DETAILED PROJECT DESCRIPTION

1. The Xiangtan Low-carbon Transformation Sector Development Program has four outputs: (i) Output 1: Low-Carbon and Resilient Infrastructure Transformation Demonstrated; (ii) Output 2: Information and Knowledge Platforms for Informed Decision-Making and Behavioral Change Enabled; (III) Capacity building and program management enhanced; and (iv) Low-Carbon Enabling Policy Reforms Adopted. Output 1, 2 and 3 are under the project loan, Output 4 is the pollicy-based loan. In this document, a detailed project description focusing on output 1 and 2 is provided to present how cross-sectoral interventions are integrated; and also physical and non-physical investment can complement each other to create transformational effects.

I. Output 1: Low-Carbon and Resilient Infrastructure Transformation Demonstrated

2. Physical infrastructure transformation with integrated design of cross-sectoral interventions will be demonstrated. **Mobility infrastructure** will be transformed to ensure seamless access to public mobility systems that are safe and inclusive to all, including children, elderly people, and persons with disabilities. Incorporating safety will support the shift to low-carbon modes of transport. The output includes the development of a priority bus system including the deployment of 100 battery electric buses (BEBs) and the installation of 778 e-charging units at 30 locations, integrated with improved bicycle network and pedestrian facilities; school zone transformation for children's road safety at five primary schools; and street transformation for climate resilient and multi-purposed street for users.

(i) Establishing a **priority bus system** through (a) lane modification to 31.3 km of main trunk roads in the Yuetang and Yuhu urban districts to establish priority median bus lanes; (b) lane modification to 31.5 km of other trunk roads to establish peak hour priority curbside bus lanes; and (c) traffic light reprogramming to improve bus traffic flows.

(ii) Establishing 129 pairs of bi-directional **smart accessible bus stops**, including 70 new bi-directional smart bus stops every 500 m along the median bus priority lanes (Figure 5), and upgrading of 59 existing bi-directional road side bus stops.

(iii) **Clean-energy vehicle promotion** through (a) procurement of 100 battery electric busses (BEBs); and (b) installing 778 e-chargers in 30 charging stations in Yuetang and Yuhu districts.

(iv) **Fuxing Middle Road Improvement Demonstration Project**, including an iRAP road safety assessment; road layout improvements for safety, bus stops, bike lanes and pedestrian walkways; ecosystem-based adaptation (EbA) measures to treat stormwater, alleviate drainage and runoff pollution, improve flood resilience and enhance the amenity value of the street; and drainage improvements.

(v) **Upgrading of non-motorized transport systems** by (a) improving 63.4 km of bike paths; (b) upgrading of 69 km of pedestrian walkways; (c) installing 48 safe crossing islands at major intersections for safe use and inclusive access; and (d) providing accessible and safer pedestrian crossing by adding screens with countdown red timers and synchronized sound buzzers at 3,000 pedestrian crossings across Xiangtan.

(vi) **Demonstrating user-friendly multimodal station design** at the Xiangtan Railway Station and Bantang Inter-city Railway Station, by modifying layouts to give priority access and use-space for public busses over taxis and private cars.

(vii) A **school road safety assessment** utilizing the iRAP Star Ratings for Schools (SR4S) methodology will be undertaken for five elementary schools.

3. The **building sectors** are growing and contributing to the GHG emissions. Under output 1, different building transformation cases will be presented, which are: The construction of the first "EDGE-certified" hospital building in the PRC, and the retro-fit of a semi-abandoned government building.[1] Other infrastructure transformation includes improvement of public facilities and other urban infrastructure at 20 urban communities showing practical ways to build a low-carbon, resilient, and livable Xiangtan. Specifically, output (i) includes:

(i) The construction of the first **EDGE-certified hospital building** in the PRC will demonstrate the integration of passive building design, clean energy technologies, and ecosystem-based adaptation (EbA) measures; and
(ii) **Retrofit of a run-down public building** to be equipped with high energy and water saving features and appliances.

4. Improvement of public facilities and other urban infrastructure with low-carbon features will be demonstrated at 20 urban low-income communities showing practical ways to build a low-carbon, resilient, and livable Xiangtan.

A. Mobility Infrastucture Transformation

a. Priority Bus System

5. **Priority Median Bus Lanes**. Xiangtan currently has only 207 km of bus routes. The network is inefficient and slow, and suffers from limited routes, poor bus stop locations, a lack of car-free bus lanes, and a lack of prioritization of bus traffic. Stakeholder meetings and surveys have identified slow bus speeds as the main reason urban Xiangtan residents prefer private cars over public busses.

Figure 1. Current Xiangtan bus routes and one-way bus flows.

Current Xiangtan bus route network.

Peak one-way bus flow for routes with peak flows > 3000 passengers/hour.

Source: Xiangtan City Public Transport Special Planning Unit.

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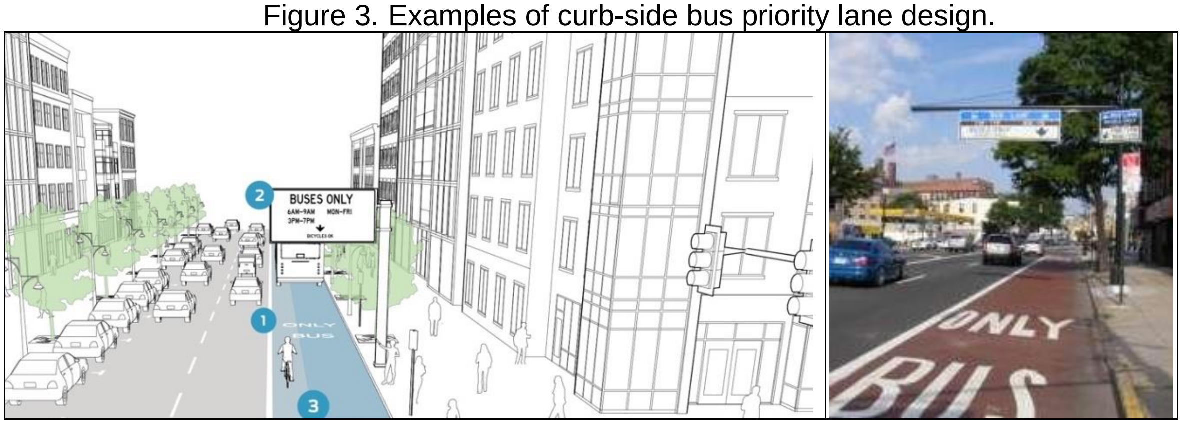
[1] Ecosystem-based adaptation measures using urban water (blue) infrastructure with green assets and ecosystem services are effective measures for flood control, drought mitigation, heat stress reduction, and carbon sink, and also provide co-benefits like aesthetic quality, recreational and restorative capacity, improved local air quality, and health benefits. .

6. The program will establish priority median bus lanes[2] on 31.3 km of main trunk roads and peak-hour (07:00-10:00; and 17:00-19:00) curb-side bus priority lane in 31.5 km of the remaining bus routes in Yuetang and Yuhu districts, to form an integrated network connecting main transport hubs which promotes faster bus flows. The priority median bus lanes were selected based on the Xiangtan urban layout, road type (two way, six lanes or more), current bus routes, and current and predicted passenger flows. Hard separations will be adopted to isolate the two-way bus lanes, with green belts used where road width allows. Lane design will be in accordance with *DG/TJ 08-2172-2015 J 13115-2015 Bus Lane System Design Specification*, and lanes will be painted a bright, distinct color and equipped with appropriate signage.

Figure 2. Examples of priority median bus lanes, Republic of Korea.

Source: ADB PPTA consultant, 2019.

Figure 3. Examples of curb-side bus priority lane design.



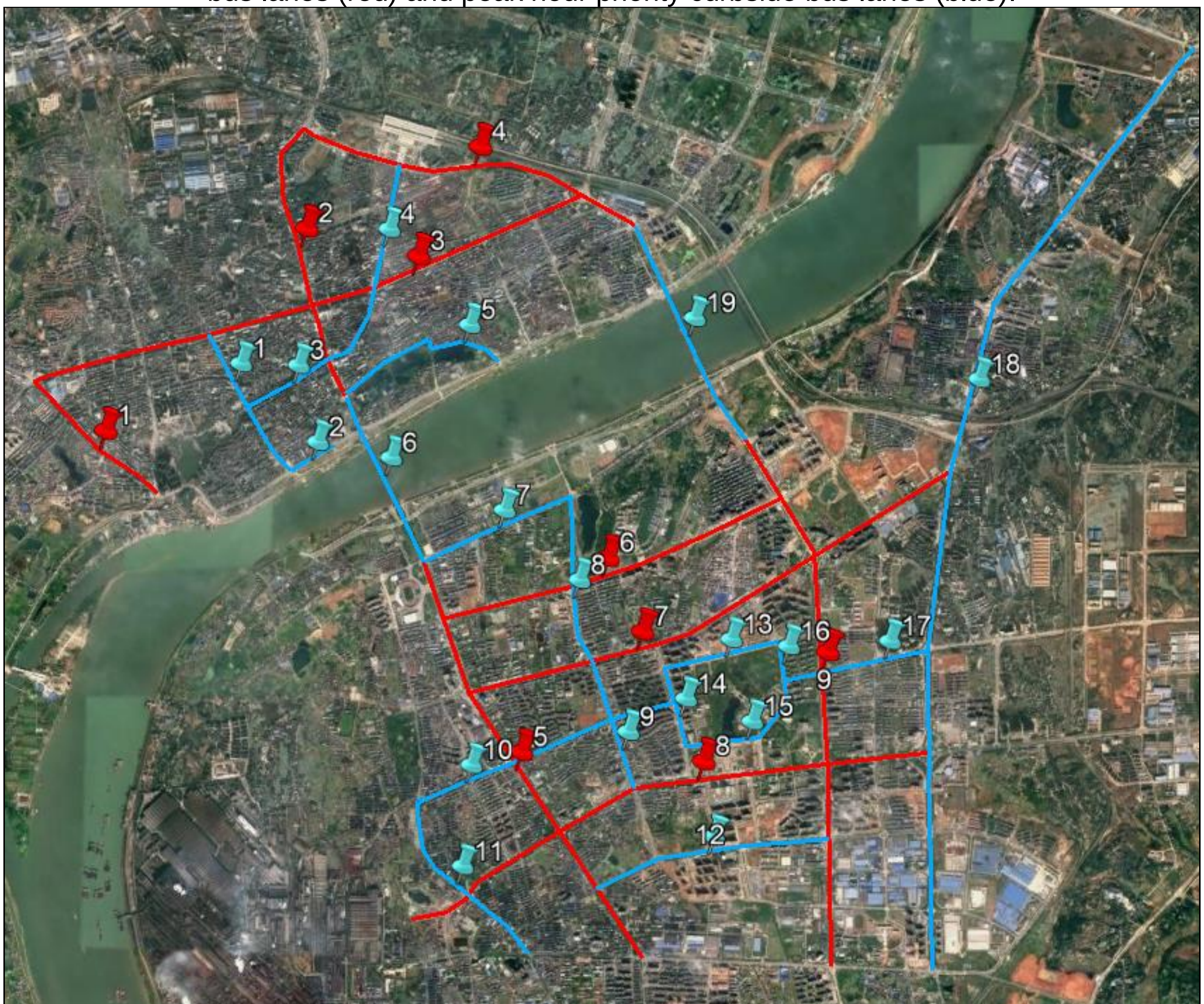
Source: NACTO design guidelines.

7. **Traffic Light Reprogramming**. Currently trunk roads in Xiangtan urban areas, including those to receive priority bus lanes, are equipped with three traffic lights. The far right-side traffic lights are used to signal right-turns, which is not actually required as right turns are permitted on

[2] There are four basic types of bus lanes: curbside, median, sub-curbside and reverse. A curbside bus lane is located in the outmost lane. A median bus lane is located in the innermost lane. A sub-curbside bus lane can be set on the lane next to the outmost lane when the road is one-way three or more lanes. A reverse bus lane is set on one-way road to allow busses to pass in the opposite direction.

both green and red lights. Priority median bus lanes will be supported by exclusive traffic light management to give priority signals to busses over other vehicles. Far left-side traffic lights will be reprogrammed to be used for bus flow management, and the two remaining traffic lights will be reprogrammed for other traffic flow management. Figure 5 presents current traffic light use and the bus-designated traffic light reprogramming that will be implemented to support the bus priority system.

Figure 4. Xiangtan urban trunk roads to receive lane modifications to establish priority median bus lanes (red) and peak hour priority curbside bus lanes (blue).



No	Priority Median Bus Lanes Road Name (Road Section)	Road Type	Length (km)	# of Stops (both directions)
1	Baoqing Road (XinMa Road - Lushan West Road)	Structural Trunk	1.4	6
2	Jianshe North Road (One Bridge North Approach Bridge - Wenxingmen Road)	Structural Trunk	2.7	14
3	Shaoshan Road (Baoqing Road – Wenxingmen Road)	Structural Trunk	4.7	22
4	Wenxingmen Road (Building North Road - Sanqiao North Approach Bridge)	Trunk	2.4	12
5	Jianshe South Road (One Bridge South Approach Bridge - Shuyuan West Road)	Structural Trunk	4.1	18

6	Fuxing Middle Road (Fuxing Middle Road)	Trunk	2.9	12
7	Hedong Avenue (Jiannan South Road - Qiangtang Station)	Structural Trunk	4.6	22
8	Xiangtan Avenue (Tie Niu Road - Furong Avenue)	Structural Trunk	4.1	16
9	Shuangyong Road (Sanqiao South Approach Bridge - Shuyuan Middle Road)	Structural Trunk	4.4	18
	Total		**31.3**	**140**

No.	Priority Curbside Bus Lanes Road Name (Road Section)	Road Type	Length (km)	# of Stops (both directions)
1	Bai Ma Hu Road	Structural Trunk Road	1.2	4
2	Zhong Shan Road	Structural Trunk Road	0.4	2
3	Min Zhu Road	Trunk Road	0.9	4
4	Che Zhan Road	Trunk Road	1.6	6
5	Yu Hu Road	Structural Trunk Road	1.5	6
6	Jian She Middle Road	Trunk Road	1.4	4
7	Dong Hu East Road	Structural Trunk Road	1.3	4
8	Bao Ta North Road	Trunk Road	1	4
9	Bao Ta Middle Road	Trunk Road	1.4	4
10	Xia Guang Road	Trunk Road	2.2	8
11	Yue Tang Road	Trunk Road	3.7	12
12	Xiao Tang Middle Road	Trunk Road	1.9	8
13	Hu Xiang North Road	Structural Trunk Road	0.9	4
14	Hu Xiang West Road	Structural Trunk Road	0.6	4
15	Hu Xiang South Road	Structural Trunk Road	1	6
16	Hu Xiang East Road	Structural Trunk Road	0.5	2
17	Gao Xin Road	Structural Trunk Road	1.2	6
18	Fu Rong Avenue	Structural Trunk Road	6.9	24
19	Xiang Tan 3rd Bridge	Trunk Road	1.9	6
	Total		**31.5**	**118**

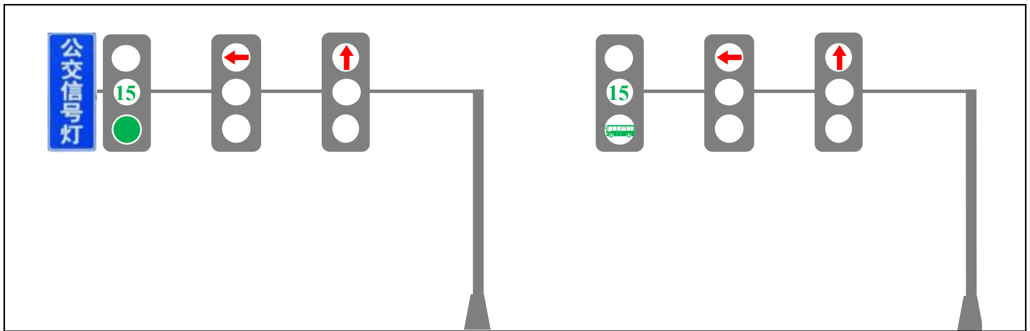
Source: ADB PPTA consultant, 2019.

