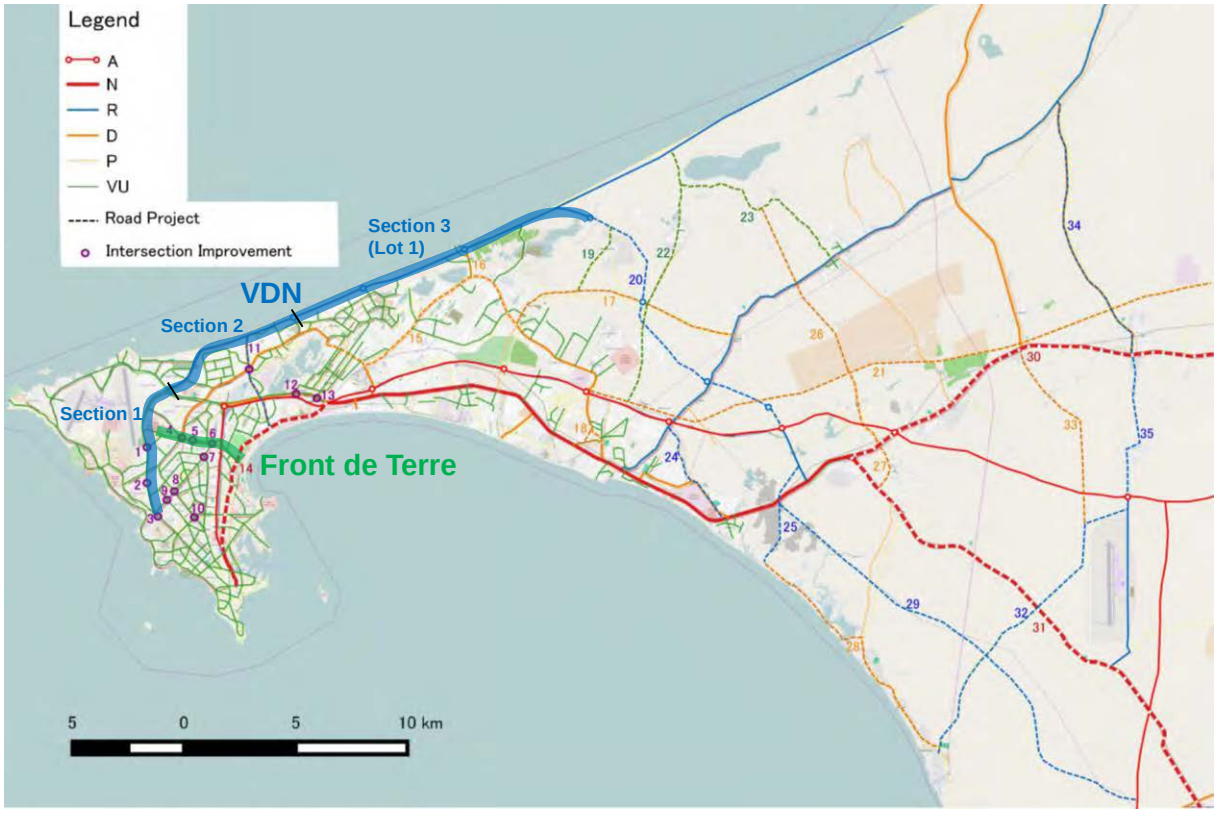
CHAPTER 12 INTERSECTION IMPROVEMENT PROJECT ON VDN AND FRONT DE TERRE

12.1 Introduction

VDN was originally planned as a regional arterial road, serving the traffic to and from Dakar via the Northern part of the peninsula. At present, Section 1 (6 km) in the city of Dakar is in service and the work is in progress in Section 2 (9 km) and part of Section 3 (17 km). As presented in Section 7.2, there are three bottleneck intersections (T01: Station SDE, T02: Cité Keur Gorgui, and T03: Aimé Césaire, from North to South) on VDN Section 1.

Meanwhile, Front de Terre road is a major arterial road in the city of Dakar, connecting East-West with VDN, Routes des Niayes, the toll motorway and National Route 1. Furthermore, as presented in Section 7.2, at present, there are three bottleneck intersections (T04: Liberte 6, T05: Khar Yalla and T06: Bourguiba, from West to East) on this road. Out of these three intersections, the improvement of Liberte 6 intersection (T04) is being studied, along with the implementation of the pilot project of BRT by the World Bank.



Note: A (motorway), N (national road), R (regional road), D (department road), P (listed track), VU (urban road)
Source: JICA Study Team

Figure 12.1.1 Location of VDN and Front de Terre Roads

The result from the latest household travel survey, which will support the new plans, has not been released yet. So far, there is no plan for the development of new arterial roads in the center of Dakar, which will drastically change the future traffic situation. Therefore, if no proper improvement

measures are taken for these intersections, they will remain bottlenecks. Thus, this pre-feasibility study particularly targets the project that consists of five sub-projects, namely, the improvement of the above-mentioned five intersections (Station SDE, Cité Keur Gorgui, Aimé Césaire on VDN, Khar Yalla and Bourguiba on Front de Terre). These projects aim to recover the traffic function of the regional arterial road, realize smoother traffic inside the city and deal with the future growth in traffic demand. They also hope to contribute to the development of the overall economic and logistic activities of the Dakar metropolitan area, as well as the whole country.

12.2 Current Situation

12.2.1 Location Map

Figure 12.2.1 shows a location map of the target area for the five intersections that are under study. Station SDE, Cité Keur Gorgui and Aimé Césaire are the intersections that are located along VDN, whereas Khar Yalla and Bourguiba are located along Front de Terre. To comprehend the current situation of these intersections, a directional traffic count survey, a signal phasing survey, a traffic queue length survey and a travel speed survey were conducted. The results of these surveys are presented in the following sub-sections.

Source: JICA Study Team

Figure 12.2.1 Location Map of the Target Area

12.2.2 Directional Traffic Count Survey

Table 12.2.1 summarizes the traffic volumes at the sub-project locations along VDN and Front de Terre, which were obtained from the directional traffic count survey. The directions of the flyovers/underpasses that are being proposed as improvement alternatives (as shown in Section 12.5) are also included in the table to check the consistency between the directions of the grade separation

structures and the directions of major traffic flow. Figure 12.2.2 presents the traffic volume by turning direction at each of the sub-project locations. A more detailed description of the directional traffic count survey is presented in Appendix A, Section A.6.1.

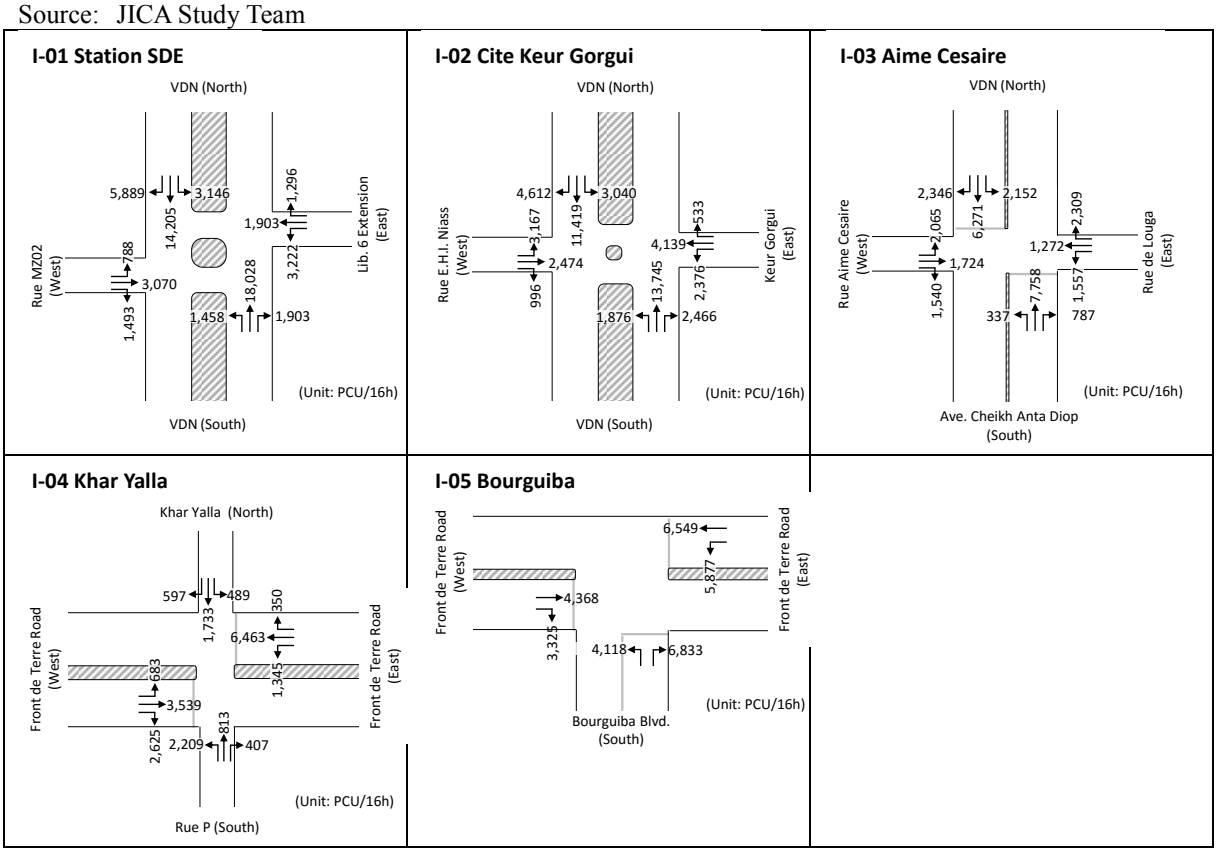
Among the five intersections, (I-01) SDE and (I-02) Cité Keur Gorgui are relatively large-scale, as the passing traffic volume over 16 hours exceeds the passenger car units (PCU) of 50,000. It is observed that the directions of the flyovers/underpasses that are proposed as improvement alternatives match with the major directions of traffic flow.

Table 12.2.1 Traffic Volume at the Sub-project Locations

Code	Location	Traffic Volume (PCU/16hrs)					Flyover/ Underpass Direction
		From North	From South	From East	From West	Total	
I-01	SDE	23,240	21,388	4,907	5,350	54,886	N-S
I-02	Cité Keur Gorgui	19,071	18,087	7,048	6,637	50,842	N-S
I-03	Aimé Césaire	10,769	8,883	5,138	5,328	30,117	N-S
I-04	Khar Yalla	2,820	3,429	8,158	6,874	21,281	E-W
I-05	Bourguiba	-	10,951	12,426	7,693	31,071	E-S / E-W

Note: Shaded cells indicate the main traffic directions for which the flyovers/ underpasses are proposed as improvement alternatives.

Source: JICA Study Team



Source: JICA Study Team

Figure 12.2.2 Directional Traffic Volume at the Sub-project Locations

12.2.3 Signal Phasing Survey

As a result of the signal phasing survey, the cycle lengths[1] of the traffic signals at the five sub-project

[1] The cycle length is the total signal time that serves all of the signal phases, including the green time, plus any change interval. Longer cycles will accommodate more vehicles per hour but will also produce longer average delays.

locations are summarized in Table 12.2.2. A more detailed description of the signal phasing survey is presented in Appendix A, Section A.6.1.

The overall average cycle length of the intersections along VDN is over three minutes and those along Front de Terre are almost three minutes. In general, a long cycle length not only causes travel time delay but also, generates dangerous driving behavior such as rushing to the intersection.

Table 12.2.2 Average Cycle Length at the Sub-project Locations

Code	Location	Feature	Cycle Length (sec)			Flyover/ Underpass Direction
			Morning (6:00-9:00)	Noon (11:00-14:00)	Evening (17:00-20:00)	
I-01	SDE	Unsignalized	210	139	412	N-S
I-02	Cité Keur Gorgui	Unsignalized	105	186	251	N-S
I-03	Aimé Césaire	Unsignalized	200	112	223	N-S
I-04	Khar Yalla	Signalized	-	-	-	E-W
I-05	Bourguiba	Signalized	152	194	138	E-S / E-W

Note: At the unsignalized intersections, the average cycle lengths of the manual control of traffic by police officers are adopted. At (I-04) Khar Yalla, the traffic signal did not function and police officers were not present throughout the survey period.

Source: JICA Study Team

12.2.4 Travel Speed Survey

The average travel speeds around the sub-project locations in the morning hours (6:00-9:00), noon hours (11:00-14:00) and evening hours (17:00-19:00) are presented in Table 12.2.3. Further details of the travel speed survey are described in Appendix A, Section A.6.1.0.

In general, the average travel speeds are low and the lowest speeds are often observed during the evening hours. Among the five intersections, the travel speeds around (I-05) Bourguiba are considerably low compared with the others, as evidenced by severe traffic congestion at most periods of the day. This is caused by the excessive inflow from the East of vehicles leaving the motorway and inflow from the South of vehicles leaving the city center of Dakar.

Table 12.2.3 Average Travel Speed at the Sub-project Locations

Code	Location	Inflow Direction	Average Travel Speed (km/h)			Flyover/ Underpass Direction
			Morning Hours (6:00-9:00)	Noon Hours (11:00-14:00)	Evening Hours (17:00-20:00)	
I-01	SDE	From North	24.7	25.8	23.8	N-S
		From East	12.4	10.8	9.8	
		From South	37.5	38.2	15.5	
		From West	11.2	9.9	8.0	
I-02	Cité Keur Gorgui	From North	28.6	24.3	22.7	N-S
		From East	12.8	8.6	9.5	
		From South	52.1	43.3	32.0	
		From West	19.0	14.8	14.6	
I-03	Aimé Césaire	From North	29.4	11.8	28.4	N-S
		From East	23.7	20.2	17.1	
		From South	27.1	12.2	14.3	
		From West	19.0	17.3	19.4	
I-04	Khar Yalla	From North	9.4	6.1	5.5	E-W
		From East	22.6	13.3	8.8	
		From South	10.7	6.5	5.6	
		From West	11.8	6.4	6.5	
I-05	Bourguiba	From East	11.5	7.6	6.2	E-S / E-W
		From South	10.0	7.7	3.1	
		From West	27.9	13.5	16.9	

Source: JICA Study Team

12.2.5 Traffic Queue Length Survey

Table 12.2.4 shows the average queue length at the sub-project locations. Most of the intersections are observed to have long queues (over 100m) during the evening hours (17:00-20:00). The result of the traffic queue length survey suggests that (I-05) Bourguiba suffers from heavy congestion along the East inflow direction throughout the three periods of the survey (i.e., morning hours, noon hours and evening hours). Further details of the queue length survey are described in Appendix A, Section A.6.1.

Table 12.2.4 Average Queue Length at the Sub-project Locations

Code	Location	Inflow Direction	Average Traffic Queue Length (m)			Flyover/ Underpass Direction
			Morning Hours (6:00-9:00)	Noon Hours (11:00-14:00)	Evening Hours (17:00-20:00)	
I-01	SDE	From North	51	87	81	N-S
		From East	40	48	85	
		From South	40	87	450	
		From West	60	52	71	
I-02	Cité Keur Gorgui	From North	40	54	53	N-S
		From East	80	60	76	
		From South	-	50	106	
		From West	33	69	69	
I-03	Aimé Césaire	From North	-	42	36	N-S
		From East	30	21	23	
		From South	20	27	25	
		From West	27	43	59	
I-04	Khar Yalla	From North	-	63	51	E-W
		From East	53	70	72	
		From South	49	67	68	
		From West	36	57	59	
I-05	Bourguiba	From East	145	145	189	E-S / E-W
		From South	49	42	31	
		From West	43	95	122	

Note: Shaded cells indicate the average queue lengths that are longer than 100m.
Source: JICA Study Team

12.3 Proposed Alternatives for Improvement

Based on the traffic survey results presented earlier, it was found that traffic congestion has occurred at all of the sub-project locations. To cope with the traffic congestion, a number of improvement alternatives, including grade separation structures (i.e., flyovers and underpasses) and other suitable at-grade improvement options (e.g., traffic signals, U-turn lanes) were proposed, as shown in Table 12.2.1. Table 12.2.1 also indicates the reference figure numbers for their respective designs, which are presented later in Section 12.5. Based on these alternatives, the necessary analyses were conducted, as shown in later sections of this chapter.

The fundamental bases for proposing the alternatives for individual sub-projects are summarized as follows:

(1) SDE Intersection Improvement

Taking advantage of the large ROW and the wide median, a variety of improvement alternatives were proposed. There are four grade separation alternatives and two at-grade alternatives, as shown in Table 12.3.1. Further in Section 12.5, there is a discussion as to why and how the four grade separation alternatives derived.

As for the two at-grade alternatives, a traffic signal was proposed because it is an unsignalized intersection that currently allows direct inflows of crossing vehicles from East and West into VDN,

hampering the traffic flow and resulting in traffic congestion, especially during peak hours. In addition, with the U-turn lanes, vehicles from the East and West approaches, which presently cross at this intersection, are required to make a right turn and merge into the traffic of VDN (i.e., Northbound and Southbound) until they reach the locations where the U-turn lanes are provided in order to minimize the traffic flow conflicts.

(2) Cité Keur Gorgui Intersection Improvement

The characteristic of the site is similar to that of SDE, as described above. Therefore, the same improvement alternatives are proposed, as shown in Table 12.3.1. Further in Section 12.5, there is a discussion as to why and how the four grade separation alternatives derived. The two at-grade alternatives that are proposed for this unsignalized intersection are described in that of the SDE above and share the same reasons.

(3) Aimé Césaire Intersection Improvement

Aimé Césaire intersection is a heavily congested dividing point between VDN and Avenue Cheikh Anta Diop. It has a small ROW (approximately 25m) and is closely surrounded by buildings with busy vehicular traffic and pedestrians.

Similar to the other sub-projects, a series of discussions was made with relevant agencies on the improvement alternatives and their respective designs. AGEROUTE was convinced that an underpass is the most suitable solution for the Aimé Césaire intersection, as it minimizes the impact on private land and properties on the ground. As shown later in Section 12.5, the width of the grade separation structure requires at least 31.8m, considering the minimum width of all elements, which is larger than the existing ROW. With this commitment, in recent years, AGEROUTE conducted a study of an underpass but this was suspended until now. Discussions were also held in weekly meetings with DUA staff. These yielded a similar recommendation on the basis that there are a significant number of pedestrians in the vicinity of this intersection, where a hospital, university and some shops are located. With an underpass for the Northbound and Southbound vehicular traffic, some space on the ground can be secured for pedestrians in this area. Therefore, only an underpass was considered as an improvement alternative. At-grade improvement alternatives, namely a traffic signal and a U-turn lane, were dropped.

(4) Khar Yalla Intersection Improvement

This is currently a signalized intersection on Front de Terre where the road has a narrow ROW (approximately 30m), which is not suitable for introducing U-turn lanes. Therefore, only two grade separation alternatives were proposed, as shown in Table 12.3.1. Section 12.5 later presents a discussion as to why and how the two grade separation alternatives derived.

(5) Bourguiba Intersection Improvement

This is currently a signalized T-junction on Front de Terre, which suffers from heavy congestion. Similarly to Khar Yalla, a U-turn lane is not suitable for this sub-project site due to its narrow ROW and proximity to the roundabout of the motorway interchange.

There are three grade separation alternatives proposed, as shown in Table 12.2.1, i.e., an East-West flyover, an East-West underpass and an East-South flyover. The East-South flyover is considered because there are high traffic inflows from the East and South, according to Table 12.2.1 and Figure 12.2.2. Moreover, CETUD has planned a BRT route that crosses the intersection in the direction of

East-South. Section 12.5 later presents a discussion as to why and how the three grade separation alternatives derived.

Table 12.3.1 Proposed Alternatives for Improvement

Sub-projects	Alternatives		Types of Structure	Reference Figures
SDE Intersection Improvement	I-01a	Flyovers on both sides	Grade separation	Figure 12.5.1
	I-01b	Underpasses on both sides		
	I-01c	Flyover in the center		Figure 12.5.3
	I-01d	Underpass in the center		
	I-01e	At-grade improvement with traffic signals	At-grade	Figure 12.5.5
	I-01f	At-grade improvement with U-turn lanes		Figure 12.5.6
Cité Keur Gorgui Intersection Improvement	I-02a	Flyovers on both sides	Grade separation	Figure 12.5.7
	I-02b	Underpasses on both sides		
	I-02c	Flyover in the center		Figure 12.5.9
	I-02d	Underpass in the center		
	I-02e	At-grade improvement with traffic signals	At-grade	Figure 12.5.11
	I-02f	At-grade Improvement with U-Turn Lanes		Figure 12.5.12
Aimé Césaire Intersection Improvement	I-03	Underpass	Grade separation	Figure 12.5.13
Khar Yalla Intersection Improvement	I-04a	Flyover	Grade separation	Figure 12.5.16
	I-04b	Underpass		
Bourguiba Intersection Improvement	I-05a	East-West flyover	Grade separation	Figure 12.5.18
	I-05b	East-West underpass		
	I-05c	East-South flyover		Figure 12.5.20

Source: JICA Study Team

12.4 Future Traffic Analysis

12.4.1 Travel Demand Forecast

For the five sub-project locations, a traffic demand forecast at each intersection was conducted. These were based on the results of the traffic survey presented in Section 2.1 and the demand forecasting model, which was developed in the latest study by CETUD on the BRT project in Dakar. Certain adjustments were made, taking into consideration the socioeconomic framework (population and GRDP) and car-ownership estimated by JICA Study Team in the present project. Table 12.4.1 shows the forecast traffic volume at the sub-project locations.

Table 12.4.1 Traffic Demand Forecast at the Sub-project Locations

Code	Location	Daily Traffic Volume (PCU)			Growth 2025/2015	Growth 2035/2015	Flyover/ Underpass Direction
		2015 Existing	2025 Forecast	2035 Forecast			
I-01	SDE	64,425	128,016	208,469	1.99	3.24	N-S
I-02	Cité Keur Gorgui	58,010	118,808	193,688	2.05	3.34	N-S
I-03	Aimé Césaire	34,076	69,627	112,986	2.04	3.32	N-S
I-04	Khar Yalla	26,466	43,624	71,498	1.65	2.70	E-W
I-05	Bourguiba	34,318	70,400	115,411	2.05	3.36	E-S / E-W

Source: JICA Study Team

12.4.2 Traffic Analysis of the Sub-projects

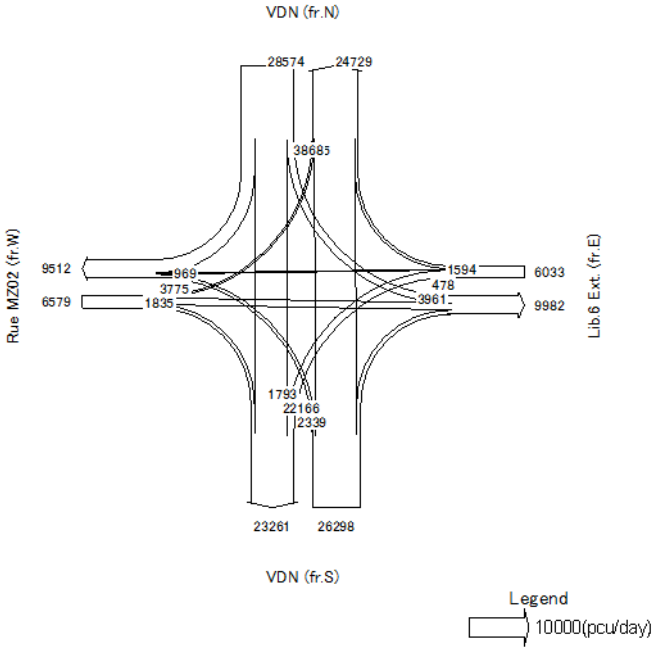
(1) SDE [I-01]

As shown in Figure 12.4.1, the main traffic flow directions are the through traffic Northbound and Southbound. It is observed that the congestion occurring at this sub-project location is generally caused by the conflict of left-turning traffic from the East inflow and the North inflow.

Improvement alternatives for this sub-project location are presented in Table 12.4.2. The alternatives I-01a, I-01b, I-01c and I-01d are grade separation structures. Other possible at-grade improvement alternatives below are also considered for the traffic analysis:

Alternative I-01e: At-grade improvement with traffic signals;
Alternative I-01f: At-grade improvement with U-turn lanes.

The traffic analysis results in Table 12.4.3 indicate that the SDE intersection is currently oversaturated. At-grade improvement, such as traffic signals and U-turn lanes, i.e., alternatives I-01e and I-01f, respectively shown in Figure 12.4.2 and 12.4.3, are capable of solving traffic congestion in the short-term (up to 2020). In contrast, the grade separation structure is a long-term solution to coping with the traffic at this sub-project location.



Source: JICA Study Team

Figure 12.4.1 Existing Directional Traffic Volume at SDE

To sum up, the installation of traffic signals (alternative I-01e) is recommended as an immediate solution for traffic congestion. This is because it performs better than the U-turn lanes (I-01f) and requires a lower cost and shorter time to realize compared to the grade separation alternatives. To accommodate 81m of necessary queue length without disturbing the traffic flow of other directions, it is advisable to widen the short approaches connecting the Northbound and Southbound of VDN to two lanes per direction.

Table 12.4.2 Improvement Alternatives for SDE

Alternatives for Improvement			Traffic Analysis
I-01a	Flyovers on both sides	Grade separation	√
I-01b	Underpasses on both sides		
I-01c	Flyover in the center		
I-01d	Underpass in the center		
I-01e	At-grade improvement with traffic signals	At-grade	√
I-01f	At-grade improvement with U-turn lanes		√

Source: JICA Study Team

Table 12.4.3 Results of the Traffic Analysis for the Improvement Alternatives at SDE

Year	Indicators	Improvement Alternatives			
		Existing	I-01a/I-01b/I-01c /I-01d	I-01e	I-01f
2015	Degree of saturation	1.48	-	0.69	0.80
	Queue length (m)	153	-	65	81
2020	Degree of saturation	-	-	1.02	1.10
	Queue length (m)	-	-	81	117
2025	Degree of saturation	-	1.11	-	-
	Queue length (m)	-	123	-	-
2035	Degree of saturation	-	1.59	-	-
	Queue length (m)	-	176	-	-

Source: JICA Study Team

Source: JICA Study Team

Figure 12.4.2 Installation of Traffic Signals at SDE

Source: JICA Study Team

Figure 12.4.3 U-turn Lanes at SDE

(2) Cité Keur Gorgui [I-02]

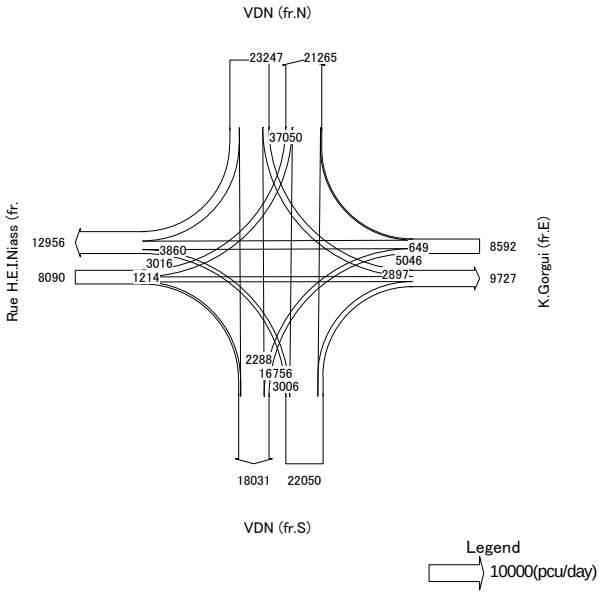
Similar to the SDE intersection, the main traffic flow directions at this sub-project location are the through traffic Northbound and Southbound, as shown in Figure 12.4.4. However, the magnitude of traffic inflows from the East and West are higher and the left-turn movements from all of the inflows are considerably busier than those of SDE.

The improvement alternatives for this sub-project location are presented in Table 12.4.4. The alternatives I-02a, I-02b, I-02c and I-02d are grade separation structures. Other possible at-grade improvement alternatives are listed below. These are also considered for the traffic analysis:

Alternative I-02e: At-grade improvement with traffic signals;
Alternative I-02f: At-grade improvement with U-turn lanes.

The results in Table 12.4.5 show that at-grade improvement alternatives are not suitable for this sub-project location. Even under the present traffic demand, the degrees of saturation are 0.970 and 0.966, respectively for alternatives I-02e and I-02f.

In short, the grade separation alternative is the best option for solving the traffic congestion problem at this sub-project location. By 2035, this sub-project location is expected to return again to an oversaturated intersection. This is due to increases in traffic inflows from the East and West against the capacity constraint of the one-lane approach. To overcome this future problem, increasing the capacity by widening the East and West approach roads is recommended.



Source: JICA Study Team

Figure 12.4.4 Existing Directional Traffic Volume at Cité Keur Gorgui

Table 12.4.4 Improvement Alternatives for Cité Keur Gorgui

Alternatives for Improvement			Traffic Analysis
I-02a	Flyovers on both sides	Grade Separation	√
I-02b	Underpasses on both sides		
I-02c	Flyover in the center		
I-02d	Underpass in the center		
I-02e	At-grade improvement with traffic signals	At-grade	√
I-02f	At-grade improvement with U-turn lanes		√

Source: JICA Study Team

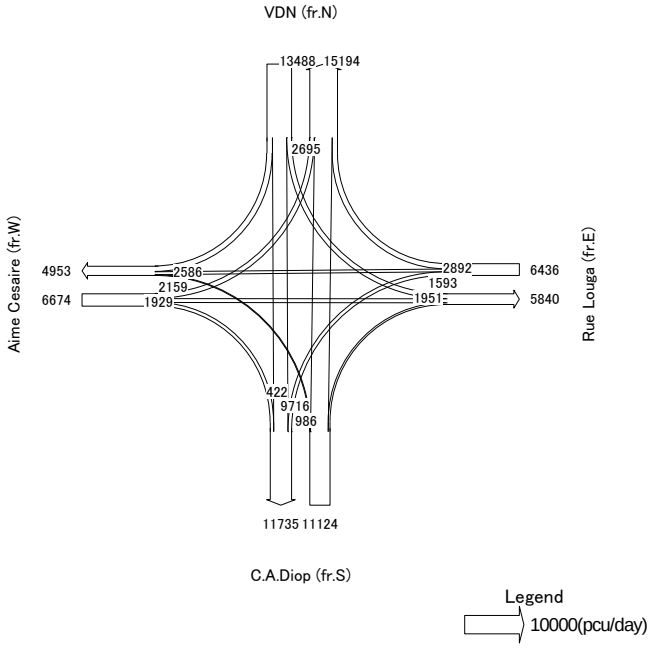
Table 12.4.5 Results of the Traffic Analysis for the Improvement Alternatives at Cité Keur Gorgui

Year	Indicators	Improvement Alternatives			
		Existing	I-02a/I-02b/I-02c /I-02d	I-02e	I-02f
2015	Degree of saturation	1.77	-	0.97	0.966
	Queue length (m)	182	-	65	90
2020	Degree of saturation	-	-	1.65	1.473
	Queue length (m)	-	-	81	135
2025	Degree of saturation	-	0.91	-	-
	Queue length (m)	-	176	-	-
2035	Degree of saturation	-	1.86	-	-
	Queue length (m)	-	270	-	-

Source: JICA Study Team

(3) Aimé Césaire [I-03]

This sub-project location is at the South of SDE and Cité Keur Gorgui at one end of VDN, where the width of the road considerably narrows. Although the trough traffic Northbound and Southbound characterize the main traffic flow directions, as seen in Figure 12.4.5, the traffic inflows from the East and West are relatively high. It is observed that the congestion occurring at this sub-project location is generally caused by the conflicts of left-turning traffic from the East inflow, from the North inflow and from the West inflow with the main directions.



Source: JICA Study Team

Figure 12.4.5 Existing Directional Traffic Volume at Aimé Césaire

Only one improvement alternative is proposed for this sub-project location, which is an underpass, as presented in Section 12.4. As indicated by the result of the traffic analysis in Table 12.4.6, the sub-project location functions as an oversaturated intersection. Constructing an underpass will reduce traffic congestion, as it ensures an undisturbed flow of through traffic Northbound and Southbound. Nevertheless, the future traffic growth from the East inflow and West inflow is forecast to again cause congestion at the sub-project location by 2035, unless additional measures to increase the capacity of the East and West approach roads, or to manage the traffic movement around the area, are envisioned.

