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CRITERIA FOR SELECTION OF LOCATION OF VEGETABLE VENDORS: THE ANALYTICAL HIERARCHY PROCESS

SUSHMITA CHAKRABORTY

PhD in Department of Architecture from National Institute of Technology, Raipur, India.
E-mail: schakraborty.phd2018.arch.nitrr.ac.in

ABIR BANDYOPADHYAY

Professor in Department of Architecture at National Institute of Technology, Raipur, India.
E-mail: abandyopadhyay.arch@nitrr.ac.in

SWASTI STHAPAK

Associate Professor in Department of Architecture at National Institute of Technology, Raipur, India.
E-mail: ssthapak.arch@nitrr.ac.in

Abstract:

Worldwide, location plays a significant role in launching a successful enterprise. Extensive research has been conducted on location selection for starting a business. Several studies from various fields have identified suitable locations, but very little research has been performed to find proper locations for vegetable vendors, especially in urban settings. This study aims to establish the criteria and attributes for finding the locations for vegetable vendors using the analytical hierarchy process (AHP). For this study, four criteria and eleven attributes were selected from the literature, and the AHP was applied to determine their weights. The findings suggest that access, environment, infrastructure, and population are important indicators for predicting suitable locations for vegetable vendors. The results provide useful insights for urban planners, municipality officials, and development authorities to distinguish or anticipate the most appropriate locations for vegetable vendors in urban areas.

Index terms: Analytical Hierarchy Process (AHP), vegetable vendor, location, criteria.

1 INTRODUCTION

Consuming vegetables is an inexpensive way of meeting nutritional requirements [1]. Culture, however, determines the significance of such consumption in terms of diet [2]. In India, the vegetable sector is perceived to be important by farmers, consumers, and vendors [3]. Most Indians usually consume vegetables along with rice (the nation's major staple diet). According to the Household Consumption of Various Goods and Services [4], milk, milk products, and vegetables are the most widely consumed goods among perishable food items. Vegetables are available in shopping malls, convenience stores, (local) markets, and from street vendors [3][5]. In many developing nations, they play a significant role in urban areas [5].

Street vegetable vendors (SVVs) use temporary trucks, carts, and other items to sell goods and services to the public [6]. SVVs provide high-quality vegetables to maintain good customer relationship to sustain at particular location and mostly tend to settle in busy locations [3], [6].

Street vendors encounter several challenges in daily life such as competing for

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customers, dealing with the unstable prices of vegetables, and finding suitable locations. Typically, street vendors are associated with entering crowded locations near residential areas, causing encroachment, traffic, pollution (e.g., littering), and improper garbage disposal [7],[8]. Apart from this, they have limited access to basic facilities like toilets and fresh drinking water [9]. Furthermore, the government does not recognize the contribution of SVVs towards economic and social wellbeing of urban population [10].

A proper location is one of the most critical aspects for vegetable vendors in the urban landscape as it can provide them with entry to basic facilities and ease of access to potential customers on a regular basis [11]. Few studies have described the location importance and its criteria's for location of SVVs, especially in the Indian context [8], [12]–[17]. The location of street vendors in the paper of Widjajanti, (2016) [18] was between educational and residential landuses. These spaces have a high amount of community and visitor mobility. Rajkumar & Jacob, (2010) [14] talks about the smartly chosen location for the vending by the street vendors for their activities.

While there are business models [17], [19] for vegetable vendors, mathematical model formulations for a location identification model are still inconclusive, especially for vegetable vendors, since very limited research has been performed on this topic [20]. Thus, additional research is required to better understand the location preferences of SVVs. This paper aims to establish appropriate criteria and attributes for vegetable vendors location using a model that entails the analytical hierarchy process (AHP).

Background

In 1909, facility placement theory was first proposed [21]. Weber was the first to develop concepts of facility location and cost reduction in a particular year; numerous, similar ideas and models were also published [22]. There are various location models, each of which seeks an optimal facility location by evaluating a set of criteria. There have been several approaches for selecting a location such as mathematical and scientific programming, to find optimal sites for retail stores, as described by Aikens, (1985) [12].