Figure 5.Changes in traffic light management.

Current Traffic Lights at Trunk Roads in Xiangtan

At trunk roads in Xiangtan three traffic lights are installed. Right hand traffic lights are used to signal right-turns, which is not necessary.

Traffic Light Reprogramming for Designated Bus Traffic Lights



By re-programing the traffic lights, the left traffic light will be designated for busses only, allowing for faster bus traffic flows.

Source: ADB PPTA consultant, 2019.

b. Smart Accessible Bus Stops

8. Bus stops in Xiangtan are typically narrow, and do not have sufficient space for bus users to sit or stand comfortably. They also are not easily accessible and do not provide safe spaces for the disabled. While the stops are often equipped with digital screens, the content is dominated by advertisements and the screens are not very helpful to users.

9. A total of 129 pairs of bi-directional smart accessible bus stops will be established, including 70 new bi-directional smart bus stops every 500 m along the median bus priority lanes, and upgrading of 59 existing bi-directional road side bus stops. The stops will be equipped with bus information systems to provide real-time bus arrival, departure and route information. In addition, the bus stops will incorporate user-friendly designs including wider roofs to protect against sun and rain, room for comfortable benches, and improved access for elderly, children, and the disabled. All stops will have demarcated safety lines to protect passengers from bus traffic, and high passenger volume stops will be equipped with safety barriers.

Figure 6. Typical bus stops in Xiangtan.

Narrow width forces waiting riders onto the road. Typically the width of Xiangtan bus stops is just 0.5 m.	Insufficient space to sit especially for more vulnerable groups like pregnant women, elderly, children, and the disabled.

Unnecessarily high bus stop islands are not user-friendly, especially for vulnerable groups.

Source: ADB PPTA consultant, 2019.

Figure 7.Conceptual design for improved smart bus stops.

Wide bus stops will provide room for pedestrians, comfortable sitting benches and wheelchairs, and tactile pavement will improve safety. Wider roofs will provide better protection from sun and rain.

Safety barriers will be installed on high volume smart bus stops.

Digitalized real-time bus arrival information system will inform riders.

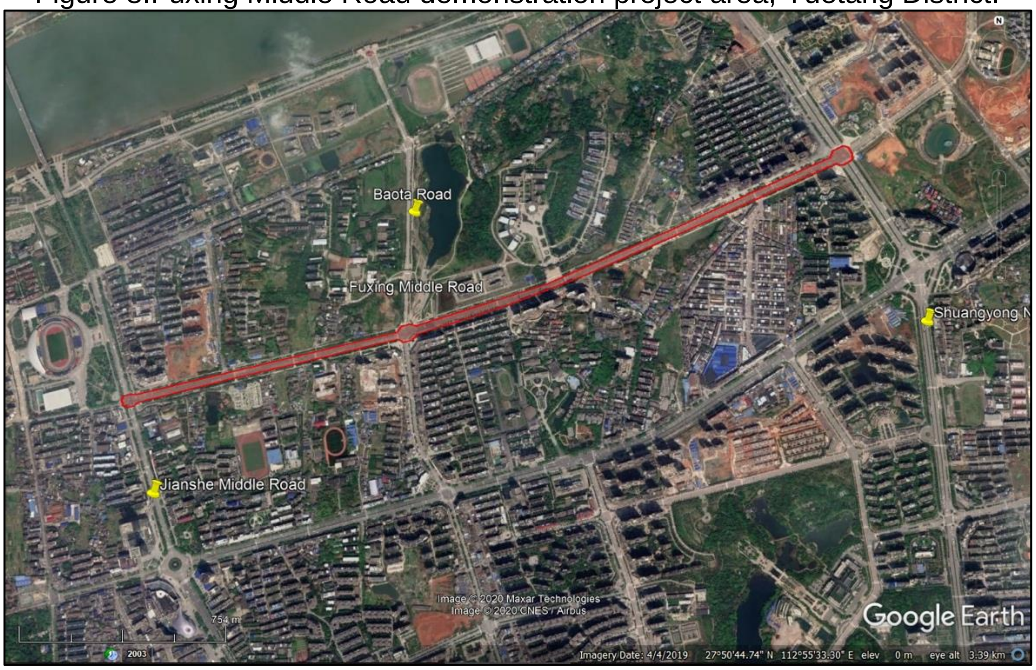
Source: ADB PPTA consultant, 2019.

c. Multi-functional Fuxing Middle Road Improvement Demonstration

10. A Xiangtan pluvial flood assessment was carried out during the program preparation. (See Supplementary Document on Climate Risks and Vulnerability Assessment and Xiangtan Climate Resilient City Toolbok). The assessment shows that Fuxing Middle Road, an important feeder road into the city center in Yuetang District and one of the output (i) trunk roads, is located in a flood prone-zone. A comprehensive road improvement demonstration project will be undertaken at Fuxing Middle Road, with the goal to create a safer, convenient, accessible and user-friendly street.

11. Fuxing Middle Road runs from Jianshe Middle Road to Shuangyong North Road, and is 2.9 km long. It is a two way trunk road with 6 lanes, and has several intersections with 6 lane cross streets. It has 4 to 8 m wide sidewalks. According to the Xiangtan Urban Master Plan, the road is targeted for education, scientific research and green space.

Figure 8.Fuxing Middle Road demonstration project area, Yuetang District.



Source: ADB PPTA consultant, 2019.

Figure 9. Photos from Fuxing Middle Road.

Source: Baidu map street view captured by ADB PPTA consultant, 2019.

12. **Road Layout Improvements**. The main layout problems with Fuxing Middle Road are: (i) road space is inefficient and designed for cars only; (ii) pedestrian crossings design is not user-friendly; (iii) the cycle lanes are discontinuous (some sections do not have cycle lanes), and there is conflict between cycle ways and on-street parking; and (iv) sidewalks are often occupied by parked cars.

13. To address these problems the program will undertake section-by-section road layout modifications as described in detail in IEE Appendix D. It should be noted that some of these modifications may undergo design changes as a result of the above noted iRAP Star Rating Assessment.

14. **EbA Measures**. Flooding of Fuxing Middle Road and adjacent blocks is caused by stormwater runoff from the road and buildings. The runoff is seriously polluted due to the high traffic load on the street. Substantial retention of stormwater along Fuxing Middle Road will rduce flood risk and damage in this downstream area, and improve runoff water quality.

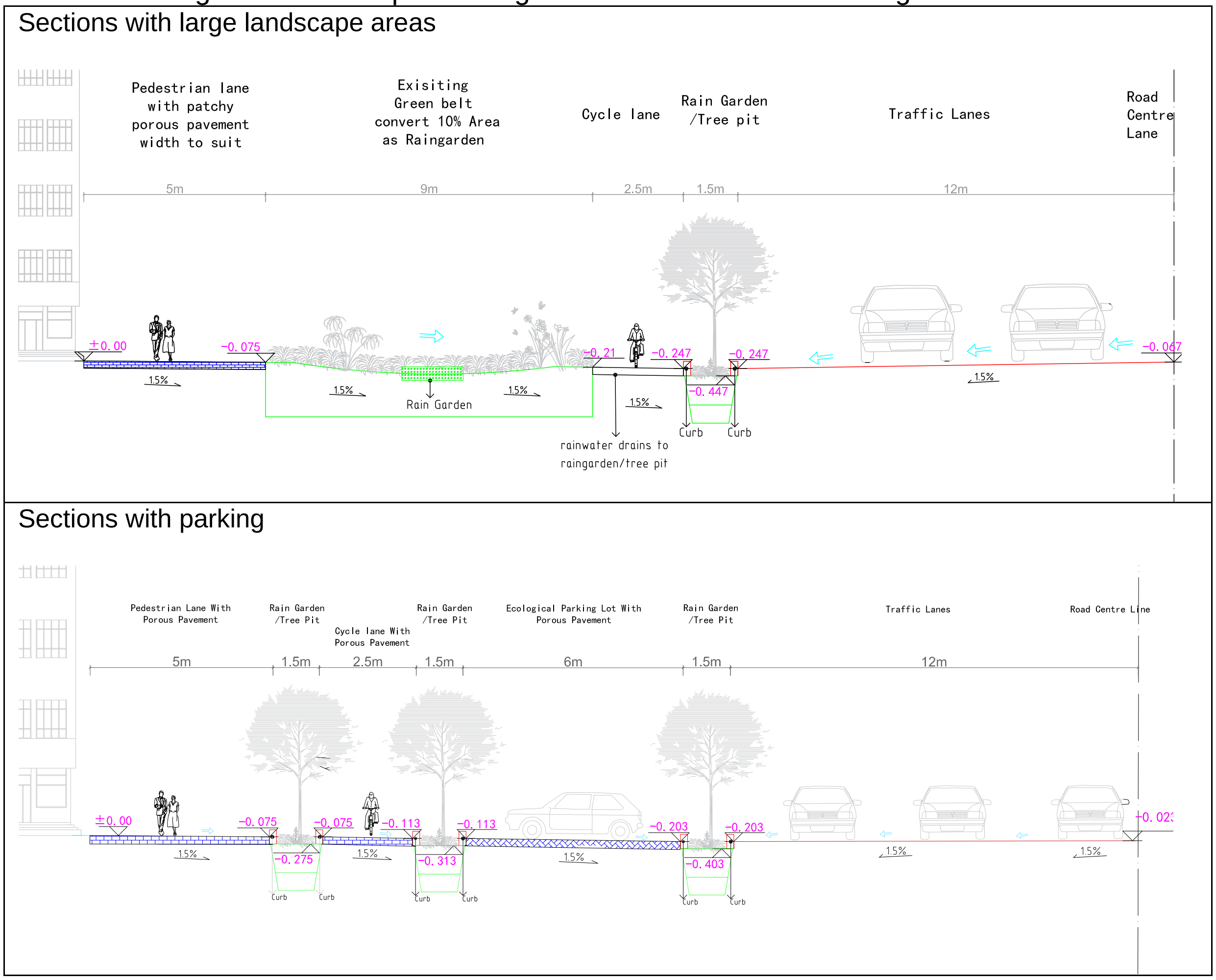
15. A range of ecosystem-based adaptation (EbA) measures will be installed. The measures were identified in cooperation with Xiangtan government staff in a series of ecosystem-based training and design workshops, and then further developed in a customized Chinese-language version of the Adaptation Support Tool,[3] called the Xiangtan Climate Resilient City Toolbox (XCRC Toolbox). The XCRC Toolbox contains a set of nature-based solutions and information on their water storage effectiveness and costs. Customization of the Toolbox included fine-tuning the Chinese translations to the local professional terminology, adding pictures of local examples of measures, adding an assessment of the effectiveness of each of the adaptation measures under the local climate conditions and land use in the pilot areas, and adding an assessment of the unit cost prices for implementation and maintenance of each of the measures.

16. EbA measures to be implemented include converting existing trees to tree pits, the size and type to be dependent on the local site conditions; new raingardens or swales for treating stormwater from the side pathways, size and type to be dependent on the local site conditions such as gradient; abandon/relocate/modify existing catchpits to new raingarden areas; porous pavement for cycle lanes; patchy porous pavement for the pedestrian walkways; and subsurface infiltration/detention boxes for water storage under cycle lanes and pedestrian

[3] The Adaptation Support Tool is an on-line resource developed by Deltares which can be used to explore measures that increase the water resilience of an area. See: https://crctool.org/en/.

walkways. Figure 10 presents an EbA conceptual plan, and illustrates the range of measures to be implemented.

Figure 10. Conceptual design of EbA measures for Fuxing Middle Road.

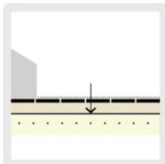


Source: ADB PPTA consultant, 2020.

17. The EbA measures will support and be coordinated with the road, sidewalk and cycle lane improvements, and will increase and capture infiltration, retain part of the runoff for peak reduction, treat the stormwater, reduce drainage and runoff pollution to the downstream system, and improve the street amenity value. The EbA facilities on each side of the road will each be capable of storing two m3 of stormwater for each m of road length, and are supportive of Xiangtan's transition to a "sponge city"

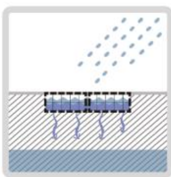
Figure 11.EbA measures to be implemented, Fuxing Middle Road.

Permeable pavement (infiltration & storage)



Permeable pavements consist of porous material that absorbs rainfall. Water can be stored either in the top layer (e.g. very open asphalt concrete) or in below the top layer in the foundation. Besides reducing runoff, permeable pavements can trap suspended solids and filter pollutants from the water.

Infiltration boxes

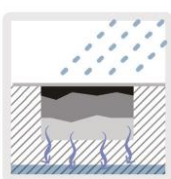


Infiltration boxes buffer rainwater underground and allow using a single area for two purposes. In general they offer more storage capacity than above-ground infiltration installations. More rainwater can be buffered temporarily and gradually released into the groundwater. The extra infiltration leads to less drought damage, subsidence and salinization.

Bioretention cell

Bioretention cells are stormwater detention features that collect, detain, infiltrate, and filter stormwater runoff prior to releasing it to a storm sewer system via an overflow or discharge mechanism. These facilitie typically feature both surface level (freeboard) and subsurface stormwater detention. Starting from the surface, it is commonly composed by: planting (trees & native shrubs), mulch layer, bioretention soil, aggregate bridging course, aggregate subbase, pipe underdrain, and undisturbed native soil.

Rain garden



These are sandy soil or aggregate filled depressions that treat stormwater runoff to improve water quality. Stormwater is captured and allowed to percolate through the soil/aggregate layer, where pollutants are removed, prior to being released through an underdrain located at the bottom of the depression.

Source: ADB PPTA consultant, 2019.

18. The pollution load of a busy road like Fuxing Middle Road is substantial. In addition to suspended sediments there are substantial concentrations of heavy metals, poly-aromatic hydrocarbons and mineral oil due to traffic, and pesticides may also be present from riparian vegetation. Most of these pollutants are particle-bound, and filtering and settling are effective techniques to remove such pollutants from the runoff. The rain gardens and the catch pits will play an important role in retaining pollutants. Filtration though a layer of soil aggregate and

settling in special catch basins will achieve estimated retentions of 80 to 90 % of these pollutants.

d. Non-motorized Transport System Improvement

19. Cycle Lanes. Typical problems with current Xiangtan cycle lanes include unsafe design such as being too narrow; lack of connectivity such as lanes not extending through intersections; cars using cycle lanes for driving or parking; and, poor or confusing signage. A total of 63.4 km of urban cycle lanes will be improved, including ensuring a minimum width of 1.5 m per lane; separating cycle lanes from vehicle roads where possible, or providing barriers to separate lanes from road traffic; demarcating lanes through brightly colored pavement and appropriate signage; and provision of bicycle parking.

Figure 12.Problems with existing cycle lanes.

	
Cycle lanes do not extend through intersections, creating confusion and a safety hazard.	Wide cycle lane allows passenger car access.
	
Poor design can be unsafe, for example riders may run into doors or cars during parking.	Signage is confusing and difficult to understand. Landscaping creates blind-spots.
	
Cycle parking spaces are frequently occupied by cars.	There are no cycle lanes around Xiangtan Train Station, a major public transport hub.

Source: ADB PPTA consultant, 2019.

Figure 13.Cycle lanes to be improved.

