Developing an Assessment Model for Selecting Sites of Ecological Communities in Rail Transit Corridor of Kaohsiung City

Kang-Li Wu* Hsing-Ping Kuo Hsing-Fu Kuo*****

ABSTRACT

With the trend of promoting ecological cities and transit-oriented development, developing ecological communities in rail corridors has become an important research issue in Taiwan. However, how should the sites of potential ecological communities be selected to better utilize rail transit investment remains an unanswered research issue required in-depth research investigation. This paper attempts to address this issue. Through an examination of the suggested indicators and the critical issues of selecting the sites of ecological communities in coordinated with rail transit planning, this study identifies the important indicators for selecting the sites of building ecological communities. By incorporating research methods involving field survey, GIS analysis, and AHP method, this study develop a framework and indicator system for such a purpose. Based on the results of the empirical study, this study also suggests a research approach which help to promote the development of ecological communities by utilizing GIS spatial analysis.

Keywords: Ecological communities, Transit-Oriented Development (TOD), Assessment Model, Site Selection, Geographic Information System (GIS)

1. INTRODUCTION

Promoting Transit Oriented Development (TOD), especially structured and compact urban development in and around rail transit corridors, has been considered as a solution to many urban problems such as automotive abuse and urban sprawl. TOD attempts to structure urban development (or redevelopment) in coordination with transit planning as well as to attract compatible mixed-uses and middle-to-high density land development in and around rail station areas. It is assumed that by integrating rail transit planning, urban design and land-use development patterns, and housing and community planning in and around rail transit corridors, TOD may create a livable and sustainable living environment which benefits both the transit system and associated local communities. The concept of TOD, to various degrees, is closely related to the concept of ecological communities. Therefore, promoting the concept of TOD provides a good opportunity for integrating these two related concepts. However, how should the suitable sites of ecological communities in rail serving corridors be identified in order to implement these two concepts remains a critical issue required in-depth research investigation. Using the selected districts in and around rail corridor of the Kaohsiung City of Taiwan, this study attempts to explicitly address this issue. An assessment model for evaluating and identifying suitable sites for ecological communities in and around major rail

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transit station areas were proposed in this study. By employing research methods involving field survey, Geographic Information System (GIS) spatial analysis, and the AHP methods, a evaluation framework and the key indicators of the assessment model for selecting potential Eco-community sites based on the concepts of TOD and ecological communities are suggested and tested in this study. Finally, GIS simulation was conducted in order to suggest the suitable sites for developing ecological communities for the decision-making of housing and community planning.

2. REVIEW OF LITERTURE AND THEORIES

2.1 Theories and Planning Consideration of Transit-Oriented Development

TOD attempts to create a compact urban development pattern together with the development transit corridors, and promote mixed land and housing development within a reasonable walking distance of transit stations (Cervero, 1998). The TOD mode attempts to promote the rail station areas to be the center of transportation services and local living functions, with a focus on the combination of public infrastructure planning and local land development (or redevelopment) (Calthorpe, 1993). It also intends to develop the station area into a cozy and livable place by controlling the density, diversity, and design of land development (Cervero and Kockelman, 1997). In practice, TOD could be implemented in various scales along with cooperative planning and design. On the local scale, it is advocated that business, residence, employment, as well as parks and public facilities be carefully planned and located in the station areas in accordance with the degree of relevance among these activities. Also, the abovementioned facilities and services should be available within a reasonable walking distance of a transit station, and there should be good quality of daily service functions in transit corridor (Barton, 2000). In order to support the operation of the transit system and the surrounding service facilities, adequate housing and community design is necessary which need to provide required services that match local living functions and the need of urban development. These include providing a comfortable and livable walking environment as well as a good quality neighborhood functions (Calthorpe, 1993; Barton, 2000; Southworth, 2003). The walking environment should be connected to the abovementioned service facilities and integrated with the street design. Moreover, In terms of ecological planning and design, open space design with ecological and landscape values should be retained, and the associated ecological green resources should be properly connected (Roseland, 1998).

