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CHINA SUSTAINABLE CITIES
INTEGRATED APPROACH PILOT PROJECT

TECHNICAL SUMMARY SERIES

GUIYANG
SUMMARY REPORT

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GUIYANG

SUMMARY REPORT

GEF-6 CHINA SUSTAINABLE CITIES INTEGRATED APPROACH PILOT PROJECT

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Preface

The Sustainable Cities Integrated Approach Pilot was a worldwide program established by the multinational Global Environment Facility in its sixth funding round (GEF-6). As implemented in China, it was aimed at helping Chinese cities use the principles of transit-oriented development (TOD) to achieve sustainable land use policies and transit plans at the levels of city, transit corridor, and transit station. The five-year China project (GEF-6 China TOD) ran from December 2017 to March 2023. It was managed by the World Bank and implemented by China's Ministry of Housing and Urban-Rural Development (MoHURD) and seven representative large cities: Beijing, Tianjin, Shijiazhuang, Ningbo, Nanchang, Guiyang, and Shenzhen.

The Guiyang Municipal Transportation Bureau was in charge of the Guiyang GEF-6 Project Management Office. The planning and design of the project were undertaken by several institutes and consulting organizations.* This report summarizes and evaluates the technical outputs of the Guiyang GEF-6 China TOD Project.

* The city-level study was undertaken by Tsinghua University Institute of Transportation Research.
The corridor-level study was undertaken by China Academy of Urban Planning and Design.
The station-level study was undertaken by Hyder Consulting (Shanghai).
The environmental and social report was undertaken by Guizhou Water and Power Survey-Design Institute.


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Abstract

Guiyang, the hilly capital of Guizhou Province in southwest China, has limited available urban land and a relatively low road density. Its urban space exhibits characteristics of clustered development. The transit-oriented development (TOD) strategy for urban development aims to optimize the urban spatial structure with the strategic application of high-density land development along transit corridors, spreading out population, and reducing urban traffic congestion. The integration of regional transportation networks in this strategy is crucial for achieving the integrated development of Guiyang and Guian New Area.*

A hierarchical classification strategy based on indicators such as station functions and land use characteristics has been implemented at the city level, resulting in differentiated planning strategies for various transit stations. In the city center, emphasis has been placed on combining TOD planning with urban renewal, while in the suburbs, efforts have been made to enhance the capacity of rail transit services.

At the corridor level, the development of Metro Line 3 and the S1 Line supports the dispersal of population density in the old city and the structural adjustment of residential and industrial clusters along the corridor.

At the station level, spatial planning and design guidelines for typical TOD station development models have been implemented in areas such as the old city district, Wudang, and Guian. The strategy for the development of transit station surroundings is illustrated by Luowan Station.

During project implementation, the technical team of the Guiyang Municipal Government conducted TOD planning research at various scales, employing diverse TOD hierarchical classification methods. Planning guidelines supported the development goals of "low-carbon ecology" and "transit-oriented city," and the TOD strategies for Guiyang were refined to provide references for similar cities in China and other developing countries.

* Guian New Area is the eighth national-level new area in China, located at the junction of Guiyang City and Anshun City in Guizhou Province. The regional scope of TOD encompasses both Guiyang and Anshun. Guiyang and Guian share resources and complement each other in functions, jointly promoting the development of the metropolitan area.


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Part 1: TOD Strategy at the City Level

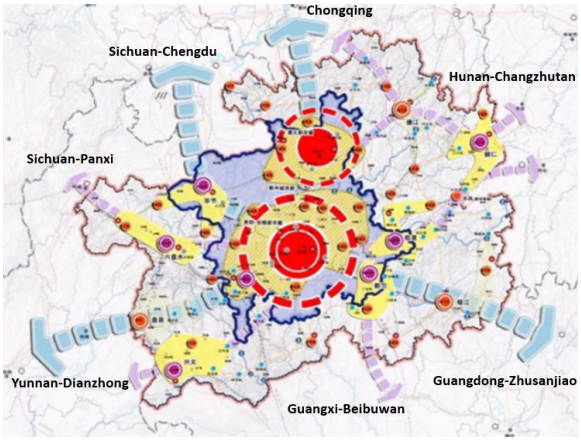
Guiyang City, the capital of Guizhou Province, is one of the central cities in China's southwest and the core area of the Qiannan Economic Zone. With its abundant natural and tourism resources, it is also China's first approved demonstration city for ecological development. Although it enjoys a favorable geographic location in the plateau basin region, its hilly terrain and surrounding mountains have resulted in limited available urban land, an uneven distribution of population, and a low-density road network.[1] The city's automobile traffic is concentrated on a few main roads and is severely congested.

Transit-oriented development (TOD) is the key strategy for Guiyang to address these limitations. By developing new transit configurations, TOD can help redistribute population densities, connect clusters, and thereby reduce urban traffic congestion and carbon emissions. In particular, it can advance intensive land development by connecting the old city area with the Guanshanhu district and multiple surrounding clusters. This TOD approach works with the city's "dual core, multiple clusters" structure (figure 1) and supports Guiyang's development concept of low-carbon sustainability.

The Guian New Area, a pole for economic growth designated in 2014, is located about 50 kilometers southwest of Guiyang. The construction of a multinetwork rail transit system is still in the early stages of development. There is ample room for the deep integration of urban land use and transportation systems.

1 The road network density in the built-up area of Guiyang City is about 6 kilometers per square kilometer, significantly lower than the standard of 8 kilometers per square kilometer specified in China's Urban Integrated Transportation System Planning Standard (GBT51328-2018).

Figure 1: Guiyang and Guanshanhu—Guiyang's Structure of "Dual Core, Multiple Clusters"



Source: Tsinghua University Institute of Transportation Research, *TOD Diagnosis Report of Guiyang City.*

1. Urban Overview

Guizhou Province and Guiyang City strongly support TOD. The provincial and municipal levels of government have proposed TOD as the means to achieve their objectives of "Transport Powerhouse" and "Strong Provincial Capital." The construction of public transport in Guiyang has rapidly progressed since 2005, when the Guiyang Municipal People's Government released *Opinions on Prioritizing Urban Public Transport Development in Guiyang City. In 2015, the city released Management Measures for Urban Rail Transit Construction in Guiyang City and Urban Rail Transit Network Planning of Guiyang City (Revised Edition)*, which gave important guidance for TOD construction in Guiyang.

As a hilly city ringed by mountains, Guiyang faces the development challenges of limited available land resources and high population density. Only 11 percent of the city's total land area is suitable for development. The central urban area of Guiyang has an average population density exceeding 30,000 people per square kilometer, roughly the same as the average of 32,000 people per square kilometer in Hong Kong Special Administrative Region (SAR). But some communities with severe geographical and transit constraints within the city, such as Huaguo Yuan, have densities as high as 100,000 people per square kilometer.

According to the city's overall planning scheme, Guiyang's goal of sustainability includes environmental, social, and economic factors. Resolving urban traffic congestion, improving quality of life, and boosting economic productivity while maximizing the protection of the mountainous terrain and natural ecological environment requires intensive land use through the TOD model.

The latest comprehensive plan of Guiyang alters the city's spatial form from a central radiating structure with the old city as the core to a large circular structure centered around the construction of the Guanshanhu "Ecological Green Heart." The rail transit system will need to overcome geographic difficulties to address this shift. For example, the old city area and the Guanshanhu district are separated by a height difference of approximately 200 meters, a significant engineering challenge for the construction of rail transit to connect the two areas.

Guizhou Province is implementing its "Strong Provincial Capital Action" plan, focusing on the integrated development of Guiyang and Guian New Area. Guian is a pole for economic growth designated in 2014 that is located about 50 kilometers southwest of Guiyang. This project is another example of the value of TOD for the integration of urban land use and transportation systems.

