**Research Proposal**


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## 1 Research Topic

Carbon Sequestration by Trees Species in Urban Forest

## 2 Research Aim

The aim of this study is to investigate amount of carbon stock by urban tree species. This will reveal the importance of trees in carbon sequestration, and put urban trees at higher level in term of protection and conservation.

## 3 Research Objectives

To reach the aim, the following research objectives are developed:

i. To identify tree community structure and its distribution for trees species in urban forest.
ii. To measure amount of carbon sequestration by the urban trees species.
iii. To discover amount of carbon stock accumulate in urban trees species.
iv. To produce a carbon sequestration map for urban tree species.

## 4 Hypothesis

This study hypothesized that urban tree efficiently store carbon in the urban area.

## 5 Assumption

Increase amount of carbon dioxide as a major Green House Gases (GHG) in atmosphere will raise total carbon sequestration by urban trees also carbon stock accumulation in urban forest.

## 6 Research Questions

Below are research questions for this study:

i. What is the plant community structure of urban trees species?
ii. How much carbon sequestration by urban trees species?
iii. What is amount of carbon stock by urban trees species?
iv. How carbon sequestrations display the importance of trees in urban forest?

## 7 Research Background

A lot of people move from rural to an urban area to reach better and comfortable life with modern facilities. Moreover, more employment is offered from cities and towns. This situation was started since 19th century because of the urbanization process (Ye et al. 2012). In Malaysia, industrialization altered pioneer land use type which are rice fields, coconut stand and rubber plantation into large palm oil plantations (Hussain & Byrd 2012). Urbanization influences the economic growth, human health and urban vegetation. Moreover, urbanization also reduce green spaces and turn to land use (Choi et al. 2012). Because, high demand for houses, building and other facilities according to human need in achieving developed country. However, rapid urbanization in Asia and Africa increase number of urban population which this number will be double between 2000 and 2030 (Ho et al. 2013). After reducing urban forest area for developing activities, gave many consequences emerged. The consequences are emission of major Green House Gases (GHG) which is carbon dioxide, degraded of human health according to air pollution that come from factory and vehicles also occur from diminishing this area. According to Zhang et al. (2012), 0.21 part per gram carbon release to the atmosphere during rapid urbanization from 1945 until 2007. Increasing energy demand from large populations also contribute to a large amount of carbon in an urban area (Wang et al. 2013).

Carbon dioxide is the major contribution for GHG in an atmosphere. This gas emitted from human activities such as open burning, coal burning, transport and frequent maintenance activities which come from maintenance equipment e.g chainsaws, chippers, stump removers and leaf blowers (Mcpherson 1998). In the United States almost 40 percent of total carbon emission from association between residences and cars, exchanging patterns in urban development and local transportation (Glaeser & Kahn 2008). An urban metabolism studied was done by Kellett et al., (2013) which represent clear view about value of carbon emission and uptake in urban area (Figure 1). When this gas accumulates in the atmosphere, it will trap most of the heat and radiation from the land rather than pass through the atmospheric layer (Mountain et al. 2011). Enlargement of heat in the atmosphere increase global temperature and finally create global warming. Global warming affected ice layer in North and South Pole become thin and raise the ocean level further shrink land area (Nowak 2004). Furthermore, carbon dioxide can effect human health if the concentration become high (Woodbury et al. 2006). Although, there were various disadvantages from accumulation of carbon dioxide in the atmosphere, indeed trees the only creature that really needs this gas to make their own food during Calvin Cycle in the photosynthesis process (Smith 2009).

