the human being [26].

All the possibilities and environmental conditions that enable the user not to hear in physiological, psychological, and social aspects while being alive and to be productive in their works are his needs. The user requirements; the environment in the user and the user have to perform specific actions is a necessary compromise [26].

Physical User Requirements

Research shows that the physical environment affects job satisfaction by 24%. The office's physical environment typically includes privacy and acoustics, air quality and heat comfort, lighting, and layout of work areas [29].

The physical user needs in the office are grouped under four main categories (see- Table 1).

Physical user requirements are the physical conditions that the environment in which the current environment must-have when acting. Protection of the environment against adverse physical conditions and comfort, health, and safety are the requirements for survival. The space-related properties of the number of users in the space, the characteristics of the actions and the equipment elements used are the dimensions of the user (anthropometric, sensory, perceptual), the number of users, the equipment elements used, and consequently the size of the required space [31].

Depending on the equipment size of the people in the working environment, the sequence and the arrangement of the equipment, the relationship between the equipment and the structure and material of the equipment should be determined and the working area should be adapted to the human characteristics [32].

Psychosocial User Requirements

Psychological needs; needs of individual expectations and desires that may vary depending on the user's cultural group. The privacy needs, operational space needs, and aesthetic needs can affect the psychology of users in the office [33].

Psychosocial user needs are defined as the conditions for avoiding any psychological disturbance during an action. These are auditory and visual privacy, social environment characteristics, human behaviors, and aesthetic conditions such as form, color, and texture of the place where humans are located. Psychosocial requirements are personal desires and desires that vary depending on the user's cultural group (Table 2) [26].

Table 1. The physical needs of the office user [30]

Physical user requirements	Description of requirements
Dimensional	Static and dynamic anthropometric dimensions of human in space, actions and forms of actions i.e. behaviors.
Thermal	Suitable temperature, humidity, radiation and air movements in the space.
Auditory	The sound of the space is the appropriate intensity and sound reflection-distribution properties.
Visual	Appropriate light intensity and luminance levels.

Table 2. The psychosocial needs of the office user [30]

Psychosocial user requirements	Description of requirements
Privacy	The place is suitable for visual, auditory and social privacy.
Behavioral	The actions of individuals in space are the distances they need instantly (individual boundary, distance between individuals, distance within the community, public distance).
Aesthetic	Appropriate form, color and textural characteristics of the space.

When designing an office space, no matter how good the physical characteristics are, it is not possible to obtain the expected performance if the psychological characteristics of the people and the resulting behavioral factors are not examined and reflected in the design. Therefore, behavioral factors should be examined and reflected in the design. Because users cannot be productive unless they get the morale they can concentrate on. Physical aspects in the place can put people under different behavioral influences or behavioral characteristics that can change the place's physical properties [31].

As a result, when the interactions between psychosocial environmental conditions and human beings are not taken into consideration in terms of comfort, safety, and efficiency, it is necessary to regulate the work and living environment which provides aesthetic saturation which takes into consideration the work order, group behavior and boringness for the creation of motivational factors in monotonous works [31].

Office Plan Types

Employees exhibit behaviors within the working environment and engage in behaviors that adapt to changing workplace conditions. These behaviors that the employee expresses are put forward to protect themselves, define their personal and social identity, regulate social interaction, and are commonly explained by four behavior mechanisms. [33];[34]:

- Personal space
- Domination area
- Privacy
- Crowding and isolation

Personal space: Environmental psychologists conceptualize personal space as a space similar to distance and with a high level of privacy. The office space can be described as a fictional space where individuals and groups define their boundaries among themselves and others. In other words, it refers to the personal space in which the boundaries are defended and the individual is physically and cognitively dominant.

Domination area: It can be defined as owning and arranging the boundaries of the personal space that the person thinks belongs to themselves in working environments. The area of sovereignty includes defense and control behaviors and tendencies to personalize the defended space emerge. Particularly in open office spaces, the fact that the staff adds details (photographs, texts, flowers, ornaments, etc.) to their workplaces reflecting the character traits, results from the need to determine the area of sovereignty.

Privacy: It refers to the extent to which others will be close to the person or group in the working environment and an appropriate level of spatial relationship. The concept of design flexibility used in office spaces, especially in open office spaces, reduces or eliminates privacy. People do not want to hear their phone calls from being heard, heard, or heard by other employees. Sound absorbing divider panels are used to eliminate the sense of observation and to prevent private conversations from being heard in the environment.

