

**ASSESSING GREENWAY NETWORK CONNECTIVITY  
FOR UNIVERSITY CAMPUS**

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*To my brothers and sisters in USIM who love trees.....*

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## ABSTRACT

Greenway is a route to connect people with places. It is a multi-objective planning approach in order to improve the quality of campus environment and to enhance its identity as an academic village. Campus greenway is composed of roadside trees, pedestrian way, cycle way and river or lake corridors connecting play fields, gardens and squares. Thus, to establish a greenway in a university campus, the road reserve which is a ready network is used as main linear resource. Nonetheless, the foremost challenge in establishing a campus greenway is to counter the fragmentation of all physical elements such as walkways and trees along the road reserve. Therefore, the study analyzed the physical characteristics such as walkway width, trees shape and planting continuity as well as types of nodes which constitute a greenway in a university campus. The study has measured variables such as connectivity, naturalness and nodes within and along the campus road reserve. A site inventory was conducted and site photographs taken. ArcGIS 9 (ArcMAP release version 9.1) was used to visualize and analyze the data. The study has identified two factors, too narrow road reserve and too many gaps (breaks) and barriers that obstruct the flow of pedestrians or cyclists along the greenway and hence, constraint the formation of campus greenway. The gaps were road junctions, opened drains and discontinuous walkway, and the barriers were signage boards and lighting poles improperly located on walkways. Thus, the study contends that to establish a greenway in campus, the forms and functions of all linear and non-linear elements should be carefully analyze to ensure its appropriateness and connectivity so as to ensure a successful greenway on campus.

## ABSTRAK

Laluan hijau menghubungkan pengguna dengan tempat-tempat tertentu. Ia bersifat pelbagai objektif yang bertujuan untuk meningkatkan kualiti persekitaran serta menyerlahkan identiti kampus universiti sebagai sebuah perkampungan akademik. Laluan hijau kampus adalah terdiri daripada jalanraya yang ditanam dengan pohon-pohon teduhan, laluan pejalan kaki, lorong basikal serta sungai atau koridor-koridor tasik yang menghubungkan padang-padang permainan, taman-taman dan dataran-dataran. Bagi membangunkan sesebuah laluan hijau kampus, koridor jalanraya sediaada merupakan sumber utama elemen linear yang boleh digunakan. Walaubagaimanapun, cabaran utama di dalam membetuk laluan hijau ini adalah untuk menyambung kesemua elemen fizikal yang berpecah-pecah yang terdapat di sepanjang koridor jalanraya kampus. Oleh itu, kajian ini menganalisis ciri-ciri fizikal setiap elemen fizikal yang membentuk sesebuah laluan hijau di dalam kampus seperti kelebaran laluan pejalan kaki dan kesinambungannya (*connectivity*), bentuk silara pohon-pohon teduhan di tepi jalanraya termasuk susunatur penanamannya serta jenis nod yang membentuk laluan hijau. Kajian ini mengukur pembolehubah iaitu kesinambungan (*connectivity*), kehijauan (*naturalness*) dan nod yang terdapat di dalam serta di sepanjang rizab atau koridor jalanraya di dalam kampus. Inventori tapak serta pengambilan gambarfoto di tapak telah dijalankan bagi mendapatkan maklumat sediaada manakala aplikasi ArcGIS 9 (Arc MAP versi 9.1) digunapakai untuk mengenalpasti faktor-faktor yang mempengaruhi ciri-ciri fizikal sediaada laluan hijau di dalam kampus secara sistematik. Kajian ini mengenalpasti dua faktor iaitu rizab jalan yang sempit serta jarak dan halangan yang mengganggu kelancaran pergerakan pejalan kaki serta penunggang basikal yang menggunakan laluan hijau kampus seterusnya menghalang kejayaan pembentukan laluan hijau kampus. Elemen pemutus adalah seperti persimpangan jalan, longkang-longkang yang terbuka serta laluan pejalan kaki yang terputus. Elemen penghalang pula ialah lokasi papantanda serta tiang lampu jalan yang tidak terancang. Oleh itu, kajian ini mendapati bahawa untuk membentuk rangkaian laluan hijau yang berjaya, bentuk serta fungsi setiap elemen linear dan bukan linear (non-linear) hendaklah dianalisa dengan terperinci bagi memastikan kesesuaian serta kesinambungan (*connectivity*) laluan hijau yang berjaya dapat dicapai.