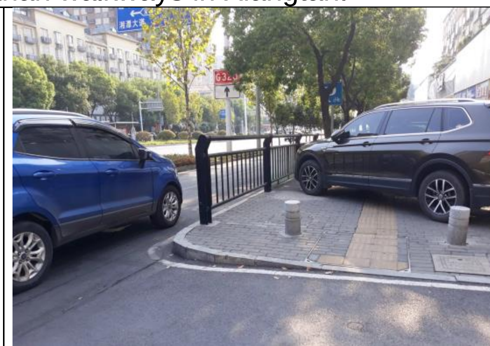
Road Name (Road Section)	Road Type	Length (km)	Width (m)
Chezhan Road(Wenxingmen Road - Jianshe Avenue)	Sub-Trunk	1.8	1.5
Jianshe North Road (Bridge no. One Northbound – Approach - Wenxingmen Road)	Structural Trunk	2.7	2.5
Jianshe South Road (Bridge no. One Southbound Bridge - Shuyuan West Road)	Structural Trunk	4.1	2.5
Shuangyong road (Bridge no. Three Southbound Bridge - Shuyuan Middle Road)	Structural Trunk	4.4	2.5
Shaoshan Road (Baoqing Road - Wenxingmen Road)	Structural Trunk	4.7	2.5
Renmin Road -Yuhu Road - Xichunmen Road (Baoqing Road - Shuangyong North Road)	Trunk	4.2	1.5
Fuxing Road(Jianshe South Road - Huoju North Road)	Trunk	3	2.5
Hedong Avenue (Jianshe South Road - Furong Avenue)	Structural Trunk	4.6	2.5
Xiangtan Avenue (Yuetang Road - Furong Avenue)	Structural Trunk	4.1	2.5
Xiaotang Road (Yuetang Road-Furong Avenue)	Trunk	3.5	1.5
Shuyuan Road (Yuetang Road-Furong Avenue)	Trunk	3.3	2.5
Wenxingmen Road (Jianshe North Road - Bridge no. Three Northbound Bridge)	Trunk	2.4	2.5
Fuxing Middle Road (Fuxing Middle Road)	Trunk	2.9	1.5
Xiaguang Road (Huxiang West Road - Yuetang Road)	Trunk	2.3	1.5
Huoju road (Gaoxin Road-Hedong Avenue))	Sub-Trunk	1.2	1.5
Yuetang Road(Liyuan Road - Zhongzhou Road)	Sub-Trunk	3.6	1.5
Dongsi Road (Donghu West Road - Lanyuan Road)	Sub-Trunk	1.1	1.5
Baoqing Road (Xinma Road -Shaoshan West Road)	Structural Trunk	1.4	2.5
Baimahu Road (Shaoshan West Road – Yanjiang West Road)	Trunk	1.3	1.5
Minzhu Road(Jianshe North Road - Baimahu Road)	Sub-Trunk	0.8	1.5
Yinbin Road(Baimahu Road - Baoqing Road)	Sub-Trunk	1.4	1.5
Furong Avenue (Hedong Avenue - North Second Ring Road)	Trunk	4.6	2.5
Total		**63.4**	**-**

Source: ADB PPTA consultant, 2019.

20. **Pedestrian Walkways**. Typical problems with urban pedestrian walkways in Xiangtan include frequent access barriers at main road crossings; narrow widths; lack of pedestrian road crossing lights; blockage by parked cars and motorcycles; blockage by improperly sited public facilities such as power poles and garbage cans; uneven and unsafe surfaces that can be a tripping hazard; impervious surfaces and poor drainage which can lead to flooding; and poor accessibility for the disabled.

Figure 14.Problems with existing pedestrian walkways in Xiangtan.

Pedestrian road crossings frequently have barriers preventing access to strollers and wheelchairs, and may lack pedestrian crossing lights.



Pedestrian walkway blocked by parked cars.

Uneven and impervious walkways can flood easily and be a fall hazard.

Infrastructure blocking pedestrian walkway.

Source: ADB PPTA consultant, 2019.

21. A total of 69 km of pedestrian walkways will be upgraded, including ensuring a minimum width of 2 m to allow for two-way wheel chair passage; removal of approximately 5,000 isolation barriers at sidewalk entrances; removal or re-siting of public facility obstacles such as garbage cans; and resurfacing over 250,000 m^2 of walkway with water pervious non-slip surfaces.

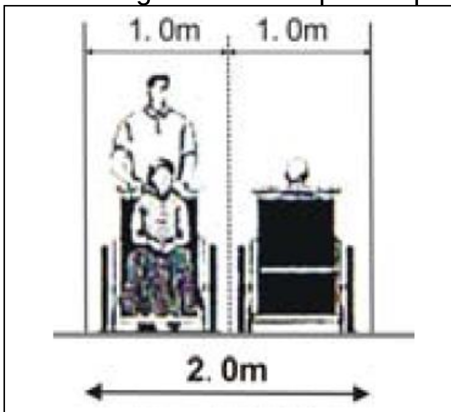
Figure 15.Pedestrian walkways to be improved.

Type of Improvement	Road (Section)	Length (km)
Removing approx. 5,000 walkway access barriers	Main urban core trunk roads in the such as Jianshe Rd., Shaoshan Rd. and Xiangtan Avenue	NA
Sidewalk quality improvement, including ensuring a minimum width of 2 m to allow for two-way wheel chair passage; removal of isolation barriers at sidewalk entrances; removal or re-siting of public facility obstacles such as garbage cans; and resurfacing with water pervious non-slip surfaces. Relevant standard is Accessibility Design Specification (GB50763-2012).	Heping Rd. (Shaoshan East Rd. - Yuhu Rd.)	0.62
	Yuetang Rd. (Xiaguang Rd. — Shuyuan West Rd.)	1.6
	Yingbin Rd. (Baimahu Rd. - Baoqing Rd.)	1.95
	Chezhan Rd. (Wenxingmen Rd. - Jianshe North Rd.)	1.9
	East Huxiang Rd. (Hedong Avenue - Xiangtan Avenue)	1.58
	Jie Fang Rd. (Guangyun Rd. - Yanjiang Middle Rd.)	1.74
	Jianshe North Road (Bridge no. One Northbound – Approach - Wenxingmen Road)	2.7
	Jianshe South Road (Bridge no. One Southbound Bridge - Shuyuan West Road)	4.1
	Shuangyong road (Bridge no. Three Southbound Bridge - Shuyuan Middle Road)	4.4
	Shaoshan Road (Baoqing Road - Wenxingmen Road)	4.7
	Renmin Road -Yuhu Road - Xichunmen Road (Baoqing Road - Shuangyong North Road)	4.2
	Fuxing Road(Jianshe South Road - Huoju North Road)	3
	Hedong Avenue (Jianshe South Road - Furong Avenue)	4.6
	Xiangtan Avenue (Yuetang Road - Furong Avenue)	4.1
	Xiaotang Road (Yuetang Road-Furong Avenue)	3.5
	Shuyuan Road (Yuetang Road-Furong Avenue)	3.3
	Wenxingmen Road (Jianshe North Road - Bridge no. Three Northbound Bridge)	2.4
	Fuxing Middle Road (Fuxing Middle Road)	2.9
	Xiaguang Road(Huxiang West Road - Yuetang Road)	2.3
	Huoju road (Gaoxin Road-Hedong Avenue))	1.2
	Yuetang Road(Liyuan Road - Zhongzhou Road)	3.6
	Dongsi Road (Donghu West Road - Lanyuan Road)	1.1
	Baoqing Road(Xinma Road -Shaoshan West Road)	1.4
	Baimahu Road (Shaoshan West Road – Yanjiang West Road)	1.3

	Minzhu road(Jianshe North Road - Baimahu Road)	0.8
	Furong Avenue (Hedong Avenue - North Second Ring Rd.)	4.6
Total		**69.5**

Source: ADB PPTA consultant, 2019.

Figure 16.Examples of pedestrian walkway improvements.



Minimum safe width for sidewalks

Isolation posts at sidewalks entrances to be improved to provide easier pedestrian access

Source: ADB PPTA consultant, 2019.

22. **Safe Islands.** Trunk roads in Xiangtan are typically six lanes wide and traffic lights are timed based on traffic flows. Pedestrian, especially children, the elderly and disabled, may not have time to cross completely and risk being caught in traffic flows. A Safe Island is a small protected area where pedestrians can stop before finishing crossing a road. They are typically used on streets so wide that some individuals may not be able to cross in one traffic light cycle. A total of 48 Safe Islands will be installed at major intersection crossings to allow for safe pedestrian access and use.

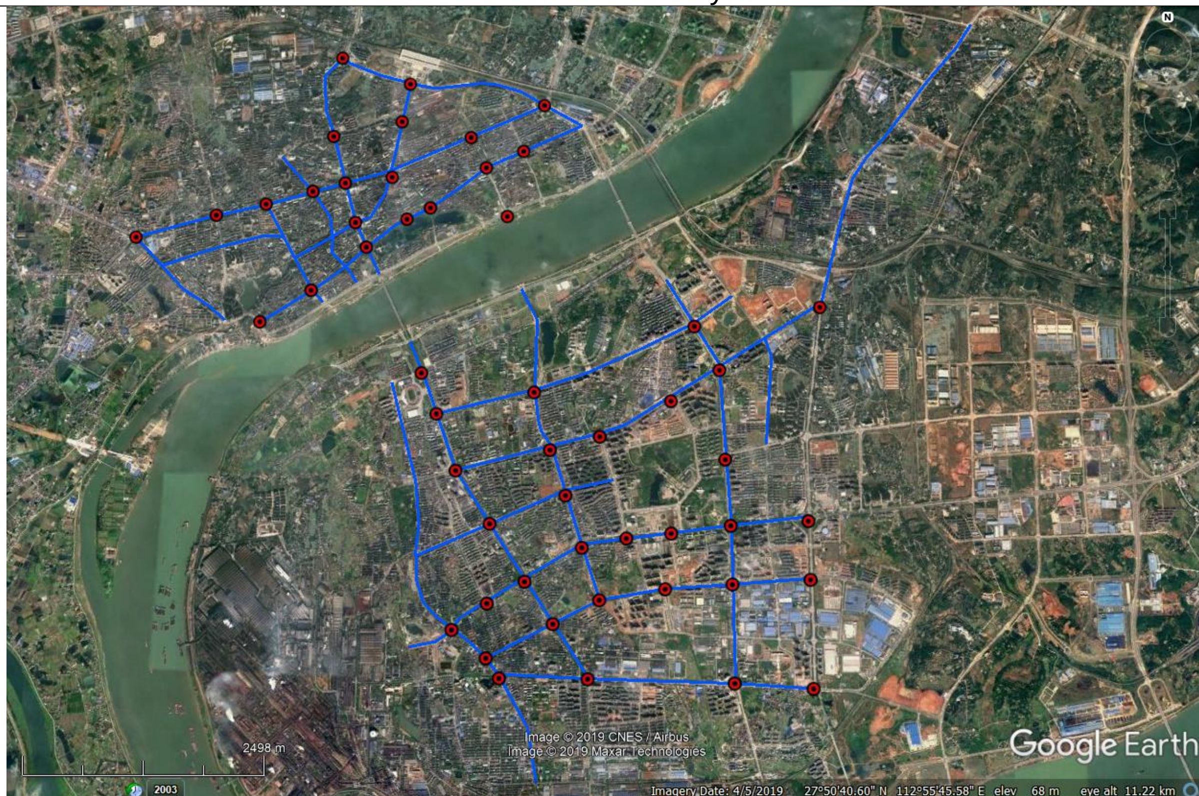
Figure 17. Typical Xiangtan wide intersection, and sample conceptual drawing of wide intersection safety islands.

Intersection of Baota and Fuxing middle road in Xiangtan

Conceptual drawing of Safe Islands at a wide intersection

Source: ADB PPTA consultant, 2019.

Table 1.Locations for intersection Safety Islands to be installed.



No	Road	Intersection Name	Intersection Type	Road Connection Type
1	Shaoshan Road	Tanshao Rd.-West Shaoshan Rd.	Cross Intersection	Trunk-Trunk
2		West Shaoshan Rd.-Naling Rd.	Cross Intersection	Trunk-Sub Trunk
3		West Shaoshan Rd. -Baimahu Rd.	T Intersection	Trunk-Trunk
4		Middle Shaoshan Rd.-Middle Jiefang Rd.	Cross Intersection	Trunk-Sub Trunk
5		West Shaoshan Rd. -North Jianshe Rd.	Cross Intersection	Trunk-Trunk
6		Chezhan Rd.-East Shaoshan Rd.	Cross Intersection	Sub Trunk-Trunk
7		East Shaoshan Rd. -Tongjimen Rd.	T Intersection	Trunk-Trunk
8		East Shaoshan Rd. -Wenxingmen Rd.	Cross Intersection	Trunk-Trunk
9	Xichunmen Road	Xichunmen Rd.-Tongjimen Rd.	Cross Intersection	Trunk-Trunk
10		Xichunmen Rd.-Guanxiangmen Rd.	Cross Intersection	Trunk-Sub Trunk
11	Yuhu Road	Yuhu Rd.-Wenhua Street	T Intersection	Trunk-Branch
12		Yuhu Rd.-Heping Rd.	Cross Intersection	Trunk-Branch
13	Renmin Road	Renmin Rd.-Baimahu Rd.	Cross Intersection	Trunk-Trunk
14		Renmin Rd.-Xinma Rd.	T Intersection	Trunk-Trunk
15	Middle Fuxing Road	Middle Fuxing Rd.-North Baota Rd.	Cross Intersection	Trunk-Trunk
16		Middle Fuxing Rd.-North Shuangyong Rd.	Cross Intersection	Trunk-Trunk
17	Hedong Avenue	Hedong Avenue-Furong Avenue	T Intersection	Trunk-Trunk
18		Hedong Avenue-North Shuangyong Rd.	Cross Intersection	Trunk-Trunk
19		Hedong Avenue-East Huxiang Rd.	T Intersection	Trunk-Sub Trunk
20		Hedong Avenue-West Huxiang Rd.	T Intersection	Trunk-Sub Trunk
21		Hedong Avenue-Middle Baota Rd.	Cross Intersection	Trunk-Trunk
22		Hedong Avenue-South Jianshe Rd.	Cross Intersection	Trunk-Trunk
23	Xiangtan Avenue	Xiangtan Avenue-FuRong Avenue	Cross Intersection	Trunk-Trunk
24		Xiangtan Avenue-Middle Shuangyong Rd.	Cross Intersection	Trunk-Trunk
25		Xiangtan Avenue-Wangyue Rd.	T Intersection	Trunk-Sub Trunk
26		Xiangtan Avenue-West Xianghu Rd.	T Intersection	Trunk-Sub Trunk

27		Xiangtan Avenue-Middle Baota Rd.	Cross Intersection	Trunk-Trunk
28		Xiangtan Avenue-South Jianshe Rd.	Cross Intersection	Trunk-Trunk
29		Xiangtan Avenue-Lanxia Rd.	T Intersection	Trunk-Sub Trunk
30		Xiangtan Avenue-Yuetang Rd.	T Intersection	Trunk-Trunk
31	Xiaotang Road	West Xiaotang Rd.-Yuetang Rd.	T Intersection	Trunk-Trunk
32		Middle Xiaotang Rd.-South Baota Rd.	Cross Intersection	Trunk-Trunk
33		Middle Xiaotang Rd.-Yuehua Rd.	T Intersection	Trunk-Trunk
34		Middle Xiaotang Rd.-South Shuangyong Rd.	Cross Intersection	Trunk-Trunk
35		East Xiaotang Rd.-Furong Avenue	Cross Intersection	Trunk-Trunk
36	Shuyuan Road	Middle Shuyuan Rd.-Furong Avenue	Cross Intersection	Trunk-Trunk
37		Middle Shuyuan Rd.-South Shuangyong Rd.	Cross Intersection	Trunk-Trunk
38		West Shuyuan Rd.-South Jianshe Rd.	Cross Intersection	Trunk-Trunk
39		West Shuyuan Rd.-Yuetang Rd.	Cross Intersection	Trunk-Trunk
40	Jianshe Road	North Jianshe Rd.-Guangyun Rd.	Cross Intersection	Trunk-Trunk
41		North Jianshe Rd.-Wenxingmen Rd.	T Intersection	Trunk-Trunk
42		Chezhan Rd.-Guangyun Rd.	T Intersection	Branch-Trunk
43		North Jianshe Rd.-Minzhu Rd.	Cross Intersection	Trunk-Sub Trunk
44		North Jianshe Rd. -Yuhu Rd.	Cross Intersection	Trunk-Trunk
45		Middle Jianshe Rd.-Donghu Rd.	Cross Intersection	Trunk-Trunk
46		Middle Jianshe Rd.-Middle Fuxing Rd.	Cross Intersection	Trunk-Trunk
47		South Jianshe Rd.-Middle Xiaotang Rd.	Cross Intersection	Trunk-Trunk
48		South Jianshe Rd.-Xiaguang Rd.	Cross Intersection	Trunk-Trunk
49	Other	Tongjimen Rd.-Middle Yanjiang Rd.	T Intersection	Trunk-Trunk
50		Middle Baota Rd.-Xiaguang Rd.	Cross Intersection	Trunk-Trunk
51		Middle Shuangyong Rd.-Gaoxin Rd.	Cross Intersection	Trunk-Trunk
52		Chezhan Rd.-Wenxingmen Rd.	T Intersection	Trunk-Sub Trunk

Source: ADB PPTA consultant, 2019.