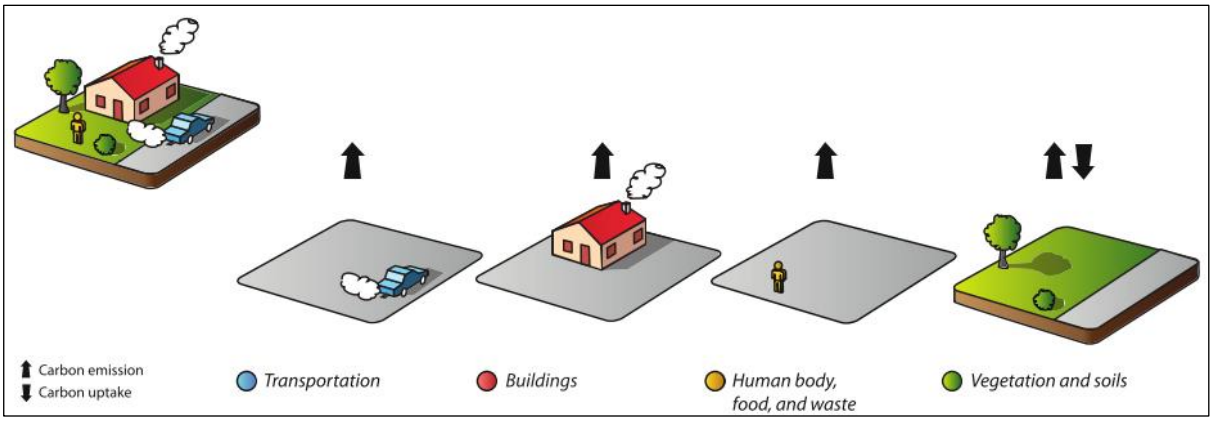


Figure 1: Carbon emission and uptake in urban metabolism. (Source: Kellett et al., 2013)

Urban greenery areas become smaller since human highly demanded to houses and building. Urban greenery refers to a wide variety of different element such as street tree and square plantings, cemetery and woodlands (Konijnendijk 2013). However, with burden of population in urban areas put urban greenery in stressed condition. Urban greenery areas have to clear and give a space to sky scrapper and other building which to enhance quality of life and modern cities. Therefore, urban forest also include in this situation and have to manage it properly with better planning and scientific organization (Jim & Chen 2009).

Urban forests play a crucial role in temperature reduction, better health, cooling effect, carbon sequestration, carbon stock, habitat for animal and an aesthetic value. Urban forests were defined as grouping of trees and other vegetation located in the urban area (Nowak, 2004). Other definition of urban forest from Escobedo (2011), stated that urban forest is the total number of urban trees, shrubs, lawn and pervious soil located in a complex area and manage by human. However, urban trees are woody perennial plant emerged in the city with single bole and separate crown (Roy et al. 2012). But, these urban forests became smaller because of higher population demand in urbanization. Kuala Lumpur is one of the mega cities in Malaysia, start developed in 1870s and population turn into 1,887,674 in 2007 from 977,102 in 1980. This population expected to change to 2.1 million of a human population in Kuala Lumpur (Akmar et al. 2011). According to this number, a lot of urban forests and green area will be converting to streets and buildings to fulfill human need. But, in Malaysia National Landscape Guideline (2008), already mentioned about 10 percent from a residential and 30 percent from factories areas should be reserved as green area. In Vadodara City, a studied has shown that 73.59 percent of carbon dioxide was reduced by trees which planted along the roadsides (Kiran & Kinnary 2011). Therefore, the planner should aware with this quantity which strengthens to conserve more urban area from being destroyed.

In order to reduce this GHG effect, a few plans have been implementing. Starting in 1988, Intergovernmental Panel on Climate Change (IPCC) was established. This panel was set up by World Meteorological Organization (WMO) and United Nations Environment Program (UNEP) to create policy that relate to climate change mitigation. Further, Kyoto Protocol was formed in 1997 to urge industrialized country to limit their GHG emission. At first, this agreement was members by all industrialized country and the United States. But, this agreement has not been force until after 55 countries involved and this agreement started to work (Hagem, Cathrine and Holtsmark 2004). Clean Development Mechanism (CDM) is one of the emission permits under Kyoto Protocol for developing countries. CDM offer carbon credit to the developed country from degradation of the urban area (Yong Shin et al. 2007). Then, United Nation Framework Convention on Climate Change (UNFCCC) was developed which comprises 150 countries include Malaysia. This framework also aims to reduce carbon dioxide and GHG emission (Woodbury et al. 2006). In Malaysia, Low Carbon Society (LCS) was developed to set a plan at Iskandar Malaysia in Johor Bahru regarding carbon issues. A few steps have to followed for achieving development for LCS (Ho et al. 2013).

