DEVELOPMENT OF A TREE RISK INVENTORY FRAMEWORK FOR URBAN TREES IN MALAYSIA

By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

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In Malaysia, planting urban trees often receives attention as they provide city dwellers with beauty and many other advantages. However, studies show that many trees have deterioted and died early in urban cities due to the urban stress ecosystem. Hence, it is crucial to accompany planting initiatives with clear guidance and specifications for tree provision and protection. The current Tree Risk Assessment (TRA) methods were designed to determine the danger of the tree to direct practitioners through the tree inspection process. Some methods from the international organization have been modified for the Malaysian context to help arborists, and tree workers assess tree risk, yet limited to mature and senescent trees that carry high risk. Although it enables to perceive the symptoms of hazardous trees, the risk of trees should be controlled since trees' early living. The aim of this study is to develop a framework for tree risk inventory for urban trees in Malaysia. This study applied a qualitative method which is the focus group discussion (FGD) and Semi-Structured Interview (SSI). Twelve experts were involved during the focus group discussion, and ten more experts

have been interviewed during the expert interview sessions. A conceptual framework of Tree Risk Inventory for Urban Trees in Malaysia was exposed to the informants and their feedbacks is examined, categorized, tabulated, and recombined. After the presented conceptual framework was accepted, the conceptual framework is improved as suggested by all the experts and the detailed framework of tree risk inventory is served as the findings. Data collected through the literature review, focus group discussion, and expert interviews, reveal that proper planning, as well as management by the local government system, can enhance and increase the management and maintenance of urban trees in Malaysia. In conclusion, this tree risk inventory framework will be beneficial for encouraging the future studies in developing systems and methods that can accommodate urban tree maintenance and management issues in Malaysia.

Keywords: hazardous trees; tree assessment, tree monitoring; urban forestry

SDG: GOAL 15: Life on Land

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains.

PEMBANGUNAN KERANGKA INVENTORI RISIKO POKOK UNTUK POKOK BANDARAN DI MALAYSIA

Oleh

WAN ADHWA EZZDIHAR SHARFA BINTI WAN AZULKEFELI

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Di Malaysia, penanaman pokok di bandar sering mendapat perhatian kerana ia menyediakan keindahan dan pelbagai kelebihan lain kepada penduduk bandar. Namun begitu, kajian menunjukkan bahawa banyak pokok yang telah merosot dan mati awal di bandar-bandar akibat ekosistem tekanan bandar. Oleh itu, adalah penting untuk inisiatif penanaman pokok diiringi dengan panduan dan spesifikasi yang jelas untuk penyediaan dan perlindungan pokok. Kaedah Penilaian Risiko Pokok (TRA) yang sedia ada wujud direka untuk menentukan bahaya pokok bagi membantu pengamal melalui proses pemeriksaan pokok. Beberapa kaedah daripada organisasi antarabangsa telah diubah suai untuk konteks Malaysia bagi membantu arboris dan pekerja pokok menilai risiko pokok, namun ia hanyalah terhad kepada pokok matang dan pokok tua yang membawa risiko tinggi sahaja. Walaupun ia membolehkan pengenalpastian gejala pokok berbahaya, namun risiko pokok perlu dikawal sejak awal kehidupan pokok. Matlamat kajian ini adalah untuk membangunkan rangka kerja bagi inventori risiko pokok di kawasan bandar di Malaysia. Kajian ini

menggunakan kaedah kualitatif iaitu perbincangan kumpulan fokus (FGD) dan Temu Bual Separuh Berstruktur (SSI). Dua belas pakar terlibat dalam perbincangan kumpulan fokus, dan sepuluh lagi pakar telah ditemu bual dalam sesi temu bual pakar. Rangka kerja konseptual Inventori Risiko Pokok untuk Pokok Bandar di Malaysia telah didedahkan kepada informan dan maklum balas mereka dikaji, dikategorikan, ditabulasikan, dan digabungkan semula. Selepas rangka kerja konseptual yang dikemukakan diterima, rangka kerja konseptual itu diperbaiki mengikut cadangan semua pakar dan rangka kerja terperinci inventori risiko pokok dijadikan sebagai penemuan akhir kajian ini. Data yang dikumpulkan melalui kajian literatur, perbincangan kumpulan fokus, dan temu bual pakar, menunjukkan bahawa perancangan yang betul serta pengurusan oleh sistem kerajaan tempatan boleh meningkatkan pengurusan dan penyelenggaraan pokok bandar di Malaysia. Kesimpulannya, rangka kerja inventori risiko pokok ini akan memberi manfaat dalam menggalakkan kajian masa depan dalam membangunkan sistem dan kaedah yang dapat menangani isu penyelenggaraan dan pengurusan pokok bandar di Malaysia.