23. **Pedestrian Crossing Timers**. Xiangtan's pedestrian crossing times vary by intersection, and it can be difficult for pedestrians to predict the duration of crossing signals. To improve pedestrian crossing safety, countdown screens with audible warning buzzers (speaker units) will be installed at 3,000 pedestrian crossings across Xiangtan. This will provide pedestrians accurate signal information and reduce pedestrian anxiety about abrupt signal changes, making it safer to cross Xiangtan roads.

e. School Safety Road Assessment

24. The program will undertake a road infrastructure safety assessment at five elementary schools utilizing the **iRAP Star Ratings for Schools (SR4S) methodology** at two to three select points at each school. The assessment will identify potential safety enhancements for the schools and provide cost estimates. The objective is to achieve at least a 3-star rating for all road users and a 5-star rating for students, other pedestrians, and cyclists.The five schools have been selected by the Xiangtan DRC, and are among the largest elementary schools in Xiangtan. As an example, Table 2 shows Xiangji Primary School, located on Yunhe Road. The road is narrow and roadside parking causes problems during the school rush hour. A preliminary recommendation is to make Yunhe Road one way, and strengthen the management and enforcement of roadside parking.

Table 2.Elementary schools to undergo the iRAP Star Ratings for Schools assessment.

No	School Name	Relevant Roads
1	Heping Primary School	Yuhu Road, Wenhua Street
2	Jinting Primary School	Baimahu Road, Jinting Street
3	Huoju Primary School	Huoju Zhong Road
4	No. 3 Primary School	Sanxiao Street
5	Xiangji Primary School	Yunhe Road

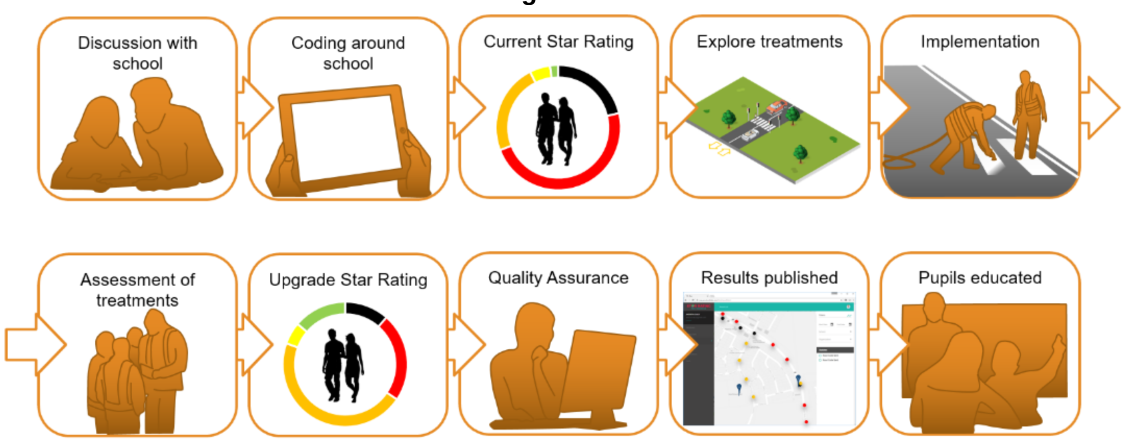
Source: ADB PPTA consultant, 2019.

Figure 18. iRAP Star Rating for Schools.

iRAP Star Rating for Schools

The iRAP Star Rating for Schools program applies specifically to school zones: users assess the roads around a school, input the assessment data into an app, and receive a star rating. Once the risk is measured, effective treatments to mitigate the risk can be considered by exploring the impact of changes in various road features and speed management actions. The implementation of the treatments can be tracked so that the partner and funder can see the benefits of their investment and the school teaching staff can educate the pupils on the correct use of the treatments.

iRAP Star Rating for Schools Process



Source: iRAP, 2019.

Figure 19.Yunhe Road at Xiangji Elementary School.

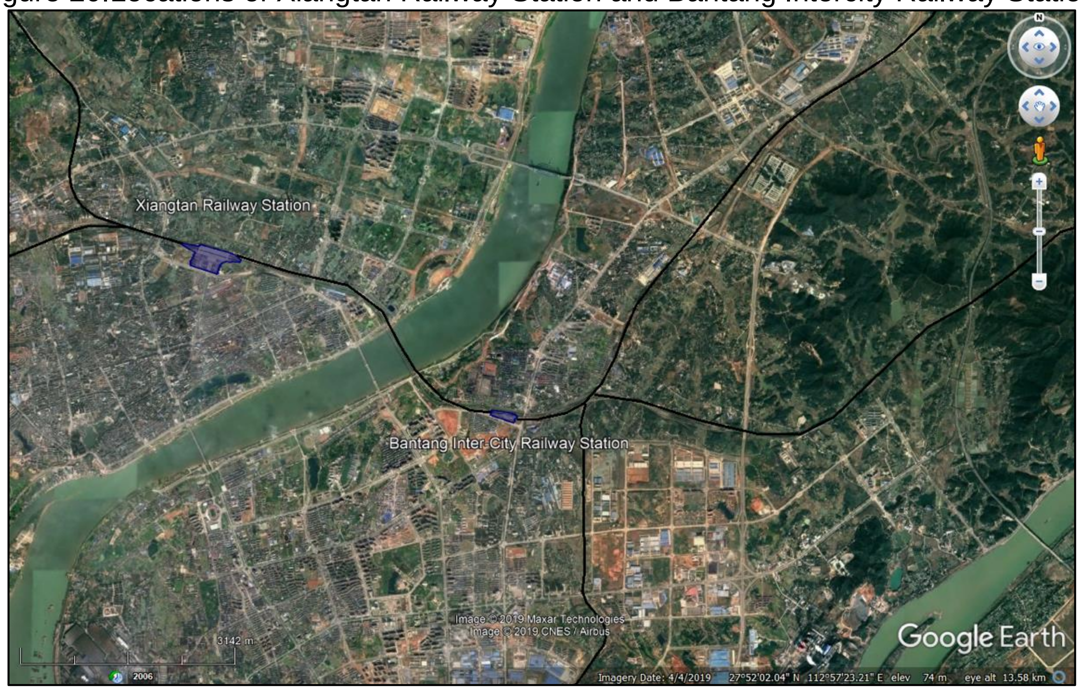
Source: ADB PPTA consultant, 2019.

f. Multi-modal transport hubs transformation

25. A multi-modal passenger transport station is one that connects two or more transport modes, such as rail, bus, waterway, aviation, etc. The efficiency of the connections between the various modes will directly affect the overall operational efficiency of the station. At present the connection between bus and train modes in Xiangtan is not very efficient, which negatively affects the experience of bus and rail passengers.

26. The program will support the development of two demonstration inner-city multi-mode passenger transport stations, Xiangtan Railway Station and Bantang Intercity Railway Station. By modify layouts, improvements will optimize bus access to the stations over taxis and private cars, establish bus stops with shelters, and establish safe taxi and passenger pick-up and drop-off areas.

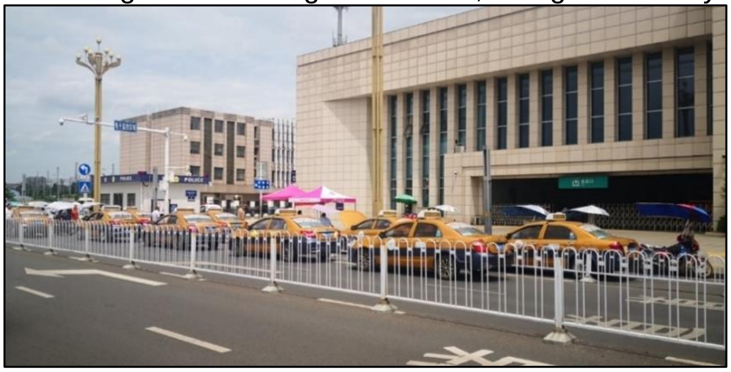
Figure 20.Locations of Xiangtan Railway Station and Bantang Intercity Railway Station.



Source: Google Earth 2019, and ADB PPTA consultant, 2019.

27. **Xiangtan Railway Station**. Xiangtan Railway Station is a second-class station on the Shanghai-Kunming Railway and the starting station of the Changzhu-tan intercity railway. It is located off Chezhan Road in Yuhu District, and is administered by the China Railway Guangzhou Group. The Xiangtan Railway Station was built in 1958, and a reconstruction and expansion project was completed in 2012. Problems with the current station design include the taxi que blocks public bus access; passengers need to cross the road twice when exiting the station to transfer to the nearest bus stop; and there is no shelter at the bus stop.

Figure 21.Waiting taxis blocking bus access, Xiangtan Railway Station.

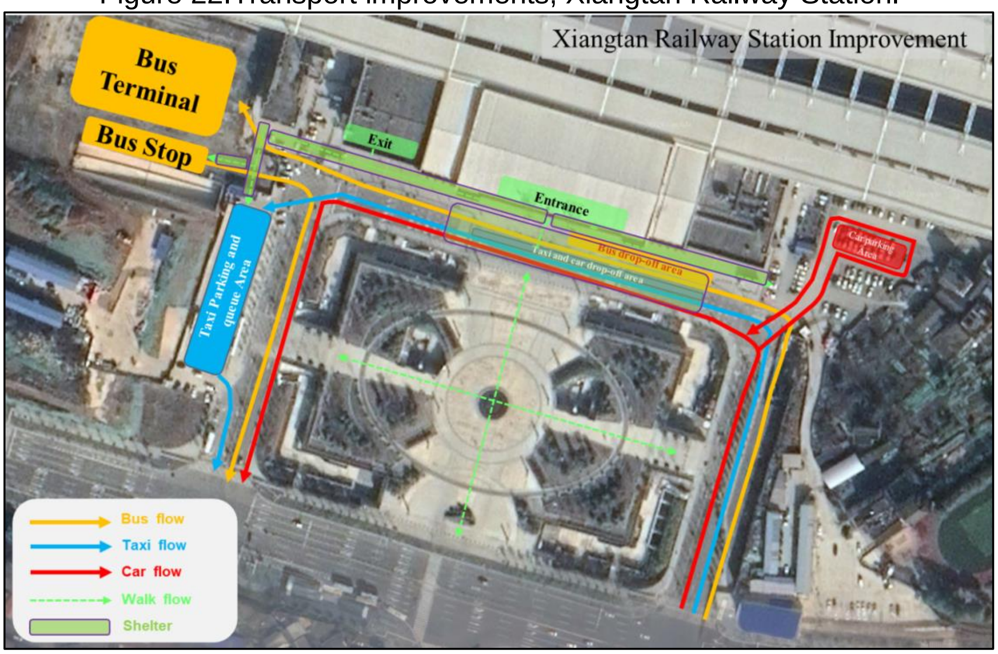


Source: ADB PPTA consultant, 2019.

28. To address these problems the program will:

(i) optimize the bus access route - the nearest position from the entrance of the railway station will be used as the bus unloading area, and the current bus stop will be moved to the exit of the railway station to improve pedestrian safety by eliminating the need to cross the road to access the bus stop;
(ii) establish a covered bus shelter;
(iii) establish safe taxi and private car unloading area;
(iv) establish a new taxi parking and queuing area

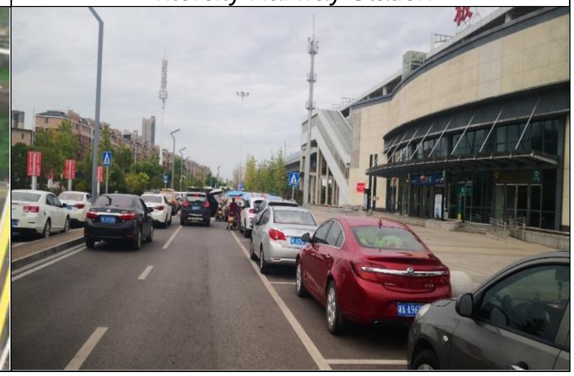
Figure 22.Transport improvements, Xiangtan Railway Station.



Source: ADB PPTA consultant, 2019.

29. **Bantang Intercity Railway Station.** Bantang station is located at the intersection of Furong Avenue and Banwu Road in Yuetang District. There are currently two bus stops located to the south of the station. The station is being further developed as a transport hub in two stages by the Xiangtan City Development Group.

Figure 23.Bantang Intercity Railway Station in Xiangtan.

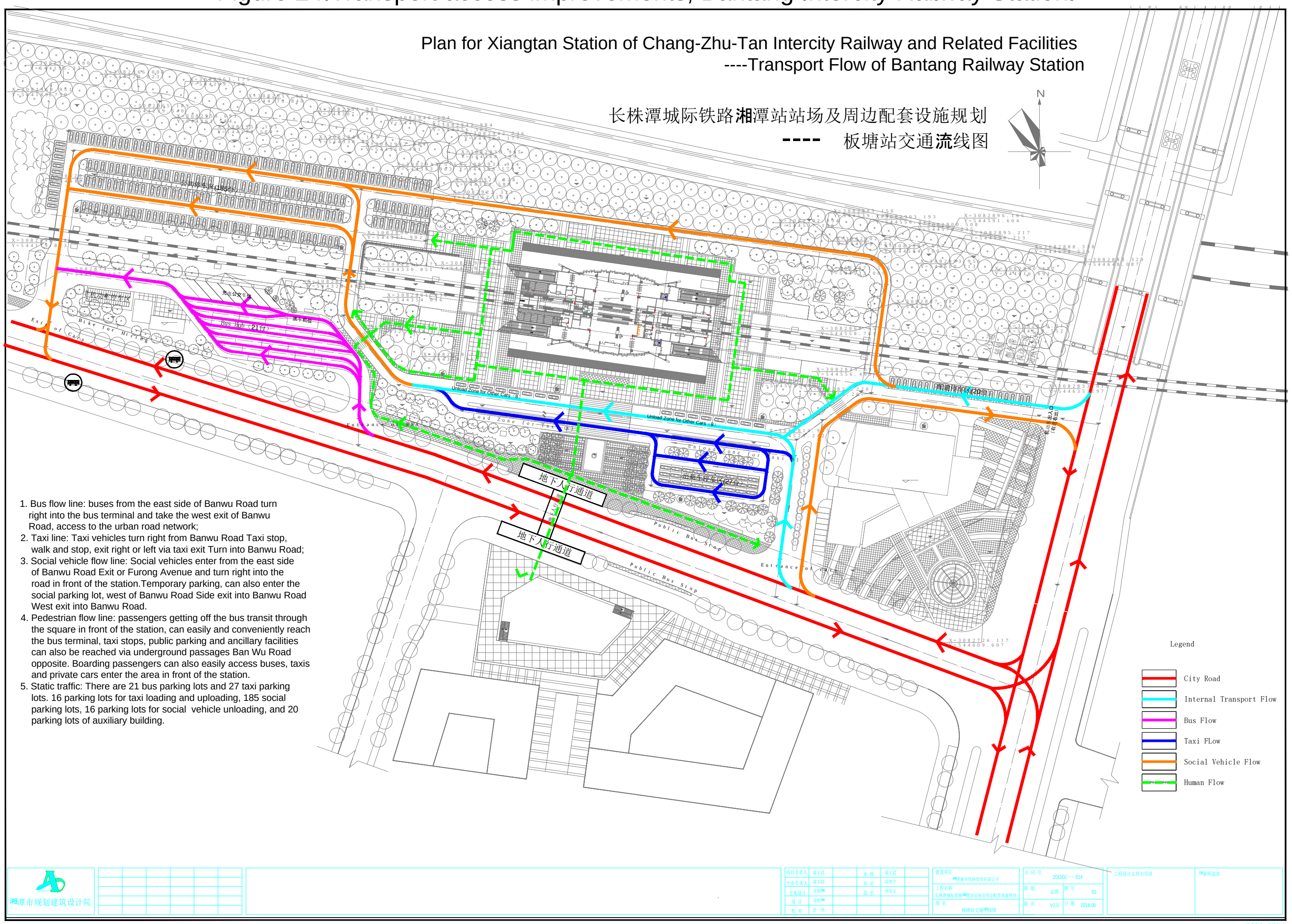
In-city bus stations are located outside of the Bantang Intercity Railway Station	Private cars blocking access to the Bantang Intercity Railway Station
	

Source: ADB PPTA consultant, 2019.