2. TOD Opportunities and Challenges

According to regional development plans, Guiyang is an important city for the "Belt and Road" initiative, the Yangtze River Economic Belt, and the new land-sea corridor in western China—strong indicators of the city's potential for economic growth. The city's population is expected to grow from 5 million to 8 million, or even 10 million, within two years, requiring breakthroughs in development strategies and further expansion of urban space.

As one of the first pilot provincial capital cities for the national "Transport Powerhouse" initiative, Guiyang is entering a strategic period for optimizing and adjusting its urban spatial structure. The city's existing built-up area covers 369 square kilometers and is expected to exceed 600 square kilometers by 2025. The "Strong Provincial Capital Action" policy of Guizhou Province has also brought unprecedented opportunities for the integrated development of Guiyang and Guian New Area.

To realize these opportunities, Guiyang must improve its economic competitiveness; its contribution to the national GDP ranks 52nd nationally, low compared with that of coastal provinces. And with its extremely high population density, it must increase its land use efficiency, which puts the spotlight on strategies for rail development.

The rail transit network only partially supports the distribution of the most densely populated areas. High-density areas still require stronger support from rail transit construction. To achieve internal and external connectivity, future development must combine urban renewal with spatial displacement—the rail network must extend to the city's outskirts to alleviate high-density populations. Here are further details on rail connectivity issues in Guiyang.

Insufficient Rail Support for New Area Developments

Rail transit construction in rapidly expanding new areas still needs to improve and catch up. More rail lines are needed in Qingzhen, Guian New Area, and Huaxi. Guian New Area's connections with the old city, Guanshanhu, and Huaxi are limited, as well as the connections between the northern industrial belt and the central urban area. Rail transit construction needs to be synchronized with growth. Further development in Guian and other expanding areas that lacks matching rail transit and supporting infrastructure will only worsen peak-hour traffic congestion.

Insufficient Integration of Rail Transit Stations with Major Hubs and Surroundings

The major railway hubs, such as Guiyang Station and Guiyang North Station, should be connected efficiently and conveniently with urban rail transit. The combination of passenger flow hubs and rail transit should be closer, and large residential areas lack coverage from rail transit stations. Many stations on Line 1 have a limited number of entrances and exits—eight stations have only two entrances and exits. The planning and site selection stages should have considered the layout of rail lines. Adding rail lines or stations is challenging due to the difficulty in providing large-capacity public transportation corridors.

Poor Connectivity among Urban Clusters

Guiyang's hilly topography has caused it to develop in a clustered manner. The establishment of fast rail transit connections between clusters will help them adapt to future metropolitan area development and will help support future shifts of population and employment.

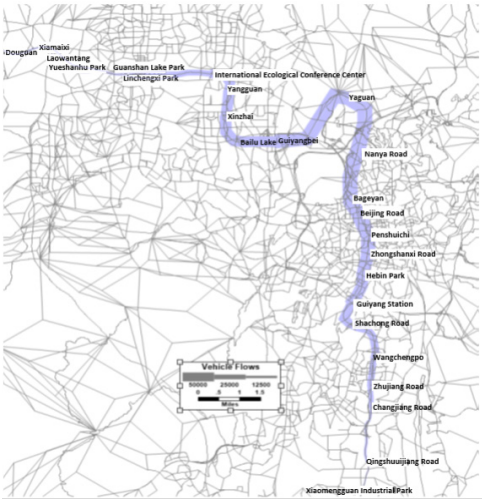
High Imbalance of Passenger Distribution among Line 1 Stations

A daily total of 142,000 people take 600 one-way trips between the 25 stations of Line 1. One-way trips between only three station pairs (Guiyang North Station–Guiyang Station, Guiyang North Station–Zhongshan West, and Guotai–Zhongshan West) account for about 9 percent of total passenger volume. The top 15 one-way trips by passenger volume account for about 30 percent of total volume, and the top 37 one-way trips account for 50 percent. To improve both the volume and distribution of rail station traffic, the city must improve TOD around rail transit stations and increase the coverage of feeder bus services for low-demand stations (figure 2).

Imbalance between Residential and Employment Spaces in the City

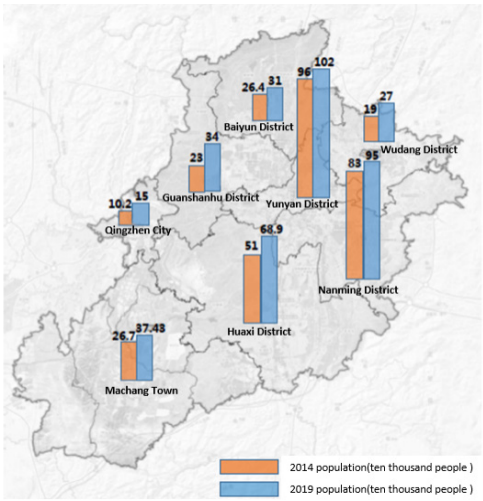
An imbalance exists between residential and employment populations along Line 1 (figure 3). Distinct TOD models at different levels and categories—based on the city's functions, hub characteristics, and surrounding supply and demand—should be developed to enhance the level of integrated development around station areas. By creating industrial corridors, commercial corridors, and comprehensive TOD corridors, the integration of urban functions can be balanced across residential and employment areas, service facilities, and amenities.

Figure 2: Passenger Volume of Guiyang's Rail Transit Line 1



Source: Tsinghua University Institute of Transportation Research, *Main TOD Strategy Report.*

Figure 3: Population and Travel Volume between Various Districts in Guiyang



Source: Tsinghua University Institute of Transportation Research, *Main TOD Strategy Report.*

3. Development Strategy

TOD in Guiyang aims to promote the formation of an optimal urban structure (urban ecology) that facilitates high-quality integrated development between Guiyang and Guian, a green transportation network, a reasonable industrial layout to improve industrial vitality, and an attractive living environment. Attaining these goals will contribute to the construction of a strong provincial capital.

TOD Goals

- Use rail transit to expand the city's framework, overcome spatial limitations in urban development, and form a polycentric urban structure, thereby promoting the creation of the "Greater Guiyang" metropolitan area.
- Enhance the level of public service facilities, including educational and medical resources, along transit routes, strengthening Guiyang's position as a city providing premier urban services. The enhancement of services promotes high-quality integration between Guiyang and Guian.
- Promote urban industrial development. TOD will support digitalization, tourism, wellness, and high-end manufacturing industries to strengthen Guiyang's industrial position. The big data and artificial intelligence industries in Guiyang, free of spatial constraints, will support the development of Greater Guiyang.

Big Data Information Management

A big data information management platform can be invaluable in supporting TOD. Like the six other pilot cities participating in the GEF-6 China TOD project, Guiyang has developed such a facility in coordination with the project's national TOD platform (see *The National Platform for TOD Information Management: Technical Summary Report*). The deep big-data expertise available in Guiyang helped the city's platform earn a nomination for the 12th Qian Xuesen Urban Science Gold Award in 2022.

TOD information platforms are websites containing applications that can apply big data from the monitoring of transit and urban development activity to support real-time evaluation, quantitative analysis, and scientific decision-making regarding local TOD plans. Pilot project cities, including Guiyang, can also obtain a wealth information maintained by the national platform and, through the national platform, access and learn from data on the status of TOD in the other pilot cities.

4. Rail Planning Scheme

The TOD planning research outcomes at the city level are reflected in the city's outer Guiyang City Ring Rail Transit and internal rail transit. The outer ring mainly serves as an integrated transportation hub to facilitate efficient transportation transfers between the main urban area and suburban town clusters and to promote the aggregation of surrounding industries.