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5.97	A good tree canopy shape but poor planting intervals in segment C2 and C4 with total score of 4	160
5.98	A good tree canopy shape but poor planting intervals in segment D1 with total score of 4	161
5.99	A poor tree canopy shape and planting intervals in segment D3 with total score 2	161
5.100	A moderate tree canopy shape but poor planting intervals in segment E1 with total score of 3	162
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## CHAPTER 1

### RESEARCH BACKGROUND

#### 1.0 Introduction

Provision of quality living and learning setting is crucial for staff and students in university campuses. Buildings and roads are essential infrastructure to ensure safety, security and comfort to the campus users. Inasmuch, greenway also plays a crucial role for healthy and responsive working and learning environment. Greenway network is greenery and interconnected linear open spaces formed by roadside trees, waterways and drainage ways around and between urban areas, at all spatial scales (Little, 1990; Smith, 1993; Gobster and Westphal, 2004) where people can use it to reach places of work or study (Tocolini et al., 2004). Thus, campus greenway composed of treed street, walkways, drainage ways, lake corridors and trails (Dober, 2000; Tan, 2006). It connects and organizes every fragmented open spaces or buildings as well as facilitates people movement in and around campus under safe and comfortable conditions in natural settings. The greenway allows campus residents to undergo their daily activities such as walking, jogging, biking, experiencing nature, watching people, meeting friends, displaying artworks and many more. According to Tzoulas et al. (2007), in campus, it can be greenery that promotes healthy society. This means greenery and open spaces are not just amenities but also an interconnected network of ecological systems that conserve air, water, microclimate, energy resources and enriches human quality of life. Tolley (1996) suggested that students might prefer a university with a vast green area as their conducive places to study. Campus greening is one of the approaches taken

to achieve environmentally good campus through improving and maintaining all the landscape elements in campus as well as other recreational facilities (Habib and Ismaila, 2008). Campus greenway can be an instrument for greening a campus by connecting every open space with other spaces, as an alternative route to facilitate users' movement and social space for community integration in comfort and pleasant settings (Conine et al., 2004; Tan, 2004). Greenway in campus may also offer an opportunity to preserve the remnant green spaces, which almost disappear from a campus scene due to a development pressure.

### **1.1. Problem Statement**

Campus is a unique place with a distinctive community with green spaces such as streets, squares, amphitheaters, courtyards, small gardens and lakes. It also accommodates buildings such as student centers, offices, halls, childcare facilities, shops and sports arena. The activities conducted in and around these buildings, physically and socially occur throughout the day (Balsas, 2003) and consequently the campus tends to suffer from the pressure of development in order to cope with the rapid emergence of communities demand for their facilities and amenities. Habib and Ismaila (2008) explained that campus sustainability has become a global issue among the university administrators, policy makers, planners as well as stakeholders. Thus, Balsas (2003) suggested that the development for campus infrastructure should be provided or maintained without jeopardizing the quality of campus environment.

Since 1970s, many universities in Malaysia have gone through many physical changes. Inevitably, campus is losing its green spaces due to the needs of more spaces for parking and new buildings (Balsas, 2003). Shuhana et al. (2007) found that most of universities in Malaysia are practicing scattered development pattern. This piecemeal fashion of development fragmenting all spaces and has caused highly demanded areas in campus such as clinics, sports center and recreational area isolated and difficult to

access by the users. Dober (2000) suggested that campus may be perceived as a landscape environment which can be designed or redesigned. One can enter the campus gateway and traverse in and around it and as such it should be connected. Connectivity and continuity is important because it allow users to move from one space to another. It also provides a transition from one type of landscape element to another to form a landscape structures. For example, a row of shady trees along the roadside gives a sense of direction for the users. Connectivity can be distracted by the breaks occurred along the route or corridor. The landscape with several numbers of breaks is lack of connectivity and is considered as suffering from fragmentation (Thorne, 1993). Serrano et al. (2002, pp. 113) have defined that fragmentation is “the landscape's lack of connectivity, the mechanism that cause it and the subsequent alteration of ecological processes”. According to Herzele and Wiedemann (2003), fragmentation disturbs the perception of a space as a whole. Viles and Rosier (2001) note that the number and severity of breaks along a given stretch of corridor determine connectivity. The lack of connectivity may lead to the difficulties of user’s accessibility (Shuhana et al., 2007). Eventually, according to Quayle (1995) this scenario may turn some spaces to be neglected or confused.

