Journal of Information System and Technology Management
JISTM
EISSN: 0128-1666
Volume 9 Issue 35 (June 2024) PP. 130-146
DOI: 10.35631/JISTM.935008

JOURNAL OF INFORMATION SYSTEM AND TECHNOLOGY MANAGEMENT (JISTM)
www.jistm.com

GLOBAL ACADEMIC EXCELLENCE

MAPPING THE CARBON SEQUESTRATION OF MATURE TREES FOR LANDSCAPE PLANNING AND MANAGEMENT USING GEOGRAPHIC INFORMATION SYSTEM (GIS): A CASE STUDY OF HOSPITAL GERIK, PERAK

Norsyazlin Mohd Rosli[1*], Ruwaidah Borhan[2], Nur Shaffiqa Muhammad Soffian[3], Amelia Ahmad[4]

[1] Department of Built Environment Studies and Technology, College of Built Environment, Universiti Teknologi MARA, Perak Branch, Malaysia.
Email: norsy986@uitm.edu.my
[2] Department of Built Environment Studies and Technology, College of Built Environment, Universiti Teknologi MARA, Perak Branch, Malaysia.
Email: aidah866@uitm.edu.my
[3] Department of Built Environment Studies and Technology, College of Built Environment, Universiti Teknologi MARA, Perak Branch, Malaysia.
Email: shaffiqa7785@uitm.edu.my
[4] Department of Built Environment Studies and Technology, College of Built Environment, Universiti Teknologi MARA, Perak Branch, Malaysia.
Email: ameli620@uitm.edu.my
[*] Corresponding Author

Article Info:

Article history:
Received date: 18.04.2024
Revised date: 13.05.2024
Accepted date: 15.06.2024
Published date: 30.06.2024

To cite this document:

Rosli, N. M., Borhan, R., Soffian, N. S. M., & Ahmad, A. (2024). Mapping The Carbon Sequestration Of Mature Trees For Landscape Planning And Management Using Geographic Information System (GIS): A Case Study Of Hospital Gerik, Perak. *Journal of Information System and*

Abstract:

This paper seeks to address the existing research gap by introducing a novel database in the context of mapping the carbon sequestration of mature trees, utilizing Geographic Information System (GIS) for enhanced landscape planning and management strategies. While previous studies have explored the use of GIS in landscape planning, limited attention has been directed towards its application in mapping the carbon sequestration of mature trees, particularly in health facilities. One objective of this study is to provide a carbon sequestration database that consists of spatial and attributes data that can be used by the management of landscape planning for monitoring works and become more aware of existing trees that can give more benefit to the environment and climatic change globally. The methodology consists of presenting the sequential method of developing the database with spatial and attribute data using Entity-Relationship Diagram (ERD), and performing spatial analysis and carbon sequestration of mature trees map at Hospital Gerik, Perak using GIS software. The analysis shows the total amount of carbon sequestration area for 14 species of trees and 49 trees with a range of Diameter Breast at Height (DBH) between 0.5 cm to 450cm and a range height between

Copyright © GLOBAL ACADEMIC EXCELLENCE (M) SDN BHD - All rights reserved

Journal of Information System and Technology Management
JISTM
EISSN: 0128-1666
Volume 9 Issue 35 (June 2024) PP. 130-146
DOI: 10.35631/JISTM.935008

Technology Management, 9 (35), 130-146.

DOI: 10.35631/JISTM.935008.

This work is licensed under CC BY 4.0

0.6m to 20m height. This paper provides valuable insights for health facility management, highlighting the environmental value of the mature trees currently located within the vicinity of their buildings. Depending on spatial maps of carbon sequestration, the recommendations and implications for improving the landscape planning and management at Hospital Gerik are discussed in comprehensively.

Keywords:

Carbon Sequestration, Health Facilities, Matured Trees, Landscape Planning, GIS, Database Structure, ER Diagram

Introduction

Developing countries are in the planning stages of decarbonizing their health facilities by migrating to renewable energy and transforming their facilities' energy systems. As an initiative of the Twelfth Malaysia Plan (12thMP), Malaysia has established the objective of achieving carbon neutrality by the year 2050. Currently, gardens have become a key element in the development of hospitals because of their natural elements and their ability to promote health. In fact, gardens help reduce stress, improve well-being, and enhance the hospital atmosphere (Nieberler-Walker, et.al., 2023). According to the guideline set by Jabatan Perancangan Bandar dan Desa (2022), it is recommended that 5 percent of the total area of a health facility be allocated for green open space. The green procurement standards emphasize the importance of landscape planning and management as effective solutions for reducing GHG emissions (Unit Perancang Ekonomi, et.al., 2020). Furthermore, the integration of gardens and landscaping in hospital environment aims at maximizing their potential for healing, therapy, restoration, and rehabilitation. The health facilities play an essential position as a first responder to climate change it, in addition, indirectly contributes to carbon sequestration.

There are several diverse natural and manmade methods that are used to achieve carbon sequestration. As part of the natural system, trees contribute to the biological sequestration process by absorbing carbon and storing it in their stems, branches, and leaves. This contributes to the accomplishing of carbon neutrality and the mitigation of the negative impacts of global climate change. As stated by Jithila and Prasadan (2018), a positive correlation occurred between the number of trees and the DBH, as determined by the regression analysis relating to the rate of carbon sequestration in tree species. Nowak (2002), as cited in Mishra et al. (2014) stated, large healthy trees (with a diameter more than 100 cm) store around 150 times more carbon than small healthy trees (with a diameter less than 100 cm). Moreover, it is important to recognize that large trees possess the capacity to store around 600 times more carbon than smaller trees.

In order to accurately measure the amount of carbon stored and absorbed in urban forests, it is necessary to have comprehensive data on forest resources and an extensive knowledge of the carbon sequestration characteristic of the majority of tree species. GIS can improve the landscape planning process and archive the outcomes in present information systems for future reference or as part of environmental information or decision support systems. GIS is a computerized system used to manage geographical information. Moreover, GIS can be utilized to capture data for inventory purposes, scientific analysis, the description of objectives, scenarios, and alternative futures, and it can even be used for planning purposes. The general uses of GIS include the processing of model inputs and the visualization of results. In addition

Copyright © GLOBAL ACADEMIC EXCELLENCE (M) SDN BHD - All rights reserved

Volume 9 Issue 35 (June 2024) PP. 130-146
DOI: 10.35631/JISTM.935008
to supporting emergent management workflows including data management, situation awareness, planning, and field operations, GIS technology additionally provides base-level specifications for data. While previous study has addressed the use of GIS in landscape planning, there has been a lack of emphasis on the implementation of mapping the carbon sequestration of mature trees, especially in health facilities.