Internally, the passages between city clusters have a belt-like characteristic. An important objective of the city's internal rail transit development is to bridge the fragmented city clusters to allow them to access urban resource advantages and create greater access to Guiyang's abundant tourism resources.

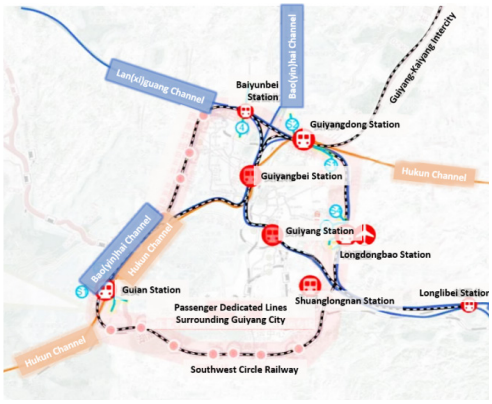
External Rail Transit Planning

The Guiyang City Ring Rail Transit, also known as commuter rail or suburban rail, belongs to the category of urban rail transit and serves as an intermediate mode of transportation between national railways and urban rail transit. The core task of the City Ring Rail Transit, which opened in March 2022, is to strengthen the connection between the old city and peripheral clusters by facilitating transfers. With the support of the "strengthening the provincial capital" policy, the opening of the City Ring Rail Transit will accelerate the integration of Guiyang's and Guian's development, better serving the development of urban clusters and city clusters.

Achieving Internal and External Connections

According to the *In-depth Study of the Bus Operation Plan for Guiyang City Ring Rail Transit*, prepared by the Guiyang municipal government, the future major passenger stations on the ring rail system will be Guiyangbei, Guian, and Shuanglong. At the same time, Guiyang and Guiyangdong will serve as auxiliary passenger stations. The planning of Guiyang's urban rail transit network will include a total of 14 internal transit hub stations along the ring rail system, with Guian Station, Longdongbao Station, Baiyunbei Station, and Guiyangdong Station serving as external transit hubs for transfers between internal and external transportation. The other 10 stations will facilitate transfers within the urban rail transit network (figure 4).

Figure 4: External Transfer Connections of the City Ring Rail Transit



Source: Tsinghua University Institute of Transportation Research, *Classification, Grading, and Functional Positioning of City Ring Rail Transit Stations.*

Achieving a One-Hour Commuting Circle

Achieving one-hour commuting circles—residential areas within a one-hour commuting range of a central city—is part of the national strategy to foster the growth of modern urban clusters. The Guiyang urban rapid transit ring line will enable the realization of a one-hour commuting circle within the Guiyang-Guian metropolitan area, leading to the development of suburban new towns and the expansion of Guiyang's urban cluster, thus facilitating long-term population attraction.

Achieving a One-Hour Economic Circle

A one-hour economic circle—an economic zone within a one-hour commuting range of a central city—will promote industrial clustering. The Guiyang urban rapid rail network is an important transportation carrier for the integration and development of a one-hour economic circle for the Guiyang-Guian area. It will facilitate the development of dominant industries and the clustering of related industries, thereby promoting economic growth.

5. Station Classification Scheme

Classification of rail stations in Guiyang according to "level" (their geographic scope of service) and "category" (the development goals of their surrounding area) is the fundamental basis for TOD station planning. In particular, the assignment of level and category is based on the station's geographical location, service scope, functional requirements, and accessibility.

Four Levels, Six Categories

The classification by geographic scope consists of four levels:

1. City: the comprehensive hub serving as the city's external transportation
2. Cluster: serving clustered areas of Guiyang's urban layout
3. Zone: related to the area's functional zoning
4. Neighborhood: the immediate area

Six TOD categories designating the type of development planned for a station area, based on the dominant functions of the area and the guidelines published by the Chinese Society of Urban Studies, are as follows:

1. Commercial
2. Industrial
3. Life Service (residential-related)
4. Transportation
5. Scenic-Leisure
6. Comprehensive (a multiuse combination of the above five types, with at least two being dominant)

Case Study: Station Classification in Huaxi District

Four stations in the Huaxi District of Guiyang can serve as an example of how the classification into levels and categories is applied in practice. Each of the four stations represents one of the four classification levels and one of the six TOD classification categories. First, here is some background on economic activity in the Huaxi District.

The commercial and service industries in the district are currently mainly located in the central city and the Shibian and Mengguan clusters. The dominant service sectors are wholesale and retail trade, and those sectors will see expansion with the formation of a logistics port in the district.

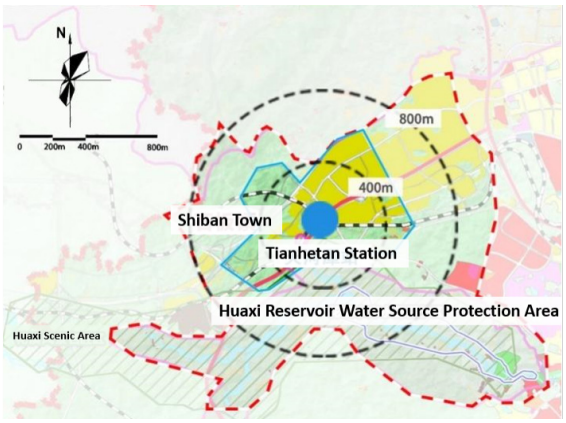
The proportion of firms related to big data, the internet, and other advanced technical activities is significantly lower in Guiyang than other cities. Guizhou University, the only "211 Project" university in the province, has so far failed to take full advantage of the government support offered to it.[2] Although Guiyang has been approved as a national demonstration zone for comprehensive tourism, and it benefits from tourist flow, it needs to further develop its tourism advantages and promote itself.

Tianhetan Station: City Level, Scenic-Area Leisure TOD

The planned area within the Tianhetan Station (S1 Line) covers approximately 150 hectares, with nonconstruction land covering about 64 hectares, or about 43 percent of the planned areas (figure 5). Through the transformation of old villages, the aim is to create a cultural-and-tourism town that is marketed along with the Tianhetan Scenic Area, build distinctive corridors, and establish convenient connections between the cultural-and-tourism town and secondary transportation such as buses and shuttles.

2 The "211 Project" universities are schools that have been designated by the Ministry of Education for significant support. They receive substantial government investment to enhance faculty strength, research capabilities, educational quality, and academic reputation.

Figure 5: Zoning around Tianhetan Station (S1 Line)

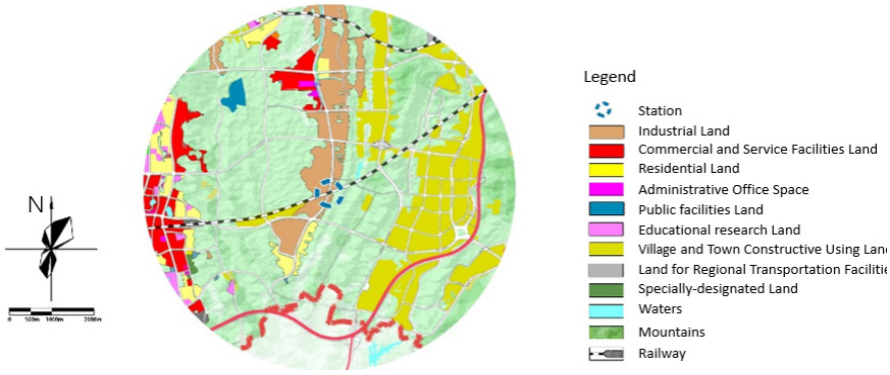


Note: The blue border shows the core area, and the red border encloses the influence area.
Source: Tsinghua University Institute of Transportation Research, *2-4 Guiyang TOD Classification and Drawing.*

Mengguan Station: Cluster Level, Industrial TOD

Although Mengguan Station itself is in a low-density area in which most of the developed land consists of old houses (such as Hongxing Village and Heluzhai) and commercial enterprises (small restaurants and shops), the Mengguan cluster is one of the main locations of the district's wholesale and retail service firms and will be a prime beneficiary of the logistics port (figure 6).