Malaysia located near to equator line and receives humid and warm temperature all the year. With this beauty of climate, most tropical trees sequester more carbon compared to the temperate trees that meet four seasons in one year (Yashiro et al. 2008). According to Rasineni (2011), tropical growing deciduous tree increased level of photosynthesis during spring because at that time the trees start to refoliate but will reduce in late summer. Temperature influence photosynthesis rate because trees will increase photosynthesis rate when higher temperature compare to the lower temperature. Trees will reduced their photosynthesis level for forty percent when lower temperature compare to the temperature at 30°C (Oku et al. 2014). Therefore, there was a fluctuation in photosynthesis rate in temperature country because of the temperature behavior. This situation develops the annual rings inside the bole for the temperate trees.

## 8 Problem Statement

As a developed country, Malaysia always plans a better life and modern infrastructure in urban area. To create a superior environment in urban, government and city planner always disregards with the important roles of the urban forest. After the urban forest was converting to building and street, most of the urban forest becomes smaller and fragmented. This situation becomes poorer when no replanting programmed implement to increase number of urban forest and greenery area around the development area. After high number of population in urban area, amount of carbon dioxide release

to the air also increase. This situation needs a well plan urban area in order to minimize amount of carbon accumulate in the atmosphere. More carbon store in the air, this will reflect more contribution to global warming and climate change. Therefore, plant existing is important to balance this situation essentially in urban area with high development. Increase development processes on the other hand government must try to increase number of trees and conserve it.

## 9 Research Gap

Many studies have been done before regarding to carbon sequestration in temperate urban forest, agroforestry, reserve forest and plantation e.g (Camacho et al. 2009; Byrne & Black 2003; Firdaus et al. 2010). A study was done before in tropical rain forest and Pasoh Reserve Forest as the study site. This study identifies effect of logging on soil GHG but lack of study covered urban forest areas (Yashiro et al. 2008). However, this study will concentrate towards carbon sequestration in tropical urban forest. Moreover, there is a rapid develop area in Malaysia name as Iskandar Malaysia which start developed from year 2005. This area located at southern part of Peninsular Malaysia and areas of this site is three times larger than Singapore. As a new place to develop, lacks of study have been done according to carbon stock and sequestration. Previously, researchers start measuring source of carbon dioxide emission and little studies about mapping carbon stock in this area (Ho et al. 2013).

## 10 Theoretical Framework

Carbon sequestration is total amount of carbon that store in above and below ground in one growing season. Sequestration process will depend on tree growth and mortality. Tree with large diameter sequester more carbon compared to small diameter. Besides, forest with particular management also influence rate of carbon sequester by urban trees (Mcpherson 1998). In fact, tree is an autotroph organism which produces their own food during photosynthesis process. To complete photosynthesis, trees need water, carbon dioxide and sunlight (Shively et al. 2004). Here, is the photosynthesis equation that show carbon will take during photosynthesis:

$$6CO_2 \text{ (carbon dioxide)} + 6H_2O \text{ (water)} + \text{Energy} \rightarrow C_6H_{12}O_6 \text{ (glucose)} + 6O_2 \text{ (water)}$$

Then, glucose will produce as the major product meanwhile oxygen is the by product in photosynthesis. Chlorophyll which is the green pigment in leaf acts as a site of photosynthesis after carbon enters the leaf from stomata. Therefore, trees play importance roles in reducing carbon dioxide in atmosphere because trees assimilate carbon during photosynthesis process and along their life span.

Amount of carbon that tree assimilate from atmosphere during also define as carbon sequestration. Usually carbon was measure as oven dry metrics tons which one metric ton 1000 kilograms and equal to one megagrams (Bragg & Guldin 2010). This study was proposed after review the important role of trees in carbon sequestration during photosynthesis process and store it as carbon stock (Smith 2009).