This study is aimed to address the existing research gap by introducing a novel database in the context of mapping the carbon sequestration of mature trees, GIS for enhanced landscape planning and management strategies at Hospital Gerik, Perak. The objective of this paper is to provide a carbon sequestration database that consists of spatial and attributes data that can be used by the management of landscape planning for monitoring works and become more aware of existing trees that can give more benefit to the environment and climatic change globally. Depending on spatial maps of carbon sequestration, the recommendations, and implications for improving the landscape planning and management at the study area are discussed in comprehensively.

Literature Review

There are four (4) points to be discussed in literature review which is carbon sequestration, mature trees, landscape planning and management in health facilities and mapping the carbon sequestration.

Carbon Sequestration

The world is now facing drastic climate change and the harmful role of greenhouse gases, due to increased population, rapid urbanization, and deforestation rate. It was reported that 20% of annual greenhouse gas (GHG) emissions were produced by carbon sinks, conversion, and loss of forests (Matthew, et.al., 2018). This highlighted the major potential of urban trees and forests role as carbon sinks, amidst lack of information on urban trees biomass allometry (Stoffberg, et.al., 2010). Urban trees and forests can help in reducing atmospheric carbon dioxide (the major heat-trapping gas), in two possible ways, namely, by directly sequestering CO2 as woody and foliar biomass, and reducing the demand for heating and air-conditioning, thus reducing emissions related to electric power generation (McPherson, 1998). Carbon sequestration is the process of removing carbon dioxide from the atmosphere (Matthew, et.al., 2018). Plants absorb carbon dioxide during their photosynthesis process and eventually store them inside the tree's biomass (Nowak, et.al., 2013). Johnson and Coburn (2010) asserted that nearly half of the dry weight of a tree's biomass is carbon. Plants, especially trees, help in regulating and improving air quality. Through transpiration, plants absorb carbon dioxide and produce oxygen as they emit moisture into the air. They also reduce particulate matter and air pollution, thus producing clean air. Sachs (2019) asserted that tree species and planting configurations differ in the amount of oxygen they can produce and the amount of carbon dioxide and particulate matter they can absorb. This means that the selection of the right plants creates significant differences in air quality in environments like healthcare facilities with vulnerable populations.

Mature Trees

Shadman, et.al., (2022) highlighted that tree's potential to sequester carbon increases with an increase with age (increase in height and d.b.h.). Another study by Almeida, et.al. (2018) also highlighted on the varied amount of carbon sequestrated based on the age of the species and the density of the forested areas. McPherson, et.al., (2016) asserted how tree size and age can influence management costs and ecosystem services received from urban trees. Tree age

Copyright © GLOBAL ACADEMIC EXCELLENCE (M) SDN BHD - All rights reserved

Journal of Information System and Technology Management
JISTM
EISSN: 0128-1666
Volume 9 Issue 35 (June 2024) PP. 130-146
DOI: 10.35631/JISTM.935008

information is important in predicting species diameter at breast height (DBH), whilst diameter at breast height is used in predicting tree height, crown diameter, crown height, and leaf area. It is further asserted that to calculate tree wood volume and stored carbon, data such as tree species, wood density, moisture content, and size (DBH. and height) are used with biomass equations and other information (tree conditions). A study by McPherson, et.al. (2013) incorporated field surveys, biometric information for urban tree species, GIS data sets and remote sensing of urban tree canopy (UTC) in calculating and mapping carbon storage, sequestration, and emissions. Age-related differences were also included in this study, in enhancing carbon estimation and increasing the resolution of carbon to be mapped. Coomes, et.al. (2012) asserted the need for understanding how productivity varies with tree's age in calculating future carbon sequestration rates. Using a stand-development sequence, biomass representation percentage was less in a younger tree, as compared to the matured trees.

Landscape Planning and Management in Health Facilities

People often associates plants, may it be trees, shrubs, flowers, or grass, when envisioning gardens or outdoor spaces in healthcare facilities. Sachs (2019) asserted the main reason people visited gardens or outdoor spaces in healthcare facilities is to get a breath of fresh air. In a Healthcare Garden Visitor Survey (for patients and visitors) and Healthcare Garden Staff Survey, Sachs (2017) reported that getting fresh air rank as the number one reason for visiting the garden. In a recent study, in healthcare facilities focusing on caregivers, the physical environment and access to nature are substantial in overcoming the level of stress, burnout, fatigue, and moral distress faced by the caregivers (Sachs, 2023). The significance of having clean and fresh air to breathe is one of man's survival needs. In an area associated with disease and sickness, such as a hospital, the existence of a garden or open space provides consolation to, not just the patients and staff but also the visitors. At present, gardens have become an important part in hospital developments due to their nature content and health promoting qualities, in combating stress and improving the well-being and enhancing the hospital environment (Nieberler-Walker, et.al., 2023). In the guideline by Jabatan Perancangan Bandar dan Desa (2022), 5 percent of the total area in a healthcare facility should be allocated for green open space. The significance of landscape planning and management as strategies to reduce GHG emissions is highlighted by the green procurement guidelines (Unit Perancang Ekonomi, et.al., 2020). Integrating gardens and landscaping in hospital environments envisages their potential as a healing, therapeutic, restorative, and rehabilitative functions (Marcus, 2007).

Mapping The Carbon Sequestration

Ma, et.al., (2024) highlighted the need to have comprehensive forest resource inventory data and knowledge of the carbon sequestration characteristics of dominant tree species in correctly quantifying carbon stocks and sinks in urban forests. In addition, urban settings, where trees play a critical role in mitigating climate change through carbon storage potential, it is also significant to determine species responses in recommending species with high carbon sequestering ability. Behera, et.al. (2022) on the assessment of biomass production and carboxylation efficiency of three native tropical trees, data analyzed consist of the location, tree's age, tree species, above ground biomass, carbon stock estimation, tree height, tree diameter (DBH) and leaf area index. A study by Nowak and Crane (2002) estimated carbon storage and sequestration ability of urban trees for USA, included field data such as location, species, stem diameter (DBH), tree and crown height, crown width, and canopy conditions. Kanniah, et.al., (2014) study on the role of trees in an urban forest, at Mutiara Rini, Johor, involved data such as, tree species, geographical coordinates, the above ground biomass/carbon

Copyright © GLOBAL ACADEMIC EXCELLENCE (M) SDN BHD - All rights reserved

Journal of Information System and Technology Management
JISTM
EISSN: 0128-1666
Volume 9 Issue 35 (June 2024) PP. 130-146
DOI: 10.35631/JISTM.935008

stock, tree's biometric data (diameter at breast height (DBH)), and vegetation indices. In another study, Kanniah, et.al. (2022) reported differences in carbon storage capacity of different tree species and their location.

