Risk Possibility of Plane trees in Chahār Bāgh Abbasi Street of Isfahan

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Abstract— *Trees are one of the most critical indicators in green space and urban forestry planning. Knowing information about street trees is of paramount importance for proper planning and management. Any defect that causes trees to be hazardous can result in dangers to humans and vehicles. For this reason, qualitative and quantitative features and the risk potential of Oriental Plane (Platanus orientalis L.) trees on both sides of Chahār Abbasi Street and part of Chahār Bāgh Paeen Street, Isfahan, were investigated using the point transect method with a random starting point. Results showed that two criteria of deviation from a vertical position (62%) and root problems (44%) have the greatest contribution to hazard creation. Sixty-three percent of surveyed trees were classified as very low-risk trees. By selecting the most suitable tree species, taking preventive measures prior to the incidence, and applying proper management techniques, we can avoid the hazards of these trees to a large extent.*

Keywords— Urban Forestry, Oriental Plane, Urban Management, Isfahan, Risk Possibility.

I. INTRODUCTION

As one of the most important development indicators of urban communities, green space has various functions in different dimensions of urban life, including air softening, shading, and reducing heat (Akbari & Dorsano, 1992), reducing noise pollution (Nowak, 1992; 48), decreasing water and soil erosion (Colding, 2007), creating physical privacy fences (Tang et al., 2007), developing tourism industry and creating beautiful landscapes (Fung & Wong, 2003). First and foremost, urban space is a geographical space that is determined by distances, areas, and densities. Urban green spaces have social, economic, and ecological roles; they have benefits such as treating diseases, and at the same time, they are considered as an indicator for promoting the quality of living space and improving community (Nahibi & Hasandokht, 2014). Among important debates on urban streets are green space and green space aesthetics. Due to its environmental values, urban green space is one of the most important characteristics of each city such that the first step in planning and managing urban green space is to know information about street trees (Pourmajidian et al., 2014, Nafian et al. 2019). Urban green spaces play a main role in the function of cities, and their shortage can cause disturbances in urban life (Mohammadi et al., 2007). Today, hazard trees are of particular importance in the management of urban forests. Hazardous trees are often neglected unless damage occurs due to their hazard (Mortimer & Kane, 2004). Additionally, we cannot separate the hazardous and non-hazardous trees regularly since most trees are potentially hazardous (Harris, et al, 1999). Always large numbers of people and vehicles pass by hazardous trees, and if these trees are damaged and broken for any reason, they will directly damage people, vehicles, and facilities adjacent to them (Pourhashemi et al., 2012; Pourmajidian et al., 2014, Nafian et al. 2020).

Oriental Plane (*Platanus orientalis* Linn.) is one of the most ancient and oldest trees that have received attention from all ethnic groups and different nations, especially Iranians (Sharifinia, 1992). Having unique characteristics such as great stature, well-shaped branches, wide crown, and broad shadow, the Plane tree has created beautiful landscapes and is considered one of the important and effective factors in green space (Khoshgoftarmanesh, 2007). The large size, beauty, and rapid growth rate of the Plane tree have made it the first choice for streets margin in many parts of Iran (Mortimer & Kane, 2004; Roohani, 2005;