## 11 Scope of Study and Variables

This study identify amount of carbon stock accumulate in five urban tree species. Besides, to measure carbon sequestration by five urban tree species. Five species of trees that will be selected is the most common species that have been planted as a cultivated plant in urban areas. Nusajaya that located in Iskandar Malaysia was choose because of this location is in rapid developing site. To achieve the aims of this study field survey and satellite data will be used along this study. In field survey, plant community structure data will be collected by plot setting. Plot setting will be established according to the distribution of five tree species that have been selected. Thirty plots with width 20 m x 50 m will set up and stratified sampling method will be use along this study. Five tree species that have been choose will be identified and tag in each plot to avoid error during collecting DBH and height data. A form (Appendix C) with details data that will be collected is created and will be using throughout the sampling process. Each trees location will be map using GPS then picture of each tree will be taken. From these data, it will create a map of carbon stock later after DBH and height for each trees analyzed using biomass and carbon sequestration equation. Crown cover will be measure by satellite image using grid for estimating the growth of each trees. Then, Leaf Area Index will be collected by LAI-2000 for estimating total area of leaf that responsible in carbon assimilation during photosynthesis. All of the data from above ground biomass or carbon stock, carbon sequestration, crown cover and LAI will be analyzed using Analysis of Variance (ANOVA) manage by SPSS to view the mean relationship among this parameters.

## 12 Significance of Study

This study will add to a body of knowledge total of carbon stock and sequester by urban trees. Then, this data will help future researcher gather information regarding to carbon stock. Furthermore, this study will improve forester which types of trees that sequester carbon more and can increase total number of selected trees in urban area. Moreover, carbon stock map that will be establish make

researcher easier to estimate next ten or five years carbon stock and to locate for each trees. Since, large amount of carbon stock was recorded in Sacramento which is 36.1 kg Carbon per meter square (Nowak & Crane 2002), urban forest show importance role in carbon reduction. Other effort also needed in order to maintain amount of carbon dioxide in atmosphere rather than increase the amount of it. Moreover, urban forest have to conserve because of carbon stock in urban forest will release back to the atmosphere if there is human interference (Ren et al. 2012) and a policy should be create to overcome this problem. Besides, Carbon credit under Clean Development Mechanism (CDM) that support reforestation and afforestation in order to help developed country in mitigating GHG (Yong Shin et al. 2007).

## 13 Research Design

This study will identify five urban tree species community structure. These data will show the correlation between growths of trees in urban forest that will reflect the amount of carbon sequestration by the trees. Data such as Leaf Area Index (LAI), crown cover, Diameter at Breast Height (DBH) and tree height are needed to produce good finding. Below are the stages and variables that are essential in completing this study.

i. Study area selection

This study will implement at urban forest in Iskandar Malaysia. Total Iskandar Malaysia area is 2216.3 $km^2$. This study will be focus in Flagship Zone B. In Iskandar Malaysia, five Flagship was developed according to development. In Flagship Zone B is Nusajaya (Figure 2) area which comprises Johor state administrative center, medical center and resort (Ho et al. 2013). The importance factor that Nusajaya has been selected as a study site because of Iskandar Malaysia aims in reducing carbon in atmosphere. As a new place to develop, there is little data regarding to carbon stock and sequestration.