2.2 The Concept and Elements of Ecological Community

The fundamental idea of ecological community is to integrate the following concepts in community planning and design, including sustainable development, ecological planning and design, environmental justice, public involvement, and community empowerment(Reseland, 1998, 2000; Barton, 2000; Wu, 2005, 2009). By such endeavors, the ecological community concept aims to establish a livable community which has sustainable ecology and daily conveniences, high security and properly allocated resources, equity and justice, as well as great efficiency in administration. According to related literature and practical experience, this research defines “an ecological community” as “a community that utilizes minimal global natural resources and emits the least amount of wastes. Such a community should also sufficiently utilize regional environmental resources and micro-climate characteristics to implement a natural approach of community planning and design. It should also encourage the public to engage in community administration so that the residents, their future generations, and the environment on this planet can be maintained and sustainably developed.

The concept of ecological community includes the meaning of ecology and of community. It also includes an important meaning of "succession," which applies not only in ecology aspect, but also in economic and social aspects. As noted by Roseland (2000), a sustainable (ecological) community is a community that uses its resources to meet current needs while ensuring that adequate resources are available for future generations. US environmental protection agency points out that the key idea is that the people involved in any "community" have a common interest in protecting an identifiable, shared environment and their quality of life (USEPA, 1999). In summary, an ecological community resembles a living system and community governing institution where human, natural, and economic elements are interdependent and draw strength from each other. In addition, rather than being a fixed community development pattern, an ecological community will continually adjust itself to meet the social and economic needs of its residents while at the same striving to preserve the ecological integrity of its supporting ecological system. This new approach of community design and governance provides an alternative of community development that is suggested by many researchers to be able to avoid many of the current planning problems, such as the destruction of natural capital, unmanaged urban sprawl, declining quality of life, loss of species, and increasing in social inequality.

Based on literature review and our interviews with planning experts, the key elements of ecological community can be summarized in Table 1 (see e.g., Van der Ryn and Calthrope, 1991; Calthorpe, 1993; Moughtin, 1996; Sustainable Seattle, 1998; Leitmann, 1999; Beatley, 1998; Roseland, 1998; Barton, 2000; ODPM, 2004; Wheeler, 2004; Wu, 2005, 2009).

Table 1. The key elements of ecological communities

Local development planning and local environmental improvement:
land development plans that encourage compact development in rail station areas; land use planning that encourages compatible mix-use; land use plans and measures that conserve environmentally sensitive areas; comprehensive community landscaping and community greening
Local transportation planning and management:
provision of convenient public transit service; manage the supply and demand of parking spaces in rail station areas to discourage car use; planning of pedestrian network and activities; supply of bicycle networks; livable street design
Community environmental management:
household waste recycling and waste reduction; supply of green infrastructure (e.g., green space; a sewerage system; green ecological corridors); recycled product purchasing; second stores
Energy efficiency:
green building; energy conservation and renewable energy use; land use adjustment to enhance energy saving; building layout and street block design to improve energy saving; employing natural cooling
Community socioeconomic Development:
housing development that attracts residents from diverse socio-economic backgrounds; economic development that encourages local employment; community self-help programs; improve community identity and livability to reduce vacancy rate
Organization/administration/governance:
community self-management and self-help; community citizen participation and education programs; community safety guard programs; community involvement of local governmental agencies; community partnership programs and various partnership networks.

3. RESEARCH DESIGN

To achieve the purposes of this paper, this research employs a case-study approach. The Kaohsiung city was selected as an empirical case. Previously a port-based industrial city, Kaohsiung city has now been transformed into a multi-functional metropolis. During the process of the adjustment of its urban form and industrial structure, the development of a

comprehensive rail transit system in Kaohsiung plays an important role in shaping urban structure as well as promoting housing and community development. Therefore, how to develop feasible a TOD planning model that is connected to ecological community development has become an important issue in urban development. Given this special opportunity, this paper intends to explore the possibility of promoting the concept of ecological community development in MRT corridors. Through such an exploration, research efforts were made to investigate how to develop a methodology for selecting the suitable sites of ecological communities in Kaohsiung MRT corridor. The major research methods employed are as follows:

Field Investigation: Field investigation was employed to analyze the environmental characteristics, local and regional resources, land-use patterns, demand of public facilities in communities, industries, and social-economic background of the research area. Apart from taking notes and map during on-spot observations, photography was also taken to record the environmental images and spatial characteristics of the research areas.

GIS Analysis: GIS mapping was used to show the spatial distribution of population, employment, and housing. It was also used to examine the spatial relationship of the key factors influencing the determination of location of ecological communities, such as land price, housing affordability, vacancy rate, and transportation accessibility. GIS overlaying and simulation techniques were used to study the influence of the key factors in selecting the sites of ecological communities in MRT corridors.

