Available online at www.sciencedirect.com
SCIENCE DIRECT®
Landscape and Urban Planning 76 (2006) 45–66
LANDSCAPE AND URBAN PLANNING
This article is also available online at:
www.elsevier.com/locate/landurbplan

A greenway network for singapore

Kiat W. Tan*

National Parks Board, Singapore Botanic Gardens, 1 Cluny Road, Singapore 259569, Singapore

Available online 8 December 2004

Abstract

The greenway movement in Singapore began in the late 1980's as a proposal for an island-wide network of green corridors. The paper traces the conceptualization, planning strategy and implementation of this greenway network. The capitalization of under-utilized land along drainage channels and beside carriageways for pilot greenway projects ensured government backing for the projects. The challenges faced in implementing the projects and the solutions taken to advance the greenway concept are discussed. Garnering public support for the completed sections generated resources and conferred additional flexibility to the land allocation process, allowing the concept to evolve. Strategic partnership with key land-use agencies and the overview of a national Garden City Action Committee for conflict resolution facilitated the process. Lessons are drawn from the implementation of the pilot projects to inform subsequent greenway development efforts, enhancing the usage and multi-functional capacity of the greenways. The Singapore experience provides a model for greenway planning and implementation for other rapidly urbanizing cities in Asia.
© 2004 Elsevier B.V. All rights reserved.

Keywords: Greenways-Singapore; Park connectors; Drainage-carriageway buffers; Garden City; Urban park planning; High density city-state.

1. Introduction

1.1. Background

The Republic of Singapore comprises the main island of Singapore and a number of smaller islands at the tip of the Malay Peninsula. It has progressed from its status as a British colony in 1819 to self governance in 1959, union with Malaya as a member of the Federation of Malaysia in 1963, and finally as a fully independent sovereign nation in 1965. In the process, Singapore has grown from a fishing village into a vital global city housing a population of more than four million residents. As a city-state with an area of 682.7 square km and a population of 4.17 million in 2002, Singapore ranks as one of the most densely populated cities in the world. Singapore's population density of more than 6000 persons per square km is comparable to that of San Francisco (Harnik, 2000) and Hongkong (source: Hongkong Planning Department). In the pursuit of modernity, old architecture and streetscape inevitably give way to contemporary buildings and multi-layered transportation systems. Skyscrapers spring up with the rapidity of growth associated with the rainforests of the region. What has served to differentiate Singapore from other cities in similar transition is that in Singapore, the lush vegetation supported by the

* Tel.: +65 64717800; fax: +65 64723033.
E-mail address: kiat_tan@nparks.gov.sg.

0169-2046/$ – see front matter © 2004 Elsevier B.V. All rights reserved.
doi:10.1016/j.landurbplan.2004.09.040

equable climate of the tropics has featured significantly in the process of planning and development of infrastructure, housing, and industrial and commercial facilities to support its vibrant economy.

1.2. Purpose of paper

Despite the challenge of competing land uses for economic development, much has been done to ensure that parks, open spaces and nature areas are set aside to counter the effects of high density urban living (Keung, 1998). In the last decade, Singapore embarked upon the implementation of an island-wide network of greenways with the vision of linking parks and nature areas by capitalizing on existing drainage culverts and river systems (Briffett et al., 1999). In describing Singapore's experience in planning and implementing its greenway network, this paper purports to show how a greenway network evolves in a densely populated island city-state. In the face of intense pressure to maximize the development potential of every square inch of land to yield direct economic gain, a strategic phasing of pilot projects is incorporated into the planning process. This has allowed the concept of a network of greenways to evolve. Strategic alliances are made with key land-use agencies and local government leaders. Some pilot projects for the installation of the greenway system are described. The problems encountered and solutions arrived at are discussed. The response of stakeholders to the pilot projects implemented are evaluated and used to inform to inform subsequent efforts in greenway planning.

1.3. Garden City Singapore

Today, Singapore has achieved a Garden City ambience with a luxuriance of greenery along its tree-lined roads and a hierarchy of parks ranging from the large regional open parklands to intimate pocket parks within the city and in residential neighborhoods. This city in a Garden effect contributes as much to the identity of the nation as does its busy port, ranking international airport and airline, and multiracial community. So omnipresent is the greenery that it has been easy to overlook the thinking, passion and toil behind their existence and maintenance. It has been a journey of nearly 40 years of dedicated effort and political will.