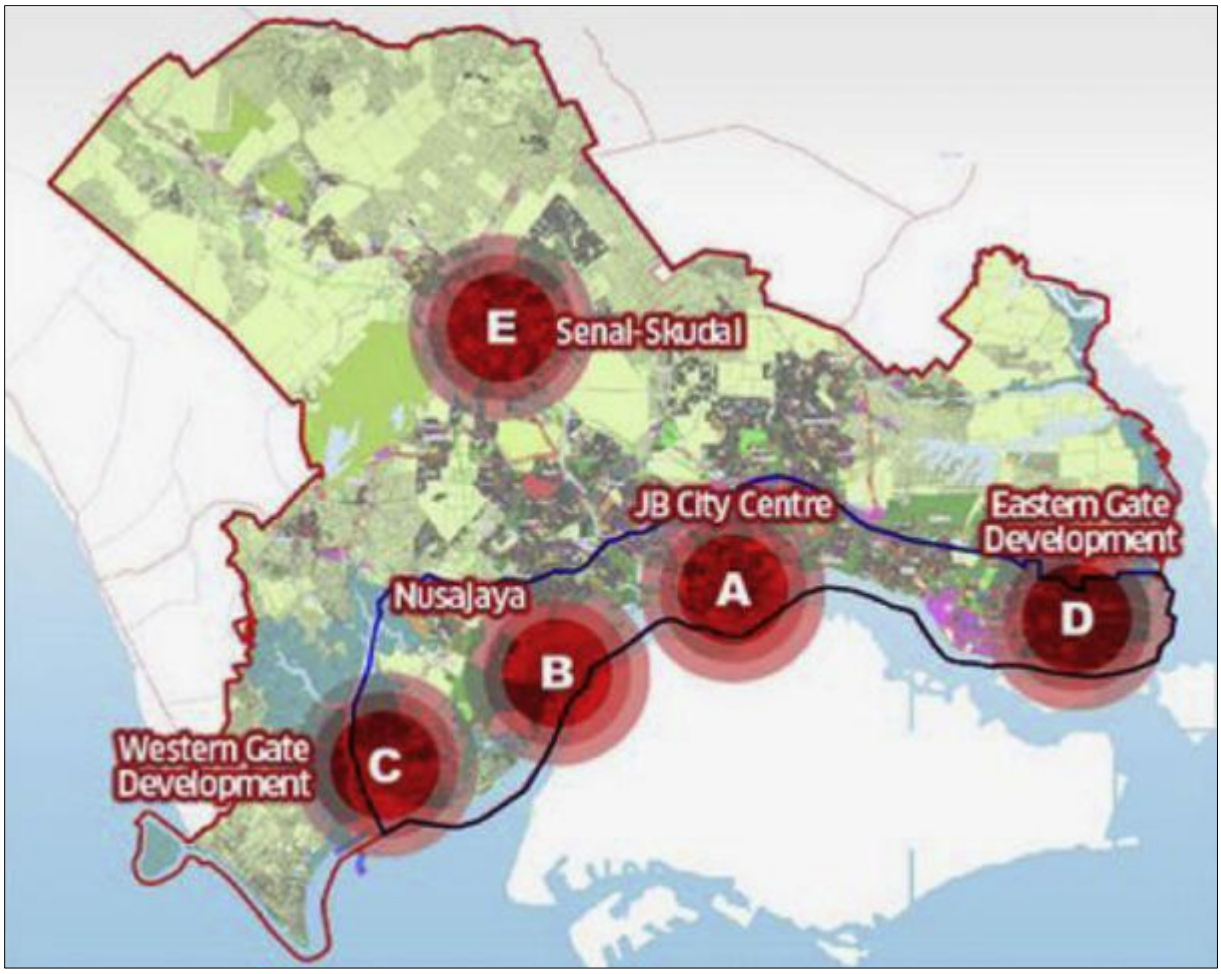


Figure 2: Shows location of Nusajaya as Flagship B in Iskandar Malaysia (Source: Ho et al., 2013)

ii. Plot setting

Stratified sampling methods will implement during sampling stages. Thirty plots with total sampling areas is 3 hectare size with width 50 m x 20 m will establish for each plot (M. Khairil, W.A. Wan Juliana 2011). These plots will set up 100 meter from buffer zone.

iii. Field Data Collection

Field data collection or sampling phase will do in order to obtain data of plant community structure at the study site. Most of the data acquire are five common tree species that have been selected, number of the trees available at the study area, height using clinometer, diameter at breast height (DBH) using DBH tape, crown cover using satellite image, tree condition (health)

and location of the trees. Table 1 shows equipment that will use during data collection. All the data will be recorded in a form that will include date, time, name of collector and location of the plot which is latitude and longitude that will be achieve from Global Positioning System (GPS). Leaf Area Index (LAI) will be recorded using LAI-2000. LAI will expose photosynthesis rate by the urban trees according to the leaf surface area also amount of carbon dioxide absorb and oxygen released by the trees (Jim & Chen 2009).