Study Area

The study area is located at Hospital Gerik with the coordinates of 5°25'45"N (latitude) and 101°07'39"E (longitude) which covers an area of 3.22 hectares including a development area/building of 1.83 hectares and a green area of 1.39 hectares. Through this study area, the percentage of grey and green areas have been computed where 57% is grey area while 43% is green area. The selection of study areas is constructed to align with the minimum percentage of comparison between grey and green areas. Figure 1 the Landscape Surface Area in the site boundaries area.

Figure 1: Landscape Surface Area Plan of Hospital Gerik

Source: (Author, 2023)

Methodology

The methodology consists of presenting the sequential method of developing the database with spatial and attribute data using Entity-Relationship Diagram (ERD) and performing spatial analysis and carbon sequestration of mature trees map at Hospital Gerik, Perak using GIS software.

Data Collection

The study implemented primary data collection techniques, specifically quantitative approaches. The methods are designed to produce a comprehensive inventory of the carbon sequestration of both young and mature trees, as well as trees of various species. Observation of green areas, identification and characteristics of trees, coordination of trees, and land use

Copyright © GLOBAL ACADEMIC EXCELLENCE (M) SDN BHD - All rights reserved

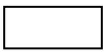
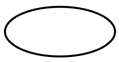
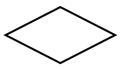
Journal of Information System and Technology Management
JISTM
EISSN: 0128-1666
Volume 9 Issue 35 (June 2024) PP. 130-146
DOI: 10.35631/JISTM.935008

surveys within healthcare facilities were included the data collection process. The study included collecting measurements of trees' height, DBH, and coordination. Trees were classified according to their DBH, and data was gathered for all species found in the study area. Two (2) groups of trees were used for data collection: (i) young trees with a DBH of less than 75 cm, and (ii) mature trees with a trunk or trunks with a DBH of more than 75 cm, which are close to their maximum height and show indications of reduced shoot elongation, such as less elongation or less flushes per year (Clark & Matheny, 1991). To estimate the rate of carbon sequestration by young and mature trees in Hospital Gerik an allometric relationship was established between biomass total above-ground and diameter and height. A comprehensive design was implemented for the study procedure in order to analyse and compare the volume of carbon sequestration presented by young and mature trees. The study used a laser range finder/electronic hypsometer to measure tree height and a diameter tape to measure breast diameter at tree height.

Developing Database Structure

This paper applies Chen's ERD notation for illustrating and developing the database structure. Chen's ERD notation is widely recognized as a standard model that remains current and is recognized for its ability to provide a more comprehensive illustration of entities and relationships (refer Table 1). Additionally, it performs spatial analysis and carbon sequestration of a mature trees map at Hospital Gerik. The fundamental principle of this system relies on Chen's ERD notations, which have been previously established and could potentially be used for the carbon sequestration database system. Sidana (2013) states that ERD is a very effective approach for database development, using graphical diagrams for illustrating data and information. Furthermore, ERD is frequently implemented in several areas as a result of its efficiency in assisting relationships with individuals at different levels of organization. In order to achieve a translation that is both accurate and useful, it is necessary to create a diagram that precisely illustrates each data point.

Table 1: ERD Notation

Components	Symbols	Explanation
Entity		Shows a group of objects in a data model that all have the same attributes. Entities represent to objects or concepts that exist in the real world, like people, places, concepts, or things.
Attributes		A data point containing a description of an entity. Entities may also be characterized according to the characteristics of their properties, specifically identifying and descriptive attributes.
Relationship		A connection between two or more entities, the details of which must be stored by the database.

Source: Rosli et.al, 2023.

This paper demands a thorough understanding of the subject matter. There are three (3) main stages, namely;

i. Stage 1: Identifying the type of data required,
ii. Stage 2: Forming entities and attributes,

Copyright © GLOBAL ACADEMIC EXCELLENCE (M) SDN BHD - All rights reserved

Journal of Information System and Technology Management
JISTM
EISSN: 0128-1666
Volume 9 Issue 35 (June 2024) PP. 130-146
DOI: 10.35631/JISTM.935008

iii. Stage 3: Identifying the relationships between the entities of trees data and carbon sequestration.

Spatial Mapping and Analysis Using GIS Software

Deng et al. (2011) in establishing a technical framework of GIS, there are four (4) key steps of evaluating and mapping the spatial and attribute data which are;

i. Step 1: Identification of study area
ii. Step 2: Data collection and database development
iii. Step 3: Material amount estimation
iv. Step 4: Valuation and mapping

This study only focusing on mapping the carbon sequestration of mature trees. Further details are discussed below.

Results and Discussions

The development of database structure using ERD have been shown in Figure 3. By using tree inventory data through the identification of tree species and measuring tree height with the classification of the tree DBH, the researcher illustrates and formulate the database structure based on three (3) main stages that can be used by the management of landscape planning for monitoring works. Based on the difference in DBH, Table 2 shows the two (2) specific groups of trees were divided into separate groups. 45 of the 49 trees were considered young because their DBH was less than 75 cm, and 4 were considered matured because their DBH on an individual trunk (s) was more than 75 cm.

Table 2: Group of Trees in Hospital Gerik, Perak

Group of categories	Diameter range (cm)	Height range (m)	No. of trees
Young Trees	0.5 - 49	0.6 - 20	45
Matured Trees	85 - 450	12 - 15.9	4
Total number of trees in Hospital Gerik, Perak			**49**

Source: Authors

Developing Database Structure

There are three (3) stages of formulating database structure using ERD that consists of spatial and attributes data that can be used by the management of landscape planning for monitoring works.