1.3.1. Park planning in Singapore

The genesis of Singapore as a Garden City dates from 1963 with the launch of Tree Planting Day by the architect of the new nation, then Prime Minister Mr Lee Kuan Yew. He set in motion, in his words, "... a careful tree planting campaign not only for the roadside and public places, but for all private land owners". When Singapore's planning authority, the Urban Renewal Authority drew up the first Concept Plan to guide the development of Singapore in 1971, the idea of turning Singapore into a Garden City was incorporated and gathered momentum. To maintain this momentum, a Garden City Action Committee was formed in 1973 to spearhead the formulation of a greening policy as well as direct the course of the Garden City Campaign in Singapore. The composition of the Garden City Action Committee comprises ranking government officials from key government agencies, reflecting the level of political will towards the greening effort. The National Parks Board is the implementing agency for the Garden City Action Committee.

Concept Plan Reviews are scheduled at regular intervals to update the Master Plan that guides the development of Singapore. In the 1989 Concept Plan Review, a Recreational Sub-committee was formed with the following terms of reference:

(a) Review the long and short-term policies on recreation provision and recommend specific recreational policies for implementation.
(b) Review the supply of land for recreational use and the relevance of the adopted open space standard of 0.8 ha per 1000 persons.
(c) Recommend recreational development strategies for the year 2000 and for a population targeted at 3.4 million.

The guiding principle of 0.8 ha of park space per 1000 persons was arrived at by benchmarking against cities of similar population density, and moderated by Singapore's constraint as an island city-state. In scrutinizing the strategy for achieving the recommended acreage for parklands, the sub-committee put forward the following proposal:

Parks and open spaces should be planned as part of a network system so as to optimize the use of limited land resources. Major parks and open spaces would be linked with green corridors derived from green buffer

zones. Such corridors should preferably be at least 20 m wide. Jogging tracks can be included as part of the landscaped corridors to provide a wider circuit of such shady and pleasant tracks. Users can then gain access to the tracks without needing to drive to specific parks, alleviating the demand for car parks. Landscaped corridors can also serve as green linkages for birds and other fauna to move from one park to another, thereby enhancing the natural elements in the environment (Source: Concept Plan Review, 1988/9, Report of the Recreation sub-committee).

1.4. Concept of greenways

The proposed network system of linear corridors linking parks and open spaces was named the park connector network, and is very similar in concept to the definition of greenway espoused by Endicott (1993). Hence in Singapore, greenways are termed "park connectors".

1.4.1. Literature review

Little (1990) defined greenways as linear open spaces established along either a natural corridor such as a riverfront, stream valley, or ridgeline, or overland along a canal, a scenic road or a disused railway line. According to Fabos (1995), greenways are corridors of various widths, linked together in a network, in much the same way as networks of highways and railroads have been linked. In general, greenways could serve to connect parks, nature reserves, cultural and historical sites and other protected lands (Arslan et al., 2001). The concept of forming a network or matrix of patches and corridors ("aggregate-with-outliers" principle) espoused by Forman (1995) has numerous ecological as well as human benefits. Ahern (1995, p. 134) emphasized that linkage is a key characteristic of greenways as "when a system is linked, it could acquire the synergistic properties of a network".

In the United States, the earliest form of greenway is the Boston Park System by Frederick Law Olmsted (Fabos, 2001). Greenways in the United State are variable in size, type and function and have evolved through different landscape forms, the latest generation being "multi-objective" greenways (Searns, 1995). They range from short, linear urban green spaces in cities to large river valleys and mountain ridges. Current greenway planning in the United States is largely focused on coastal rivers as means of connectors (Fabos, 2001).

In the United Kingdom, efforts to incorporate green open spaces into cities started from as early as the 1900s, with Ebenezer Howard as the main advocate of greenbelts at the city perimeter (Briffett et al., 1999). London has had a series of open space plans in the past 60 years, with Abercombie's 1943 plan of linked open spaces being the most influential (Turner, 1995). Greenways provide the means to link larger open green spaces with linear green corridors. For instance, London's Green Strategy of 1991 focused on a series of overlapping networks, each of distinctive qualities (Turner, 1995). While the earliest greenways in the United Kingdom were intended to serve interactive social needs, it has been recognized that the greenways also serve recreational as well as benefiting the ecology (Briffett et al., 1999).