30. Current problems at the station include private cars occupying the entrance to the station; existing bus stops being far from the station; and the lack of a covered shelter for bus passengers.

31. The program will support the development of the station through improvements to the transport access, including: i) relocating the bus drop-off area to near the station entrance; ii) moving the taxi and private cars drop-off area further to the west to avoid interference with busses and improve safety; iii) rerouting bus travel to the bus terminal station to be established to the west of the train station; and iv) establishing a covered shelter at the bus station.

Figure 24.Transport access improvements, Bantang Intercity Railway Station.



Source: ADB PPTA consultant, 2019

g. Clean Energy Vehicle Promotion

32. **Electric Bus Procurement**. Modern battery electric busses (BEBs) can have a range of up to 250 km with just one charge, and are particularly well suited to urban routes. Urban driving involves extensive accelerating and braking, and BEBs can recharge much of the kinetic energy back into the batteries in braking situations, reducing brake wear and extending range.

33. The program will procure a fleet of 100 BEBs. The 10.5 m long busses will be powered through on-board 145 to 205 kW lithium-ion (Li-ion) batteries, charged at existing bus depots and electric charging stations or at those to be established by the program. Batteries will have a guarantee of 8 years minimum lifespan at 100% state-of-charge (SOC). This type of battery set has proven able to meet the daily demands of a majority of typical bus routes with one fast-charge during the day and slow-charging during the night.

34. Busses will be equipped with onboard systems to communicate with the traffic management control and data centers. For pedestrian safety busses will also be equipped with Acoustic Vehicle Alerting Systems (AVAS), which will emit warning sounds at speeds less than 30 km/h. The average program bus route length will be 16.49 km 1-way and take 40 minutes. Due diligence has confirmed that the routes (gradients, length) and the climatic conditions in Xiangtan pose no problem for the proposed BEBs.

Table 3.Battery bus fleet technical data.

Parameter	Battery Electric Bus
Size	10.5 m
Number of busses	100
Passenger Capacity	70
Daily distance driven	160
Annual distance driven (km)	30,900
Electricity usage average (kWh)	82.8 kWh/100 km
Battery pack required (for summer with 10% reserve and 90% SOC) in kWh	145 to 205 kW
Type of Battery	Lithium iron phosphate ($LiFePO_4$)
Station Chargers	15 to 30 kW DC slow chargers for overnight charging. 45 to 160 kW DC fast chargers.
Estimated electricity cost (RMB/kWh)	0.9
Estimated annual electricity cost per bus RMB	23,000

Source: ADB PPTA consultant, 2019.

35. **E-Charging Stations.** A network of 30 electric charging stations for both private and public vehicles will be established at existing bus stations and municipal and public parking lots. The stations will have a combined total area of 58,500 m^2, and no land acquisition will be required. The stations will be equipped with automated 60 to 320 kW DC quick chargers, each having two or more 7 or 9 pin plug-in nozzles, capable of meeting the quick-charge requirements of small, medium and large sized electric vehicles. In total there will be 778 chargers providing 1,445 charging spaces.

36. Charging stations will be equipped with intelligent monitoring systems, displaying reservation and operating status of the charging points in real time on a large screen, and allowing for payment via mobile applications. Power will be sources from adjacent substations via the grid, and no new substations will be required, although substations will require upgraded

transformers. Solid waste will be collected by the municipal sanitation department, but no sanitation facilities will be provided. Charging stations will be equipped with fire alarms and suppression systems, and will be landscaped with appropriate vegetation for local conditions. The stations are described in more detail in IEE Appendix C.

Figure 25.Example of a BEB, produced by BYD, Hanzhou, PRC.

Source: ADB PPTA consultant, 2019.

Figure 26.Existing e-bus and e-bus charging station in Xiangtan, with two-nozzle charger.

Source: ADB PPTA Consultant, 2018.

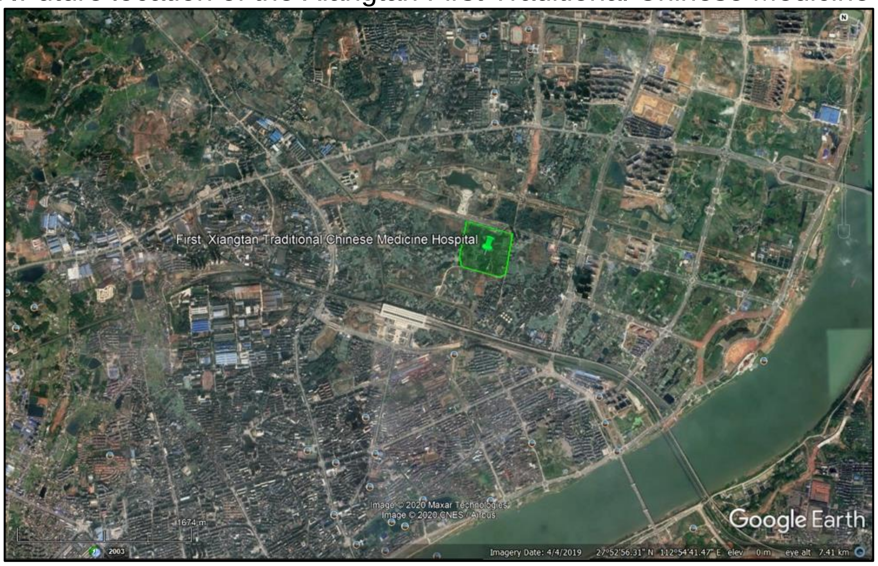
B. Building and Energy Systems Transformations

a. Xiangtan First Traditional Chinese Medicine Hospital

37. IFC Edge Certification and CCHP. The program will support the hospital in achieving EDGE certification, the first hospital in the PRC to be so certified. Developed by the International Finance Corporation (IFC) under the World Bank Group, EDGE (Excellence in Design for Greater Efficiencies) is an online platform, a green building standard, and a certification system used in over 150 countries. The EDGE application helps to determine the most cost-effective options for green design within a local climate context. EDGE can be used for buildings of all vintages, including new construction, existing buildings and major retrofits. A project that reaches the EDGE standard of 20% less energy use, 20% less water use, and 20% less embodied energy in materials compared to a base case building can be EDGE certified.

38. A review of the hospital design determined that despite a number of green building features that are incorporated into the existing design, in order to achieve EDGE certification improvements are required. The hospital will have a continuous and stable annual electricity and domestic hot water loads, a cooling load in the summer, and a heating load in the winter. In the current design cooling is provided by a water cooled centrifugal chiller and two absorption chillers, which can also provide hot water. Although this system is space saving, the efficiency of an absorption chiller in the summer is relatively low.

Figure 27.Future location of the Xiangtan First Traditional Chinese Medicine Hospital.



Source: ADB PPTA consultant 2019, and Google Earth 2019.

Figure 28.Artist rendering of the Xiangtan First Traditional Chinese Medicine Hospital.

Source: ADB PPTA consultant, 2019.

39. A assessment of gas tariffs, electricity tariffs, load profile, financial viability, available technology, energy efficiency improvements and emission reductions, and estimated capital expenses (CAPEX) and operation expenses (OPEX) was undertaken, and it was determined that the optimal energy system for the hospital to increase energy efficiency and reduce

emissions is a natural gas Combined Cooling, Heating and Power Generation (CCHP) system, developed in accordance with best international practice.[4]

Figure 29.Xiangtan First Traditional Chinese Medicine Hospital initial site plan.

Source: ADB PPTA consultant, 2019.

40. The program will install a CCHP system which will recover waste heat from a power generation unit to provide heating or drive an absorption machine for cooling. The system will consist of a 1 MW capacity natural gas internal combustion engine and generator unit; a 1.18 MW heating capacity absorber with 1.24 MW cooling capacity through heat recovered from jacket cooling water for the engine and flue gas exhausted from the engine; two 8.4 MW cooling capacity mechanical chillers for peak cooling load; two natural gas boilers with 6.4 MW heating capacity to cover peak heating load; and, other auxiliary components. The system will be intergarted with a roof-top solar system. A DeNOx system (Selective Non-Catalytic Reduction or SNCR) will be installed on the gas engine to ensure NOx emissions are less than 30 mg/Nm^3, and the gas boilers will use low-NOx burners. With the integration of CCHP into the hospital design, and the EbA measures described below, it is anticipated that the hospital design will receive EDGE certification, and will be fully functional even at flood events and/or power blackouts.

41. The wintertime heat demand and supply balance of the system is presented in Table 4. Heat recovery from CCHP will account for 15.5% of the total heating capacity. The remaining demand will be covered by the gas-fired boilers.

42. The summertime cooling demand and supply balance is presented in Table 5. The cooling capacity of absorption machine will account for 13% of the total cooling capacity. The remaining demand will be covered by centrifugal chillers. Main CCHP component parameters are presented in Table 6.

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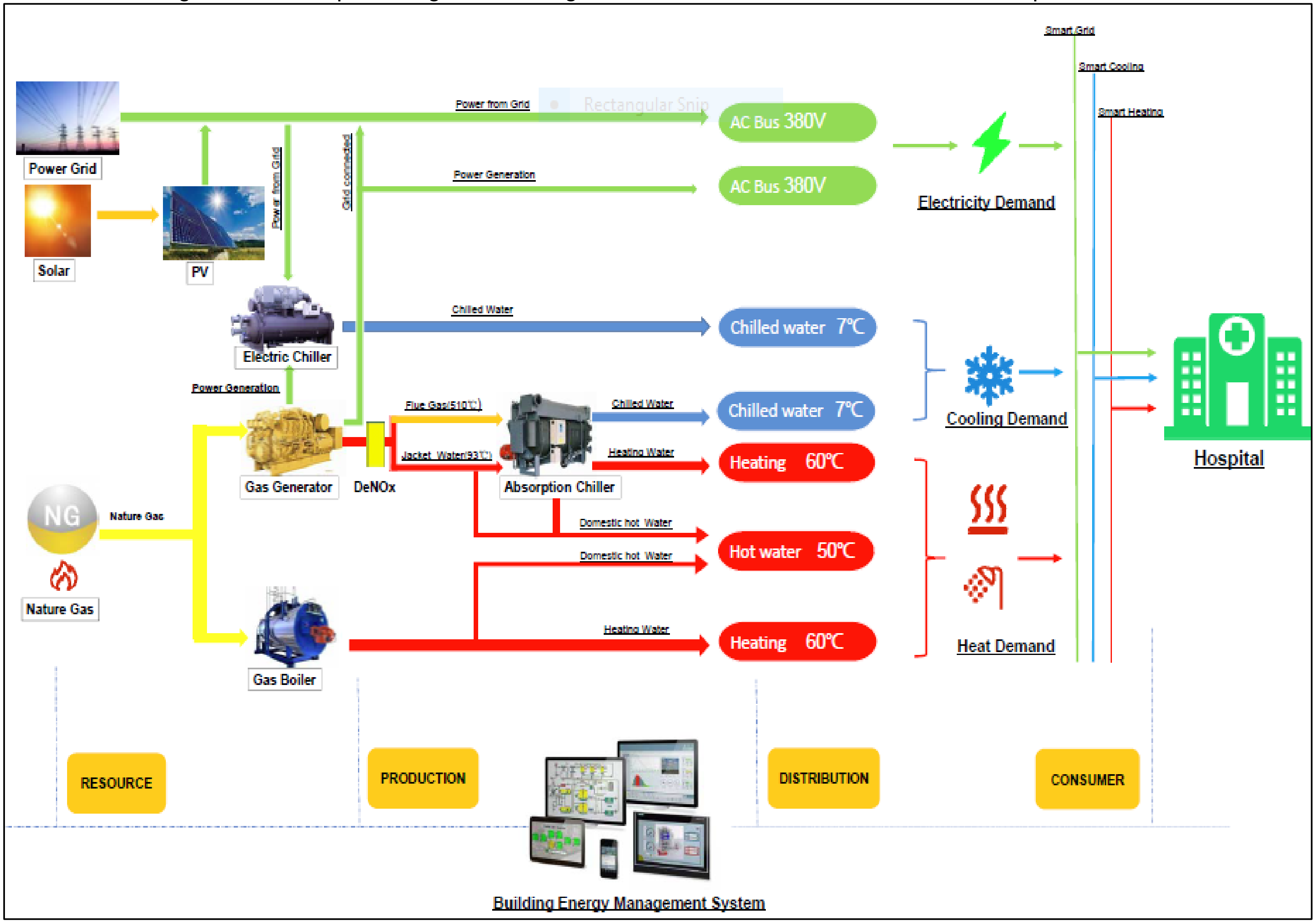
[4] CCHP is also commonly referred to as Tri-generation.

Figure 30.Conceptual diagram of Xiangtan First Traditional Chinese Medicine Hospital CCHP.



Source: ADB PPTA consultant, 2019.

Table 4.Xiangtan First Traditional Chinese Medicine Hospital CCHP wintertime heat balance.

Total Heating Supply	**7.58 MW**
CCHP heating capacity	*1.18 MW*
Boiler heating capacity	*6.4 MW*
Total Heating Demand	**6.9 MW**
Space heating load	*5.8 MW*
Domestic hot water load	*2.2 MW*
Balance	**+0.68 MW**

Source: ADB PPTA consultant, 2019

Table 5.Xiangtan First Traditional Chinese Medicine Hospital CCHP summertime cooling balance.

Total Cooling Supply	**9.64 MW**
Cooling capacity of absorption machine	*1.24 MW*
Cooling capacity of centrifugal chiller	*8.4 MW*
Total Cooling Demand	**9.5 MW**
Balance	**+0.14 MW**

Source: ADB PPTA consultant, 2019.

Table 6.Xiangtan First Traditional Chinese Medicine Hospital CCHP main components.

No.	Name	Capacity	Quantity
1	Gas Generator	1.00 MW Power Generation Capacity	1
2	Denitrification	NOx Emission <30 mg/m^3	1
3	Centrifugal Chiller	4.20 MW Cooling Capacity	2
4	Gas Boiler 1	3.70 MW Heating Capacity	1
5	Gas Boiler 2	2.70 MW Cooling Capacity	1
6	Absorption Chillers	1.24 MW Cooling Capacity 1.18 MW Heating Capacity	1

Source: ADB PPTA consultant, 2019.

43. **EbA Measures.** The hospital site is relatively flat, with elevations ranging from 34.1 to 35.5 masl. A deep creek runs through the site, draining towards the Hutan River. The flood risk hazard assessment undertaken by PPTA consultants during program preparation identified the site as being at high risk for flooding from the stream.

44. The program will help improve drought resistance and reduce flood risks at the hospital through the application of EbA measures.

(i) Drought resistance: the PRC sponge city guidelines include a Volume Capturing Ratio (VCR) of annual rainfall, which is the minimum stormwater storage volume to cover water demands in drought periods, and is set according to land use and ecological damage sensitivity of the area. An assessment of the hospital site determined that VCR target storage volume is approximately 740 m^3.