Questionnaire Survey and Interviews: Questionnaire survey was used to investigate the basic need of the ecological facilities and services of the ecological communities as well as the preference of individuals for living in ecological communities. The survey was one of the information collection method for exploring the desired location and facilities of the ecological communities in Kaohsiung. In addition, interviews with selected experts with related experiences were conducted to help develop the proposed assessment framework.

AHP Method: AHP method was used to explores the weight of the proposed evaluation dimensions and indicators. The AHP survey was given to the major decision-making group. AHP calculated the weight of the proposed evaluation indicators by pair-wise comparison. A modified snowball sampling method was used to selected the research subjects, and a total of 25 experts were surveyed to conduct the AHP survey.

4. RESEARCH RESULTS

In order to systematically address the proposed research question, this study employs the following procedure: (1) Conducting a field survey and field observations of the research areas; (2) Develop spatial database for conducting GIS analysis. (3) Conducting GIS mapping and overlay analysis to explore the environmental and housing characteristics of the study areas. (4) Conducting questionnaire survey and interviews with selected expects in order to determine the key dimensions and indicators of the proposed assessment framework for selecting the suitable sites of ecological communities. (5) Conducting AHP analysis to determine the weight of the assessment indicators and compare the relative importance of the indicators. (6) Conducting GIS spatial analysis based on the important indicators of each dimension of the assessment framework, and suggests suitable sites for developing ecological communities. The major results are summarized as follows:

4.1 GIS Spatial Mapping

Spatial mapping provide a good tool to examine the characteristics and changes of the study region under investigation. Parts of the results of GIS mapping are summarized and shown in the following figures.