Crowding and isolation: The deterioration of the balance of privacy in the working environment raises two different negative situations: crowding or isolation. Both concepts describe the personal space of the employees working in the offices and the violation of this area. Despite the limited resources, over and irregular people create a sense of crowding, and isolation in the working environment reveals a sense of isolation. As a result, ignoring these mechanisms of action or neglecting anyone and attempting to close the gap with others undermines the psychological balance of the working environment.

As a result of the change and development in the business world due to technology, it is obvious that structural and functional changes have occurred in the user profile and structure in the offices. Office planning approaches developed in line with these functional changes are explained below. Examples of office types that are mostly mentioned and studied in the literature are shown in the table and the application study has been made on these types (Table 3).

THE PROPOSED METHODOLOGY: 2-STAGE FUZZY ANP

As explained above, selecting office types effectively for work efficiency and employee health is crucial in today's world. Weighting office plan types and prioritizing the alternative offices using the weights of office plan types were chosen for this study and 2-Stage fuzzy ANP methodology was used, then the results were compared by using fuzzy AHP. 22 sector experts (namely architects, interior architects, and civil engineers) were asked with the same importance value about the problem of determining the best office plan alternative.

As the 1st Stage, two main criteria, seven sub-criteria, and five office plan types were determined and weighted accordingly (Figure 1). As the 2nd Stage, four alternative offices were determined and prioritized using the weights of office plan types (Figure 2).

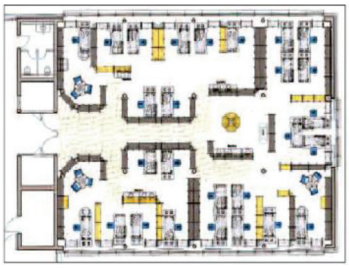
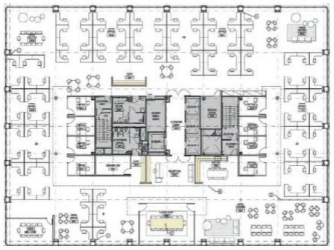
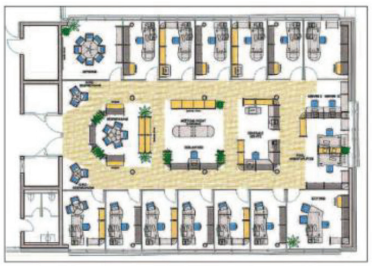
For the 1st Stage in the numerical example, the architects, the interior architects, and the civil engineers need to determine the best office plan types.

The alternatives for weighting the office plan schemes (Alternatives-1) are "Cell Regular-traditional Plan Type (SC1)", "Group Regular Plan Type (SC2)", "Open Regular Plan Type (SC3)", "Free Regular Plan Type (SC4)", and "Mixed Regular Plan Type" (SC5).

Then, for the 2nd Stage of the problem, the same expert group needs to prioritize the alternative offices using the same weights determined in Stage 1. As seen from Figure 8, the office plan types with determined weights become the criteria of the 2nd Stage.

The alternatives for prioritizing the alternative offices (Alternatives-2) are "One-fronted within the office block (A1)", "Two fronts within the office block (A2)",

Table 3. Office plan types [35]

Cell Regular (Traditional) Plan Type	Group Regular Plan Type	Open Regular Plan Type
		
Since the cellular regular plan type spaces, which were built before the 1950s, are dependent on natural lighting, the depth of the space is 5.50-6.00 m. and the chambers are capable of growing in one direction only because of the necessity to provide this depth. In this type of office, the dimensions of the space vary according to the number of employees inside, the hierarchical structure of the enterprise, and the working order [35].	The working areas in the group regular plan type, which is a transition between the cell regular plan type and the open regular plan type, vary between 40-150 m² and the depth is 6-10 m. between. There are 2 or 3 groups of 5-10 people on one floor in group regular plan type offices, which are obtained by removing the fixed walls of the cellular regular plan type and including them in the corridor [35].	As a result of the rapid development of the communication tools and their usage after the regular plan type, the group was obtained by removing the fixed walls between the corridor and the working areas from the cellular regular plan type, and the offices began to stand out from the cell walls due to communication requirements and to be positioned in open-plan [36].
Free Regular Plan Type	**Mixed Regular Plan Type**	
		
In 1960, the Quickborner team, planning, management, and business consultancy in Germany developed due to their work on office furnishing, organization, document flow studies, filing systems, and communication. It is a type of plan where it is scattered [35].	With the combination of cellular, open and free regular plan types, mixed regular plan type emerged and apart from these three plan types, which are mainly taken during the design process, divisions can be made in the space according to need or separate cells can be arranged in corridor form [35].	