Figure 6: Land Use Plan for Mengguan Station

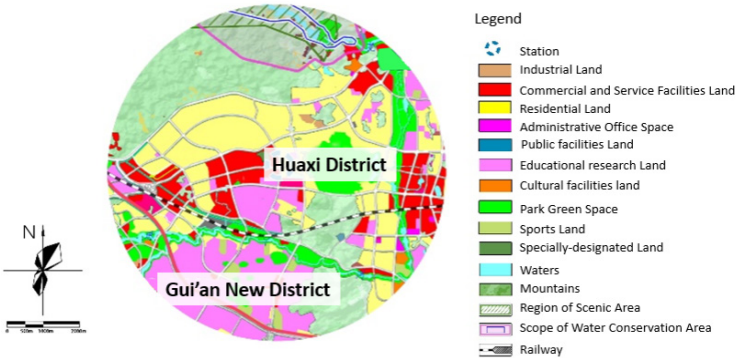


Source: Tsinghua University Institute of Transportation Research, *2-4 Guiyang TOD Classification and Drawing.*

Huaxi Tongshi World Station: Zone Level, Comprehensive TOD

Located on the S4 Line, the land within 800 meters of the Huaxi Tongshi World Station is planned for commercial and residential uses, cultural facilities, and green space (figure 7). The station area mainly contains modern service firms and advanced manufacturing industrial parks. Additionally, it can leverage the Tongshi World Park project to create a new cultural and tourism landmark in Guiyang and promote the development of important cultural and tourism stations.

Figure 7: Land Use Plan for Huaxi Tongshi World Station

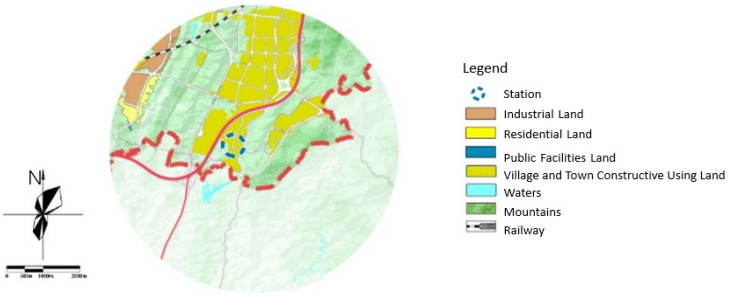


Source: Tsinghua University Institute of Transportation Research, *2-4 Guiyang TOD Classification and Drawing.*

Xiaguzhong Station: Neighborhood Level, Life Service TOD

The Xiaguzhong Station (S4 Line) primarily serves residential functions and is equipped with relevant service facilities. Land within 800 meters of the station is planned for commercial, residential, and cultural uses and green space (figure 8). TOD here should focus on improving the transportation connection system within the station area, addressing the "last kilometer" transportation gap, and better serving the travel needs of residents in the station area.

Figure 8: Land Use Plan for Xiaguzhong Station



Source: Tsinghua University Institute of Transportation Research, *2-4 Guiyang TOD Classification and Drawing.*

6. Summary of City TOD Strategy

The construction of the circular high-speed rail system has implemented external and internal aspects of Guiyang's city TOD strategies. Externally, the rail system contributes to the integrated development of Guiyang and Guian. It creates a one-hour commuting circle and one-hour economic circle for the two areas and achieves the long-term strategic goal of population attraction.

Internally, by fully utilizing Guiyang's mountainous characteristics and connecting urban clusters through rail transit, it embodies Guiyang's development philosophy of "low-carbon, ecological, and sustainable" by reducing carbon emissions and promoting the intensive development of urban land.

The circular high-speed rail system will significantly enhance Guiyang's economic position. The city's attractiveness to the population will increase, and the rail line will help further the sustainable development of urban clusters and metropolitan areas. Additionally, the TOD within the city addresses Guiyang's mountainous features, connecting urban clusters through rail transit and tapping into the city's unique characteristics, thereby enhancing Guiyang's urban vitality.

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Part 2: TOD Strategy at the Corridor Level

The existing rail transit lines 1 and 2 in Guiyang form a northwest-southeast corridor. This section examines the new corridor composed of the planned rail transit lines 3 and S1, which will intersect the existing lines. The technical team analyzed the current and potential land uses of the new configuration and formulated design schemes for integrated land development and transportation for phase 1 of each of the two new lines.

Phase 1 of the S1 line will promote the integrated development of Guiyang and Guian, helping to shift the population and urban functions from the central city to the new area. Phase 1 of Line 3 can alleviate the areas of high population density and unclog existing transportation routes.

1. Objectives and Analysis

The mountainous terrain and uneven population density distribution in Guiyang indicates that expansion of the rail network should be oriented to the relocation of the population from the old city and the expansion of urban space to accommodate it. In doing so, the attractiveness of rail and other modes of nonmotorized transit can be improved, and urban development along the corridor can be directed toward intensive, mixed land use.

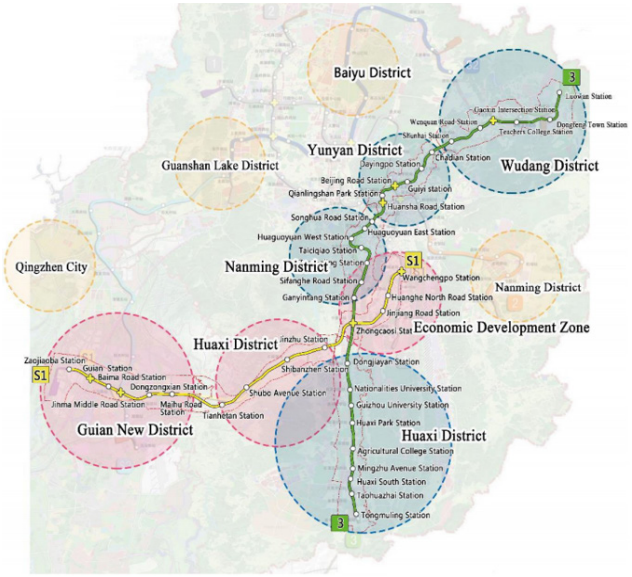
Basic Situation and Planning Scope

Phase 1 of rail transit Line 3 is about 43 kilometers long. It links several core areas that have high passenger flow; and it joins together the north and south of Guiyang, connecting the Wudang District, Old City District, Economic Development Zone, and Huaxi District.

Phase 1 of the S1 line is about 30 kilometers long, with about 22 kilometers of it underground. It links the east and west of Guiyang, connecting the Guian New Area, Huaxi District, and Economic Development Zone.

The technical team's research and planning scope for each station in phase 1 of Line 3 and S1 covers the area that forms a band that extends up to 800 meters from the station (figure 9). (Hereafter, references to Line 3 and S1 are for phase 1 of each line.)

