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Sustainable riverscape preservation strategy framework using goal-oriented method: Case of historical heritage cities in Malaysia

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Abstract

Rapid development and transformation are the main causes for declining urban natural landscapes as well as its physical and environmental qualities. Currently, rehabilitation and preservation actions cause tough pressures to cities, which lead to serious damages on urban natural landscapes. These fragmentations, particularly in historical heritage cities, cause the riverscapes to lose their sustainability qualities. People's sense of attachment, satisfaction, and social bonding with riverscapes are also being deteriorated. This subject has become one of the most challenging issues for the Malaysian government and its local authorities. This research aimed to establish the sustainable riverscape rehabilitation strategy framework for Malaysia's historical heritage cities from the urban design and planning perspectives. The research methodology was designed in two phases. Phase one has developed the sustainable riverscape rehabilitation strategy framework for Malaysia's historical heritage cities by applying the goal-oriented method. The second phase has validated the framework application using the Grounded Group Decision Making (GGDM) method. For validation, the feasibility study shows the expert input has reached more than 70% saturation for all feasibility assessment factors, except technical aspects of the factor project potential for extension, which has received 45% saturation. This strategy framework involves sustainability domains; social benefits, environmental quality, and economic growth. Moreover, this strategy framework formulates a sustainable riverscape rehabilitation index score for promoting riverscape preservation. It integrates the Malaysian government, stakeholders, and public participations in riverscape rehabilitation activities.

Keywords: Riverscape preservation; Riverscape revitalization; Heritage city; Sustainability; Goal-oriented method

1. Introduction

Urban natural landscape is one of the significant elements in urban development and rehabilitation that provides environmental sustainability, social sustainability,

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aesthetics, horticulture, as well as public psychological health. It also makes other meaningful contributions to cultural aspects (Summerville and Adkins, 2007; Korpela et al., 2009; Lamit et al., 2013a). In addition, it improves the connection between people and urban visual qualities (Lynch, 1960). Urban natural landscape directly influences people's understanding and sense about nature, how they preserve the environment and green area, and how nature affects them (Nassauer, 1995; Kaplan et al., 1998).

Many cities around the world are under active transformations due to landscaping activities. However, it has been previously established that urban transformation is a major cause for declining urban natural landscapes (Kaplan et al., 1998). In fact, urban development causes tough pressures on cities, poses serious damage to resources and environmental quality, and eventually leads to poor natural landscape aesthetics (Ngiom, 2014). Consequently, transformation due to natural landscaping activities is progressively reducing urban legibility and identity due to the lack of attachment (Ujang, 2008). This has brought about serious disorganization in urban areas and lack of visual and physical coherence (Hall and Glasser, 2003). Moreover, people tend to lose interest in public places within the cities (Dredge, 2010).

One of the most significant issues in natural landscape studies is that heritage cities should be valued, understood and preserved for future generations to provide and recover the sense of identity and community in urban areas (Lowenthal, 1999; Tweed and Sutherland, 2007). Beyond the documentation role of historical urban elements, urban heritage also includes the value of traditional cultures, meaning, value, characteristics and quality that represent public memory (Gil-Martín et al., 2012). To date, most of these qualities are either threatened, physically damaged or even destroyed, especially for less tangible elements in urban areas such as streets, people perception and activities, historical urban elements, open spaces and urban natural textures (Australian/ICOMOS, 1987; Steinberg, 1996; Tweed and Sutherland, 2007).

Among urban natural landscape elements, rivers are vital as they have exclusive and strong meanings to most people (Mir Ghasemi et al., 2014). However, due to rapid development and transformation of cities, people's perception and attachment to river environment is rapidly vanishing (Akkerman, 2006). The poor connection between urban regeneration, economic globalization, and standardized urban development with urban ecosystem, local history, culture and people's expectation cause the loss of urban riverscapes' identity, place meaning, preservation, and cultural backgrounds (Wheeler and Beatley, 2004; Kasapoğlu and Ecevit, 2004). Several studies mentioned that the characteristics, and physical and environmental qualities of natural landscapes affect sense of place (Inglis and Brazier, 2008), place attachment and place satisfaction (Stedman, 2002). In fact, the physical and environmental characteristics, qualities and attributes of riverscape can influence people's perception (Najafi and Shariff, 2011).

Indeed, the relationship between urban riverscape development and its preservation is a controversial issue in historical and heritage cities rehabilitation (Haughton, 1999). Hence, nations are attempting to create a new plan for managing and redesigning riverscapes, and in terms of sustainability, this has become an issue of global concern. Recently, government policies have emphasized on river's natural environment, and its resource evaluation. The association between a river's social and cultural values with ecological resources is crucial, but there is lack of proper studies in this area (La Rosa and Martinico, 2013). Moreover, lack of proper attention is given to rivers and entirely freshwater ecosystems, especially in terms of general identification, people perception and protection plans. More importantly, there is lack of established framework for sustainable riverscape rehabilitation. In this regard, this paper aims to develop a framework for sustainable river preservation strategy. This research also provides a clear picture of past and current importance of riverscape attachment in heritage cities rehabilitation, particularly in Malaysia's cities.

To achieve the aim, the research methodology was designed in two phases. Phase one involved developing a sustainable riverscape rehabilitation strategy framework for Malaysia's historical heritage cities by applying the goal-oriented requirements engineering method. And, the second phase involved validating the framework using the Grounded Group Decision Making (GGDM) method. The rehabilitation strategy framework was designed to identify new and profound characteristics, quality and value of a river in relation to human perception, environmental protection and landmark attachment to a natural riverscape. The framework formulates a sustainable riverscape rehabilitation index for promoting riverscape rehabilitation.

2. The developmental process of sustainable river rehabilitation strategy framework

This research develops a sustainable river rehabilitation strategy framework based on the goal-oriented requirements engineering method. The framework integrates the association between all indicators in heritage historical cites' riverscape preservation and rehabilitation. The framework conceptualizes those indicators through a rational relationship. This goal-oriented strategy framework helps to specify the association between local, national, and global sustainability issues. This framework also helps to determine the association between indicators, and ultimately, to propose a set of supportive strategies for heritage historical cities' river rehabilitation in Malaysia (Fig. 1).

In developing the goal-oriented framework, understanding and characterizing the relationships and processes between the objectives, domains, indicators, and issues and activities need to be considered (Mylopoulos et al., 1999; Kavakli, 2002). For example, Pohl (1996) stated a