Kata Kunci: pemantauan pokok; penilaian pokok; perhutanan bandar; pokok berbahaya

SDG: MATLAMAT 15: Kehidupan di Darat

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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LIST OF ABBREVIATIONS

NASA	National Aeronautics and Space Administration
UNFCCC	United Nations Framework Convention on Climate Change
^{o}C	degree Celsius
MCO	Movement Control Order
ISA	International Society of Arboriculture
DOSM	Department of Statistic Malaysia
JLN	Jabatan Landskap Negara
MaPAL	Manual Penyelenggaraan Aset Landskap Taman Awam
FRIM	Forest Research Institute Malaysia
MFRDB	Malaysian Forestry Research and Development Board
ALAM	Angkatan Landskap Arkitek Malaysia
BIM	Balai Ikhtisas Malaysia
IFLA	International Federation of Landscape Architects
TPO	Tree Preservation Order
PArM	Persatuan Arboris Malaysia
DCLG	Department of Communities and Local Government (UK)
TRA	Tree Risk Assessment
USDA	United States Department of Agriculture
VTA	Visual Tree Assessment
QTRA	Quantified Tree Risk Assessment

BMP	Best Management Practice
DBH	Diameter at breast height

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter provides an overview of the research, including a comprehensive explanation of the research subject, problem statements, and the research gap. It also outlines the research questions, aims, and objectives. Furthermore, the chapter summarizes the scope of the research, highlights its significance, and presents the overall structure of the study.

1.2 Background of Study

Climate change poses a grave threat to both human livelihoods and global ecosystems. According to the National Aeronautics and Space Administration (NASA), in the 20th century, there was an increase of approximately 1 degree Fahrenheit in the average temperature of the Earth. This modest rise in temperature has various consequences, such as extended periods of drought, heat waves, and intensified hurricanes. In the early 1990s, the United Nations Framework Convention on Climate Change (UNFCCC) was formed. Subsequently, the Kyoto Protocol was ratified in 1997, and eventually, the Paris Agreement was reached in 2015. The objective of the Paris Agreement was to sustain endeavors in order to limit the global temperature increase to 1.5 °C and, at the most, 2 °C by the close of the century. Amidst the escalating threat of climate change, the integration of trees stands as a critical measure to mitigate its impacts

and uphold the objectives set forth by international agreements such as the Paris Agreement, aiming to limit global temperature rise to 1.5°C to 2°C by the end of the century.

In Malaysia's context, it is not an exception to the fact that climate change is a global threat that transcends national borders. According to Rahman (2018), the effects of climate change on Malaysia's environment include temperature, sea level, biodiversity, land cover, water availability, and agriculture. Malaysia's contribution to global carbon pollution amounts to 0.52%, placing it as the fourth highest emitter of greenhouse gases in ASEAN, following Indonesia, Vietnam, and Thailand (Rahman, 2018). In addressing Malaysia's significant contribution to global carbon pollution and its vulnerability to the effects of climate change, the strategic integration of trees into the nation's landscape emerges as a crucial aspect of sustainable mitigation and adaptation efforts.

In the past few decades, Malaysia has undergone swift economic expansion (Embi, 2000), which has resulted in a rise and discrepancy in urban energy consumption and provision due to alterations in associated manufacturing, transportation, infrastructure, and various elements of the living environment (Lunyu Xie, Haosheng Yan, Shuhan Zhang, 2019; Mahmoud & Gan, 2018). Accelerating the development of urban was reducing the green area (Razak et al., 2016), reducing impermeable surface materials (Ramakreshnan et al., 2018), and affecting CO2 emissions in a few ways, such as energy used for infrastructure, transportation (Bekhet & Othman, 2017). The rapid urbanization and associated changes in land use and infrastructure in Malaysia have led to the reduction of green areas and increased impermeable surface materials, which have adverse

effects on CO2 emissions and exacerbate the urban heat island effect. In this context, the strategic planting and preservation of trees play a crucial role in mitigating the environmental impacts of urbanization, reducing carbon emissions, and improving overall urban sustainability.