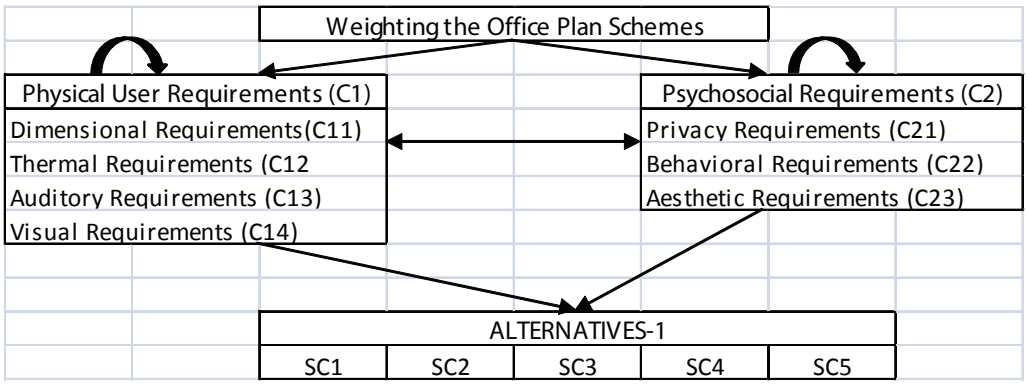


Figure 1. Network of the 1st Stage.

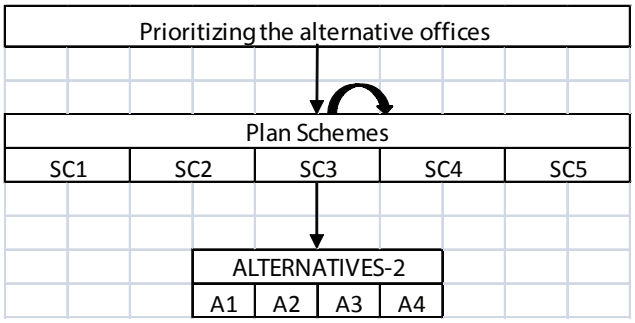


Figure 2. Network of the 2nd Stage.

"Single-fronted on the street (A3)", and "Two fronts on the street (A4)".

Application of 2-Stage Fuzzy ANP to Select Office Design Concept

Buckley's fuzzy AHP algorithm [37]; [38]; [39] based fuzzy ANP is used for selecting the best office alternative in this paper. Fuzzy ANP allows measuring qualitative factors by using fuzzy numbers instead of crisp values to make decisions easier and obtain more realistic results [40].

In this paper, the 2-Stage Fuzzy ANP methodology applied to weight the office plan types (the 1st Stage) and to prioritize the alternative offices (the 2nd Stage). 22 sector experts (namely architect, interior architect, and civil engineer) were asked with the same importance value about these problems.

The layout of the application case can be seen from Figure 3.

Stage 1: Criteria and Office Plan Evaluation

The steps of fuzzy ANP can be listed as follows [41]:

Step 1: Determine alternatives, criteria and subcriteria to be used in the model

Step 2: Create a network including alternatives, criteria, subcriteria, inner and outer dependencies among the model.

Step 3: Construct pairwise matrices of the components by the experts with fuzzy numbers.

Step 4: Construct the fuzzy comparison matrix by using triangular fuzzy numbers:

Step 5: Calculate fuzzy eigen value to find whether the constructed matrix is consistent or not:

To verify the consistency of the comparison matrix, Saaty proposed a consistency index (C.I.) and consistency ratio (C.R.). The consistency index of a matrix is given by

$$C.I. = (\lambda max - n)/(n-1) \quad (1)$$

$$C.R = C.I/R.I \quad (2)$$

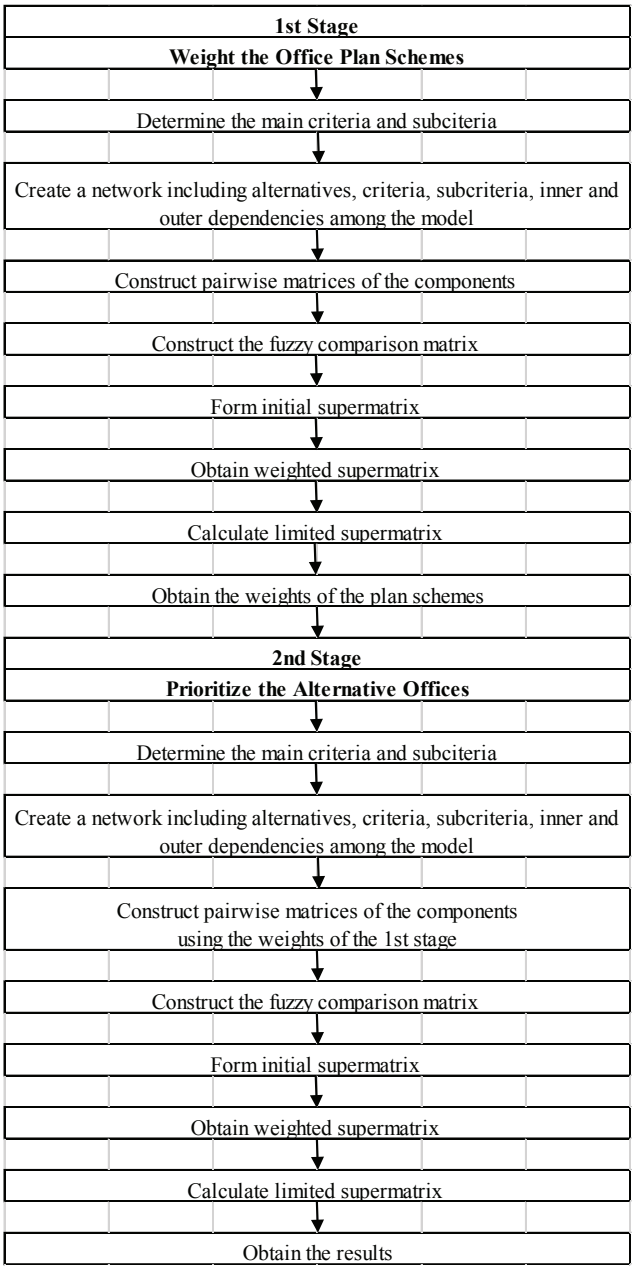


Figure 3. The flow diagram of the application of 2-Stage Fuzzy ANP methodology.

where, R.I is Random Consistency Index. The consistency index should be less than or equal to 0.10.

Step 6: Forming initial supermatrix of the network of ANP is composed by listing all nodes horizontally and vertically.

Step 7: Obtaining weighted supermatrix by multiplying the unweighted supermatrix with the corresponding cluster priorities

Step 8: Calculating limited supermatrix by limiting the weighted supermatrix by raising it to sufficiently large power so that it converges into a stable supermatrix (i.e, all columns being identical).

Table 4. Relationship between fuzzy numbers and degrees of linguistic importance

Low/high Levels		Degrees of Importance		Triangular fuzzy numbers
Label	**Linguistic Terms**	**Label**	**Linguistic Terms**	
EL	Extra low	EU	Extra unimportant	(1,1,1)
VL	Very low	VU	Very unimportant	(1,2,3)
L	Low	U	Unimportant	(2,3,4)
SL	Slightly low	SU	Slightly unimportant	(3,4,5)
M	Middle	M	Middle	(4,5,6)
SH	Slightly high	SI	Slightly important	(5,6,7)
H	High	HI	High important	(6,7,8)
VH	Very high	VI	Very important	(7,8,9)
EH	Extra high	EI	Extra important	(9,9,9)

Table 5. Results of the 1st Stage using Fuzzy ANP

	Weights	Normalized Values
SC1 (Cell Regular-traditional Plan Type)	0.21	16.64%
SC2 (Group Regular Plan Type)	0.25	19.82%
SC3 (Open Regular Plan Type)	0.22	17.88%
SC4 (Free Regular Plan Type)	0.24	19.13%
SC5 (Mixed Regular Plan Type)	0.33	26.53%

To solve the problem using fuzzy ANP, used fuzzy numbers as shown in Table 4 and compared our results with those of experts. The average of evaluations of the alternatives by 22 experts concerning the criteria can be seen in Appendix A. The fuzzy weight matrix of the criteria according to the goal, fuzzy weight matrix of the subcriteria and fuzzy weight matrix of the alternatives for each criterion are given in Appendix B, C, and D, respectively.