Figure 9: Routes of Line 3 and S1 Line

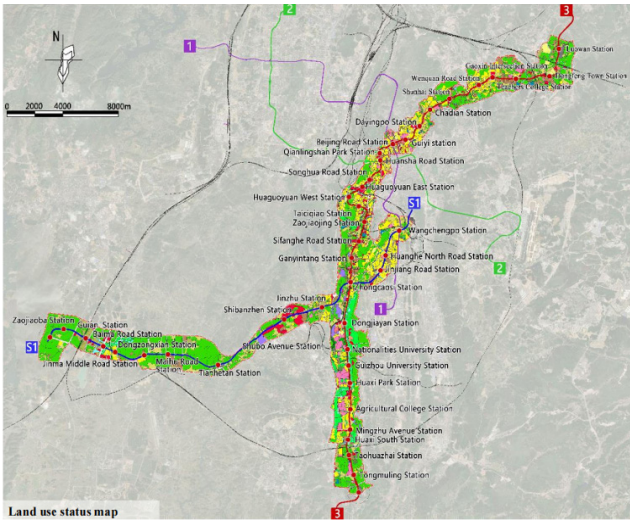


Source: China Academy of Urban Planning and Design, *Research on Comprehensive Development Planning of TOD in Guiyang Rail Transit S1 Line Phase 1 and Line 3 Phase 1 Areas.*

Current Land Use

The current land use along the two corridors mainly consists of urban, agricultural, and forestry land. Urban land is concentrated between the Huaxi South Station and Dongfeng Town Station on Line 3 and between Wangchengpo Station and Shiban Town Station on S1. At both ends of Line 3 and west of the Shiban Town Station of the S1 line, most of the land is for agriculture or forestry or is undeveloped construction land. The Guian New Area has a small amount of residential and industrial development (figure 10).

Figure 10: Current Land Use, Line 3 and S1 Line



Source: China Academy of Urban Planning and Design, *Research on Comprehensive Development Planning of TOD in Guiyang Rail Transit S1 Line Phase 1 and Line 3 Phase 1 Areas.*

Potential Land Use

Four unique categories have been selected to describe the most suitable use for an area of land:

1. Can be quickly developed
2. Suitable for transformation
3. Challenging to transform
4. Recommended for preservation.

Designating a potential use involves a five-stage process:

1. Preliminary identification of potential land based on current conditions such as land use, land leasing, feasibility of demolition and relocation, and transformation and relocation intentions
2. Excluding land designated for planned roads, forest land, and green space
3. Excluding land with "nonoperational" uses, such as for municipal facilities, public supporting services, and other noncommercial uses
4. Excluding land that is far from the rail stations, small in scale, or of low value
5. Identifying areas close to the stations that can be quickly developed to achieve higher value

Development Intensity Analysis

Under the premise of staying within the total development and construction quantity of operational land in the area, the floor-area ratio (FAR, the ratio of total building floor area to lot size)

within 500 meters of rail transit stations can be increased on the basis of existing planning and management technical regulations. Furthermore, the FAR should be moderately increased for residential land outside the urban renewal areas but within 500 meters of rail transit stations. The development capacity of land parcels for urban renewal can thus be increased by allowing for an increase in the FAR of rail transit station areas.

2. Planning Strategies

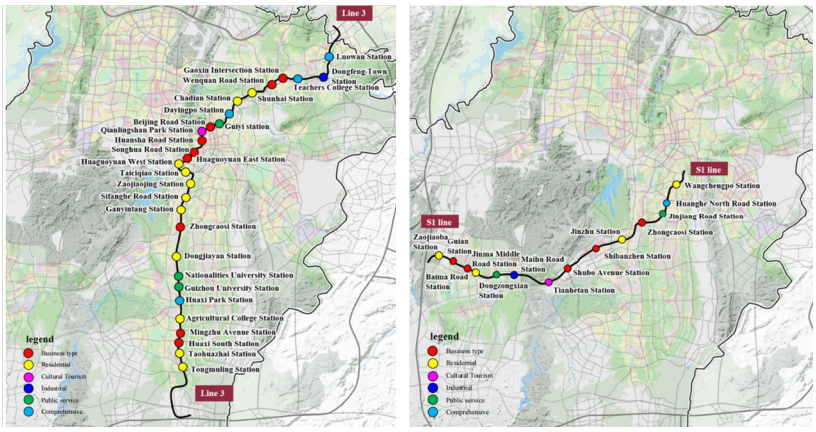
Recalling the four levels of geographic scope by which to classify station areas (city, cluster, zone, and neighborhood), about half the 29 stations of Line 3 are designated as neighborhood/community, and the rest of the stations are roughly evenly divided across the other three levels.

Of the 16 stations of the S1 line, two are zone level stations, and the rest roughly evenly distributed across the other three levels.

Recalling the five TOD categories (plus "comprehensive") for classifying stations, the Line 3 and S1 stations are further categorized into those functional areas (figure 11).

Figure 11: Classification of Stations, Line 3 and S1 Line

a. Line 3 b. S1 Line



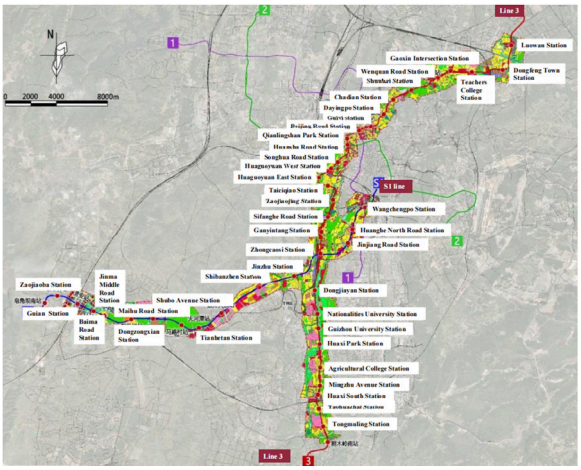
Source: China Academy of Urban Planning and Design, *Research on Comprehensive Development Planning of TOD in Guiyang Rail Transit S1 Line Phase 1 and Line 3 Phase 1 Areas, pp.*

TOD along the Rail Lines

Given the stations' TOD categories, the same categories are adapted for designating land uses along the Line 3 and S1 corridors, as follows (figure 12).

- Residential Area: Residential and public service-oriented areas
- Comprehensive Area: Exploiting regional resource characteristics, stimulating industrial vitality, and creating comprehensive development areas integrating commerce, culture, and life service areas
- Commercial and Scenic-Leisure Area: Building the core area of the new district's commercial and business office area, combining leisure, entertainment, dining, shopping, hotels, and residential functions to form the future central business and leisure zone of Huaxi District, which is the core area of economic development
- Special Industrial Area: The Tianhetan-Shiban area is based on big data and pharmaceutical industries. At the same time, in combination with the basic functions of commercial and scenic-leisure areas, it forms the Huaxi Big Data and Healthy Life Industry Zone

Figure 12: Land Use Planning along Line 3 and S1 Line



Source: China Academy of Urban Planning and Design, *Research on Comprehensive Development Planning of TOD in Guiyang Rail Transit S1 Line Phase 1 and Line 3 Phase 1 Areas.*

Classification based on Bus Connectivity

Besides four geographic levels and five (plus "comprehensive") TOD categories, the rail transit stations are classified into five categories based on transportation attributes. The categories, attributes, and number of Line 3 and S1 stations in each category, are as follows (figure 13).

Regional and Comprehensive Transportation Hub Stations

Adjacent to large-scale regional transportation hubs (such as airports, high-speed railway stations, and bus stations), serving as the start and end points and transfer stations for conventional buses.

Line 3—one; S1—one.

Urban Transportation Hub Stations

Located in the central city area with high passenger flows and commercial density, serving as hub stations for conventional buses and providing convenient access to the surrounding business areas.

Line 3—five; S1—five.

General Rail Transit

In areas without intensive passenger flows—

- Transfer stations: Located in commercially dense areas, serving as hub and midway stations for conventional buses. Line 3—five; S1—five.
- Intermediate stations: Located outside commercially dense areas, serving as midway stations for conventional buses. Line 3—14; S1—three.