It is critical for any business to understand how to attract customers and thus maximize the possibility of growth [23]. Choosing an appropriate location can significantly impact efficacy [24]. Notably, since the 1960s, several location theories have received keen attention for selecting locales for different markets. Verma & Mishra, (2021) [25] analysed that vendors tend to sit at the locations which fulfil consumer's requirements and daily demands.

Bhowmik, (2005) [26] analyzed the prevalence of street vending in Bangladesh, Sri Lanka, Bangkok (Thailand), Singapore, Kuala Lumpur (Malaysia), Manila (the Philippines), Hanoi (Vietnam), Cambodia, Seoul (South Korea), and India. Bhowmik, (2003) [27] also surveyed seven Indian cities: Mumbai, Ahmedabad, Kolkata, Imphal, Patna, and Bhubaneswar, finding that—with the exception of Kolkata—all other municipalities provide licenses for street vending.

Dimas, (2008) [28] studied the origins of street vending and proposed a mental shift among urban decision-makers as well as street vending management options based on

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international best practices. Dimas indicated that street vendors presented a significant issue for urban authorities such as destroying city landmarks.

Adhikari, (2011) [29] showed that street vending has a significant influence on the socioeconomics of developing nations, particularly in establishing employment opportunities, production, and revenue. Adhikari found that vendors should invest less if their goal is to generate more money for their lifestyle. Harendra and Rajesh (2020) [30] explained the socio-economic condition of informal sectors and their economic growth improvisation policies. Globally, informal sectors have claimed that access to information, particularly market intelligence, is their top priority for promoting their business expansion [31].

Banerjee, (2014) [32] examined the income and expenses of street vendors, a significant portion of which are self-employed. A majority of them originate from low-income families and have less money to operate their businesses due to poverty.

Bhatt et al., (2018) [33] explored roadside location settings, selling items to consumers, and social standing of consumers of goods from roadside vendors. In the paper of Tigari et al., (2020) [6] revealed the revenue and expenditure patterns of Davangere's SVVs. People increasingly purchase vegetables from street vendors due to their high quality.

Several studies have covered street and vegetable vendors' socio-economic conditions, the daily challenges they face, their daily living expenses, education level, and women's participation. However, there is very limited research on the location preferences and identification of vegetable vendors. This study establishes the criteria and attributes for identifying locations for vegetable vendors in a given urban settlement. Many tools were used to calculate the weights, but for this case, the multiple criteria decision-making method (MCDM) was best suited to distinguish sites for vegetable vendors [34], [35].

The MCDM model is an important technique for solving any decision-making problem. This approach supports evaluating information that is accessible throughout the decision-making process by considering all alternatives while reducing the chance of making incorrect conclusions. The process of deciding which option is the best out of all possibilities is classified as decision-making. However, attaining an optimum outcome can be problematic since decision-makers are frequently confronted with various decision-making challenges [36]. Decision-making is thus important in business site selection since this determines success or failure. The wrong site selection for a business could result in a non-profitable one and financial collapse; hence, site selection must be made carefully [37]. Saaty, (1977) [38] proposed AHP, which is an MCDM strategy. This technique has been extensively utilized in extensive areas and contexts to support real-world decision-making in the past few decades.

1.1 The AHP

One of the common MCDM strategies for making choices is the AHP which is used to resolve higher complex decision threats mathematically. This method has a multiple-level hierarchy organization of the goal/goals, criteria, and attributes [36].This technique determines priority among criteria and attributes and gives matrices of judgment

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consistency [38]. Using pairwise comparisons, the AHP approach simplifies preference ratings among selection criteria. The strategy is applied by using a hierarchy to decompose decision-making difficulties, and by performing pairwise comparisons and determining the factors of relative importance. The consistency ratio check is then used to analyze and verify the decision [37], [38]. Four distinct processes are involved in applying the AHP to the decision-making process [39], as outlined below:

1.1.1 A detailed description of the problem

The first step is to review related literature and interview experts [24] to describe the decision problem (goal), multiple criteria, and attributes, shown in Fig. 1.