Also initial supermatrix, weighted supermatrix and the limited supermatrix can be seen from Appendix E, F and G. The evaluation and the methodology described above produced the results shown in Table 5.

The weights of the office plan types are obtained as can be seen in Table 5. According to the results in Table 5, the ranking is obtained as SC5>SC2>SC4>SC3>SC1. Given these results, it is fair to say that selecting SC5 (Mixed Regular Plan Type) is the most reasonable outcome, followed by the others.

Stage 2: Office Plan Selection

During the application phase four office plan alternatives was analyzed i.e. one-fronted within the office block is 15m. x 6m.; two fronts within the office block space is 20m. x 10m.; a single-fronted on the street space is 12m. x 10m. and two fronts on the street is 10m. x 15m.

These alternatives for prioritizing the alternative offices are "One-fronted within the office block (A1)", "Two fronts within the office block (A2)", "Single-fronted on the street (A3)", and "Two fronts on the street (A4)".

Within the scope of the study, office design alternatives selected from the areas that were applied in the project course were evaluated. Designers were expected to evaluate these alternatives. Since it is observed that these four alternatives offer many alternatives to analyze the criteria in a wide framework when we look at them spatially, such a path has been followed. It was requested that these designs be evaluate by designers within the above office plan types, whichever is appropriate (Figure 4).

For the 2nd Stage of the problem, the same expert group needs to prioritize the alternative offices using the same weights determined in Stage 1 (Table 5). The average of evaluations of the alternatives by 22 experts with respect to the plan types can be seen in Appendix H.

Also, initial supermatrix, weighted supermatrix, and the limited supermatrix for the 2nd Stage can be seen from Appendix I, J, and K. The evaluation and the methodology described above produced the results shown in Table 6.

According to the results in Table 16, the ranking is obtained as A4>A2=A3>A1. Given these results, it is fair to say that selecting Alternative A4 is the most reasonable outcome, followed by the others.

Table 6. Results of the 2nd Stage using Fuzzy ANP

	Weights	Normalized Values
A1	0.33	21.05%
A2	0.40	25.34%
A3	0.40	25.34%
A4	0.44	28.27%