(ii) Flood protection: a site assessment determined that for protection from pluvial flooding during periods of extreme rainfall with a safety risk of 1-in-30 years, the 5.53 ha hospital site has a required retention capacity of 5,630 m^3.

45. The program will support the hospital in achieving these drought resistance and flood protection targets through the implementation of a range of sub-catchment rainwater retention

EbA measures, identified initially in cooperation with Xiangtan government staff in a series of ecosystem-based training and design workshops, and then further developed in the XCRC Toolbox. It illustrates the range of EbA measures to be used, including rainwater gardens, permeable pavement, urban wetlands and green roofs. The design also includes a 70 m^3 storage tank under the green space on the east side of the hospital to collect rainwater green space irrigation.

46. The XCRC Toolbox predicts that these measures will provide a total water storage capacity of approximately 7,840 m^3, considerably more than the drought protection VCR target of 740 m^3 and the 1-in-30 year pluvial flood protection target of 5,630 m^3. In particular the rain retention ponds, the rain gardens and the swales create large peak storage volumes for both drought resistance and flood protection. Peak flows will be reduced by a factor of 35 as compared to an area without this retention capacity. Substantial positive effects are also predicted for the reduction of suspended sediments and their adsorbed pollutants and pathogenic bacteria. However, the effect on nutrients is neutral. This is caused by the intensive green roofs used to grow medicinal plants and herbs which will needs fertilization. Some of this fertilizer will be washed out into the runoff, giving no net effect of the EbA measures on nutrient levels in the runoff.

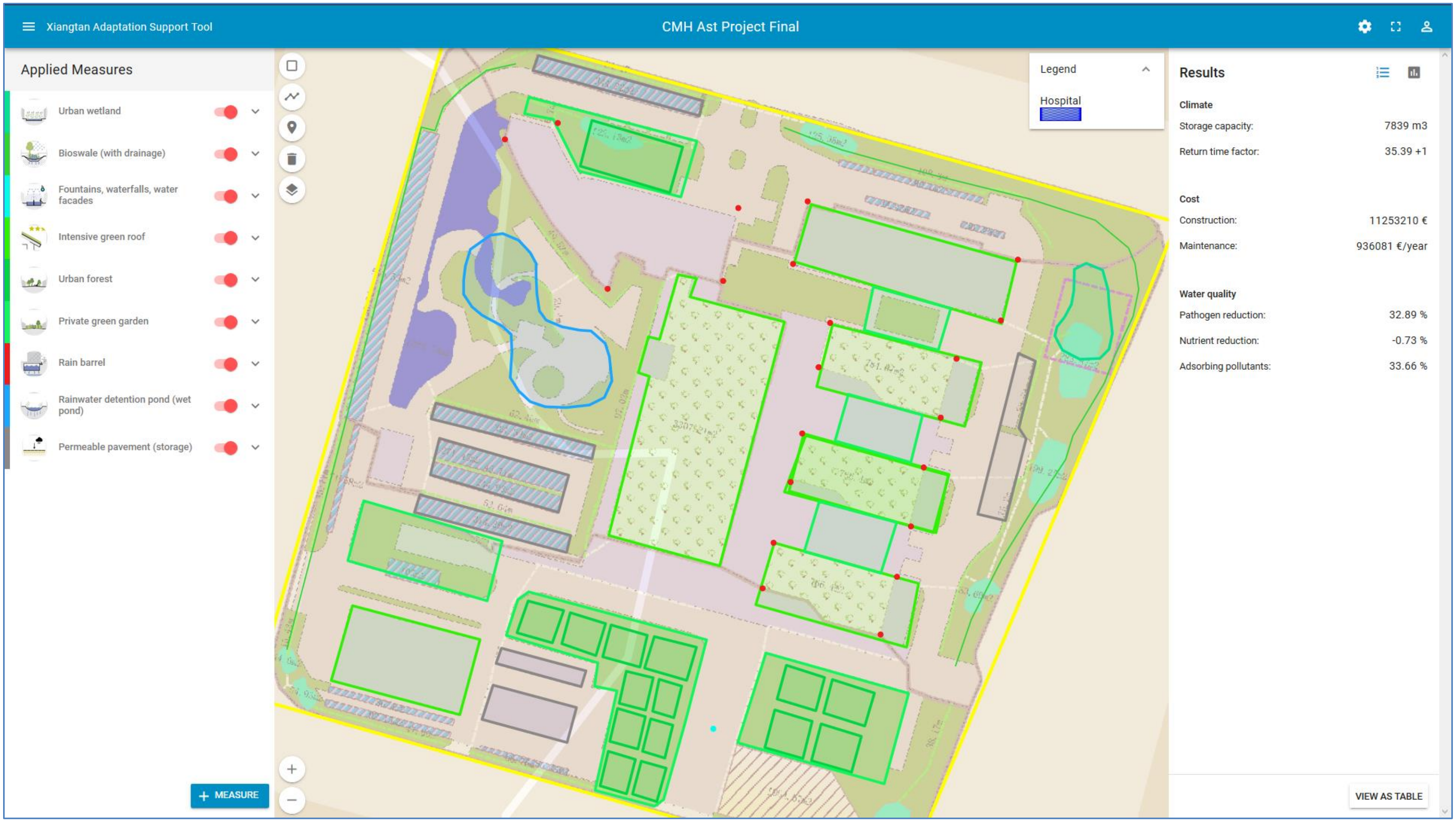
47. In addition to reducing flood risks and improving runoff water quality, the EbA measures will enhance green space, provide medicinal plants and herbs, and allow rainwater to be harvested so as to withstand periods of drought more effectively. In addition, EbA measures will help to strengthen biodiversity, and improve the landscape.

Figure 31.Design parameters of EbA measures for the Xiangtan First Traditional Chinese Medicine Hospital, as presented in the XCRC Toolbox.

Measure	Surface	Storage capacity (m3)	Return time factor (+1)	Groundwater recharge (mm/y)	Evapotranspira... (mm/y)	Heat reduction (C)	Cool areas
Urban wetland	383.9	288	0.29	0	0	0.02	0
Bioswale (with drainage)	475.43	166	0.23	25	0	0.03	0
Fountains, waterfalls, water facades	201.06	201	0	0	0	0.01	1
Intensive green roof	9246.64	3699	0.4	0	21	0.51	0
Urban forest	2114.39	922	0.68	4	8	0.12	1
Private green garden	6226.42	763	3.75	45	-2	0.35	0
Rain barrel	16.49	16	0.27	0	0	0	0
Rainwater detention pond (wet pond)	1302.32	1302	22.9	93	1	0.07	0
Permeable pavement (storage)	2175.8	481	6.89	17	-2	0.12	0

Source: ADB PPTA consultant, 2019

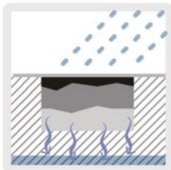
Figure 32.Conceptual design of EbA measures for the Xiangtan First Traditional Chinese Medicine Hospital, as presented in the XCRC Toolbox.



Source: ADB PPTA consultant, 2019.

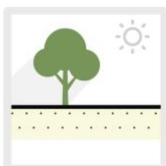
Figure 33.EbA measures to be implemented.

Rain garden



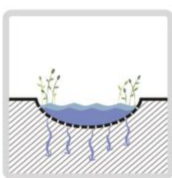
These are sandy soil or aggregate filled depressions that treat stormwater runoff to improve water quality. Stormwater is captured and allowed to percolate through the soil/aggregate layer, where pollutants are removed, prior to being released through an underdrain located at the bottom of the depression.

Creating shade



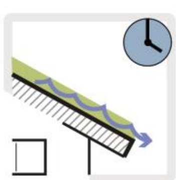
Creating shade is important to prevent surfaces from heating up and to cool the surroundings. This can be accomplished by using trees, pergolas, overhangs, awnings and such. Arcades and covered walkways are urban elements commonly used in warm countries to create shade.

Rainwater detention pond (wet pond)



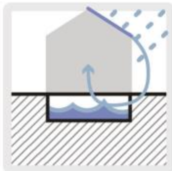
Buffer ponds temporarily capture precipitation and allow it to drain off slowly. During rainfall, the rainwater is captured in the pond and subsequently drained off to create room for the next precipitation. Buffer ponds can be designed to have a mostly stony or a mostly natural appearance.

Green roof with drainage delay



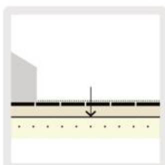
Green roofs with drainage delay are also called retention roofs. It is a green roof that can store extra water in a substrate layer under the green planted layer and is drained delayed with a pinched drain. A polder roof is a retention roof where the control system is linked to the weather forecast.

Systems for rainwater harvesting



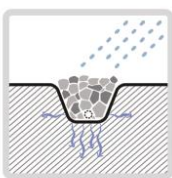
Rainwater harvesting is the collection and storage of stormwater for reuse on site. This is most commonly be achieved by capturing runoff from the roof of a building, however, it can also include the collection of runoff from throughout the site or byproducts from systems such as air conditioning condensate. The collection structures can take on multiple forms and be installed either above ground or subsurface. Depending on its source and treatment, the harvested water can be reused on site for irrigation.

Permeable pavement (infiltration & storage)



Permeable pavements consist of porous material that absorbs rainfall. Water can be stored either in the top layer (e.g. very open asphalt concrete) or in below the top layer in the foundation. Besides reducing runoff, permeable pavements can trap suspended solids and filter pollutants from the water.

Infiltration trench



An infiltration trench, also known as a French drain, is a linear feature used to reduce stormwater runoff and improve water quality. These shallow excavated trenches are filled with aggregate or crushed stone that is designed to allow for stormwater to infiltrate the ground plane and ultimately percolate though permeable soils into the groundwater. Their linear shape can also serve to convey stormwater from one area to another, or away from built structures, and typically contain a perforated pipe underdrain.

Source: ADB PPTA consultant, 2019.

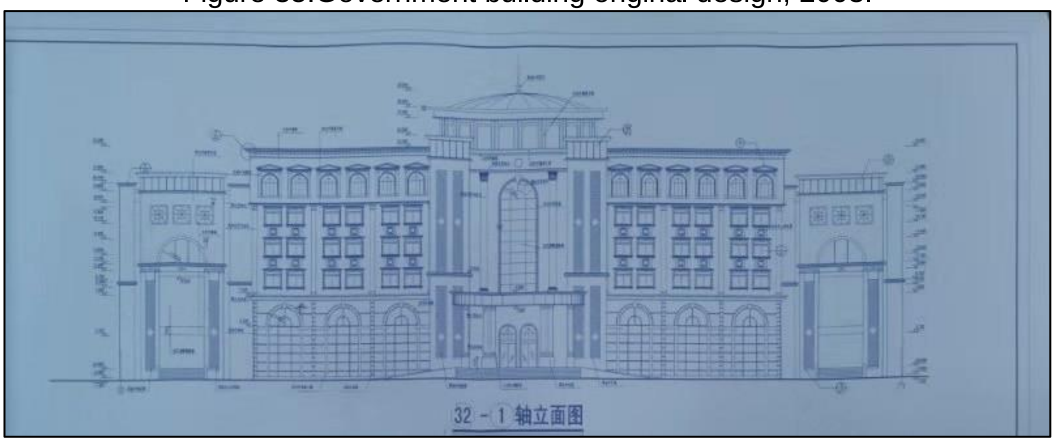
b. Government Building Retrofit

48. The program will support the retrofit a semi-abandoned government-owned office building into a training center to showcase green and low-carbon building techniques. Located in Yuetang District near the intersection of Furong Mi Road and Mudan Road, the building was originally built in 2003 and was used as government offices. Currently only the 4th floor is still in use as a Training Center, and the rest of the building has been abandoned.

Figure 34.Location of the government-owned building to be retrofitted.

Source: Google Earth, 2019.

Figure 35.Government building original design, 2003.



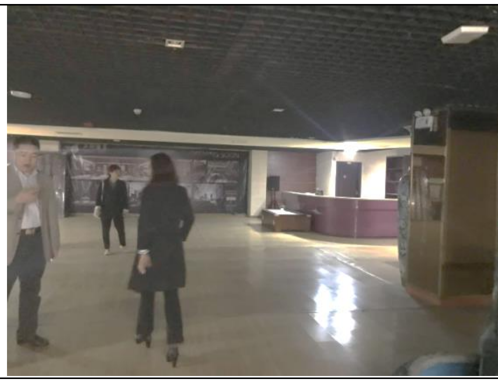
Source: Xiangtan Municipal Government FSR on Government Building (2003).

Figure 36.Government building current condition, November 2019.

Front view of the building

Current condition in a room on the first floor of the building

Inside view from the entrance door

	
Current condition of main area at the second floor of the building	Current condition of a room on the second floor of the building

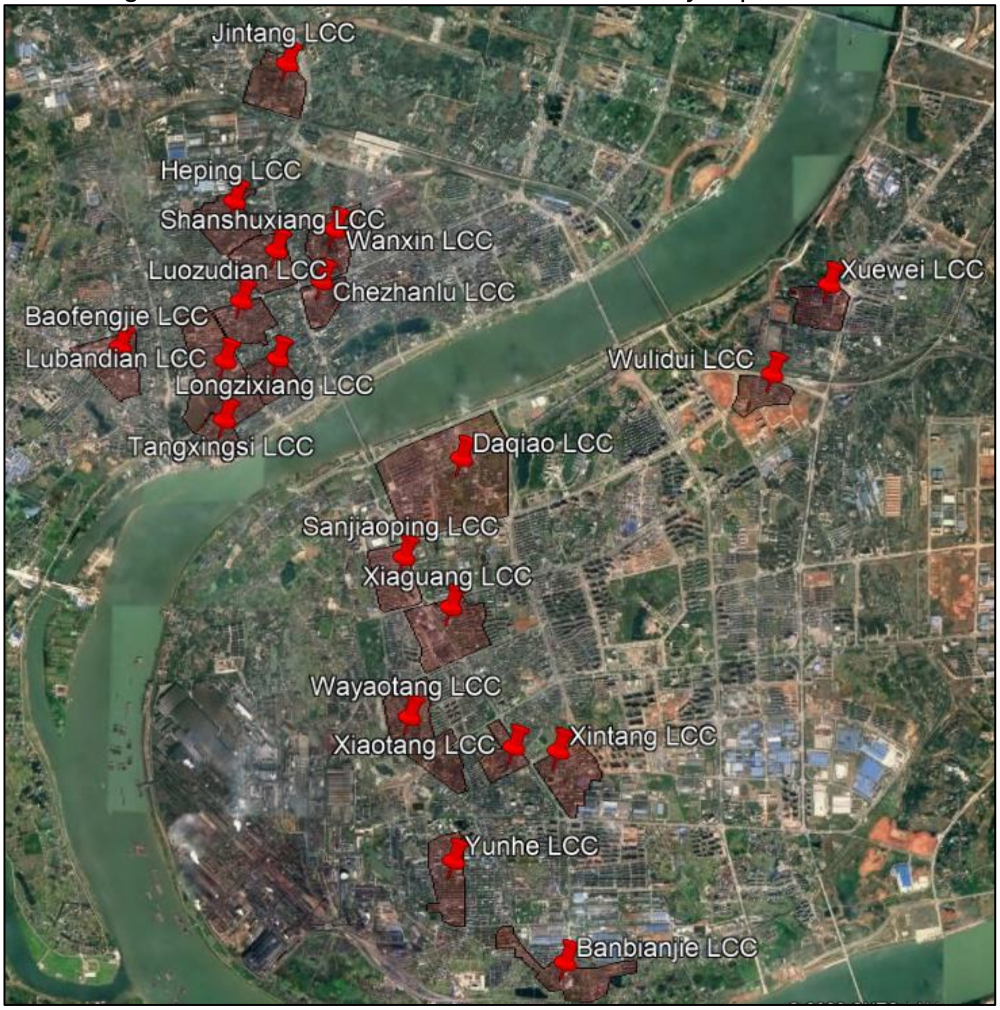
Source: ADB PPTA consultant, 2019.

