E-BOOK OF EXTENDED ABSTRACT

THE 14TH INTERNATIONAL INVENTION, INNOVATION & DESIGN COMPETITION 2025

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LANDSCAPE PLANNING, MANAGEMENT, AND MAINTENANCE DATABASE MANAGEMENT SYSTEM: A COMBINED MODELLING FRAMEWORK (ERD & SRL) IN CARBON SEQUESTRATION

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ABSTRACT

This paper presents a combined modelling framework that integrates the landscape development process with a Sustainable and Resilient Landscape (SRL) approach, in conjunction with an Entity-Relationship Diagram (ERD) to create a carbon sequestration database management system that includes both spatial and attribute data. The implementation of database management systems in carbon sequestration database structures has received less attention than their usage in landscape planning, which has been the subject of previous research. This paper considers Chen's ERD notation as a starting point for developing the database management system. Landscape development and management processes are then used as inputs for structuring complex landscape planning data, providing SRL and maintenance in line with carbon sequestration goals. This modelling framework is exemplified in landscape planning, management, and maintenance, assisting stakeholders, decision-makers, facilitative management, and other built environment professionals in identifying trees with high carbon sequestration levels, thereby enhancing environmental sustainability.

Keyword: Landscape Planning Management and Maintenance, Sustainable and Resilient Landscape, Entity-Relationship Diagram, Framework Development, Carbon Sequestration, Database Management System

1. INTRODUCTION

Plants, particularly trees, play a crucial role in regulating and enhancing air quality. During photosynthesis, carbon dioxide is absorbed by plants and subsequently stored in the biomass of the tree (Nowak et al., 2013). According to Matthew et al. (2018), the process of extracting carbon dioxide from the atmosphere is known as carbon sequestration. Sachs (2019) argued that the quantity of oxygen produced and the amount of carbon dioxide, as well as particulate matter accumulated, can vary depending on the tree species and planting configuration. It is necessary to have comprehensive database management on forest resources and a thorough understanding of the carbon sequestration characteristics of the majority of tree species. This is necessary to correctly calculate the amount of carbon that is stored and absorbed in urban forests. This must be understood as urban forests are a significant source of carbon storage (Rosli et al., 2024). The design and comprehension of diagrammatic representations are essential for the success of landscape planning, management, and maintenance. Diagrams in this field provide a compilation of related information through various perceptual signs, assisting landscape architects and planners in understanding operational systems

through different levels of the information system development process. One of the main diagrammatic representations of a conceptual data model that depicts users' data requirements in a database system is the ERD (Cagiltay et al., 2013). The use of diagrams is crucial in the representation of information systems, as they facilitate the condensed transmission of information. Database design typically begins with the development of an ERD. A conceptual data model that reflects the user data requirements in the database system is represented by the ERD, which is one of the primary diagrams. It is necessary for any database to have entities that are related to one another, and each entity must have attributes that include a primary key in addition to descriptive attributes that describe the entity's characteristics (Pulungan et al., 2023). Developers acquire a comprehensive understanding of the information system's data requirements, modelling, and database structures before the implementation phase by conducting the implementation of ERD (Cagiltay et al., 2013). The use of a suitable management system is critical for the achievement of high-quality, sustainable landscapes. The system must be sufficiently adaptable to accommodate the evolving requirements and challenges of landscape planning, management, and maintenance. Greenhalgh and Worpole (1995) indicate that a general model for managing sustainable landscapes has not been completely established. The management methods and practices might differ by location, but there should be a general system and method to improve the management system and landscape planning. By doing this, a framework of standard procedures will be created that management and other parties involved in sustainable landscapes can implement (Tahir & Roe, 2006).

2. METHODOLOGY

The methodology employs a modelling framework adapted from Chen's (1976) ERD notation, which encompasses three (3) stages and the SRL approach by Steiner (2008), which emphasises an integrated five-stage process: analysis, planning, design, implementation, and monitoring in landscape development (refer to Figure 1). The framework is utilised to illustrate and develop the database structure with spatial and attribute data to create a carbon sequestration database, which can be used by landscape planning, management, and maintenance for monitoring works.

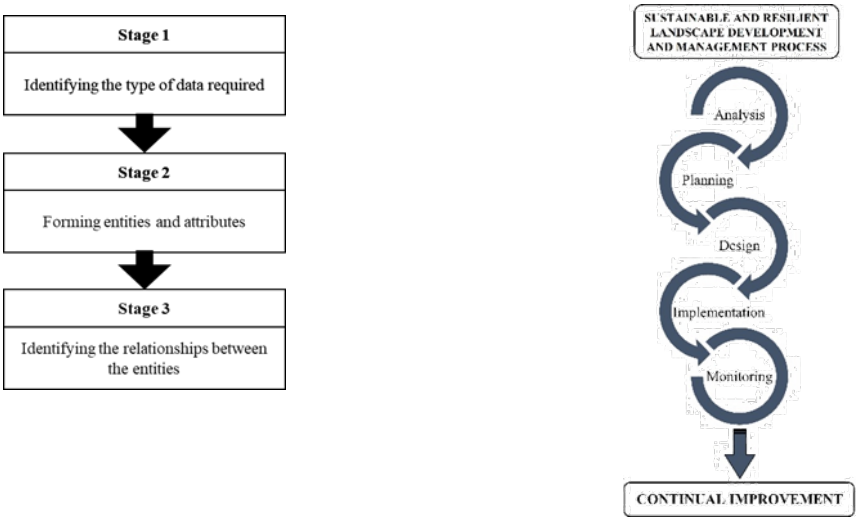

Figure 1 Chen's 1976 ERD notation (right) and SRL by Frederick R. Steiner (left

3. FINDINGS

As illustrated in Figure 2, the novel modelling framework is examined. Within the context of this framework, an ERD is taken into consideration as a starting point for the development of the database