Fig. 1 The MRT routes and stations in Kaohsiung City

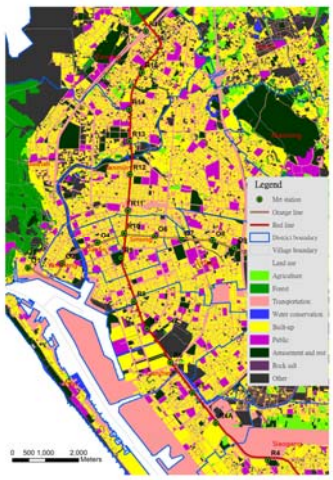

Fig. 2 The relationship between land use patterns & MRT routes

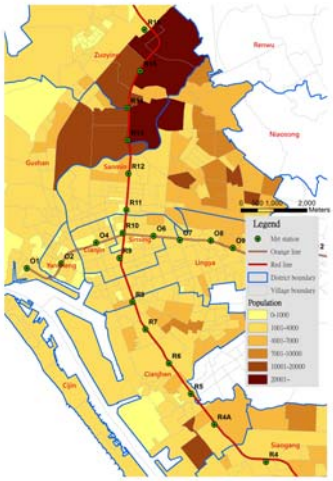

Fig. 3 The spatial distribution of population alone MRT corridor

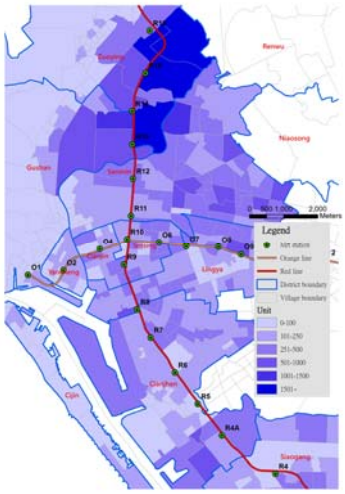

Fig. 4 The spatial distribution of employment alone MRT corridor

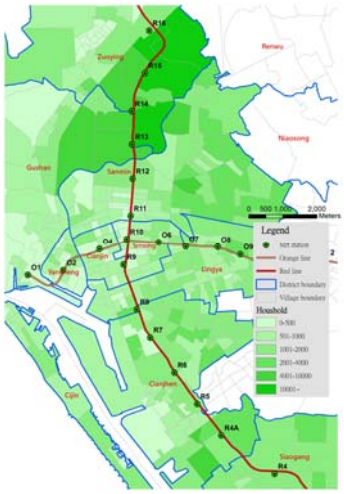

Fig. 5 Spatial distribution of households in neighborhoods

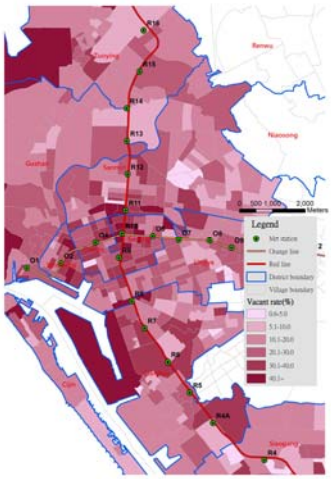

Fig. 6 Vacancy rate of neighborhoods

From Fig 1 to Fig 4, one can notes the relationship between urban development and the construction of Kaohsiung Mass Rapid Transit (MRT) system. It seems that the aggregation effects of the MRT station have not been fully realized in most station areas as suggested by traditional TOD theory (i.e., decreasing in development intensity as the distance from MRT station increase). Therefore, promoting higher density and compatible mixed-used land development in certain selected MRT station areas are necessary. Also, based on the results of spatial mapping, one can note that the MRT development of Kaohsiung is related to certain equity issues of urban planning. For example, as shown on Fig 5, households are concentrated in certain districts, while the vacancy rate in center districts are relatively low. Apart from above-mentioned GIS mapping, GIS overlaying and buffering analyses were also conducted to test the effects of the suggested indicators, and this will be discussed below.

4.2 Developing an Assessment Model for Selecting the Sites of Eco-Communities in Rail Transit Corridors

In order to systematically select suitable sites for building ecological communities in the rail transit corridors under study, developing a framework of the proposed assessment model is necessary. Based on the result of literature review and a survey of 15 planning experts, the following framework of the indicator system is proposed and tested in this study. The

framework includes five dimensions, and each has 5 to 6 indicators. The indicators were selected based on the results of literature review and interviews, local environmental characteristics, as well as the availability of data for analysis. The accessibility indicators are measured by using airline distance. The spatial unit of analysis is neighborhood which is the smallest spatial unit used in compiling demographic data in Taiwan. The land indicators were calculated on the block level land-use data obtained from governmental survey.