1.5. Park connector network

In Singapore, the proposal to form a park connector network was approved by the Garden City Action Committee on 4 December 1991. This vision is an ambitious one considering Singapore's circumstances: it is not just a thriving city but also an independent island nation that needs to set aside land for airports, seaports, reservoirs, power stations and military training areas in addition to residential, commercial and industrial uses (Keung, 1998). Despite such competing land use demands, some 360 km of greenways are identified through innovative planning and programmed for development over the next 20–30 years. This program would add another 290 ha of open parkland to the Master Plan for the development of Singapore, and constitute 7% of the quantum of land area needed to meet the target of 0.8 ha of parkland per 1000 persons. The 1991 Concept Plan adopted by the planning authority included the park connector network under its "Green & Blue Plan" (Urban Redevelopment Authority, 1991). Plans for the greenway network were reinforced in the Concept Plan Review in 2001 (Urban Redevelopment Authority, 2001) and more recently, in the Parks and Waterbodies Plan (Urban Redevelopment Authority, 2002).

"Park connectors" in Singapore today refer to the greenways linking major parks, nature reserves, natural open spaces and other places of interest in Sin-

gapore. These urban greenways connect the population centres to major parks. When the entire network is completed, the greenways will provide a green matrix of connected linear park space, making parklands in Singapore more accessible to the public. Land reserved as drainage buffers was specifically targeted for greenway development to make the "park connector" proposal palatable to pragmatic decision makers. This land has already been accepted as having 'low' economic potential. Doubling as greenways, such spaces would provide a cost effective method for facilitating the use of existing recreational venues. They would come to play an increasingly critical role in sustaining the garden ambience of Singapore as 'borrowed' greenery in the environment progressively come under development in the name of progress.

A secondary objective of the urban greenway initiative in Singapore is to enhance biodiversity in the environment by providing nature corridors within urbanised areas. As the greenery matures along the greenways, birdlife and other fauna can traverse such corridors from one refuge to another in their search for food and breeding sites (Oi, 1990). By having greenways connect major parks with the nature reserves, it is hoped that nature would be enhanced throughout the island. The park connector network is therefore intended to be a multifunctional greenway, requiring planners "to seek a balance between the ecological, cultural, social and aesthetic goals" in their planning (Ahern, 1995).

2. The methodology

2.1. Planning

The development of greenways in Singapore involves strategic planning to meet the primary dictate of optimizing land use to address its multi-functional aspects. To meet the need to align the Urban Redevelopment Authority's Green and Blue Plan and the more recent Parks and Waterbodies Plan, the National Parks Board conceived a Parks Master Plan to guide the development of parks in Singapore. There are 3 categories of parks, namely, regional parks, neighborhood parks and greenways. Regional parks are distinguished as coastal parks, hill parks, reservoir parks, town/city parks and nature parks. The range and variety caters to the different interests represented in the population, and is dictated by the terrain and site. The guiding principle of 0.8 ha of parkland per 1000 persons has resulted in the portfolio of parks listed in Table 1.

Table 1
Current[a] and targeted distribution of various categories of parks and park connector

Category	Existing (ha)	Year X[b](ha)
Regional park	2436	3607
Neighbourhood park	311	507
Park connector network	35	286
Total	2782	4400
Ha/1000	0.67	0.80

[a] As at June 2003.
[b] Based on a projected population of 5.5 million.

The competition for land is acute in Singapore because of the small size of the island nation. As the cost of land increases, so does the difficulty in obtaining parcels of land for park development (Oi, 1998). The key selling point in securing government endorsement for the park connector network concept was that the project initially required minimal additional land uptake through the optimal use of drainage buffers. Land set aside as drainage buffers is ideal for developing greenways as they abut canals, and are comparatively under-utilized. Their designated use is to provide access for the periodic de-silting of drains so essential to a land visited by monsoons. Properly landscaped as greenways, these drainage buffers could be turned into cool, quiet and safe venues for recreational activity.

In planning the island-wide park connector network, the Singapore Master Plan for the entire island was reviewed (Tan, 1999). A United Nations Planner, Professor Otto Koenigsberge, had proposed a 'Ring Concept' for Singapore in 1963 (Fig. 1). Some three thousand hectares in the middle of Singapore Island currently consists of mature secondary rainforest. This forest serves as the central water catchment area for the nation. The Ring Concept proposed fringing this Central Water Catchment Area with a ring of towns. This idea was refined and incorporated into the 1971 Concept Plan. The park connector network built upon this Ring concept planning framework. Studies showed that the catchment area in the centre of the island is linked to the coastal fringes of Singapore Island by 11 major watercourses and their tributaries. These water channels pass through major open spaces, making it logical to plan greenways along their drainage buffers. As the