49. The total floor area to be retrofitted is approximately 6,000 m^2, not including the basement parking area. The retrofit will include external wall and roof insulation, triple/quadruple-glazed windows, an intelligent sunshade system, central air conditioning, combined with heat pump system and/or roof top solar energy system to optimize energy consumption, an intelligent building energy monitoring system, high efficiency energy appliances, water saving faucets and toilets, and other green and low-carbon features. Once completed the building will be EDGE certified. The municipal government intends to use the building as the *Asia Pacific Low-Carbon Training Center* to showcase the EDGE-certified building retrofit and to disseminate Xiangtan’s LCT experience and learning to other cities in the PRC and beyond.

C. Low Carbon Community (LCC) Transformation

50. Small-scale low carbon renovations and retrofitting will be undertaken in 20 Xiangtan low-income communities (**Error! Reference source not found.**). Low carbon community (LCC) works will include building insulation improvements, conversion from coal to natural gas cooking for low income households, installation of roof top solar hot water systems and solar PV panels, LED street lighting, EbA measures in community parks, and installation of electric vehicle and bike charging stations. LCC measures by community are presented in **Appendix E**). Works will be undertaken in existing buildings or facilities, and no building demolition will be required.

Figure 37.Locations for low-carbon community improvements.



Source: ADB PPTA consultant 2019, and Google Earth 2019.

Figure 38.Typical low-income communities that will receive LCC improvements in Xiangtan.

Jintang community, Yuhu District.	Lubandian Community, Yuhu District

	
Wulidui Community, Yuetang District	Xuewei Community, Yuetang District

Source: ADB PPTA consultant, 2019.

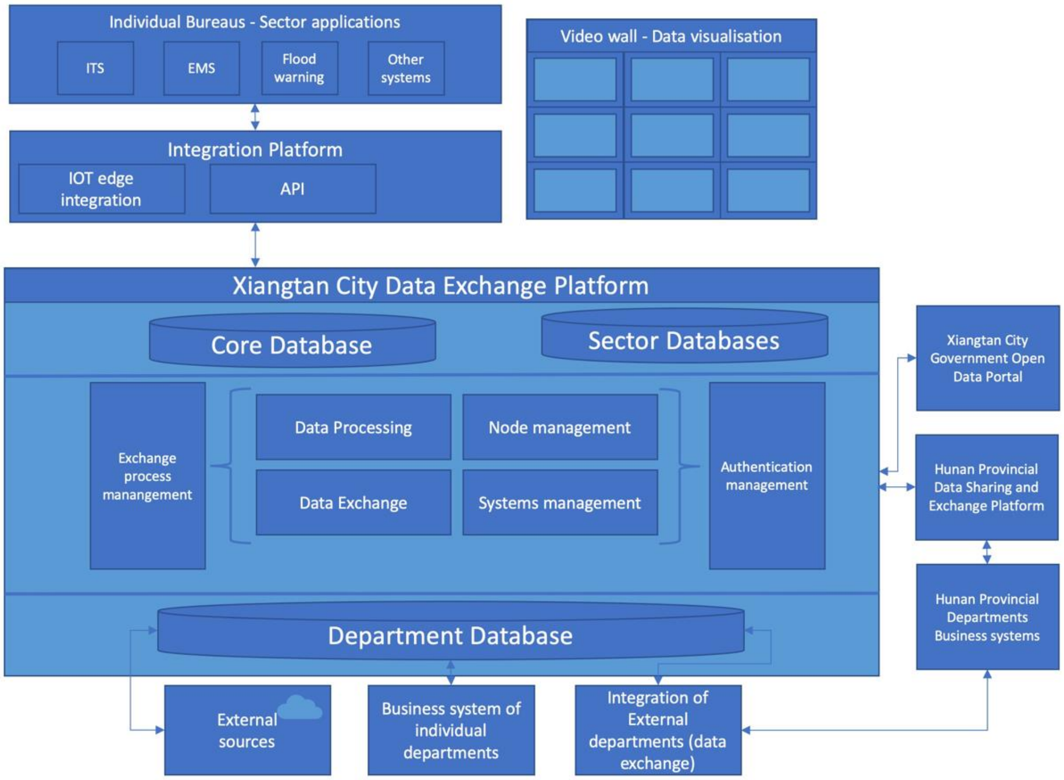
II. Output 2: Information and Knowledge Platforms for Informed Decision and Low-Carbon Behaviorial Change Enabled

51. Physical transformations in output (i) will be complemented by ICT and knowledge platforms to support Xiangtan's LCT. A number of sectoral ICT platforms will be installed or upgraded, and then consolidated into a city-wide ICT platform. These will include: (i) reprogramming the existing intelligent transport system (ITS) to prioritize people and public mobility systems; (ii) developing a smart bus information platform which combines various subsystems to enable more control over the operation of busses while sharing real time location data to passengers; (iii) a building energy management system to monitor and improve energy efficiency of 200 public buildings; (iv) a community-scale energy and utility management system to optimize operational efficiency of over 1,300 companies; (v) integrated urban catchment management plans for key flood prone areas in Xiangtan; (vi) an early flood warning system to monitor and analyze potential risks caused by fluvial and pluvial floods; and (vii) an environmental monitoring and assessment system. These platforms will enable better decision making and foster behavior changes towards LCT.

A. City-Wide ICT Platform

52. The Smart City ICT Platform will have open and scalable architecture so that the system can continuously expand by integrating sectoral ICT platforms and providing new functionalities. It will have a data exchange platform, for data sharing, data integrity verification, authentication, and data security management. The platform will result in synergies across the city, combining multi-sector data from different ICT platforms to make up a truly smart city.

Figure 39. City-wide ICT Platform Architecture of Big Data Center



B. Optimization of the Xiangtan ITS

53. The existing Xiangtan Intelligent Transport System (ITS), or Smart Integrated ITS as it is referred to by the Xiangtan Traffic Police, is a newly implemented system covering all 225 intersections in the city. The system is comprised of 225 traffic lights, 1,100 traffic sensors (cameras), and a self-optimizing algorithm and platform. The system runs on various parameters to control and optimize traffic flows. However, it was designed with a focus on car traffic and does meet the needs and demands of pedestrians and other non-car users.

54. A green wave system refers to traffic light coordination to allow continuous traffic flow over several intersections in one direction. Green wave systems can be used for certain groups of vehicles like busses and can be implemented dynamically using real-time sensors like GPS or short range proximity sensors. The sensor data is used to synchronize traffic signals to provide green lights for improved traffic flows

55. The current Xiangtan ITS is capable of implementing a green wave for any vehicle without any additional hardware. With the right parameters as input to the smart intersections, busses can be given priority in traffic inside or outside the median bus lane.

56. The program will modify the Xiangtan ITS parameters by prioritizing public transport bus traffic, followed by pedestrians, thereby improving services for bus operators and providing better pedestrian flows. Each of the 225 intersections signals will be self-optimized in real time according to the traffic flow. With correct programming and calibration the system will be capable of providing both priority signaling to green waves for busses, without any changes or additional components.

57. The ITS improvements will include a combination of exclusive traffic signals for busses with priority signal programming optimized for increasing bus speeds in the median bus lanes as well as for the busses in mixed traffic. This will reduce travel time for bus users making travelling by busses more appealing. The system will work best if it can detect an incoming bus before it reaches the signal. To achieve this the system will utilize highly accurate real time GPS positions of the busses provided by the bus operator, the Jiaofa Group.

58. Overall, the combination of priority bus lanes, traffic light reprogramming, smart bus platform and human-optimized traffic operation and management, will prioritize bus flows over other traffic flows and increase public transport efficiency.

a. Smart Bus Platform

59. Public transportation systems are increasingly equipped with information and communication technologies in order to improve the level of service and facilitate fleet management. Automatic Vehicle Location (AVL) was first used for improving operations and management. Later, these systems were also utilized to provide real-time information (RTI) to passengers in the context of public transport systems. More specifically, in the context of public transport busses, bus RTI refers to information on service disruptions, crowding conditions, prescriptive journey planners or the time remaining until the arrival of the next bus.

60. The program will develop a smart bus information platform which combines various AVL and RTI subsystems to enable more control over the operation of busses while sharing real time location data to passengers and service providers. The system will include upgrading of the existing bus RTI system in combination with a bus dispatch system which make use of real time GPS location of the busses; smart accessible bus stops (see above); and installation of system devices on the bus including IC Card terminals, coin machines, face recognition terminals, and GPS modules, to make the system more connected and hence easier to monitor and operate more efficiently.

61. A bus monitoring control room equipped with 24 large screens to monitor various data from the smart bus platform will be installed at the new headquarter building of Jiaofa Group, the Xiangtan bus operator. The screens will act as a display to the smart bus platform, showing amongst other things the bus RTI and position of the busses, bus routes, information on service disruptions, crowding conditions, communications with the driver, and passenger and road videos. This will give the operators a better overview of their services for all their bus routes at one place using a single platform.

C. Building and Utility Energy Management Systems

62. In cooperation with the Xiangtan Housing Bureau the program will develop and install intelligent building and utility energy management system (BEMS), to monitor electricity, water, and gas consumption, in 200 public government buildings. In total approximately 900,000 m^2 floor area will be covered. The main works will include minor updates of existing monitoring platform, installation of sensors and meters, and integration into the ICT platform.

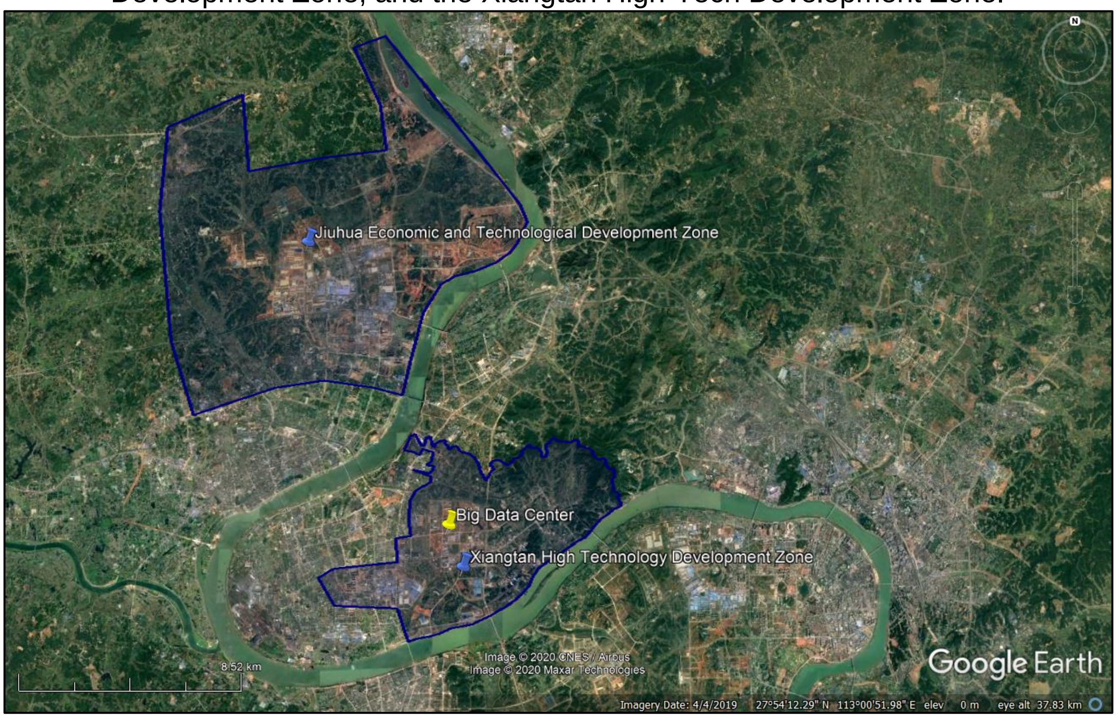
63. A BEMS will also be installed in the Xiangtan First Traditional Chinese Medicine Hospital, to manage multi energy systems such as grid connection and the CCHP. The BEMS will continuously monitor operation data, forecast demand based on weather, customer behaviors and actual indoor indicators such as room temperature and lighting, and automatically control

energy production and distribution to meet the demand. It will also pro-actively promote demand side energy conservation through timing schedule, detection of occupation, etc.

D. Community-scale Multi-Energy and Utility Management System

64. A community-scale multi-energy and utility management system (CMEUMS) is used in an unstable system based on renewable energy (photovoltaic and wind power) generation, to realize optimal operation that minimizes CO_2 emission while solving power quality problems due to supply-demand imbalance and reverse power flows. A CEMS can optimize energy savings of an entire community. The program will develop a CEMS for the Jiuhua Industry Development Zoneto monitor electricity, water, and gas consumption of over 1333 enterprises and other relevant buildings in the zone.

Figure 40. Locations of the Xiangtan Big Data Center, Jiuhua Economic and Technological Development Zone, and the Xiangtan High-Tech Development Zone.



Source: Google Earth, 2019; and ADB PPTA consultant, 2019.

65. The CMEUMS will include:

i) digital dispatch and control system for zone operation;
ii) administrative approval service system;
iii) online monitoring and control system for public facilities in the zone;
iv) data manufacturing public service system
v) comprehensive energy service system;
vi) spare parts and other public service systems; and,
vii) a schematic diagram of the zone.

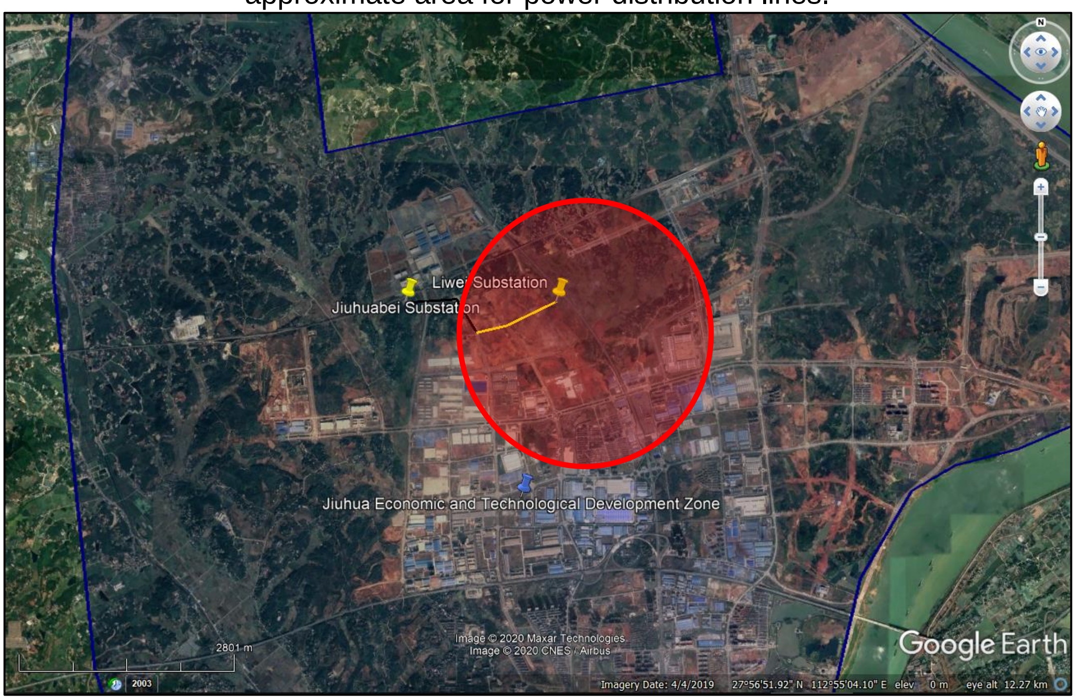
66. CMEUMS software will be developed and installed in the Xiangtan Municipal Big Data Center, one of the XMG bureaus established under the government mandate of "Xiangtan Smart City Pilot",[5] and all data will be collected and sent there.

67. The Jiuhua Economic and Technological Development Zone is currently underserved by electrical infrastructure. There are few substations, and the distribution network is limited. To address these shortcomings, the program will construct i) construct a 110 kV substation and associated transmission lines, and ii) a power distribution grid.