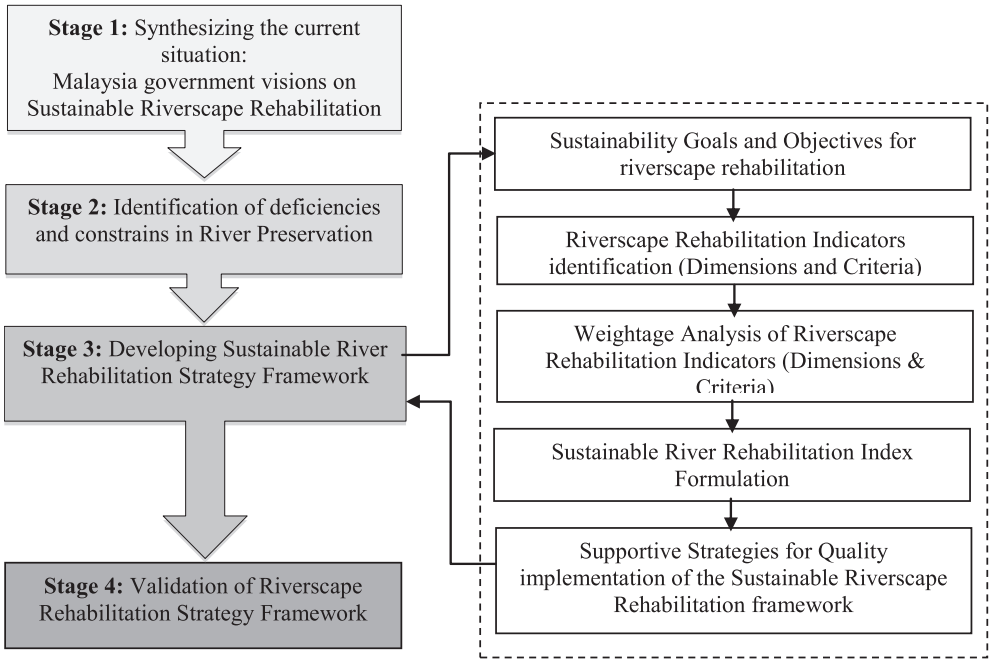

Fig. 1. The goal-oriented process of sustainable river rehabilitation strategy framework development and validation.

goal-oriented framework contains the Requirement Engineering process in three dimensions; specification, agreement, and representation. Zave (1997) expressed that a goal-oriented framework involves two major dimensions; problems and solutions. And, Sutcliffe (1996) stated that a goal-oriented framework employs Requirement Engineering for the initiating conditions and task activities. Kavakli (2002) stated that the Requirement Engineering goal-oriented framework is "mainly a knowledge modelling process" which integrates between the current situation (i.e. problem), alternative solutions, and possible future approach. In this regard, Kavakli (2002) stated that goal-oriented framework has the following knowledge modelling attributes:

1. The As-Is: which presents the knowledge on existing situation,
2. The Change: which presents the need (demand) to generate alternatives for existing situation,
3. The To-Be: which defines the knowledge on future situation,
4. The Evaluation: which presents an assessment of the current situation, the appropriateness of a changed plan, or the suitability of a future plan.

The first step in developing a goal-oriented framework is to conduct a literature review, and to assess the applicability of extracted indicators (Geniaux et al., 2005). The goal-oriented sustainability framework assists users by providing indicators to (Alkan Olsson et al., 2007): "(i) facilitate the identification of the objectives for a specific policy, and link the policy goals with the process and the means to achieve these goals, (ii) identify relevant indicators to assess a given problem, (iii) ensure balanced selection of indicators in relation to the three aspects of sustainable development, and (iv) support the process of achieving the end-user's main goal (i.e. to create a more sustainable new policy)". So, the goal-oriented framework captures the interdependencies between objectives, expedites the understanding of requirements' origins, and also, "can assist the requirements process more thoroughly, completely, and consistently" (Mylopoulos et al., 1999). The framework focuses on the early stages of requirements analysis, and then, on the validation of the development process (Mylopoulos et al., 1999).

The goal-oriented requirements engineering method has been frequently applied in urban sustainability studies (Cabot et al., 2009; Mahaux et al., 2011) which uses the qualitative approach. Alkan Olsson et al. (2007) stated that a goal-oriented sustainability framework goes beyond managing indicators into lists of indicators for each Sustainability Development's aspects. The goal-oriented method has "the significance and usefulness of goals in their respective approaches" (Kavakli, 2002). However, "the qualitative nature of the model offers only very limited support for decision making" (Stefan et al., 2011). For this reason, the current research has applied the quantitative approach based on the Grounded Group Decision Making (GGDM) method, where the problem posing, selecting alternative and validating were conducted quantitatively. Therefore, this framework includes multiple decision-definitive, sustainability domain-definitive, and in particular, river rehabilitation-definitive indicators.

Goal-oriented framework is a network composition "representing arbitrarily complex plans" (Grando et al., 2010). It also concerns managing modifications on the sys-

tem including modifications in legislations, in objectives and evolving indicators, and also in stakeholders' attitude towards the system (Stefan et al., 2011). By applying the goal-oriented method and requirements engineering approach (Letier and van Lamsweerde, 2004; van Lamsweerde, 2009), the current framework has been designed in the form of a networking system, which interconnects and integrates sustainability domains (i.e. social, environment, and economic), strategic goals and objectives of river preservation and rehabilitation. This framework is such a fundamental knowledge-sharing system that assists urban developers in making more inclusive, effective, and precise decisions for achieving sustainable river development.

In conclusion, this research has applied the goal-oriented method to develop a sustainable river rehabilitation strategy framework, which systematically defines the goals and objectives of riverscape rehabilitation, identifies the obstacles towards achieving the goals, and explores supportive strategies for achieving and implementing the goals and objectives. The following sections detail each stage of the framework development.

2.1. Malaysia government's visions on sustainable riverscape rehabilitation

This section describes current Malaysian government visions on the issue of developing a sustainable riverscape rehabilitation strategy framework. In the context of Malaysia, the government vision is to transform the entire country into a fully industrialized nation by 2020 and to place 70% of the population in urban areas (JPBD, 2006). Jabatan Perancangan Bandar and Desa (JPBD, 2005, 2006) and also the 9th Malaysian Plans reported that rapid urban developments have caused inappropriate physical changes to rivers, which has led to changes in the meaning of local places, disassociations between the local culture and people's perception and life style (Ismail et al., 2008).

In Malaysia, heritage cities are facing intense urbanization problems as a result of rapid population growth, economic development, and urbanization (Mohamed et al., 2001). These threats resulted from insensitive redevelopment schemes that were carried out before the introduction of the National Heritage Act 2005. Mohamed et al. (2001) conducted a research on the most challenging issues in major historic heritage cities in Malaysia (i.e. George Town, Kota Baharu, Melaka, Taiping and Ipoh). In his research, he highlighted the following main issues, which need to be dealt with in historic cities' development in Malaysia:

- Design of new township development,
- Depopulation of inner city intensive and uncontrolled development pressures,
- Insufficient legislations and enforcement,
- Changing lifestyles and consumption patterns of city dwellers,
- Expectation of new tourists,
- Public awareness, and
- Environmental degradation.

In the 9th Malaysian Plan, the Malaysian government has reported that rapid urban development is the cause of urban physical changes, which have led to less meaningful historical and heritage places, disassociations between the local culture and people's perception and lifestyle (Ismail et al., 2008), as well as fragmentation of place attachment and landmarks (Ismail et al., 2008). The consequences of development, demolitions, and destructions have affected Malaysian cities' familiarity, legibility and historical landmark since the early 80s (Wan Hashimah and Shuhana, 2005). For heritage city landmark preservation, the National Heritage Department was established in 2006. In addition, the National Heritage Act 2005 was established to "support the conservation and preservation of national heritages including the natural heritage and rivers" (Harun et al., 2011).