Table 12.4.6 Results of the Traffic Analysis for the Improvement Alternatives at Aimé Césaire

Year	Indicators	Improvement Alternatives	
		Existing	I-03 Underpass
2015	Degree of saturation	2.07	-
	Queue length (m)	108	-
2025	Degree of saturation	-	1.05
	Queue length (m)	-	132
2035	Degree of saturation	-	1.79
	Queue length (m)	-	331

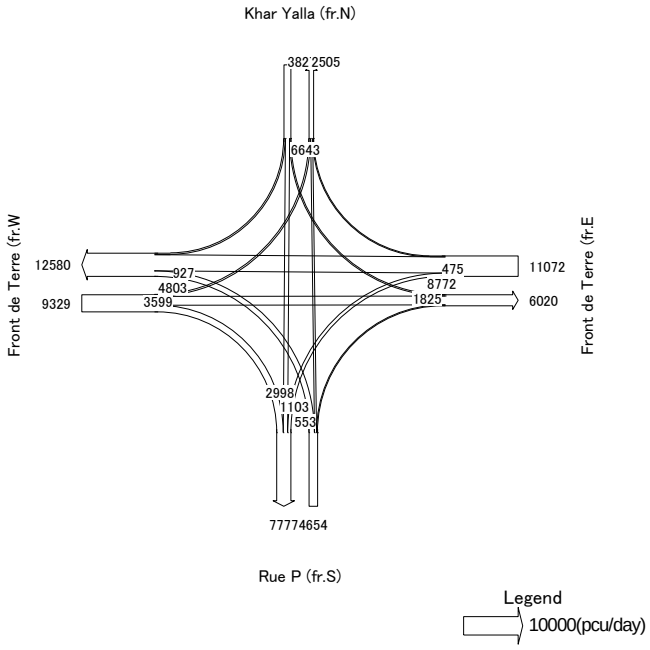
Source: JICA Study Team

(4) Khar Yalla [I-04]

As shown in Figure 12.4.6, the main traffic flow directions are the through traffic Eastbound and Westbound. The improvement alternatives for this sub-project location are a flyover and an underpass in the main traffic directions, as presented in Table 12.4.7.

It is important to note that Khar Yalla is currently a signalized intersection. Table 12.4.8 shows that the intersection is oversaturated and congested. Taking this analysis result and the current narrow ROW into consideration, a U-turn lane is not suitable as an alternative for improvement.

Table 12.4.8 shows that constructing a grade separation is a long-term solution for the sub-project location from the viewpoint of traffic performance.



Source: JICA Study Team

Figure 12.4.6 Existing Directional Traffic Volume at Khar Yalla

Table 12.4.7 Improvement Alternatives for Khar Yalla

Alternatives for Improvement			Traffic Analysis
I-04a	Flyover	Grade separation	√
I-04b	Underpass		

Source: JICA Study Team

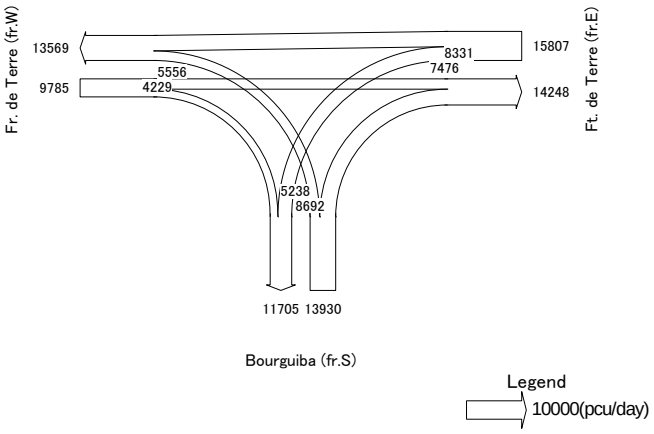
Table 12.4.8 Results of the Traffic Analysis for the Improvement Alternatives at Khar Yalla

Year	Indicators	Improvement Alternatives	
		Existing	I-04a / I-04b
2015	Degree of saturation	1.72	-
	Queue length (m)	26	-
2025	Degree of saturation	-	0.61
	Queue length (m)	-	113
2035	Degree of saturation	-	1.45
	Queue length (m)	-	189

Source: JICA Study Team

(5) Bourguiba [I-05]

Figure 12.4.7 shows that the through traffic from East to West and traffic flows between East and South constitute the major traffic directions at the sub-project location.



Source: JICA Study Team

Figure 12.4.7 Existing Directional Traffic Volume at Bourguiba

Improvement alternatives for this sub-project location are presented in Table 12.4.9. As discussed later in Section 12.5, the alternatives I-05a and I-05c are the most preferable. Nevertheless, from a traffic flow viewpoint, alternative I-05c is recommended, as it contributes to reducing the conflict points of the major traffic directions at this intersection, specifically the conflict between the left-turn of East inflow and left-turn of South inflow. Moreover, one of the BRT lines planned by CETUD is also located in this direction.

Similar to Khar Yalla [1-04], Bourgiba intersection is signalized and currently congested, as shown in Table 12.4.10. Taking into consideration the analysis result and current narrow ROW, a U-turn lane is not suitable as an alternative for improvement.

Based on the result of the traffic analysis in Table 12.4.10, it can be concluded that the alternative I-05c is suitable for solving the traffic at this sub-project location. The alternative I-05c is expected to significantly contribute to the reduction of traffic congestion, which has been a chronic problem at this intersection.

Table 12.4.9 Improvement Alternatives for Bourguiba

Alternatives for Improvement			Traffic Analysis
I-05a	East-West flyover	Grade separation	
I-05b	East-West underpass		
I-05c	East-South flyover		√

Source: JICA Study Team

Table 12.4.10 Results of the Traffic Analysis for the Improvement Alternatives at Bourguiba

Year	Indicators	Improvement Alternatives	
		Existing	I-05c
2015	Degree of saturation	1.91	-
	Queue length (m)	401	-
2025	Degree of saturation	-	0.61
	Queue length (m)	-	113
2035	Degree of saturation	-	1.45
	Queue length (m)	-	189

Source: JICA Study Team

12.5 Road and Structure Design Alternatives for Improvements

A number of improvement alternatives, including grade separation structures (i.e., flyovers and

underpasses) and suitable at-grade improvement options (e.g., traffic signals, U-turn lanes) were proposed. Before examining the comparison of these alternatives, this section describes the analyses and evaluations that were made to select the technically most desirable design option for the alternatives for each sub-project location.

Table 12.5.1 provides an abstract summarizing the comparison of the alternatives for the individual intersections, in which a few of the main features, such as the length of structure, traffic volume, economy, cost and evaluation, are presented. A detailed comparison, taking into account all of the features, is shown in Table 12.5.2.

The geometric design was based on the "Japanese Road Design Standard" and the main geometric parameters for a design speed of V=40, 50 and 60km/h are shown in Table 12.5.3.

Table 12.5.1 An Abstract of the Alternative Comparisons

		I-01 SDE					
		Both Sides		Center		Traffic Signals	U-turn Lanes
		Flyover	Underpass	Flyover	Underpass		
ID		I-01a	I-01b	I-01c	I-01d	I-01e	I-01f
Length of Structure	Bridge	99m	-	99m	-	-	-
	Box Culvert	-	99m	-	99m	-	-
	Retaining Wall	432m	522m	432m	522m	-	-
Traffic Volume		54,886 PCU/16hrs					
Economy		Inferior to the center plan because of the separate structures in inbound and outbound directions.	In addition to the flyover plan, installation and maintenance of the drainage and pump are required.	Excellent because it only requires integrated structures for both inbound and outbound directions.	In addition to the flyover plan, installation and maintenance of the drainage and pump are required.	Highly economical compared to grade separation alternatives.	Highly economical compared to grade separation alternatives.
Cost (mil. FCFA)		18,491	29,756	15,040	19,603	1,229	178
Evaluation		Fair	Poor	Good	Fair	Good	Good

		I-02 Cité Keur Gorgui					
		Both Sides		Center		Traffic Signal	U-turn Lane
		Flyover	Underpass	Flyover	Underpass		
ID		I-02a	I-02b	I-02c	I-02d	I-01e	I-01f
Length of Structure	Bridge	74m	-	74m	-	-	-
	Box Culvert	-	74m	-	74m	-	-
	Retaining Wall	611m	342m	611m	342m	-	-
Traffic Volume		50,842 PCU/16hrs					
Economy		Inferior to the center plan because of the separate structures in inbound and outbound directions.	In addition to the flyover plan, installation and maintenance of the drainage and pump are required.	Excellent because it only requires integrated structures for both inbound and outbound directions.	In addition to the flyover plan, installation and maintenance of the drainage and pump are required.	Highly economical compared to grade separation alternatives.	Highly economical compared to grade separation alternatives.
Cost (mil. FCFA)		19,758	29,246	14,881	19,091	591	230
Evaluation		Fair	Poor	Good	Fair	Poor	Poor

		I-03 Aimé Césaire	I-04 Khar Yalla		I-05 Bourguiba		
		Underpass	Flyover	Underpass	Flyover (East-West Direction)	Underpass (East-West direction)	Flyover (East-South direction)
ID		I-03	I-04a	I-04b	I-05a	I-05b	I-05c
Length of Structure	Bridge	34m	54m	-	54m	-	64m
	Box Culvert	-	-	54m	-	54m	-
	Retaining Wall	439m	510m	531m	345m	513m	328m
Traffic Volume		30,117 PCU/16hrs	21,281 PCU/16hrs		31,071 PCU/16hrs		
Economy		Pre-cast products are adopted to reduce the construction period and land acquisition.	Preferable to an underpass as installation and maintenance of the drainage and pumps are not required.	In addition to the flyover plan, installation and maintenance of the drainage and pump are required.	More preferable than an underpass as installation and maintenance of the drainage and pump are not required.	In addition to the flyover plan, installation and maintenance of the drainage and pump are required.	Inferior to the flyover East-West direction due to higher cost of a steel superstructure .
Cost (mil. FCFA)		28,805	12,715	41,612	10,451	32,103	13,990
Evaluation		Good	Good	Poor	Good	Poor	Good*

Note: *Although a flyover in the direction East-South is inferior to that of East-West in terms of economy, it is in-line with the BRT route that is being planned by CETUD in this direction.

Source: JICA Study Team

(1) SDE Intersection (I-01)

1) Grade Separation Alternatives (I-01a, I-01b, I-01c and I-01d)

VDN road has three lanes in each direction and the median width is 23m. There are already several grade-separated intersections along VDN at locations other than the three intersections that are currently under study.

However, the present intersections have traffic conflicts between VDN, which is the main road, and frontage roads on the West side and the East side. As a consequence, congestion is generated due to the traffic flow's conflicts. The vehicles from the main road are blocking the passage of flow from/to the frontage road. This retains the traffic, which, in effect, obstructs the main road. The crossing conflict can be eliminated by implementing a grade-separated intersection plan. The planned road design speed is V=60km/h, with two lanes in each direction in the grade-separated section and one lane in each direction in the ramp section.

The median is approximately 23m in width. Therefore, the grade-separated intersection implementation will not interfere with private land.

The grade-separated intersection can be implemented by a flyover bridge or a box underpass. However, considering the longitudinal profile to connect with the existing road, an underpass will require a longer distance of 620m in length (compared with a 530m length by a flyover). In addition, drainage facilities, such as pumps, will increase the project implementation cost. Regarding the road drainage, there is no problem with using the existing facilities that are installed under the sidewalk.

The proposed main alignment configuration is two lanes, 3.6m width each (7.2m in total), plus a 0.25m shoulder on both sides, giving a total width of 7.7m. The ramp width of 5.45m (design width 5.5m) was adopted as the minimum necessary width to allow the passage of vehicles in the case of any small or large vehicle failure.

In addition, two alternative types of horizontal alignment were studied. Side alternative (1) is to use the side space that controls the existing road and sidewalk. The center alternative (2) is to use the center space. The difference between these two options is that the horizontal alignment of the center alternative requires an S curve. Therefore, the traveling performance is not as smooth as the side alternative. However, the retaining walls are necessary in only two points of the embankment before/after the bridge section, leading to a cheaper project cost, which is the strong point of this alternative.

Figure 12.5.1 illustrates the outline drawings of the flyovers and underpasses on both sides. Figure 12.5.3 shows the outline drawings of the flyover and underpass in the center.

2) At-grade Alternatives (I-01e and I-01f)

This intersection is a roundabout where the East and West approach roads are on different alignments. The traffic conflict and interference at the weaving sections of the roundabout are predominant and cause congestion. Generally, re-aligning the East-West approaches could be done by horizontally shifting one of them. However, the existing buildings on the Southern side of the East approach and a cemetery on the Northern side of the West approach pose difficulty for the horizontal re-alignment of these approaches. Therefore, in an attempt to eliminate the traffic conflicts at the roundabout, the installation of traffic signals at the four crossing points (I-01e) is considered.

There is another possibility to avoid the crossing between the vehicles of the through traffic and those turning left/right. This alternative involves the closing of the existing roundabout and construction of

new U-turn lanes located 200m away from the existing intersection both on the Northern and Southern sides. While traffic safety will be enhanced by this alternative, drivers will experience inconvenience due to the increased driving distance. Additionally, it is necessary to validate the traffic capacity of the U-turn lanes.

The at-grade improvement alternatives, i.e., the installation of traffic signals and U-turn lanes, are shown in Figure 12.5.5 and 12.5.6, respectively.

Table 12.5.2 Comparison of the Alternatives

		I-01 SDE Intersection					
		Both Sides		Center		Traffic Signals	U-turn Lanes
		Flyover	Underpass	Flyover	Underpass		
ID		I-01a	I-01b	I-01c	I-01d	I-01e	I-01f
Outline of Planning		This intersection is currently oversaturated. At-grade alternatives (traffic signals and U-turn lanes) will solve the traffic congestion but the saturation will be reached by 2020. Therefore, a grade separated intersection was also studied. The median strip of the construction site is wide. Therefore, grade separation work can use this median strip. This alternative planned that the main track and the ramp will be constructed on the median strip side while controlling the existing sidewalk. There is a water supply facility in the center of the median strip. The flyover plan can avoid the facilities but the underpass plan cannot. Therefore, in the case of the underpass, it is necessary to relocate the water supply facility.		This intersection is currently oversaturated. At-grade alternatives (traffic signals and U-turn lanes) will solve the traffic congestion but the saturation will be reached by 2020. Therefore, a grade separated intersection was also studied. The median strip of the construction site is wide. Therefore, grade separation work can use this median strip. This alternative plan is that the main track is planned in the center of the road as other existing grade separation intersections. There is a water supply facility in the center of the median strip. The flyover plan can avoid the facility but the underpass plan cannot. Therefore, in the case of the underpass, it is necessary to relocate the water supply facility.		This intersection is a roundabout where the East and West approach roads are on different alignments. The traffic conflict and interference at the weaving sections of the roundabout are predominant and cause congestion. Generally, re-aligning the East-West approaches could be done by horizontally shifting one of them. However, the existing buildings on the Southern side of the East approach and a cemetery on the Northern side of the West approach pose difficulty for the horizontal re-alignment of these approaches. Therefore, this alternative attempts to eliminate the traffic conflicts by installing a traffic signal at the four crossing points.	To avoid the crossing between the vehicles of the though traffic and those turning left/right, this alternative involves the closing of the existing roundabout and the construction of new U-turn lanes located 200m away. While traffic safety will be enhanced by this alternative, driving distance will be increased.
Design Speed		V=60km/h		V=60km/h		-	-
Number of Lanes		Grade Separation: Two-lane x 2 Ramp: One-lane		Grade Separation: Two-lane x 2 Ramp: One-lane		Additional right-turn only: One-lane	U-turn lane: One-lane
Design Criteria	Minimum Radius	1000m		1000m		15m (intersection turning radius)	18m (U-turn radius)
	Maximum Grade	5%		5%		0%	0%
	Other	-	-	-	-	-	-
Length of Structure	Bridge	99m	-	99m	-	-	-
	Box Culvert	-	99m	-	99m	-	-
	Retaining Wall	432.2m	521.5m	432.2m	521.5m	-	-
Facility of Drainage		The existing drainage facilities that are located under the sidewalks on both sides can be used.	Pump facilities for road drainage is required. The median is wide. Therefore, additional land for the pump facility is not needed.	The existing drainage facilities that are located under the sidewalks on both sides can be used.	Pump facilities for road drainage is required. The median is wide. Therefore, additional land for the pump facility is not needed.	Drainage can be planned as in the existing situation.	Drainage can be planned as in the existing situation.
ROW	Compensation	No compensation		No compensation		No compensation	No compensation
	Land Acquisition	No land acquisition		No land acquisition		No land acquisition	No land acquisition
Judgment of the Plan		A detour road (three-lane) will be constructed on the center side of VDN. Plan is available.		Grade separation work can be done using the existing three-lane carriageway. However, a detour road should be constructed for one part of retaining the wall section. Plan is available.		Traffic control is necessary because the shape of the intersection changes.	There is no particular problem because the construction work is on the median, which is 200m away from the existing intersection.
Relation to Other Facilities		The existing drainage canal on the sidewalk can be used for rainwater flow. The water supply facility on the median needs to be relocated.		The existing drainage canal on the sidewalk can be used for rainwater flow. The water supply facility on the median needs to be relocated.		It is just a renovation of the existing facilities; there is no problem.	There is no particular problem.
Traffic Operations		Existing Traffic Volume: 54,886 PCU/16hrs To cope with the traffic congestion and to accommodate the anticipated future traffic, the grade separation alternatives for the main traffic directions are also studied.				Existing Traffic Volume: 54,886 PCU/16hrs This alternative can solve the current traffic congestion. However, the intersection will again be saturated by 2020. Therefore, it is a short-term solution.	Existing Traffic Volume: 54,886 PCU/16hrs This alternative is able to solve the current traffic congestion but it is a short-term solution (by 2020). Additionally, it has a relatively lower capacity than traffic signal. The dissemination of information and installation of a sign board are required because the traffic movement patterns change.
Workability		A detour road is necessary.	Same as on the left.	No detour road is necessary. Therefore, workability is better than side alternative.	Same as on the left.	A detour road is not necessary. The impact on the traffic flow is minor.	A detour road is not necessary. The impact on the traffic flow is minor.
Economy		This alternative plan is inferior in economic	In addition to the flyover plan, installation and	This alternative plan is excellent in economic efficiency	In addition to the flyover plan, installation and	As an at-grade improvement, it is highly economical compared to the grade separation alternatives.	As an at-grade improvement, it is highly economical compared to the grade separation

	efficiency to the center plan because of the separate structure of inbound and outbound directions.	maintenance of the drainage facility (pumping stations) are required.	compared to the side plan because of the integral structure of the inbound and outbound directions.	maintenance of the drainage facility (pumping stations) are required.		alternatives.
Cost (Million FCFA)	18,491	29,756	15,040	19,603	1,229	178
Evaluation	Fair	Poor	Good	Fair	Good	Fair

Note: Shaded cells indicate that the alternatives are superior to others with regard to their attributes being compared.

Source: JICA Study Team

Table 12.5.2 Comparison of the Alternatives (Continued)

		I-02 Cité Keur Gorgui Intersection					
		Both Sides		Center		Traffic Signal	U-turn Lane
		Flyover	Underpass	Flyover	Underpass		
ID		I-02a	I-02b	I-02c	I-02d	I-02e	I-02f
Outline of Planning		This intersection is currently oversaturated and at-grade improvements are not suitable for solving the present traffic congestion (degree of saturation exceeds 0.9). Therefore, the grade separation alternatives are urgently required. The median strip of the construction site is wide. Therefore, grade separation work can use it. This alternative was planned that the main track and the ramp will be constructed on the median strip side while controlling the existing sidewalk.		This intersection is currently oversaturated and at-grade improvements are not suitable for solving present traffic congestion (degree of saturation exceeds 0.9). Therefore, the grade separation alternatives are urgently required. The median strip of the construction site is wide. Therefore, grade separation work can use it. This alternative plan is that the main track is planned in the center of the road as other existing grade separation intersections.		This intersection is a roundabout formed by an oblique angled crossing (approximately 65 degree), where traffic inflows from the North and South are separated by a wide median. The traffic conflict and interference at the weaving sections of the roundabout are predominant and cause congestion. Hence, installation of a traffic signal is proposed as an improvement alternative.	To avoid the crossing between the vehicles of the though traffic and those turning left/right, this alternative involves the closing of the existing roundabout and the construction of new U-turn lanes located 200m away on both sides. While traffic safety will be enhanced by this alternative, driving distance will be increased.
Design Speed		V=60km/h		V=60km/h		-	-
Number of Lane		Grade Separation: Two-lane x 2 Ramp: One-lane		Grade Separation: Two-lane x 2 Ramp: One-lane		Additional right-turn only: One-lane	U-turn lane: One-lane
Design Criteria	Minimum Radius	700m		700m		15m (intersection turning radius)	18m (U-turn radius)
	Maximum Grade	5%		5%		0%	0%
	Other	-	-	-	-	-	-
Length of Structure	Bridge	74m	-	74m	-	-	-
	Box Culvert	-	74m	-	74m	-	-
	Retaining Wall	611m	342.2m	611m	342.2m	-	-
Facility of Drainage		The existing drainage facilities located under the sidewalks on both sides can be used.	Pump facilities for road drainage are required. The median is wide. Therefore, additional land for the pump facility is not needed.	The existing drainage facilities that are located under the sidewalks on both sides can be used.	Pump facilities for road drainage are required. The median is wide. Therefore, additional land for the pump facility is not needed.	Drainage can be planned as in the existing situation.	Drainage can be planned as in the existing situation.
ROW	Compensation	No compensation		No compensation		No compensation	No compensation
	Land Acquisition	No land acquisition		No land acquisition		No land acquisition	No land acquisition
Judgment of the Plan		A detour road (three-lane) will be constructed on the center side of VDN. Plan is available.		Grade separation work can be done using the existing three-lane carriageway. However, a detour road should be constructed for one part of retaining the wall section. Plan is available.		Traffic control is necessary because the shape of the intersection changes.	There is no particular problem because the construction work is on the median, which is 200m away from the existing intersection.
Relation to Other Facilities		The existing drainage canal on the sidewalk can be used for rainwater flow.		The existing drainage canal on the sidewalk can be used for rainwater flow.		It is just a renovation of the existing facilities; there is no problem.	There is no particular problem.
Traffic Operations		Existing Traffic Volume: 50,842 PCU/16hrs Under the current traffic volume, at-grade improvements are not able to solve the present traffic congestion. Therefore, the grade separation alternatives for the main traffic directions are required to cope with the traffic congestion and to accommodate future traffic growth.				Existing Traffic Volume: 50,842 PCU/16hrs This alternative is not able to solve the traffic congestion even under the present demand. From the viewpoint of traffic, the grade separation alternatives are urgently needed.	Existing Traffic Volume: 50,842 PCU/16hrs This alternative is not able to solve the traffic congestion even under the present demand. For this alternative, the dissemination of information and installation of a sign board are required because the traffic movement patterns change. From the viewpoint of traffic, the grade separation alternatives are urgently needed.
Workability		A detour road is necessary.	Same as on the left.	A detour road is not necessary. Therefore, workability is better than side alternative.	Same as on the left.	A detour road is not necessary. The impact on the traffic flow is minor.	A detour road is not necessary. The impact on the traffic flow is minor.
Economy		This alternative plan is inferior in economic efficiency to the center plan because of the separate structure of inbound and	In addition to the flyover plan, installation and maintenance of the drainage facility (pumping	This alternative plan is excellent in economic efficiency compared to the side plan because of the integral structure of the inbound and outbound	In addition to the flyover plan, installation and maintenance of the drainage facility (pumping	As an at-grade improvement, it is highly economical compared to the grade separation alternatives.	As an at-grade improvement, it is highly economical compared to the grade separation alternatives.

	outbound directions.	stations) are required.	directions.	stations) are required.		
Cost (Million FCFA)	19,758	29,246	14,881	19,091	591	230
Evaluation	Fair	Poor	Good	Fair	Poor	Poor

Note: Shaded cells indicate that the alternatives are superior to others with regard to their attributes being compared.

Source: JICA Study Team

Table 12.5.2 Comparison of the Alternatives (cont'd)

		I-03 Aimé Césaire	I-04 Khar Yalla		I-05 Bourguiba		
		Underpass	Flyover	Underpass	Flyover (East-West)	Underpass (East-West)	Flyover (East-South)
ID		I-03	I04a	I-04b	I-05a	I-05b	I-05c
Outline of Planning		This intersection is currently oversaturated (degree of saturation: 2.07). Therefore, grade separation is considered. While the grade separation could be a flyover or an underpass, there is already an existing flyover on the North-West side of the intersection. Therefore, only an underpass is planned because a flyover was judged to be difficult for construction from the viewpoint of alignment and the performance of traffic flow. The design condition is studied within the ROW (avoiding the private property). However, there is the possibility of widening on the West side (where the hospital is located). The run-off part of the down slope of the adjacent existing elevated main track shall be demolished and connected to a newly planned underpass structure. In the case of a flyover plan, all sections of the retaining wall of the adjacent existing elevated main track shall be demolished and traffic problem will occur. Therefore, it was excluded from the alternatives. The minimum required width 32m (sidewalk 1.5m and without shoulder of main track) is needed for the elevated intersection plan because the existing ROW is as narrow as 25m. The existing drainage facility crosses this road. Therefore, the drainage facility needs to be relocated.	The capacity of the road and intersection is affected by the street stalls on the median (on the underground drainage) and the parking vehicles of the roadside shops. In addition, the current degree of saturation of the intersection is 1.7, whereas the design condition of the intersection should be done within the ROW. Therefore, a grade separation alternative is studied. As the existing ROW is only 30m, the grade separation structure will be narrowed down without a shoulder lane and with only 1.1m sidewalk width. The Saturday market is held by using the median strip (on the drainage box culvert of width 4.0m). Therefore, its relocation is a problem. Securing the weaving length from the existing roundabout is controlled. Additionally, the drainage box culvert (W=4m) underneath the center median shall be relocated.		The capacity of the road and intersection is affected by the street stalls on the median (on the underground drainage) and the parking vehicles of the roadside shops. This intersection is a T-shape intersection around which widening on the North side of the road is possible. Despite the existence of a traffic signal, most of the time, this intersection is manually controlled by police officers due to the excessive traffic volumes. It is observed that the manual control also contributes to the overall delay and capacity reduction at the intersection. In addition, the current degree of saturation of the intersection is 1.9, whereas the design condition of the intersection should be done within the ROW. Therefore, a grade separation alternative is studied. As the existing ROW is only 30m, the grade separation structure will be narrowed down without a shoulder lane and with only 1.1m sidewalk width. The Saturday market is held by using the median strip (on the drainage box culvert of width 4.0m). Therefore, its relocation is a problem. Securing the weaving length from the existing roundabout of highway ramp is controlled. Additionally, the drainage box culvert (W=4m) underneath the center median shall be relocated.		The capacity of the road and intersection is affected by the street stalls on the median (on the underground drainage) and the parking vehicles of the roadside shops. This intersection is a T-shape intersection around which widening on the North side of the road is possible. Despite the existence of a traffic signal, most of the time, this intersection is manually controlled by police officers due to excessive traffic volumes. It is observed that the manual control also contributes to the overall delay and capacity reduction at the intersection. In addition, the current degree of saturation of the intersection is 1.9, whereas the design condition of the intersection should be done within the ROW. Therefore, a grade separation alternative is studied. This alternative is proposed in-line with the future BRT planned by CETUD. There is no impact on the median strip and the shops of the Saturday Market. Additionally, there is no problem concerning the relocation of the drainage facility on the median strip because around this area, the drainage is in the form of a pipe culvert (φ0.8+0.4m) under the road. Securing the weaving length from the existing roundabout of the highway ramp is controlled.
Design Speed		V=40km/h	V=60km/h		V=50km/h		V=40km/h
Number of Lanes		Grade Separation: Two-lane x 2 Ramp: One-lane	Grade Separation: Two-lane x 2 Ramp: One-lane		Grade Separation: Two-lane x 2 Ramp: One-lane		Grade Separation (S⇔E): Two-lane x 2 Straight Lane: 2-lane x 2
Design Criteria	Minimum Radius	500m	∞		∞		70m
	Maximum Grade	7%	5%		6%		6%
	Other	-	-	-	-	-	-
Length of Structure	Bridge	34m (for Crossing Road)	54m	-	54m	-	64m
	Box Culvert	-	-	54m	-	54m	-
	Retaining Wall	439.4m	510.3m	531.2m	345.2m	513.4m	327.6m
Facility of Drainage		Pump facilities for the road drainage are required. The land beside the intersection can be used for pump facility of road drainage.	The existing box culvert (W=4m), located in the center, can be used as the drainage terminal. However, with the elevated structure being planned in the center median, the drainage needs to be relocated to both sides.	Pump facilities for the road drainage are required. Pump facility land is separately required.	The existing box culvert (W=4m), located in the center, can be used as a drainage terminal. However, with the elevated structure being planned in the center median, the drainage needs to be relocated to both sides.	Pump facilities for the road drainage are required.	The existing box culvert (W=4m), located on the West side of the intersection, and the existing pipe culverts (φ800 and φ400), located on the East side of the road center, can be used for the drainage.
ROW	Compensation	Grade separation is impossible in the existing ROW = 25m. Necessary widening to minimum ROW = 32m. Therefore, land acquisitions of the 5m wide green space on the East side and 2m wide	Necessary land acquisition for corner cut. The installation of blindfold wall functioning as a soundproof should be considered to protect noise from		Necessary land acquisition for construction of two right turn lanes (from East to South direction) except a corner cut of the intersection.		Two straight lanes are planned. Therefore, additional compensation for houses is required except a corner cut of the intersection.