Disorganized campus expansion is the second factor, which caused green spaces to be converted to buildings and roads. Lim et al., (2006) explained that due to the urgent need of facilities, many natural assets in Universiti Sains Malaysia such as undulating terrain, huge heritage trees and water bodies were destroyed to give way to the new buildings and parking spaces. According to Balsas (2003), campus expansion has resulted in campus users relying too much on motor vehicles as their mode of transportation, thus contributed to the reduction of air quality, increased traffic congestion and gradual loss of campus greens to allow more parking spaces. The loss of green spaces in campus may affect campus microclimate. At the National University of Singapore, Wong et al. (2007) found that there are ‘hot’ and ‘cool’ spots at many parts of the campus. By using thermal satellite image, cool spot indicated by the green color, which means that the area is highly vegetated area and yellowish color indicates ‘hot’ spot, which means the area, is lack or no vegetation at all. This study also noted that the

temperature differences between these two areas are as high as 4°C in the afternoon and 3.3°C at mid-night. Clearly, the greenery plays an important role for keeping the campus microclimate comfortable and gives more benefits for user outdoor activities.

At present, none of the 23 governmental universities has applied the concept of greenway network successfully. Much of the land use zoning and buildings as well as open spaces are not connected by the green network that affords well being, physically and socially.

## **1.2. Research Gap**

A study on campus environment done by Tolley (1996) emphasized only on domination of private car usage in campus, which has affected the quality of its environment. Inasmuch, his study suggested a bicycle-friendly campus because it is environmental friendly transportation mode as it produces no air or noise pollution, acquires little space, and is fast and cheap. Similarly, Balsas (2003) added that sustainable transportation planning strategy on college campuses is necessary, such as by changing a commuting mode from cars to walking and bicycling. His study suggested too that by walking or cycling is much faster and at no costs and has health benefits too. In addition, Shannon et al. (2005) explained that walking, cycling and using public transport are physically active transportation forms. These activities will reduce demand on parking space as well as can improve campus community's health. Aldrin et al. (2006) added that walking is a good culture and practice for a healthy lifestyle for campus community. The walking culture can be created through an integrated planning and creation of pedestrian network in a campus garden-like setting. In sum, it is understood that many researches only focused on promoting a walkable and bicycle-friendly campus environment without any consideration on the need to connect to each other every landscape elements and structures, which incorporated in the greenway. Once the interconnected network of greenway is established, it may help to



elevate the ambience of the whole settings for generating campus communities' life and activities.

Table 1.1 shows that there is lack of study on a greenway in campus planning as a green linkage for every open space and other space particularly in campus context. Two disciplines which widely discuss greenway topics are Urban Planning and Ecology. Urban planning is the field that provides references related more to the development of greenway in urban context such as river park, island-city and residential. While ecological areas providing references mostly associated with habitats, patches and corridors that play an important role in the ecological connectivity. In sum, all authors found that the greenways are planning tools that have various functions such as preservation, conservation, protection, education, recreational, cultural and heritage as well as structuring community. Therefore, there is a need to study the role of campus greenway as a linking element to connect every space in campus for the benefits of campus environment and its community – physically and socially.

**Table 1.1:** Studies on greenway from 1995 to 2008

<b>Authors and Year</b>	<b>Findings</b>	<b>Context</b>
<b>Urban Planning</b>		
Searns (1995), Conine et al. (2004), Gobster and Westphal (2004), Toccolini et al. (2006), Tan (2006), Yu et al. (2006), Khalid (2004).	A preservation and connectivity for balanced land development of the areas of recreation, nature conservation, education and community bonding, recreational uses of cycling and hiking, education, exchange information, minimize the effects of development upon environmentally sensitive area, mitigate the ills of urbanization, preserving the quality of environmental resources,	Urban , River Park, Island-City, Riparian, Transportation Corridor, Farmland, Residential Neighborhood