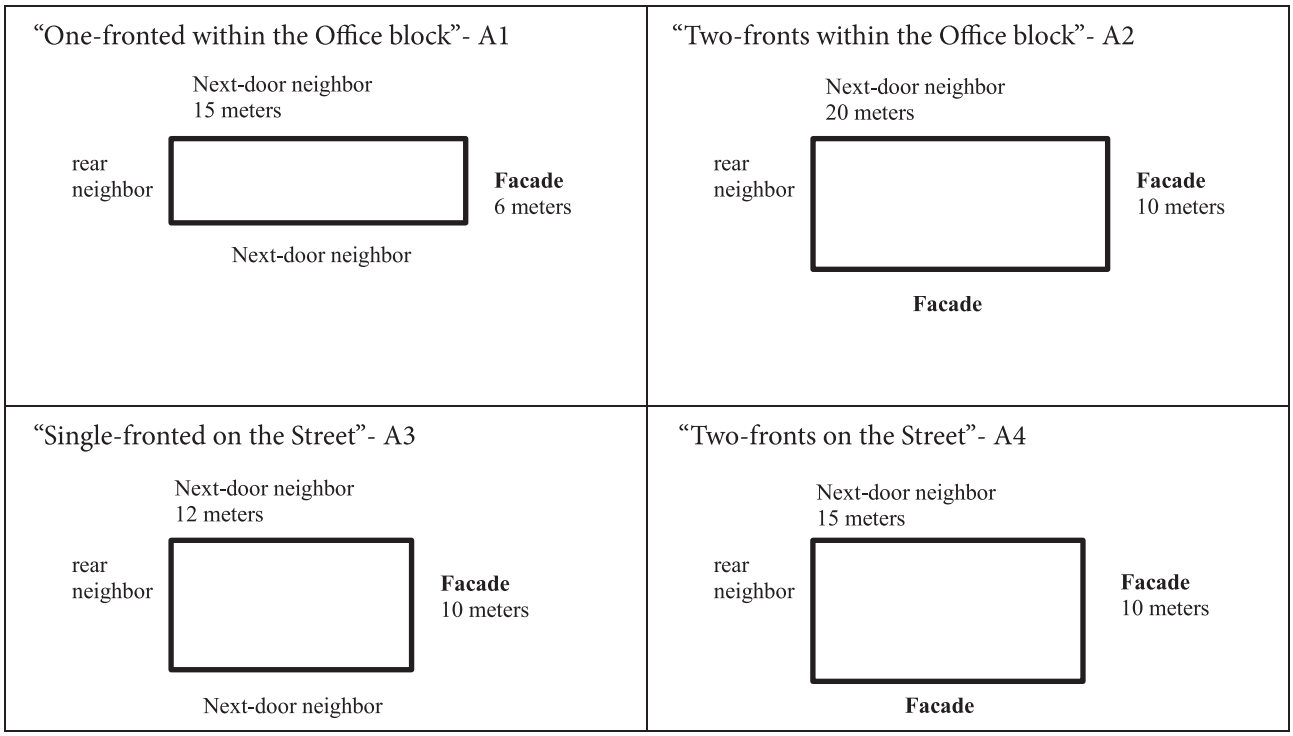


Figure 4. Office Plan Alternatives.

Comparison of the Results Using Fuzzy AHP Methodology

To evaluate the results of fuzzy ANP, we used one of the most common MCDM methodologies, fuzzy AHP, using the same data of the fuzzy ANP.

The steps of fuzzy AHP can be listed as follows [42]; [43]; [44]:

Step-1: Determining alternatives, main-criteria and subcriteria.

Step-2: Creating the hierarchy including aim, main-criteria, subcriteria, and alternatives.

Step-3: Evaluating the relative importance of the criteria using pairwise comparisons and assigning linguistic terms to the pairwise comparisons by evaluators with fuzzy numbers.

$$\tilde{A} = \begin{bmatrix} 1 & \cdots & \tilde{a}_{1n} \\ \vdots & \ddots & \vdots \\ \tilde{a}_{n1} & \cdots & 1 \end{bmatrix} = \begin{bmatrix} 1 & \cdots & \tilde{a}_{1n} \\ \vdots & \ddots & \vdots \\ 1/\tilde{a}_{1n} & \cdots & 1 \end{bmatrix} \quad (3)$$

Step-4: Defining the fuzzy geometric mean and fuzzy weight of each criteria.

$$\tilde{r}_i = \left(\tilde{a}_{i1} \otimes \tilde{a}_{i2} \otimes \ldots \otimes \tilde{a}_{in}\right)^{1/n} \quad (4)$$

$$\widetilde{w}_i = \tilde{r}_i \otimes (\tilde{r}_1 \oplus \ldots \oplus \tilde{r}_n)^{-1} \quad (5)$$

In (10-12), $\tilde{a}_{in}$ is the fuzzy comparison value of criteria i to criteria n, $\tilde{r}_i$ is the geometric mean of fuzzy comparison value of criteria i to each criteria and $\widetilde{w}_i$ is the fuzzy weight of the i^{th} criteria.

Step-5: Defuzzifying and normalizing the fuzzy weights.

Using the same data of the fuzzy ANP methodology given above, the fuzzy AHP methodology produced the results and the both results are compared in Table 7 and Table 8.

Table 7. The comparison of the results of the 1st Stage using Fuzzy ANP and Fuzzy AHP

Office Plan Types	Fuzzy ANP		Fuzzy AHP	
	Weights	Normalized Values	Weights	Normalized Values
SC1 (Cell Regular-traditional Plan Type)	0.21	16.64%	0.41	16.57%
SC2 (Group Regular Plan Type)	0.25	19.82%	0.49	19.79%
SC3 (Open Regular Plan Type)	0.22	17.88%	0.44	17.95%
SC4 (Free Regular Plan Type)	0.24	19.13%	0.47	19.16%
SC5 (Mixed Regular Plan Type)	0.33	26.53%	0.65	26.53%

Table 8. The comparison of the results of the 2nd Stage using Fuzzy ANP and Fuzzy AHP

Office Plan Alternatives	Fuzzy ANP		Fuzzy AHP	
	Weights	Normalized Values	Weights	Normalized Values
A1	0.33	21.05%	0.65	21.04%
A2	0.40	25.34%	0.78	25.35%
A3	0.40	25.34%	0.78	25.35%
A4	0.44	28.27%	0.87	28.27%

The results of the both stages and the both methodologies give the same rankings with close normalized values.