The need for successful planning in terms of resource management is recognized in government policies. The "Cintailah Sungai Kita" campaign, which means "Love Our Rivers" is one of the campaigns that is currently being run by "Jabatan Alam Sekitar" (Ministry of Environment) which was launched on 2nd of February, 1993. Many of its activities include river adoptions, river monitoring, river beautifications and installation of rubbish traps, waste treatment, awareness and education (Abdullah, 2004). The Sanitary Board Enactment was established in 1857 to set up the rules related to riverine area and riverside cities such as Kuala Lumpur and Melaka. The Sanitary Board Enactment establishes the most basic law on urban river in 1907, whereby its main goal is to maintain the cleanliness and healthiness of the water. Moreover, to promote river conservation, the Water Act 1920 was enacted with the goal of preventing land fragmentation, landslides and soil erosion. Accordingly, the Land Conservation Act 1960 and the National Land Code 1965 were also established. Later, the government established a plan called the 6th Malaysia Plan, which aimed to conserve and protect natural resources as well as environmental areas. Consequently, the 7th Malaysia Plan 1996–2000 was strategized to consider initial factors such as social, economic, aesthetic values, cultural and historical aspects for sustainable development of historical heritage cities. The most significant establishment is the National Heritage Act 2005, which outlines preservation conditions and laws in saving natural heritage. This is included in both the "8th Malaysia Plan (8MP, 2001–2005)" and the "3rd Outline Perspective Plan (OPP3, 2001–2010)" which encourages state governments to establish water management for appropriate and effective planning, monitoring, enforcement, rehabilitation and management of water resources on the basis of river basin. Since the 18th century, swift urbanization, rash development, industrialization, and intensive farming activities have caused extreme changes in river quality and

functions in terms of economy, national development and the environment in Malaysia (Idid, 2004). Idid (2004) states that riverscapes are one of the most magnificent urban natural landscapes, for which immediate preservation, rehabilitation and conservation actions are needed. In this regard, the 9th Malaysia Plan (2006–2010) highlights the improvement of quality of life and sustainability standards in order to aspire the integration between waterfront and urban river for the purpose of beautification and flood mitigation.

Indeed, the government has the responsibility to manage our rivers. As well, non-governmental organizations (NGOs), public, industrialists, farmers, and other stakeholders are also responsible for river rehabilitation. Sustainable management of rivers needs the support and collaboration between the government, public, and stakeholders (such as industrialists, entrepreneurs, planters, educational system). Inviting NGOs and local communities to propose effective roles in river management and protection has been increasing. Consequently, since people are not engaged in or properly educated in river protection, they could also be recognized as a blameful part of society that contributes to river deterioration. Therefore, it is essential for the public to play a significant role in river conservation and management (Low and Altman, 1992).

2.1.1. Melaka city river cruise historical corridor

The Straits of Melaka historic city has been urbanized and developed more than 500 years ago through the exchange of cultural aspects between the East and the West (Jabatan Warisan Negara, 2012). Melaka has been appointed as a UNESCO World Heritage Site that puts Malaysia in the heritage tourism map in 2008 (Isa et al., 2011). The Melaka river cruise corridor has significant historical and cultural backgrounds as well as environmental values and characteristics, which promotes economic, social, cultural and religious aspects of people's life since the early centuries. Currently, most of the environmental, cultural and historical characteristics are gradually eroding due to modern urbanization and increasing number of tourism and commercial activities (Fig. 2). Today, the government of Malaysia is trying to renew and restore the olden memories and the magnificent years of Melaka river cruise so that it is cleaner, less polluted, less smelly, and also, more attractive (Jabatan Warisan Negara, 2012).

The government has applied the middle-out approach in riverscape preservation and rehabilitation. The middle-out approach deals with "ideas, practices and behavioural norms coming from the middle could be better tailored to downstream needs, better communicated upstream and more acceptable by both up and down streams" (Janda et al., 2011). Using this approach, the riverscape rehabilitation strategy framework for this heritage historical city would be formulated with sustainability goals and objectives, government plans, local authorities' participation, public participation deemed critical in riverscape rehabilitation in Malaysia.

2.2. Identification of deficiencies and constrains associated with sustainable riverscape rehabilitation

This section explains the second stage in developing the sustainable riverscape rehabilitation strategy framework, which is called as deficiencies in successful rehabilitation achievements. According to Jim (2002), half of the world's population are living in cities, and urban natural landscape plays a critical role in environmental recovery and health issues. In developing cities, urban natural landscapes usually tolerate high stresses during their life cycle, and eventually wear out due to severe physical and environmental tensions (Jim, 2002; Herz et al., 2003). Rivers are considered as a place in the city, which can provide magnificent survival and deep associations with culture, religion, economic (Kasapoğlu and Ecevit, 2004), and historical backgrounds. Also, urban rivers are considered as memorable urban landmarks that influence the sense of place in people (Moughtin et al., 1995; Hopman, 2007), and human communities (Dougherty et al., 2006). The attachment to a place has been described in different disciplines, including psychology, geography, and urban design and planning. However, it has not been appropriately explored in riverscape studies (Sofianian et al., 2013). There are two main concepts in place attachment, namely social bonding and social satisfaction, which need to be considered in the attachment to a river as well. In fact, these concepts can

Fig. 2. The river cruise preservation in historical heritage city of Melaka (left: Source: http://www.asiaexplorers.com/malaysia/malacca_river) (right: Source: https://www.flickr.com/photos).

significantly aid in revitalizing and rehabilitating urban riverscapes. The following briefs on these concepts:

I) Place social bondingA particular place has values, special qualities and characteristics as it can increase an individual's and a social group's relationships and bonding (Hammitt et al., 2009; Scannell and Gifford, 2010). In this regard, Ramkissoon et al. (2012) expressed that urban landscape areas can lead to high levels of attachment and social bonding.
II) Place satisfactionPlace satisfaction is defined as multi-dimensional characteristics and qualities of an exclusive place or element, which fulfils an individual's needs, expectation, and preferences to physical and emotional qualities of a place (Stedman, 2002). It has been suggested that place attachment, conceptualized dependent place, place identity, and place effects may considerably contribute to individuals' satisfaction (Prayag and Ryan, 2012; Keyvanfar et al., 2014). In specific, the majority of people who are satisfied with a place tend to have pro-environmental intentions and behaviours (López-Mosquera and Sánchez, 2011).

Moreover, the protection and maintenance of rivers and its ecosystem due to changes in urban natural area are still important issues. Shortage in proper methods that incorporate the relationship between public perception and urban green area to evaluate the importance of an ecosystem for the public and effective riverine conservation still need to be improved (Dwyer et al., 2000). In addition, there is a lot of disagreement and differences between experts' point of view and people perception of nature (Buijs, 2009; Wohl and Merritts, 2007). Indeed, the landscape and attachment to riverscape is still incomplete, and much more research is needed to explore and evaluate our understanding on rehabilitating the rivers.

2.3. The components of sustainable river rehabilitation strategy framework

This section describes the framework's components, and the interconnection between the components which were part of the third stage in developing the sustainable riverscape rehabilitation strategy framework.

2.3.1. Sustainability goals and objectives for riverscape rehabilitation

The following presents an investigation on the goals and objectives for developing a framework for heritage city riverscape rehabilitation strategy. The goals and objectives were investigated across three aspects of sustainability; social, environmental, and economics.