Shiravand & Rostami, 2009). Additionally, the presence of plane trees of great antiquity in most streets of Isfahan city indicates the history of using these trees in creating urban green space (Khoshgoftarmanesh et al., 2013). Pourhashemi et al. (2012) assessed the hazardous oriental plane (*Platanus orientalis* Linn.) trees on Valiasr Street in Tehran. Results showed that dead branches and twigs and structural weakness have the greatest contribution to hazard trees while unsuitable branching and decay are the least important criteria. Assessing hazardous Plane trees in Babol city, Pourmajidian et al. (2014) found that dead branches and twigs and root problems criteria had the greatest contribution to hazard. In a case study conducted in Shahrekord city, Moradian et al. (2016) investigated the hazard of Elm (*Ulmus carpinifolia var. umbelifera*) trees planted on the verge of the streets. Results showed that dead branches and twigs and structural weakness in 49% and 39% of the whole trees had the greatest contribution to hazard potential in trees, respectively, while the existence of cracks in the trunks was the least important criterion. Finally, it was recommended to take corrective and care measures such as crown and dead branches pruning. Banj Shafiei et al. (2015) also sought to determine the quantitative and qualitative characteristics and the level of risk posed by Plane trees in Urmia city. In their study, which was conducted based on risk factors rating, 18 trees with moderate risk ratings were identified. Today, in different developed countries, criteria for diagnosis and identifying hazardous trees have received a lot of attention from environmental and urban green space researchers (Golkar, 2001; Pourhashemi et al., 2012: Albers et al, 1992: Kane, 2008; Kong, 2000; Laflamme, 2005; Maruthaveeran & Yaman, 2010; Murad, 2000; Roloff et al., 2009; Yang, 2009).

Investigating the level of risk posed by urban trees in Chahār Bāgh Abbasi Street and part of Chahār Bāgh Paeen Street, Isfahan, is of paramount importance. Given the necessity of awareness of hazards posed by street trees as one of the prerequisites for their proper management and the importance of Plane tree as one of the largest and oldest trees from past to present, attempts were made to identify the hazardous Plane trees in Isfahan city and investigate the level of risk posed by them in the above-mentioned region for the first time so that in addition to identifying and investigating these trees, urban forestry of Palm trees can be managed in a better way.

II. METHODS AND MATERIALS

2.1 The study area

The study area, in Isfahan province, Isfahan city, is situated between the latitudes 30° 43' to 34° 27' N and longitudes 49º 36' to 55º 31' E of Greenwich Meridian. Isfahan province is located in the central part of Iran (Fig. 1). After field visiting and observing the number of oriental Plane trees, Chahār Bāgh Abbasi Street and part of Chahār Bāgh Paeen Street, Isfahan, were divided into four regions, including 1- between Enghelab square and Sed Ali Khan street, 2- between Sed Ali Khan street and Amadegah street, 3- between Amadegah street and Imam Hossein square (Darvazeh Doulat)**,** 4- between Imam Hossein square and Takhti crossroad.