Kuala Lumpur, the urban center in Malaysia, boasts the largest population of approximately 1.31 million residents. However, this figure remains relatively small when compared to Malaysia's total population of approximately 31 million. As many land surfaces have been transformed and influenced by humans (Razak et al., 2016), this has caused an increase in air surface temperature and given rise to the Urban Heat Island (UHI) effect, which has altered the Earth's landscapes, notably soil bodies (Sanusi et al., 2017). The rapid urbanization and resultant Urban Heat Island (UHI) effect in Kuala Lumpur highlight the urgent need for strategic tree planting initiatives to mitigate rising temperatures, improve air quality, and enhance the overall livability of urban environments for its large population.

The Urban Heat Island (UHI) effect exacerbates the consequences of temperature increase and heat stress in urban areas. Through the presence of dark surfaces, heat emissions from residential and commercial buildings, limited vegetation, and air pollution, temperatures in major cities worldwide can exceed those in rural regions by an average of 0.1 to 3 degrees Celsius. In Kuala Lumpur, UHI has been measured in the 4-6°C range, often peaking at night. This phenomenon is increasingly growing because of the alterations of surface area, improper urban planning, etc. (Nuruzzaman, 2015). It intersects with the intricate issues of urbanization, climate crisis, well-being of the community, and the growing need for cooling as energy demand rises (Osborne & Alvares-sanches, 2019). Strategic

tree planting and urban greening initiatives are essential in mitigating the Urban Heat Island effect in major cities like Kuala Lumpur, as trees provide shade, reduce surface temperatures, and absorb heat, thereby helping to alleviate the heat stress experienced by urban residents and improve overall urban environmental quality.

Research has shown that the process of urbanization has had a notable influence on temperatures in local areas by altering the heat flow within the affected regions (Zhao et al., 2019). It has been found that the rapid development of urban areas since the late 1970s has contributed to over 40% of global warming (Yang et al., 2011). However, in this rapid urbanization, trees could be crucial in changing climates and improving thermal comfort. By eliminating carbon dioxide from the atmosphere during photosynthesis, trees help stabilize both the microclimate and the macroclimate.

1.3 Research Problem

By 2030, it is anticipated that over 77.6% of Malaysia's total population will live in urban areas (Ho, 2008). Consequently, the escalating needs for construction aimed at residential, business sectors, transportation, and other urban development have significantly strained public greenspace and landscape areas, as highlighted by Kanniah & Siong in 2017 and Noresah in 2010. These green spaces play a vital role in preserving a sustainable urban setting by providing recreational pursuits. However, there is still a need for further research and comparative analysis regarding the number of urban trees and green areas and their development and sustenance, as Nor Akmar et al. mentioned in 2011.

The rapid urbanization in Malaysia has also increased pressure on government resources, as highlighted by Ibrahim et al. in 2020. Therefore, Malaysia's 7th Prime Minister has launched the ‘100 Million Tree Planting Campaign 2020-2025' with the theme "Greening Malaysia: Our Trees, Our Life" (Bernama, 2021, January 5). As part of the Greening Malaysia Program, the campaign aims to have 100 million trees planted nationwide by 2025. Furthermore, it is considered a priority at the national level to tackle climate change and enhance the population's well-being. Although the planting programs have progressed as expected, managing trees and plants could have been more satisfactory. More maintenance still needs to be done, and public safety should be addressed more frequently. Some urban trees, however, failed because the emerging concerns have yet to be resolved in time (Sreetheran et al., 2006).

Urban trees are found within urban or populated areas, including cities, towns, and suburban environments. These trees are a vital component of urban ecosystems and contribute to the overall well-being of the environment, residents, and the urban landscape. Urban trees provide numerous benefits, including aesthetic value, shade, air purification, carbon sequestration, habitat for wildlife, and overall enhancement of the quality of life in urban areas. Proper management, including tree risk assessment, is essential to ensure urban trees' health, safety, and sustainability in the face of challenges such as urban development, pollution, and climate change. Figure 1 shows the number of fallen tree cases reported by the media from 2015 to 2020.