I. Social platform of heritage city riverscape rehabilitation:Half of the world's population are living in cities and therefore, plays a crucial role in social recovery and health (Jim, 2002). Indeed the growth and development of cities are harming urban green area and consequently destroying the nature and its environmental quality. For instance, most urban trees are suffering from stresses and damages caused by urban development and population growth, which has led to several physical and physiological tensions (Jim, 2002). In Malaysia, the placement of 70% of the population in urban areas has transformed the capital city of Malaysia and other states due to fast urbanization and development (Hall and Glasser, 2003). Besides that, Jabatan Perancangan Bandar and Desa (JPBD, 2005) and the 9th Malaysian Plan reported that rapid urban developments have caused inappropriate physical changes, which lead to changes in the meaning of local places, disassociations from the local culture and changes in people's perception and lifestyle (Ismail et al., 2008). These rapid transformations have led to disorganization in urban areas as well as poor visual and physical coherence (Hall and Glasser, 2003). Consequently, the reduction in urban legibility and urban identity due to poor attachment to a place has been observed (Ujang, 2008). Furthermore, it was stated that there is no deep association between Malaysians' cultural orientation and people's behaviour (Dewan Bandaraya Kuala Lumpur -DBKL, 2012). As a consequence, it impacts public preference towards individual activities, communications and social interaction in urban areas (DBKL, 2012).
II. Environmental platform for heritage city riverscape rehabilitation:The Department of Irrigation and Drainage Malaysia (DID) agrees that most of the riverscapes in the country are suffering from water scarcity and indeed, most are at risk now, which leads to water stress and droughts. This may be caused by the waste resulting from human activities such as farming, transportation, marketing and industrial waste. As a result, the rivers face a high level of pollution and most need to be rehabilitated (Abdullah, 2004). In fact, the local government is spending millions of Ringgit to clean the rivers every year, but the main issue is still river restoration, which requires a lot of time, money, and efforts (Junker and Buchecker, 2008). Consequently, the government invites NGOs and local groups to encourage their efforts in managing rivers in recent years. If the public are not involved or properly educated on river management and conservation, they would then contribute to river deterioration. For that reason, the people propose to conserve, protect and manage the rivers (Low and Altman, 1992; Shafaghat et al., 2016a,b). In this regard, the Ministry of Natural Resources and Environment Malaysia has launched a campaign known as 'Cintailah Sungai Kita' (Love Our Rivers) in 1993. Thereafter, many activities, including river adoptions, river inspection, river

beautifications, rubbish traps installation, domestic and industrial waste treatment, as well as awareness and education have been implemented (Abdullah, 2004).

III. Economic platform of heritage city riverscape rehabilitation:Riverscapes are one of the most magnificent elements in heritage historical cities in Malaysia in terms of natural resources and they are necessary for economic growth. Inherently and historically, the connection and association between cities and river can considerably enhance economic conditions. Indeed, all cities in Malaysia have been developed close to the river or riverscape. Due to the rash development strategy, especially in last two decades, the tourism industry has now become the main key player in the economy of the country. Most of the environmental, cultural and historical characters and values are gradually eroding due to the processes of urbanization and increased tourism and commercial activities (Yassin et al., 2011). Currently, the satisfaction of heritage cities' visitors, tourism leisure, and tourism recreation have become the most challenging issues in Malaysia's economic growth.

2.3.2. Identification of riverscape rehabilitation indicators

In this research, the indicators were defined as a set of dimensions and criteria. The following presents the identification of riverscape rehabilitation dimensions and criteria. Riverscape rehabilitation dimensions were extracted from the literature which focuses on policy making, while riverscape rehabilitation criteria were extracted from the literature which focuses on urban design and planning. Therefore, different sources of literatures are provided in the form of two different packages: riverscape rehabilitation dimensions (macro view), and riverscape rehabilitation criteria (micro view).

i. Riverscape rehabilitation dimensionsTable 1 presents diverse dimensions of river rehabilitation from the policy-making perspective. As seen in Table 1, a river in a city can fulfil the dimension of aesthetics, place meaning, place legibility and prospects. Moreover, it provides excitement, recreation, attraction, health, psycho-physiological benefits, people willingness, emotional feeling, relaxation as well as happy and leisure moments. Indeed, all the mentioned dimensions should be considered in any city's rehabilitation actions. Among the dimensions, recreation was the most frequently considered in previous studies, whereas emotional dimension received minimal attention.

ii. Riverscape rehabilitation criteriaUrban designers and planners proposed the term riverscape, which means to use and describe the broad-scale physical, biological, and aesthetic features of river (Allan and Southgate, 2002; Sullivan et al., 2007; Wu, 2013). This research has reviewed literatures on riverscape rehabilitation from the urban design and planning perspectives. The studies showed that urban design and planning researchers have focused on various criteria, including clustered to physical, social, environmental, and economic aspects (Table 2). According to Table 2, the most challenging criterion in riverscape studies is people's perception under the social cluster, followed by ecological integrity under the environment cluster, while cultural heritage was indicated as the least-important criterion in riverscape rehabilitation.

2.3.3. Weightage analysis of riverscape rehabilitation indicators

The research conducted the weightage analysis to determine the impact value of each indicator to sustainable riverscape rehabilitation. The weightage is calculated based on frequency (i.e. depth of citation) recorded in the tables of content analysis (i.e. Tables 2 and 3) via applying Eq. (1).

$$\text{Weight Score } (WS_{a_i}) = DC_{a_i} = \frac{\sum_{k=1}^{n} CR_{a_i}}{\sum_{k=1}^{n} R} \quad (1)$$

where DC_{a_i}, refers to frequency (Depth of Citation) of indicator 'a_i' (extracted from Content Analysis Tables 1 and 2); C, number of total articles involved in the content analysis table (extracted from Content Analysis Tables 1 and 2); CR, number of articles have cited the indicator 'a_i' (extracted from Content Analysis Tables 1 and 2).

According to Table 3, recreation has received the highest weightage (0.207) followed by Aesthetic (0.132). In contrast, People willingness has obtained the lowest value (0.018). It is indicated that the Recreation and Aesthetic can contribute considerably in sustainable riverscape preservation, while People willingness contributes a little.

Table 4 shows among all Riverscape Preservation criteria, Perception plays a significant role (0.085), followed by Restoration Sceneries (0.078), and Ecological integrity (0.070). In Physical cluster, Marine conservation (0.031) then Water quality (0.023) can enhance the riverscape physical qualities. In Environmental cluster, Restoration Sceneries (0.078), Ecological integrity (0.070), and Riverscape management (0.054) play significant roles of environmental qualities. In Social cluster, Perception plays a significant role (0.085) followed by Socio-Cultural perception (0.039). There is a bug gap between the results of these clusters and economic cluster. The River Trading (0.023) and Socio-economic value (0.015) of economic cluster can contribute to sustainable riverscape development; although the contribution is not considerable as other clusters

2.3.4. Sustainable river rehabilitation index formulation

According to results output from weightage analysis of riverscape rehabilitation indicators, the research has for-

Table 1
The river rehabilitation dimensions from urban design and planning perspectives.

Riverscape Benefit Dimensions	Aesthetic	Place meaning	Make place readable	Excitement	Recreation	Attractiveness	Health	Psychophysiological benefits	People willingness	Emotional benefit	Landscape design	Relaxing	Happy mood	Leisure time
Burmil et al. (1999)	✓	✓	✓	✓	✓								✓	
Litton (1977)	✓	✓	✓	✓	✓									
Kaplan and Kaplan (1982)						✓								
Kaplan et al. (1998)				✓	✓									
Ulrich (1986)							✓	✓						
Loomis et al. (2000)									✓					
Williams (2010)										✓	✓			
Yassin et al. (2011)												✓	✓	✓
Junker and Buchecker (2008)	✓				✓	✓								
Piégay et al. (2005)	✓				✓									
Pflüger et al. (2010)	✓													
Dobbie (2013)	✓	✓			✓	✓		✓						
Cottet et al. (2013)	✓	✓			✓	✓	✓	✓				✓		
Wu (2013)					✓						✓	✓		
Zhou et al. (2014)					✓						✓			
Le Lay et al. (2013)					✓	✓				✓				
Hammitt et al. (2009)					✓									
Zhang et al. (2010)											✓			
He et al. (2011)											✓			
Low and Altman (1992)												✓		✓

Table 2
Riverscape rehabilitation criteria in urban design and planning studies.