		of the hospital land on the West side are needed. Number of compensation: two houses	the road and the privacy of inhabitants of along this road. The ROW=30m and the distance between the structure of the grade separation and the private houses is as close as 6.8m. Number of compensation: three houses.	The installation of blindfold wall functioning as a soundproof should be considered to protect noise from the road and the privacy of inhabitants along this road. The ROW=30m and the distance between the structure of the grade separation and private houses is as close as 6.8m. Number of compensation: three houses.		The installation of blindfold wall functioning as a soundproof should be considered to protect noise from the road and the privacy of inhabitants along this road. The ROW=30m, and the distance between the structure of grade separation and private houses is as close as 6.8m. Number of compensation: two houses.
	Land Acquisition	Necessary widening of ROW using green belt of the East side of road.	Necessary land acquisition for a corner cut of the intersection.	Necessary land acquisition for a corner cut of the intersection.		Necessary land acquisition for a corner cut of the intersection.
Judgment of the Plan		The closed restaurant located on the East of the off-ramp side is controlled for the alignment plan. To avoid this restaurant, the alignment should be made as an S-line. However, straight alignment is adopted at present. Safety facilities or measures are required because the minimum geometric criteria value is being adopted.	For the underpass plan, the weaving length cannot be kept more than the standard from the existing roundabout. Therefore, this plan is impossible. The flyover can be planned as the weaving length can be kept more than 300m up to I-05 intersection.	In the flyover plan, the design speed and longitudinal gradient becomes 50km/h and 6% each, considering the weaving distance between the highway ramp and roundabout, but the planning is possible. In the underpass plan, the planning is possible as the weaving length can be kept more than the standard length. The weaving length can be kept more than 300m up to I-04 intersection.		In order to plan the bridge of the East-South direction in the intersection, the horizontal curve radius and the design speed are required to use a small radius and design speed of 40km/h, but the planning is possible.
Relation to Other Facilities		The existing drainage canal in the center should be relocated to the side. The relocated drainage canal will be used for rainwater flow.	The drainage facility (box culvert: B=4m) in the center of the road should be relocated. The relocated drainage facility will be used for rainwater flow.	The drainage facility (box culvert: B=4m) in the center of the road should be relocated. This relocated drainage facility will be used for rainwater flow after construction of underpass.		There are two drainage pipe culverts (φ800, φ400), located in the East of the intersection, which should be relocated for the construction of the new bridge foundation.
Traffic Operations		Existing Traffic Volume: 30,117 PCU/16hrs Due to heavy traffic congestion (degree of saturation 2.07), at-grade improvement is not seen as a suitable solution for this intersection. The grade separation alternative is immediately required. Despite the grade separation, the intersection will again experience the degree of saturation of 1.05 and 1.79 in 2025 and 2035, respectively. This is because the available ROW limits the design of the satisfactory number of lanes. Therefore, land acquisition and compensation become a future issue.	Existing Traffic Volume: 21,281 PCU/16hrs Grade separation is able to solve the traffic congestion up to 2025. However, by 2035, the degree of saturation will reach 1.45. Therefore, in the long run, land acquisition is expected for further road widening and intersection improvement.		Existing Traffic Volume: 31,071 PCU/16hrs From a traffic operation viewpoint, the grade separation structure in East-West direction is inferior to that of the East-South direction.		Existing Traffic Volume: 31,071 PCU/16hrs This alternative is preferable from a traffic flow viewpoint as it contributes to reducing the conflict points of the major traffic directions and it is in the same direction as the one of the BRT lines, planned by CETUD. Grade separation is able to solve the traffic congestion up to 2025. However, by 2035, the degree of saturation will reach 1.31. Therefore, in the long run, land acquisition is expected for further road widening and intersection improvement.
Workability		A steel pipe sheet pile press-fit method will be adopted to suppress vibrations and noise and shorten the construction period because the construction site is in the urban narrow land, which is dotted with shops and a hospital. A square steel pipe slab bridge will also be adopted to shorten the construction period for the crossing bridge. This is possible to suppress the required construction land and the type of construction equipment, and is excellent in workability. A detour road is required because the construction site will be closed during the construction period.	A detour road is required because the construction site will be closed during the construction period.	A steel pipe sheet pile press-fit method will be adopted to suppress vibrations and noise because the construction site is in the urban narrow land. A detour road is required because the construction site will be closed during the construction period.	A detour road is required because the construction site will be closed during the construction period.	A steel pipe sheet pile press-fit method will be adopted to suppress vibrations and noise because the construction site is in the urban narrow land. A detour road is required because the construction site will be closed during the construction period.	With a steep curve of the horizontal alignment, the superstructure should be a steel structure. The erection method is also limited compared with the East-West direction straight bridge plan. However, the workability may be better than the East-West direction straight bridge plan by the construction method and the expense because it is a steel structure. A detour road is required because the construction site will be closed during the erection work of the bridge.
Economy		This alternative plan will use the pre-cast products. Therefore, the transport cost becomes expensive. However, the construction period will be shortened and the land acquisition cost will also be reduced.	This plan is excellent in economic efficiency compared to the underpass plan because the drainage facility is not required.	In addition to the flyover plan, installation and maintenance of the drainage facility (pumping stations) are required.	This plan is excellent in economic efficiency compared to the underpass plan because the drainage facility is not required.	In addition to the flyover plan, installation and maintenance of the drainage facility (pumping stations) are required.	This alternative plan is inferior in economy compared with the East-West direction alternative plan because of the steel superstructure.
Cost (Million FCFA)		28,805	12,715	41,612	10,451	32,103	13,990

Evaluation	Good*	Good	Poor	Good	Poor	Good

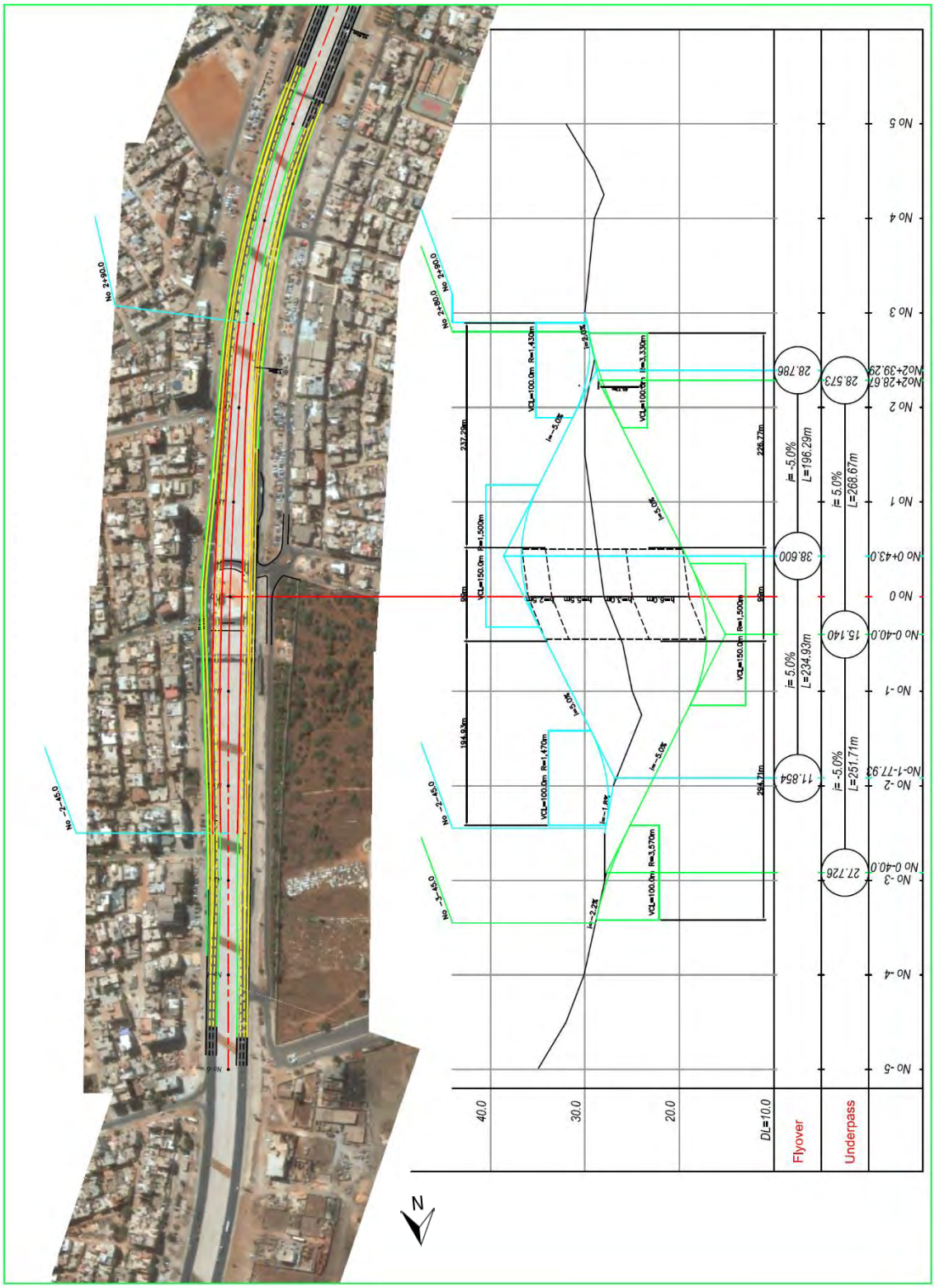
Note: Shaded cells indicate that the alternatives are superior to others with regards to the attributes being compared; "*" indicates single alternative for the sub-project and shading of the cells is not necessary.
Source: JICA Study Team

Table 12.5.3 Geometric Criteria

Design speed V (km/h)					60	50	40	Remark				
Skid friction coefficients for the design: f					0.13	0.14	0.15					
Combination of alignments	Limit curve radius	Horizontal			200	–	100	The value in brackets () is the vertical curve length. When combining the horizontal and vertical alignments, one of them should be kept more than two times of the value indicated in the table below.				
		Vertical			2,500(25⊿)	–	2,000(20⊿)					
Horizontal alignment	Minimum curve radius: R (m)	Desirable value			200	150	100	Special value is applied when the superelevation is 10%.				
		Standard value			150	100	60					
		Special value			120	8	50					
	Minimum curve length: L (m)	θ ≥ γ°			100	80	70	When θ is less than 2 °, θ is calculated as 2 °.				
		θ < γ°	Standard		700/θ	600/θ	500/θ					
			Special		100	80	70					
	Minimum curve radius to abort superelevation: R (m)	Paved road	2.0%		2,000	1,300	800	Design f ＝ 0.035				
			1.5%		1,500	1,000	600					
Superelevation	Curve radius and superelevation	Standard Superelevation 2%	10%		120 or more less than 150	80 or more less than 100	50 or more less than 65	Maximum superelevation of the curve section: i				
			9		150 or more less than 190	100 or more less than 130	65 or more less than 80	Road Category	Location of road	i %		
			8		190 or more less than 230	130 or more less than 160	80 or more less than 100	Category-3		10		
			7		230 or more less than 270	160 or more less than 200	100 or more less than 130	Category-4		6		
			6		270 or more less than 330	200 or more less than 240	130 or more less than 160	In the case of category -3 road without a bicycle road, the superelevation should be less than 6%. In the case of unavoidable by terrain and other special reasons, category-4 road can be omitted superelevation.				
			5		330 or more less than 420	240 or more less than 310	160 or more less than 210					
			4		420 or more less than 560	310 or more less than 410	210 or more less than 280					
			3		560 or more less than 800	410 or more less than 500	280 or more less than 400					
			2		800 or more less than 2,000	500 or more less than 1,200	400 or more less than 600					
		1.5%	2%		800 or more less than 1,370	500 or more less than 1,000	400 or more less than 600	Widening width of curve (per 1-lane).				
			1.5		1,370 or more less than 1,500	–	–	Curve radius: R (m)			Width of widening (m)	
	Curve radius and gradient of special value at the urban	Standard Superelevation 2%	6%		–	–	60 or more less than 63	Category-3 Category -4, Class-1	Other category			
			5		–	100 or more less than 105	63 or more less than 65	Less than 280 150 or more	Less than 160 90 or more		0.25	
			4		150 or more less than 160	105 or more less than 110	650 or more less than 70	Less than 150, 100 or more	Less than 90, 60 or more		0.50	
								Less than 100, 70 or more	Less than 60, 45 or more		0.75	
			3		160 or more less than 165	110 or more less than 115	70 or more less than 74	Less than 70, 50 or more	Less than 45, 32 or more		1.00	
									Less than 32,		1.25	

								26 or more	
			2	165 or more less than 220	115 or more less than 150	74 or more less than 100		Less than 26, 21 or more	1.50
								Less than 21, 19 or more	1.75
		1.5%	2%	155 or more less than 170	115 or more less than 120	74 or more less than 75		Less than 19, 16 or more	2.00
			1.5	170 or more less than 220	120 or more less than 150	75 or more less than 100		Less than 16, 15 or more	2.25

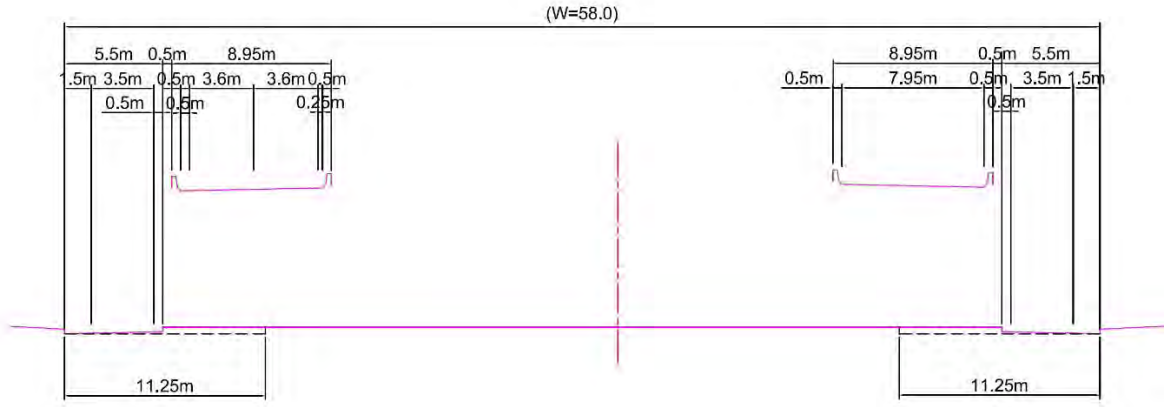
Source: JICA Study Team



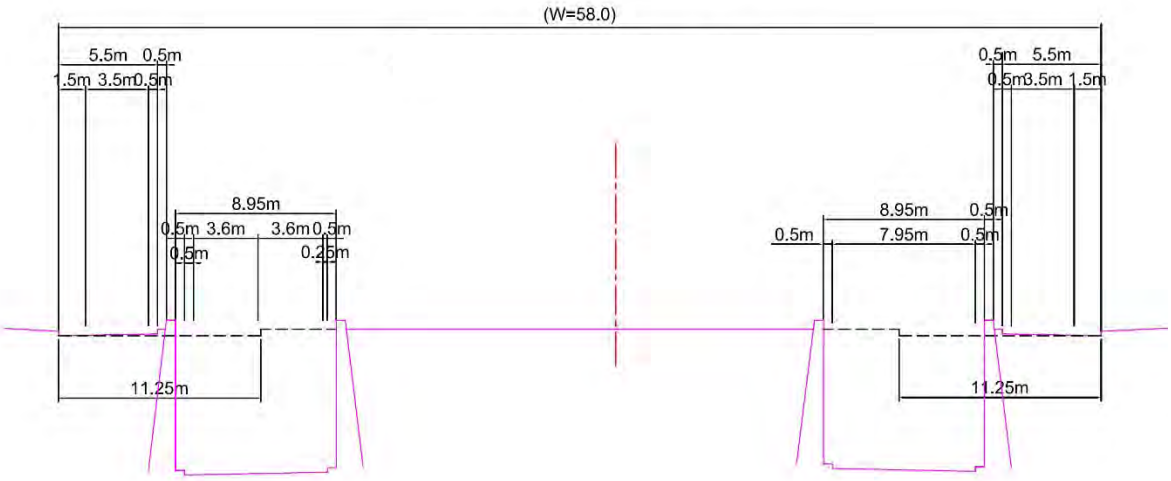
Source: JICA Study Team

Figure 12.5.1 Flyovers and Underpasses on Both Sides at SDE (I-01a, I-01b)

Flyovers on Both Sides (I-01a):

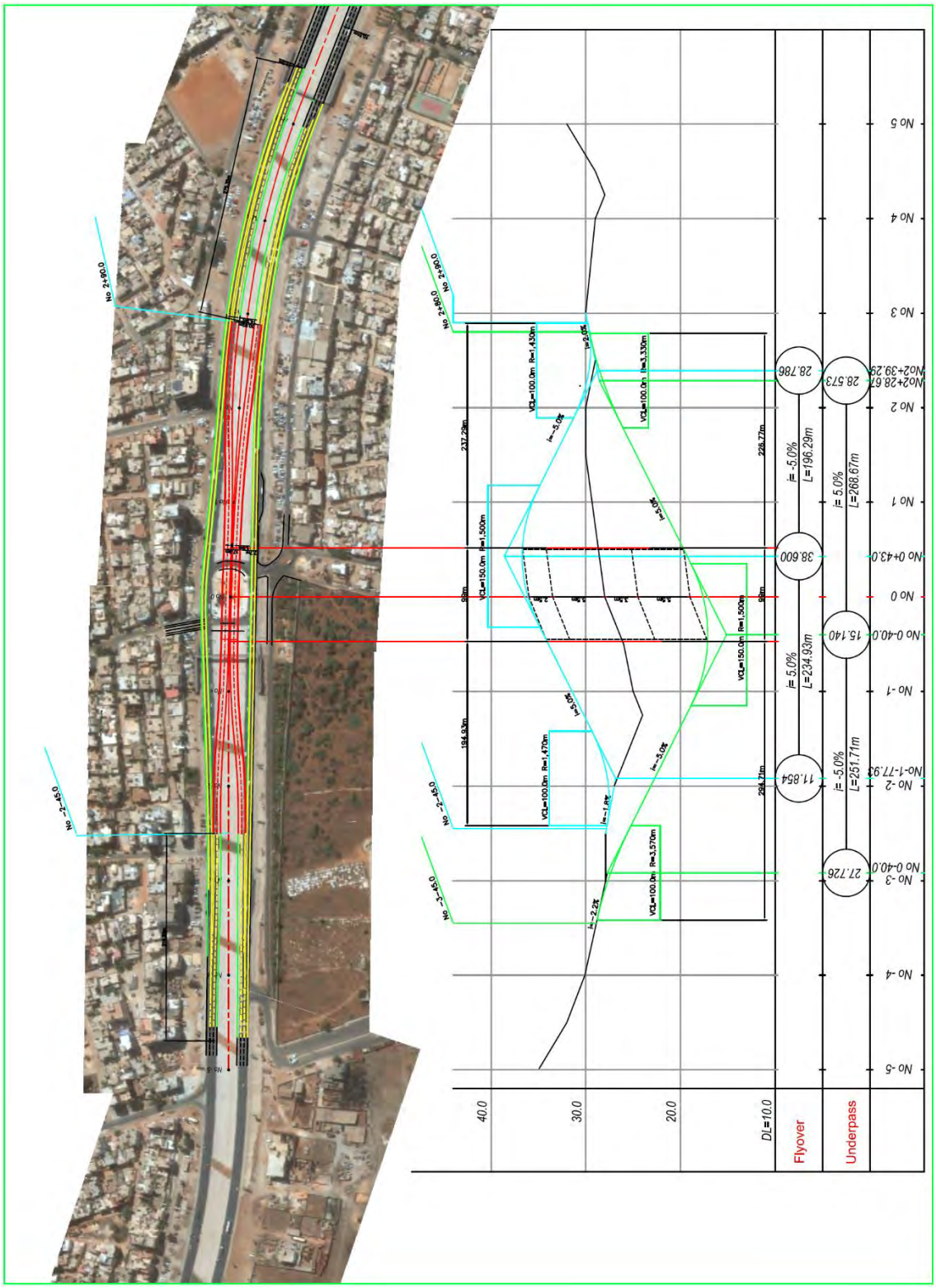


Underpasses on Both Sides (I-01b):



Source: JICA Study Team

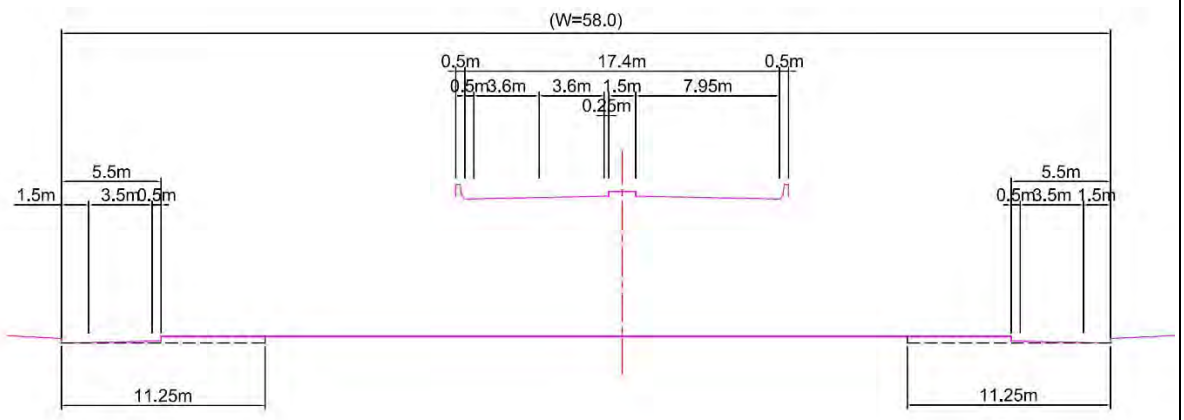
Figure 12.5.2 Typical Cross Section of Flyovers and Underpasses on Both Sides at SDE



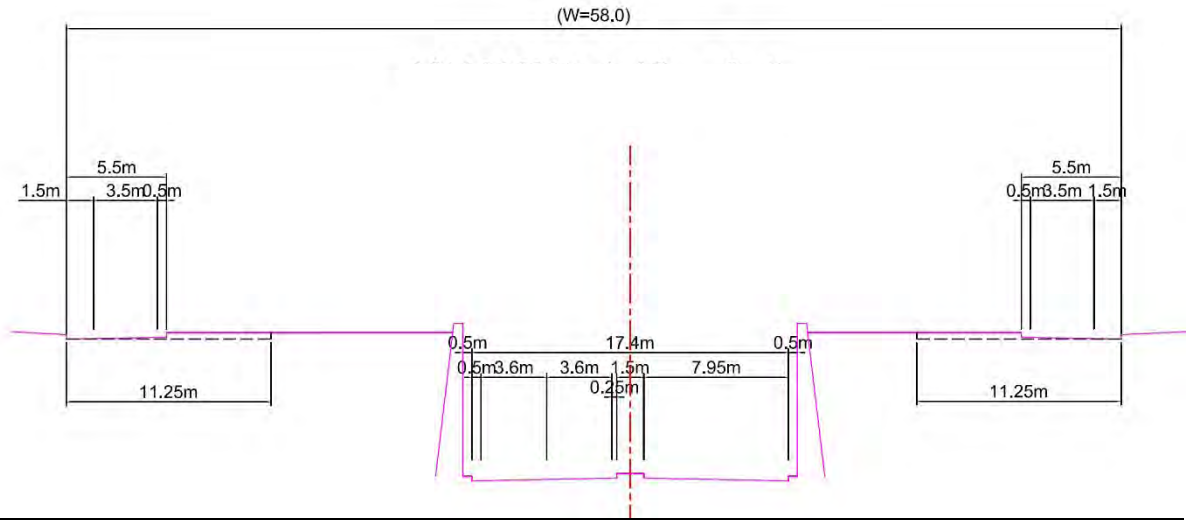
Source: JICA Study Team

Figure 12.5.3 A Flyover and an Underpass in the Center at SDE (I-01c, I-01d)

A Flyover in the Center (I-01c):



An Underpass in the Center (I-01d):



Source: JICA Study Team

Figure 12.5.4 Typical Cross Section of a Flyover and an Underpass in the Center at SDE

Figure 12.5.5 At-grade Improvement with Traffic Signals at SDE (I-01e)

Source: JICA Study team

Source: JICA Study Team

Figure 12.5.6 At-grade Improvement with U-turn Lanes at SDE (I-01e)

(2) Cité Keur Gorgui intersection (I-02)

1) Grade Separation Alternatives (I-02a, I-02b, I-02c, and I-02d)

The current situation is similar to I-01. However, the short distance from the North side confluence does not allow an independent intersection. The decreasing gradient of the current road can be used for the underpass alternative, which is an advantage from an alignment point of view.

In the case of a flyover, a nose distance of 60m is too short and an S curve is not desirable with regard to traveling performance. However, considering the excavation of an underpass tunnel into the hard rock layer and the drainage facility installations, such as pumps, the project implementation cost will be approximately 1.5 times that of the flyover alternative.

Figure 12.5.7 illustrates the outline drawings of the flyovers and underpasses on both sides. Figure 12.5.9 shows the outline drawings of the flyover and underpass in the center.

2) At-grade Alternatives (I-02e and I-02f)

This intersection is a roundabout formed by an oblique angled crossing (approximately 65 degrees) where traffic inflows from the North and South are separated by a wide median. The traffic conflict and interference at the weaving sections of the roundabout are predominant and cause congestion. Hence, the installation of a traffic signal (I-02e) is considered as an at-grade improvement alternative.

There is another possibility to avoid the crossing between the vehicles of the though traffic and those turning left/right. This alternative involves the closing of the existing roundabout and the construction of new U-turn lanes located 200m away on both sides (I-02f). While traffic safety will be enhanced by this alternative, driving distance will be increased. Furthermore, it is necessary to validate the traffic capacity of the U-turn lanes.

The outline drawings of the at-grade improvement alternatives, i.e., the installation of traffic signals and U-turn lanes, are shown in Figure 12.5.11 and 12.5.12, respectively.

(3) Aimé Césaire Intersection (I-03)

This intersection is located in an extension section of I-01 and I-02, and the ROW is narrower (25m). This is also a very busy four-lane road due to the hospital and commercial stores along the side road.

There is currently an existing flyover on the North side of this intersection. Therefore, the grade-separated plan of a new underpass requires the partial demolition of the existing retaining wall, due to the short distance between the existing flyover and the planned underpass. If a flyover is chosen for the grade separation, the section of retaining the wall of the existing road that requires demolition is larger than the underpass plan. The vertical alignment also causes inconvenience for the traffic flow. Therefore, the underpass plan was selected as an extension of the current state of the descending slope from the existing flyover.

However, the road ROW of 25m is not enough for implementing a grade-separated intersection plan, which requires at least W=31.8m, considering the minimum necessary width of all elements. Therefore, this plan uses 4~5m green open space in the vicinity of the intersection on the Eastern side of the road, as well as a minimum of 1~2m of land on the Western side of the road (hospital side) to accommodate the grade separation structure. However, it is difficult to secure the shoulder width, hence the lane configuration is 3.6m x two lanes = 7.2m width. For the ramp, the reduced value W=5.2m is adopted, since securing a sidewalk width of 1.5m shown in I-01 is impossible. Figure 12.5.13 shows the outline drawing of the underpass plan for I-03.

Based on the preliminary design shown in Figure 12.5.13, which is a restaurant located on the Eastern side of the road around the separation point between the ramp and the main alignment of the underpass structure of the South inflow, will be partly affected. To avoid the effect on the restaurant, an additional alternative was considered as a reference. Figure 12.5.14 presents this additional alternative, which is proposed as an S horizontal curve underpass, thereby shifting the alignment to the hospital side (i.e., the West side), avoiding the restaurant and reducing compensation costs. However, both of these plans will need compensation to rebuild/displace the affected ATM facility (1~2m) and the

hospital facilities that are located on the West side of the road.

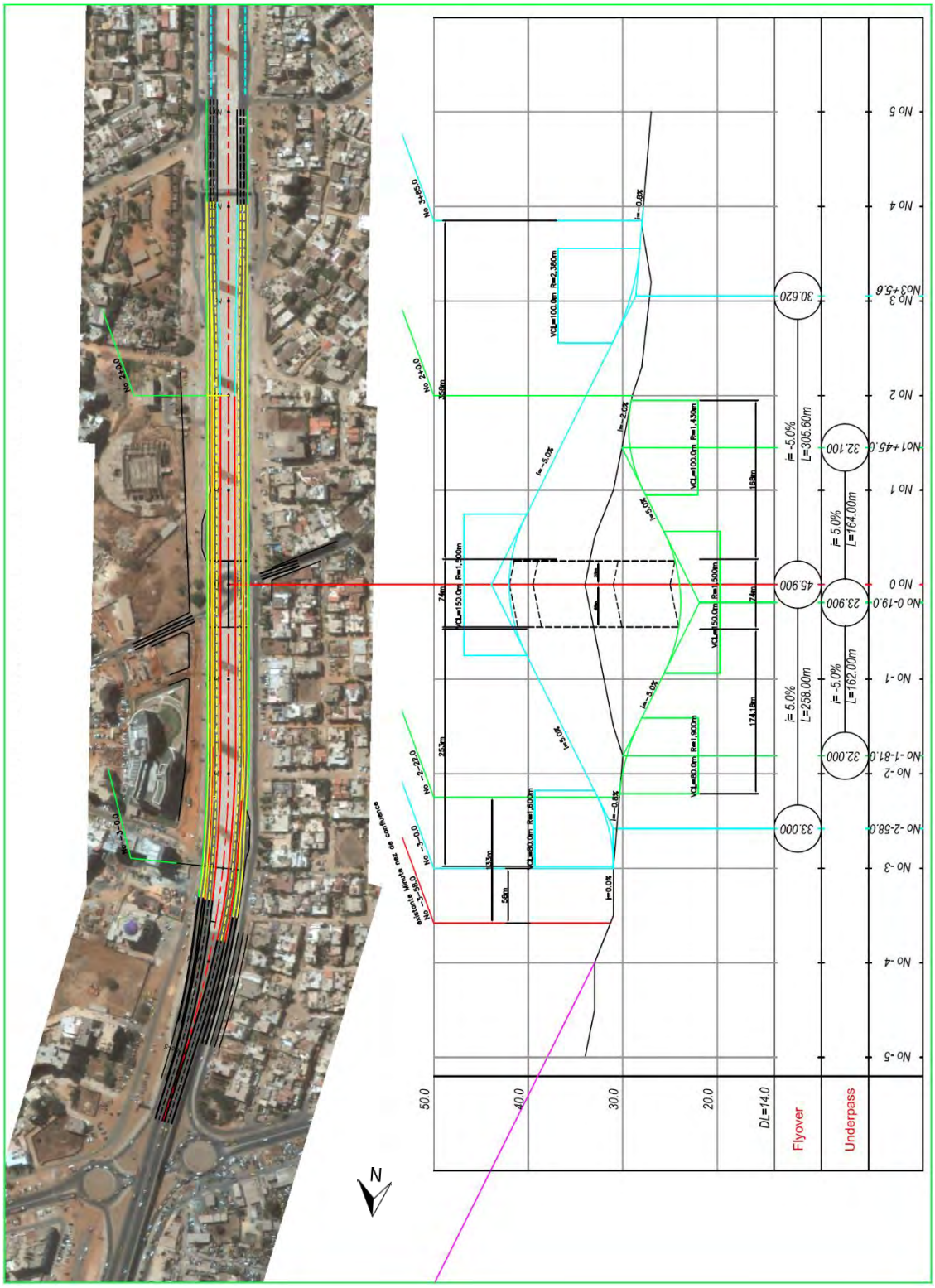
(4) Khar Yalla Intersection (I-04)

The current road has a ROW of 30m with two lanes in each direction and a 5m median. Right under the median, there is a large drainage box culvert with a width of 4m and variable depth. Therefore, relocating the drainage from the median to under the side ramp is necessary for the construction of a grade-separated intersection. In addition, the local vendors open small shops in the median space every Saturday. Therefore, there are also issues regarding compensation to relocate the affected people. Furthermore, it is difficult to widen the road width, since houses and stores occupy the roadside.

Therefore, although this plan considered the minimum cross section (no shoulder on the main road and a total 5.2m width of ramp), the sidewalk width became very narrow. As a result, the design speed of 60km/h was adopted considering the present condition.

An underpass alternative was also considered. However, taking into account the short distance between the existing junction on the West side and the vertical alignment, it is difficult to secure the necessary distance for the weaving section. For this reason, a flyover solution was adopted.

An outline drawing of the flyover and underpass at Khar Yalla intersection is illustrated in Figure 12.5.16.