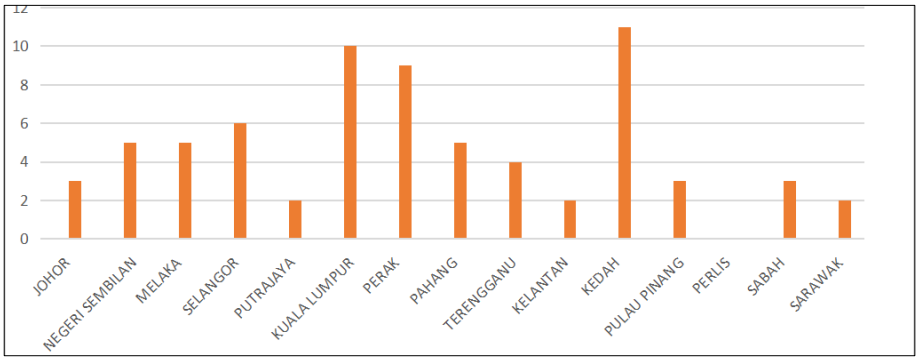

Figure 1: A media analysis of fallen tree cases in Malaysia since 2015-2020
(Source: Author, 2022)

Figure 1 shows the media analysis of fallen tree cases in Malaysia from 2015 to 2020, revealing insightful patterns in the distribution of incidents across different states. The data shows that Kedah consistently records the highest number of fallen tree cases, establishing itself as a prominent hotspot for such incidents throughout the six years. Following closely are Kuala Lumpur and Perak, which also experience notable occurrences of fallen trees. In contrast, the states with the lowest incidence of fallen trees are Putrajaya, Pulau Pinang, and Sabah, indicating a comparatively lower risk or occurrence of such incidents in these regions.

Studies show that many trees have deteriorated and died early in urban cities due to the urban stress ecosystem (Fazamimah et al., 2019). Issues regarding hazardous urban trees have been expected, and the cases related to dangerous trees have escalated over the years (Hasan et al., 2017). Urban trees are increasing their risk with age. Large urban trees also have a target zone equal to their height, and the weight may cause severe harm or damage to people or assets in the event of structural instability (Koeser & Smiley, 2017). The previous study has shown that internal decay leading to tree failure is prevalent in more extensive and older trees (Koeser et al., 2016; Luley et al., 2009). The data reveals that

Subang Jaya Municipal Council (MPSJ) received 5512 reported trees fall incidents from the public over three years (2012–2014). The unsuccessful planting and growth of trees can result from several factors, such as insufficient root development, inadequate or excessive water provision, deep planting, compacted soil, and the quality of the plant specimens. In addition to these factors, natural disasters such as tempests, deluges, and cyclones can also lead to tree failures. These events create a sense of insecurity and threaten the surrounding environment, affecting the safety and well-being of society and the public. It is essential to address these causes and implement proper tree care and management practices to mitigate the risks associated with tree failures and enhance the safety of the environment (Lazim & Misni, 2016).

To secure the enduring durability of a country's landscape and green zones, it is crucial to accompany planting initiatives with clear guidance and specifications for tree provision and protection, as stated by Sreetheran et al. in 2006. Trees within these green zones contribute to the aesthetic appeal and play a vital role in fostering biodiversity, mitigating air pollution, and providing crucial ecosystem services. The synergy between greenspace and trees underscores the need for comprehensive management strategies that not only guide the planting of trees but also ensure their sustained growth, health, and coexistence within the broader green landscape. The management of green spaces aims to enhance public safety, improve the livability of cities, and promote a healthier environment, as highlighted by Hasan et al. in 2018. Hence, adequate control measures are necessary to achieve this goal, as emphasized by Darkhani et al. in 2019.

In arboriculture and urban forestry, practitioners must employ a Tree Risk Assessment (TRA) method that is befitting for the specific tree or trees being evaluated, considering the necessary tools and management purposes. TRA is a process used to evaluate and manage three potential risks. It involves identifying and assessing the likelihood of hazards related to trees that could lead to property damage, injuries, or other negative impacts. Arborists and professionals in arboriculture typically conduct TRA to ensure trees' safety in urban areas. TRA plays a crucial role in urban tree management in Malaysia, addressing a spectrum of concerns ranging from public safety to environmental sustainability. As urban areas in Malaysia experience high human activity, identifying and mitigating potential tree hazards contribute significantly to public safety and property protection.

While more detailed and advanced levels of risk assessment are believed to provide more precise information regarding the likelihood of tree failure, the effect of this supplementary information on the efficacy of tree assessment remains to be determined. Although higher levels of risk assessment that offers more detailed and advanced information regarding the probability of tree failure are thought to enhance precision, the impact of this extra information on the efficiency of tree assessment in inspecting the risk status of trees throughout their life cycle remains unclear, as mentioned by Koeser et al. in 2017. Therefore, there is a need for a less comprehensive TRA approach to accommodate a broader range of professionals in urban forestry. Nonetheless, exploring the criteria necessary to evaluate the state of trees in their early or juvenile stages is imperative.