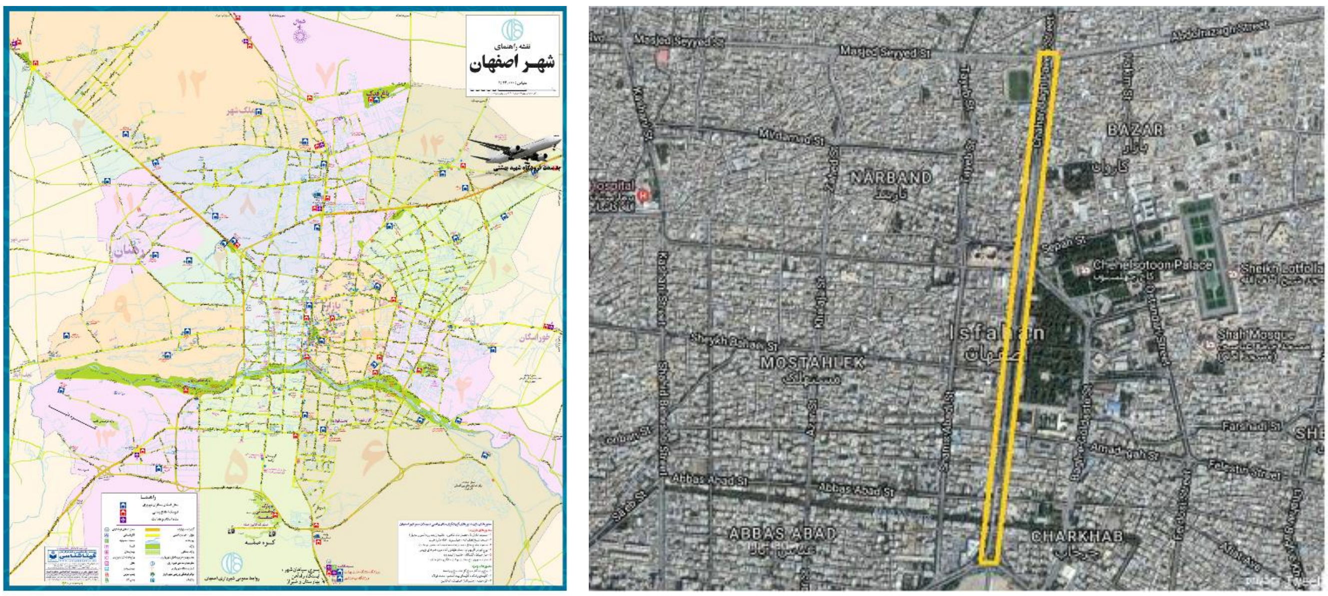

FIGURE 1: Geographical location of the study are

2.2 Methodology

In order to measure and record quantitative and qualitative variables, point transect method with random starting point was used. At first, of the first three trees one was selected randomly, and measurements were carried out every three trees.

For each tree, the diameter at breast height (DBH) and total height were measured. In order to determine the level of hazard posed by trees, the following classification was used (Pourhashemi et al., 2012).

1) Dead branches and twigs (low risk: sub-branches and twigs are dried, moderate risk: the tree crown, including thick and main branches is dried, in a way that about one third to two third of the crown is dried, high risk: the tree crown is completely dried).
2) Crack (low risk: thick branches are cracked, moderate risk: there is a deep gap in the main trunk of the tree and this gap is seen in a large length of the trunk or there is two or more gaps in a certain part of the tree, high risk: on the trunk gap or crack site there is other defects such as decay or disease).
3) Poor branching (low risk: forking in main trunk, moderate risk: multi-stemming in main trunk, high risk: there are other defects such as dead branches in the forking or multi-stemming trees).
4) Decay of the main trunk and branch (low risk: the presence of advanced decay in main thick branches, moderate risk: the presence of advanced decay in the main trunk, high risk: there are other defects such as gap or crack, forking trunk or multi stemming trunk on the site of advanced decay in the main trunk).
5) Wound (low risk: the wound perimeter is less than 10% of the entire trunk perimeter, moderate risk: the wound perimeter is greater than 10-30 % of the entire trunk perimeter, high risk: the wound perimeter includes more than 30 % of the entire trunk perimeter and on the wound site there are other defects such as gap or hole due to living and non-living things), (DBH: d, tree perimeter: C, $C = d \times \pi$)
6) Root problems (low risk: food shortage symptoms which emerge as paleness, burn, or color change in leaves, moderate risk: advanced decay is observed on roots and buttresses, high risk: more than half of the roots under the tree crown have been cut or crushed, or exposed roots)
7) Structural or physical weakness (low risk: a large and main branch is out of proportion with crown leading to an imbalance in the crown and crown asymmetry, moderate risk: the tree is slightly tilting/leaning (vertical deviation of 15 - 30 degrees), and/ or slenderness coefficient is 80-100, high risk: the tree is too much tilting (more than 30 degree) and/or slenderness coefficient is more than 100).
8) Interfering with power lines (low risk: power lines are placed 10 meters from the tree, moderate risk: power lines cross the nearby of the tree crown at a distance about 2-3 m, high risk: power line are adjacent to the crown, or pass along or through the crown).

In order to investigate the risk posed by trees, rating method was used such that the score values were assigned to each criterion in terms of its rating (High=3, Moderate=2, Low= 1) and the sum of the above scores for the above eight mentioned criteria was analyzed. Then the hazard score for each tree was determined. Considering the intended criteria, this score was between 0 and 24. Therefore, the higher the score, the greater the hazard potential of the tree was. After that, based on the obtained scores and in accordance with empirical classification, they were classified in 6 hazard classes (table 3) and the trees distribution in hazard classes was determined (Pourhashemi et al., 2012; & Pourmajidian et al., 2014, Ghehsareh Ardestani et al. 2020).