<p><b><u>Ecology</u></b></p> <p>Viles and Rosier (2001), Jongman et al. (2004), Asakawa et al. (2004), Parker et al. (2008).</p>	<p>Road reserve areas as ecological corridors, as both ecological and social network on different levels, the delineation of corridor linkages revealed that riparian habitat has a particularly significant role to play in achieving connectivity between the terminal habitat patches.</p>	<p>Road Network, Urban Stream Corridor, Urban</p>
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### 1.3. Aim and Objectives

The aim of the research is to study a greenway network as a strategic approach for linking all fragmented spaces and buildings in university campus that enhances and creates campus quality and identity. To achieve this aim, the following research objectives are formulated:

- i. To understand the concept of greenway and its multifunctional benefits as a formative device for linking the fragmented spaces in university campus.
- ii. To assess the physical characteristics of greenway network in university campus for a conducive environment for walking, and
- iii. To recommend a set of design criteria for establishing a greenway network in university campus to successfully function as a space connector, alternative route and communal space.

#### **1.4. Scope of Study**

This study focuses only on a governmental university campus. The main reason of selecting a governmental university is the availability of land for the development of campus greenway compared to private university. The site, which was selected for the study area, is Universiti Teknologi Malaysia (UTM). It is approximately 25 years old university and located in Johor Bahru, Johor. The study only investigated the physical characteristics of landscape elements in the greenway. The physical characteristics are based on the quality whether it is poor, moderate or good of each element which is connected to each other to form a greenway. Linkages are a key characteristic of greenway and are formed by natural or man-made structures such as roads, pedestrian walkways, drainage ways and lake corridor (Little, 1990). Therefore, this study examines what are the types of elements that link every space in campus, which characterized the greenway. For example, an element such as a tree is examined according to its form and planting location whereas walkway is examined according to its type, width and availability. The research also investigated the degree of connectivity of the corridor because it affects user's accessibility and the continuity of the corridor. The investigation looked into the identification of what are the fragmentary elements that occur along the greenway corridor affecting the degree of connectivity between two or more points connected by the greenway. Eventually, the study recommends design criteria in order to establish planning and designing of a greenway for university campus.

#### **1.5. Limitation of Study**

The scope of this study is limited to investigation of the physical characteristics of the greenway along the campus road corridor. It is due to the limited time and logistics. Factors such as topography and gradient, other open spaces such as courtyards, gardens, spaces between building or play fields as well as users behavior

and perception towards greenway that also affect the success and effectiveness of the greenway as a route for movement are not be included in this research. It is hope that other researchers will conduct further research of these aspects in the future.

### **1.6. Significance of Study**

Over the next decades, with the uncertainty in future campus development, it is anticipated that universities will continue adding new buildings and facilities in their campuses to accommodate more students and staff. In other words, generally the campus is growing each year with the enrollment of new students, more spaces needed to accommodate hostels, road signage for managing traffic flows, new schools for new courses as well as parking space (Lim et al.,2006). In addition, Turner (1984) explained that the uncertainty in the student's enrollment is complicated as the university is changing in unpredictable ways. This possibly twists the campus into a clog development area. Speculatively, introduction of greenway network will organize the site planning of the buildings, open spaces and road systems as well as structuring community (Tan, 2004; Khalid, 2006). It means that the network enables the campus planners to create a quality physical environment that provides conducive milieu for working and learning as well as establishes identity to the institution (Dober, 2000). Simultaneously, the planning of the network maximizes non-vehicular travel which emphasizes the planning of integral pedestrian routes. In other words, the green network connects one cluster of buildings and spaces to another that facilitates users to walk with ease and safe under shaded and pleasant conditions, which associated, to campus quality and identity.

Alternatively, the greenway may also play a significant role in campus planning. It is able to adapt in many different contexts whether it is in urban, rural or town area, it plays multiple role such as for environmental protection, ecological protection, recreational, educational, expression and alternative route. In campus, the greenway may function as a space connector to counter space fragmentation due to campus

development and expansion. It also may provide an alternative route for pedestrians and cyclists to boost health benefits via contact with nature when they use the greenway and promotes 'green' transportation mode. Greenway in campus also may become a communal space because it offers an opportunity to congregate and communicate through simple greetings and smiling (Bischoff, 1995).