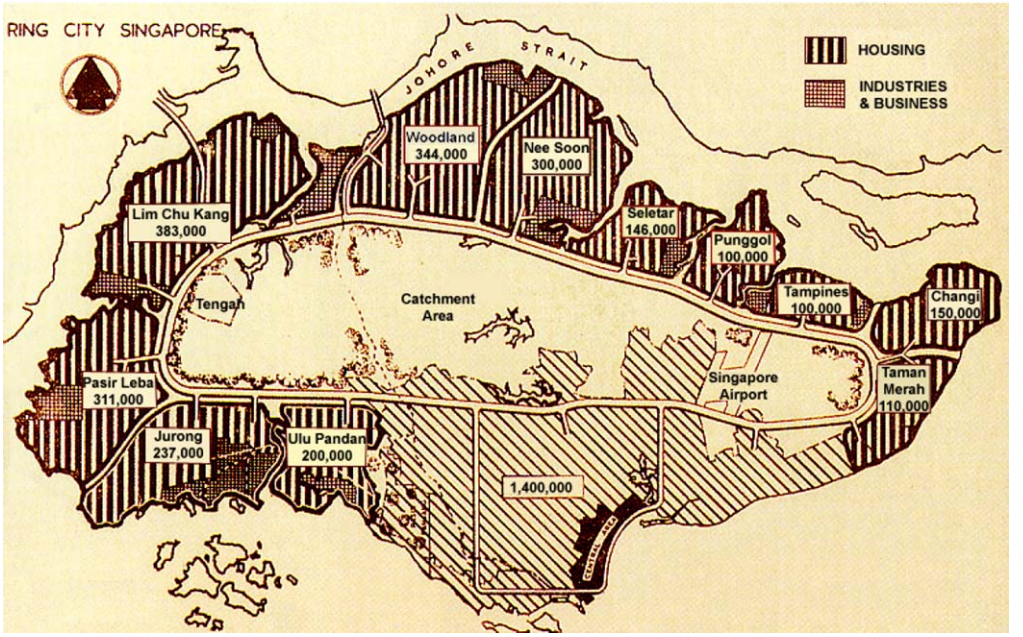

Fig. 1. Ring Concept Plan proposed by UN Planner, Professor Otto Koenigsberger in 1963 (Adapted from Home Work Play, Sumiko Tan, 1999).

choice of drainage buffers for developing greenways is determined by both their proximity to parks as well as the quantum of land available, not all drainage buffers along the above list of channels can be used for greenways.

Since the rivers are not linked to one another, the riverine greenways would have to be linked through the use of public land designated primarily as road reserves (the space beside road carriageways), foreshore reserves and the under-utilised land beneath overhead rail system (Mass Rapid Transit viaducts). This would evolve into a matrix of greenways throughout the entire island (Fig. 2). At this stage, it should be noted that the criteria for selection of greenway development land is almost entirely predicated upon availability of unencumbered buffer land, with little consideration as to the communities served. The intense urban development would guarantee that much of the greenways developed would abut estates of human habitation and cater to the residents.

2.2. Design concept

In the Singapore context, the park connectors are perceived to be greenways within an urban setting. They comprise simple asphalt tracks lined with dense plantings of native as well as introduced and ornamental trees shrubs. In Singapore's hot and humid climate, shade is essential. Since much of the original vegetation, with the exception of the Central Catchment Nature Reserve, had been cleared since colonial times, plant cover in the city is almost entirely introduced. The densely planted trees along the greenway would form a continuous canopy upon maturity, providing a protective cover over the jogging and cycling paths below (Figs. 3 and 4). They would also form continuous arboreal passageways for animal life.

2.2.1. Drainage buffers

Greenways are developed along land reserved as drainage buffers to provide access for the periodic desilting of monsoon canals. Given appropriate design treatment, these greenways would allow a pedestrian, cyclist or jogger to transverse a highly built-up area of Singapore, and yet be sequestered from motorised traffic.

Since greenways on drainage buffers must comply with Public Utilities Board's requirements, the Public Utilities Board and the National Parks Board have jointly drawn up the following guideline:

'The width of the greenways should consist of a 4 m-wide cycling cum jogging track at minimum, with a 2 m-wide planting strip along the outer edge of the drainage reserve. This minimum width is to allow access by maintenance vehicles to carry out repair of the canal/drain as well as to maintain the greenway.'

