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EXPECTED UTILITY AND RISK CONSIDERATIONS IN URBAN TREE MANAGEMENT: THE ROLE OF DECISION-MAKING DETERMINANTS

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Abstract

This study examined how key decision-making determinants influence urban tree retention and removal decisions in Malaysian development areas. Drawing upon the Expected Utility Theory (EUT), data were gathered through a structured survey involving 265 practicing landscape architects. The exploratory factor analysis (EFA) revealed two key dimensions of expected decision outcomes—utility maximisation and risk avoidance. Multiple regression analyses further indicated that considerations such as cost–benefit considerations, spatial and project limitations, institutional guidelines, social perception, tree characteristics, and resource availability all play significant roles in influencing these outcomes. Retention decisions were driven by long-term benefits and risk avoidance, whereas removal decisions emphasised cost efficiency, project feasibility, and institutional requirements. Overall, the findings suggest that managing urban trees effectively requires balancing practical benefits with risk considerations, supported by expert judgement and stronger policy frameworks for tree conservation.

Keywords: Decision Making, Expected Utility Theory, Urban Trees, Development Area

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INTRODUCTION

Urbanisation is advancing rapidly across the globe, intensifying the tension between the demand for new infrastructure and the preservation of urban green spaces. Trees in cities serve multiple ecological and social functions—they moderate the microclimate, support biodiversity, enhance public well-being, and contribute to cultural identity. Yet, despite these well-established benefits, many urban development projects continue to result in large-scale tree removal. The absence of a consistent and integrated decision-making framework for determining whether trees should be retained or removed remains a major challenge (Conway, 2016; Hassan et al., 2024; Hilbert et al., 2019; Jim, 2017; Kronenberg, 2014; Maidin & Mobarak Ali, 2009; Suliman et al., 2021). In Malaysia, this issue has become increasingly visible as rapid urban expansion places pressure on balancing development objectives with the conservation of existing trees. Previous studies have highlighted the ecological and social importance of urban trees, but decisions are often shaped by economic, spatial, institutional, and social constraints. Expected Utility Theory (EUT) provides a useful framework for understanding how decision-makers evaluate uncertain outcomes by weighing potential benefits against perceived risks. The theory was first formalised by von Neumann and Morgenstern (1944) and later refined by Mongin (1997) to address behavioural and contextual dimensions of rational choice. While Expected Utility Theory has been extensively used in economics and risk management, its application within urban forestry and planning remains limited.

Accordingly, this study pursued two main objectives. The first was to identify and validate the dimensions of expected decision outcomes—utility maximisation and risk avoidance through Exploratory Factor Analysis (EFA). The second was to examine how key determinants of decision-making, including cost–benefit considerations, institutional influences, social perceptions, spatial and physical environment factors, tree characteristics, survivability, project factors, and resource availability, shape retention and removal decisions using multiple regression analysis. Beyond its theoretical contribution, this study extends the application of Expected Utility Theory within the Malaysian development context and contributes to the growing literature on urban tree management. The study also sought to offer practical insights to support policy formulation, planning guidelines, and professional practice among landscape architects, local authorities, and developers. By providing empirical evidence on how benefits and risks are assessed in urban tree management, the research aimed to strengthen evidence-based decision frameworks and encourage more sustainable tree conservation practices in Malaysian cities. The following sections of this paper review the relevant literature and theoretical foundations,

describe the research methodology, present the findings, and discuss their implications for policy and professional practice.

LITERATURE REVIEW

Urban trees provide multiple ecosystem services, including shading, air purification, stormwater control, microclimate regulation, and aesthetic enhancement, and cultural identity while fostering biodiversity and public well-being (Jones & Cloke, 2002; Maleknia & Pakravan-Charvadeh, 2025; O'Brien et al., 2022; Wolf et al., 2020). However, these benefits are often disregarded during urban development, where trees are perceived as physical or financial constraints (García, 2025; Willis et al., 2024). Determinants influencing urban tree decisions can be categorised into several groups. Economic factors include the costs of tree protection, maintenance, or removal, as well as the long-term benefits such as increased property value (Beuschel & Rudel, 2010; Conway, 2016; Song et al., 2018). Trees are more likely to be retained when removal costs are high or replacement planting is expensive, whereas removal can be justified when it supports efficiency, safety, or other project gains (Nik Mohamed Sukri et al., 2022). Closely related are spatial and project-related factors, which involve site suitability, underground conditions, and compatibility with development designs. Previous studies have shown that tree retention is facilitated when projects incorporate layout planning to integrate trees into design concepts, despite enhancing ecological and aesthetic values (Nik Hanita, 2012). Conversely, space constraints, narrow frontages, and infrastructure access requirements often drive tree removal (Croeser et al., 2020; Guo et al., 2018, 2019; Lavy & Hagelman, 2017; Morgenroth et al., 2017). Institutional determinants further shape decision outcomes through laws, guidelines, and compliance requirements. While tree inventories, protection lists, and enforcement mechanisms can strengthen retention, weak legislation, ineffective penalties, and limited regulation on private land often undermine protection (Clark et al., 2020; Guo et al., 2019; Ordóñez-Barona et al., 2021).