## **1.7. Research Design**

Conceptualization of this study is divided into five sections: (1) Literature Review, (2) Data Collection, (3) Data Analysis (4) Results and Discussion and (5) Recommendations. Figure 1.1 in page 13 of this chapter illustrates a flowchart of the research design.

### **1.7.1.Stage 1 : Literature Review**

A review of literature covers two chapters. Firstly, the study of greenway network which traces the historical background, the evolution, definitions, categories, properties and attributes, the usage, potentials and benefits of greenway network activities which have been implemented throughout the world at all spatial scale. Secondly, the study of campus planning looks into a history of campus planning and its two basic common planning approaches namely, spatial arrangement and land use zoning. Universiti Teknologi Malaysia (UTM) is selected as a study area in which the arrangement of the land uses and its components such as roads alignment, car park area, buildings, natural features or open spaces are also investigated. Apparently, these two chapters are interconnected in terms of significance information of the greenway theory and concept can be adapted in the university campus planning and designing. Thus, these literatures are relatively important for planning and designing a campus greenway as a space connector, alternative route and communal space in the campus for the benefits of its users; students, faculty member, staff and visitors.

### 1.7.2.Stage 2 : Data Collection

The research gathered three types of data from the Universiti Teknologi Malaysia campus master plan that includes:

- i. Existing greenway characteristics along the campus road corridor in relation to the land use pattern in the campus.
- ii. Existing greenway network such as roads and its reserves, lake-corridor and walkway which are linking the elements of interest or nodes such as car park, bus stop or campus gateway present in the area. The nodes may represent the origin and destination for campus users to enter and exit the greenway.
- iii. Fragmentary elements on the existing network such as roads junctions, drainages, fences, lighting poles or directional signages.

The gathered data from the master plan is observed on site to identify and verify each of the elements. A checklist form is used to record every elements or structures that exist along the greenway. This helps the study to determine and to understand the physical formation and characteristic of existing greenway network in the study area. The variables used for this study are connectivity, fragmentary elements, naturalness and nodes (Untermann, 1984; Dober, 2000; Strange and Banning, 2001; Tan, 2004; Toccolini et al., 2006). Connectivity is a fundamental variable to be measured because designing a route for movement allow user's to move from one space to another. Secondly, the study observes the fragmentary nature of the greenway connectivity (Toccolini et al., 2006) which affects its connectivity and continuity. Thirdly, the study observes on the aspect of naturalness as to provide a restorative opportunity through a greenway for campus community (Gobster and Westphal, 2004). Finally, node is recorded to identify whether it is available or not available along the greenway such as cafeteria or shelter for the users to rest and pause, fountains, planters, bicycle racks, area

for art display or books selling (Dober, 2000; Bischoff, 1995). According to Untermann (1984), an adequate provision of these features will contribute to a good pedestrian environment. This variable will also help to strengthen the sense of place of the greenway as a communal space.

### **1.7.3.Stage 3 : Data Analysis**

The data is analyzed using ArcGIS 9 (ArcMap release version 9.1), a derivative of Geographical Information System (GIS) as a tool. The analysis enabled the study:

- i. To identify zones that require greenway connectivity. For instance, student's residential zone and recreational zone are located separately thus, they need to be linked in order to facilitate user's movement between these two points.
- ii. To define greenway elements either it is natural or man-made which should be included, improved or maintained. The physical characteristic of each element such as trees and its distribution, type of landscape features, corridor width and length will be analyzed (Tan, 2004; Parker et. al., 2008).
- iii. To determine which route has or in need of a good, moderate or poor connectivity according to the number and type of breaks and obstacles present along the corridor (Conine et al., 2004).