Much research concerning TRA has been published (Norainiratna et al., 2013), but only some TRA methods are recognized as the industry norm (Klein et al., 2019). Generally, there are a few standard methods for assessing hazardous trees in Malaysia, but this information is only essential for developing urban management guidelines. The limited adequate knowledge of urban trees in Malaysia was only obtained by Murad (2000), Sreetheran (2002), and Noor Syakila (2002) (Maruthaveeran & Yaman, 2010).

As conclusion, research problems of this study are:

1. Rapid urbanization in Malaysia leads to increased construction activities, putting strain on public greenspaces and landscapes. It also strains government resources, creating challenges in managing urban environments.

2. Despite tree planting initiatives, management and maintenance of trees remain unsatisfactory, leading to concerns about tree health and public safety.

3. Urban trees face risks such as deterioration, early mortality, and structural instability, posing hazards to property and public safety.

4. There is a lack of standardized tree risk assessment (TRA) methods in Malaysia, hindering effective management of urban trees and landscapes.

5. Despite the importance of urban trees, research on urban tree management and TRA methods in Malaysia is limited, impacting the development of management guidelines and strategies.

Figure 2 below summarizes the research problem, the gap, and the solution.

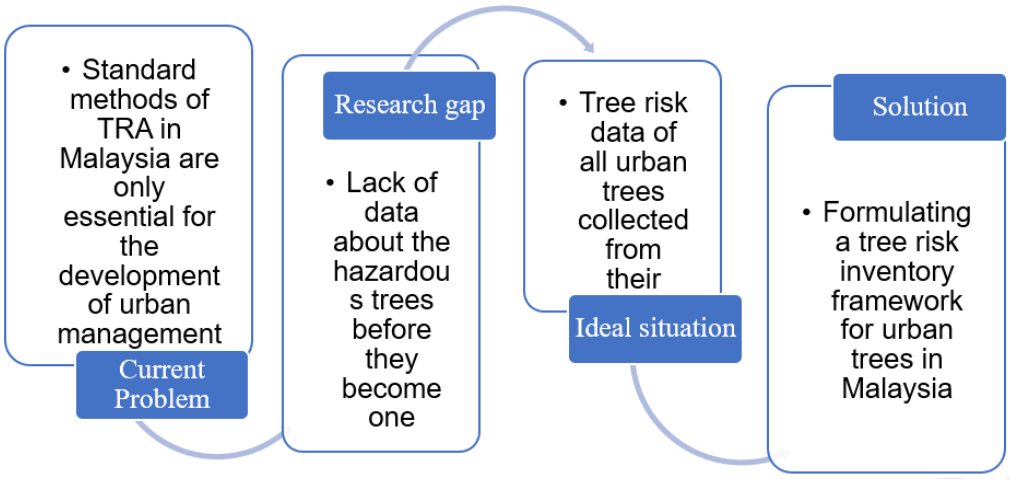

Figure 2: The research problems, research gaps, and solutions.

1.4 Research Questions

There are three main research questions for this study. The first research question concerns the method used to determine the risk of urban trees in Malaysia. This study will explore the existing tree risk assessment methods to find out what methods are used to assess the risk of urban trees in Malaysia. The second research question is, what are the corresponding criteria for monitoring the risk of urban trees in Malaysia? In this study, the researcher will also explore the suitable criteria needed to monitor the risk of urban trees in Malaysia. The last research question addresses how to develop a tree risk inventory framework for urban trees in Malaysia. During the study period, the researcher will develop a framework for tree risk inventory for urban trees in Malaysia.

1.5 Research Aim and Objectives

The aim of this study is to develop a framework for tree risk inventory for urban trees in Malaysia.

The specific objectives of this study are:

1. To gain experts point of views on the current tree risk assessment methods used and analyse it to suite Malaysian context.

2. To analyse the corresponding criteria of risk inventory for urban trees in Malaysia.

3. To propose a tree risk inventory framework for urban trees in Malaysia.

1.6 Significance of Study

This research significantly improves understanding and knowledge about urban trees in Malaysia. Urban trees play a crucial role in enhancing the livability of urban areas and are a fundamental element of urban environments. They contribute to a more favorable living environment, promote environmental improvement, enhance public health, and serve as a valuable and economically efficient asset for the development of our infrastructure. Despite their numerous benefits, there is a need to raise public awareness and understanding of the advantages associated with urban trees (Ruth et al., 2010).