Stage 1: Identifying The Type Of Data Required

In creating spatial and attribute data of trees and carbon sequestration, it is necessary to categorise the trees based on DBH. A study by Behera, et.al. (2022), Nowak and Crane (2002) and Kanniah, et.al., (2014) stated estimation of carbon sequestration included data such as location, species, tree height, DBH, and geographical coordinates. The analysis was conducted to compare young and mature tree carbon sequestration volume. Table 3 shows the trees data according to group of trees categories that required in formulating ERD.

Copyright © GLOBAL ACADEMIC EXCELLENCE (M) SDN BHD - All rights reserved

Journal of Information System and Technology Management JISTM
EISSN: 0128-1666
Volume 9 Issue 35 (June 2024) PP. 130-146
DOI: 10.35631/JISTM.935008

Table 3: Trees Data Required in Formulating ERD

Group of categories	Type of data
Young Trees	Botanical (Scientific) names
	Common names
	Number of trees
	Diameter (cm)
	Height (cm)
	Coordinate
Mature Trees	Botanical (Scientific) names
	Common names
	Number of trees
	Diameter (cm)
	Height (cm)
	Coordinate

Nevertheless, in order to determine spatial and attribute data of carbon sequestration according to group of trees categories at study area, it is necessary to measure DBH of each tree and the required data are the mass of the stem (Ms), the mass of the branch (Mb), and the mass of the leaves (Ml). The total biomass was calculated by integrating all the biomasses of the stem, branch, and leaves. Table 4 shows the carbon sequestration data according to group of trees categories that required in formulating ERD.

Table 4: Carbon Sequestration Data Required in Formulating ERD

Group of categories	Type of data
Young Trees	Botanical (Scientific) names
	Common names
	Diameter (cm)
	Height (cm)
	The Mass of The Stem (Ms)
	The Mass of The Branch (Mb)
	The Mass of The Leaves (Ml)
Mature Trees	Botanical (Scientific) names
	Common names
	Diameter (cm)
	Height (cm)
	The Mass of The Stem (Ms)
	The Mass of The Branch (Mb)
	The Mass of The Leaves (Ml)

Stage 2: Forming Entities And Attributes

The structure of the trees and carbon sequestration database requires four (4) entities and their related attributes, as shown in Table 5.

Copyright © GLOBAL ACADEMIC EXCELLENCE (M) SDN BHD - All rights reserved

Journal of Information System and Technology Management
JISTM
EISSN: 0128-1666
Volume 9 Issue 35 (June 2024) PP. 130-146
DOI: 10.35631/JISTM.935008

Table 5: Entities and Attributes of Trees and Carbon Sequestration Database Structure

Entities	Attributes
Tree Data_Young Trees	Botanical (Scientific) names
	Common names
	Number of trees
	Diameter (cm)
	Height (cm)
	Coordinate
Tree Data_Mature Trees	Botanical (Scientific) names
	Common names
	Number of trees
	Diameter (cm)
	Height (cm)
	Coordinate
Carbon Sequestration_Young Trees	Botanical (Scientific) names
	Common names
	Diameter (cm)
	Height (cm)
	The Mass of The Stem (Ms)
	The Mass of The Branch (Mb)
	The Mass of The Leaves (Ml)
Carbon Sequestration_Mature Trees	Botanical (Scientific) names
	Common names
	Diameter (cm)
	Height (cm)
	The Mass of The Stem (Ms)
	The Mass of The Branch (Mb)
	The Mass of The Leaves (Ml)

Subsequently, using the method of diagramming known ERD, as originally proposed by Chen, can simplify transforming of entities and attributes using symbols. This method not only simplifies and clarifies an illustration of data, but also assists in its processing as shown in Figure 2.

Copyright © GLOBAL ACADEMIC EXCELLENCE (M) SDN BHD - All rights reserved

Journal of Information System and Technology Management
JISTM
EISSN: 0128-1666
Volume 9 Issue 35 (June 2024) PP. 130-146
DOI: 10.35631/JISTM.935008

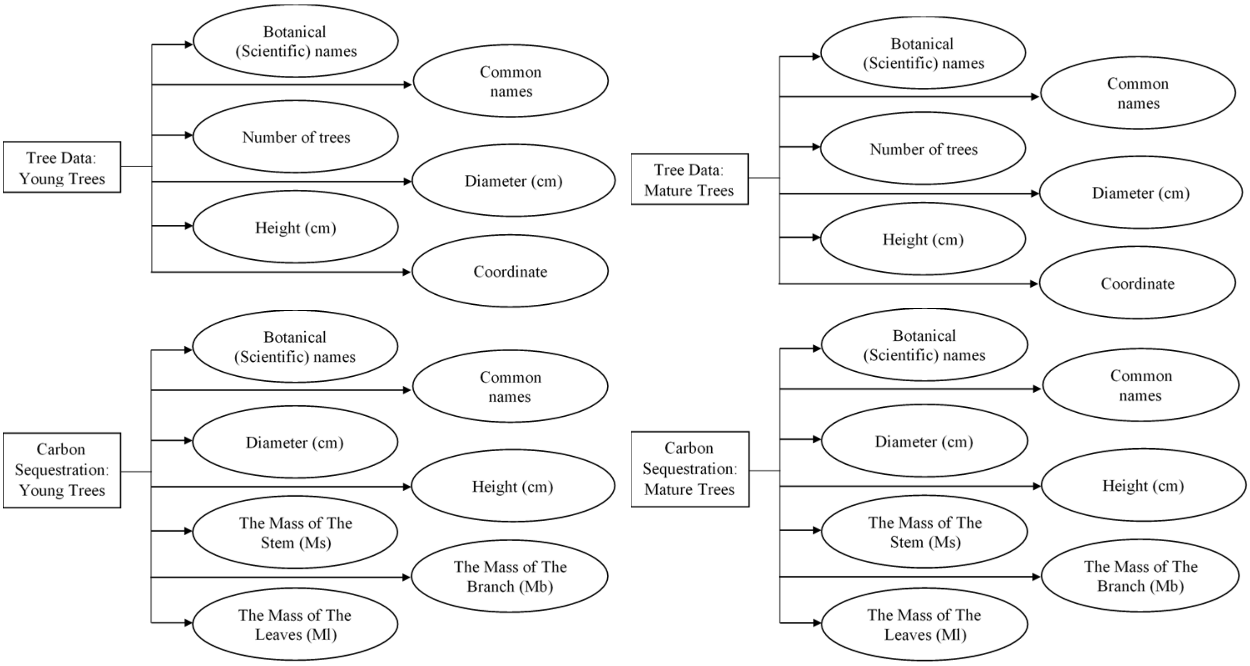


Figure 2: Entities and Attribute Diagram of Trees and Carbon Sequestration Database Structure