Greenways may run through residential areas. In such cases, these residential estates are provided with direct linkages to parks and nature reserves. Such greenways can also serve as alternate circuits for non-motorised travel. The smaller circuits serve local residential areas while the larger greenways can serve entire regions, or even the whole island (Oi, 1998).

A key challenge in implementing the park connector network is to ensure connectivity between stretches of greenways. This is not possible if development of greenways is solely along drainage buffers. Road reserves and additional public land must be used to effect connectivity. To facilitate the process, a working group comprising representatives from key government agencies involved in land management and enforcement such as the Land Transport Authority, the traffic police, the housing and development board, town councils, urban redevelopment authority and Singapore land authority is formed to coordinate and formulate guidelines for the development of greenways on lands under their jurisdiction. The Garden City Action Committee (GCAC) steps in to resolve any potential conflict.

2.3. Public support for greenway projects

Since the National Parks Board is tasked with the development and maintenance of the greenway system in Singapore, its officers are in regular contact with the local grassroots leaders of electoral precincts served by the greenways. The National Parks officers work jointly with community leaders to launch and popularize each new section of greenway. This is to introduce the community to the new concept of public space, and hopefully to engender a sense of public ownership of the park connector network. Increasing usage of the greenways by the public would fuel demand for additional tracks, better connectivity and additional recreational amenities like park furniture, exercise equipment, and resting areas. Parks officers making scheduled spot checks throughout the day during the week and week ends over a period of half a year would make observations on usage patterns. Feedback is obtained through regular meetings of the staff with community leaders and from letters and e-mail from a vocal public on the effectiveness and utility of the development. Such feedback is channeled to decision makers via the Garden City Action Committee and political channels, which, in turn, enables decision makers to direct more resources to the program. This allows the basic design concept to be improved.

As a result of the strategy of 'marketing' the park connector network, the development of greenways in Singapore is evolving. The original strategy to only optimize use of drainage buffers into a greenways system now includes the use of carriageway reserves. A typical road reserve consists of a carriageway and road 'side-tables' on both sides of the carriageway. Road side-tables vary in width, but usually consist of a footway over a covered drain, a tree planting strip and a service-verge. The National Parks Board proposes to use existing footways as jogging paths, and double-up the use of the service-verge as a cycling path. Since road reserves are under the management of Land Transport Authority and subject to traffic rules enforced by the traffic police, support from these authorities is crucial. To elicit such support, a working group comprising representatives of the key agencies involved is established.

A basic typology for greenways on road reserves is proposed (Fig. 5). The working group recommends a minimum width of 1.5 m for footpaths, 2.0 m for cycling paths while retaining the 2.0 m wide planting strips. A road side-table narrower than 5.5 m is thus not suitable for greenway development.

2.4. Road crossings

Connections at road crossings are critical to the design of greenways if human traffic flow along a comprehensive and continuous green network is to be realized. Road crossings can be achieved with signalized traffic lights, underpasses or overhead bridges. The choice depends on site and traffic conditions. The working group is currently working on establishing guidelines for the various types of crossings. The National Parks Board and the Land Transport Authority is developing a system to allow cyclists to cross the road without dismounting at designated signalized crossings. It is

against regulations to cycle across an at-grade crossing designed purely as pedestrian crossings, but at suitable locations, bicycle crossings with signals showing a green or red bicycle are proposed (Oi, 1998).

3. Application

Actual application of the methodology is illustrated by case studies of two greenway projects, one developed on drainage buffer land and the other on road reserve land. A pilot project for bicycle crossing was also carried out.

3.1. Case study of greenway along drainage buffer: Kallang park connector

Kallang park connector, completed in 1995, is a first generation greenway running along Kallang river. It is 9 km long linking two regional parks, Bishan Park and Kallang riverside park (Fig. 6). The development was carried out in two phases, starting from Bishan Park to Potong Pasir avenue 1 in the north, followed by the southern stretch from Serangoon road to Kallang riverside park. Flanking Kallang river are residential estates and schools. The practical reason for the selection of the site was the availability of the land for the development, but the proximity of the residential estates would ensure a source of potential users for the greenway (Fig. 7).

Kallang River has a drainage buffer of 6 m on both sides of the river. Occasionally, the buffer extends beyond 6 m. Kallang park connector was designed to provide a greenbelt within an urban setting that was basically a cycling and jogging track embellished with lush greenery. The only park amenities provided were a few park benches and trash-cans.