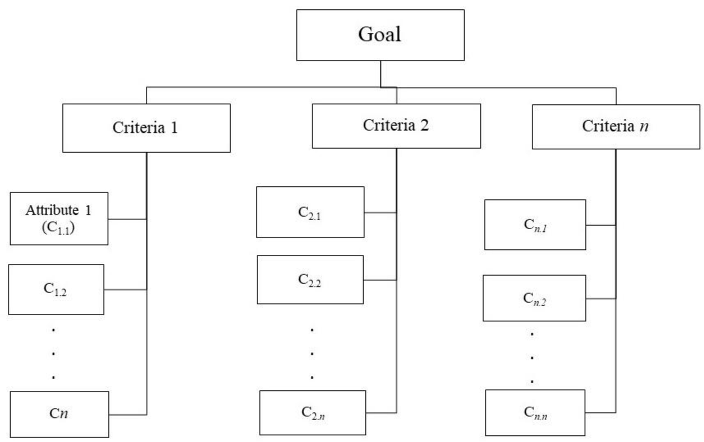

Fig. 1: AHP hierarchy structure

Source: Authors, 2023

1.1.2 Developing the Problem's Hierarchical Structure

The problem is divided into criteria for which every potential attribute (sub-criterion) is grouped hierarchically at numerous levels [36]. Each criterion is subdivided into its own attributes, which are arranged at the same level [38], [40], [41]. The highest level of hierarchy in the decision-making process represents the objective (i.e., problem). The subsequent level consists of a series of decision criteria used to solve the problem. Then, attributes are listed under the corresponding decision criteria [24].

1.1.3 Establishing the Priority Weight of the Elements Via Pairwise Comparisons

The purpose of pairwise comparison is to establish the relative importance of items (criteria and attributes) at each level of a hierarchy [41]. On the basis of their own experience and expertise, decision-makers compare all aspects within the same level in pairs in terms of their relative weight of importance [36]. In the paper of Ho, (2008) an example was illustrated as, "every two criteria in the second level are compared with regard to the objective, whereas every two attributes of the same criterion in the third level are compared with regard to the respective criterion" [36]. In order to calculate the associated weights, a survey questionnaire is given to decision-makers in the form of a pairwise comparison matrix for each pairing inside a hierarchical framework [42] [43]. In

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the pairwise comparison given in equation 1, the weight of each factor is measured using Saaty's scale, as seen in Table 1. For the detailed AHP process the research article of Taherdoost Hamed (2017) [42] can be referred.

$$\lambda_{max} = \frac{1}{n} = \sum_{i=1}^{n} \frac{(Aw)i}{\omega_i} \quad (1)$$

n = Comparison number of factors

A = Pairwise comparison matrices

i = 1,2,3……..n

w = Eigen vector

λ_{max} = Maximal eigenvalue

Table 1: The 9-point intensity scale of relative weight (importance or well-being)

The intensity of Relative Importance	**Definition**	**Explanation**
1	Equal importance	Two activities contribute equally to the objective.
3	Moderate importance of one over another	Experience and judgment slightly favor one activity over another.
5	Essential or strong importance	Experience and judgment strongly favor one activity over another.
7	Demonstrated importance	Activity is strongly favored, and its dominance is demonstrated in practice.
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation.
2,4,6,8	Intermediate values between the two adjacent judgments	When a compromise is needed.

Source: [38], [43], [44]

1.1.4 Consistency Check

Saaty, (1990) [45] suggested employing the consistency index (CI) as well as the consistency relation (CR) to find the consistency of comparison matrixes, whereby both the terms CI, as well as CR, are determined as follows:

$$CI = (\lambda_{max}-n)/(n-1) \quad (2)$$

$$CR = CI/RI \quad (3)$$

In the last phase of the AHP, all relative weights that indicate the relative impact of a set of elements on a single element are combined using the set of pairwise comparison

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matrices. AHP further calculates a consistency index (or inconsistency ratio) to indicate the consistency of the decision. Furthermore, λ_{max} represents maximum eigenvalue of the comparison matrix proposed by Saaty, (1990) [45] n is the order of matrix. In the above equation (3) RI indicates random index using the following table 2 where *n* indicates the order of matrix [46]. The consistency check is performed to check the consistency of the survey data, which denotes the value ≤ 0.1 [43] [44][47].