III. RESULTS

Descriptive statistics of quantitative variables for 144 Oriental Plane trees are presented in Table 1. Also, hazard criteria and their degree of importance in the studied trees are displayed in Table 2.

TABLE 1
DESCRIPTIVE STATISTICS -MEASURED QUANTITATIVE VARIABLES

Height m		DBH cm	
Mean	**Standard deviation**	**Mean**	**Standard deviation**
9.1	1.41	30.53	8.03

TABLE 2
HAZARD CONTRIBUTION OF ORIENTAL PLANE TREES

Hazard Criterion	Degree of importance	Hazardous trees		Number of healthy trees in the class of the investigated criterion
		Nr.	%	
Dead branches and twigs	Fully dried	-	-	96 (66%)
	More than 2/3 dried	-	-	
	1/3-2/3 dried	8	6	
	Less than 1/3 dried	40	28	
	Sum	48	34	
Trunk gap	Deep gap or crack	3	2	(%96) 139
	2 or more gaps in the trunk	-	-	
	Gap or crack in the main thick branch	-	-	
	The presence of other defects on the crack site	2	2	
	Sum	5	4	
Deviation from a straight line or vertical position	More than 30 degrees	36	25	(%38) 55
	15-30 degrees	20	14	
	5-15 degrees	33	23	
	Sum	89	62	
Deviation to the sides	Deviation toward street	88	61	
	Deviation toward building	56	39	
Root problems	Due to tree tilting/leaning some roots are coming out of the soil (exposed roots)	14	10	(56%) 80
	more than half of the roots under the tree crown have been cut or crushed	12	8	
	advanced decay is observed on roots and buttresses	15	10	
	Paleness and food shortage in the leaves	23	16	
	Sum	64	44	
Advanced decay	Decay in the main trunk	10	6	124 (88%)
	Decay in the thick branches	10	6	
	Sum	20	12	
Wound on the trunk and root	The wound perimeter is greater than half of the trunk perimeter	8	6	(%85)123
	The wound perimeter is less than half of the trunk perimeter	13	9	
	Sum	21	15	
Interfering with power and phone lines	In contact with power lines and telephone	5	3	(97%) 139
	Nearby power lines and telephones	-	-	

Results obtained from Table 2 show that among investigated hazard criteria, two criteria of deviation from a straight line (62%) and root problems (44%) had the greatest contribution to hazard, respectively. On the other hand, contact with power and telephone lines (3%), trunk gap or crack (4%), advanced decay (12%), wound on the trunk and root (15%), and dead branches and twigs (34%) had the lowest contribution to hazard, respectively.

TABLE 3
CLASSIFICATION OF THE LEVEL OF HAZARD POSED BY THE INVESTIGATED ORIENTAL PLANE TREE

Class code	Hazard score	Hazard situation	Trees percentage	Number of trees
1	0	Safe	15.27	22
2	5-Jan	Very low risk	63.2	91
3	10-Jun	Low risk	21.53	31
4	15-Nov	Moderate risk	0	0
5	16-20	High risk (hazardous)	0	0
6	21-24	Very high risk (extremely hazardous)	0	0
		Sum	100	144

Results of Table 3 show that 63.20% of surveyed trees are classified under the very low risk class. Additionally, results show that no tree with moderate risk, high risk (hazardous), and very high risk was placed in the hazard criterion classification.