Regulatory and socio-cultural contexts further influence tree management issues in Malaysia. For example, Hamzah et al. (2017) examined urban dwellers' applications for tree removal in Kajang, revealing that cost implications, space limitations, and lack of enforcement contribute significantly to removal decisions. Local planning guidelines (PLANMalaysia, 2021) also show that weak implementation of tree protection bylaws and insufficient arboricultural expertise hinder consistent decision-making. Complementing these are social factors, which reflect the role of public perceptions, community participation, and expert involvement. Awareness of tree protection policies, socio-economic conditions, and cultural values all influence stakeholder attitudes toward tree retention, with arborists and landscape architects often serving as

mediators, while public protests or community support may sway decisions (Conway & Bang, 2014; Danquah et al., 2023; Ordóñez-Barona, 2017). Biological and survivability factors also play a key role, including species, age, health, and structural condition. Mature, healthy, or culturally significant trees are often prioritised for retention due to their ecological and social value, whereas unsafe, diseased, or poorly adapted trees may be removed (Jim, 2005; Morgenroth et al., 2017; Roman et al., 2020). Finally, resource factors reflect the availability of funding, technical expertise, and technology. Financial constraints and insufficient training often limit local authorities' ability to manage trees effectively, leading to removal rather than retention (Brunner & Cozens, 2013; PLANMalaysia, 2021). Altogether, these determinants influence how decision-makers judge whether trees should be retained or removed when outcomes are uncertain. In this study, the Expected Utility Theory (EUT) provided the theoretical foundation for understanding this evaluation process. The theory explains decision-making as a balance between two key considerations: utility maximisation and risk avoidance. Utility maximisation reflects the pursuit of optimal benefits—such as economic gains, project efficiency, and value enhancement—when determining whether to retain or remove trees. In contrast, risk avoidance focuses on reducing potential losses and uncertainties related to safety hazards, maintenance costs, or ecological degradation. By weighing these two aspects, decision-makers aim to reach a rational, benefit–risk–based judgement under uncertain conditions.

METHODOLOGY

Study Sample and Data Collection

This study adopted a quantitative survey design to examine decision-making determinants in urban tree retention and removal in Malaysia. The study population comprised 829 landscape practitioners registered with the Institute of Landscape Architects Malaysia (ILAM) for the 2021/2022 session. Using the Krejcie and Morgan (1970) formula, a minimum of 262 samples was required, and data collection was completed after 265 valid responses were obtained, giving a 77% response rate. A simple random sampling technique was applied to ensure equal chances of selection (Gay & Airasian, 2003). Data were collected using an online questionnaire (Google Form) distributed from March to September 2022 via email, WhatsApp, Facebook, Instagram, and direct emails to registered landscape firms. The questionnaire consisted of four sections: demographics, determinants of retention, determinants of removal, and expected decision outcomes. Fourteen items were developed to measure expected decision outcomes. The determinant constructs were adapted from previous studies related to urban forestry and development planning, covering economic, institutional, social, spatial and physical environment, project-related, biological,

survivability, and resource-related considerations. All items were measured using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The questionnaire items were reviewed by local authority officers (PBT) to ensure contextual relevance and content validity. To minimise potential common method bias, respondent anonymity was maintained and the questionnaire items were presented in a clear and neutral format.