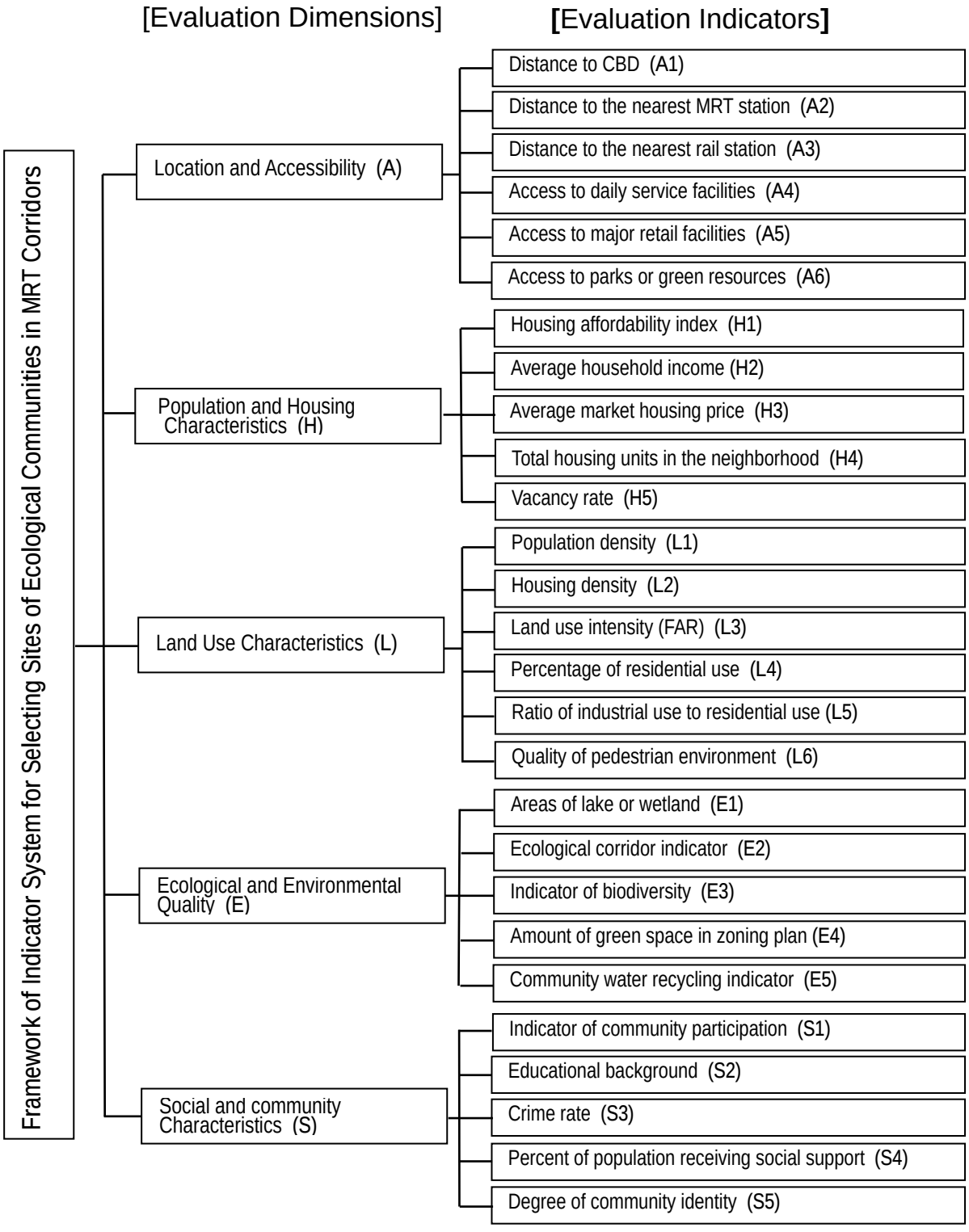

Fig. 7 The Proposed Framework of the Assessment model

4.3 Determining the Weights of the Indicators of the Assessment Model

After collecting and coding the survey data, the AHP method was conduct to explore the relative importance of evaluation dimensions and indicators. After calculating the matrix and conducting a consistency test (using CR＜0.1 as the criteria), the results are shown in Table 2 and Fig 8. In summary, the results revealed that while the five dimensions of the framework seem to be all are important, while a bit more on emphasis is place on location and accessibility, population and housing characteristics, and ecological and environmental quality. This result is consistent with TOD and eco-city theories. In particular, the indicators of relative higher weight are items such as: distance to the nearest MRT station, access to parks or green resources, market housing price, housing density, land use intensity, amount of green space in zoning plan, crime rate, and the degree of community identity. Again, this reminds us the importance of green space, MRT accessibility, land use density and diversity, community safety, and maintain special place characteristics with identity.

Table 2. Weights of the Evaluation Indicators

Evaluation Dimensions	Relative Weight	Evaluation Indicators	Relative Weight
Location and Accessibility (A)	0.235	Distance to CBD (A1)	0.143
		Distance to the nearest MRT station (A2)	0.203
		Distance to the nearest rail station (A3)	0.120
		Access to major daily service facilities (A4)	0.173
		Access to major retail facilities (A5)	0.166
		Access to parks or green resources (A6)	0.195
Population and Housing Characteristics (H)	0.213	Housing affordability index (H1)	0.185
		Average household income (H2)	0.211
		Average market housing price (H3)	0.223
		Total housing units of the neighborhood (H4)	0.174
		Vacancy rate (H5)	0.207
Land Use Characteristics (L)	0.183	Population density (L1)	0.155
		Housing density (L2)	0.175
		Land use intensity (FAR) (L3)	0.180
		Percentage of residential use (L4)	0.171
		Ratio of industrial use to residential use (L5)	0.162
		Quality of pedestrian environment (L6)	0.157
Ecological and Environmental Quality (E)	0.201	Areas of lake or wetland (E1)	0.204
		Ecological corridor indicator (E2)	0.212
		Indicator of biodiversity (E3)	0.182
		Amount of green space in zoning plan (E4)	0.224
		Community water recycling indicator (E5)	0.178
Social and Community Characteristics (S)	0.168	Indicator of community participation (S1)	0.188
		Educational background (S2)	0.205
		Crime rate (S3)	0.214
		Percent of population receiving social support (S4)	0.183
		Degree of community identity (S5)	0.210

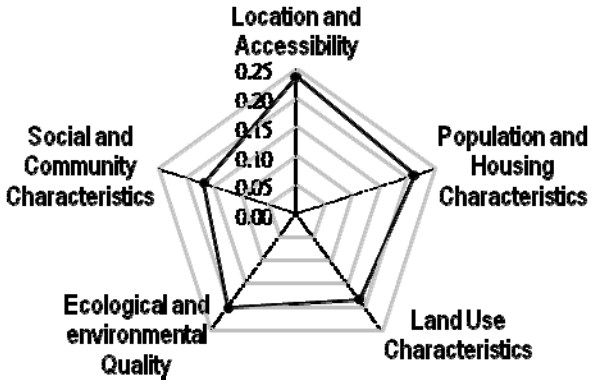

Fig. 8 Comparison of the Weights of Evaluation Dimensions of the Assessment Model