Citations	Physical Aspect							Environmental Aspect														Social Aspect																Economic Aspect	
	Water quality	Soil erosion	Water treatment	Anthropogenic impacts	Marine conservation	Natural heritage	Cultural heritage	Environmental sustainability	Environmental management	Environmental quality	Landscape rehabilitation	Riverscape management	River Rehabilitation	Riverfront development	Landscape quality	Landscape protection	Landscape pattern	Restoration Sceneries	Ecological integrity	Riverine	Stream ecology	Wetland	River Meaning/Value	Aesthetic preference	Perception	Urbanization	Social benefit	Well-being/Healthiness	Recreation interest	Socio-Cultural perception	Emotional influence	Visual sense/Attractiveness	Need and Preference	Environmental Education	Perceived naturalness	Cognitive structure	Importance/Satisfaction	Personal and social Value	Socio-economic value	River Trading
Hammitt et al., 2009																√	√	√	√																				√
Zhou et al., 2013												√				√	√			√																			
Junker and Buchecker, 2008																	√	√					√	√															
Zhou et al., 2012	√							√				√				√	√																						
Zhang et al., 2010		√						√				√				√		√																					
He et al., 2011								√								√		√							√														
La Rosa and Martinico, 2013											√				√																								
Juahir et al., 2011									√						√				√																				
Le Lay et al., 2008									√								√							√														
Piégay et al., 2005																	√	√	√				√	√														
Larson et al., 2013														√			√	√	√																			
Ismail et al., 2008								√					√					√							√		√	√	√									√
Pflüger et al., 2010															√								√														√	
Hopman, 2007			√																																			
Chin, 2006												√													√													
Le Lay et al., 2013												√												√					√	√	√							
Faggi et a, 2013																													√			√						
Azrina et al., 2006	√			√																																		
Mohamed et al., 2012														√											√													
Juahir et a, 2011	√				√				√																													
Weng, 2005								√				√				√								√					√				√					
Dwyer et al., 2000					√					√						√												√				√						
Panelli an Pini, 2005																								√					√									
Le Lay et al., 2013																√																	√					
Wohl and Merritts, 2007											√	√	√					√	√					√	√							√			√			
Dobbie, 2012					√													√			√	√	√	√	√			√										√
Cottet et al., 2013																√		√		√	√	√	√	√	√			√	√	√								
Larson et al. 2013																			√																	√	√		
Gandin, 2012					√	√	√	√	√											√					√												√	

mulated the Sustainable River Rehabilitation Index (Eq. (2)). The index involves the list of indicators; dimensions and criteria (identified in Tables 1 and 2), and the coefficient for each one (calculated in Tables 3 and 4). The index can be applied in any riverscape sites to measure the correspondence of river rehabilitation impact to sustainability. The urban developers and planner can apply this index to benchmark the sustainable rehabilitated riverscape; and also, apply the index to compare rehabilitation impacts among diverse riverscape sites.

Sustainable riverscape rehabilitation index score

$$= \sum_{i=1}^{n} D_i X \times \sum_{j=1}^{n} C_j Y \tag{2}$$

where i, refers to dimension item (extracted from Table 1) ($i = 1, 2, 3, \ldots, 14$); D_i; refers to weightage value of dimension item (i.e. dimension item coefficient) (resulted in Table 3); X, refers to value appointed for dimension item 'i' in the riverscape case study; j, refers to criterion (extracted from Table 2) ($j = 1, 2, 3, \ldots, 40$); C_j, refers to weightage value of criterion (i.e. criterion coefficient) (resulted in Table 4); Y, refers to value appointed for criterion 'j' in the riverscape case study.

2.3.5. Supportive strategies for quality implementation of the sustainable riverscape rehabilitation strategy framework

In spite of increasing governmental and public concern on natural urban conservation, there is still insufficient effective legal protection. Public awareness on urban natural landscape protection and preservation is still new in Malaysia. Recently, public concern has increased due to the destruction of urban natural landscape that is a crucial threat for historical heritage cities, and consequences of changing characteristics and quality of urban area. In 2003, the "President of the Heritage of Malaysian Trust" (Badan Warisan Malaysia) declared that the oldest construction, buildings and riverscape in Melaka city are at risk and under threat. For example, although the Melaka historical city is in the list of "UNESCO" as a "World Heritage Site", the damages and destruction caused by human and urban development affected throughout the country (Heritage of Malaysia Trust, 2004).

Political issues, lack of adaptation to ecological ecosystem, and minimal participation in riverscape design have damaged urban environment, ecological system, historical and cultural properties. For these reasons, a comprehensive goal of improving the process of designing riverscapes is tremendously essential to protect human well-being, environmental and cultural aspects, and historical characteris-

Table 3
Weightage analysis of riverscape rehabilitation dimensions.

Riverscape Benefit Dimensions	Aesthetic	Place meaning	Make place readable	Excitement	Recreation	Attractiveness	Health	Psychophysiological benefits	People willingness	Emotional benefit	Landscape design	Relaxing	Happy mood	Leisure time
Frequency	7	4	2	3	11	5	2	3	1	2	5	4	2	2
Weightage value (%) (Total Citation = 53)	0.132	0.075	0.037	0.056	0.207	0.094	0.037	0.056	0.018	0.037	0.094	0.075	0.037	0.037

Table 4
Weightage analysis of riverscape rehabilitation criteria.

Riverscape Benefit Indicators	Physical Aspect							Environmental Aspect												Social Aspect										Economic Aspect	
	Water quality	Soil erosion	Water treatment	Anthropogenic impacts	Marine conservation	Natural heritage	Cultural heritage	Environmental sustainability	Environmental management	Environmental quality	Landscape rehabilitation	Riverscape management	River Rehabilitation	Riverfront development	Landscape quality	Landscape protection	Landscape pattern	Restoration Sceneries	Ecological integrity	Riverine	Stream ecology	Wetland	River Meaning/Value	Aesthetic preference	Perception	Urbanization	Social benefit	Well-being/Healthiness	Recreation	Socio-Cultural perception	Emotional influence	Visual sense/Attractiveness	Need and Preference	Environmental Education	Perceived naturalness	Cognitive structure	Importance/Satisfaction	Personal and social Value	Socio-economic value	River Trading
Frequency	3	1	1	1	4	1	1	6	4	1	2	7	2	1	1	7	5	10	9	6	3	2	2	6	11	3	1	3	3	5	1	2	2	2	1	1	1	1	2	3
Weightage (%) (Total Citation = 128)	0.023	0.007	0.007	0.007	0.031	0.007	0.007	0.046	0.031	0.007	0.015	0.054	0.015	0.007	0.007	0.054	0.039	0.078	0.070	0.046	0.023	0.015	0.015	0.046	0.085	0.023	0.007	0.023	0.023	0.039	0.007	0.015	0.015	0.015	0.007	0.007	0.007	0.007	0.015	0.023

tics. This promotion has created a vital need to discover supportive strategies (i.e. involvement of urban development stakeholders, NGOs, urban designer and planners, landscape architects, as well as local authorities in heritage city's riverscape rehabilitation) to improve the heritage urban river corridor development in Malaysia without severe changes to the landscape characteristics and river quality.