3.1.1. Observations

Upon completion of the pilot project, National Parks Board staff observed usage patterns during their spot checks. The greenway was used as both a recreational venue and a shortcut between residential estates and transportation nodes. As expected, most of the visitors to the greenway walked from residences in the vicinity

vicinity. The periods of use were early morning between 6.30 and 9.00 a.m. and in the evening between 5.00 and 7.00 p.m. The National Parks Board began to receive requests for more amenities, such as fitness stations and rain shelters. This was relayed to parks staff either directly or through the grassroots leaders whose interest in the project was stimulated into active mode by the public response. The observations resulted in re-thinking as well as reinforcement of some earlier approaches in the concept design.

It is not easy to get Singapore's urbanized public to buy into the idea of natural and rustic greenways without the usual park amenities. Although providing additional amenities was initially low in priority for greenways, a balance between the original vision and the public's expectations had to be struck.

Shade proved the most important factor in affecting usage in the tropical climate. Physically, the ideal visiting times are during early morning hours and in the evening when sunlight is less intense. This time frame for optimal use unfortunately coincides with office hours during the week, although more non-office goers such as housewives and students would have used the greenway if it had been well shaded.

3.2. Modification of design concept

In order to make future greenways more attractive and accessible, the tracks would be made to meander more where the drainage buffer is wider than 6.0 m wide. Strategically locating Plaza areas and focal points would also add interest along the greenway. Abutting open spaces along the corridor route can be incorporated into the development to allow greater flexibility in design. A co-ordinated set of street furniture comprising signage, map boards, distance markers, fitness stations, trash cans, light fittings, and shelters would enhance the identity of each new

section of greenway, augmenting a distinct planting theme. A natural forest ambience is desired to counteract the increasing density of urban development. Select fast growing trees to provide shade. These trees take priority over elaborate shrubs bedding, and are to be planted such that their crowns touch upon maturity to facilitate movement of wildlife and provide continuous shelter. Plant species particularly attractive to birdlife and indigenous plant species are preferred.

3.3. Case study on park connector along road reserve: Ang Mo Kio park connector

A pilot greenway project on road reserve was undertaken to specifically test the guidelines established by the working group for greenways development on road reserve land. A short 1 km stretch linking Bishan Park to Ang Mo Kio Town Garden West was identified as a pilot project (Fig. 8). This stretch was selected because it was a comfortable length to work with, links

two parks and is close to public housing. Part of the greenway was also developed within public housing land owned and managed by the Housing and Development Board (HDB). Land ownership issues including maintenance, legal and enforcement aspects would inevitably surface, and solutions can be sought.

The pilot project was completed in August 2002 (Fig. 9). From the problems that surfaced, the working

group is currently focusing upon developing guidelines for safety measures such as physical barriers and information/warning signage for future greenways to be developed along road reserve land.

3.4. Case study on bicycle crossing

The concept for bicycle crossing along a greenway at a road junction was tested in a pilot project. This cyclist crossing was installed across Bishan road in 1996, when new traffic regulations came into effect concerning cyclists. In monitoring the usage pattern, it was observed that while the bicycle crossing was convenient for cyclists, neither the pedestrians nor cyclists necessarily used the crossings designated for them. A family group comprising joggers and cyclists are unlikely to split into two just to conform to the traffic rules. Moreover, as the Land Transport Authority requires a clearance of 3 m between bicycle and pedestrian crossings, it would require additional land uptake, a cardinal sin in greenway development in the city. The concept of bicycle crossings was dropped in favor of the simple installation of "Dismount and Push" signs as reminder for cyclists.

4. Discussion

4.1. Strategic planning

Greenway planning and implementation in Singapore share common ground with similar efforts in major cities in United States, Canada and United Kingdom. Plans for greenways are conceived only after much of land use planning for major infrastructure had been undertaken. In many cities, greenways initially planned for recreation, social interaction, and cultural and historical preservation have been adapted to accommodate additional uses such as natural habitat protection, flood protection and climate regulation. For example, greenway planning in Ankara, Turkey has moved from a greenbelt approach to an ecologically based planning approach (Arslan et al., 2001).