Stage 3: Identifying The Relationships Between The Entities Of Trees Data And Carbon Sequestration

The following stage is to determine the type of relationship that exists between the two entities. When an attribute of one entity is connected to the attribute of another entity, a relationship exists between those two entities. The significance of the relationship is linked with that of a verb that connects two nouns (entities). In this study, the database structure represents the relationship as CARBON SEQUESTRATION (refer figure 3). The Chen-like Model defines a relationship between two entities: GROUP OF CATEGORIES_TREE DATA (Tree Data: Mature Trees and Tree Data: Young Trees) and GROUP OF CATEGORIES_CARBON SEQUESTRATION DATA, which can be referred to as CARBON SEQUESTRATION (refer to figure 4). The GROUP OF CATEGORIES_TREE DATA has data on trees grouped by tree category. This data will assist the GROUP OF CATEGORIES_CARBON SEQUESTRATION DATA figure out the calculation of DBH. The GROUP OF CATEGORIES_CARBON SEQUESTRATION DATA will then use the data from GROUP OF CATEGORIES_TREE DATA to compare the amount of carbon sequestered by young and mature trees in the study area. The two entities (GROUP OF CATEGORIES_TREE DATA and GROUP OF CATEGORIES_CARBON SEQUESTRATION DATA) have a one-to-many relationship (1:M). This is because GROUP OF CATEGORIES_TREE DATA can be used to calculate carbon sequestration for GROUP OF CATEGORIES_CARBON SEQUESTRATION DATA, but the attributes of GROUP OF CATEGORIES_CARBON SEQUESTRATION DATA are linked to and depend on only one element of GROUP OF CATEGORIES_TREE DATA.

Copyright © GLOBAL ACADEMIC EXCELLENCE (M) SDN BHD - All rights reserved

Journal of Information System and Technology Management
JISTM
EISSN: 0128-1666
Volume 9 Issue 35 (June 2024) PP. 130-146
DOI: 10.35631/JISTM.935008

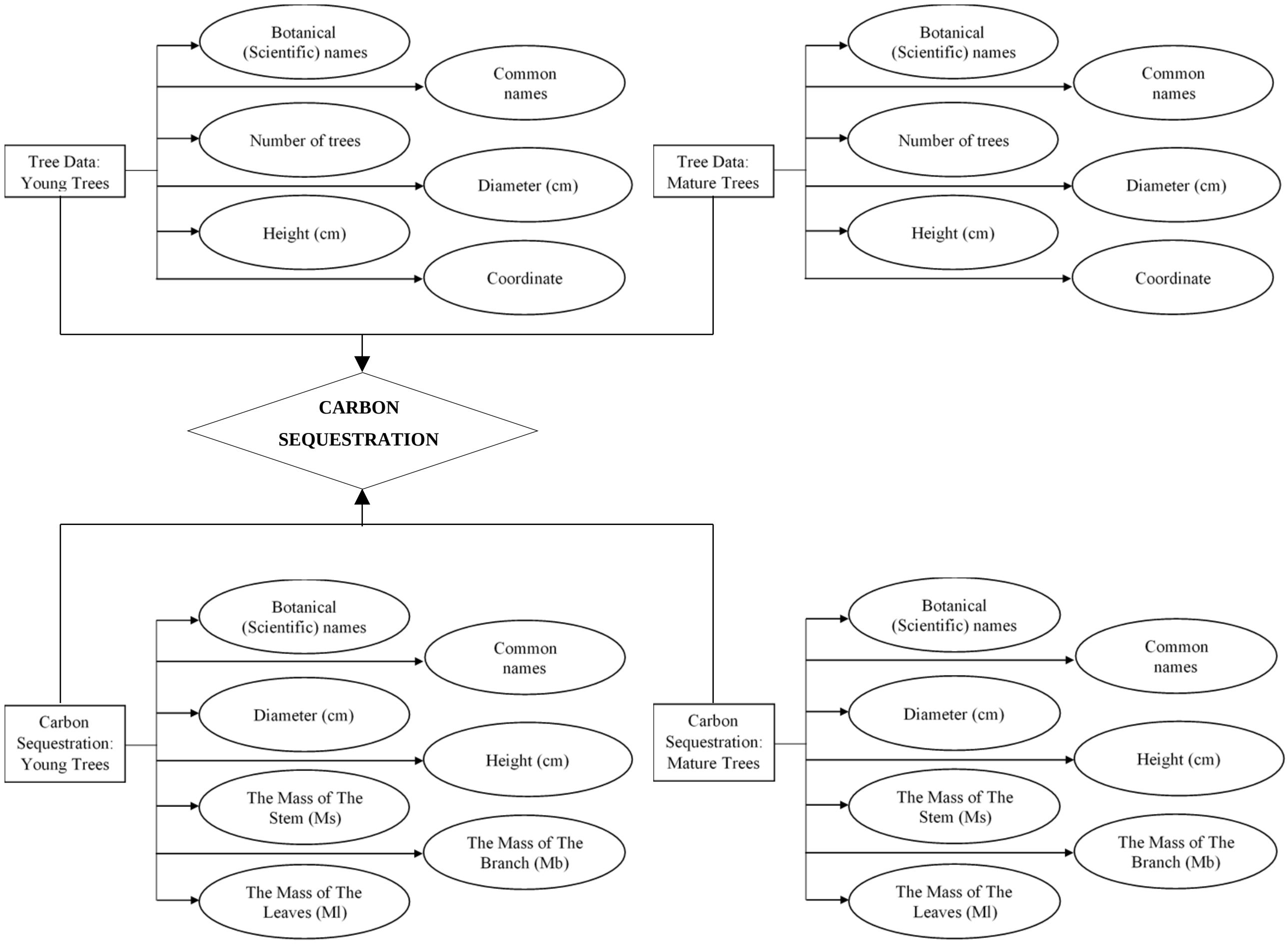


Figure 3: The Relationship Between Entities of Trees Database Structure

Spatial Mapping and Analysis Using GIS Software

This study, applied four (4) steps of valuating and mapping the spatial and attribute to establish a technical framework of GIS based on Deng et al (2011) study that can be used by the management of landscape planning for monitoring works. Further details of framework are discussed below.