Based on the discussed issues, Fig. 3 illustrates the framework for sustainable riverscape rehabilitation strategy for heritage historical cities in Malaysia. The framework integrates between establishing sustainable goals and objectives for riverscape rehabilitation, identifying riverscape rehabilitation indicators, applying the sustainable river rehabilitation index formula, and establishing supportive strategies for quality implementation of framework (i.e. government, authorities, urban development stakeholders, and public).

3. Validation of the sustainable riverscape rehabilitation strategy framework

In second phase, the research conducted an expert input study to validate feasibility of the developed framework across four (4) aspects; Problem Definition, Viability of Framework Model Process, Expected Framework Outcomes, and Potential of the Project to be continued further. The feasibility factors examined in this research are; Technical aspect, Operational aspect, and Economical aspects as referred to:

- Technical aspect: This refers to the observation where the stage was technically feasible for the users and the users did not face the problem of lack of needed technology and knowledge to conduct it.
- Operational aspect: This refers to the observation where the stage was operationally feasible for the users and the users did not face lack of resource (e.g. data and respondent) or problems (e.g. language problem in questionnaires sheet) to conduct it.
- Economical aspect: This refers to the observation where the stage was economically feasible for the users and the users did not face the problem of lack of unexpected monetary resources (e.g. cost of data).

Field expert Delphi structured Close Group Discussion was used as the method of data collection, which is the most applicable group decision making method (Green

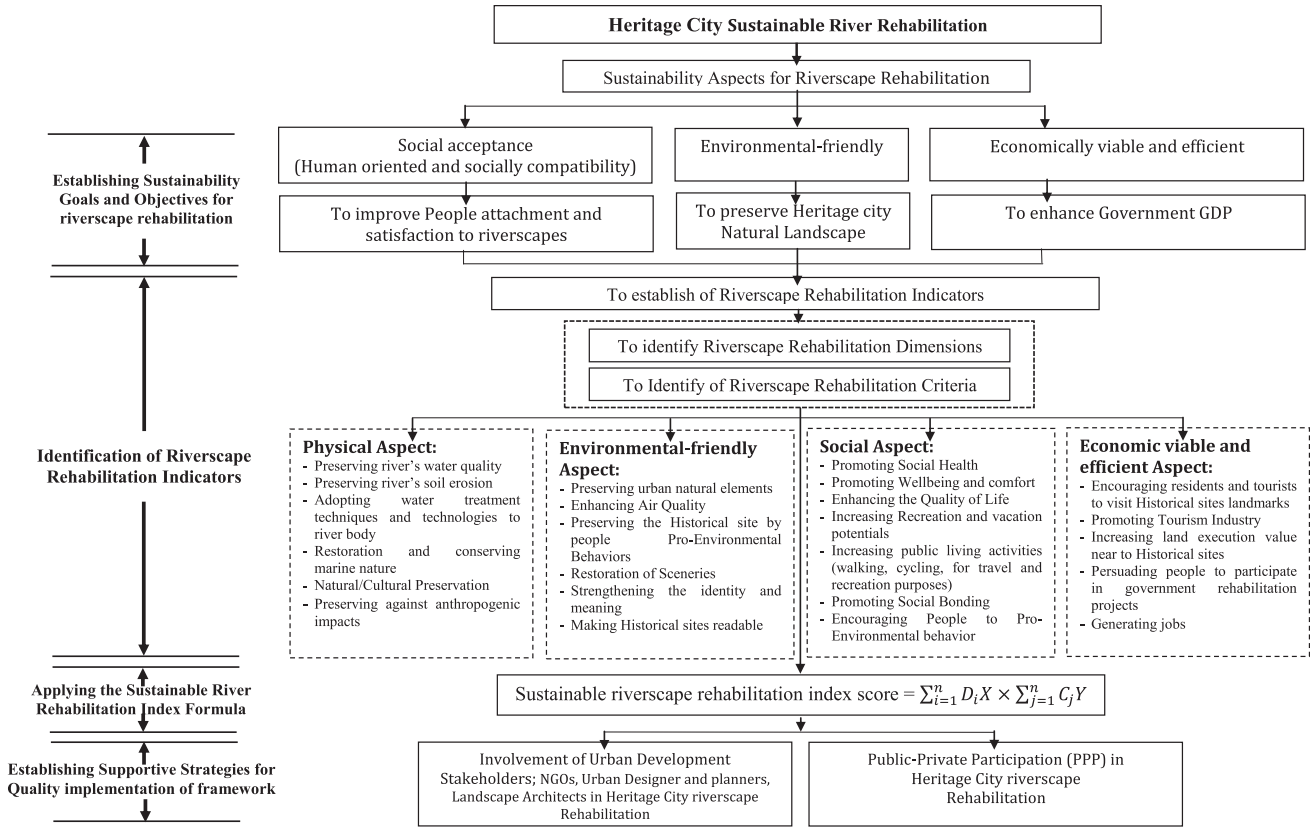

Fig. 3. Sustainable riverscape rehabilitation strategy framework applicable for heritage historical cities in Malaysia

et al., 2007; Ozer, 2007). A structured fixed format self-reporting questionnaire form was designed to be filled up in discussions. The group discussions have been preceded by expert's judgment collection using 5-point likert scaling (from number 1 refers to Weak to number 5 refers to Excellent). Based on purposive sampling method, a total number of eight experts were involved within four group decision making sessions. The experts have been invited who are practicing urban design and planning in heritage city conservation and preservation.

Data analysis was conducted using Grounded Group Decision Making (GGDM) method. Adapted from Lamit et al. (2013b), $FW(a_i)$ (Eq. (3)) is to calculate final weight (FW) of sub-issue number 'i', ($\boldsymbol{a_i}$), of the discussion.

$$FW(a_i) = \left(\sum_{j=1}^{n}(\min\{WP_j, WPr_j\} \times SV_j)\right) \times a_i, \times (\text{for } i = 1, 2, 3, \ldots, m) \quad (3)$$

where WP_j, refers to assigned weight by participants number 'j' in close group discussion for sub-issue 'a_i', WPr_j refers to assigned weight by resource(s) relevant to the issue, whom introduced by participants number 'j' in close group discussion for sub-issue 'a_i', a_i refers to sub-issue of discussion, $FW(a_i)_{max}$, refers to maximum possible weight can be given for sub-issue 'a_i', SV_j, refers to CGD sessions value (SV) considered by the decision researcher which the CGD session included participant number 'j'.

Eq. (4) indicates the consensus calculation in GGDM for sub-issue 'a_i'. If the final consensus calculated more than 70% the alternative is selected, and that criterion is approved

$$FW(a_i)/FW(a_i)_{max} = \text{Consensus in } \%. \quad (4)$$

3.1. Expert inputs validation results

In GGDM application, the researcher appointed the Session Value (SV) for each session of CGD. The researcher appointed SV 1 for two first sessions and SV 3 for the session 3 and SV 4 for the session 4 of CGDs. In the first session, two (2) participants (i.e. experts) have been involved. According to Table 5, participant 1 appointed WP = 3 for the criterion 'C1' (i.e. Technical aspect of Problem Definition) as his weighting value to validation. The participants were asked to introduce any other resource to validate the list of criteria, if needed. As can be seen in Table 5, participant 1 introduced participant 3 (WPr = c-WP3). Then, the research has to conclude the minimum between WP's weighting value and c-WP3's weighting value.

For example, according to WP column of participant 3, the researcher had to select the minimum between 3 and 5 as the weighting value indicated by participants 1 and 3 for the criterion 'C1' (i.e. Technical aspect of Problem Defini-

Table 5
Summary of GGDM feasibility validation analysis of heritage historical city riverscape rehabilitation strategy framework.