structure of a carbon sequestration database, which includes both spatial and attribute data. Stage 1 involves identifying the type of data required. To create a database of carbon sequestration, it is important to classify the trees according to their Diameter at Breast Height (DBH) (Behera et al., 2022; Nowak and Crane, 2002; and Kanniah et al., 2014). In this combination, two (2) key processes of SRL are required, which are planning and monitoring. Steiner's ecological planning model comprises the approach that aligns with the concept that effective landscape planning must include provisions for long-term care and adaptability to ensure ecological resilience and sustainability (Steiner, F. 2008). The key concepts related are adaptive management, involvement of organisations, and integration of sustainable landscape ecological principles. In addition, Stage 2 focuses on structuring the carbon sequestration database, which requires three (3) entities and their related attributes, as shown in Figure 2. The formation of attributes for SRL entities is by referring to ten (10) key criteria checklists as stated in the Sustainable Sites Initiative (SITES v2, 2014). Furthermore, Stage 3 highlights the relationship between the management (decision makers, facilitative management, and other built environment professionals) and executors who are responsible for the maintenance scope of works (landscape contractor and gardener) as reflected in the database structure of this modelling framework.

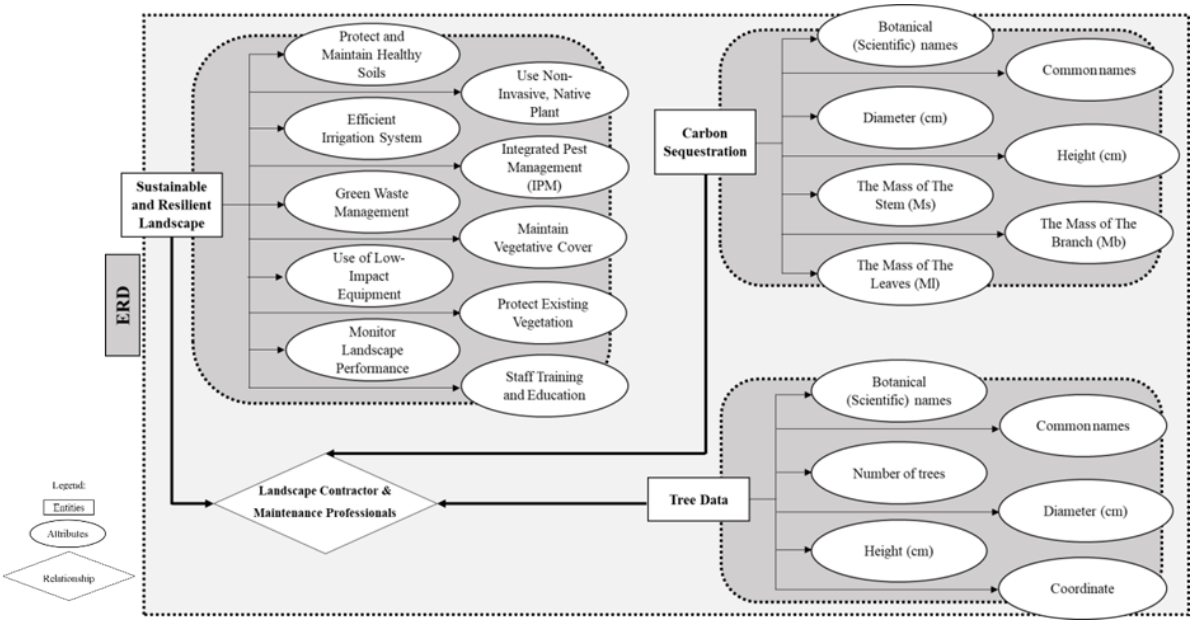

Figure 1 The Novel Modelling Framework for Landscape Planning, Management, and Maintenance Database Management System in Carbon Sequestration

4. CONCLUSION

In conclusion, a carbon sequestration database can be possibly developed using the Landscape Planning, Management, and Maintenance Database Management System for monitoring works. By using Geographic Information Systems (GIS) in landscape planning, we can improve how we measure and manage carbon storage, while also keeping the data for future planning and environmental decision-making. In the context of regional development, both the SRL and the use of ERDs within GIS environments present a novel framework for the Landscape Planning, Management, and Maintenance Database Management System with a strong focus on carbon sequestration. While SRL integrates technological tools to monitor and manage landscape ecological assets such as mature trees, enhancing their role as carbon sinks, ERDs structure and define the relationships between critical data entities, including tree species, age, biomass, and spatial attributes. When embedded in a GIS platform, this combined framework allows for efficient data management, spatial analysis, and decision-making, supporting the long-term goal of optimising urban forest carbon storage through informed planning

and systematic maintenance. By improving air quality, reducing heat, and creating healthier outdoor environments, this approach contributes to a better quality of life in urban areas.

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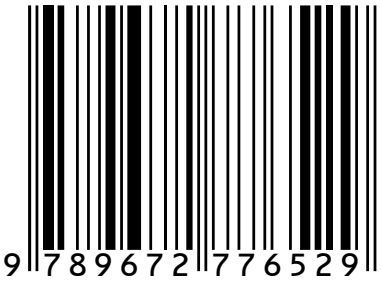

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