Procedure and Data Analysis

Data analysis was conducted using SPSS Version 26. Normality tests confirmed that the dataset satisfied the assumptions required for multivariate analysis. The analysis involved two main stages. In the first stage, Exploratory Factor Analysis (EFA) with Varimax rotation was performed on 14 items to identify the latent structure of expected decision outcomes. Prior to factor extraction, the suitability of the data for Exploratory Factor Analysis (EFA) was assessed using the Kaiser–Meyer–Olkin (KMO) Measure of Sampling Adequacy and Bartlett’s Test of Sphericity. The KMO value of 0.829 indicated very good sampling adequacy, exceeding the recommended threshold of 0.60 (Hair et al., 2010). Bartlett’s Test of Sphericity was statistically significant [$\chi^2(91) = 1765.335$, $p < 0.001$], confirming sufficient intercorrelations among the variables and supporting the appropriateness of factor analysis. The communalities of the retained items ranged from moderate to high, indicating acceptable representation of the variables within the extracted factor structure. Although several items showed moderate cross-loadings and lower communalities, these items were retained because they remained theoretically important within the Expected Utility Theory (EUT) framework and satisfied the factor loading retention criteria. Reliability analysis was conducted to assess the internal consistency of the extracted constructs. The Cronbach’s alpha values for utility maximisation and risk avoidance were 0.829 and 0.836 respectively, indicating good internal consistency and satisfactory reliability of the measurement scales. Two distinct components emerged, representing utility maximisation and risk avoidance. Item inclusion was guided by factor loadings greater than 0.40 and cross-loadings below 0.40 (Maskey et al., 2018). Mean scores for each extracted factor were computed and subsequently used as dependent variables in the regression analyses.

In the second stage, multiple regression analyses using the stepwise method were carried out to examine how various decision-making determinants predicted these two expected outcomes across both tree retention and removal contexts. The approach was used to identify the most influential predictors for each decision outcome dimension. Prior to regression analysis, diagnostic assessments were conducted to ensure that the assumptions of multiple regression were adequately satisfied. Four regression models were tested: (i) retention and

utility maximisation, (ii) retention and risk avoidance, (iii) removal and utility maximisation, and (iv) removal and risk avoidance. This two-phase analytical process, which combined construct validation through factor analysis with explanatory testing through regression, offered a systematic way to examine how practitioners weigh anticipated benefits against potential risks in urban tree management decisions. Figure 1 presents an overview of the methodological flow, outlining the sequence from data collection and factor validation to regression analysis and interpretation of the decision outcomes.

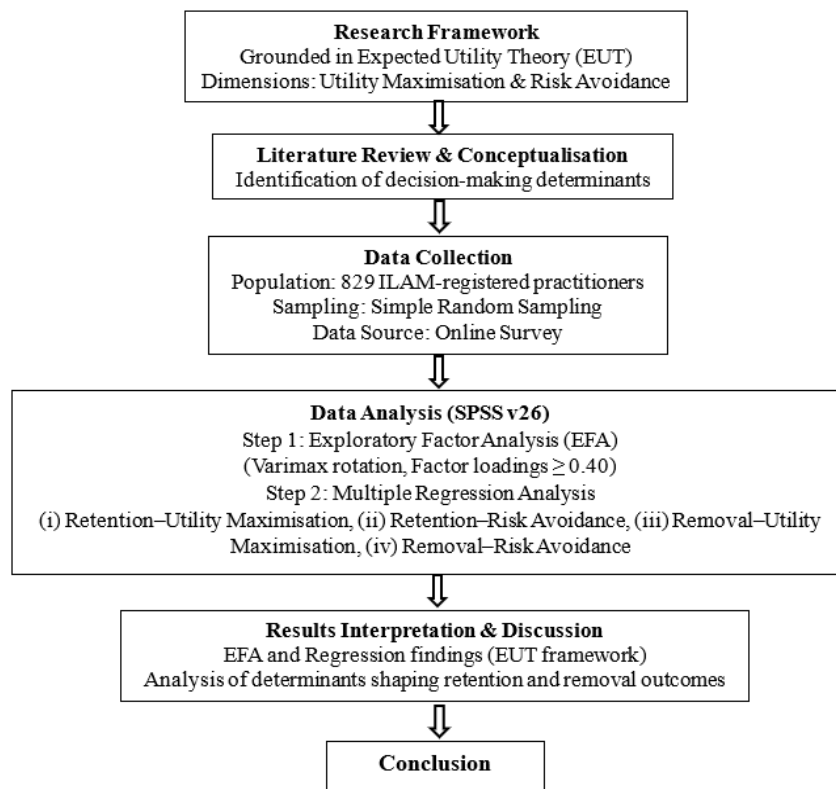


Figure 1: Summary of the research methodology

ANALYSIS AND DISCUSSION

Exploratory Factor Analysis (EFA) of Expected Decision Outcomes

Exploratory Factor Analysis (EFA) with Varimax rotation was conducted on all 14 items measuring expected decision outcomes. The analysis extracted two

components consistent with theoretical expectations, together explaining 53.81% of the total variance. Factor 1 accounted for 43.11%, while Factor 2 explained 10.70% (Table 1).