The Conceptual framework validation Aspect	The conceptual framework feasibility validation Sub-aspect	Validation session 1							Validation session 2				Validation session 3										Validation session 4							Cons. (%)	GGDM Consensus
		Participant 1			Participant 2			SV	Participant 3			SV	Participant 4			Participant 5			Participant 6			SV	Participant 7			Participant 8			SV		
		WP	WPr = c-WP3	c-WP	WP	r-WP = c-WP4	c-WP		WP	WPr = -	c-WP		WP	WPr = c-WP7	c-WP	WP	WPr= WP7	c-WP	WP	WPr = c-WP7	c-WP		WP	WPr = -	c-WP	WP	WPr = c-WP5	c-WP			
Problem Definitation	C1.Technical aspect	3	4	3	4	5	4	1	3	-	3	1	5	5	5	5	5	5	-	5	5	3	3	-	3	-	5	5	4	85	Aprv.
	C2. Operational aspect	2	3	2	4	5	4	1	3	-	3	1	5	5	5	5	5	5	-	5	5	3	5	-	5	-	5	5	4	92	Aprv.
	C3. Economical aspect	3	5	3	5	5	5	1	5	-	5	1	5	4	4	4	4	4	-	4	4	3	4	-	4	-	4	4	4	81	Aprv.
Viability of Framework Model Process	C4. Technical aspect	2	5	2	3	4	3	1	5	-	5	1	4	5	4	5	5	5	-	5	5	3	5	-	5	-	5	5	4	92	Aprv.
	C5. Operational aspect	3	5	3	4	5	4	1	5	-	5	1	5	5	5	5	5	5	-	5	5	3	5	-	5	-	5	5	4	97	Aprv.
	C6. Economical aspect	2	3	2	3	5	3	1	1	-	1	1	5	4	4	4	4	4	-	4	4	3	4	-	4	-	4	4	4	74	Aprv.
Framework Expected Outcomes	C7. Technical aspect	4	3	3	4	5	4	1	3	-	3	1	3	5	3	4	5	4	-	5	5	3	5	-	5	-	4	4	4	86	Aprv.
	C8. Operational aspect	3	4	3	4	4	4	1	4	-	4	1	4	5	4	5	5	5	-	5	5	3	5	-	5	-	5	5	4	93	Aprv.
	C9. Economical aspect	4	5	4	4	4	4	1	5	-	5	1	4	4	4	5	4	4	-	4	4	3	4	-	4	-	5	5	4	85	Aprv.
Potential of project to be Countiniued further	C10. Technical aspect	2	2	2	3	3	3	1	2	-	2	1	3	2	3	3	2	2	-	2	2	3	2	-	2		3	3	4	45	n-Aprv.
	C11. Operational aspect	3	5	3	4	5	4	1	5	-	5	1	5	5	5	5	5	5	-	5	5	3	5	-	5	-	5	5	4	97	Aprv.
	C12. Economical aspect	4	4	4	4	4	4	1	4	-	4	1	4	5	4	5	5	5	-	5	5	3	5	-	5	-	5	5	4	94	Aprv.

Note. **WP:** Participant's Rate to the validation aspect, **c-WP:** conclusion of Participant's Rate to the validation aspect considered as $min\{WP_j, WPr_j\}$, **WPr:** Participant introduced resouce Rate to the validation aspect, **-**: Participant did not provide value, **SV:** CGD Session Value considered by the GGDM researcher, **Aprv**.: the validation aspect is approved based on GGDM Consensus rate of more than 70% agreement, **n-Aprv**.: the validation aspect is not approved based on GGDM Consensus rate of not more than 70% agreement.

tion), which equals 3. Then, researcher considered this value in the column c-WP for participant 1's records.

In the second, third, and fourth sessions, all the mentioned process has been conducted. For example, for the criterion 'C1' (i.e. Technical aspect of Problem Definition), the following calculations have been conducted:

$$FW(C_1) = (3*1) + (4*1) + (3*1) + (5*3) + (5*3) + (5*3) + (3*4) + (5*4) = 85$$

$$FW(C_1)/FW(C_1)_{max} = 85/100 = 85\%$$

In some cases the participants did not introduce any other sources for the CGD, for example, participant 3 (i.e. WPr = –). Also, in some cases the participant did not appoint any value, and accepts all identified by his/her introduced resource expert. For example, participant 6 did not rate (i.e. WP = –) and introduced participant 7, and accepted all weighting values appointed by participant 7.

Experts in Delphi structured close group discussions validated feasibility aspects of the 'heritage historical city riverscape preservation and rehabilitation conceptual framework' based on four aspects (i.e. 'Problem Definition', 'Viability of Framework Model Process', 'Expected Framework Outcomes', and 'Potential of the Project to be continued further') (Table 5). The GGDM results show that expert inputs reached more than 70% saturation on all factors; except, the technical feasibility aspect of the 'Potential of project to be continued further' criterion that got the saturation less than 70% (i.e. 45%). On this technical problem, the experts asked researcher to measure the correlation between all framework's components in future, in order to prove framework's applicability and implementation capabilities.

4. Discussion

Currently, river management is one of the main issues in the world and also in Malaysia. On the one hand, the government holds the responsibility of managing the rivers, while the public, NGOs, industries, farmers and other stakeholders too play important roles in this matter. On the other hand, sustainable river management needs collaboration among government, the public and all stakeholders. Besides these agencies, there are few other public organizations established by groups of architects, planners, journalists, artists and historians, such as the Malaysian Architects Association and Malaysian Institute of Planners to support and maintain national heritage rivers for future generations (Ismail and Shamsuddin, 2005). In addition, there are few support groups, such as Penang Heritage Trust and the Heritage of Malaysia Trust, who are the two main pressure groups campaigning on heritage conservation and regeneration issues. So far, the pressure groups have created awareness on the importance of heritage to the public. Newsletters, heritage awareness campaigns in schools and workshops on conservation have been carried out to encourage public participation in the protection of heritages in Malaysia. Local authorities such as in Kuala Lumpur, Penang, Melaka and Taiping are the frontliners in introducing conservation-based policies to regenerate historic areas in their Special Area Plan. The Kuala Lumpur Structure Plan 2020 serves as a reference for urban development in Malaysia. The Malaysian government has started to implement the Archeological Finding Act to pre-

vent the destruction and promote the preservation of urban landmarks. However, after more than 30 years, the situation and policies in terms of conservation and planning movements in Malaysia have not changed. In fact, the plan for preservation and maintenance in most historical cities in Malaysia still concentrates on monuments and buildings protection.

This research developed a strategy framework for sustainable riverscape in heritage historical cities in Malaysia using the goal-oriented method. Findings of this study may help governments, local authorities, and all riverscape development stakeholders around the world by providing a broad array of knowledge to serve diverse preferences, needs, and motivations. The research has identified a comprehensive list of riverscape rehabilitation indicators, which should be considered in any sustainable riverscape rehabilitation. The indicators have been clustered into dimensions and criteria. The weightage of the indicators is reported in Tables 3 and 4.