As an island-city-state with a burgeoning population, Singapore has to develop a unique strategy for greenway planning to secure land for development in the face of intense competition over land-use demands. There is no hinterland wherein to situate national infrastructure for industry, housing, military use, water catchment and storage, power plants and the like. Land for recreational use and amenity is pragmatically accorded 'nice-to-have' rather than 'need-to-have' priority. In order for the greenways concept to receive a hearing, political backing and clearance from land-use management and enforcement authorities must first be sought. For Singapore, a key strategy for obtaining land for greenways is the identifying and maximising of development potential of under-utilised and 'non-economic' land. Grassroots support from the public and their political leaders for the pilot projects is nurtured to lend voice to the need to increase flexibility in the land allocation process for greenway development. While public involvement in greenway planning and implementation is comparatively lower than for greenways established in US, UK and Canada (Quayle, 1995), the value of securing public 'buy-in' for each greenway projects cannot be underestimated. Feedback is sought and suggestions to enhance the developed greenway sections acted upon. To cut red tape, a working committee comprising key land management and enforcement agencies is formed at an early stage to tackle technical matters and enforcement issues. The clout to form such a committee under the chairmanship of the National Parks Board comes from the strong political will of the founding father of modern Singapore, Lee Kuan Yew, to grow a Garden City on the equator. A Garden City Action Committee comprising high-level participation from relevant government agencies oversee the progress of Garden City programmes and initiatives. The Singapore greenways system, named the park connector network, is one such initiative. The implementing arm of the Garden City Action Committee is the National Parks Board. Conceptual planning and design methodology are dictated by practicality. The routing of greenways has to be flexible and be readily modified because of land issues. Singapore's Greenway Concept is evolving, and gains are captured in the Concept Plans that update the Master Plan guiding the development of Singapore.

4.2. Implementation

A typical stretch of greenway traverses land under management by many different agencies. Consequently, the implementation schedule of greenways must be flexible to take into consideration develop-

ment programs of other agencies. The funding structure also has to be flexible to allow re-prioritization and re-scheduling of greenway projects. Networking with community leaders would therefore need to be effective in order to manage unrealistic expectations of the implementation schedule. To date, 22 stretches of greenways totalling 51.8 km have been developed in Singapore. This is 14.4% of the planned 360 km for the entire network. These completed greenways have been well received by the public, resulting in increasing requests from all levels of Singapore society for more greenways to be completed, so much so that the National Parks Board has had to accelerate its program. Significant constraints encountered include the following:

4.2.1. Securing land

The biggest hurdle is the acquisition of land. There are two ways whereby land may be secured for greenway projects in Singapore:

(a) Land is re-zoned as Parks & Gardens and allocated directly to the National Parks Board to carry out parks or park-related development
(b) Land is "borrowed" by the National Parks Board to develop greenways on land not owned by the Board.

In the latter case, the land status remains unchanged but National Parks Board funds the development and is responsible for the subsequent maintenance and management of the greenways. Both schemes may be required in the same development in order to achieve connectivity of sections of the greenway. Thus far, greenways have only been developed on "borrowed land". Negotiation with the relevant agencies is often long drawn out, taking two years for the Ang Mo Kio park connector project. A mindset change and a more collaborative approach is therefore necessary, with all relevant government agencies treating the park connector network as a national priority.

4.3. Improvement to greenways

Lessons drawn from the pilot projects are applied to improve designs, products and processes. Subsequent greenway developments using the revised design guidelines are enhanced with better landscaping, recreational amenities and park furniture such as exercise equipment, shelters, benches and lighting. Examples of new generation greenways are Tampines park connector (Fig. 10), Siglap park connector (Fig. 11), Bukit Panjang park connector (Fig. 12) and Ulu Pandan park connector (Fig. 13). These improved products have contributed greatly to the popularity of greenways, resulting in increasing demand for more sections to be developed at a faster rate.

4.4. Multifunctional greenway

Greenways are taking on multiple roles: as recreational venues, alternative transportation routes, nature corridors for flora and fauna and also as a useful educational resource (Briffett et al., 1999). Besides providing an increasingly popular and excellent recreational avenue for jogging and cycling in a city, greenways also serve to introduce city dwellers to nature by providing and improving accessibility to major parks and nature areas. Residents are discovering convenient shortcuts to key transportation nodes, town centres and educational institutions via greenways. This in turn generates a new challenge—to integrate greenways implemented by the National Parks Board with public spaces and transportation corridors under the purview of other land management agencies.

For nature lovers, greenways play a vital role as vegetated linkages that provide a protected path and cover for wildlife to move from one habitat to another, thereby increasing biodiversity throughout the island. Adjoining areas to each greenway can play a complementary role, and help to determine the function and character, creating identity. For instance, the marsh vegetation of the wetland environment along certain stretches of the Ulu Pandan park connector serves as refuge and habitat for migrating and resident bird and wildlife communities. This has developed into a linear nature area.