This study will also be helpful in addressing the urban tree coordination challenges and highlighting the importance of urban trees in Malaysia. This is because the management of urban trees in Malaysia has been unsatisfactory because of common absence of upkeep, and public safety is frequently ignored.

Besides that, there is an observation that there needs to be greater focus and a clearer understanding of urban tree management in Malaysia. Hence, the

successful completion of this study holds significant importance.

This research also hopes to increase awareness of the importance of an appropriate sustainable system for managing urban trees in Malaysia's overall urban landscape development process. This is timely as there is a growing realization that urban landscapes, including green spaces and parks, are becoming more critical for urban living.

1.7 Scope of Research

This study focuses on analyzing the tree risk and related issues in urban environment. The study aims to propose a new framework for tree risk inventory for urban trees in Malaysia. The literature review is based on the history of tree management in Malaysia, the organizations involved in tree management, and the methods used. The experts and professionals in related fields verify the preliminary conceptual framework before the focus group discussions. It is then reviewed by different experts and professionals in expert interview sessions. Finally, the findings will be discussed to propose the final framework.

1.8 Research Limitation

While this study was successfully completed, there were some limitations since this study was done during the Covid-19 pandemic. The first issue was the time limitation for the researcher to collect the data. The data collection could be more effective if the researcher had more time to finish the study. Besides that, the study is also limited to the TRA common in the International Society of Arboriculture (ISA)

and among experts in Malaysia. The professional practice of arboriculture under the ISA in Malaysia is still new, which may lead to some confusion regarding the knowledge about temperate trees. Thus, there is also a need for further clarification regarding the understanding of the trees. Next, this research is also limited to data collection from the local authorities in Klang Valley due to restrictions on regional border crossing during the Movement Control Order (MCO). Another limitation of this research pertains to the utilization of self-report surveys as a data collection method. This approach is susceptible to potential misinterpretation of questions and intentional deception, which may introduce inaccuracies into the obtained results (Podsakoff et al., 2003).

1.9 Definition of Terms

The following definitions are provided to enhance the understanding of key concepts addressed in this study.

a. Urban Tree

Urban tree is a tree found in urban areas, such as those in lawns, along streets and utility easements, in protected areas, and in drainage basins (Abdullah et al., 2018; Sreetheran et al., 2006).

b. Hazardous Trees

The term "hazardous tree" refers to a tree with a structural flaw that increases the likelihood that it will fail entirely or partially (Forest Service U.S. Department of Agriculture).

c. Risk of Tree

The risks posed by trees refers to the potential for a threatened trees to cause damage to property or harm to individuals. It encompasses both the probability of a tree failure event occurring and the seriousness of the potential consequences resulting from that event. (Purcell, 2015).

d. Tree Risk Assessment

Tree risk assessment is a structured procedure that involves the identification, analysis, and evaluation of potential risks associated with tree failure. The level of complexity in this process can be tailored according to the preferences of the tree manager, ranging from a simple and straightforward approach to a more intricate one (E. Smiley et al., 2016).

1.10 Thesis Structure

Chapter 1 presents the background of the research by showing a detailed explanation of its subject, problem statement and justifications, research gaps, research goal, research questions, and research objectives. The significance of studies, research scope, limitations, and some definitions of terms are also discussed in this chapter.

Chapter 2 reviews literature about the fundamental concepts of urban tree development and the importance of trees for urban dwellers. The in-depth review also includes the International and Malaysian policies toward the preservation of trees. It then explores the history and the concepts of Tree Risk Assessments used by experts worldwide. These evaluations are critical for the study's completion as

they streamline and present the conceptual framework for supervising tree assessment in Malaysia's urban areas. This chapter highlights a list of critical components and the main criteria of tree risk assessments.

Chapter 3 explores the research methodology, elucidating the formulation and progression of the research strategy. It encompasses various components such as focus group discussions, interviews, the rationale behind the chosen methodology, and the techniques employed for data collection. Additionally, the chapter delves into the initial concept and highlights the preferred methodological approaches.

Chapter 4 showcases the insights gained and discoveries made from the qualitative study conducted through focus group discussions and expert interviews. This chapter also explores the prior iterations of the research instrument using textual analysis and highlights the divergent results unveiled during the focus group discussions.

Chapter 5 directs attention to the paramount discoveries, revisits the aim and research objectives, provides a condensed overview of the outcomes, discusses the implications of the findings, puts forth recommendations, acknowledges limitations, and, finally, proposes areas for future research.

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