68. **Liwei Substation.** The program will construct the 110 kV Liwei Substation, consisting of one 63 MVA transformer, one 110 kV feeding bus, 14 outgoing feeder lines of 10 kV, and one 6000 kvar low voltage capacitor. One bay will be added to the existing Jiuhuabei 220 kV Substation, and it will be the 110 kV power source for the Liwei Substation. A 0.8 km JL/G1A-300/25 overhead transmission and a 1.9 km of YJLW-110-1600 underground cable will connect the Liwei Substation with the Jiuhuabei substation.

69. **Power Distribution.** The program will install 10 kV power distribution lines in a pilot area within the Jiuhua Economic and Technological Development Zone. The lines will have a maximum length of 1.8 km, and in total of 7.3 km of lines will be installed.

Figure 41.Locations of the Liwei Substation, transmission lines and power distribution area, Jiuhua Economic and Technological Development Zone. The black lines denotes an underground cable, the yellow an above ground transmission line. The red zone is the approximate area for power distribution lines.



Source: Google Earth, 2019; and ADB PPTA consultant, 2019.

[5] A data center is building, dedicated space within a building, or a group of buildings used to house computer systems and associated components, such as telecommunications and storage systems. Data over the size of a petabyte is considered Big Data.

70. The power demand in the pilot area is predicted to be 344 MW in 2025, and 469 MW in 2030. Annual power consumption in the pilot area is predicted to be 1.769 billion kWh in 2025, and 2.234 billion kWh in 2030.

E. Smart Early Flood Warning System

71. Xiangtan City has experienced substantial economic loss and social impacts caused by river and urban flooding. Existing flood warning systems relevant to Xiangtan are as follows:

Four-level (province, city, county and township) Early Warning Platform

a) The platform has videos, images and monitoring data (from rainfall station, water stage gauging station, and rainfall- water stage integrated station). Every city, county, and town is responsible for monitoring by itself, including automatic monitoring and simple manual monitoring.
b) Data is sent to counties and Hunan province, but not to the city level.
c) There are some emergency operational plans that have been developed.

Xiangtan City Mountain Torrents Disaster Monitoring and Early Warning System

Its disadvantages are:

a) The collection of engineering information is relatively limited, so the system is lacking in decision-making support capacity.
b) Poor operation for pumping stations and reservoirs.

Hunan Province Cloud-based Flood Warning System

The provincial Water Conservancy Department is responsible for this system and provide a terminal for each city. Data from this system covers the data provided by the Xiangtan City Mountain Torrents Disaster Monitoring and Early Warning System.

Xiangtan City Small Watershed Flood Analysis System

Because there are a few rainfall stations and water stage gauging stations, and small slopes in this watershed, intelligent early warning for reservoirs has not been implemented.

Xiangtan City Small and Medium River Hydrological Monitoring System

This system was established by the Hydrological Bureau of Hunan Province. 20 stations can cover information of watersheds above 200 km^2, but there is no information for small watersheds (below 200 km^2), so flood forecasting cannot be performed.

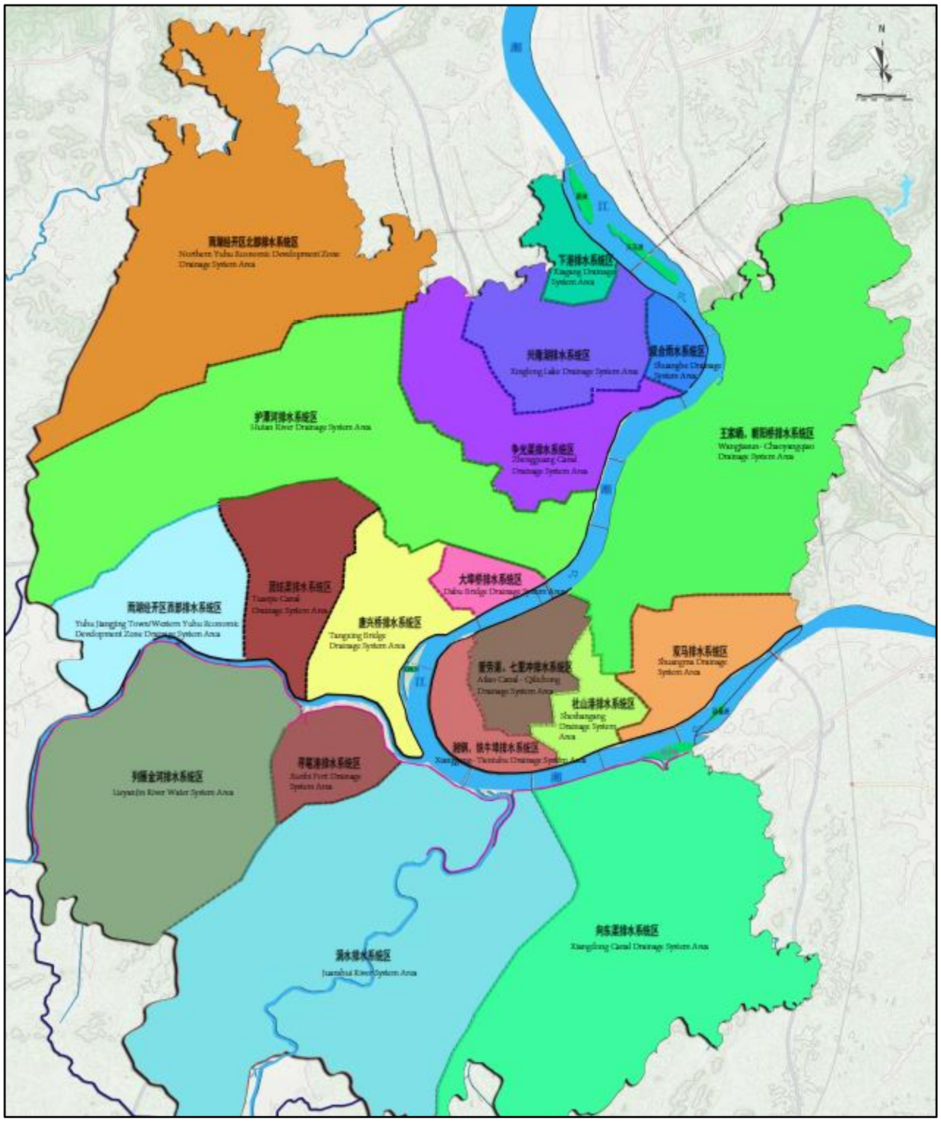
72. The above systems are described by municipal authorities and PPTA flood response experts as lacking functionality to support effective emergency management. Deficiencies include:

(i) low density of rainfall and stream level gauges;
(ii) limited status monitoring of major control structures;
(iii) limited functionalities within the existing software;
(iv) risk information output from the existing system only covers rainfall from the flash flood warning system, and some river levels, and is insufficient to support effective emergency response and management.

73. In addition, there is currently no existing Xiangtan urban flood management system.

74. In response to these deficiencies, the program will develop a modern early flood warning system at the Xiangtan Big Data Center. The flood warning system was proposed in Section 10.3.1 of the *Urban Water Conservancy Plan of Xiangtan (2016-2030)* as one of 8 supporting systems for modern water conservancy development in Xiangtan. The early flood warning system will be consistent with the Xiangtan Urban Master Plan and the Xiangtan Urban Flood Management Plan. The system will cover 5 drainage areas and 19 sub-catchments, with a total catchment area of 1,069 km^2 (Figure 42).

Figure 42: Coverage of the Xiangtan Early Flood Warning System.



Source: ADB PPTA consultant, 2019.

75. The system will support flood risk assessment, information dissemination and emergency response during flood events. The system will also share and exchange necessary data through secure protocols with other smart city sub-components, such as the road ITS.

76. The system will be built by integrating large amount of real time hydrological and hydraulics monitoring data with river catchment, urban drainage, and risk assessment models.

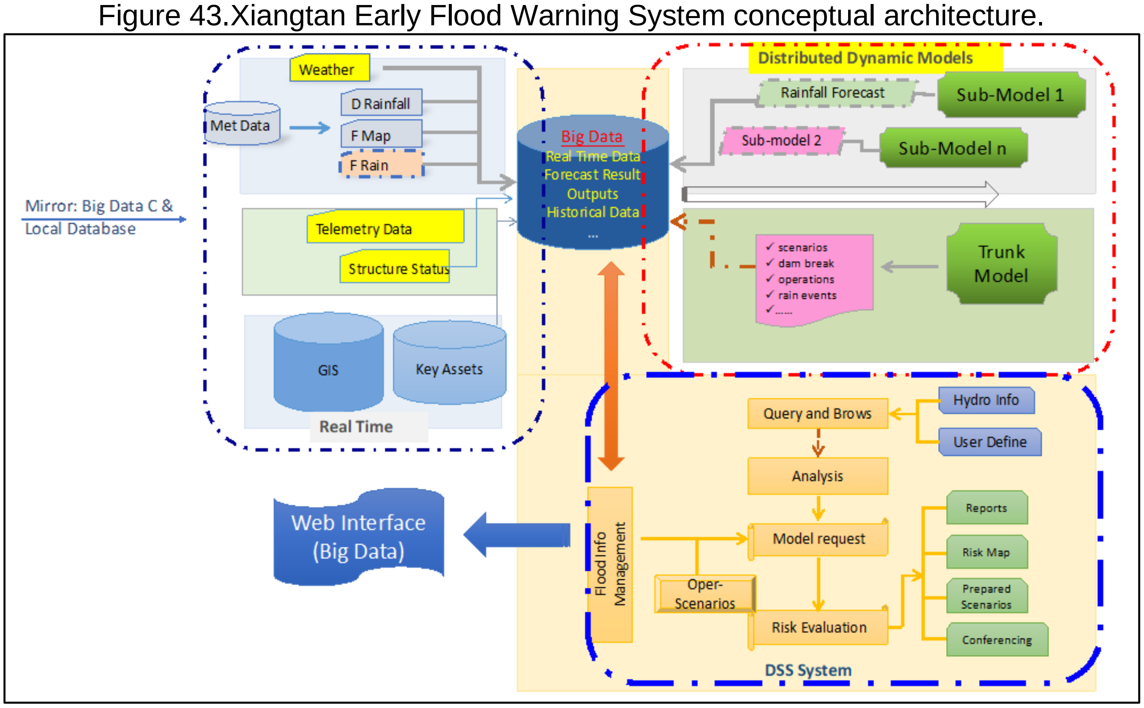
The system will be able to quickly process large amounts of data and provide rapid forecasting models to provide necessary information for decision making. The early warning system will automatically trigger workflows to facilitate daily operations. However, operators will still be able to run forecasts manually if necessary. A diagram of the system conceptual architecture is presented in Figure 43.

77. Data for the system will be sourced from:

(i) 62 rain gauges within Xiangtan City administrative boundary;
(ii) 5 hydrological monitoring stations;
(iii) major river flood gates and pump operational status;
(iv) central city drainage pump operational status;
(v) rainfall, wind, atmospheric pressure, and evaporation data from the Xiangtan climate center;
(vi) rainfall, wind, atmospheric press data from the National Climate Centre;
(vii) rainfall, river level and flow forecast from the provincial Flood Management Department;
(viii) urban flood incident records;
(ix) traffic flow data;
(x) key infrastructure data; and
(xi) the Xiangtan municipal GIS.

78. In addition, in order to ensure model accuracy, the municipality will provide digital elevation maps, river and pipe data, and long time series of model input data for model calibration and validation.

Figure 43.Xiangtan Early Flood Warning System conceptual architecture.



Source: ADB PPTA consultant, 2019.

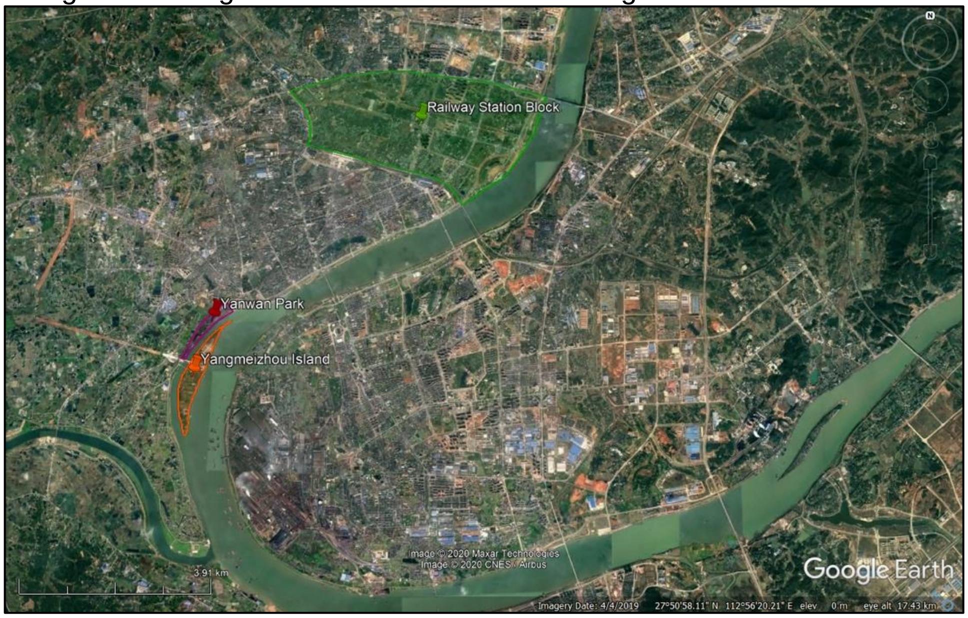
79. Key tasks in the system development include:

(i) review existing systems, quality check and process all data required for dissemination and model use;
(ii) build city-wide river network hydrological and hydraulic models to predict flows and water levels;
(iii) build 4 small Type I reservoir operational models;
(iv) build urban drainage models for central city with rapid 2D, if DEM supports;
(v) model calibration and validation;
(vi) develop early warning system framework which facilitates data (both observed and forecasted) processing and hydrological forecasting, as well as information dissemination. For urban flooding, the system will provide the inundation area and depth, as well as the flood propagation, to facilitate decision making;
(vii) data communication between the Big Data Centre and the Flood Management Department;
(viii) build data management module;
(ix) integrate real time data and model within the system framework;
(x) integration with existing system, to maximize the use of existing information;
(xi) installing, testing and troubleshooting on site; and
(xii) provide extensive training to local forecasting teams, and 3 years support and maintenance after system completion.

F. Integrated Urban Catchment Management Plans

80. The Xiangtan pluvial flood assessment (**Chapter III**) determined that some planned Xiangtan urban development zones are in high flood risk areas, including the ‘Railway Station Block’, ‘Yaowan Park’ and Yangmeizhou Island. These areas are already suffering from frequent flood events and associated economic losses. The program will develop Integrated Urban Catchment Management Plans for each area. The plans will be developed through comprehensive flood modelling, flood hazards assessment studies, geotechnical surveys, and conceptual design. Plan development will be based on the principles of resilience improvement, and the “room for river” principle that allows flooding in upstream areas of the river to lessen flood impacts on downstream urban areas. Plan development will help avoid economic loss induced by future flood events.

Figure 44.Integrated Urban Catchment Management Plans locations.



Source: ADB PPTA consultant 2019, and Google Earth 2019.

G. Environment Monitoring and Assessment System

81. The program will develop a top-level environment monitoring and assessment system (EMAS), which will acquire data from sub-systems including air, surface water, and ground water monitoring networks.

82. The development of the EMAS concept is based on input from Environmental Bureau. The concept is visualized as “One Platform”, “One Center” and “Three Networks”, where:

(i) “One Platform” is an ecological and environmental data application;
(ii) “One Center” is an ecological and environmental data hub at the Xiangtan Municipal Big Data Center; and
(iii) “Three Networks” is comprised of air quality, surface water quality and ground water quality monitoring networks.

83. The EMAS will include an automated environment monitoring network covering the entire Xiangtan city, and a region-wide ecological and environmental monitoring system. The EMAS will utilize an information management platform to achieve accurate environment monitoring, intelligent management, and scientific decision-making based on ecological and environmental data.