Table 1. List of equipment that will use during sampling stage.

| Number | Name of the Equipment | Function | Figure |
|---|---|---|---|
| 1. | SUUNTO Clinometer | To measure tree height |   |
| 2. | DBH Tape | To measure diameter of trees |   |
| 3. | LAI-2000 | To measure leaf area index which the total surface of leaf for each trees |  |
| 4. | Garmin Oregon 500t GPS with built in camera | To map the location of each trees include the picture |   |

iv. Data analysis

Plant community structure will be divided into two parts. First part is for species diversity and second part is species richness. In species richness, species density is one of the data that will determine richness of the species in per $m^2$. For species diversity, Shannon-Weiner Diversity Index will be used and formula is shown below. This formula will reveal which species among five selected species more diverse in this study area (Magurran 1988).

Shannon-Weiner Diversity Index formula:

$$H' = -\sum_{i=1}^{S} pi \ln pi$$

Where

H' = species diversity Index

s = the number of species

pi = the proportion of individuals of each species in the particular saiz of study area from total number for all species

Species Richness will analyze using equation below:

$$E(S) = \sum \left\{1 - \left[\binom{N - Ni}{n}\right] \middle| \binom{N}{n}\right\}$$

Where

E(S) = expected number of species

n = standardized sample size

N = total number of individuals recorded

Ni = number of individuals in the *i*th species

To measure carbon stock in urban forest, aboveground biomass from Kato et al (1978) equation will be used. This is because 80 percent of carbon which store in tree located at bole, leaves and trunk. Only 20 percent of carbon located at roots (Kim Phat et al. 2004). For carbon sequestration measurement, basal area will calculate first before obtain total amount of carbon sequestration using equation from (Kiran & Kinnary 2011).

Below is the equation for carbon sequestration measurement:

Basal Area ($m^2$) = $(DBH/2\pi)^2 \times \pi$

Standing Woody Biomass = -1.689 + 8.32 x Basal Area

Carbon sequestration = 0.46 x Standing Woody Biomass

After all the data was collected and analyzed according to the carbon equation. Analysis of Variance will be doing using SPSS to show the relationship of mean among the parameters. Then, map will produce to show the distribution of five urban trees that have been selected before.

## 14 Anticipated Findings

This study will discover amount of carbon sequestration by urban trees and carbon stock accumulate in Nusajaya. Nusajaya is a rapid development areas starting year 2005. Furthermore, the result from this study will shows that among five tree species that have been chosen which is the major tree species that contribute to the higher amount accumulate carbon sequestration as well as carbon stock. Later, this species characteristics will study and recognized the character that made this species efficient in sequester carbon also in carbon stock. As known, urban trees will reduce the amount of carbon dioxide accumulate in the urban area (Breugel 2011). Carbon stock data will be used to construct a carbon stock map in Nusajaya that will help further planner and foresters in compiling data for tree species, frequency and distribution of each tree that already cultivated around Nusajaya. Furthermore, these data will support Carbon Credit under CDM that established under Kyoto Protocol for developed country to mitigate GHG.

## 15 Research Schedule

| STAGES OF STUDY | YEAR 1 | | YEAR 2 | | YEAR 3 | |
|---|---|---|---|---|---|---|
| | Sem 1 | Sem 2 | Sem 3 | Sem 4 | Sem 5 | Sem 6 |
| Proposal | | | | | | |
| Literature Review | | | | | | |
| Problem Statement, Aim, Objective formulation | | | | | | |
| Methodology | | | | | | |
| Data Collection | | | | | | |
| Data input and analysis | | | | | | |
| Findings | | | | | | |
| Writing | | | | | | |
| Submission | | | | | | |