Table 2. The value of 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

Source: [45] [47]

1.1.5 Ranking and Selecting an Optimal Element

The last step of the AHP aggregates all relative weights of different domains to calculate the global weights. Here, “global weights for each element (i.e., attribute or alternative) are synthesized from the second level down by multiplying the relative weights by the corresponding criterion (or alternative) in the level above and adding them for each element at a level based on the criterion (alternative) it affects” [48]. Consequently, the discovered global priorities are utilized for the final ranking of the criteria, attributes, and choices, as well as the selection of the ideal option for each.

2 METHODOLOGY

This study investigates how to use the AHP to find suitable locations for vegetable vendors. In this regard, the study’s workflow approach is described. The AHP can be applied to any decision-making procedure with several quantitative criteria if these criteria can be organized hierarchically. According to this description, the AHP appears to cover nearly all decision-making processes [44].

2.1 Criteria Description

The attributes considered in establishing locales for vegetable vendors are shown in Figure 2: roadside dumping, type of road, accessibility, street lights, land use, water supply, and waste disposal, type of parking, drainage, parking space, and population count. The selection of criteria may change from one study to another based on the study area. The criteria were divided into four main groups: access, environment, infrastructure, and population. For the present study, four criteria and eleven attributes were determined for location identification of vegetable vendors, these are described hereunder:

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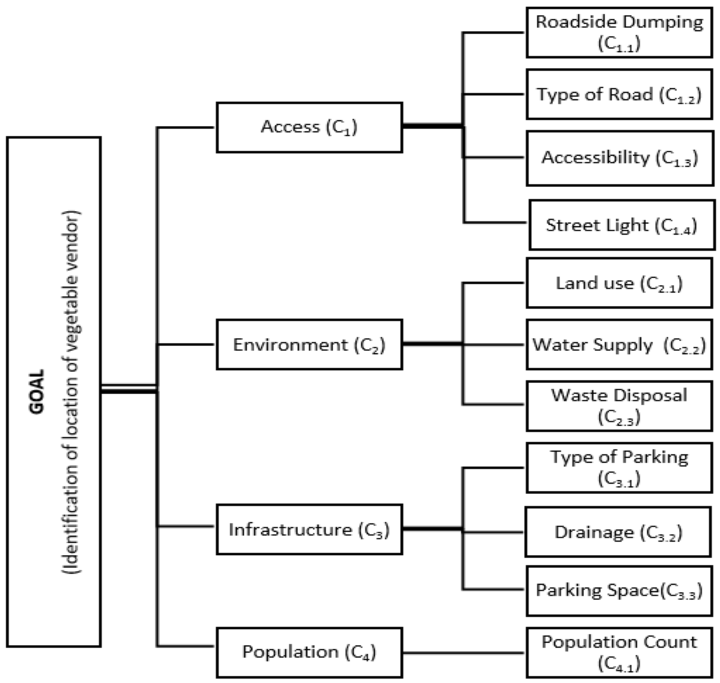

Fig. 2. The research model and AHP structure for identifying locations for vegetable vendors.

Source: Authors, 2023

Access

Access, as a criterion, is very important for this study. The attribute of roadside dumping entails the illegal dumping of waste, which is associated with the vendor's location being unhealthy. Also critical is road type: arterial, sub-arterial, collector, and local. Accessibility, as an attribute, involves the approach to the vendor's location. Street lights define the availability of light when needed and where the vendors establish themselves.

Environment

Environmental considerations are extremely relevant in site location. We used the three attributes of land use, water supply, and waste disposal in our analysis. Land usage is critical for determining ideal locations for vegetable vendors. Major land use consists of residential, commercial, mixed use, and industrial. It is vital that vegetable vendors have nearby access to water. The vending space is also used to wash and dispose of waste daily, so availability of waste disposal facilities relates to convenience for vendors.