Step 1: Identification Of Study Area

Hospital Gerik was chosen as the study area because health facilities or institutions are significant energy users because they are dependent on a continuous and reliable energy supply to operate both medical and non-medical equipment, including ventilators, lights, and air conditioning. Gases are released by the equipment that absorb and disseminate off thermal infrared radiation. The result preserves heat in the atmosphere. Although the health facilities are positioned to be at the front lines of the global battle against climate change as a first responder, it is additionally a contributor to the issue in an unexpected way. Hence, total acreage of the study area is 3.22 hectares including a development area/building of 1.83 hectares and a green area of 1.39 hectares. The site boundary was identified, and the tree inventory has been classified through the inventory phase.

Copyright © GLOBAL ACADEMIC EXCELLENCE (M) SDN BHD - All rights reserved

Journal of Information System and Technology Management
EISSN: 0128-1666
JISTM
Volume 9 Issue 35 (June 2024) PP. 130-146
DOI: 10.35631/JISTM.935008

Step 2: Data Collection And Database Development

In this study, depending on the primary data collection which is trees identification, and characteristics were defined as group of tree categories, botanical (scientific) names, common name, number of trees, diameter of trees and height of trees. Then, the trees was divided into two (2) groups of trees (i) young trees with a DBH of less than 75 cm, and (ii) mature trees with a trunk or trunks with a DBH of more than 75 cm, which are close to their maximum height and show indications of reduced shoot elongation, such as less elongation or less flushes per year. According to trees identification and characteristics, in the study area, there are a total of 14 tree species. Among of that, 49 trees have a DBH in the range of 0.5 cm to 450 cm, and a height range from 0.6 m to 20 m. With a DBH of less than 75 cm, 45 of the 49 trees were categorized as young trees, while four (4) were classed as mature trees with individual trunk(s) DBH of more than 75 cm. The use of GIS offers the mapping of the spatial distribution of tree identification and characteristics, which can then be analysed in more detail. Hence, all the data of tree identification and characteristics are input into the layer as attributes in GIS.

Step 3: Carbon Sequestration Amount Estimation For Mature Trees

As mentioned before, carbon sequestration is the process of removing carbon dioxide from the atmosphere. Air quality may be regulated and improved with the support of plants, especially trees. Plants absorb carbon dioxide from the air and release oxygen into it by transpiration. It shows that the selection of the appropriate plants might result in substantial differences in the air quality in environments such as health facilities that consist of people that are especially vulnerable. In this study, Kato's (1978) formula was implemented, where tree inventory was managed to calculate the amount of carbon sequestration every existing tree in the study area. Firstly, to determine the mass of the stem (Ms), the mass of the branch (Mb), and the mass of the leaves (Ml), it is necessary to measure the DBH for each tree. The aboveground biomass (AGB) was determined using allometric equations in this study. The weight of carbon sequestration was estimated using the following formula.

$$\text{Carbon sequestration (tonne/tree)} = \text{Tree biomass(ton)} \times 0.45 \times \frac{44 \text{ amu of } CO2}{12 \text{ amu of } C}$$

In the study area, young trees and mature trees were compared according to the estimated total AGB, carbon, and carbon sequestered. The analysis of carbon sequestration based on each group of trees categories. The analysis found the total carbon sequestration (tonne/year) for 49 nos of trees is 172.66 tonne per year. It shows that the carbon sequestration value of mature trees is not influenced by their quantity. Specifically, the results show that four (4) mature trees have a higher rate for carbon sequestration compared to 45 young trees. This study only focused on carbon sequestration of mature trees database development and spatial analysis mapping. It has been determined by the analysis of the data that the four (4) mature trees that have been found in the study area are from three (3) different species. These species were Delonix regia, Hura crepitans and Samanea saman. Based on the data, it can be concluded that the species Samanea saman has the maximum capacity for carbon sequestration. With a DBH of 450 cm and a height of around 15.9 m, it has the potential to absorb approximately 144.65 tons of carbon dioxide per year per tree. The spatial distribution of carbon sequestration for mature trees is mapped using GIS so that further analysis.

Copyright © GLOBAL ACADEMIC EXCELLENCE (M) SDN BHD - All rights reserved

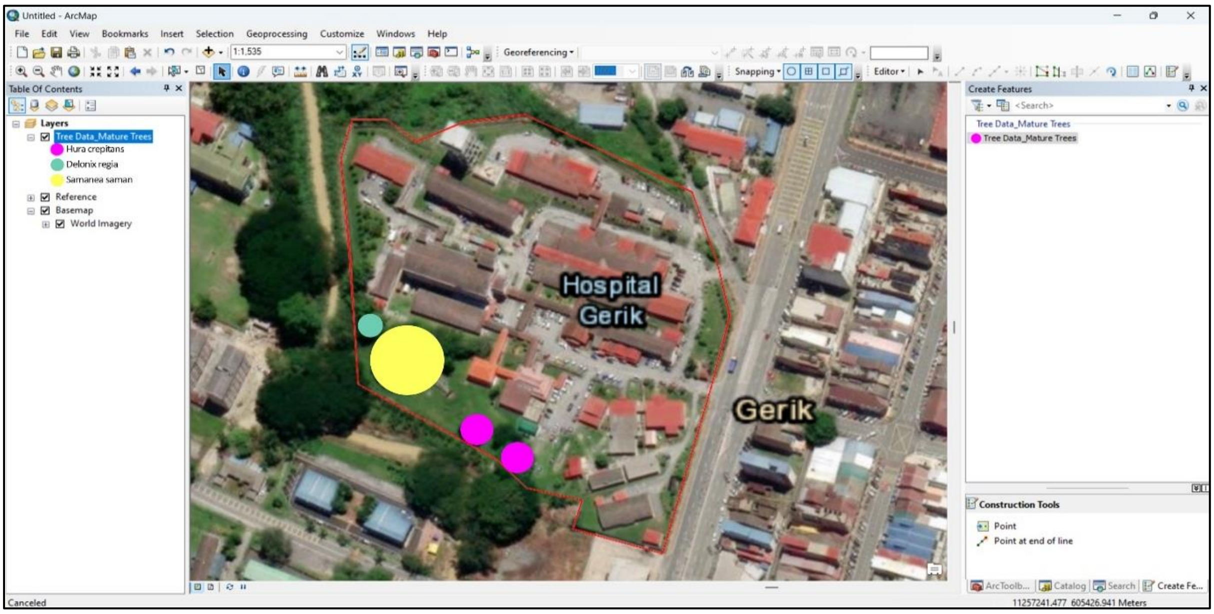
Journal of Information System and Technology Management
JISTM
EISSN: 0128-1666
Volume 9 Issue 35 (June 2024) PP. 130-146
DOI: 10.35631/JISTM.935008