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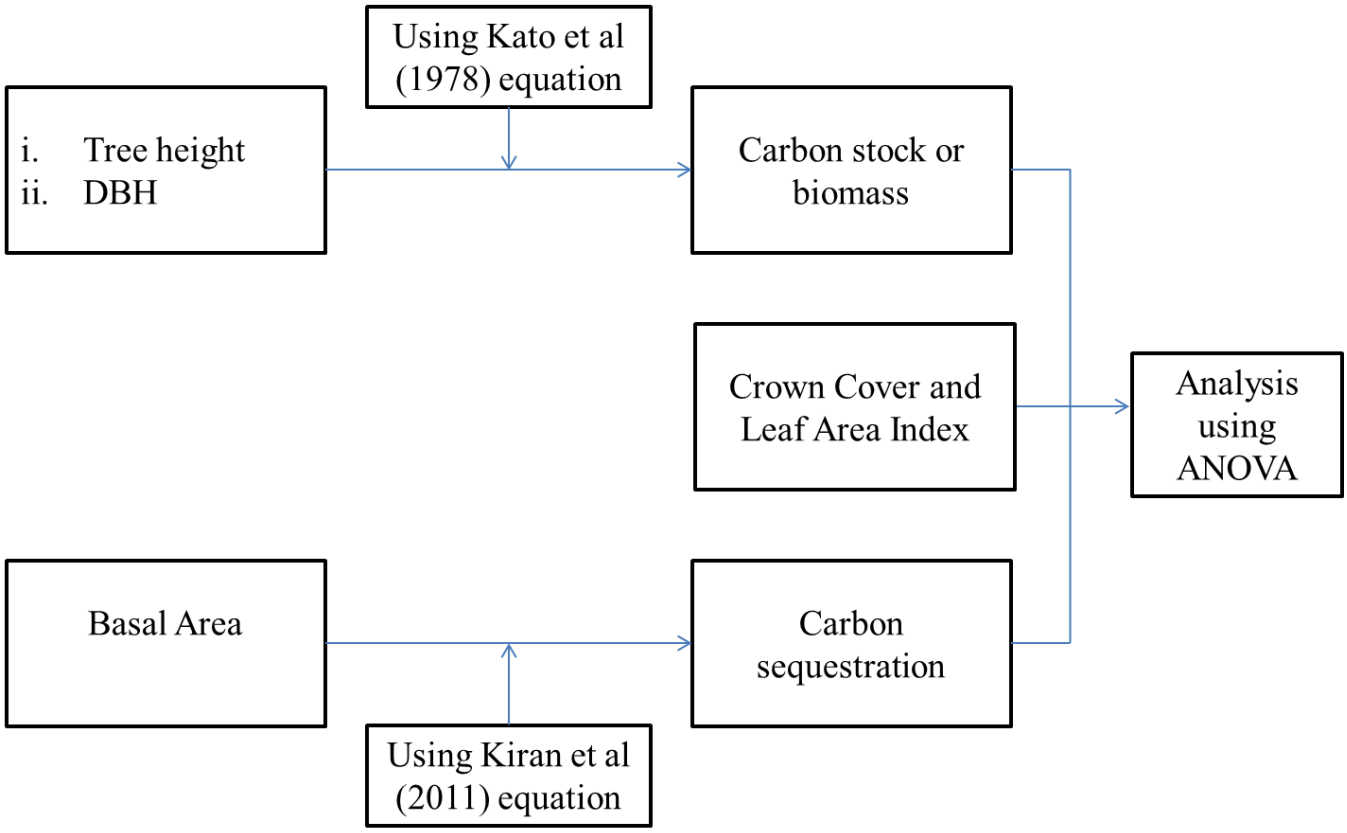
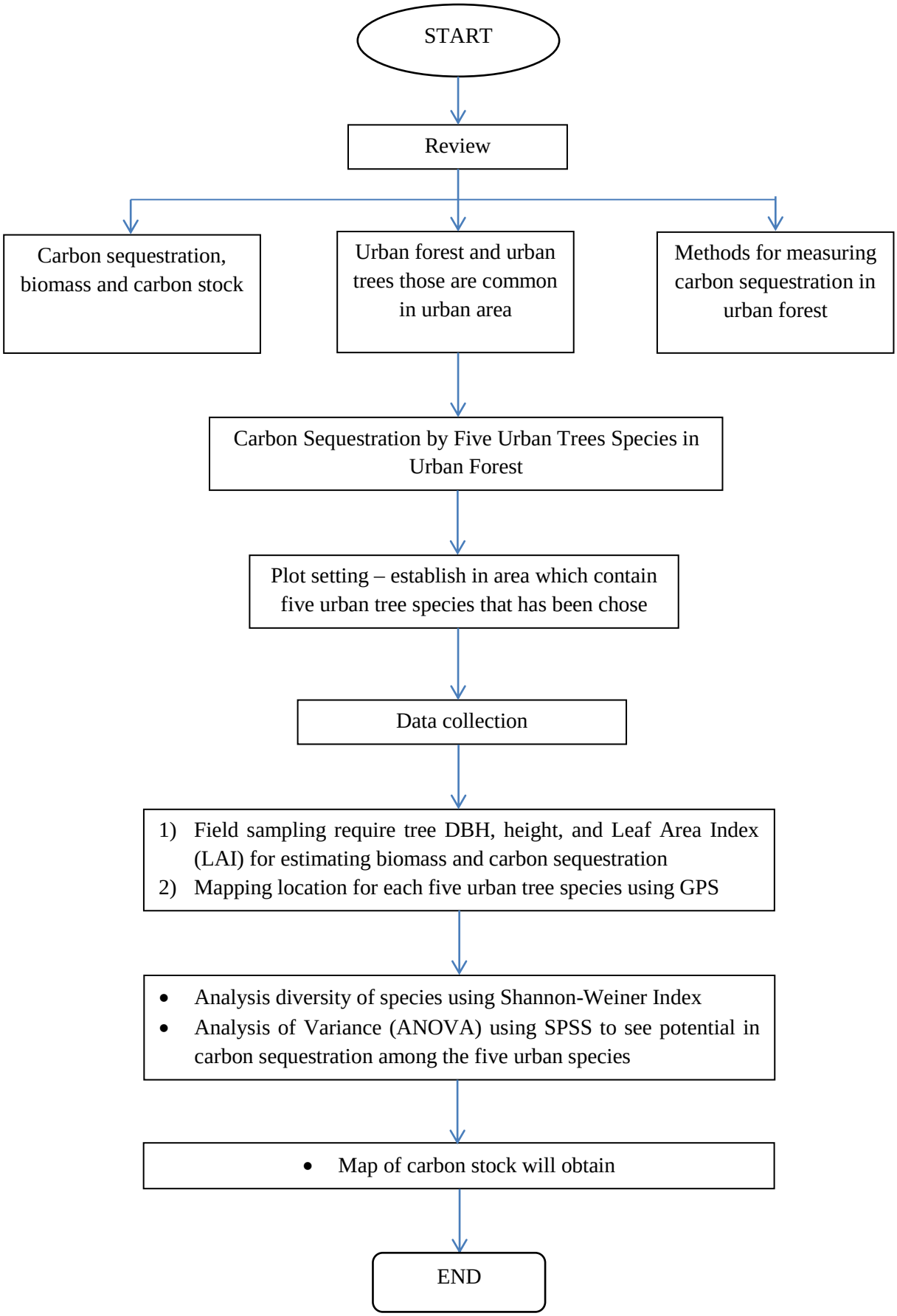
APPENDIX A

Research Design



APPENDIX B


START
Review
Carbon sequestration, biomass and carbon stock
Urban forest and urban trees those are common in urban area
Methods for measuring carbon sequestration in urban forest
Carbon Sequestration by Five Urban Trees Species in Urban Forest
Plot setting – establish in area which contain five urban tree species that has been chose
Data collection
1) Field sampling require tree DBH, height, and Leaf Area Index (LAI) for estimating biomass and carbon sequestration
2) Mapping location for each five urban tree species using GPS
• Analysis diversity of species using Shannon-Weiner Index
• Analysis of Variance (ANOVA) using SPSS to see potential in carbon sequestration among the five urban species
• Map of carbon stock will obtain
END

APPENDIX C

Sampling Record (Data Collection Form)

| | |
|---|---|
| **Name of collector** | |
| **Data** | |
| **Time** | |
| **Weather** | |
| **Plot Number** | |
| **Plot Location** | |

Tree Details

| Species Name /Tag Number | Location | DBH (cm) | Height (m) | Crown Cover | LAI | Notes (Tree health) |
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