With the improved accessibility created by greenways, teachers and students are able to discover living classrooms for imparting nature awareness and appreciation. Foundation forging by educators to service the life sciences industry is particularly facilitated by the green trails that fringe a primary forest area, such as those around Bukit Timah Nature Reserve (Fig. 14).

Greenways don different attires depending on the types of environments, and the functions they serve:

they are rustic when in proximity to the nature conservation areas, catering to the more adventurous. In more urban environs, a simple asphalt cycling track along a landscaped road reserves presents a gateway to new recreational opportunities. When the bulk of the population is at work or in school, the senior citizens are discovering that greenways are very accessible for passive recreation, or for bringing pre-schoolers for some fresh air out of their domiciles. Community leaders are also noticing that increasingly, residents are adopting certain stretches of greenways as regular gathering places after work. These venues for social interaction are beginning to loom large in importance for developing communal bonds so critical in a multiracial society of today.

5. Conclusion

The Singapore experience in greenway planning and implementation can serve as a model for other rapidly urbanizing cities that recognize the various human and ecological benefits of urban greenways. Strategic planning targeting low-utilization space, forging strategic partnerships with community leaders, net-working with key land management and enforcement agencies, and securing the support of city planners are some of the initiatives that facilitate a successful outcome. Garnering of feedback for enhancing the greenways inform future greenways development. The application of lessons learned from the pilot projects allow the greenways concept to evolve.

Greenways, with their multifunctional capacity, have great potential in the areas of recreation, nature conservation, education and community bonding. The proximity of greenways to a wide variety of urban and natural environments and their inherent function to link them, present further opportunities for the diversification and improvement of the greenways network concept. Such potential should be developed further in partnership with community groups and stakeholders to meet the needs of today's multiracial societies. With the demand for and popularity of greenways in Singapore growing in tandem with the support by the relevant government bodies, the current challenges encountered in the implementation of the network program should see expedient resolution. Singapore looks forward to completing its network of greenways to connect people to places wherein to experience life's essential moments of rest, recreation and wellbeing.

Acknowledgements

Many officers of the agencies represented in the Garden City Action Committee have contributed time and effort to the work encapsulated in the article. The contributions of officers of the National Parks Board have formed the foundation for greenway development in Singapore. I would like to thank the team in charge of developing the park connector network, in particular, Shamril Jamil, G. Kannagi and Tan Siew Tin, for their able assistance in the preparation of this manuscript.

References

Ahern, J., 1995. Greenways as a planning strategy. Landscape Urban Plan. 33 (1–3), 131–155.

Arslan, M., Erdogan, E., Dilaver, Z., 2001. Greenways and the making of urban form: Ankara city. In: Asian Places in the New Millennium: Proceeedings of 38th Conference International Federation of Landscape Architects, Singapore.

Briffett C., Kong L., Yuen, B., Sodhi, N., 1999. Nature in urban areas: the planning and ecology of green corridor systems in Singapore, National University of Singapore.

Endicott, E., 1993. Land Conservation Through Public/Private Partnerships. Island Press, Washington, DC.

Fabos, J.G., 1995. Introduction and overview: the greenway movement, uses and potentials of greenways. Landscape Urban Plan. 33 (1–3), 1–13.

Fabos, J.G. 2001. Greenway Planning as part of Landscape Planning. In: Asian Places in the New Millennium: Proceedings of 38th Conference International Federation of Landscape Architects, Singapore, in press.

Forman, R.T.T., 1995. Land Mosaics: the Ecology of Landscapes and Regions. Cambridge University Press, Cambridge; New York.

Harnik, P. 2000. Inside City Parks. Urban Land Institute, Washington, DC.

Keung, J., 1998. Planning for sustainable urban development: the Singapore approach. In: Yuen, B. (Ed.), Planning Singapore: From Plan to Implementation. Singapore Institute of Planners, Singapore, pp. 11–16.

Leow, B.G. 2001. Census of Population 2000 Geographic Distribution and Travel, Singapore Department of Statistics.

Little, C.E., 1990. Greenways for America. The John Hopkins University Press, Baltimore and London.

Oi, K.H. 1990. Park Connectors. Planews, The Journal of the Singapore Institute of Planners, 13 December, MCI (P) No. 99/9/90.

Oi, K.H., 1998. Park Connectors. In: Yuen, B. (Ed.), Planning Singapore: From Plan to Implementation. Singapore Institute of Planners, Singapore, pp. 31–41.