4.4 GIS Simulation of Selecting Sites of Eco-communities in Rail Transit Corridors

After determining the framework of the proposed assessment model and the relative importance of the indicators in the model, GIS analysis was conducted by using the important indicators in each dimension of the framework. The important indicators used in the GIS spatial analysis include: access to the nearest MRT station, access to parks and green resources, average household income, average market housing price, vacancy rate, housing density, land use intensity, percentage of residential use, areas of lakes or wetland, ecological corridor indicator, amount of green spaces in zoning plan, community educational background, community crime rate, and degree of community identity. After conducting GIS buffering and overlaying analyses, the suitable sites of building ecological communities are suggested as shown on Fig 9., and most of them are located in northern Kaohsiung alone MRT corridor. Further study can distinguish the types of ecological communities based on the evaluation scores of key indicators.

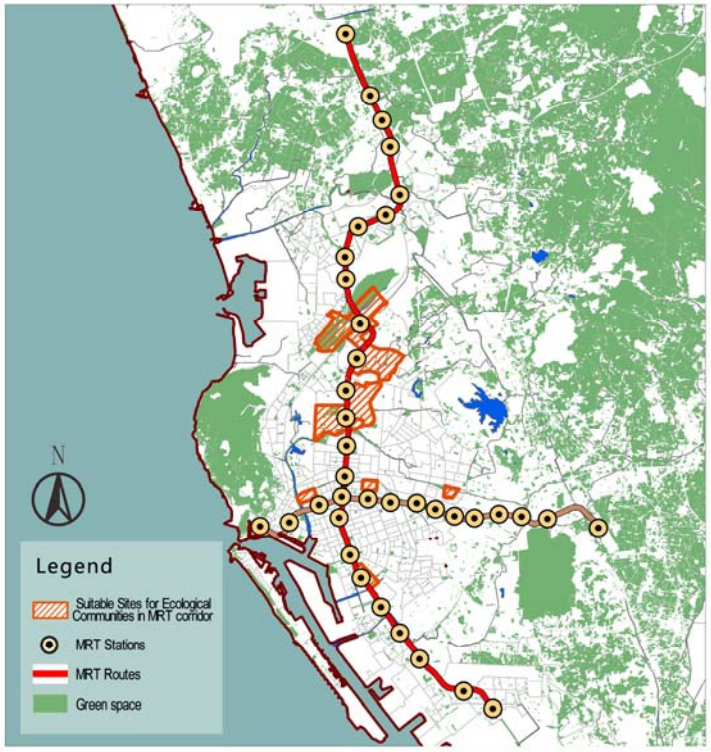

Fig. 9 GIS analysis of the suitable sites of building ecological community under the concept of TOD

5. CONCLUSION

This study proposes a research approach for developing an assessment model for selecting sites of ecological community in rail transit corridors. The concept of TOD and ecological communities were employed in order to develop a comprehensive evaluation framework and indicator system for the assessment model. Through empirical study of the Kaohsiung city, the result shows that the assessment model can serve as a guide for related policy making. The methodology can also be modified based on local environmental characteristics and local planning institutions in order to be applied to other places in China. By comparing the opinions of planning experts, this study discovers that these experts pay more attention to evaluation items such as the indicator of community greening, average housing price, land development density, and access to MRT system. This provides useful reference for government agencies in determining the priority of related urban policies. Also, in cooperative with the result of GIS mapping, this study provides useful information for home buyers in selecting suitable places to live if they appreciated a living environment of ecological communities and support the idea of transit oriented development. Finally, it is suggested that because of the limits on survey sample sizes and the limited number of evaluation items included in analysis, this study should serve as a pilot study. It is suggested that a more comprehensive and detailed study be conducted which considers different types of ecological community and the demand of home buyers, before any important policy decision been made. TOD and ecological communities cannot be developed over-night, developing a useful assessment model for building public consensus could be a good start.

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Acknowledgement: The authors thank the support of the project "The National 12th Five-Year Supporting Plan (Project No. 2013BAJ12B02)" from Harbin Institute of Technology.