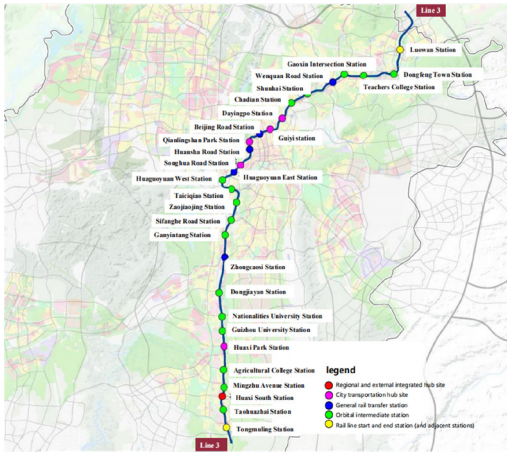
Rail Transit Terminus and Adjacent Stations

Serve as start, end, and midway stations for conventional buses.

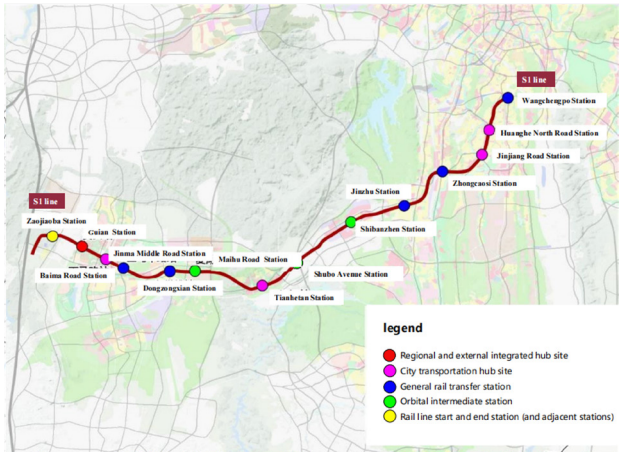
Line 3—four; S1—two.

Figure 13: Classification of Stations by Bus Connectivity

a. Line 3



b. S1 Line



Source: China Academy of Urban Planning and Design, *Phase 1 Results: Comprehensive Development Planning of Land and Integrated Transportation along the TOD Corridor (Chinese Version).*

3. Summary of Corridor TOD Strategy

At the corridor level, TOD in Guiyang focuses on population dispersal given the city's uneven distribution of population density. From a transportation perspective, TOD along the corridors can replace a significant proportion of private car travel, thereby dispersing the population in high-density areas, alleviating traffic congestion, reducing carbon emissions, and promoting sustainable urban development.

From a land use perspective, by improving land use according to the positioning of the corridor stations, TOD along the corridors can alleviate traffic congestion and reduce unnecessary travel distances for residents, thereby also helping to disperse population and promote sustainable urban development.

As the city develops and grows, land use along the corridors along with supportive transportation resources will likewise need to change according to residents' needs.

Part 3: TOD Strategy at the Station Level

At the station level, TOD can alleviate urban traffic congestion—the main obstacle to low-carbon transportation—and support intensive land development. The mountainous terrain of Guiyang puts significant constraints on the construction and use of roads and increases travel distances. With the population, job opportunities, and urban public services still concentrated in the old city area, the rapid growth of motor vehicles and insufficient road resources have created a bottleneck in the old city for fast cross-region travel.

Intensive land development can optimize spatial layout around stations. In turn, by bringing residences and workplaces in closer alignment, it reduces residents' travel distances, improves internal transportation efficiency within clusters, and decreases traffic carbon emissions.

Land use and the transportation system interact and mutually restrict each other: On the one hand, land use directly determines a region's transportation demand and population distribution; on the other hand, the development of the transportation system also affects residents' travel patterns. Low-carbon development aims to have 50-80 percent of the urban population living within TOD areas. Therefore, developing high-intensity land use in coordination with a well-planned transportation system based on public transit is the foundation for low-carbon development.

1. Carbon Reduction Strategies

Transit-oriented development of land use and public transportation use a variety of strategies to reduce carbon emissions.

Carbon Reduction Based on Land Use

TOD land-use strategies for stations can be applied to their geographic relationship (spatial structure), to the colocation of diverse uses around them (complementary land use), and to mixing different time-of-day uses (complementary time use).

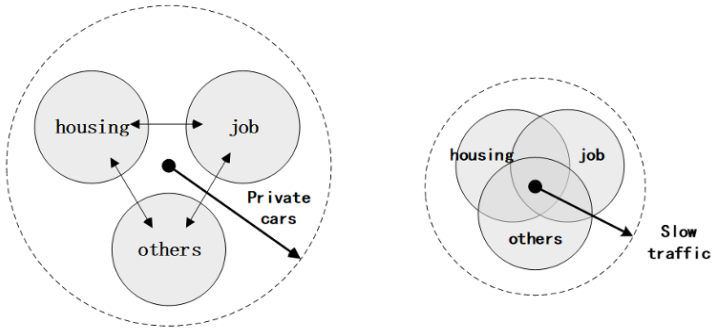
Spatial Structure

Domestic and international experience shows that achieving a "string of pearls" pattern of land development along rail or bus lines is an ideal model for the positive interaction between land use and public transportation. A string of pearls refers to the result achieved by a graduated intensity of land development between stations: high intensity near a station that gradually transitions to medium intensity farther away and then rises again to a peak level close to the next station. Specifically, intensity is designated to be highest in the TOD core area of 0–500 meters away from the station, gradually deceasing in the area that is 500–800 meters away.

Complementary Land Use

High-intensity development areas should contain a mixture of complementary functions. This pattern shortens travel between residences, jobs, shopping, and leisure, allowing residents to fulfill more of their travel needs through cycling, walking, and other low-carbon modes (figure 14).

Figure 14: Illustration of Mixed-Use Land



Source: China Academy of Urban Planning and Design, *Research on Comprehensive Development Planning of TOD in Guiyang Rail Transit S1 Line Phase 1 and Line 3 Phase 1 Areas.*

Complementary Time Use

The benefits of designing mixed-use areas can also be understood in terms of the complementary time use strategy. Different can also vary in their times of use. Exploiting that fact—interweaving functions that have peak uses that differ by time of day—can maintain a minimum level of activity and vitality both day and night.

Carbon Reduction Based on Block Scale

Numerous studies have shown that implementing small blocks and thereby increasing the density of road networks improves accessibility and increases travel by low-carbon modes such as walking and cycling. A comparison of the block scales and road densities of six low-carbon cities in China shows that the block scales are no larger than 500 meters, which is within a 5-minute walking distance at an average walking speed (table 1). Cao Fei Dian Eco-City and Shenzhen International Low-Carbon City have higher road densities, better meeting the demand for walkable transportation. During planning, it is recommended to set the block scale at a maximum of 300 meters and the road network density above 8 km/km2 for TOD areas. Additionally, a higher proportion of local streets should be included in the road network structure to encourage walking and cycling by the public.

Table 1: Comparison of Block Scale and Road Density in Low-Carbon Cities

Indicator	Tianjin Sino-Singapore Eco-City	Cao Fei Dian Eco-City	Wuxi Taihu New Town	Shenzhen International Low-Carbon City	Guangzhou Haizhu Eco-City	Guangzhou Sino-Singapore Knowledge City
Block scale (meters)	200-300	220	150-500	150-250	150-250	300-500
Road network density (km/km2)	6.5	8.1	5.1	9.1	7.0	3.7

Source: Hyder Consulting (Shanghai), *2-6 Guiyang TOD Low-Carbon Development Special Report*.

Carbon Reduction Based on Transportation

Efficient rail transit, especially when complemented by a bus network, serves as the main framework for urban development. A rail network plan should accommodate different land-use functions to achieve balanced land development, reduce transfer times, and improve travel efficiency.