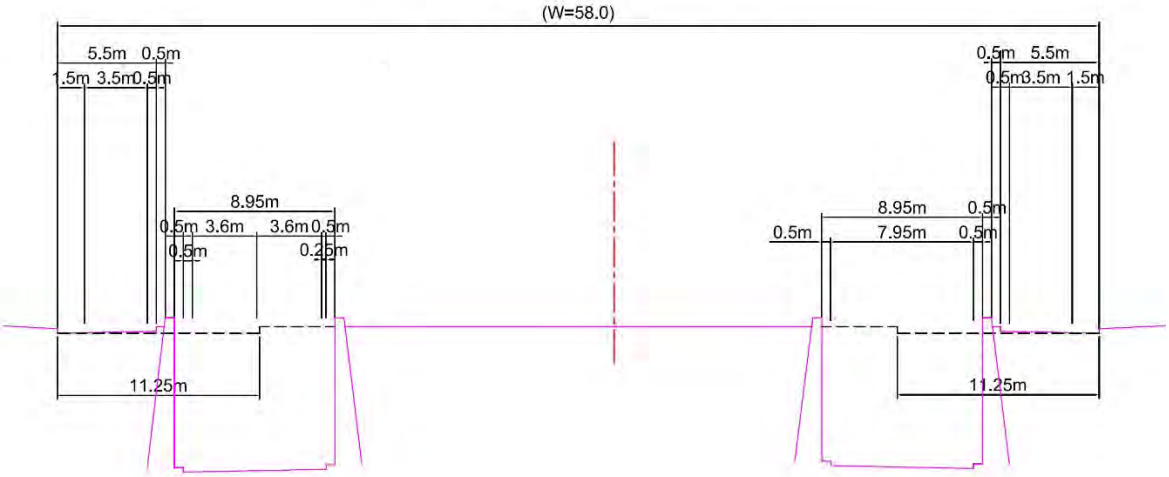


Source: JICA Study team

Figure 12.5.7 Flyovers and Underpasses on Both Sides at Cité Keur Gorgui (I-02a, I-02b)

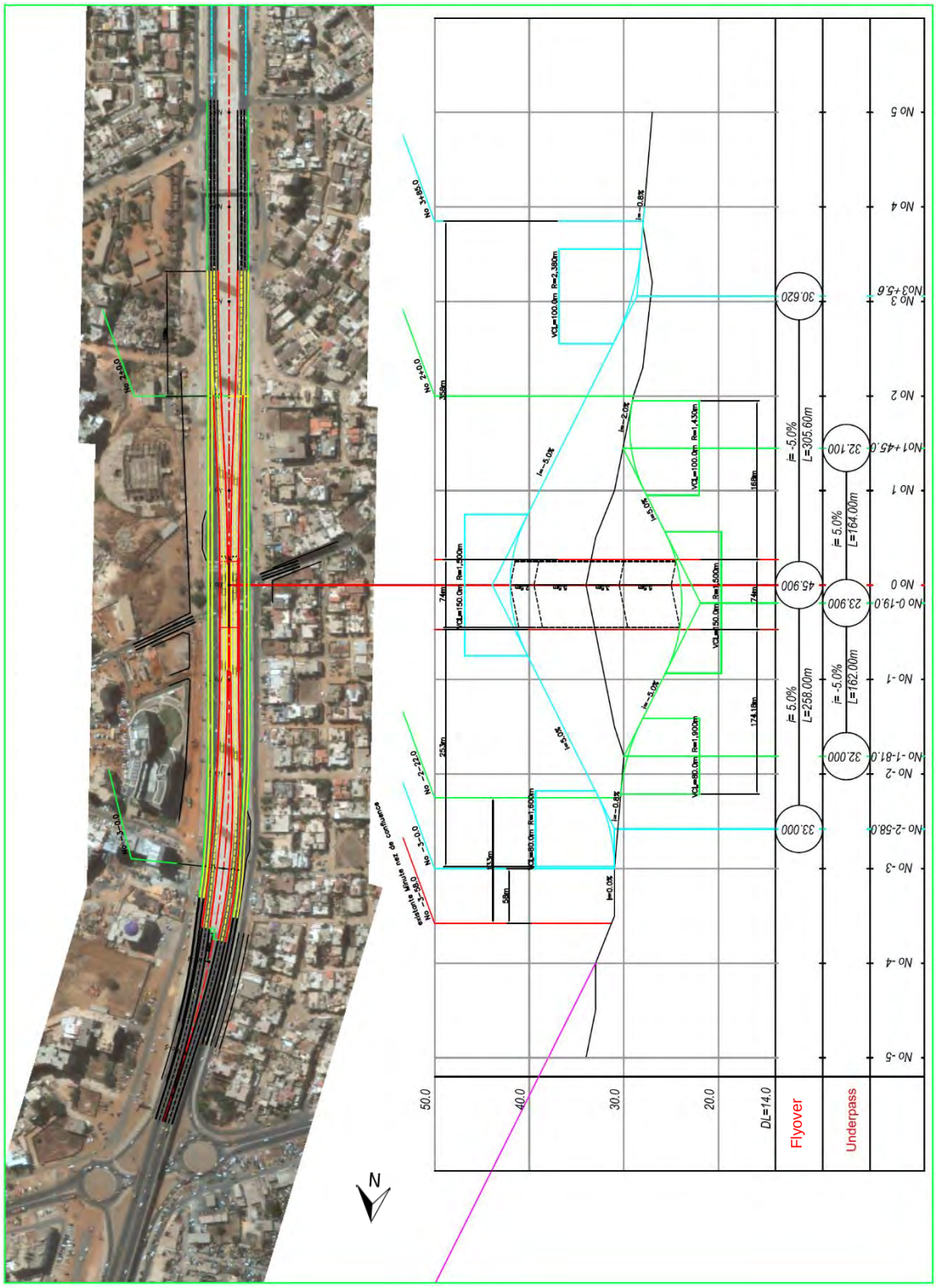
Flyovers on Both Sides (I-02a):

Underpasses on Both Sides (I-02b):



Source: JICA Study Team

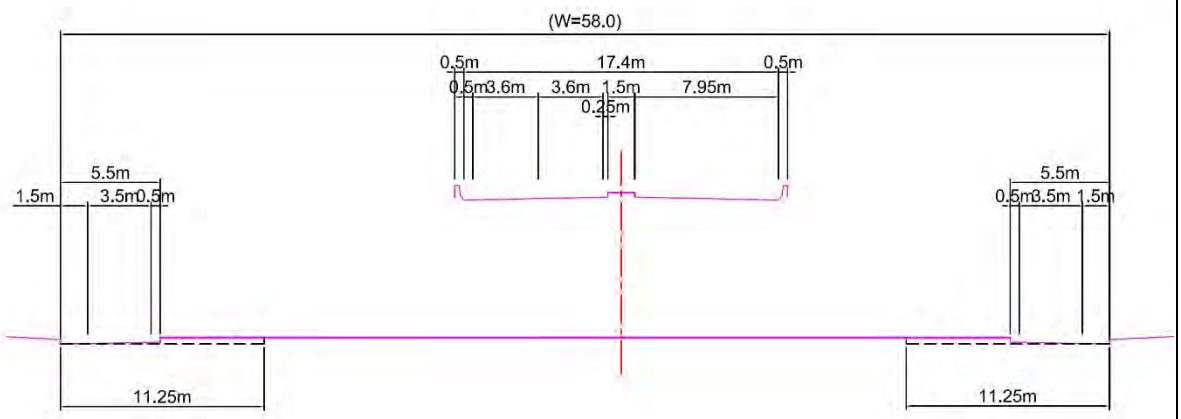
Figure 12.5.8 Typical Cross Section of Flyovers and Underpasses on Both Sides at Cité Keur Gorgui



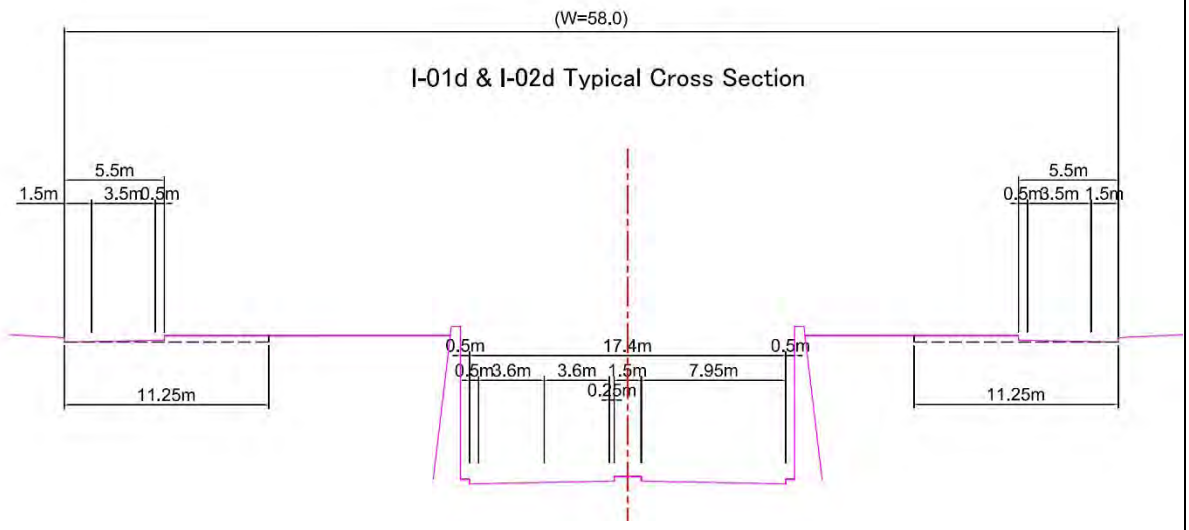
Source: JICA Study team

Figure 12.5.9 A Flyover and an Underpass in the Center at Cité Keur Gorgui (I-02c, I-02d)

A Flyover in the Center (I-02c):



An Underpass in the Center (I-02d):



Source: JICA Study Team

Figure 12.5.10 Typical Cross Section of a Flyover and an Underpass in the Center at Cité Keur Gorgui

Source: JICA Study team

Figure 12.5.11 At-grade Improvement with Traffic Signals at Cité Keur Gorgui (I-02e)

Source: JICA Study team

Figure 12.5.12 At-grade Improvement with U-turn Lanes at Cité Keur Gorgui (I-02f)

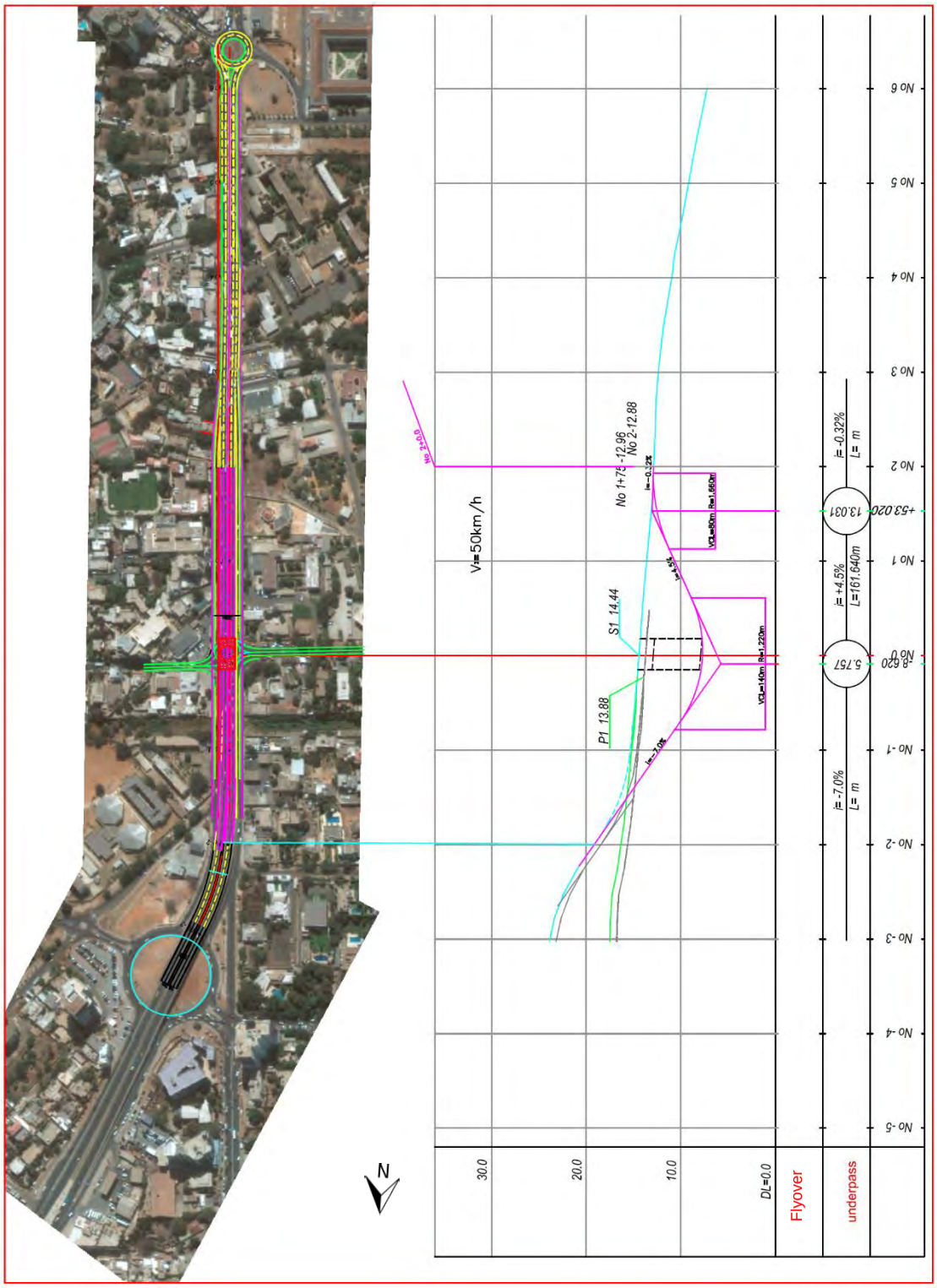
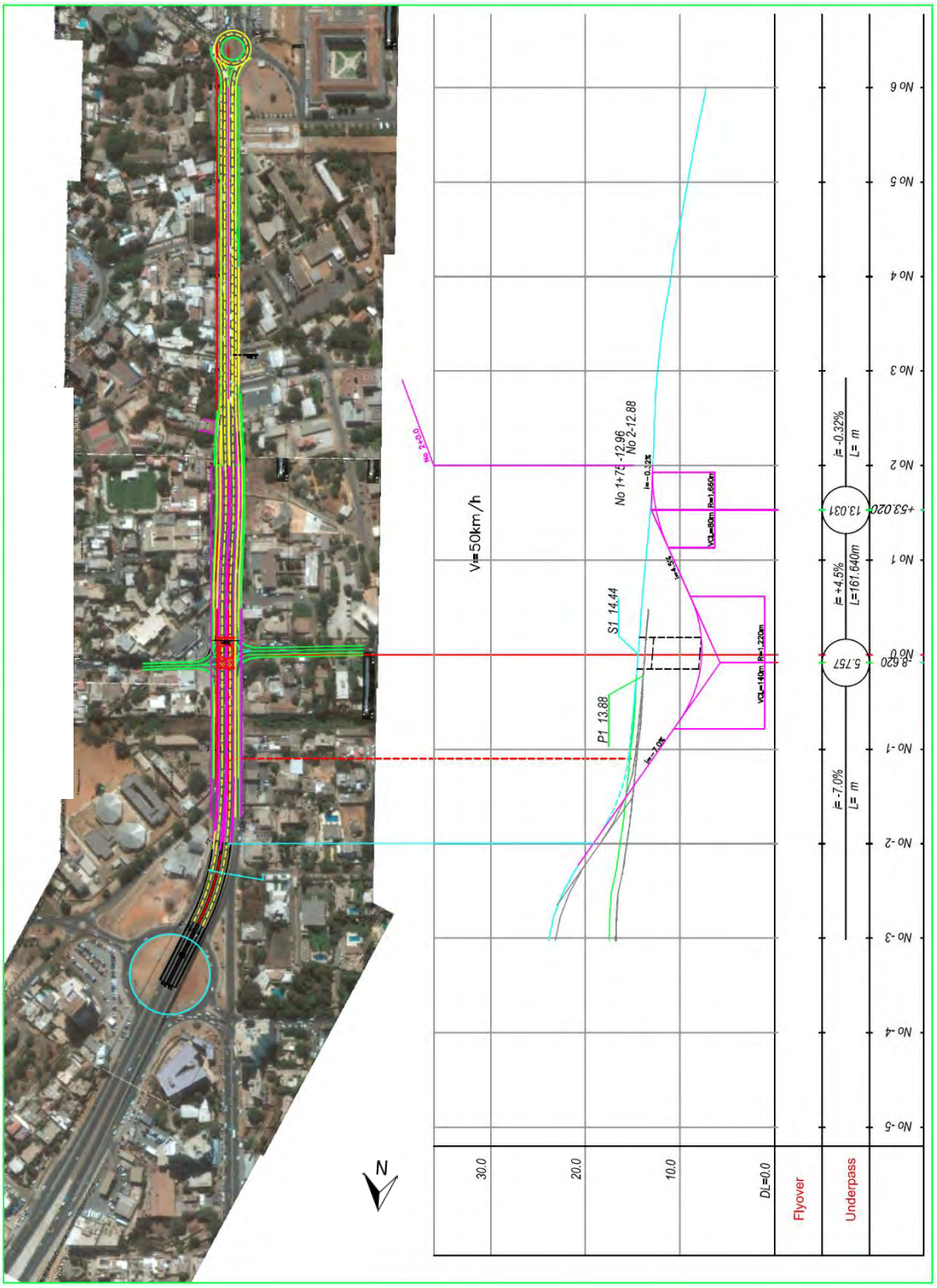


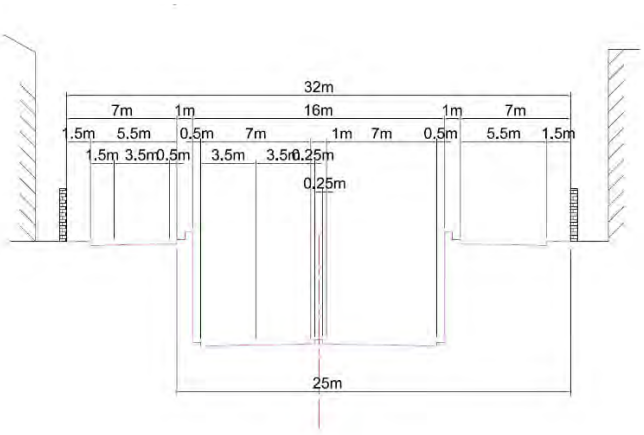
Figure 12.5.13 An Underpass at Aimé Césaire (I-03)

Source: JICA Study team



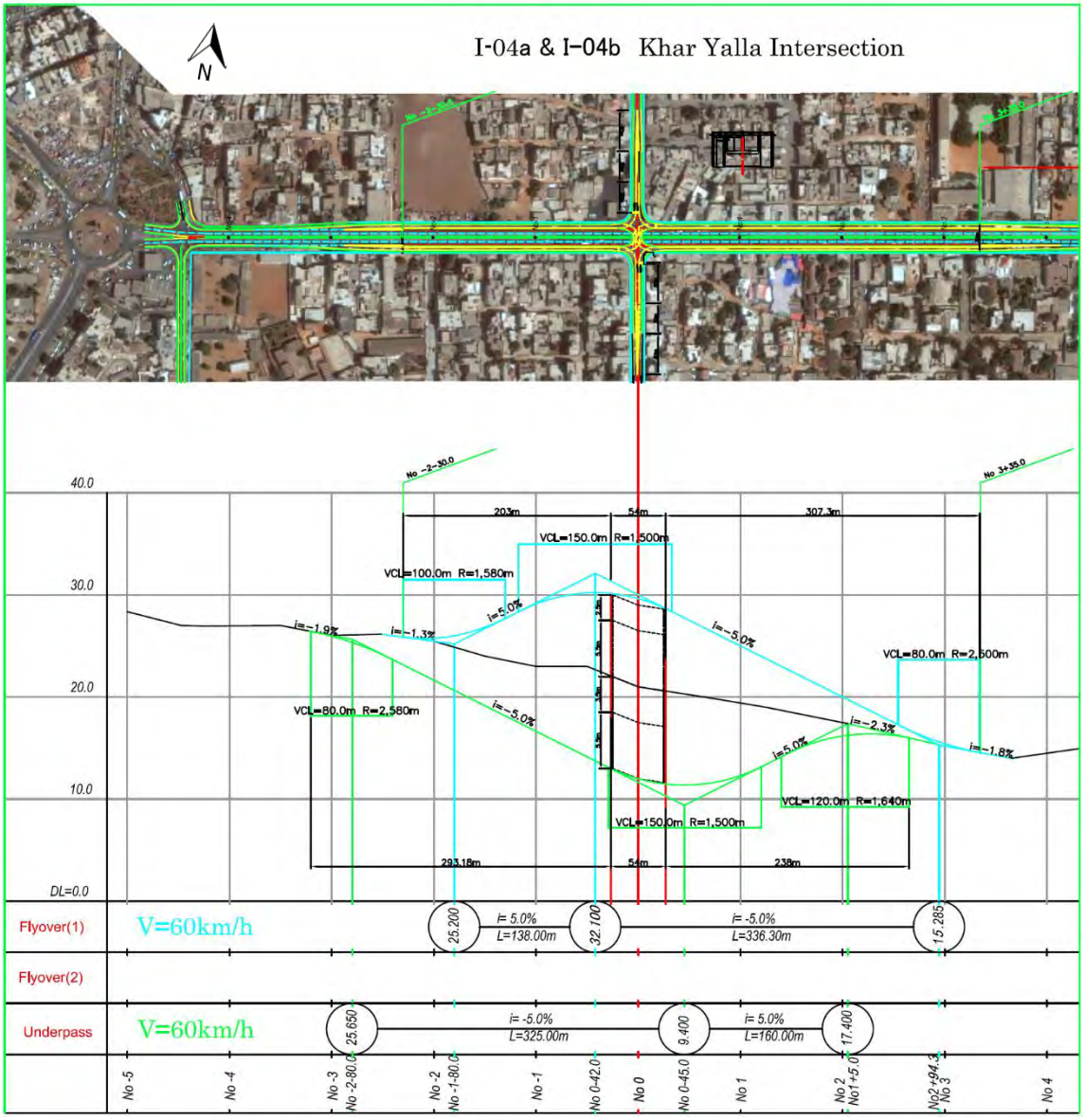
Source: JICA Study team

Figure 12.5.14 An "S Curve" Underpass at Aimé Césaire (for Reference)



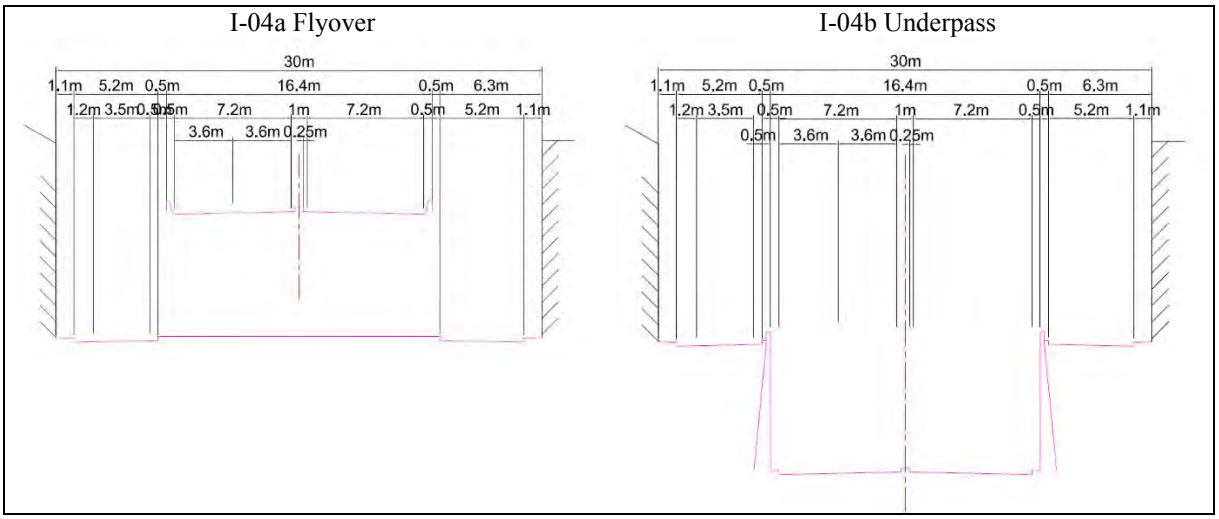
Source: JICA Study Team

Figure 12.5.15 Typical Cross Section of an Underpass at Aimé Césaire



Source: JICA Study Team

Figure 12.5.16 A Flyover and an Underpass at Khar Yalla (I-04a, I-04b)



Source: JICA Study Team

Figure 12.5.17 Typical Cross Section of a Flyover and an Underpass at Khar Yalla

(5) Bourguiba Intersection (I-05)

Grade-separated intersection plans by the East-West flyover on the Front de Terre and the East-South flyover, which connects the left-turn lane from the East inflow of Front de Terre to the south, were carried out.

The current condition is the same as Intersection I-04.

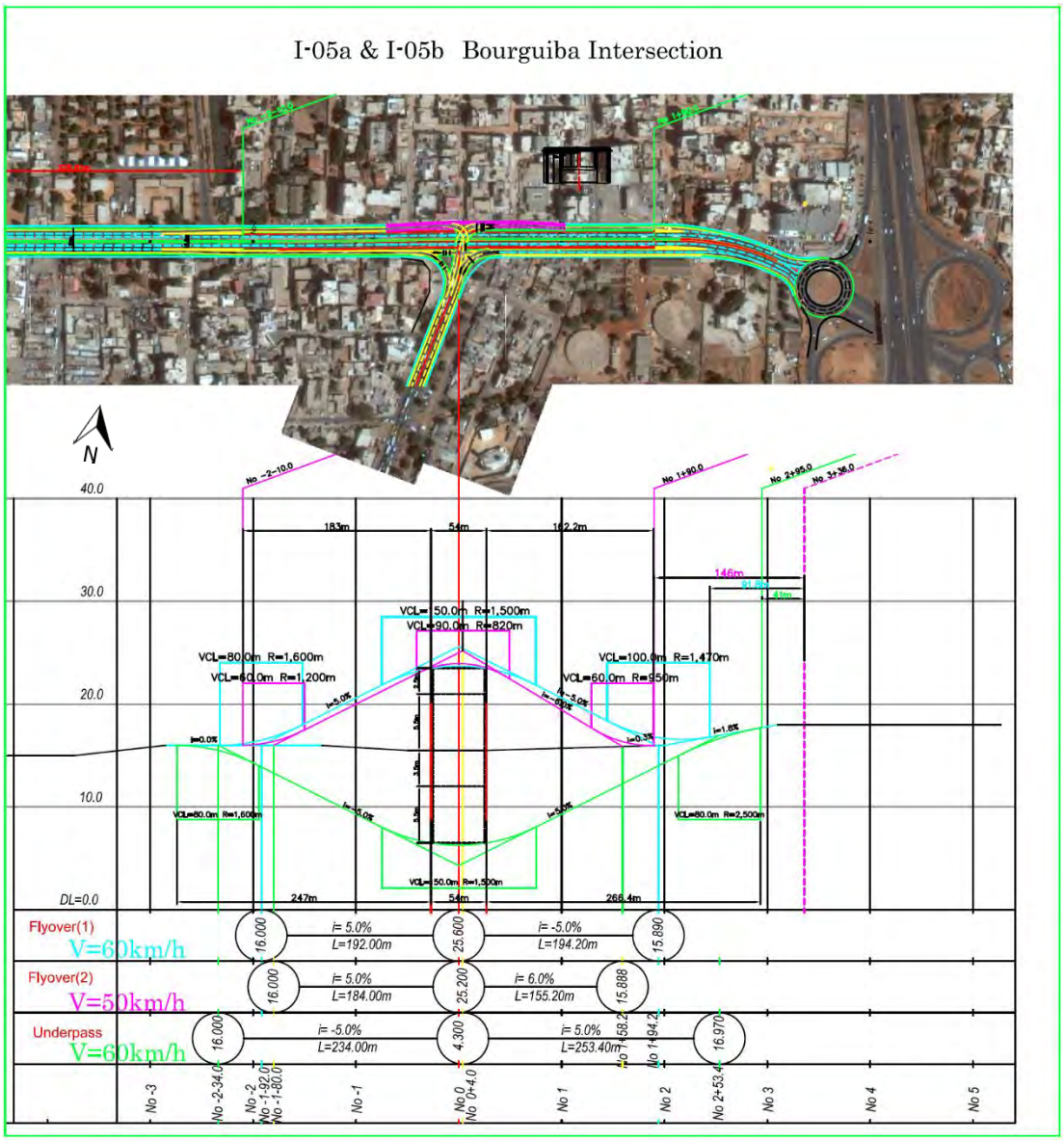
However, in the case of the East-West flyover, the maximum length of the weaving section will be 140m, even if it is designed with a speed of 40km/h and a vertical gradient of 6%, which is too short to secure a safe connection between the intersection and the roundabout on the East side. Therefore, the number of lanes should be increased from two to three and the weaving section of the main alignment should also increase to three lanes (main alignment: two lanes + ramp: one lane = three lanes).

In the case of the East-South flyover, considering the planned intersection occupying the same area, the horizontal radius is R=70m and the design speed is V=40km/h. Since the necessary weaving section L=110m for the expressway roundabout is short, the same treatment as the straight intersection must be applied to the three lanes.

An underpass solution is difficult due to the vertical alignment and necessary distance for the weaving section.

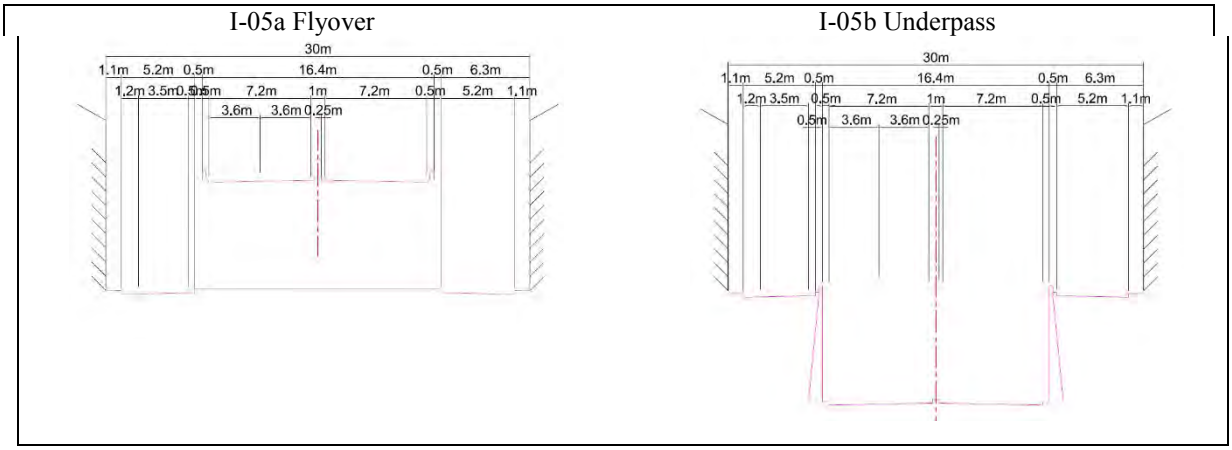
The existing drainage in the I-04 central portion was installed from the beginning of the intersection to the retention basin on the North side. It consists of two drainage pipes (Ø800 and Ø600), which need to be relocated and transferred depending on the construction process.

Figure 12.5.18 shows the outline drawings of the East-West flyover and underpass, and Figure 12.5.20 shows the outline drawings of the East-South flyover.