CONCLUSION

Today, with the development of business lines in different fields of activity, variations in office plan types have started to be seen. According to the interior layout, it is possible to gather office plan types in four main groups. These can be treated as cellular, open plan, free order, and mixed regular spaces.

In this paper, 2-Stage fuzzy ANP methodology is used; firstly, for the weighting of office plan types and secondly, for prioritizing the alternative offices using the obtained weights in the 1st Stage. As a result of the evaluation process, the 1st Stage has determined the weights of office plan types Mixed Regular Plan Type (SC5) as 26.53%, Group Regular Plan Type (SC2) as 19.82%, Free Regular Plan Type (SC4) as 19.13%, Open Regular Plan Type (SC3) as 17.88%, and Cell Regular (traditional) Plan Type (SC1) as 16.64% from the largest to the lowest.

Using these weights of the office plan types and the same experts' pairwise comparisons of the alternative offices with respect to each plan types, the 2nd Stage has given the results of alternative offices A4 as 28.27%, A2 and A3 as 25.34%, and A1 as 21.05%, respectively. Then the obtained results of the both stages are compared using fuzzy AHP. The both methodologies, fuzzy ANP and fuzzy AHP, give the same rankings with close normalized values.

The reason for this different normalized values can be thought of as, at the fuzzy ANP calculation step, all of the pairwise comparisons are taken into account. Fuzzy ANP methodology considers interactivity among all subcriteria. The main contribution of this paper is to prioritize the office plan types and the office plan alternatives using numerical methods with experts' views.

The general limitation of the proposed model is the costly and exhausting information requested from experts (approx. 120 pairwise comparisons per one expert). Other limitations of the model are the expert's preferences, including uncertainty and conflicts, and there is often more than one expert to make decisions.

As regards future research, each type of plan can be assessed by these MCDM techniques. On the other hand, the problem could be solved by other MCDM techniques with fuzzy numbers and more solutions compared for office plan alternatives evaluation processes. Also, intelligent software to calculate solutions automatically could be developed.

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AUTHORSHIP CONTRIBUTIONS

Authors equally contributed to this work.

DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

ETHICS

There are no ethical issues with the publication of this manuscript.

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APPENDIX

A. Average values used in 1st Stage of Fuzzy ANP.

Criteria	Importance Value	SC1	SC2	SC3	SC4	SC5
C1	VH	H	H	H	H	H
C11	H	H	H	H	H	H
C12	H	H	H	H	SH	H
C13	VH	H	H	H	H	H
C14	VH	SH	H	SH	H	VH
C2	H	H	H	H	H	H
C21	VH	H	H	H	H	VH
C22	H	H	H	H	H	H
C23	VH	SH	H	H	H	H

B. Fuzzy weight matrix of the criteria according to the goal.

	L	M	U
C1	0.37	0.67	1.10
C2	0.21	0.33	0.63

C. Fuzzy weight matrix of the subcriteria.

	L	M	U
C11	0.06	0.09	0.18
C12	0.06	0.09	0.18
C13	0.11	0.18	0.29
C14	0.11	0.18	0.29
C21	0.11	0.18	0.29
C22	0.06	0.09	0.18
C23	0.11	0.18	0.29

D. Fuzzy weight matrix of the plan types with respect to each criterion.

Plan Types	C11			C12			C13			C14		
	L	M	U	L	M	U	L	M	U	L	M	U
SC1	0.20	0.20	0.20	0.17	0.22	0.28	0.20	0.20	0.20	0.06	0.11	0.22
SC2	0.20	0.20	0.20	0.17	0.22	0.28	0.20	0.20	0.20	0.11	0.21	0.40
SC3	0.20	0.20	0.20	0.17	0.22	0.28	0.20	0.20	0.20	0.06	0.11	0.22
SC4	0.20	0.20	0.20	0.07	0.11	0.23	0.20	0.20	0.20	0.11	0.21	0.40
SC5	0.20	0.20	0.20	0.17	0.22	0.28	0.20	0.20	0.20	0.17	0.37	0.69
Plan Types	C21			C22			C23					
	L	M	U	L	M	U	L	M	U			
SC1	0.13	0.17	0.24	0.20	0.20	0.20	0.07	0.11	0.23			
SC2	0.13	0.17	0.24	0.20	0.20	0.20	0.17	0.22	0.28			
SC3	0.13	0.17	0.24	0.20	0.20	0.20	0.17	0.22	0.28			
SC4	0.13	0.17	0.24	0.20	0.20	0.20	0.17	0.22	0.28			
SC5	0.16	0.33	0.57	0.20	0.20	0.20	0.17	0.22	0.28			