According to Table 3, recreation and aesthetic are the most effective dimensions that should be considered in riverscape rehabilitation of heritage cities. Similar results have been obtained in Table 4 for riverscape rehabilitation criteria. The weightage analysis shows that aesthetic preferences and recreation, after perception, can play significant roles in social rehabilitation of riverscapes in heritage cities. Previous researchers have also supported this statement. Williams and Cary (2002) stated that the relationship between aesthetic and ecological integrity is influenced by a third criterion, namely wetland perception. Zedler and Leach (1998) and Nassauer (2004) stated that the impact of river restoration on people's aesthetic is the ultimate goal of landscape ecological designers and planners. Aesthetic assessment of diverse types of landscape, such as national parks (Steinitz, 1990) and wetlands (Nassauer, 2004), and urban areas (Gobster, 1994; Nassauer, 2004) is a controversial topic. Junker and Buchecker (2008) expressed a positive relationship between aesthetic preferences of public and ecological quality in river restoration projects. Junker and Buchecker (2008) stated that river restoration needs extensive aesthetic appeals, which is normally recommended by landscape designer, planners, project teams, and the public users. However, some studies have found general in-correspondence between wetland aesthetic assessment and ecological quality (Van den Berg and Koole, 2006; Williams and Cary, 2002).

Weightage analysis shows that perception can significantly aid socially-oriented riverscape rehabilitation. Human disruption to river rehabilitation and restoration influences public perception adversely, mainly on vegetation and wildlife recoveries (i.e. biophysical values), and the condition and availability of infrastructure (such as, footpaths accessibility) as stated by Westling et al. (2014). Public perception can strengthen visual access to riverscape, vegetation diversity (Davenport and Anderson, 2005), interactions with physical landscape elements and the scenic beauty of the riverine (Kearney et al., 2008; Westling et al., 2014). In order to sustain public perception, river rehabilitation has to maintain the infrastructure (Westling et al., 2014).

The analysis of this research shows that recreation contributes to socially-oriented riverscape rehabilitation after aesthetic preference and perception. This has been also declared by Gobster (1994) and Jacobs and Buijs (2011). They expressed the changes in aesthetic value, recreational value, place attachment, and water quality attribute contribute to perception on river revitalization. The relationship between public recreation and preferences specialization have been studied using different approaches, such as site attributes, backcountry hikers, and rock climbers (Galloway, 2012; Ferwati and Shafaghat, 2015). These studies showed that users' preference and perception is a key driver in preservation and rehabilitation activities.

From the environmental point of view, it was found that ecological integrity significantly contributes to riverscape preservation and rehabilitation. The habitat ecological integrity in riverine physical assessment is defined by biodiversity measurement (Duelli et al., 2007) and is a global controversial issue (Michez et al., 2013; Baek et al., 2014). These research have mostly emerged from fishery communities (Vezza et al., 2014; Zhao et al., 2015a), but few have investigated the relationships between ecology and hydrology for diverse hydromorphological types and aquatic ecosystems (Parasiewicz et al., 2012; Shi et al., 2017). For example, Shi et al. (2017) developed the River Habitat Integrity framework "which involves human disturbances, multi-scale and elements, including hydromorphology, water quality and aquatic ecosystems". Shi et al. (2017) stated "poor hydrological conditions do not lead to poor ecological integrity".

From the physical point of view, the marine conservation has to be significantly considered in riverscape rehabilitation of historical cities. Marine conservation can be conducted through spatially adaptive methods to monitor the variability of diversity (Doxa et al., 2016), biodiversity and ecosystem functioning (Srivastava et al., 2012). In marine conservation, species evolutionary history (i.e. phylogenetic diversity) and species ecological traits (i.e. functional diversity) are critical for biodiversity facets evaluation (Doxa et al., 2016; Srivastava et al., 2012).

This research found out water quality considerably contributes to riverscape preservation, and then, marine conservation can significantly help to riverscape preservation. In this regards, Walker et al. (2015) declared that "water quality plays a vital role in all aspects of human and ecosystem survival". Xu (2015) expressed that human activities and disturbances have greatly impacted water quality and hydrological regime in urban lands and landscapes, which has led to pollutant loads and habitat conditions in riverine environments (Walters et al., 2009; Zhao et al., 2015b), and biodiversity in aquatic ecosystems (Svircĕv et al., 2014). Moreover, Bellmore et al. (2012) stated that river habitat restoration is a very useful conservation and recovering strategy which can enhance water

quality, aquatic habitats, biodiversity and aquatic ecosystem health. River's water quality needs a set of physical and chemical constituent analysis to obtain better water resources (Saxena and Gangal, 2010). Several techniques and methods have been developed for water quality analysis to evaluate the effect of pollution and anthropogenic influences, which mainly include modelling approaches, multivariate statistical techniques (such as, Principal Component Analysis-PCA), artificial intelligence, and artificial neural networks (Saxena and Gangal, 2010; Taner et al., 2011; Ma et al., 2013). Such techniques and methods are MCDM (multi-criteria decision making) techniques, which help decision makers to indicate the river's water quality related to site management, land use, soil preservation against pollutants, and remedial actions.

Finally, from the economic point of view, this research indicated that river trading has to be extensively considered in riverscape rehabilitation of historical cities. In this regards, Wang (2011) and Kiem (2013) stated that river is a natural resource for business and economic growth. Tourism leisure and tourism recreation can be considered as predominant activities for economic growth (Yassin et al., 2011). Kiem (2013) expressed that river trading impacts rural communities in economic region; however, social implications of river trading need further investigation.

5. Conclusion and future study

Reviewed previous studies have confirmed there is no heritage historical city riverscape preservation and rehabilitation strategy framework that considers all three fundamentals of sustainability for Malaysia's heritage cities. This research formulates the framework to provide a goal-based solution for promoting riverscape preservation in historical heritage cities by involving the government, stakeholders, and the public. Besides, this research has developed the strategy framework based on the perspective of urban design and planning. The characteristics, quality, and value of heritage city's riverscape are incorporated with human attachment and pro-environmental behaviours that cause positive effects on social, economic and environmental aspects of sustainable urban development. In terms of the physical/environmental aspect, the conceptual framework can have positive effects by cultural preservation, strengthening the identity and meaning of a heritage city, and promoting a sense of attachment and sense of place with historical rivers. Meanwhile, in terms of the social aspect, the conceptual framework can have positive effects by promoting social health, wellbeing and comfort, and quality of life, encouraging people to have pro-environmental behaviour, and strengthening the sense of attachment to the historical site, in addition to pursuing people to participate in government rehabilitation and conservation projects. From the economic aspect, the conceptual framework can have positive outcomes by encouraging residents and tourists to visit historical sites, promoting tourism industry, increasing land execution value near to historical sites, and generating jobs and commercial opportunities.

Moreover, the findings are useful for experts practicing heritage cities conservation and preservation, including urban designers and planner, landscape architects, architects, government as well as local authorities and policy makers. This strategy framework allows river rehabilitation stakeholders to quantitatively measure the weightage of problem description, supportive strategies selection, and tradeoffs analysis among supportive strategies accurately. The feasibility of the framework was validated using GGDM method. The GGDM resulted in technical, operational, and economical feasibility of framework implementation at a rate of more than 70% saturation. However, the technical aspect of the project for potential extension only received 45%, thus it is not approved.

In summary, the research has obtained the following key findings:

- The research developed a riverscape rehabilitation strategy framework for Malaysia's historical heritage cities.
- The framework applies the goal-oriented strategy method for sustainable development of heritage cities.
- The framework is technically, operationally, and economically feasible to be applied in any historical heritage city.
- Applying this framework rectifies rapid riverscape transformations and fragmentations.

For further study, there is a need to examine the correlation between the components of the framework. The future study can develop a Structural Equation Modeling (SEM) model to analyse the correlation between dependent and independent components of the framework model.

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