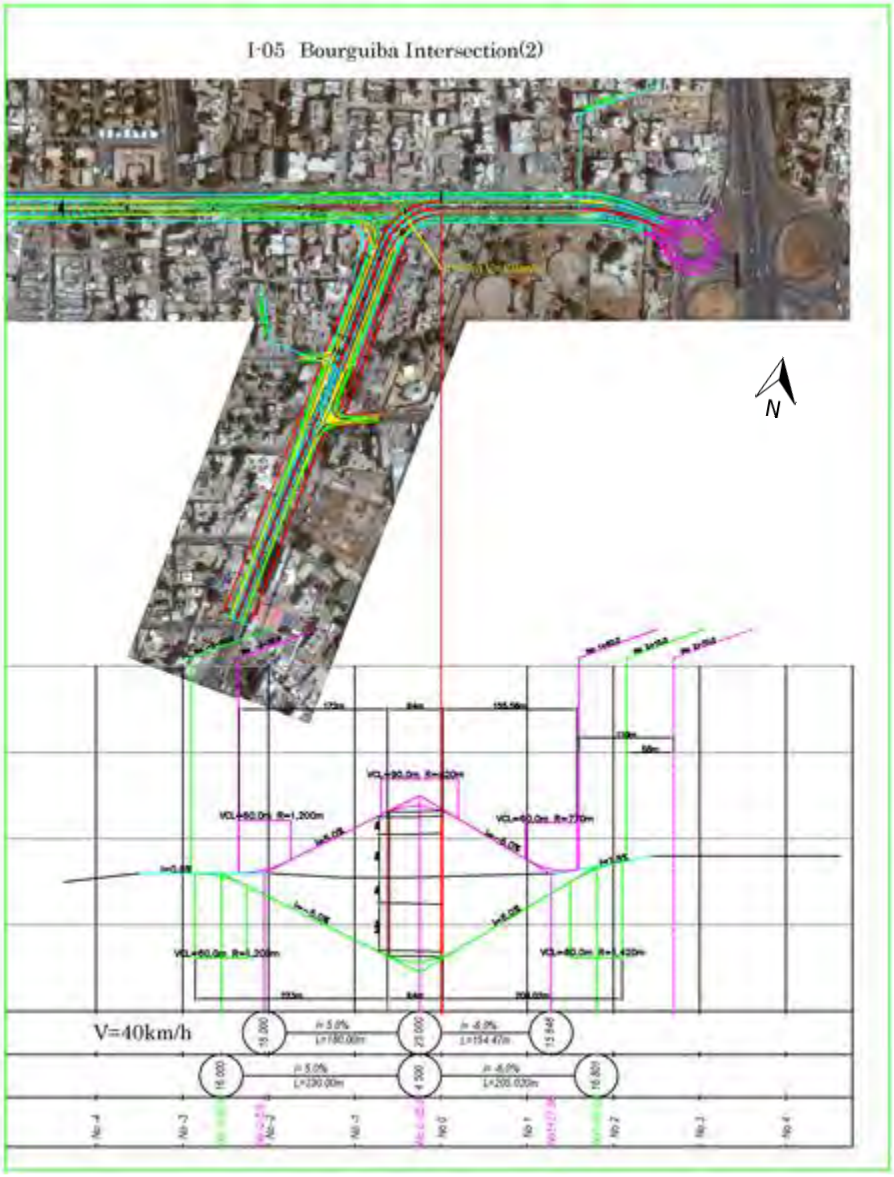
Source: JICA Study Team

Figure 12.5.18 East-West Flyover and Underpass at Bourguiba (I-05a, I-05b)



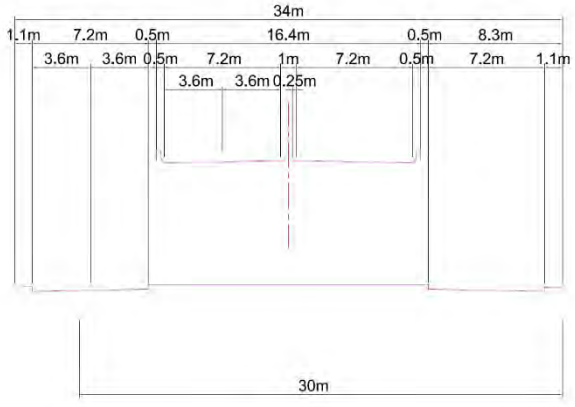
Source: JICA Study Team

Figure 12.5.19 Typical Cross Section of the East-West Flyover and Underpass at Bourguiba



Source: JICA Study Team

Figure 12.5.20 East-South Flyover at Bourguiba (I-05c)



Source: JICA Study Team

Figure 12.5.21 Typical Cross Section of the East-South Flyover at Bourguiba

12.6 Construction Plan

12.6.1 Characteristics of the Sub-project Sites

(1) SDE (I-01) and Cité Keur Gorgui (I-02)

These intersections are located on VDN with a large ROW. A sufficient distance can be secured from the building along the roadsides. Thus, securing detour land and construction space is easy. However, the traffic volumes are large and the vehicles usually drive at a high speed on this road. Therefore, a construction method that requires a short construction period is preferable. The new construction technology that is adaptable to this project is shown below.


(I-01) SDE Intersection


(I-02) Cité Keur Gorgui Intersection

Source: JICA Study Team

Figure 12.6.1 Situation of SDE (I-01) and Cité Keur Gorgui (I-02)

(2) Aimé Césaire (I-03), Khar Yalla (I-04) and Bourguiba (I-05)

The sites of the sub-projects I-03, I-04 and I-05 are located in a narrow urban area, where there are buildings, such as houses, shops, a hospital and a school, which are located close to the road. Thus, securing detour land and construction space is generally difficult. Moreover, traffic will be closed during the construction period. In consideration of these factors, the preferable construction method should have the following characteristics: (i) suppression of noise, (ii) suppression of vibration, (iii) shortening of the construction period and (iv) reduction of space. The new construction technology that is adaptable to the sub-project sites is shown below.


(I-03) Aimé Césaire Intersection


(I-04) Khar Yalla Intersection


(I-05) Bourguiba Intersection

Source: JICA Study Team

Figure 12.6.2 Situation of Aimé Césaire (I-03), Khar Yalla (I-04) and Bourguiba (I-05)

12.6.2 New Construction Technology

With respect to the concerns over the construction issues at the sub-project sites, this sub-section presents the new construction technologies that are suitable for the sub-project sites, along with their advantages. In addition, the application of each construction technology is presented in Table 12.6.1.

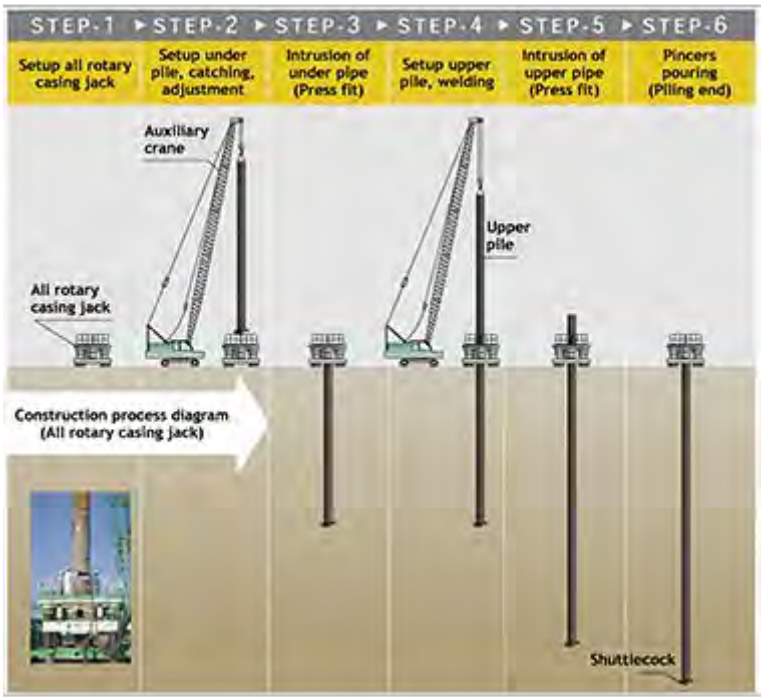
(1) Steel Pipe Press Pile

The advantages of this technology are:

- By using a press, it does not produce surplus soil or sewage;
- Transportation of the surplus soil to the dump site is not required;
- It does not create noise and vibration;
- It can be applied in narrow construction sites;
- The construction period is short compared with the cast-in-place pile.

Therefore, it is efficient to adopt the method for the foundation construction in the urban area. Figure

12.6.3 shows the steps of how the steel pipe press pile works.



Source: Manufacturer catalog

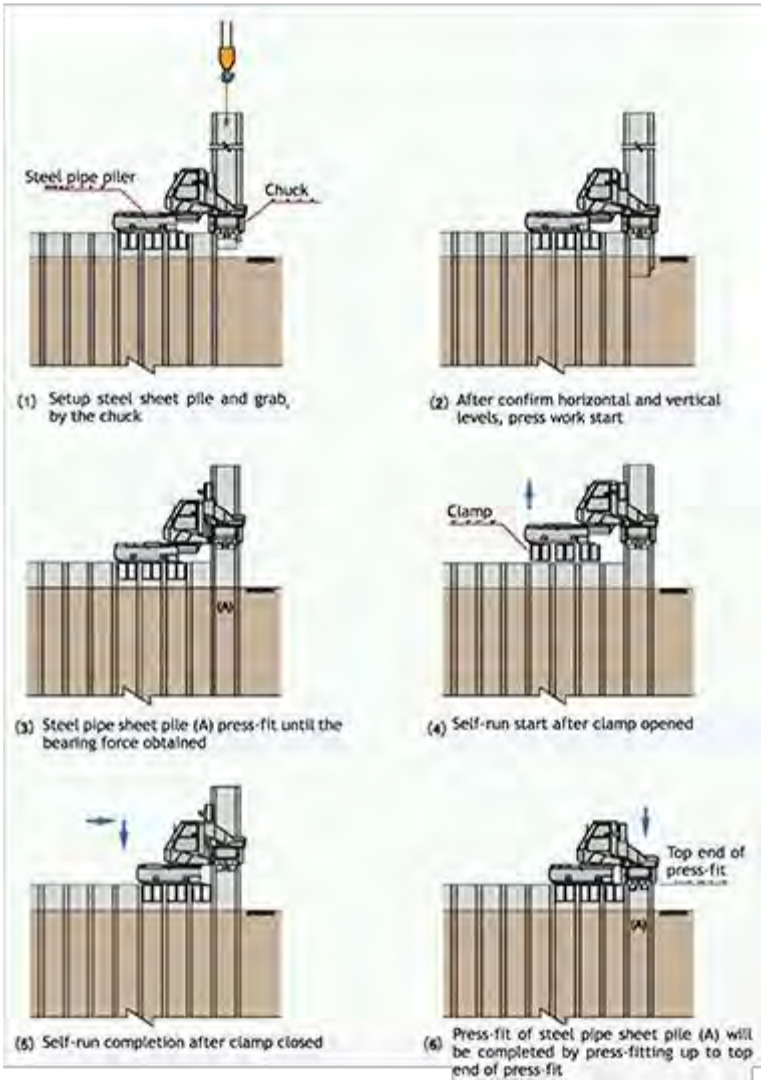
Figure 12.6.3 Steel Pipe Press Pile Method

(2) Steel Pipe Sheet Pile Press

The advantages of this technology are:

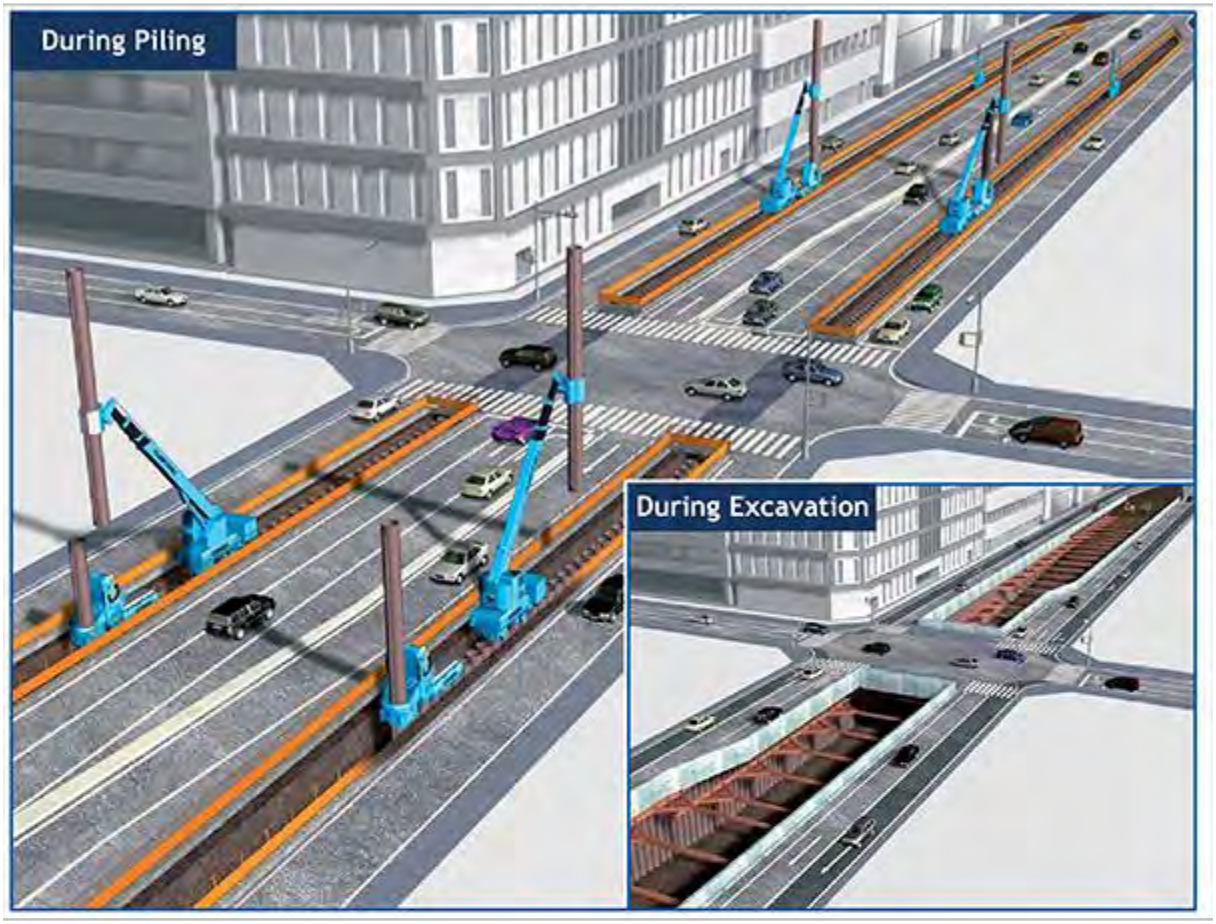
- Excavation work is not necessary;
- Therefore, it can be applied in narrow construction sites;
- It does not create noise and vibration;
- It is a rigid wall because high-quality material of plant products is used.

Therefore, this method is efficient for retaining the wall work of the underpass in the urban area. Figure 12.6.4 illustrates the construction procedure using the steel pipe sheet pile press, while Figure 12.6.5 gives a construction example that uses this method.



Source: Manufacturer catalog

Figure 12.6.4 Construction Procedure of the Steel Pipe Sheet Pile Press Method



Source: Manufacturer catalog

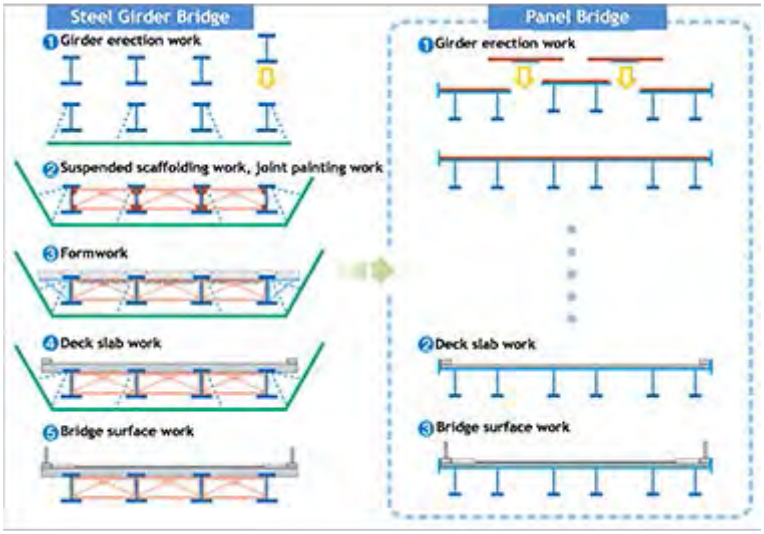
Figure 12.6.5 Construction Example of the Steel Pipe Sheet Pile Press Method

(3) Panel Bridge

The advantages of this technology are:

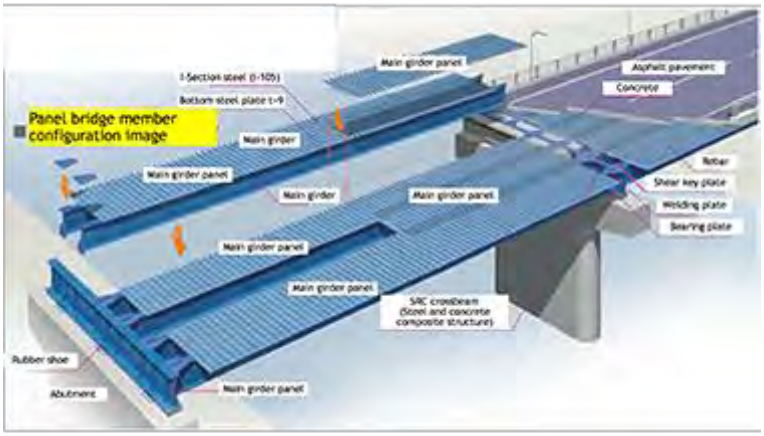
- Construction is fast because the main girder and synthetic deck are integrated;
- It is factory-produced and of high quality;
- Reduction in maintenance because a rust preventive treatment is performed;
- There is no work under the deck, thus no impact on traffic flow.

Therefore, it is efficient for bridge construction in a narrow place of an urban area or under heavy traffic road. Figure 12.6.6 shows a comparison between the panel bridge and the conventional steel girder bridge method. Figure 12.6.7 illustrates the configuration of members of the panel bridge.



Source: Manufacturer catalog

Figure 12.6.6 Comparison of the Steel Girder Bridge and Panel Bridge



Source: Manufacturer catalog

Figure 12.6.7 Panel Bridge Member Configuration Image

(4) H-shaped Steel Bridge

The advantages of this technology are:

- Possible to construct in a narrow site because the members of bridge are small and lightweight due to use of a factory production unit;
- Possible to construct by a small machine and construction first;
- Length of the span can be longer than the panel bridge;
- It is easy for maintenance by weathering steel use.

Therefore, it is efficient for bridge construction in a narrow place of an urban area or under heavy

traffic road. Figure 12.6.8 shows the construction examples of an H-shaped steel bridge.

Source: Manufacturer catalog

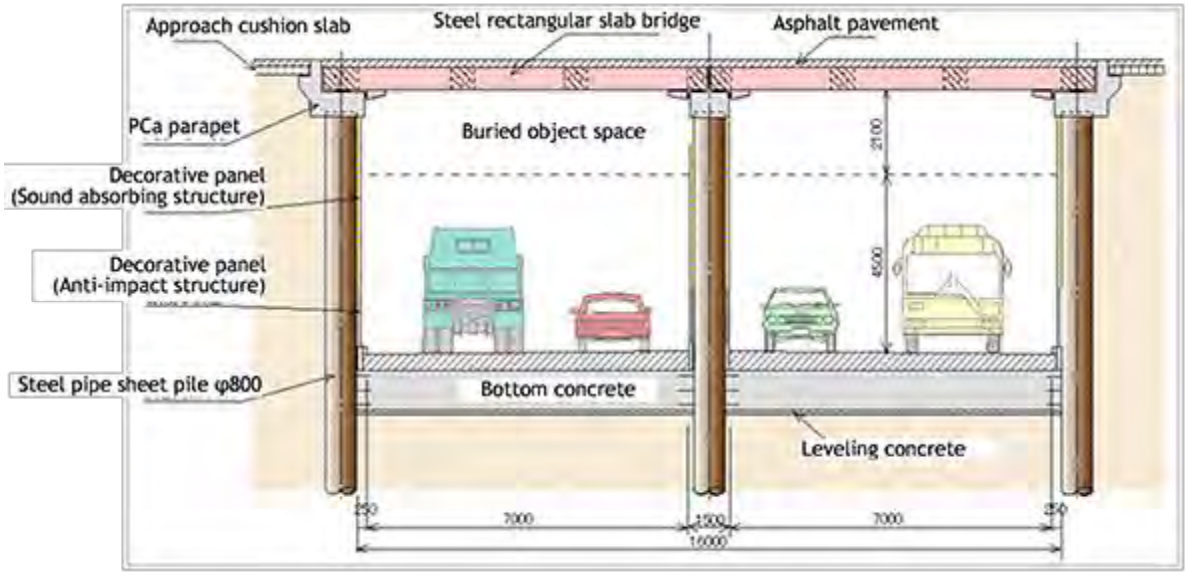
Figure 12.6.8 Construction Examples of an H-shaped Steel Bridge

(5) Steel Rectangular Slab Bridge

The advantages of this technology are:

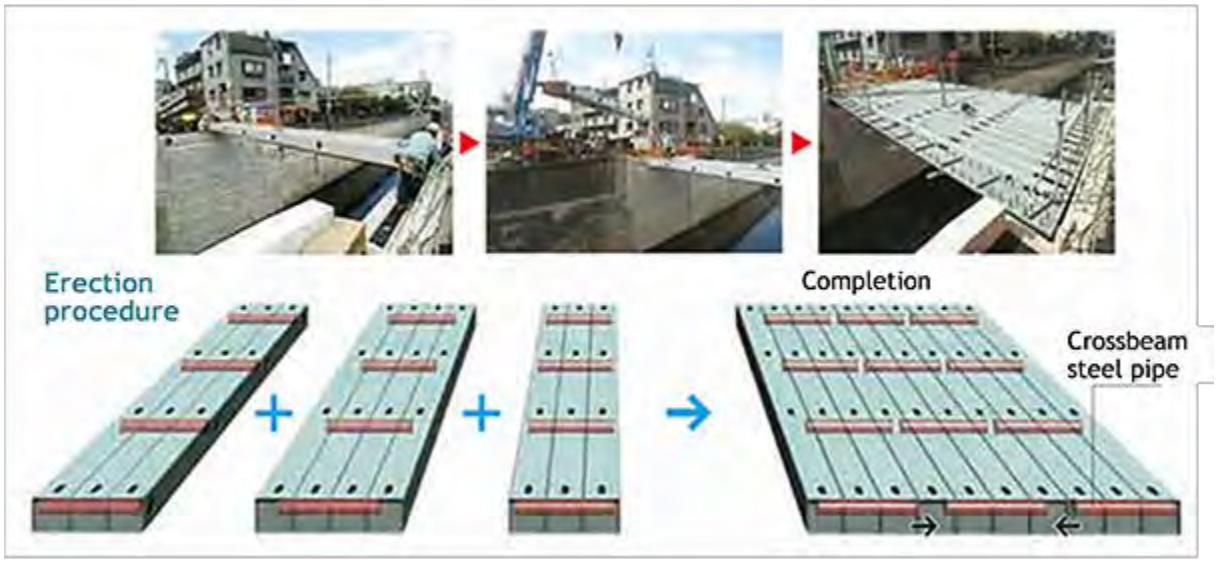
- Low girder height;
- Construction is fast because of the use of a factory production unit;
- It can be erected by small heavy equipment because the parts of the bridge are small;
- It is suitable for construction in a narrow site.

Therefore, it is efficient for bridge construction in a narrow place of an urban area. Figure 12.6.9 shows an underpass structure that uses a steel rectangular slab bridge and Figure 12.6.10 presents the erection procedure.



Source: Manufacturer catalog

Figure 12.6.9 Underpass Structure at an Intersection - Four-Lane



Source: Manufacturer catalog

Figure 12.6.10 Erection Procedure of a Steel Rectangular Slab Bridge

Table 12.6.1 New Construction Technology Methods and Their Application

New Technology	Application	Suppression of Land	Suppression of Noise	Suppression of Vibration	Shortening of Construction Period	Maintenance and Repair	Application
Steel pipe press pile	Pile foundation	–	○	○	–	–	I-01, I-02 Flyover
Steel sheet pipe press pile	Retaining wall	○	○	○	○	–	I-03, I-04, I-05 Underpass
Panel bridge	Bridge	–	○	–	○	○	I-01, I-02, I-04, I-05 Flyover
H-Shaped Steel Bridge	Bridge	–	○	–	○	○	I-01, I-02 Flyover
Steel rectangular slab bridge	Bridge	○	○	–	○	–	I-03 Underpass

Source: JICA Study Team

12.7 Project Cost Estimate

12.7.1 Conditions of the Cost Estimate

(1) Term of Cost Estimate

According to JICA's manual of design and cost estimation for ODA, the cost estimation of this study was made based on the data as of August, 2015.

(2) Exchange Rate

According to JICA's manual of design and cost estimation for ODA, the exchange rate is based on the average rate for the most recent three months. This is the average rate from May, 2015 to July, 2015. The exchange rates of EURO (€) and CFA Franc (FCFA) are shown in Table 12.7.1.

Table 12.7.1 Exchange Rate

Currency	Exchange Rate
EURO (€)	FCFA659.95/€
US Dollar (USD)	FCFA594.04/USD

Source: Banque Centrale des Etats de l'Afrique de l'Ouest (BCEAO) Rate

(3) Taxes and Duties

The main taxes are shown as follows:

1) Custom Duty

A 0～20% tax rate is adopted for imported goods only.

2) Corporate Income Tax

A 30% corporate income tax is adopted.

3) Payroll Tax

A 3% Payroll tax is adopted.

4) VAT

A 18% VAT is adopted.

(4) Other Indicators

1) Price Escalation

There will be a 2.066% per year IMF rate applied. Therefore, the price escalation from 2015 up to 2020 is approximately 11%.

2) Contingency

A 5.0% of total construction cost is applied.

3) Administration Cost of AGEROUTE

A 10.0% of direct construction cost is applied.

4) Base Year for Cost Escalation

The base year is set at August, 2015 and construction work is assumed to start in April, 2017 and end in March, 2021.

12.7.2 Unit Cost for the Pre-feasibility Study

The unit costs for the pre-feasibility study have been determined based on the BOQ price of other similar projects in Dakar from AGEROUTE. Meanwhile, the unit prices of special work using new technologies were set with reference to the unit prices in Japan for which data were available. The unit costs applied for this study are as follows:

Table 12.7.2 Unit Prices for the Intersection Improvement Project on VDN and Front de Terre

Description	Unit	Unit Price (FCFA)
Excavation work	m3	5,200
Filling work	m3	10,400
Bridge work for steel girder	m2	2,581,300
Bridge work for steel box girder	m2	3,226,600
Bridge work for steel box girder (curve section)	m2	5,162,600
Retaining wall work for flyover	m2	548,600
Retaining wall work for underpass	m2	1,075,600
Demolishing work for existing wall	m2	4,800
Box culvert work	m	9,679,800
Pavement work for bridge section	t	180,700
Pavement work for earth section	m2	60,300
Pavement work for side walk	m2	19,000
Traffic Sign	no	1,118,600
Road Marking	m2	4,800
Drainage pump facility	ls	2,077,915,900
Drainage relocation	ls	645,315,500
Steel rectangular slab bridge	m2	2,151,100
Steel pipe sheet pile	m2	15,702,700
Demolishing existing box drainage and installation of pipe drainage	ls	430,210,400
Installation traffic signal (4 no.)	ls	413,002,000

Source: JICA Study Team

12.7.3 Cost Estimate for the Preliminary Design

The results of the cost estimation for the intersection improvement project on VDN and Front de Terre are as shown in Table 12.7.3.

Table 12.7.3 Result of the Cost Estimation for the Intersection Improvement Project on VDN and Front de Terre

Unit: Million FCFA

	I-01				I-02				I-03	I-04	I-05	
	Center	Side	Signal	U-turn	Center	Side	Signal	U-turn			East-West	East-South
ID	***I-01c***	***I-01a***	–	–	***I-02c***	***I-02a***	–	–	–	***I-04a***	***I-05a***	***I-05c***
Flyover	15,040	18,491	–	–	14,881	19,758	–	–	–	12,715	10,451	13,990
ID	***I-01d***	***I-01b***	–	–	***I-02d***	***I-02b***	–	–	***I-03***	***I-04b***	***I-05b***	–
Underpass	19,603	29,756	–	–	19,091	29,246	–	–	28,805	41,612	32,103	–
ID	–	–	***I-01e***	***I-01f***	–	–	***I-02e***	***I-02f***	–	–	–	–
At-grade	–	–	1,229	178	–	–	591	230	–	–	–	–

Source: JICA Study Team

(1) SDE Intersection

The results of the cost estimation for SDE intersection are shown in Table 12.7.5, which can be summarized as follows.

1) Construction Cost (E)

The construction costs with price escalation and contingencies are at 11,407 million FCFA for the

flyover/center (I-01c) plan, 1,4024 million FCFA for the flyover/side (I-01a) plan, 14,867 million FCFA for the underpass/center (I-01d) plan, 22,568 million FCFA for the underpass/side (I-01b) plan, 930 million FCFA for the at-grade/signal (I-01e) plan and 133 million FCFA for the at-grade /U-turn (I-01f) plan.

2) Engineering Service Cost (F)

The engineering service costs with price escalation and contingencies are estimated at 1,195 million FCFA for the flyover/center (I-01c) plan, 1,469 million FCFA for the flyover/side (I-01a) plan, 1,558 million FCFA for the underpass/center (I-01d) plan, 2,364 million FCFA for the underpass/side (I-01b) plan, 97 million FCFA for the at-grade/signal (I-01e) plan and 14 million FCFA for the at-grade/U-turn (I-01f) plan.

3) Project Cost

The total project cost, including the compensation (land acquisition and others), administration cost, tax, interest and commission charge, is estimated at 15,040 million FCFA for the flyover/center (I-01c) plan, 18,491 million FCFA for the flyover/side (I-01a) plan, 19,603 million FCFA for the underpass/center (I-01d) plan, 29,756 million FCFA for the underpass/side (I-01b) plan, 12.50 million FCFA for the at-grade/signal (I-01e) plan and 178 million FCFA for the at-grade/U-turn (I-01f) plan, respectively.