E. Initial supermatrix of the 1st Stage.

	C11	C12	C13	C14	C21	C22	C23
C11	0.00	0.22	0.27	0.27	0.18	0.18	0.18
C12	0.22	0.00	0.27	0.27	0.18	0.18	0.18
C13	0.39	0.39	0.00	0.46	0.32	0.32	0.32
C14	0.39	0.39	0.46	0.00	0.32	0.32	0.32
C21	0.39	0.39	0.39	0.39	0.39	0.50	0.63
C22	0.22	0.22	0.22	0.22	0.22	0.00	0.37
C23	0.39	0.39	0.39	0.39	0.39	0.50	0.00

F. Weighted supermatrix of the 1st Stage.

	C11	C12	C13	C14	C21	C22	C23
C11	0.00	0.07	0.09	0.09	0.06	0.06	0.06
C12	0.07	0.00	0.09	0.09	0.06	0.06	0.06
C13	0.13	0.13	0.00	0.15	0.11	0.11	0.11
C14	0.13	0.13	0.15	0.00	0.11	0.11	0.11
C21	0.13	0.13	0.13	0.13	0.13	0.17	0.21
C22	0.07	0.07	0.07	0.07	0.07	0.00	0.12
C23	0.13	0.13	0.13	0.13	0.13	0.17	0.00

G. Limited supermatrix of the 1st Stage.

	C11	C12	C13	C14	C21	C22	C23
C11	0.07	0.07	0.07	0.07	0.07	0.07	0.07
C12	0.07	0.07	0.07	0.07	0.07	0.07	0.07
C13	0.10	0.10	0.10	0.10	0.10	0.10	0.10
C14	0.10	0.10	0.10	0.10	0.10	0.10	0.10
C21	0.15	0.15	0.15	0.15	0.15	0.15	0.15
C22	0.07	0.07	0.07	0.07	0.07	0.07	0.07
C23	0.11	0.11	0.11	0.11	0.11	0.11	0.11

H. Fuzzy weight matrix of the alternative offices with respect to each plan types.

Alternative Offices	SC1			SC2			SC3			SC4			SC5		
	L	M	U	L	M	U	L	M	U	L	M	U	L	M	U
A1	0.20	0.29	0.38	0.20	0.29	0.38	0.09	0.14	0.29	0.25	0.25	0.25	0.07	0.12	0.27
A2	0.20	0.29	0.38	0.20	0.29	0.38	0.20	0.29	0.38	0.25	0.25	0.25	0.13	0.23	0.42
A3	0.20	0.29	0.38	0.20	0.29	0.38	0.20	0.29	0.38	0.25	0.25	0.25	0.13	0.23	0.42
A4	0.09	0.14	0.29	0.09	0.14	0.29	0.20	0.29	0.38	0.25	0.25	0.25	0.20	0.42	0.79

I. Initial supermatrix of the 2nd Stage.

	SC1	SC2	SC3	SC4	SC5
SC1	0.00	0.21	0.20	0.21	0.23
SC2	0.24	0.00	0.24	0.25	0.27
SC3	0.21	0.22	0.00	0.22	0.24
SC4	0.23	0.24	0.23	0.00	0.26
SC5	0.32	0.33	0.32	0.33	0.00

J. Weighted supermatrix of the 2nd Stage.

	SC1	SC2	SC3	SC4	SC5
SC1	0.00	0.11	0.10	0.10	0.11
SC2	0.12	0.00	0.12	0.12	0.14
SC3	0.11	0.11	0.00	0.11	0.12
SC4	0.12	0.12	0.12	0.00	0.13
SC5	0.16	0.17	0.16	0.16	0.00

K. Limited supermatrix of the 2nd Stage.

	SC1	SC2	SC3	SC4	SC5
SC1	0.09	0.09	0.09	0.09	0.09
SC2	0.10	0.10	0.10	0.10	0.10
SC3	0.09	0.09	0.09	0.09	0.09
SC4	0.10	0.10	0.10	0.10	0.10
SC5	0.12	0.12	0.12	0.12	0.12