Infrastructure

The infrastructure is a criterion that defines the vegetable vendor's location facilities. The type of parking defines vehicular space availability. The drainage line has some space above it which is usually covered, which is sometimes used by vendors to sit. Parking space for one's vehicle is the most important attribute and also determines the location

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[49].

Population

According to Turhan et al., [50], [51], the most important variable for a vendor is the demographic structure of the market in a potential location. Population information is necessary so the vendor may decide if it matches his/her target market [50]. Therefore, it is critical to analyze the potential location's population count and characteristics.

2.2 Data Collection

The data collection phase involved identifies specific locations for vegetable vendor. A questionnaire survey was administered to acquire sample data for the study. A total of 60 academics and experts were selected to participate belonging to Indian different cities. Out of the 60 experts, 45 responded to our questions with a 75% response rate. These respondents were required to evaluate the relative performance of diverse parameters concerning the ultimate purpose of selecting a location for vegetable vendors. For instance, when asked, "In regard to roadside dumping and road type, which is more significant?", equal importance was assigned to the relative position scaling (see Table 3). Table 3 is the primary questionnaire design for pairwise comparison assessment. After implementing pairwise comparisons, the pairwise matrix was constructed. In addition, the pairwise comparison method was applied to all data. The primary datasets were collected using both online and offline Google forms, depending on the experts' availability.

Table 3: The primary questionnaire design: Efficient criteria and pairwise assessment.

Factor	Factor weighting score																	Factor
	More important than								Equal	Less important than								
L1	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	L2
L2	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	L3
L3	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	L1

Source: [29]

3 RESULTS AND DISCUSSION

At this phase, the hierarchical structure of the model's criteria and attributes at each level were compared. Thus, binary benchmarking matrices for each criterion and attribute were constructed. Each criterion was compared to itself in each of these matrices; there is a continuous 1 on the diagonal of the comparison matrix shown in tables 4 and 5. Below is a representation of one of the matrices for each criterion. Similarly, another matrix was solved and global weights were calculated. The weight of each criterion was determined using the comparison matrix of the criteria outlined in Table 4; the outcome of the calculations, which the evaluator assessed for the criteria, was smaller than 0.1.

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Table 4. Pairwise comparison matrix of the criteria

Criteria	Access	Environment	Infrastructure	Population	Weight (w_c)[1]	Consistency ratio
Access	1.00	0.50	3.00	0.25	0.16	0.098<0.1 Matrix is consistent
Environment		1.00	5.00	0.50	0.30	
Infrastructure			1.00	0.33	0.09	
Population				1.00	0.45	

Source: Authors

Below in Table 5 is a matrix access attributes showing the pairwise comparison of attributes. Whereas, the additional matrices were solved for the calculation of the global weight.

Table 5. Pairwise comparison matrix for the attribute of access

Criteria	Roadside dumping	Type of road	Accessibility	Street lights	Weight (w_a)[1]	Consistency ratio
Roadside dumping	1.00	0.11	0.17	0.13	0.04	0.090<0.1 Matrix is consistent
Type of road		1.00	7.00	2.00	0.53	
Accessibility			1.00	0.25	0.12	
Street lights				1.00	0.31	

Source: Authors

Table 6 illustrates the consistency ratio of all criteria and attributes. The consistency ratio for 45 experts was calculated and the mean values were considered for the final consistency ratio. The consistency ratio value for the attribute of access was 0.090 and that of the environment was 0.098; that of the infrastructure was 0.097. The criterion of population only had one attribute, so the consistency ratio was not defined. The overall consistency ratio for the criteria was 0.098. Hence, the values were <0.1, so the data are consistent.

For this study, selecting the criteria and attributes was a critical step. To choose ideal locations for vegetable vendors, access, environment, infrastructure, and population must be considered. When criteria are selected and evaluated for any city, the international literature should be taken into account.