Table 12.7.4 Summary of the Estimated Cost for SDE Intersection

Description		Amount (mil. FCFA)				Remarks
		Center	Side	Signal	U-turn	
ID		***I-01c***	***I-01a***	—	—	
Flyover	Construction Cost	11,407	14,024	—	—	Include price escalation and contingency
	Engineering Cost	1,195	1,469	—	—	
	Project Cost	15,040	18,491	—	—	Include compensation, administration cost, tax and commission charge
ID		***I-01d***	***I-01b***	—	—	
Underpass	Construction Cost	14,867	22,568	—	—	Include price escalation and contingency
	Engineering Cost	1,558	2,364	—	—	
	Project Cost	19,603	29,756	—	—	Include compensation, administration cost, tax and commission charge
ID		—	—	***I-01e***	***I-01f***	
At-grade	Construction Cost	—	—	930	133	Include price escalation and contingency
	Engineering Cost	—	—	97	14	
	Project Cost	—	—	12.50	178	Include compensation, administration cost, tax and commission charge

Source: JICA Study Team

Table 12.7.5 Result of the Cost Estimation for SDE Intersection

Alternative	Description		Unit Price (FCFA)	Unit	Center Plan		Side Plan		Remark
					Quantity	Amount (FCFA)	Quantity	Amount (FCFA)	
Flyover	***ID***				***I-01c***		***I-01a***		
	Preparation Work		965,100,000	ls	1	965,100,000	1	965,100,000	9.86
	Bridge Work		2,581,300	m2	1,723	4,446,547,380	1,723	4,446,547,380	Panel Bridge
	Retaining Wall Work		548,600	m2	4,322	2,371,158,920	8,644	4,742,317,840	Terre Armee Method
	Earth Work	Filling	10,400	m3	42,202	438,900,392	30,083	312,858,125	
	Pavement Work	Bridge Part	180,700	t	45	8,131,500	45	8,131,500	
		Earth Work Part	60,300	m2	25,028	1,509,199,736	25,028	1,509,199,736	
	Incidental Work		48,260,000	ls	1	48,260,000	1	48,260,000	0.49
	Sub Total (A)					9,787,297,928		12,032,414,581	
	Price Escalation (B)					1,076,602,772		1,323,565,604	11% of (A)
	Sub Total (C)=(A)+(B)					10,863,900,700		13,355,980,185	
	Contingency (D)					543,195,035		667,799,009	5% of (C)
	Construction Cost (E)=(C)+(D)					11,407,095,735		14,023,779,194	
	Engineering Service (F)					978,729,793		1,203,241,458	10% of (A)
	Price Escalation (G)					107,660,277		132,356,560	11% of (F)
	Contingency (H)					108,639,007		133,559,802	5% of ((F)+(G))
	Engineering Cost (I)=(F)+(G)+(H)					1,195,029,077		1,469,157,820	
	Compensation Cost (J)					0		0	
	Administration Cost (K)					119,502,908		146,915,782	10% of (I)
	Tax (L)					2,268,382,466		2,788,728,663	18% of ((E)+(I))
	Interest (M)					37,806,374		46,478,811	0.5% of ((E)+(I))
	Commitment Charge (N)					12.702,125		15,492,937	0.1% of ((E)+(I))
	Project Cost (E)+(I)+(J)+(K)+(L)+(M)+(N)					15,040,418,685		18,490,553,207	
Underpass	***ID***				***I-01d***		***I-01b***		
	Preparation Work		1,053,000,000	ls	1	1,053,000,000	1	1,053,000,000	8.25
	Box Culvert Work		9,679,800	m	99	958,300,200	99	958,300,200	
	Retaining Wall Work		1,075,600	m2	6,197	6,665,686,808	12.594	13,331,373,616	
	Earth Work	Cutting	5,200	m3	59,515	309,480,409	48,225	250,771,706	
	Pavement Work	Box Culvert Part	180,700	t	45	8,131,500	45	8,131,500	
		Earth Work Part	60,300	m2	27,048	1,630,997,536	27,048	1,630,997,536	
	Incidental Work		52,650,000	ls	1	52,650,000	1	52,650,000	0.41
	Drainage Facility Work		2,077,915,900	ls	1	2,077,915,900	1	2,077,915,900	
	Sub Total (A)					12,756,162,353		19,363,140,458	
	Price Escalation (B)					1,403,177,859		2,129,945,450	11% of (A)
	Sub Total (C)=(A)+(B)					14,159,340,212		21,493,085,908	
	Contingency (D)					707,967,011		1,074,654,295	5% of (C)
	Construction Cost (E)=(C)+(D)					14,867,307,223		22,567,740,203	
	Engineering Service (F)					1,275,616,235		1,936,314,046	10% of (A)
	Price Escalation (G)					140,317,786		212,994,545	11% of (F)
	Contingency (H)					141,593,402		214,930,859	5% of ((F)+(G))
	Engineering Cost (I)=(F)+(G)+(H)					1,557,527,423		2,364,239,450	
	Compensation Cost (J)					0		0	
	Administration Cost (K)					155,752,742		236,423,945	10% of (I)
	Tax (L)					2,956,470,236		4,487,756,338	18% of ((E)+(I))
	Interest (M)					49,274,504		74,795,939	0.5% of ((E)+(I))
	Commitment Charge (N)					16,424,835		24,931,980	0.1% of ((E)+(I))
	Project Cost (E)+(I)+(J)+(K)+(L)+(M)+(N)					19,602,756,963		29,755,887,855	
Signal	***ID***				***I-01e***				
	Preparation Work		77,800,000	ls	1	77,800,000	8.25		
	Earth Work	Cutting	5,200	m3	775	4,030,000			
		Filling	10,400	m3	110	1,144,000			
	Pavement Work	Earth Work Part	60,300	m2	48,000	289,440,000			
	Signal Work		413,002,000	ls	1	413,002,000			
	Incidental Work		3,890,000	ls	1	3,890,000			
	Sub Total (A)					798,205,079			
	Price Escalation (B)					87,802,559	11% of (A)		
	Sub Total (C)=(A)+(B)					886,007,638			
	Contingency (D)					44,300,382	5% of (C)		
	Construction Cost (E)=(C)+(D)					930,308,020			
	Engineering Service (F)					79,820,508	10% of (A)		
	Price Escalation (G)					8,780,256	11% of (F)		
	Contingency (H)					8,860,076	5% of ((F)+(G))		
	Engineering Cost (I)=(F)+(G)+(H)					97,460,840			
	Compensation Cost (J)					3,000,000			
	Administration Cost (K)					9,746,084	10% of (I)		
	Tax (L)					184,998,395	18% of ((E)+(I))		
	Interest (M)					3,083,307	0.5% of ((E)+(I))		
	Commitment Charge (N)					1,027,769	0.1% of ((E)+(I))		
	Project Cost (E)+(I)+(J)+(K)+(L)+(M)+(N)					1,229,624,415			
U-turn	***ID***				***I-01f***				
	Preparation Work		11,200,000	ls	1	11,200,000	8.25		
	Earth Work	Cutting	5,200	m3	775	1,378,000			
		Filling	10,400	m3	110	4,316,000			
	Pavement Work	Earth Work Part	60,300	m2	48,000	96,480,000			
	Incidental Work		560,000	ls	1	560,000			
	Sub Total (A)					113,934,000			
	Price Escalation (B)					12,532,740	11% of (A)		
	Sub Total (C)=(A)+(B)					12.7,466,740			
	Contingency (D)					6,323,337	5% of (C)		
	Construction Cost (E)=(C)+(D)					132,790,077			
	Engineering Service (F)					11,393,400	10% of (A)		
	Price Escalation (G)					1,253,274	11% of (F)		
	Contingency (H)					12.74,667	5% of ((F)+(G))		
	Engineering Cost (I)=(F)+(G)+(H)					13,911,341			
	Compensation Cost (J)					3,000,000			
	Administration Cost (K)					1,391,134	10% of (I)		

	Tax (L)		26,406,255	18% of ((E)＋(I))
	Interest (M)		440,104	0.5% of ((E)＋(I))
	Commitment Charge (N)		146,701	0.1% of ((E)＋(I))
	Project Cost (E)＋(I)＋(J)＋(K)＋(L)＋(M)＋(N)		178,085,612	

Source: JICA Study Team

(2) Cite Keur Gorgui Intersection

The results of the cost estimation for Cité Keur Gorgui are shown in Table 12.7.7, which can be summarized as follows.

1) Construction Cost (E)

The construction costs with price escalation and contingencies are at 11,286 million FCFA for the flyover/center (I-02c) plan, 14,985 million FCFA for the flyover/side (I-02a) plan, 14,479 million FCFA for the underpass/center (I-02d) plan, 22,181 million FCFA for the underpass/side (I-02b) plan, 591 million FCFA for the at-grade/signal (I-02e) plan and 230 million FCFA for the at-grade/U-turn (I-02f) plan.

2) Engineering Service Cost (F)

The engineering service costs with price escalation and contingencies are estimated at 1,182 million FCFA for the flyover/center (I-02c) plan, 1,570 million FCFA for the flyover/side (I-02a) plan, 1,516 million FCFA for the underpass/center (I-02d) plan, 2,324 million FCFA for the underpass/side (I-02b) plan, 62 million FCFA for the at-grade/signal (I-02e) plan and 24 million FCFA for the at-grade/U-turn (I-02f) plan.

3) Project Cost

The total project cost, including the compensation (land acquisition and others), administration cost, tax, interest and commission charge, is estimated at 14,881 million FCFA for the flyover/center (I-02c) plan, 19,758 million FCFA for the flyover/side (I-02a) plan, 19,091 million FCFA for the underpass/center (I-02d) plan, 29,246 million FCFA for the underpass/side (I-02b) plan, 782 million FCFA for the at-grade /signal (I-02e) plan and 307 million FCFA for the at-grade /U-turn (I-02f) plan, respectively.

Table 12.7.6 Summary of the Estimated Cost for Cité Keur Gorgui Intersection

Description		Amount (mil. FCFA)				Remarks
		Center	Side	Signal	U-turn	
ID		***I-02c***	***I-02a***	―	―	
Flyover	Construction Cost	11,286	14,985	―	―	Including price escalation and contingency
	Engineering Cost	1,182	1,570	―	―	
	Project Cost	14,881	19,758	―	―	Including compensation, administration cost, tax and commission charge
ID		***I-02d***	***I-02b***	―	―	
Underpass	Construction Cost	14,479	22,181	―	―	Including price escalation and contingency
	Engineering Cost	1,516	2,324	―	―	
	Project Cost	19,091	29,246	―	―	Including compensation, administration cost, tax and commission charge
ID		―	―	***I-02e***	***I-02f***	
At-grade	Construction Cost	―	―	591	230	Including price escalation and contingency
	Engineering Cost	―	―	62	24	
	Project Cost	―	―	782	307	Including compensation, administration cost, tax and commission charge

Source: JICA Study Team

Table 12.7.7 Result of the Cost Estimation for Cité Keur Gorgui Intersection

Alternative	Description		Unit Price (FCFA)	Unit	Center		Side		Remark
					Quantity	Amount (FCFA)	Quantity	Amount (FCFA)	
Flyover	***ID***				***ID-2c***		***ID-02a***		
	Preparation Work		954,900,000	ls	1	954,900,000	1	954,900,000	9.86
	Bridge Work		2,581,300	m2	1,288	3,323,681,880	1,288	3,323,681,880	Panel Bridge
	Retaining Wall Work		548,600	m2	6,110	3,351,946,000	12,220	6,703,892,000	Terre Armee Method
	Earth Work	Filling	10,400	m3	59,658	620,443,616	42,526	442,266,240	
	Pavement Work	Bridge Part	180,700	t	34	6,143,800	34	6,143,800	
		Earth Work Part	60,300	m2	22,865	1,378,783,620	22,865	1,378,783,620	
	Incidental Work		47,750,000	ls	1	47,750,000	1	47,750,000	0.49
	Sub Total (A)					9,683,648,916		12,857,417,540	
	Price Escalation (B)					1,065,201,381		1,414,315,929	11% of (A)
	Sub Total (C)=(A)+(B)					10,748,850,297		14,271,733,469	
	Contingency (D)					537,442,515		713,586,673	5% of (C)
	Construction Cost (E)=(C)+(D)					11,286,292,812		14,985,320,142	
	Engineering Service (F)					968,364,892		1,285,741,754	10% of (A)
	Price Escalation (G)					106,520,138		141,431,593	11% of (F)
	Contingency (H)					107,488,503		142,717,335	5% of ((F)+(G))
	Engineering Cost (I)=(F)+(G)+(H)					1,182,373,533		1,569,890,682	
	Compensation Cost (J)					0		0	
	Administration Cost (K)					118,237,353		156,989,068	10% of (I)
	Tax (L)					2,244,359,942		2,979,937,948	18% of ((E)+(I))
	Interest (M)					37,405,999		49,665,632	0.5% of ((E)+(I))
	Commitment Cgarge (N)					12.568,666		16,555,211	0.1% of ((E)+(I))
	Project Cost (E)+(I)+(J)+(K)+(L)+(M)+(N)					14,881,138,305		19,758,358,683	
Underpass	***ID***				***I-02d***		***I-02b***		
	Preparation Work		1,020,200,000	ls	1	1,020,200,000	1	1,020,200,000	8.21
	Box Culvert Work		9,679,800	m	99	958,300,200	99	958,300,200	
	Retaining Wall Work		1,075,600	m2	6,197	6,665,686,808	12.594	13,331,373,616	
	Pavement Work	Box Culvert	180,700	t	34	6,143,800	34	6,143,800	
		Earth Work Part	60,300	m2	22,132	1,334,562,736	22,132	1,334,562,736	
	Incidental Work		51,010,000	ls	1	51,010,000	1	51,010,000	0.41
	Drainage Facility Work		2,077,915,900	ls	1	2,077,915,900	1	2,077,915,900	
	Sub Total (A)					12.523,299,853		19,031,449,788	
	Price Escalation (B)					1,366,562,984		2,093,459,477	11% of (A)
	Sub Total (C)=(A)+(B)					13,789,862,837		21,12.5,909,265	
	Contingency (D)					689,493,142		1,056,245,463	5% of (C)
	Construction Cost (E)=(C)+(D)					14,479,355,979		22,181,154,728	
	Engineering Service (F)					12.52,329,985		1,903,144,979	10% of (A)
	Price Escalation (G)					136,656,298		209,345,948	11% of (F)
	Contingency (H)					137,898,628		2112.59,093	5% of ((F)+(G))
	Engineering Cost (I)=(F)+(G)+(H)					1,516,884,911		2,323,740,020	
	Compensation Cost (J)					0		0	
	Administration Cost (K)					151,688,491		232,374,002	10% of (I)
	Tax (L)					2,879,323,360		4,410,881,055	18% of ((E)+(I))
	Interest (M)					47,988,723		73,514,684	0.5% of ((E)+(I))
	Commitment Charge (N)					15,996,241		24,504,895	0.1% of ((E)+(I))
	Project Cost (E)+(I)+(J)+(K)+(L)+(M)+(N)					19,0912.57,705		29,246,169,384	
Signal	***ID***				***I-02e***				
	Preparation Work		49,100,000	ls	1	49,100,000	8.25		
	Earth Work	Cutting	5,200	m3	225	1,898,000			
		Filling	10,400	m3	330	3,229,200			
	Pavement Work	Earth Work Part	60,300	m2	2,860	235,170,000			
	Signal Work		413,002,000	ls	1	206,501,000			
	Incidental Work		970,000	ls	1	2,460,000			
	Sub Total (A)					506,797,561	8.25		
	Price Escalation (B)					55,747,732	11% of (A)		
	Sub Total (C)=(A)+(B)					562,545,293			
	Contingency (D)					28,127,265	5% of (C)		
	Construction Cost (E)=(C)+(D)					590,672,558			
	Engineering Service (F)					50,679,756	10% of (A)		
	Price Escalation (G)					5,574,773	11% of (F)		
	Contingency (H)					5,625,453	5% of ((F)+(G))		
	Engineering Cost (I)=(F)+(G)+(H)					61,879,982			

	Compensation Cost (J)				3,000,000		
	Administration Cost (K)				6,187,998		10% of (I)
	Tax (L)				117,459,457		18% of ((E)＋(I))
	Interest (M)				1,957,658		0.5% of ((E)＋(I))
	Commitment Charge (N)				652,553		0.1% of ((E)＋(I))
	Project Cost (E)＋(I)＋(J)＋(K)＋(L)＋(M)＋(N)				781,810,206		
U-turn	***ID***				***I-02f***		
	Preparation Work		19,500,000	ls	1	19,500,000	
	Earth Work	Cutting	5,200	m3	225	1,170,000	
		Filling	10,400	m3	330	3,432,000	
	Pavement Work	Earth Work Part	60,300	m2	2,860	172,458,000	
	Incidental Work		970,000	ls	1	970,000	
	Sub Total (A)				197,530,000		
	Price Escalation (B)				21,728,300		11% of (A)
	Sub Total (C)＝(A)＋(B)				19,258,300		
	Contingency (D)				0,962,915		5% of (C)
	Construction Cost (E)＝(C)＋(D)				30,2212.25		
	Engineering Service (F)				9,753,000		10% of (A)
	Price Escalation (G)				2,172,830		11% of (F)
	Contingency (H)				2,192,583		5% of ((F)＋(G))
	Engineering Cost (I)＝(F)＋(G)＋(H)				4,118,413		
	Compensation Cost (J)				3,000,000		
	Administration Cost (K)				2,411,841		10% of (I)
	Tax (L)				5,781,133		18% of ((E)＋(I))
	Interest (M)				763,019		0.5% of ((E)＋(I))
	Commitment Charge (N)				254,340		0.1% of ((E)＋(I))
	Project Cost (E)＋(I)＋(J)＋(K)＋(L)＋(M)＋(N)				06,549,961		

Source: JICA Study Team

(3) Aimé Césaire Intersection

The results of the cost estimation for Aimé Césaire Intersection are shown in Table 12.7.9, which can be summarized as follows:

1) Construction Cost (E)

The construction costs with price escalation and contingencies are estimated at 21,845 million FCFA.

2) Engineering Service Cost (F)

The engineering service costs with price escalation and contingencies are estimated at 2,288 million FCFA.

3) Project Cost

The total project costs, including compensation (land acquisition and others), administration cost, tax, interest, and commission charge are estimated at 28,805 million FCFA.

Table 12.7.8 Summary of the Estimated Cost for Aimé Césaire Intersection

	ID	Description	Amount (mil. FCFA)	Remarks
Underpass	***I-03***	Construction Cost	21,845	Including price escalation and contingency
		Engineering Cost	2,288	
		Project Cost	28,805	Including compensation, administration cost, tax and commission charge

Source: JICA Study Team

Table 12.7.9 Result of the Cost Estimation for Aimé Césaire Intersection

Alternative	Description		Unit Price (FCFA)	Unit	Quantity	Amount (JPY)	Remark
Underpass	***ID***				***I-03***		
	Preparation Work		1,579,700,000	ls	1	1,579,700,000	
	Bridge Work		2,151,100	m2	555	1,193,860,500	Steel rectangular slab bridge
	Retaining Wall Work	Underpass Part	15,702,700	m	726	11,393,879,120	Steel pipe sheet pile press-fit method
		Embankment Part	1,075,600	m2	383	411,417,000	
	Demolish Work	Existing Retaining Wall	4,800	m2	192	919,200	
	Earth Work		5,200	m3	39,780	206,856,520	Steel rectangular slab bridge
	Preparation Work	Earth Work Part	60,300	m2	18,213	1,098,234,873	
		Sidewalk	19,000	m2	2,923	55,540,344	
	Incidental Work		78,980,000	ls	1	78,980,000	
	Drainage Facility Work		2,077,915,900	ls	1	2,077,915,900	
	Relocation Work	Existing Drainage Canal	645,315,500	ls	1	645,315,500	
	Sub Total (A)					18,742,618,957	
	Price Escalation (B)					2,061,688,085	11% of (A)
	Sun Total (C)=(A)+(B)					20,804,307,042	
	Contingency (D)					1,040,215,352	5% of (C)
	Construction Cost (E)=(C)+(D)					21,844,522,394	
	Engineering Service (F)					1,874,261,896	10% of (A)
	Price Escalation (G)					206,168,809	11% of (F)
	Contingency (H)					208,043,071	5% of ((F)+(G))
	Engineering Cost (I)=(F)+(G)+(H)					2,288,473,776	
	Compensation Cost (J)					3,000,000	
	Administration Cost (K)					228,847,378	10% of (I)
	Tax (L)					4,343,939,311	18% of ((E)+(I))
	Interest (M)					72,398,989	0.5% of ((E)+(I))
	Commitment Charge (N)					24,132,996	0.1% of ((E)+(I))
	Project Cost (E)+(I)+(J)+(K)+(L)+(M)+(N)					28,805,314,844	

Source: JICA Study Team

(4) Khar Yalla Intersection

The results of the cost estimation for Khar Yalla Intersection are shown in Table 12.7.11, which can be summarized as follows:

1) Construction Cost (E)

The construction costs with price escalation and contingencies are estimated at 9,641 million FCFA for the flyover (I-04a) plan and 31,558 million FCFA for the underpass (I-04b) plan.

2) Engineering Service Cost (F)

The engineering service costs with price escalation and contingencies are estimated at 1,010 million FCFA for the flyover (I-04a) plan and 3,306 million FCFA for the underpass (I-04b) plan.

3) Project Cost

The total project costs, including compensation (land acquisition and others), administration cost, tax, interest and commission charge, are estimated at 12,715 million FCFA for the flyover (I-04a) plan and 41,612 million FCFA for the underpass (I-04b) plan.

Table 12.7.10 Summary of the Estimated Costs for Khar Yalla Intersection

	ID	Description	Amount (mil. FCFA)	Remarks
Flyover	***I-04a***	Construction Cost	9,641	Including price escalation and contingency
		Engineering Cost	1,010	
		Project Cost	12,715	Including compensation, administration cost, tax and commission charge
Underpass	***I-04b***	Construction Cost	31,558	Including price escalation and contingency
		Engineering Cost	3,306	
		Project Cost	41,612	Including compensation, administration cost, tax and commission charge

Source: JICA Study Team

Table 12.7.11 Result of the Cost Estimation for Khar Yalla Intersection

Alternative	Description		Unit Price (FCFA)	Unit	Quantity	Amount (FCFA)	Remark
Fly-over	***ID***				***I-04a***		
	Preparation Work		773,300,000	ls	1	773,300,000	
	Bridge Work		3,226,600	m2	778	2,509,004,160	Small Number Main I-Girder＋Synthetic Floor Bridge
	Retaining Wall Work		548,600	m2	5,103	2,799,505,800	Terre Armee Method
	Earth Work	Filling	10,400	m3	39,293	408,648,240	
	Pavement Work	Bridge Part	180,700	T	23	4,156,100	
		Earth Work Part	60,300	m2	20,564	12.59,987,010	
		Side Walk	19,000	m2	3,609	68,571,000	
	Incidental Work		38,660,000	ls	1	38,660,000	
	Relocation Work	Existing Drainage Facility	430,210,400	ls	1	430,210,400	
	Sub Total (A)					8,272,042,710	
	Price Escalation (B)					909,924,698	11% of (A)
	Sub Total (C)＝(A)＋(B)					9,181,967,408	
	Contingency (D)					459,098,370	5% of (C)
	Construction Cost (E)＝(C)＋(D)					9,641,065,778	
	Engineering Service (F)					827,204,271	10% of (A)
	Price Escalation (G)					90,992,470	11% of (F)
	Contingency (H)					91,819,674	5% of ((F)＋(G))
	Engineering Cost (I)＝(F)＋(G)＋(H)					1,010,016,415	
	Compensation Cost (J)					3,000,000	
	Administration Cost (K)					101,001,642	10% of (I)
	Tax (L)					1,917,194,795	18% of ((E)＋(I))
	Interest (M)					31,953,247	0.5% of ((E)＋(I))
	Commitment Charge (N)					10,651,082	0.1% of ((E)＋(I))
	Project Cost (E)＋(I)＋(J)＋(K)＋(L)＋(M)＋(N)					12,714,882,959	
Underpass	***ID***				***I-04b***		
	Preparation Work		2,422,700,000	ls	1	2,422,700,000	
	Bridge Work		9,679,800	m2	389	3,765,442,200	Steel rectangular slab bridge
	Retaining Wall Work		15,702,700	m	1,062	16,682,548,480	Steel pipe sheet pile press-fit method
	Earth Work	Cutting	5,200	m3	59,690	310,390,080	
	Pavement Work	Box Culvert Part	180,700	t	23	4,156,100	
		Earth Work Part	60,300	m2	19,792	1,193,438,425	
		Side Walk	19,000	m2	3,609	68,573,318	
	Incidental Work		12.2,140,000	ls	1	12.2,140,000	
	Drainage Facility Work		2,077,915,900	ls	1	2,077,915,900	
	Relocation Work	Existing Drainage Facility	430,210,400	ls	1	430,210,400	
	Sub Total (A)					27,076,514,903	
	Price Escalation (B)					2,978,416,639	11% of (A)
	Sub Total (C)＝(A)＋(B)					30,054,931,542	
	Contingency (D)					1,502,746,577	5% of (C)
	Construction Cost (E)＝(C)＋(D)					31,557,678,119	
	Engineering Service (F)					2,707,651,490	10% of (A)
	Price Escalation (G)					297,841,664	11% of (F)
	Contingency (H)					300,549,315	5% of ((F)＋(G))
	Engineering Cost (I)＝(F)＋(G)＋(H)					3,306,042,469	
	Compensation Cost (J)					3,000,000	
	Administration Cost (K)					330,604,247	10% of (I)
	Tax (L)					6,275,469,706	18% of ((E)＋(I))
	Interest (M)					104,591,162	0.5% of ((E)＋(I))
	Commitment Charge (N)					34,863,721	0.1% of ((E)＋(I))
	Project Cost (E)＋(I)＋(J)＋(K)＋(L)＋(M)＋(N)					41,612,249,424	

Source: JICA Study Team

(5) Bourguiba Intersection

The results of the cost estimation for Bourguiba Intersection are shown in Table 12.7.13, which can be summarized as follows:

1) Construction Cost (E)

The construction costs with price escalation and contingencies are estimated at 7,924 million FCFA for the flyover/East-West direction (I-05a), 345 million FCFA for the underpass/East-West direction (I-05b) plan and 10,609 million FCFA for the underpass/East-South direction (I-05c) plan.

2) Engineering Service Cost (F)

The engineering service costs with price escalation and contingencies are estimated at 830 million FCFA for the flyover/East-West direction (I-05a) plan, 2,550 million FCFA for the underpass/East-West direction (I-05b) plan and 1,111 million FCFA for the underpass/East-South direction (I-05c) plan.

3) Project Cost

Total project costs, including compensation (land acquisition and others), administration cost, tax, interest and commission charge, are estimated at 10,451 million FCFA for the flyover/East-West direction (I-05a) plan, 32,103 million FCFA for the underpass/East-West direction (I-05b) plan and 13,990 million FCFA for the underpass/East-South direction (I-05c) plan.

Table 12.7.12 Summary of the Estimated Costs for Bourguiba Intersection

	ID	Description	Amount (mil. FCFA)	Remarks
Flyover East-West	***I-05a***	Construction Cost	7,924	Including price escalation and contingency
		Engineering Cost	830	
		Project Cost	10,451	Including compensation, administration cost, tax and commission charge
Underpass East-West	***I-05b***	Construction Cost	24,345	Including price escalation and contingency
		Engineering Cost	2,550	
		Project Cost	32,103	Including compensation, administration cost, tax and commission charge
Flyover East-South	***I-05c***	Construction Cost	10,609	Including price escalation and contingency
		Engineering Cost	1,111	
		Project Cost	13,990	Including compensation, administration cost, tax and commission charge

Source: JICA Study Team

Table 12.7.13 Result of the Cost Estimation for Bourguiba Intersection

Alternative	Description		Unit Price (FCFA)	Unit	Quantity	Amount (JPY)	Remark
Flyover East-West	***ID***				***I-05a***		
	Preparation Work		628,000,000	ls	1	628,000,000	
	Bridge Work		3,226,600	m2	778	2,509,004,160	Small Number Main I-Girder＋Synthetic Floor Bridge
	Retaining Wall Work		548,600	m2	3,452	1,893,767,200	Terre Armee Method
	Earth Work	Filling	10,400	m3	26,580	276,436,160	
	Pavement Work	Bridge Part	180,700	t	23	4,156,100	
		Earth Work Part	60,300	m2	16,293	982,471,036	
		Side Walk	19,000	m2	2,293	43,569,432	
	Incidental Work		31,400,000	ls	1	31,400,000	
	Relocation Work	Existing Drainage Facility	430,210,400	ls	1	430,210,400	
	Sub Total (A)					6,799,014,488	
	Price Escalation (B)					747,891,594	11% of (A)
	Sub Total (C)＝(A)＋(B)					7,546,906,082	
	Contingency (D)					377,345,304	5% of (C)
	Construction Cost (E)＝(C)＋(D)					7,924,251,386	
	Engineering Service (F)					679,901,449	10% of (A)
	Price Escalation (G)					74,789,159	11% of (F)
	Contingency (H)					75,469,061	5% of ((F)＋(G))

	Engineering Cost (I)=(F)+(G)+(H)					830,159,669	
	Compensation Cost (J)					3,000,000	
	Administration Cost (K)					83,015,967	10% of (I)
	Tax (L)					1,575,793,990	18% of ((E)+(I))
	Interest (M)					26,263,233	0.5% of ((E)+(I))
	Commitment Charge (N)					8,754,411	0.1% of ((E)+(I))
	Project Cost (E)+(I)+(J)+(K)+(L)+(M)+(N)					10,4512.58,656	
	ID				***1-05b***		
	Preparation Work		2,102,300,000	ls	1	2,102,300,000	
	Bridge Work		2,151,100	m2	389	836,777,900	Steel rectangular skab bridge
	Retaining Wall Work		15,702,700	m	1,062	16,682,548,480	Steel pipe sheet pile press-fit method
	Earth Work	Cutting	5,200	m3	59,690	310,390,080	
	Pavement Work	Box Culvert Part	180,700	t	23	4,156,100	
		Earth Work Part	60,300	m2	20,058	1,209,481,179	
		Side Walk	19,000	m2	3,609	68,573,318	
	Incidental Work		105,120,000	ls	1	105,120,000	
	Drainage Facility Work		2,077,915,900	ls	1	2,077,915,900	
	Relocation Work	Existing Drainage Facility	430,210,400	ls	1	430,210,400	
	Sub Total (A)					20,888,395,457	
Underpass	Price Escalation (B)					2,297,723,500	11% of (A)
East-West	Sub Total (C)=(A)+(B)					23,186,118,957	
	Contingency (D)					1,159,305,948	5% of (C)
	Construction Cost (E)=(C)+(D)					24,345,424,905	
	Engineering Service (F)					2,088,839,546	10% of (A)
	Price Escalation (G)					229,772,350	11% of (F)
	Contingency (H)					231,861,190	5% of ((F)+(G))
	Engineering Cost (I)=(F)+(G)+(H)					2,550,473,086	
	Compensation Cost (J)					3,000,000	
	Administration Cost (K)					255,047,309	10% of (I)
	Tax (L)					4,8412.71,638	18% of ((E)+(I))
	Interest (M)					80,687,694	0.5% of ((E)+(I))
	Commitment Charge (N)					26,895,898	0.1% of ((E)+(I))
	Project Cost (E)+(I)+(J)+(K)+(L)+(M)+(N)					32,102,790,530	
	ID				***1-05c***		
	Preparation Work		897,600,000	ls	1	897,600,000	
	Bridge Work		5,162,600	m2	922	4,757,852,160	Steel Box Girder Bridge
	Retaining Wall Work		548,600	m2	3,276	1,796,994,160	Terre Armee Method
	Earth Work	Filling	10,400	m3	25,222	262,310,048	
	Pavement Work	Bridge Part	180,700	T	27	4,878,900	
		Earth Work Part	60,300	m2	21,335	1,286,474,450	
		Side Walk	19,000	m2	2,691	51,129,456	
	Incidental Work		44,880,000	ls	1	44,880,000	
	Sub Total (A)					9,102,119,174	
	Price Escalation (B)					1,0012.53,109	11% of (A)
Flyover	Sub Total (C)=(A)+(B)					10,103,352,283	
East-West	Contingency (D)					505,167,614	5% of (C)
	Construction Cost (E)=(C)+(D)					10,608,519,897	
	Engineering Service (F)					910,211,917	10% of (A)
	Price Escalation (G)					100,12.5,311	11% of (F)
	Contingency (H)					101,033,523	5% of ((F)+(G))
	Engineering Cost (I)=(F)+(G)+(H)					1,111,368,751	
	Compensation Cost (J)					3,000,000	
	Administration Cost (K)					111,136,875	10% of (I)
	Tax (L)					2,109,579,957	18% of ((E)+(I))
	Interest (M)					35,159,666	0.5% of ((E)+(I))
	Commitment Charge (N)					11,719,889	0.1% of ((E)+(I))
	Project Cost (E)+(I)+(J)+(K)+(L)+(M)+(N)					13,990,485,035	

Source: JICA Study Team

12.7.4 Maintenance Cost

Periodic inspections shall be carried out every year. These are expected to be approximately 1% of the construction costs per year. Large-scale repair shall be carried out every 10 years and this will cost approximately 10% of the construction costs.

12.8 Implementation Program

12.8.1 Possible Scheme

This pre-feasibility study was conducted assuming a possibility of finance by international partners including loan assistance from JICA. It should be noted that AGEROUTE has already begun a simple study for Aimé Césaire (I-03). However, its analysis is technically insufficient to enable it to move onto the basic design stage. For the other sub-projects, no studies have yet been made. The scheme of the project from start to completion is shown in Table 12.8.1.

Table 12.8.1 Possible Scheme

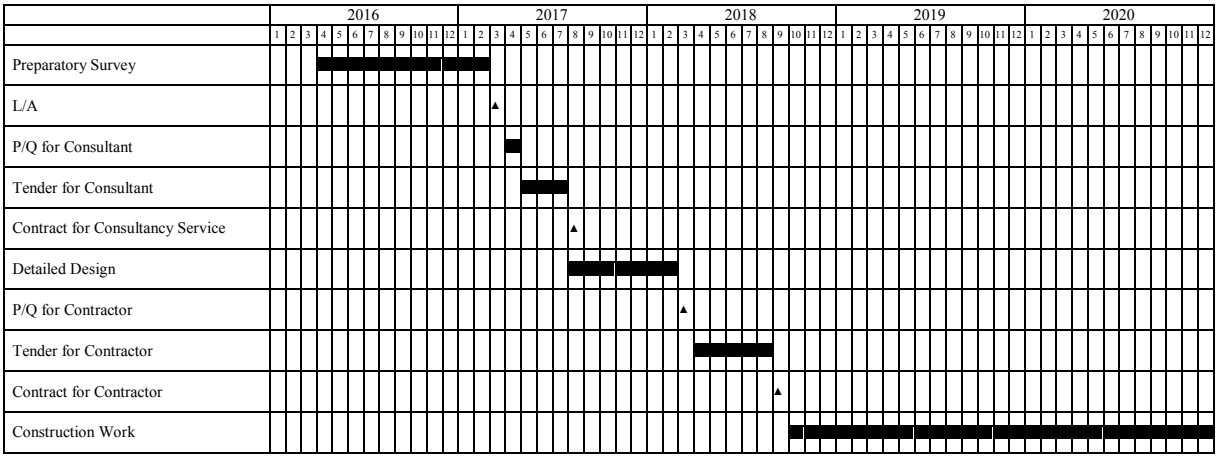
	Consultant	Contractor
Outline Design	Preparatory Survey	-
Detailed Design	Loan Assistance	-
Tender	Loan Assistance	-
Supervising / Construction Work	Loan Assistance	Loan Assistance

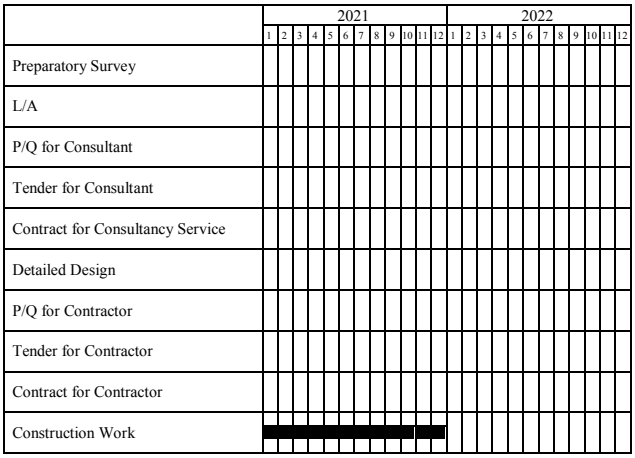
Source: JICA Study Team

12.8.2 Implementation Schedule

Assuming international financing cooperation, the intersection improvement project on VDN and Front de Terre is shown in Table 12.8.2.