Strategies to Implement Supportive Rail Transit

- Improve the service level of the public transportation system and enhance its competitiveness in medium and long-distance travel.
- Increase transit coverage and frequency.
  Accelerate the construction of the public transit systems.
- Provide diversified services for different passenger needs, such as customized buses, bus rapid transit, and responsive bus services.
- Create an integrated travel service that enables seamless connections and integrated ticketing within the city.

Strategies to Develop Slow Transportation Infrastructure

- Fill the TOD area with abundant green spaces and create integrated urban slow transportation spaces, thereby promoting walking and cycling within the TOD coverage area.
- Connect urban parks, public green spaces, open spaces, natural landscapes, water bodies, and historical cultural heritage elements while also serving transportation functions.
- Achieve seamless connections within social and daily life networks.

Strategies to Develop Specifically Bicycle Infrastructure

As a zero-emission means of transportation, the bicycle plays a crucial role in energy conservation and emission reduction; and a source of physical exercise, bicycles have direct health benefits for their users. Extensive bicycle infrastructure is essential for the development of low-carbon urban transport (figure 15).

Establish safe, continuous, and comfortable bicycle networks: Ensure the continuity and integrity of dedicated bicycle networks and implement colored bicycle lanes. In terms of signal light design and road network construction, ensure the priority rights of cyclists by prohibiting motor vehicles and pedestrians from entering, encroaching upon, or using bicycle lanes.

Establish shared bicycles/public bike rental networks: Set up rental stations at a certain density, monitor real-time vehicle availability at rental stations, and dynamically adjust the distribution to maintain supply-demand balance.

Construct bicycle lanes for distinct purposes: Urban leisure cycling routes, ecological and scenic routes, and street and lane cycling lanes will meet a range of travel needs and interests and help increase the volume of bicycle trips.

Figure 15: Bicycle and Slow Transportation System Connections

Source: Research team.

2. Planning Strategy and Implementation

The project team selected three areas in which to create a strategy for the coordination of transport and land use and to implement it—the central city; the central city's peripheral area of Wudang; and Guian New Area. Differentiated transport strategies were developed in each of these areas to ensure connectivity, but all strategies include the construction of safe pedestrian crossings, station-oriented pedestrian systems, and the separation of pedestrians and vehicles.

Central City Area

The central city area (including the Guanshanhu District) is relatively developed, with residential and commercial areas along the rail transit lines. The pedestrian and bus systems are well-established. Therefore, the main focus in the old city is to reduce block sizes so as to increase road density. Doing so helps citizens satisfy their transportation needs through walking, bicycling, and use of short-distance feeder buses. Feeder bus services help to connect with larger passenger flows and the rail networks.

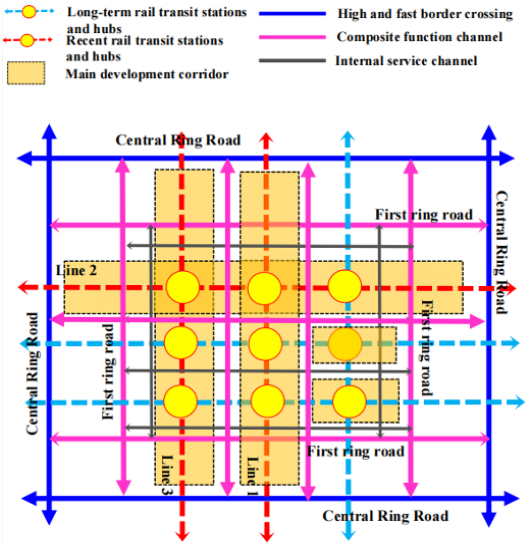
Land Use and Transport Strategy

The renovation and functional relocation of the old city relies on integrating rail transit, bus systems, slow modes of transportation, and roads to support a coordinated development pattern between land use and transportation. The focus for roads is on improving the road network and alleviating traffic congestion. Measures are taken to reduce the access of private vehicles to the old city. For public transportation, the emphasis is on integrating rail transit, bus systems, and walking.

Strategy Implementation

Three corridors for high-intensity development are created along rail transit lines 1, 2, and 3, emphasizing urban renewal and underground space development in the station areas. The scheme highlights the complementary role played by conventional buses in the corridors and prioritizes the protection of road rights for buses. It also emphasizes strong demand management for private motor vehicle travel. The development model of "narrow roads, dense road networks" is employed to improve the slow modes of the transportation system (figure 16).

Figure 16: Conceptual Diagram of Transportation Planning in the Old City Area



Source: Hyder Consulting (Shanghai), *Comprehensive Development Planning Study of TOD in the Areas along the Phase 1 of Guiyang Rail Transit Line S1 and Line 3.*

Area Adjacent to the Central City

The land extending up to 2 kilometers away from Wudang and other areas adjacent to the central city is suitable for slow modes of connecting to rail stations. But the area farther out than that relies of automobiles. Therefore, this area should construct a multimodal public transportation network and build regional parking and interchange centers to create a transportation linkage system that accommodates both motorized and nonmotorized transportation. The main strategies include setting up major stations for express rail services, connecting bus services to rail transit stations, and establishing multiple small car parking and interchange centers.

Land Use and Transport Strategy for Wudang

The recent construction of rail lines 3, S1, and S2 is supporting the development of Wudang in conjunction with other eastern regions. In addition:

- Construct the main road network to support the integrated development of Guiyang and Guian.
- Use medium-capacity public transportation to enhance the density of the rail transit network and optimize the integration of bus routes and rail transit services within the region.
- Construct nonmotorized vehicle networks in the Lewan Industrial Park and Chinese Medicine Industrial Park areas to address "last mile" connectivity.
- Promote the integrated development of park-and-ride facilities and rail transit, moderately increase the parking ratio, and control private vehicle use.

Strategy Implementation

Two corridors for high-intensity development are created with rail transit Line 3 as the core, including areas along the Line 3 extension. Use longitudinal corridors to strengthen the connection with the southern Shuanglong Aviation Economic Zone and promote the interconnected development of the eastern industrial new area.

Guian New Area

The new city should be oriented to rail transit and focus on building user-friendly rail transit hubs. The main strategies for implementation include creating a convenient and comfortable network for slow modes of transportation, establishing conventional bus stops within a 1.2 kilometer radius, and setting up ring routes for buses to serve the Guian city center. An outer ring bus route connects the core with the rail transit stations.

Land Use and Transport Strategy

The recent construction of Line S1 supports the development of Guian's central area in conjunction with that of Qingzhen, Shiban, and University City.

- Accelerate the construction of the primary and secondary road networks to support the integrated development of Guiyang and Guian.
- Make rail transit the main form of public transportation, with conventional buses and medium-capacity public transportation serving as extensions and densifications of the rail transit network.
- Optimize bus routes and rail transit services within the region.
- The strategies for nonmotorized transportation and parking are the same as those in the Wudang area.

Strategy Implementation

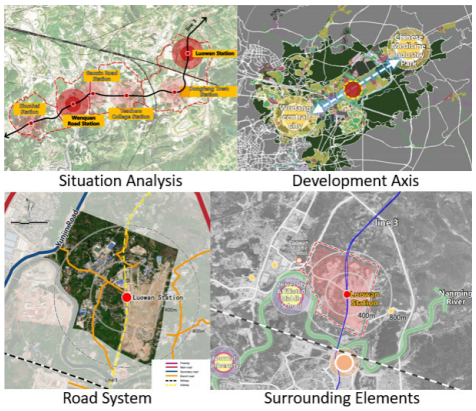
Two corridors of high-intensity development are created with Line S1 as the core. Transform Tianhetan Avenue, East Vertical Line, and Hulei Road into important public transportation corridors connecting Huaxi, Qingzhen, and Guanshanhu District to promote the integrated development of the Guiyang-Guian area. Select certain rail stations for comprehensive development.