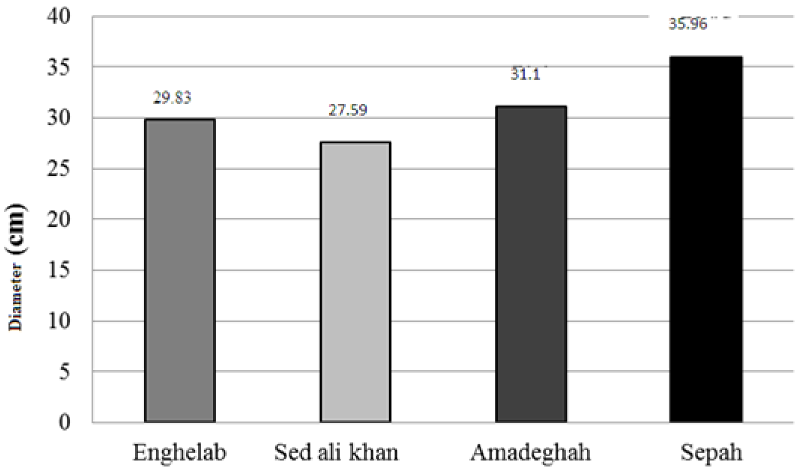

FIGURE 2: The mean DBH of trees in the investigated regions

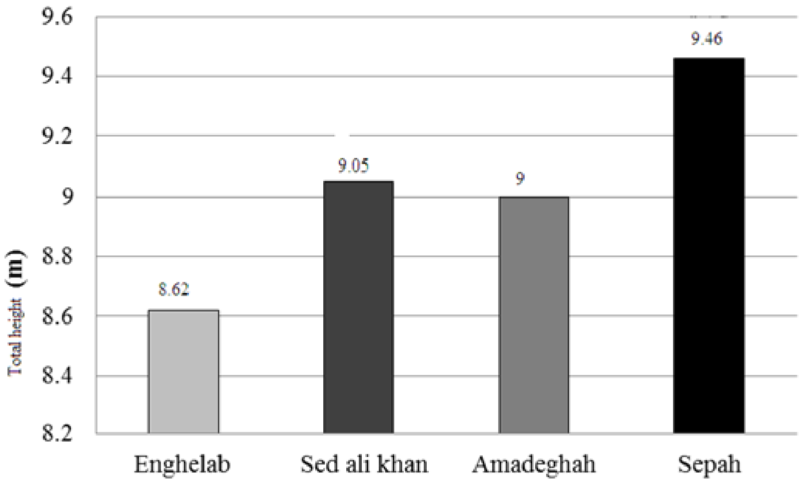

FIGURE 3: The mean total height of trees in the investigated region

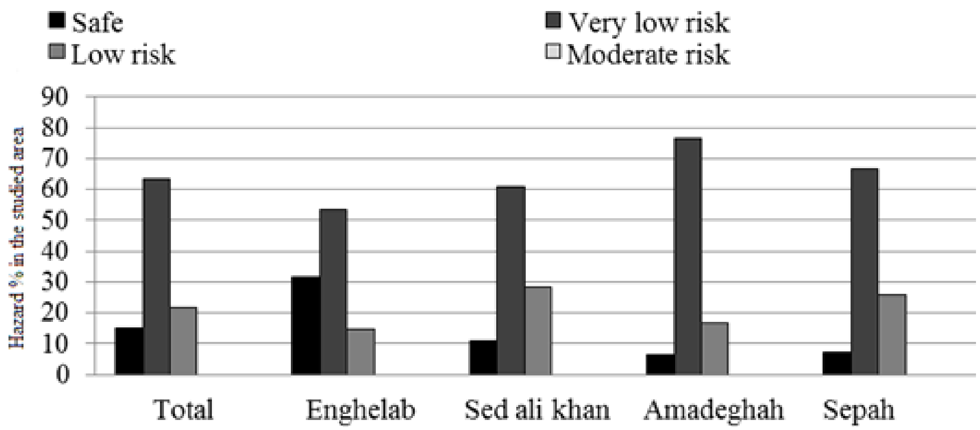

FIGURE 4: Hazard percentage of trees in the studied area

IV. DISCUSSION

Today, one of the important issues in the urban streets debate is the green space with its aesthetics. We need to pay more attention to green space and urban trees and even urban forestry and their positive effect (Panahi et al., 2003). The qualitative and quantitative information and characteristics of street trees help us plan for future. In addition, street trees are among the most important building blocks of urban green coverings. In many cases, individuals are unaware of the hazards associated with defective trees and damage caused by them (Pourmajidian et al., 2014). Therefore, it is necessary to investigate the hazard status of trees in hazard classes. This issue has received a lot of attention in many developed countries across the world (Golkar, 2001). According to the results of quantitative variables analysis in this study, the mean height of Oriental Plane trees (Table 1) is 9.1 m and the mean DHB is 30.53 cm. Overall, the old Oriental Plane trees have larger height and diameter. As Oriental Plane trees in Isfahan city have also a long history, their height and diameter values are mainly greater than the measured value. However, due to the fact that only 144 trees were randomly investigated, the height and diameter values are less than expected. Additionally, as shown in Table 2, among hazard criteria investigated, 2 criteria of deviation from a straight line (62%) and root problems (44%) had the greatest contribution to hazard, respectively. In the results of their research, Sabo et al. (2005) stated that trees planted between tall buildings suffer from shortage of light throughout the day. Marvi Mohajer (2011) also stated that the crown of trees planted on the verge of narrow streets of cities and industrial regions with tall buildings on both sides, tend to lean toward the middle of the street to get more light (figure 5).

FIGURE 5: Oriental Plane tree's deviation toward street in the studied area

FIGURE 6: Root problems of Oriental Plane tree in the studied area

Among other important hazard criteria in this study are root problems which have a high contribution to hazard. The most important root problems include a wide range of problems from roots coming out of the ground, to cut roots, root decay, and buttresses coming out of the ground, and finally the weakness and paleness of leaves due to root problems (Pourhashemi et al., 2012& Pourmajidian et al., 2014). Additionally, exposed roots can cause damage to the pavements and lead to their detachment (Fig 6), this will double the financial burden of the street (Pourhashemi et al., 2012).