The checklist ranked all the recorded elements, with respect to the priority to be incorporated into the greenway system. According to Dawson (1995), the greenway is characterized by strong interrelationships between their component parts. Therefore, this study is only considering the physical characteristics of greenway that contribute to the greenway definition for university campus. Relative values of 2-6 are assigned for each criterion (Conine et al., 2004). The values are representing the poor, moderate or good characteristics of each element. For example, trees are valued in relation to its

shape whether it is spreading, round or conical as well as planting intervals whether it is either sparsely or densely planted. Table 1.2 is an example of checklist for recording every element that has been divided based on individual physical characteristics:

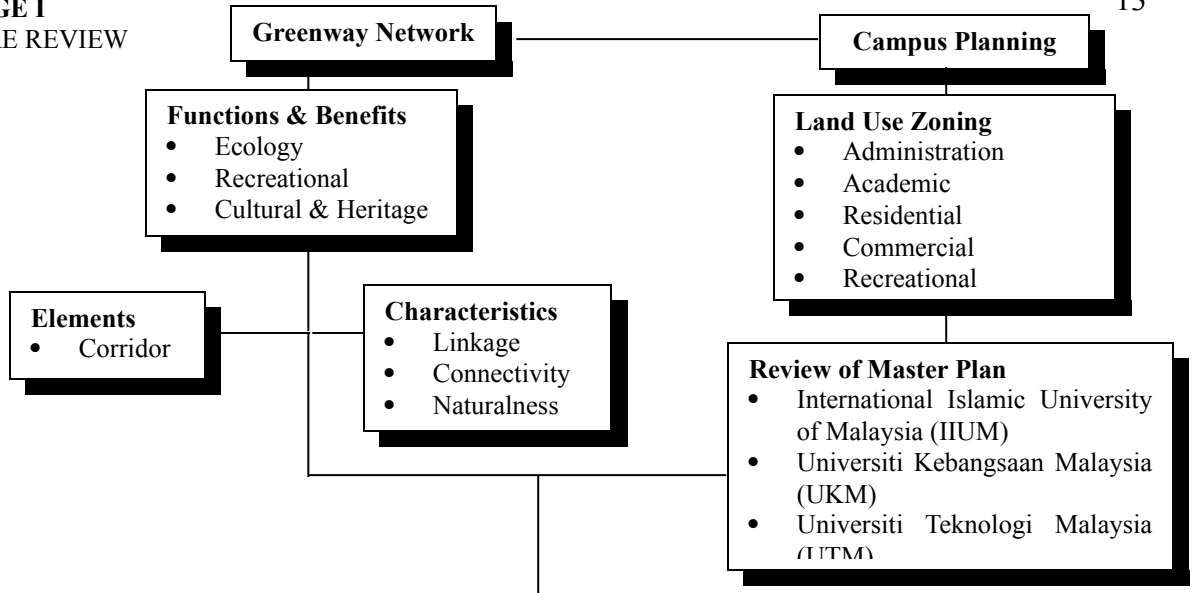
**Table 1.2:** Greenway Network Classification (Toccolini et al., (2006))

	Physical Characteristics
Surface	<ul style="list-style-type: none"> <li>• Paved</li> <li>• Unpaved</li> </ul>
Width	<ul style="list-style-type: none"> <li>• &lt; 1 meter</li> <li>• 1-2 meter</li> <li>• 2 meter</li> </ul>
Legibility	<ul style="list-style-type: none"> <li>• Legible</li> <li>• Barely legible</li> </ul>
Status	<ul style="list-style-type: none"> <li>• Good</li> <li>• Reasonable</li> <li>• Poor</li> </ul>
Dangerous Section	<ul style="list-style-type: none"> <li>• For pedestrian</li> <li>• For cyclist</li> </ul>
Accessibility: Access	<ul style="list-style-type: none"> <li>• Free</li> <li>• Restricted</li> <li>• Prohibited</li> </ul>
Practicability: Pedestrian Cycle	<ul style="list-style-type: none"> <li>• For all</li> <li>• Easy</li> <li>• Demanding</li> </ul>