Table 12.8.2 Implementation Schedule for the Intersection Improvement Project on VDN and Front de Terre





Source: JICA Study Team

12.8.3 Comparison of Improvement Alternatives

A number of improvement alternatives, including grade separation structures (i.e., flyovers and underpasses) and other suitable at-grade improvement options (e.g., traffic signals, U-turn lanes), were proposed, discussed and analyzed on the aspects of the preliminary structure design, traffic flow analysis and estimated cost up to this point.

Based on the results of the traffic analysis and cost estimation, Table 12.8.3 presents a comparison of the alternatives that are being proposed for each sub-project, in order to recommend the most appropriate one. In Table 12.8.3, there are two considerations:

- The suitability for the abatement of traffic congestion is based on the results of the traffic analysis in Section 12.5.2;
- The cost is based on the cost estimation that is presented in Section 12.6.

For the sub-projects - for which there is only one alternative - for the reasons explained in Section 12.2, one single alternative is selected/recommended.

Table 12.8.3 Comparison of the Proposed Alternatives for Sub-projects

Sub-projects	Alternatives		Suitability for the Abatement of Traffic Congestion	Cost	Recommended Alternative
SDE Intersection Improvement	I-01a	Flyovers on both sides			
	I-01b	Underpasses on both sides			
	I-01c	Flyover in the center	High	High	
	I-01d	Underpass in the center			
	I-01e	At-grade improvement with traffic signals	High	Low	√
	I-01f	At-grade improvement with U-turn lanes	Moderate	Low	
Cité Keur Gorgui Intersection Improvement	I-02a	Flyovers on both sides			
	I-02b	Underpasses on both sides			
	I-02c	Flyover in the center	High	High	√
	I-02d	Underpass in the center			
	I-02e	At-grade improvement with traffic signals	Low	Low	
	I-02f	At-grade improvement with U-turn lanes	Low	Low	
Aimé Césaire Intersection Improvement	I-03	Underpass	*	*	√
Khar Yalla Intersection Improvement	I-04a	Flyover	*	*	√
	I-04b	Underpass			
Bourguiba Intersection Improvement	I-05a	East-West flyover			
	I-05b	East-West underpass			
	I-05c	East-South overpass	*	*	√

Note: (1) Shaded cells are the grade separation alternatives that were identified as inferior as discussed in Table 12.5.1 and Table 12.5.2 for each sub-project; (2) * indicates single alternative being analyzed.
Source: JICA Study Team

12.9 Economic Analysis

12.9.1 Presumptions

The costs and benefits are calculated as the differences between "with" and "without" the intersection improvement project (the project). The with/without comparison attempts to measure the incremental benefits arising from the project. This approach can account for changes in production that would occur without the project.

The presumptions of the economic analysis of the project are shown in Table 12.9.1. The economic cost in the economic analysis is used for the purpose of applying the values accurately, reflecting the use of resources by, for example, deducting transfer payments such as tax, subsidies and interest. This conversion is commonly done by applying the standard conversion factor. The standard conversion factor that is applicable to the present economic analysis is set at 0.85 as a typical value applied to projects in developing countries.

Table 12.9.1 Presumptions of the Economic Analysis

Item	Preconditions	Remarks
Project life (evaluation period)	30 years after construction	Commencement of investment: 2016, Opening: 2021
Exchange rate	EURO (€) =659.95 FCFA /€ US Dollar (USD) = 594.04 FCFA /USD	Banque Centrale des Etats de l'Afrique de l'Ouest (BCEAO) Rate
Social discount rate (opportunity cost of capital)	12 %	
Economic price	85% of financial price	

Source: JICA Study Team

12.9.2 Cost

As shown in Table 12.9.2, the economic cost was estimated by (i) deducting the government taxes and other items from the financial cost, and (ii) applying a conversion factor of 0.85 to the rest of the financial cost. Maintenance costs are also added to the economic cost. The operation and maintenance (O&M) and renewal costs are assumed as Table 12.9.3 indicates.

Table 12.9.2 Estimated Economic Cost

Unit: million FCFA

	Sub-projects	Alternatives	Financial Cost	Economic Cost
I-01a	SDE Intersection Improvement	Flyovers on both sides	18,491	13,175
I-01b		Underpasses on both sides	29,756	21,202
I-01c		Flyover in the center	15,040	10,717
I-01d		Underpass in the center	19,603	13,968
I-01e		At-grade improvement with traffic signals	1,230	874
I-01f		At-grade improvement with U-turn lanes	178	125
I-02a	Cite Keur Gorgui Intersection Improvement	Flyovers on both sides	19,758	14,079
I-02b		Underpasses on both sides	29,246	20,839
I-02c		Flyover in the center	14,881	10,603
I-02d		Underpass in the center	19,091	13,603
I-02e		At-grade improvement with traffic signals	782	555
I-02f		At-grade improvement with U-Turn lanes	307	216
I-03	Aime Cesaire Intersection Improvement	Underpass	28,805	20,523
I-04a	Khar Yalla Intersection Improvement	Flyover	12,715	9,058
I-04b		Underpass	41,612	29,648
I-05a	Bourguiba Intersection Improvement	E-W flyover	10,451	7,445
I-05b		E-W underpass	32,103	22,872
I-05c		E-S flyover	13,990	9,967

Source: JICA Study Team

Table 12.9.3 Operation and Maintenance Cost and Renewal Cost for the Economic Analysis

Item	Cost	Remarks
O&M cost	1% of construction cost	Every year
Renewal cost	10% of construction cost	Every 10 years

Source: JICA Study Team

12.9.3 Traffic Volume

Traffic volume on the project road is estimated as shown in Section 12.5.1.

12.9.4 Benefit

Savings in VOC and TTC are taken as the benefits of the project.

(1) VOC

VOC is calculated by the type of vehicle in two scenarios: with the project and without the project. The VOC covers the fuel cost, lubricant cost and maintenance costs of the vehicles including the purchase of tires, driver cost, etc. In this analysis, the unit values of OC are estimated by studies of past road projects in Senegal, as shown in Table 12.9.4. A unit amount of savings in VOC is estimated for savings in 1 km per one car after completion of the project. A saving in VOC is the difference between VOC of travel speed without the project and VOC of travel speed with the project. The total savings in VOC (FCFA per car) are estimated by multiplying the saving in VOC, the distance of the road and the standard conversion factor.

Table 12.9.4 Vehicle Operating Costs by Travel Speed

Unit: FCFA/km/vehicle

Travel speed	Passenger Car	Small Bus	Large Bus	Small Truck	Large Truck
10 km/h	292.0	340.6	1,044.8	733.8	1,231.0
20 km/h	233.5	301.4	924.5	648.5	1,011.0
30 km/h	211.9	283.7	870.5	605.1	882.1
40 km/h	203.0	274.7	842.7	581.1	804.5
50 km/h	200.7	271.0	831.3	569.9	765.7
60 km/h	201.3	270.5	829.8	567.2	753.9

Source: JICA Study Team, based on related studies by AGEROUTE such as "Etude Economique de la Rehabilitation des Troncons Routiers Nioro-Keur Ayip (RN4) et Passy-Sokone (RN5) (2010)" and "Etude sur les Couts et Conditions d'Exploitation des Vehicules de Transport Public de Voyageurs au Senegal Pour une Tarification Optimale" (2014).

(2) TTC

Savings in traveling time costs are based on the assumption that saving time would be used for other productive activities. The unit price (or average hourly output) by the other activities is estimated for a passenger by type of vehicle and for working/non-working hours. Table 12.9.5 shows the travel time costs.

Table 12.9.5 Travel Time Costs

Item		Unit	Passenger Car	Bus
Unit price of Passenger	Working hours	FCFA/hour/person	626.2	313.1
	Nonworking hours	FCFA /hour/person	187.9	93.9
	% of workers to total passengers	%	30	30
	Average price (a)	FCFA /hour/person	319.4	159.7
Average Number of passengers *(b)		Person/car	2.5	30
Travel Time Cost (c) = (a) X (c)		FCFA /hour/car	798.4	4,790.4

Source: JICA Study Team

12.9.5 Estimate of the Economic Internal Rate of Return

Based on the costs and benefits calculated as explained above, the EIRR and ENPV at a discount rate of 12% have been calculated, as shown in Table 12.9.6.

The results of several alternatives of the project are judged to be economically viable as the calculated EIRR exceeds 12%, which is considered to be a threshold to judge project viability in developing countries.

The benefit-cost streams, in which the EIRRs are the largest among alternatives, are given in Appendix B.1.

Table 12.9.6 EIRR and ENPV by Intersection

	Place	Alternatives	EIRR (%)	ENPV (FCFA million): At discount rate of 12%	Remarks
I-01a	SDE Intersection Improvement	Flyovers on both sides	21.8	11,617	
I-01b		Underpasses on both sides	15.3	5,477	
I-01c		Flyover in the center	25.1	13,497	
I-01d		Underpass in the center	20.9	11,011	
I-01e		At-grade improvement with traffic signals	90.6	1,147	Project life: three years Opening: 2018
I-01f		At-grade improvement with U-Turn lanes	39.0	152	Project life: 10 years Opening: 2018
I-02a	Cite Keur Gorgui Intersection Improvement	Flyovers on both sides	17.9	7,499	
I-02b		Underpasses on both sides	13.4	2,328	
I-02c		Flyover in the center	21.6	10,157	
I-02d		Underpass in the center	18.3	7,863	
I-02e		At-grade improvement with traffic signals	91.6	750	Project life: three years Opening: 2018
I-02f		At-grade improvement with U-Turn lanes	20.4	71	Project life: 10 years Opening: 2018
I-03	Aime Cesaire Intersection Improvement	Underpass	19.6	14,746	
I-04a	Khar Yalla Intersection Improvement	Flyover	18.1	5,443	
I-04b		Underpass	6.7	-10,307	
I-05a	Bourguiba Intersection Improvement	E-W flyover	21.2	6,787	
I-05b		E-W underpass	8.8	-5,015	
I-05c		E-S flyover	17.4	4,857	

Source: JICA Study Team

12.9.6 Sensitivity Analysis

A sensitivity analysis has been conducted on EIRR by changing the conditions with the variation in economic benefits and costs. The results are shown in Table 12.9.7. Table 12.9.7 shows the sensitivity analysis results of the main alternatives in each place. The results indicate that, in all cases, the EIRR value would exceed 12%.

Table 12.9.7 Sensitivity Analysis of EIRR

I-01 SDE intersection improvement (flyover in the center)

		Benefits				
		80%	**90%**	**100%**	**110%**	**120%**
Costs	**120%**	18.9%	20.6%	22.2%	23.7%	25.1%
	110%	20.2%	21.9%	23.6%	25.1%	26.6%
	100%	21.6%	23.4%	25.1%	26.8%	28.4%
	90%	23.2%	25.1%	27.0%	28.7%	30.4%
	80%	25.1%	27.2%	29.1%	31.0%	32.7%

I-02 Cite Keur Gorgui intersection improvement (flyover in the center)

		Benefits				
		80%	**90%**	**100%**	**110%**	**120%**
Costs	**120%**	16.4%	17.8%	19.1%	20.4%	21.6%
	110%	17.4%	18.9%	20.3%	21.6%	22.9%
	100%	18.6%	20.2%	21.6%	23.0%	24.3%
	90%	20.0%	21.6%	23.1%	24.6%	26.0%
	80%	21.6%	23.3%	24.9%	26.5%	27.9%

I-03 Aime Cesaire intersection improvement

		Benefits				
		80%	**90%**	**100%**	**110%**	**120%**
Costs	**120%**	14.7%	16.0%	17.3%	18.5%	19.6%
	110%	15.7%	17.1%	18.3%	19.6%	20.7%
	100%	16.8%	18.2%	19.6%	20.9%	22.1%
	90%	18.1%	19.6%	21.0%	22.3%	23.6%
	80%	19.6%	21.2%	22.7%	24.1%	25.4%

I-04 Khar Yalla intersection improvement (flyover)

		Benefits				
		80%	**90%**	**100%**	**110%**	**120%**
Costs	**120%**	13.7%	14.9%	16.0%	17.1%	18.1%
	110%	14.6%	15.8%	17.0%	18.1%	19.2%
	100%	15.6%	16.9%	18.1%	19.3%	20.4%
	90%	16.8%	18.1%	19.4%	20.6%	21.7%
	80%	18.1%	19.6%	20.9%	22.2%	23.4%

I-05 Bourguiba intersection improvement (E-W flyover)

		Benefits				
		80%	**90%**	**100%**	**110%**	**120%**
Costs	**120%**	16.1%	17.5%	18.8%	20.0%	21.2%
	110%	17.1%	18.5%	19.9%	21.2%	22.4%
	100%	18.3%	19.8%	21.2%	22.6%	23.9%
	90%	19.6%	21.2%	22.7%	24.1%	25.5%
	80%	21.2%	22.9%	24.5%	26.0%	27.4%

Source: JICA Study Team

12.10 Environmental and Social Considerations

12.10.1 Present Environmental and Social Conditions

(1) Physical Conditions

The geology of the region of Dakar comprises the following geological formations:

- Volcanic rocks of Tertiary and Quaternary (head of the peninsula)
- Quaternary deposits (Niayes zones)
- Limestone and marl of the Middle Eocene (Tertiary and Secondary) (the rest of the Dakar region)

Continental dunes occupy most of the region of Dakar and the soil is poor in terms of organic material, as it is subject to wind erosion and run-off water.

The synthesis of the different pedological studies undertaken in the Cap Vert peninsula show the existence of four main types of soils:

- Undeveloped mineral soils at the level of the white dunes;
- Hydromorphic clay soils or sand-clay soils or "deck" soils;
- Sandy ferruginous tropical soils slightly leached or "Dior";
- Saline soils.

(2) Biological Conditions

The areas that are concerned with the project are artificialized and do not have flora or an ecosystem.

(3) Social Conditions

1) Administrative Division

The administrative divisions in which the respective intersections are located are shown in Table 12.10.1, with their respective populations.

Table 12.10.1 Administrative Division of the Intersections

Intersection		Department	Commune	Population
VDN	Station SDE	Dakar	Sicap/Liberté	47,164
	Cite Keur Gorgui	Dakar	Ca Mermoz/Sacré Coeur	29,798
	Aimé Césaire	Dakar	Fann/Point E/Amitié	18,841
Front de Terre	Bourguiba	Dakar	Dieuppeul/Derklé	36,917
	Khar Yalla	Dakar		

Source: ANSD

2) Intersections on VDN

Station SDE

This intersection has a pedestrian bridge. A residential area named District of Mermoz-Sacré Cœur is located nearby. The sensitive infrastructures nearby are two private higher education institutions: Ecole Eticca (60m away) and Académie Sherbrook (60m away). There is also a Catholic cemetery, Saint Lazare, nearby.

Cité Keur Gorgui

There are two vacant lots on two corners and two houses on the other two corners. The residential areas, named Houses of the Cité Keur Gorgui (40m away) and Houses of Cité Mermoz (40m away), are located nearby. The sensitive infrastructure nearby consists of a health center, Suma Assistance (110m away).

Aimé Césaire

There is a gas station, a restaurant, a hostel and a post office located on the corners. A residential area named Fann residential area is located nearby. The sensitive infrastructures nearby are Fann Hospital (400m away), Lycée Seydou Nourou Tall (150m away) and School of Franco Sénégalaise (100m away).

3) Intersections on Front de Terre

Khar Yalla

On the corner, there is a gas station, a food shop, a concrete house and a money exchange shop. A weekly market selling second-hand clothes and various other products is held every Saturday. The shops occupy the central divide of the Front de Terre from Khar Yalla intersection to Bourguiba intersection. A mosque exists 78m away. The sensitive infrastructures are a private school, Notre Dame du Liban (330m away) and clinic ASBEF (150m away).

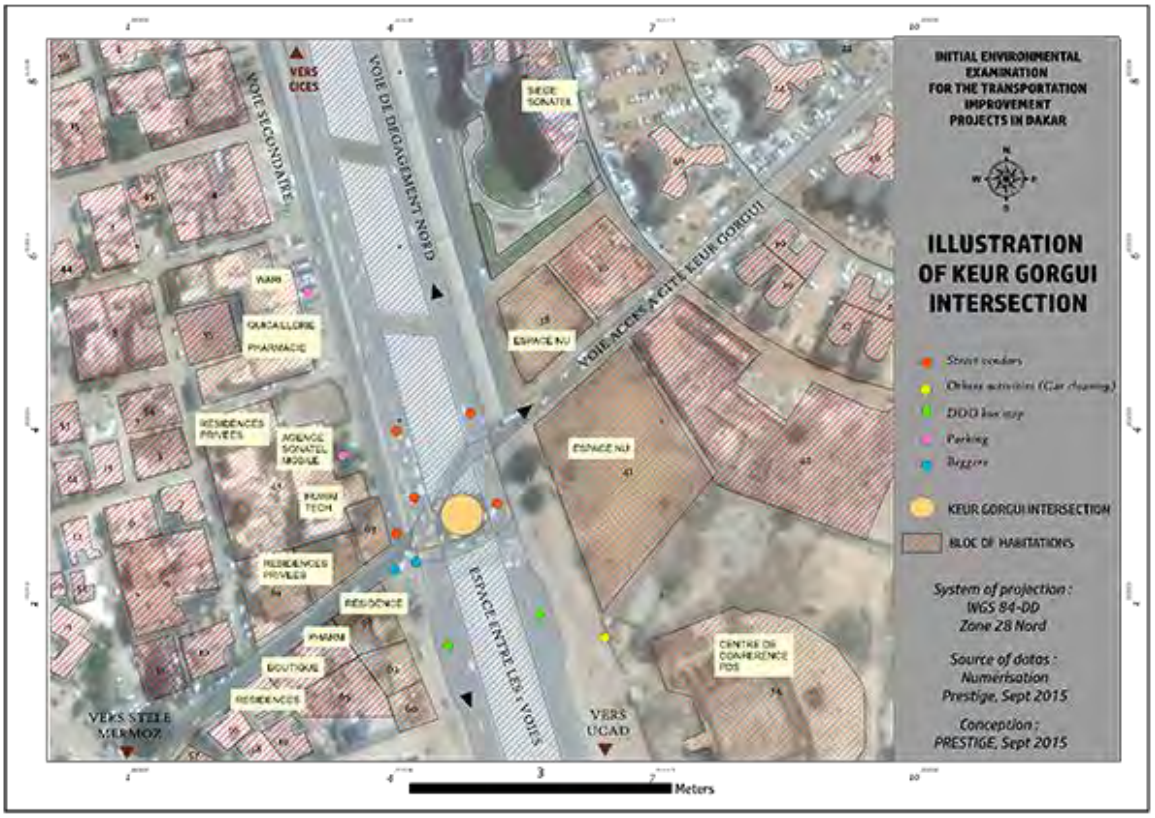
Bourguiba

On the corner, there are three shops, one of which is a bakery.

The present conditions in the respective intersections are shown in Figures 2.9.1 through 2.9.5.

Source: Prestige Cabinet Council

Figure 12.10.1 Present Conditions Around Station SDE

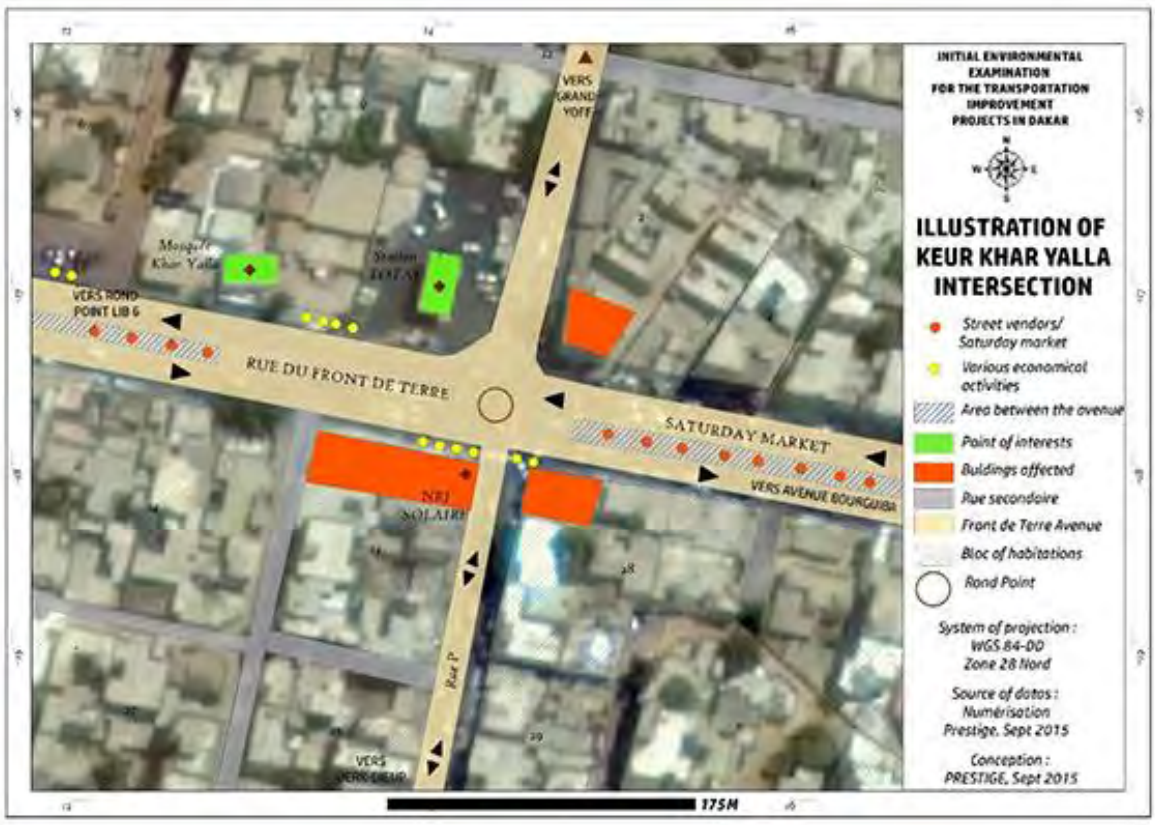


Source: Prestige Cabinet Council

Figure 12.10.2 Present Conditions Around Cité Keur Gorgui Intersection

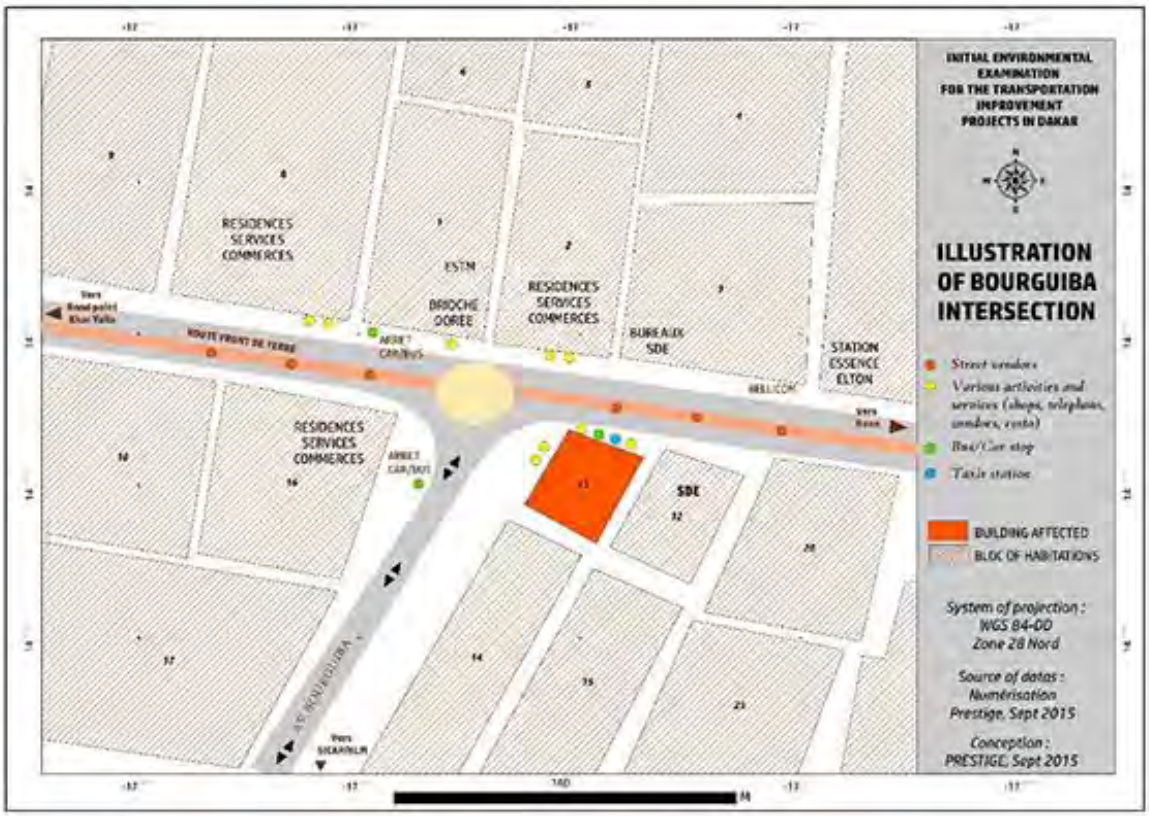
Source: Prestige Cabinet Council

Figure 12.10.3 Present Conditions Around Aimé Césaire Intersection



Source: Prestige Cabinet Council based on Google Maps

Figure 12.10.4 Present Conditions Around Khar Yalla Intersection



Source: Prestige Cabinet Council

Figure 12.10.5 Present Conditions Around Bourguiba Intersection

(4) Air Quality

Two air samples (one near the intersection and one in a nearby residential area) at each intersection were taken and analyzed for SOx, NOx, PM2.5 and PM10. The results are shown in Table 12.10.2 and Table 12.10.3. The air quality standards of WHO and Senegal are shown in Table 12.10.4.

Table 12.10.2 Concentration of NOx and Sox at and near the Intersections

		NOx	NO	SO2
Station SDE	At intersection	6 mg/m³	4 mg/m³	< 1 mg/m³
	Nearby residential area	4 mg/m³	3 mg/m³	< 1 mg/m³
Cité Keur Gorgui	At intersection	4 mg/m³	3 mg/m³	< 1 mg/m³
	Nearby residential area	2 mg/m³	1 mg/m³	< 1 mg/m³
Aimé Césaire	At intersection	6 mg/m³	4 mg/m³	< 1 mg/m³
	Nearby residential area	< 1 mg/m³	< 1 mg/m³	< 1 mg/m³
Khar Yalla	At intersection	4 ppm	4 ppm	< 1 ppm
	Nearby residential area	3 ppm or 6.188 mg/m³	3 ppm or 4.02 mg/m³	< 1 ppm
Bourguiba	At intersection	1 ppm or 2.056 mg/m³	1 ppm or 1.34 mg/m³	< 1 ppm
	Nearby residential area	1 ppm or 2.056 mg/m³	1 ppm or 1.34 mg/m³	< 1 ppm

Source: Prestige Cabinet Council

As for NO_2, the observed values at all of the sites highly exceed the WHO hourly standard of 40-50 μg/m³ or 0.04 mg/m³. The SO_2 concentrations did not exceed 1 ppm and, therefore, could not be detected because of the limit of the analyzer. However, this does not mean that levels lower than 1 ppm do not cause health problems because the daily standard of both WHO and NS-05-62 of Senegal is 125 μg/m³ or 0.125 mg/m³.

Table 12.10.3 Concentration of PM2.5 and PM10 at and near the Intersections

Measurement site		Concentration of PM2.5 (μg/m³)	Concentration of PM10 (μg/m³)
Station SDE	At intersection	7.22	43.86
	Nearby residential area	31.84	65.15
Cité Keur Gorgui	At intersection	13.47	107.53
	Nearby residential area	17.33	41.95
Aimé Césaire	At intersection	9.32	39.08
	Nearby residential area	16.56	38.01
Khar Yalla	At intersection	8.45	36.96
	Nearby residential area	24.05	61.12
Bourguiba	At intersection	9.57	24.14
	Nearby residential area	36.38	70.96

Source: Prestige Cabinet Council

As for PM2.5, the values are lower than the WHO daily standard, 10μg/m³, at all of the intersections except one. However, the values are higher than the standard in all of the residential areas. As for PM10, the values are higher than the WHO daily standard, 20μg/m³, at all of the measurement sites.

A remarkable point is that the concentration is higher in the residential areas than at the intersections, at all the points for PM2.5 and in some points for PM10. This means that the pollution observed in the residential areas is not necessarily due to traffic and may be caused by other factors such as housing configuration, human activities, etc.

Table 12.10.4 Standards for the Key Pollutants

Pollutant		Maximum Value Limit	
		WHO instructions	NS-05-62 (Senegal)
Sulfur dioxide (SO2) (in µg/m^3)	Annual	500	-
	Daily	125	125
	Hourly	50	50
Nitrogen dioxide (NO2) (in µg/m^3)	Annual	200	200
	Hourly	40-50	40
Particles <2.5 µm (PM2.5) (in µg/m^3)	Annual	25	-
	Daily	10	-
Particles <10 µm (PM10) (in µg/m^3)	Annual	50	260
	Daily	20	80
			(For reference only)
(O3) (in µg/m^3)	Hourly	150-200	-
	8 hours	120	120
Carbon monoxide (CO) (in µg/m^3)	Hourly	30 000	-
	8 hours	10 000	30 000 (24h)
	Nearby residential area	36.38	70.96

Source: WHO and NS-05-62 (Senegal regulation)

The noise and vibration was measured at the same sites as air and the results are shown in Table 12.10.5. As for noise, the maximum thresholds are 55-60 dB, so the noise levels of all of the sites exceed the thresholds.

Table 12.10.5 Noise and Vibration at and near the Intersections

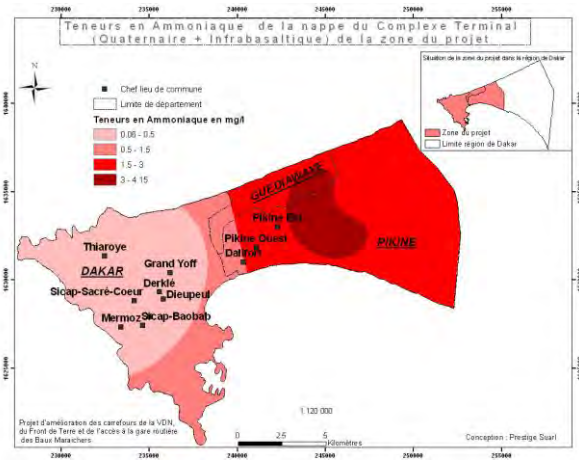
Measurement Site		Noise (dB)	Vibration (dB)
Station SDE	At intersection	71.6	84.5
	Nearby residential area	69.4	80.3
Cité Keur Gorgui	At intersection	67.1	80.2
	Nearby residential area	68.3	78.8
Aimé Césaire	At intersection	75.7	79.6
	Nearby residential area	68.1	80.8
Khar Yalla	At intersection	71.7	79.9
	Nearby residential area	70.0	80.6
Bourguiba	At intersection	71.0	84.7
	Nearby residential area	68.1	79.2
	Nearby residential area	36.38	70.96

Source: Prestige Cabinet Council

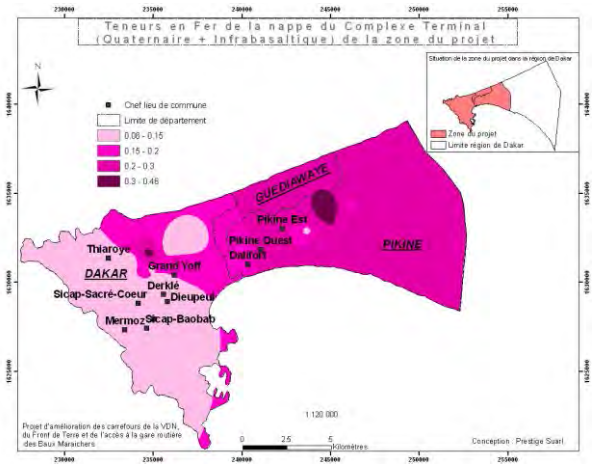
(5) Groundwater Quality

The groundwater quality of the main parameters in the Study area is shown in Figure 12.10.6. The water quality standard for drinking water by WHO is added to each chart and the EU standard is shown if the WHO standard is not available.