Contact with power lines (3%), trunk gap or crack (12%), advanced decay and wound on the trunk and root (15%) are among other important hazard criteria which have the least contribution to hazard in the study area, respectively. Of course, the existence of advanced decay (12%) is not considered to be a low important factor, because lots of decays occurred in trees are internal decays of trunk and root. If these defects are accompanied by other hazard criteria, they will be extremely hazardous (Banj Shafiei et al, 2015 & Marvi Mohajer, 2011). Additionally, the results shown in Figures 2 and 3 in four study areas showed that the mean height (35.96 cm) and DBH (9.46 m) in the last area in Sepah Street were larger than other three areas. In Fig 5, the level of risk posed by trees in all four areas has been generally assessed. The safest area in terms of hazard is the area between Enghelab Street and Sed Ali Khan. The area between Sed Ali Khan and Amadegah was rated to be a low risk area. If the hazard criteria of these trees are accompanied by factors associated with internal decay, they will become extremely hazardous. This is while trees with moderate risk and high risk were not located in this area. Street trees are of paramount importance and it is very important to investigate and prevent events that are likely to occur by hazardous trees. Generally, there are three main ways to manage hazardous trees in urban environments: keeping away the target from hazardous tree (which is possible only for moving targets such as vehicles); taking proper corrective actions and repairing tree, and at last stage tree removal or cutting down, this is done when tree is extremely hazardous and it is not possible to change, correct, fix or repair the situation (Pourmajidian et al., 2014; Fazio, 1989; Kong, 2000; Robbins, 1986; 28, & Smiley et al., 2007). The necessity to prune or cut down the hazardous urban trees is far easier to prove than the benefits of caring them, because their presence may cause the tree to collapse suddenly (Pourmajidian et al., 2014). Therefore, considering the importance of the topic of this research, it is suggested that future research consider criteria such as the precise identification of destructive fungal pathogens and diseases of these trees. It is also suggested that during the risk assessment process some forms be prepared to record and investigate information such as problems caused by the mentioned tree for residents of the region. Additionally, urban planners should pay attention to choose the best tree species to be planted on the verge of the streets and apply the best management technique.

V. CONCLUSION

In this study the risk possibility of rate of risk possibility of oriental plane (Platanus orientalis L.) trees of Chahār Bāgh Abbasi Street of Isfahan were evaluated using transect method with random start point. Overall, results indicated that deviation from vertical position (62%) and root problems (44%) have the highest contribution to hazard creation. Applying some amending processes such as crown pruning and cutting of dead branches of the trees are proposed.

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