Table 6. Consistency ratio table for the criteria

Level	Consistency ratio	Consistency test
Goal Criteria	0.098	Accepted (<0.1)
Access	0.090	Accepted (<0.1)
Environment	0.098	Accepted (<0.1)
Infrastructure	0.097	Accepted (<0.1)

Source: Authors, 2023

Using the AHP model, the local weights for the criteria and attributes were calculated, as

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illustrated in the above matrices in tables 4 and 5 for each expert. Table 7 depicts the local weights of criteria and attributes (e.g., W_1 and $W_{1.2}$). The global weights were calculated by multiplying the local weights W_1 and $W_{1.2}$. In the table 4 and 5 the weights explained are one pairwise comparison matrix. Similarly other 44 matrix were also solved similarly to get the global weights described in table 7. The ranking was performed based on global weights. The most important attribute after calculating the global weights was population count at 0.384. The second highest attribute was 0.163. The third most important attribute was accessibility at 0.082. Other attributes were waste disposal (0.075), type of road (0.071), parking space (0.070), drainage (0.054), street lights (0.050), and type of parking (0.029). The least important attributes were roadside dumping (0.011) and water supply (0.009). These are the final criteria and attributes required to identify suitable locations for vegetable vendors.

Table 7. Overall weights of criteria and attributes for identifying locations for vegetable vendors

Criteria	Local Score (W_1)	Attributes	Local Score ($W_{1.2}$)	Global Weights W_3^2	Ranking
Access (C_1)	0.215	Roadside Dumping ($C_{1.1}$)	0.053	0.011	10
		Type of Road ($C_{1.2}$)	0.330	0.071	5
		Accessibility ($C_{1.3}$)	0.383	0.082	3
		Street Light ($C_{1.4}$)	0.235	0.050	8
Environment (C_2)	0.293	Landuse ($C_{2.1}$)	0.559	0.163	2
		Water Supply ($C_{2.2}$)	0.184	0.054	7
		Waste Disposal ($C_{2.3}$)	0.257	0.075	4
Infrastructure (C_3)	0.109	Type of Parking ($C_{3.1}$)	0.268	0.029	9
		Drainage ($C_{3.2}$)	0.084	0.009	11
		Parking Space ($C_{3.3}$)	0.648	0.070	6
Population (C_4)	0.384	Population Count ($C_{4.1}$)	1	0.384	1
Total	1			1	

Source: Authors

From the Table 7 it has been identified that the ranking of the attributes is determined through the multiplication of local score of criteria with local score of attributes. As can be observed that the population criteria have the highest weight with 0.384 when multiplied with attribute population count weight 1 it comes out to be the highest-ranking weight. Similarly other attributes were ranked and the global weights were calculated. The second highest local score criteria was environment 0.293 and when it was multiplied with landuse it comes out to be the second highest global weight with ranking 2. As the local score of the criteria is important in the ranking and global weight calculation, it changes the hierarchy of the attributes.

4 CONCLUSION

The study aims to identify the location criteria and attributes of street vegetable vendors using AHP method for calculating weights. The findings of their study suggest population

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as the most essential criteria for location selection of the vegetable vendors. Due to the considerable visitor numbers, the vegetable vendor likes to establish a presence in regions where the nearby population is dense. Also, they expect more sales in these areas.

In this context, this article has emphasised the significance of choosing the weights of criteria, as the suitability of location selection differs with varied weights. In addition, the significance of our contribution resides in the intersection of all location selection appropriateness indicators, in contrast to earlier research.

Apart from this, the second most important criteria is environment following access and infrastructure. In addition to the lack of information on applying the AHP when identifying locales in the informal sector, we also observed how changes in certain criteria can affect the location of street vegetable vendor.

The model can be used by planners or administrators to determine suitable locations using the appropriate criteria and attributes for the vegetable vendors. Future research areas can be explored with the help of technologies such as the geographic information system (GIS), artificial intelligence, the global positioning system (GPS), machine learning, neural networks, and the analog approach, which are reliable and efficient.

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