Table 1: Total Variance Explained by Factors

Component	Initial Eigenvalues	% of Variance	Cumulative %	Rotation Sums of Squared Loadings	% of Variance	Cumulative %
1	6.04	43.11	43.11	3.84	27.42	27.42
2	1.50	10.70	53.81	3.70	26.39	53.81

Inspection of the rotated component matrix (Table 2) showed that items clustered into two groups representing expected outcomes related to utility maximisation and risk avoidance. Although several items demonstrated moderate cross-loadings and lower communalities, no items were removed because they satisfied the retention criteria of factor loadings ≥ 0.40 and cross-loadings < 0.40 . The communalities of the retained items ranged from moderate to high, indicating acceptable representation of the variables within the extracted factor structure.

Table 2: Rotated Component Matrix and Communalities

Expected Decision Outcomes	Utility Maximisation	Risk Avoidance	Communality
Expected outcomes related to utility maximisation			
High costs of tree protection	0.81		0.656
Low financial returns from tree retention	0.80		0.640
Profit from timber sales due to tree removal	0.62		0.384
High maintenance costs of retained trees	0.78		0.608
Retention on high-value property is not worthwhile	0.80		0.640
Expected outcomes related to risk avoidance			
Retention requires additional maintenance work	0.34	0.67	0.564
Retention complicates construction vehicle access		0.63	0.397
Tree care requires expert involvement	0.39	0.43	0.337
Limited protective equipment for retained trees	0.38	0.57	0.469
Trees have difficulty adapting if retained		0.66	0.436
Transplanted trees often fail to survive		0.61	0.372
Trend of tree failure in surrounding areas		0.62	0.384
Retention may endanger public safety		0.76	0.578
Retention may disrupt construction activities		0.66	0.436

Regression Analysis and Interpretation

Multiple regression was used to test the influence of decision-making determinants on expected decision outcomes, separately for tree retention and tree removal. The regression analyses provide insights into how different determinants influence expected decision outcomes in urban tree management.

Table 3: Summary of Multiple Regression Results

Decision Context	Outcome Dimension	Significant Predictors	R ²	F-value (p < 0.05)
Retention	Utility maximisation	Cost and benefit ($\beta = 0.40$)	0.16	50.80
Retention	Risk avoidance	Cost and benefit ($\beta = 0.54$), Spatial and physical environment ($\beta = 0.24$), Social ($\beta = 0.17$)	0.36	48.47
Removal	Utility maximisation	Cost and benefit ($\beta = 0.54$), Project ($\beta = 0.23$), Institutional ($\beta = 0.14$)	0.62	144.06
Removal	Risk avoidance	Spatial ($\beta = 0.66$), Tree characteristics ($\beta = 0.40$), Resources ($\beta = 0.34$), Project ($\beta = 0.21$), Survivability ($\beta = 0.11$)	0.69	112.76

Retention – Utility Maximisation and Risk Avoidance

For tree retention decisions, the analysis showed that cost and benefit, spatial and physical environment, and social considerations significantly influenced the expected outcomes for both utility maximisation and risk avoidance. Among these, cost and benefit were found to be the most dominant predictor of utility maximisation ($\beta = 0.40$, $R^2 = 0.16$, $F = 50.80$, $p < 0.05$), highlighting the importance of economic evaluation in shaping practical decisions. Based on the Expected Utility Theory (EUT), decision-makers tend to pursue the highest benefits while keeping potential losses to a minimum. In this study, such behaviour can be seen in the way practitioners consider financial implications, project feasibility, and social acceptance when deciding whether to retain trees within development sites.