3. Case Study: Luowan Station

Luowan Station is the terminus of Line 3. The planning area is on the north side of the Nanming River in the Wudang District, approximately 6 kilometers from the center of the district and 7 kilometers from the Chinese Medicine Industrial Park. (In the future, phase 2 of Line 3 construction will extend service from the Luowan Station all the way to the industrial park.)

Land use in the area exhibits the typical characteristics of the suburban-urban fringe, with village buildings of average overall quality, along with some manufacturing, agriculture, and forestry. The presence of the Line 3 station gives the area great potential for development (figure 17).

Figure 17: Current Analysis of Luowan Station



Source: Hyder Consulting (Shanghai), *Conceptual Urban Design Study of Important Station TOD (Phase 2).*

Objectives and Positioning

The objective is to create a new town with economic activity focusing on finance, research and development, hotels, residences, and commercial leisure functions. The town will also provide services to the surrounding industrial parks, forming a subcenter in Wudang. The high-quality development of the Luowan Station area will serve as a demonstration zone for guiding urban development in the wider Wudang area with an ecological and TOD-oriented approach.

Strategies and Plans

The natural environment within the site is diverse, with several hilly areas and a river flowing through the western part. The transportation facilities in this area include main roads, Luowan Station, bus stations, and parking.

Spatial Structure

The planning aims to create a spatial structure of two cores, two axes, one belt, and multiple zones. The two cores are the hub core area and the waterfront cultural core area. The two axes refer to the main spatial axis between the core areas and the functional subaxis in the south, forming multiple functional zones. The belt refers to the waterfront leisure area.

Slow Modes of Transportation

The layout of sidewalks, pedestrian overpasses, and nonmotorized lanes should be planned in accordance with the urban road system to meet the basic needs of slow transportation modes, including walking, bicycling, and e-biking. Skywalks should be established to facilitate access to subway stations and connections with neighboring properties. Waterfront trails should be planned along the water system to provide recreational and sports spaces.

Station Circulation

A primary transfer axis should be established to tightly connect the subway, buses, taxis, parking, commercial areas, and offices.

GUIYANG

Part 4: Summary of Achievements

Guiyang's economic development needs to catch up. Its per capita disposable income is much lower than the national average, and investing in public transportation facilities in lower-income areas is more productive than in more economically developed regions.

TOD implements a people-centered approach to transportation construction. The property development in the Qingshuijiang subway station area provides comprehensive service facilities for residents there. The affordable housing construction project in the future Huaguoyuan area will be closely integrated with transit Line 3 to solve the commuting problems in high-density areas. These projects pay more attention to the daily needs of urban residents and fully leverage TOD's advantages in bringing residents an improved sense of well-being.

As the only western city funded by the China Sustainable Cities Integrated Approach Pilot Project, Guiyang faces the challenge of rapid population growth plus motorization resulting from its uneven population density caused by the rough terrain. The project team conducted extensive stakeholder research, discussions, and in-depth public participation activities to deconstruct public demands and incorporate them into TOD planning and development.

At the city level, the construction of a comprehensive metropolitan rail system (containing both external and internal functions) aims to achieve integrated development between Guiyang and Guian. At the corridor level of development, rail transit is used to enhance the productivity and attractiveness of land use. At the station level, intensive, mixed-use land development and expansion of multimodal access demonstrates the concept of "low-carbon, ecological, and sustainable" development. Overall, the project illustrates how TOD construction can address Guiyang's urban development issues resulting from its difficult spatial and transportation structure.

1. Key Experiences

A nearly 200-meter drop separates the main urban area of Guiyang from the Baiyun and Guanshanhu districts. The TOD plan stitches together those areas with expanded rail transit: the existing transit lines 1 and 2 and the future lines 3 and S1 serve to connect and bridge the development gaps and clusters created by the mountainous environment. Further, a proposed TOD model that integrates urban and peripheral rail includes a benefit evaluation system with 20 indicators regarding land use, transportation integration, and the spatial environment.

More particularly, in terms of construction, outstanding elements of the plan include the creation of new commercial areas and novel configurations of mixed-use development. In terms of policy and process, social and environmental assessments were extensively used to support the implementation of research results; and public participation was deeply embedded in the TOD planning process.

New Underground Commercial Spaces

Rail transit development was linked to the development of new commercial spaces. Such spaces placed underground at the Zhongshan West Road station have a vibrant atmosphere and a diverse mix of businesses that incorporate local Guiyang characteristics. Features include a roof screen design and unique, themed "streets" that have contributed to the prosperous development of the station area and made it a popular landmark in Guiyang.

Rail Station Overbuild

Construction of buildings above rail transit stations (overbuild) promotes the renewal of older suburban industrial areas. The rail overbuild property above Qingshuijiang Road station is Guiyang's first such development. It follows the "rail + property" development concept and includes residential, commercial, and hotel functions. The project is divided into two sections by the extension of Pujiang Road. The two sections are connected by the station concourse, allowing residents to enter the internal passages of the community without leaving the station. The property development not only meets the residents' living needs but also fills the commercial gap in the suburban old industrial area, promoting economic prosperity and providing complete living facilities.

Integration of Environmental and Social Assessments with TOD Construction

Social and environmental assessments conducted since the beginning of the TOD project provided decision-making support for the implementation of research results and environmental and social management. The assessment process included interactive discussions with planners in the X, Y, and Z research components and yielded measures to prevent or mitigate adverse environmental and social impacts.

Public Participation

Drawing on domestic and international case experiences, four principles of public engagement were adopted by the project: extensive interaction, use of diverse channels of participation, participation throughout all stages, and information transparency. Plans for public engagement were developed for each stage of TOD planning, including formulation of plans, solicitation of draft opinions, approval, evaluation and modification, and implementation.

2. Future Improvements

Guiyang Metropolitan Rail is an integral part of improving the national high-speed railway network within Guiyang. It supports passenger transfers between internal and external transportation in Guiyang and Guian, drives the development of peripheral clusters based on the TOD approach, and strengthens integration with the city center. Guiyang Metropolitan Rail has been opened, but the operating speed and passenger flow are far below expectations based on the size of the facility investments.

The operation of the Guiyang Metropolitan Rail warrants continued monitoring to realize its promise and to ease the pressure of local costs and debt. Pursuing the following aspects of TOD will help sustain the positive economic developments achieved during the project and support the viability of the metropolitan transportation system.

Standardize City TOD Guidelines

The Guiyang project developed multiple technical guidelines and principles for TOD that have played an important role in the implementation of TOD. However, as TOD continues to integrate with the city, the guidelines must be consolidated and unified to ensure the continuous vitality of TOD in Guiyang.

Continue to Reduce Urban Carbon Emissions

The project developed an estimation model for transportation-related carbon emissions in Guiyang and an action plan for TOD of a low-carbon urban and green transportation system. Guiyang still experiences a significant amount of motorized travel during peak hours, resulting in severe congestion problems. It is necessary to continue promoting rail transit travel, implement low-carbon solutions for transportation land use, and continuously practice the concept of "low-carbon, ecological, and sustainable" development in Guiyang.

Develop the Potential of the Station-Area Economy

The station-area economy in Guiyang's city center, including the Zhongshan West Road and Fountain areas, has developed prosperously. By integrating diverse business formats and urban characteristics, the areas have become popular tourist attractions. By exploring more station-area characteristics and creating unique station identifiers ("name cards"), it is possible to attract passenger flows and stimulate the economic development of more regions.

Use the Big Data Platform to Develop TOD Efficiently

Guiyang's knowledge base in big data aided the project in developing a TOD big data monitoring and evaluation platform system. In the future, the platform, in coordination with the national platform and similar ones in other pilot cities, can support monitoring and optimizing the transportation system and its interaction with low-carbon, sustainable development.

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