Step 4: Valuation And Mapping

The study used the World Imagery base map provided in the GIS software, ArcGIS for the step of valuation and mapping in performing spatial analysis and carbon sequestration database that consists of spatial and attributes data of mature trees at Hospital Gerik. Then, the carbon sequestration value and tree's identification and characteristics data for mature trees were inserted in GIS to visualise and mapping the distribution of trees and to produce the spatial analysis. To represent tree's identification and characteristics and carbon sequestration spatial data, point features were used to digitise and locate the mature trees in Imagery base map and they are named as some new layer as "Tree Data_Mature Trees" and "Carbon Sequestration_Mature Trees". Indirectly, attribute field are created to describe and provide an information about spatial data (tree and carbon sequestration data for mature trees) as shown in Table 6. All the layers were presented in vector format as shown in Figure 4.

Table 6: Layers and Attributes of Tree and Carbon Sequestration Data for Mature Trees at Hospital Gerik

Features in GIS	Layer	Attributes
Point	Tree Data_Mature Trees	Botanical (Scientific) names
		Common names
		Number of trees
		Diameter (cm)
		Height (cm)
		Coordinate
Point	Carbon Sequestration_Mature Trees	Botanical (Scientific) names
		Common names
		Diameter (cm)
		Height (cm)
		The Mass of The Stem (Ms)
		The Mass of The Branch (Mb)
		The Mass of The Leaves (Ml)



Copyright © GLOBAL ACADEMIC EXCELLENCE (M) SDN BHD - All rights reserved

Journal of Information System and Technology Management
JISTM
EISSN: 0128-1666
Volume 9 Issue 35 (June 2024) PP. 130-146
DOI: 10.35631/JISTM.935008

Figure 4: Mapping the Tree Data_Mature Trees and Mapping the Carbon Sequestration_Mature Trees Using ArcGIS

Conclusion

GIS-based approach is proposed for valuation and mapping trees, as well as carbon sequestration data for mature trees, using the ERD method and the technological framework of GIS. The method included the integration of the data on the trees inventory, the data on carbon sequestration, and the GIS tool through the development of spatial and attribute databases. The strategy that is based on GIS has several of benefits, including its simplicity of use, affordable cost, and the ability to estimate spatially explicit patterns (Deng et al., 2011). Additionally, it can conduct the distribution of tree data and carbon sequestration values in Hospital Gerik. According to the findings of the study on value and mapping, an approach which is based on GIS can be considered feasible and reasonable. On consideration of this, it is necessary to implement actions to ensure a high level of carbon sequestration in healthcare facilities by applying an importance on landscape maintenance and planning. Based on the age of tree growth, 45 trees are enough to generate extra carbon sequestration in the research area over the following five (5) years. It is essential to include landscape planning and maintenance into the green infrastructure to encourage a cleaner and more sustainable environment. Establishing or designing new green space has much higher costs than sustaining existing trees, regardless of taking into consideration economic advantages. This should not, nevertheless, be a reason for refusing to provide more green areas and low-carbon initiatives to health facility landscape planning. Providing developed green spaces with highest carbon sequestration globally instead involves enhancing landscape maintenance efforts in the present facilities. As part of its overall management of the health facility, this study would encourage hospital management to practice and implement landscape planning and management. However, this is not a significant problem for this study, which aims more to demonstrate the application of a GIS approach than to provide reliable and significantly verified information on the assessed items' value. Even though this research only utilized GIS to quantify the data on carbon sequestration and tree allocation for mature trees in health facilities, as a result this study is a valuable research

Copyright © GLOBAL ACADEMIC EXCELLENCE (M) SDN BHD - All rights reserved

Volume 9 Issue 35 (June 2024) PP. 130-146
DOI: 10.35631/JISTM.935008

method to develop a GIS-based framework for mapping and valuation at other building areas or spaces in the future study.

Acknowledegment

There is no funding for this search. The opportunity to be involved in this study and the assistance offered along the way were both provided by Universiti Teknologi MARA (UiTM), Perak Branch, which deserves recognition.

References

Almeida, C. M. V. B., Mariano, M. V., Agostinho, F., Liu, G. Y., & Giannetti, B. F. (2018). Exploring the potential of urban park size for the provision of ecosystem services to urban centres: a case study in S˜ao Paulo. Brazil. *Build Environ, 144:450–8*. https://doi.org/10.1016/j.buildenv.2018.08.036

Behera, S. K., Mishra, S., Sahu, N., Manika, N., Singh, S. N., Anto, S., Kumar, R., Husain, R., Verma, A. K., & Pandey, N. (2022). Assessment of carbon sequestration potential of tropical tree species for urban forestry in India. *Ecological Engineering, 181(2022).* https://doi.org/10.1016/j.ecoleng.2022.106692

Clark, J.R. & Matheny, N. (1991). Management of Mature Trees. *Journal of Arboriculture 17,* 173-184.

Coomes, D. A., Holdaway, R. J., Kobe, R. K., Lines, E. R., & Allen, R. B. (2012). A general integrative framework for modelling woody biomass production and carbon sequestration rates in forests. *Journal of Ecology, 100(1).* 42-64. https://doi.org/10.1111/j.1365-2745.2011.01920.x

Denga, S., Shia, Y., Jina, Y., & Wanga, L. (2011). A GIS-based approach for quantifying and mapping carbon sink and stock values of forest ecosystem: A case study. *Energy Procedia, 5*, 1535-1545. https://doi.org/10.1016/j.egypro.2011.03.263

Jabatan Perancangan Bandar Dan Desa (2022). Garis Panduan Perancangan Kemudahan Masyarakat.

Jithila, P. J., & Prasadan, P., K. (2018). Carbon Storage and Sequestration by Trees - A Study in Western Ghats Wayanad Region. *Indian Journal of Ecology, 45(3),* 479-482.