In relation to risk avoidance, the combined influence of cost and benefit, spatial and physical environment, and social factors accounted for 36% of the variance in decision outcomes [$F(3, 261) = 48.47$, $p < 0.05$]. Proper financial planning supports adequate tree protection and maintenance, while spatial and physical environment factors, such as available planting areas and construction access help reduce possible hazards. Meanwhile, social factors like stakeholder involvement and public perception can prevent disputes and strengthen local support for retention efforts. These findings indicate that decisions to retain trees require a balanced consideration of both the expected benefits and the potential risks involved. Viewed through the EUT framework, these two dimensions are closely linked. Cost–benefit evaluations drive decisions that aim for long-term ecological, social, and economic value, whereas risk-avoidance strategies ensure that such benefits are achieved safely and sustainably. In practice, retaining high-value trees—those that contribute to air quality, energy savings, or property enhancement—is only realistic when cost, space, and safety issues are adequately managed. This suggests that tree retention is not a simple matter of cost or convenience, but rather a rational process of weighing trade-offs between

anticipated gains and possible risks, aligning well with the principles of the Expected Utility Theory (Barron et al., 2021; Fazilah et al., 2013; Kellogg et al., 2017; Pryor & Watson, 2016; Shi et al., 2023).

Removal – Utility Maximisation and Risk Avoidance

For tree removal decisions, the analysis identified two related dimensions, namely utility maximisation and risk avoidance, which reflect the complex nature of decision-making described by the Expected Utility Theory (EUT). Three determinants—cost and benefit, project-related factors, and institutional guidelines—were found to significantly predict utility maximisation, explaining 62% of the variance [$F(3, 261) = 144.06, p < 0.05$]. Cost–benefit analysis played a major role in determining whether tree removal would bring net advantages, particularly in cases involving diseased or hazardous trees. Project-related factors contributed to construction efficiency and better site planning, while adherence to institutional requirements ensured that removals followed legal and environmental standards. These findings are consistent with earlier studies that highlight the importance of economic reasoning and regulatory compliance in achieving optimal development outcomes (Clark et al., 2020; Lee et al., 2021; Willis et al., 2024).

At the same time, five key determinants, namely spatial constraints, tree characteristics, resources, project-related factors, and tree survivability, had a significant effect on risk avoidance decisions, accounting for 69% of the variance [$F(5, 259) = 112.76, p < 0.05$]. Efficient spatial planning helped reduce environmental loss and public resistance, while tree characteristics such as species, age, and health informed judgments about safety and design quality. Access to sufficient resources, including professional expertise and regulatory support, improved the quality of decisions, and consideration of survivability ensured that tree removal did not undermine long-term ecosystem services (Apfelbeck et al., 2020; Ordóñez et al., 2023). Overall, the results showed that removal decisions are shaped by a careful balance between the desire to maximise benefits and the need to minimise risks, in line with EUT's ideas. Decision-makers attempt to improve cost efficiency and project feasibility (*utility maximisation*) - while simultaneously reducing potential problems related to safety, environmental impacts, or limited resources (*risk avoidance*). In practice, choices made for economic or technical reasons are often adjusted based on risk considerations, helping to ensure that tree removal supports both short-term project success and long-term ecological resilience. This suggests that urban tree removal decisions are not purely technical or financial choices but rather deliberate assessments of benefits and risks made within the context of uncertainty.

CONCLUSION

Multiple interconnected determinants influence decisions about urban tree retention and removal, as this study demonstrates. For retention, long-term utility and risk avoidance are primarily guided by cost–benefit considerations, spatial and physical environment constraints, and social factors, ensuring trees are maintained safely and provide maximum ecological, aesthetic, and cultural benefits. In tree removal, decisions are driven by cost efficiency, project-related factors, institutional guidelines, tree characteristics, resources, and survivability, allowing practitioners to minimise ecological and social risks while maximising development outcomes. Overall, the findings reinforce the application of Expected Utility Theory in understanding urban tree decision-making under uncertainty. They also highlight the importance of evidence-based frameworks, expert input, and comprehensive planning to ensure sustainable urban tree management, balancing environmental conservation with development needs. This study provides practical guidance for policymakers, developers, and practitioners to enhance urban tree conservation and integrate trees effectively into development projects. As this study employed a cross-sectional survey design, the findings should be interpreted as associational rather than causal relationships. Future studies may adopt longitudinal or mixed-method approaches to further examine decision-making processes in urban tree management.

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