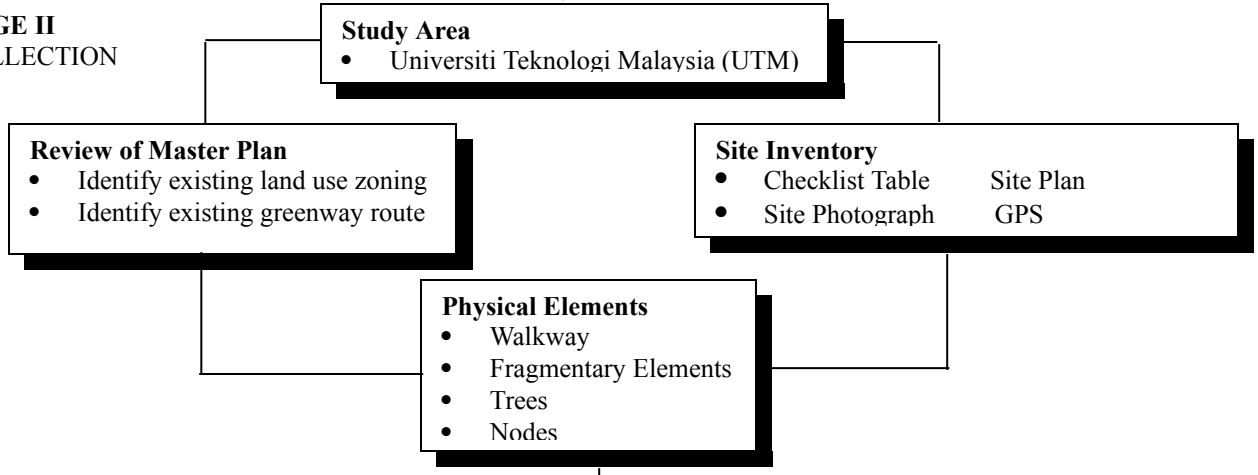
All the data is inserted in the GIS to allow the different layers to be overlaid so that all the components, which form the greenway in UTM campus, can be identified and mapped. Thus, the study identifies the formations and characteristics of the greenway network that are connecting each zone in the campus. The study reveals which route that has a good, moderate or poor greenway before any recommendation can be suggested.



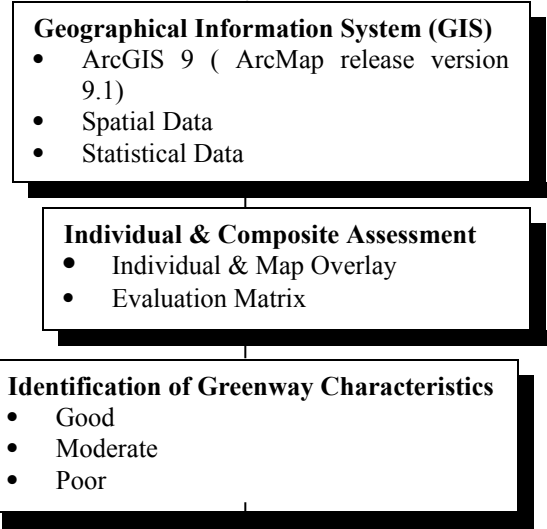
**STAGE I**  
LITERATURE REVIEW



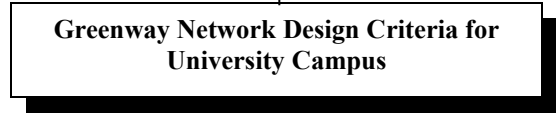
**STAGE II**  
DATA COLLECTION



**STAGE III**  
DATA ANALYSIS



**STAGE IV**  
RESULTS AND FINDINGS



**Figure 1.1:** Flowchart of Research Design

## **1.8. Organization of Thesis**

This thesis is organized in the following order:

Chapter 1 describes the content of the whole thesis. It explains the research aim, objectives and significance of this study.

Chapter 2 discusses on background, historical, theory and the concept of greenway which have been implemented throughout the world.

Chapter 3 explains the history of campus planning in general and in Malaysia. It also discusses on the formations and characteristics of greenway in each selected campus namely, International Islamic University of Malaysia (IIUM), Universiti Kebangsaan Malaysia (UKM) and Universiti Teknologi Malaysia (UTM). This helps the study to compare and evaluate the common formation and character of the greenway in the other two campuses with the selected study area, UTM campus.

Chapter 4 highlights the methodology of this study. The flow of research work is elaborated in sequence process of the study.

Chapter 5 presents the results and discussion of the reviewed and selected case study campus in order to identify which greenway is good, moderate or poorly formed or developed.

Chapter 6 concludes the research followed by suggestions and recommendations of the assessment model of greenway network for a university campus.

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