Johnson, I., Coburn, R. (2010). Trees for carbon sequestration, Primefacts 981, pp. 1-6, https://www.naturefund.de/fileadmin/pdf/Studien/Waelder/Trees-for-carbon-sequestration.pdf

Kanniah, K. D., Muhammad, N., & Kang, C. S. (2014). Remote sensing assessment of carbon storage by urban forest. *IOP Conference Series: Earth and Environmental Science, 18(2014).* doi:10.1088/1755-1315/18/1/012151

Kanniah, K. D., Abdullah, R., & Siong, H. A. (2022). Potential Carbon Storage and Sequestration by UrbanTrees in Malaysia. *Urban Forestry and Arboriculture in Malaysia*, pp 105–133.

Kato, R., Tadaki, Y., & Ogawa, F. (1978). Plant Biomass and Growth Increment Studies in Pasoh Forest. *Malayan Nature Journal, 30,* 211-224.

Ma, F., Zhang, W., Yan, J., Zhang, T., Lu, N., Yao, M., Zhang, T., Zheng, J., & Shan Yin. (2024). Early advantage for carbon sequestration of monocultures and greater long-term carbon sink potential of broadleaf mixed forests: 20-year evidence from the Shanghai Green Belt. *Ecological Indicators, 159.* https://doi.org/10.1016/j.ecolind.2024.111655

Marcus, C. C. (2007). Healing Gardens in Hospitals. *Interdisciplinary Design and Research e-Journal, 1(1).*

Copyright © GLOBAL ACADEMIC EXCELLENCE (M) SDN BHD - All rights reserved

Volume 9 Issue 35 (June 2024) PP. 130-146
DOI: 10.35631/JISTM.935008

Matthew, N. K., Shuib, A., Muhammad, I., Eusop, M. E. M., Ramachandran, S., Afandi, S. H. M., & Samdin, Z. (2018). Carbon Stock and Sequestration Valuation in a Mixed Dipterocarp Forest of Malaysia. *Sains Malaysiana*, *47(3),* 447–455. http://dx.doi.org/10.17576/jsm-2018-4703-04

McPherson, E. G., (1998). ATMOSPHERIC CARBON DIOXIDE REDUCTION BY SACRAMENTO'S URBAN FOREST. *Journal of Arboriculture, 24(4),* 215-223.

McPhersona, E. G., Xiao, Q., & Aguaronc, E. (2013). A new approach to quantify and map carbon stored, sequestered and emissions avoided by urban forests. *Landscape and Urban Planning, 120,* 70–84. https://doi.org/10.1016/j.landurbplan.2013.08.005

McPherson, E. G., van Doorn, N. S., & Peper, P. J. (2016). Urban Tree Database and Allometric Equations. United States Department of Agriculture.

Mishra, A. K., Singh, J., & Srivastava, R. (2012). Standing carbon stock estimation in different tree species grown in dry tropical forests of vindhyan highland, Mirzapur, India. *Ecology, Environment and Conservation*. *19,* 401-407.

Nieberler-Walker, K., Desha, C., Bosman, C., Roiko, A., & Caldera, S. (2023). Therapeutic Hospital Gardens: Literature Review and Working Definition. *Health Environments Research & Design Journal*, *16(4),* 260-295. DOI: 10.1177/19375867231187154.

Nowak, D. J., & Crane, D. E. (2002). Carbon storage and sequestration by urban trees in the USA. *Environmental Pollution, 116(2002),* 381-389.

Nowak, D. J., Greenfield, E. J., Hoehn, R. E., & Lapoint, E. (2013). Carbon storage and sequestration by trees in urban and community areas of the United States. *Environmental Pollution*, *178(2013),* 229-236.

Rosli, N. M., Soffian, N. M., & Ahmad, A. (2023). Hiking Incidents Database Structure Using Entity-Relationship Diagram (ERD). *JOURNAL OF INFORMATION SYSTEM AND TECHNOLOGY MANAGEMENT (JISTM), 8(31),* PP 129-147

Sachs, N. A. (2019). A Breath of Fresh Air: Outdoor Spaces in Healthcare Facilities Can Provide Clean Air and Respite. *Health Environments Research & Design Journal, 12(4),* 226-230.

Sachs, N. A. (2017). The healthcare garden evaluation toolkit: A standardized method for evaluation, research, and design of gardens in healthcare facilities. (Ph.D. Dissertation), Texas A&M University.

Sachs, N. A. (2023). Caring for Caregivers: Access to Nature for Healthcare Staff. *Health Environments Research & Design Journal, 16(4).* 206-212.

Shadman, S., Khalid, P. A., Hanafiah, M. M., Koyande, A. K., Islam, M. A., Bhuiyan, S. A., Woon, K. S., & Show, P. L. (2022). The carbon sequestration potential of urban public parks of densely populated cities to improve environmental sustainability. *Sustainable Energy Technologies and Assessments, 52(5864)*:102064. https://doi.org/10.1016/j.seta.2022.102064

Sidana, A. S. (2013). Key Benefits of Using Entity Relationship Diagrams. EzineArticles. Retrieved 8th March 2023 from https://ezinearticles.com/?Key-Benefits-Of-Using-Entity-Relationship-Diagrams&id=7525910

Stoffberg, G. H., van Rooyen, M. W., van der Linde, M. J., & Groeneveld, H. T, (2010). Carbon sequestration estimates of indigenous street trees in the City of Tshwane, South Africa. *Urban Forestry & Urban Greening*, *9(1),* 9-14. https://doi.org/10.1016/j.ufug.2009.09.004

Unit Perancang Ekonomi, Jabatan Perdana Menteri Kementerian Alam Sekitar dan Air Malaysian Green Technology and Climate Change Centre (2020). Garis Panduan

Copyright © GLOBAL ACADEMIC EXCELLENCE (M) SDN BHD - All rights reserved

Journal of Information System and Technology Management
JISTM
EISSN: 0128-1666
Volume 9 Issue 35 (June 2024) PP. 130-146
DOI: 10.35631/JISTM.935008
Perolehan Hijau Kerajaan (GGP) 3.0. Unit Perancang Ekonomi, Jabatan Perdana Menteri Kementerian Alam Sekitar dan Air Malaysia.

Copyright © GLOBAL ACADEMIC EXCELLENCE (M) SDN BHD - All rights reserved