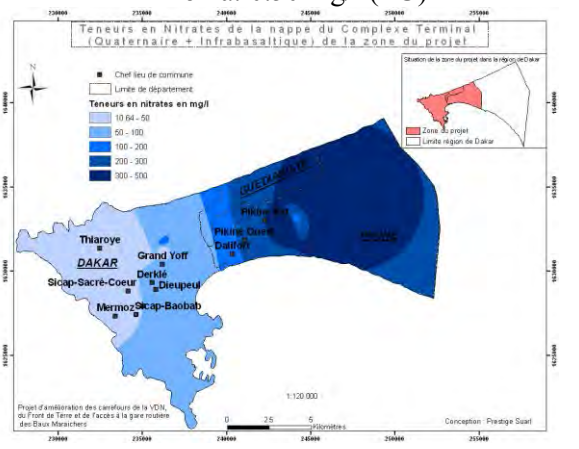
Generally, the water quality is good in the West area and meets the requirements for drinking water.



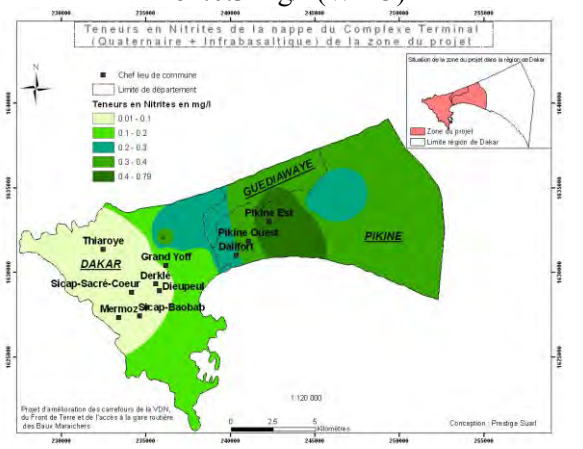
Ammonia: 0.50 mg/l (EU)



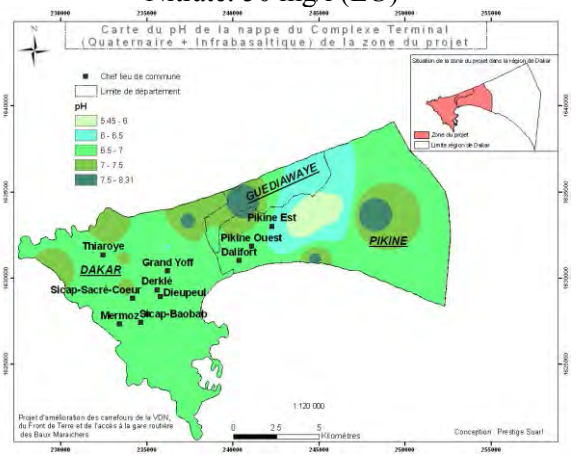
Iron:0.3 mg/l (WHO)



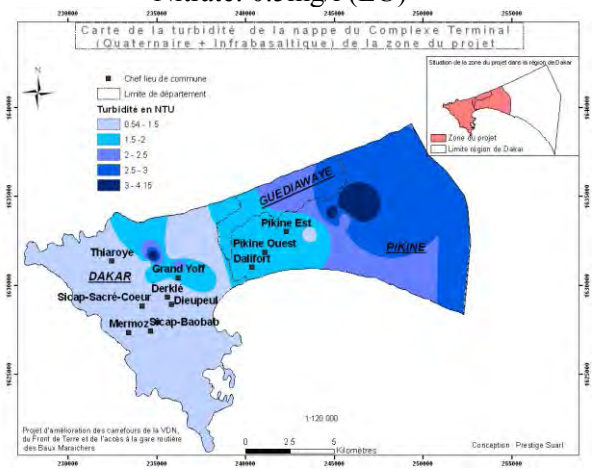
Nitrate: 50 mg/l (EU)



Nitrate: 0.5mg/l (EU)



pH: 6.5-8.5 (WHO)



Turbidity: less than 5NTU (WHO)

Source: DGPRE

Figure 12.10.6 Ground Water Quality in the Study Area

12.10.2 Related Laws and Regulations

From a legislative perspective, the Senegalese government has adopted a new environment code since 2001 through law No. 2001-01 of January 15th, 2001 and its application decree no. 2001-282 of April 12th, 2001.

Table 12.10.6 Related Articles of the Environment Code

Theme	Article	Outline
Environmental Code		
Air	Articles L76, L78, R72, R80	To prohibit the emission of air pollutants
Water	Articles L59, L63, R46, R56	To prohibit the discharge of water pollutants
Waste	Articles L30, L31, L37	To promote waste management, including recycling, in an environmentally rational matter
Soil	Articles L81, L82	To prohibit the degradation of soil
Noise	Articles L84 L85, R84	To stipulate that maximum thresholds are 55 to 60 decibels in daytime and 40 decibels at night

Source: Environment Code

The environment code is strengthened by several decrees, such as NS 05-062 norms for atmospheric pollution; NS 05-061 for the rejection of waste water; NS 06-060 on automobile pollution; Departmental Order 009468/MJEHP/DEEC of November 29th, 2001, providing modalities of public participation in environmental impact studies; Departmental Order 009471/MEJHP/DEEC of November 28th, 2001, setting the content of the reference terms of EIS; and Departmental Order 009472/MEJHP/DEEC of November 28th, 2001 on the structures and contents of EIS reports.

The detailed limit values for air quality and water quality are stipulated in other documents of environmental standards but there is no regulation on vibration in Senegal. Therefore, it is suggested that the WHO or EU standards are used when required.

As for land acquisition and resettlement, the Law 76-67 of July, 1976 is the legal basis and explanation is given in the Resettlement Policy Framework section.

12.10.3 Studies on the Alternatives

The alternatives for the improvement plan of each intersection and their comparison are found in the environmental and social views of this chapter.

In general, there are two alternatives - a flyover and an underpass. The cost of the flyover is cheaper by 25-35%. The construction period is also shorter, which means that the period of nuisance and inconvenience caused by the project is shorter and, hence, better for nearby residents.

Needless to say, it is desirable to reduce the number of buildings to be resettled and this point is always considered when alternatives are prepared.

Station SDE and Cite Keur Gorgui

There are two alternatives for these intersections – a flyover and an underpass. A flyover was selected for the above reasons. In addition, it was found that an underpass is not possible for Cite Keur Gorgui because the geological layer is hard.

There are two options for these two intersections: one bridge (to build a 2 x two-lane bridge in the central reservation along the VDN) and two bridges (2 x one-lane in each direction along the VDN). In the former alternative (one bridge in the center), traffic noise in the residential areas is less than the latter because the road is in the central part, further from the right of way (ROW). This alternative has been selected at the present stage. No buildings are required to be resettled for these two intersections.

Aimé Césaire

Through the technical study for this intersection, it was found that a flyover cannot be built, due to the present network and framework of the roads.

Therefore, there are two options: one is a straight, ordinary layout and the other is a winding layout. The straight layout would cover the yard of a gas station and would require one building to be resettled.

The winding layout involves no resettlement. Although resettlement should be avoided as much as possible, a winding flyover needs more material, cost and time, which is not good for the environment. In addition, the building to be resettled is a restaurant, which is not operating, and the impact of loss of business is considered to be relatively small. Therefore, the straight layout has been selected at the present stage.

Bourguiba and Khar Yalla

There is only one option for these two intersections respectively. No alternatives are feasible from a technical point of view, although both layouts require the resettlement of a few buildings.

The selected alternatives and their characteristics for the intersections are summarized in Table 12.10.7.

Table 12.10.7 Selected Alternatives and Their Characteristics

Inter-section	Alternative	Selected Alternative	Characteristics
Station SDE and Cite Keur Gorgui	Flyover / Underpass One bridge / Two bridges	Flyover and one bridge in the center	- Cheap - Short construction period - Relatively little noise - Resettlement: none
Aimé Césaire	Straight / Winding	Underpass and straight	- Only an underpass is available - Resettlement: two buildings
Bourguiba	None	Overpass	Resettlement: three buildings
Khar Yalla	None	Overpass	Resettlement: one building

Note: Identification of the buildings to be resettled was done based on readily accessible maps, so the information is not always exact.
Source: JICA Study Team

As for the 'without project' case, no cost and no impact by the project are anticipated. However, the conditions of difficulty of movement will continue, resulting in loss of time and energy, and worsening the environmental conditions such as air quality and noise.

12.10.4 Scoping

The scoping results are shown in Table 12.10.8. The items that are evaluated as B- or C were included in the TOR for the IEE.

Table 12.10.8 Scoping Results

	Item	Evaluation		Reason
		CP	OP	
Pollution				
1	Air pollution	B-	D	CP: There may be pollution to some extent because of equipment operation. OP: No additional air pollution is expected because traffic is improved.
2	Water pollution	B-	D	CP: There may be pollution to some extent because of equipment operation. OP: There is no pollution source.
3	Waste	B-	D	CP: Waste soil or waste material may occur. OP: There is no pollution source.
4	Soil contamination	B-	D	CP: There may be pollution because of oil spill. OP: There is no pollution source.
5	Noise and vibration	B-	D	CP: There may be some noise and vibration because of equipment operation. OP: No additional noise and vibration is expected.
6	Ground subsidence	D	D	Construction work that may cause ground subsidence is not included.
7	Offensive odor	D	D	Construction work that may cause offensive odor is not included.
8	Bottom sediment	D	D	No river system is included in and around the projects.
Natural Environment				
9	Protected area	D	D	There is no protected area in and around the projects.
10	Flora, fauna and biodiversity	D	D	There is no flora or fauna.
11	Hydrological situation	D	D	There is no hydrological system nearby.
12	Topography and geographical features	D	D	Large change to topography and geographical features is not planned.
Social Environment				
13	Involuntary resettlement and land acquisition	B-	B-	Several buildings (mainly business entities) may be resettled.
14	Poor people	D	D	There are no activities to affect them.
15	Indigenous and ethnic people	D	D	There are no indigenous and ethnic people nearby.
16	Local economy such as employment and livelihood, etc.	B+	B+	CP: There may be a positive impact because of the inflow of workers. OP: There may be a positive impact on the local economy because people can save time due to reduced traffic congestion.
17	Land use and utilization of local resources	C	C	Part of land use may be restricted.
18	Water use	D	D	There will be no activities that may affect this item.
19	Social infrastructure and social service	D	D	There will be no activities that may affect this item.
20	Social institutions such as local decision making system, etc.	D	D	There will be no activities that may affect this item.
21	Misdistribution of benefit and damage	C	C	There may be misdistribution because beneficiaries are car users from outside, not the nearby residents.
22	Local conflict of interests	C	C	There may be conflict because limited people will be negatively affected.
23	Cultural heritage	D	D	There is no cultural heritage in and around the project area.
24	Landscape	D	B+	CP: Landscape is changed but not always worse. OP: Landscape will be improved because of less traffic congestion.
25	Gender	D	D	There will be no activities that may affect this item.
26	Children's rights	D	D	There will be no activities that may affect this item.
27	Hazards (risk) Infectious diseases such as HIV/AIDS	C	C	Senegal has low rate of HIV/AIDS, but impact not known.
28	Working conditions including security for workers	B-	D	CP: Working conditions may be bad, if proper consideration is not made. OP: There are no construction workers, though limited number of maintenance staff work.
29	Accidents	B-	B+	CP: There may be accidents, if proper consideration is not made. OP: Traffic accidents may be reduced because of smooth transportation.
30	Impacts on broad area;	D	D	Construction work is limited to part of the roads and not large. Therefore,

	Item	Evaluation		Reason
		CP	OP	
	climate change			no impact is expected.

Note: A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: Extent of positive/negative impact is unknown (a further examination is needed and the impact could be clarified as the Study progresses).
D: No impact is expected.
CP: Pre-construction and construction period
OP: Operation period
Source: JICA Study Team

12.10.5 Anticipated Environmental Impact

The following negative impacts can be anticipated. These are common among the three intersections.

(1) Before and During Construction

1) Air

- Dust from soil excavation, land clearance and ground leveling pollutes air environment.
- Pollution is caused by emissions from working equipment and machinery in soil excavation, land clearance, ground leveling, etc.
- Main pollutants are SOx, NOx and CO.

2) Water

- Waste water is generated from the cleaning and maintenance of machinery. The main pollutants are COD, oil and grease, and SS.
- Human waste is generated by the workers' use of toilets.
- Domestic waste water is generated by the workers. The main pollutants are BOD5, COD, SS, NH3, N, and P.
- The above kinds of waste water may pollute soil and groundwater, if not treated properly.

3) Waste

- Construction waste, such as pebbles, sand, cement, wood, paint, etc., is generated at the construction site.
- Hazardous solid waste generated includes oil, grease, glue, paint, paint containers, gasoline and batteries. Based on previous practical experience, hazardous solid waste occupies about 5% of the construction waste.

4) Soil

- Waste water (including waste water from the washing of equipment) and waste as detailed above may contaminate soil.

5) Noise and Vibration

- Ground leveling, soil excavation and construction work generate noise through operation of heavy equipment. Generally, noise (8m distance from the site) is estimated at 86-98 dB and the acceptable level is about 60 dB. Noise will cause discomfort to the nearby residents, if no measures are taken.

- Vibration sources are heavy machinery and vehicles such as bulldozers, trucks, etc. The vibration level of all kinds of machinery is estimated as 64-71 dB at a point 30m away from the sources. The general standard is 75 dB.

6) Involuntary Resettlement and Land Acquisition

- Some business entities or residences are required to be resettled. The numbers are two (at Aimé Césaire), three (at Khar Yalla) and one (at Bourguiba) under the most probable plan at present.
- There are street vendors on the sidewalks along the roads at all five intersections and a weekend market is held in the central divide of the Front de Terre. These shops are required to suspend their businesses or move to another area.
- The survey on land ownership is not covered by the IEE because it is carried out when the design is finalized.

7) Social Infrastructure

- Excavation may disrupt underground infrastructure, such as electric cable, telegraphic wire, water pipe or sewerage pipe, provided by SDE, SENELEC and SONATEL, etc., resulting in inconvenience of the nearby residents.
- Mobility for motorists, cyclists and pedestrians may be reduced because of traffic overload on alternative ways and detours.

8) Misdistribution of Benefit and Damage

- The beneficiaries are mainly car users. They can drive more comfortably and can save time.
- On the other hand, the residents may suffer from inconvenience caused by road closure, partial loss of business activities, air/noise pollution and other negative impacts during the construction period.

9) Risk of Infectious Diseases (HIV/AIDS)

- There may be appearance and spread of STDs as a consequence of the arrival of workers and their interactions with the communities.

10) Working Conditions Including Security for Workers

- If the working environment is bad or the workers neglect working rules, it can cause fatigue, dizziness, etc., while working.

11) Accidents

- The number of vehicles going in and out of the construction area will increase, which may lead to a rise in traffic accidents.
- Accidents may be caused due to the negligence of workers, lack of protective equipment or lack of awareness about the strict compliance with safety rules for construction workers.

(2) During Operation

Involuntary Resettlement and Land Acquisition

- The quality of life of the people who are resettled may be worsened if the proper compensation and rehabilitation are not provided.

(3) Summary of the Impact

The anticipated impact can be summarized as shown in Table 12.10.9.

Table 12.10.9 Summary of the Anticipated Impact

	Item	Evaluation		Description of Impact
		CP	OP	
Pollution				
1	Air pollution	B-	D	CP: Pollution is caused from working equipment and machinery. OP: No additional air pollution is expected because traffic is improved.
2	Water pollution	B-	D	CP: Waste water is generated from cleaning and maintenance of machinery and human activities. OP: There is no pollution source.
3	Waste	B-	D	CP: Construction waste is generated, part of which is hazardous waste. OP: There is no pollution source.
4	Soil contamination	B-	D	CP: Waste water and waste may contaminate soil. OP: There is no pollution source.
5	Noise and vibration	B-	D	CP: Construction work causes noise and vibration. OP: No additional noise and vibration is expected.
Social Environment				
6	Involuntary resettlement and land acquisition	B-	B-	CP: Some business entities or residences are required to be resettled. Street vendors and the weekend market are required to be moved. OP: The quality of life of the people who are resettled may be worsened.
7	Social infrastructure	B-	D	CP: Electric cable, telegraphic wire, water pipe, etc., may be disrupted, resulting in inconvenience. Mobility is reduced in detours. OP: There is no impact after construction.
8	Misdistribution of benefit and damage	B-	D	CP: Residents may suffer from inconvenience, loss, etc. OP: Residents do not suffer from inconvenience, loss, etc.
9	Local conflict of interests	D	D	Judging from similar works in Dakar, it is not expected.
10	Risk of infectious diseases (HIV/AIDS)	B-	D	CP: Sexually transmitted diseases (STDs) may be brought by the workers. OP: There are no construction workers.
11	Working conditions including security for workers	B-	D	CP: It may cause fatigue, dizziness, etc., if working conditions are bad. OP: There are no construction workers, though limited number of maintenance staff work.
12	Accidents	B-	B+	CP: Construction vehicles may increase traffic accidents. Accidents may be caused due to the negligence of workers. OP: Traffic accidents may be reduced because of smooth transportation.

Note: A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
D: No impact is expected.
CP: Pre-construction and construction period
OP: Operation period
Source: JICA Study Team

12.10.6 Proposed Mitigation Measures

The mitigation measures to be taken against the anticipated negative impacts described above are explained below. The contractor of the construction work is responsible for all of the measures and is required to implement them.

(1) Before and During Construction

1) General

- Conducting training sessions for all of the workers before starting work at the site to raise awareness of environmental and social management and to sensitize the personnel of the contractor
- Tailoring the contents of the above-mentioned training for each target group
- Sensitizing the surrounding communities including nearby public institutions (schools, health centers, water points, etc.) and common places (markets, places of worship, etc.)

2) Air

- Limiting the speed of trucks involved in transporting the materials to 30 km/h
- Spraying work surfaces and deviations of areas
- Equipping trucks carrying materials, such as laterite, sand and gravel with tarpaulin, to minimize the dispersion of fine particles
- Supplying dust masks to site staff
- Giving out information and prior sensitization of the local population
- Raising awareness of truck drivers towards a smooth discharge of materials

3) Water

- Establishing mobile toilet facilities in the yards
- Providing a paved area for washing and maintenance of gear with an oil separator

4) Waste

- Collecting waste separately by type and value (foam board, iron scrap, etc.)
- Preparing a special yard of waste to be delivered by an approved company for treatment
- Storing hazardous substances in sealed containers in secure storage areas to be protected
- Handling hazardous substances under constant surveillance
- Collecting hazardous waste (waste oil, used batteries, oil filters, contaminated rags, etc.) in sealed containers and storing in paved areas protected from the weather to be treated later by the licensed treatment company

5) Soil

- Providing a paved area for the washing and maintenance of gear with an oil separator
- Storing the oil products on a concrete pad to minimize all forms of degradation and pollution of soil and groundwater

6) Noise and Vibration

- Installing noise isolation devices into the machines with high noise levels such as excavators, compressors, excavator, etc.
- Using appropriate noise protection gear (helmet, ear plugs) to avoid noise impact on the workers

7) Involuntary Resettlement and Land Acquisition

- Holding consultations with the owners/users of the buildings to be resettled, explaining what kinds of compensation and rehabilitation support can be provided
- Holding consultations with the vendors and other stakeholders, showing what kinds of compensation can (or cannot) be provided

8) Social Infrastructure

- Making efforts to reduce the impact on the residents with coordination with related organization, such as SDE, SENELEC and SONATEL, etc., resulting in inconvenience of the nearby residents.
- Arranging the layout and operation of alternative ways and detours to not bother the mobility of the people
- Explain the alternative ways and detours, asking for residents' understanding

9) Misdistribution of Benefit and Damage

- Holding stakeholder meetings with the nearby residents, providing all of the information as per the schedule, kinds of anticipated impact and asking for understanding and cooperation
- Providing compensation or solatium for their loss or inconvenience

10) Risk of Infectious Diseases (HIV/AIDS)

- Raising the awareness of construction workers and other related people

11) Working Conditions Including Security for Workers

- Equipping the workers with suitable safety equipment (safety shoes, helmets, face masks, earmuffs, gloves, etc.)
- Training workers on workplace safety in construction

12) Accidents

- Keeping a proper work schedule to avoid fatigue
- Training workers on workplace safety in construction

(2) During Operation

Involuntary resettlement and land acquisition

- Conducting monitoring regularly as scheduled and taking prompt action if improper conditions are found

12.10.7 Proposed Monitoring Plan

Monitoring measures to be taken against the anticipated negative impacts described above are explained in Table 12.10.10. A consultant hired by the project owner can conduct monitoring. The project owner will be responsible for all of the monitoring results and can instruct the contractor to improve the way in which mitigation measures are conducted, if a problem is found in the monitoring results.

Table 12.10.10 Monitoring Plan

Environmental Item	Method of Monitoring (with an Index, If Any)	Monitoring Place	Frequency
Pre-construction and Construction Period			
Air pollution	To check whether the respective mitigation measures are followed or not	Construction site	Once/week (Irregularly)
Water pollution	-	-	-
Waste	To check whether the respective mitigation measures are followed or not	Construction site	Once/week (irregularly)
Soil contamination	To check whether the respective mitigation measures are followed or not	Construction site	Once/week (irregularly)
Noise and vibration	To check whether the respective mitigation measures are followed or not	Construction site	Once/week (irregularly)
Involuntary resettlement	As the ARAP, to be prepared, requires (stakeholder meetings, interviews, etc., may be used)		
Social infrastructure	To have opportunities to hear residents' opinions/requests/grievances on the project through meetings/interviews as often as possible.		
Misdistribution of benefit and damage	To have opportunities to hear residents' opinions/requests/grievances on the project through meetings/interviews as often as possible		
Risk of infectious diseases	To check that an education program is properly held	Construction site	When construction starts and once/two months
Working conditions including security for workers	To check whether the respective mitigation measures are followed or not	Construction site	Once/week (irregularly)
Accidents	a. To check whether the respective mitigation measures are followed or not b. To keep the records of accidents and analyze them to learn lessons	Construction site	a. Once/week (irregularly) b. Once/week (regularly)
Operation Period			
Involuntary resettlement	As the ARAP, to be prepared, requires (stakeholder meetings, interviews, etc., may be used)		

Note: ARAP: Abbreviated Resettlement Action Plan (to be prepared with F/S)
Source: JICA Study Team

12.10.8 Resettlement Policy Framework

(1) General

The layouts of the improvement plans for the intersections sometimes overlap part of the existing buildings, although efforts were made to avoid overlap and minimize the numbers of such buildings. Therefore, some buildings are required to be moved.

There are two more groups of people to be moved: one group is the street vendors on the walkways at and around the intersections and the other group is the shops in the weekly street market. These two groups are not usually categorized as displaced people but this section includes them.

(2) Laws in Senegal

The Law 76-67, July 1976, relating to the eminent domain, is the legal basis for the expropriation for public purposes. The following two fundamental conditions should be met:

- Compensation is fixed, paid or recorded before taking possession.
- The expropriated should be relocated, in almost similar conditions to the previous situation. The compensation must cover all of the direct material damage that is caused by the expropriation.

The Law 76-67 stipulates the procedure of expropriation and compensation, and is supported by other related laws and decrees. As for compensation, it lays down that compensation in kind or in cash is paid for the loss of property and loss of facility. Support for moving is included, although compensation for income loss is not included.

(3) World Bank Manual and Guidelines

As for resettlement, the Operation Manual OP 4.12 Involuntary Resettlement is generally referred to. The policy objectives of this document can be summarized as follows:

- Involuntary resettlement should be avoided where feasible or minimized, exploring all viable alternative project designs.
- Displaced people should be meaningfully consulted and should have opportunities to participate in planning and implementing resettlement programs.
- Displaced people should be assisted in their efforts to improve their livelihoods and standards of living or at least to restore them.

There are some street vendors who are required to move by the implementation of this project. The World Bank suggests the following in regard to those street vendors (source: Involuntary Resettlement Sourcebook, WB):

- Unlicensed street vendors (such as mobile enterprises lacking structures or other fixed improvements to land) lose no land or assets through displacement and, hence, are not covered by OP 4.12.
- However, vendors with official site licenses have recognized rights and must be provided with an alternative site and compensation for any transition expenses.
- Good practice recommends the provision of a transition allowance to unlicensed vendors, or alternative market areas can be provided.

(4) Comparison of the Policies

Comparison of the policies in Senegal and the ones of international aid organizations are made, and

the suggested policies to be adopted in this project are shown based on the comparison results in Table 12.10.11

Table 12.10.11 Comparison of the Policies on the Resettlement

Law/Policy in Senegal	JICA Guidelines	World Bank Policy	Suggested Policy to be Adopted in the Project
1.Basic Policy on Resettlement			
Resettlement should be avoided and minimized.	Involuntary resettlement is to be avoided when feasible by exploring all viable alternatives.	Resettlement should be avoided and minimized.	Resettlement should be avoided and minimized.
2.Consultation			
Involvement of the public and publicity should be secured.	In preparing a resettlement action plan, consultations must be held with the affected people and their communities.	Meaningful consultation and opportunities for participation is required.	Meaningful consultation and opportunities for participation is required.
3.Basic Policy on Living Standards			
[Not mentioned]	Host country must make efforts at least to restore these to pre-project levels.	Livelihood and living standards should be at least restored.	Livelihood and living standards should be at least restored.
4.Form of Compensation for Land			
By land or cash (depends on the case)	Land and monetary compensation.	By land or cash.	By land or cash (depends on the case).
5.Valuation of Land			
Valuation depends on the legal price per m2	Full replacement cost must be provided as much as possible.	Replacement cost is used.	Replacement cost is used.
6.Timing of payment			
Prior payment or deposit for the provisional indemnity should be provided.	Prior compensation must be provided.	After paying compensation, the taking of land and related assets takes place.	After paying compensation, the taking of land and related assets takes place.
7.Grievance mechanism			
-Negotiation through the Conciliation Commission; -Local negotiation -Referral to the courts and the Ombudsman -Involvement of traditional authorities.	Appropriate and accessible grievance mechanisms must be established for the affected people and their communities.	Appropriate and accessible grievance mechanisms should be set up.	A mechanism that is locally accepted may be adopted, if no problems have been found so far.

(5) Present Conditions of the People to be Affected

1) Owners/ Users of the Buildings to be Resettled

As explained in the section of studies on alternatives, the buildings to be resettled are estimated at the present stage. Most of them are CBEs, located at or near the corner of the intersections to be included. All of them are small-scale buildings and, therefore, the number of the PAPs is not big.

- Station SDE and Cite Keur Gorgui: None
- Aimé Césaire: 2
- Khar Yalla: 3
- Bourguiba: 1

2) Street Vendors

The City Hall of Mermoz-Sacré Cœur does not accept any form of unauthorized occupation without payment of the tax on occupation of the public highway. Each intersection has street vendors, as

described below:

Station SDE

Some trading activities to sell newspapers, utensils, pastries, coffee, etc., are seen.

Cite Keur Gorgui

The number of vendors is smaller than other intersections. There are some vendors who handle traveling bags and fans, and are shaded under trees without any installation. A phone credit card salesman is located on the other side under a parasol.

Aimé Césaire

The vendors do not have fixed installations, take shelter under parasols and exhibit their products in glass structures of small sizes. They take everything away at the end of each workday. On the other side, on the way to Lycée d'application Seydou Nourou Tall, they sell coffee, snacks and accessories on carts.

3) Related People of the Weekly Market

A market that stretches from the roundabout in Liberté VI to the crossroads in Bourguiba on the central divide of the Front de Terre is held every Saturday. Both of the intersections of Bourguiba and Khar Yalla are included. This market is said to have a 20-year history and to have around 1,500 vendors. It is essentially a second-hand imported clothes market.

It has three main actors:

- Local authorities that receive benefit: the City Hall of Dieupeul-Derklé, which receives tax from holding the market, based on a contract with MADS (see below) of about 750,000 FCFA/month and the City Hall of Grand Yoff, which obtains tax from the use of the public highway (PHO) and advertising,
- Société MADS SARL, a company that controls the market and takes care of tent installations for the shops, and
- Shops.

(6) Entitlement Matrix

The following Entitlement Matrix is proposed, considering all of the above conditions. The street vendors and the related people of the weekly market are not covered by OP 4.12. However, it is suggested to provide some kind of compensation to them so as to have an amicable relationship with them.

Table 12.10.12 Entitlement Matrix

Potential Impact	Categories of People	Compensation or Support to Be Given	Law/Guidelines to Be Based on
Land loss	- Individual person who owns land they occupy - Legal entity that owns the same	- Compensation in kind of a property of the same value plus transaction fees, or cash depending on the market price - Support for resettlement	- Constitution of January 22nd, 2001 - Law 76–67 of July 2nd, 1976 - Law 64–46 of June 17th, 1964 - Decree 64–573 of July 30th, 1964 - Law 76–66 of July 2nd, 1966 - Decree 81–557 of May 21st, 1981 - Decree 91-838 of August 22nd, 1991
Facility loss	- Individual person who owns a fixed facility (e.g., building, shop, warehouse, billboard) - Legal entity that owns the same	- Compensation in kind with a structure of equal value, or in cash at the replacement cost without depreciation - Support for resettlement	- Constitution of January 22nd, 2001; - Law 76–67 of July 2nd, 1976 - Law 64–46 of June 17th, 1964 - Decree 64–573 of July 30th, 1964 - Law 76–66 of July 2nd, 1966 - Decree 81–557 of May 21st, 1981 - Decree 91-838 of August 22nd, 1991
Income loss (formal sector such as shop owner)	- Individual person who occupies a business place, or loses their income source - Legal entity that occupies a business place, or loses their income source (local authorities, companies)	- Compensation for income loss for a period to be determined according to the impact severity and the estimated time necessary to recover the livelihood - Support for resettlement	- O.P 4.12 of World Bank
Income loss (informal sector such as street vendors)	- Vendor with an official site license	- Alternative site and compensation	- Involuntary Resettlement Sourcebook, WB
	- Vendor without an official site license	- Alternative site, or transition allowance	

Source: JICA Study Team

12.10.9 Consultation with Stakeholders

Consultation with the stakeholders, relevant governmental agencies and municipalities shown below and Société MADS SARL, a company that controls the weekend market on Front de Terre, was held. Their main opinions are summarized in Table 12.10.13.

- DUA
- CETUD
- DTT
- Municipality of Mermoz-Sacré Cœur
- Municipality of Fann-Point E
- Municipality of Grand Yoff
- Municipality of Dieupeul-Derklé
- Municipality of SicapLiberté

Table 12.10.13 Summary of Opinions of the Relevant Organizations

Concern	Expectation/Recommendation
Relevant Governmental Agencies and Municipalities	
- Hann-Fann wastewater collection system in KharYalla/Front de Terre (It may be an obstacle). - There are underground water supply pipes and/or fiber optic along the roads. - Compatibility of the technical options proposed at Aimé Césaire and Front de Terre/Bourguiba with the BRT project (Fast Buses project). - Construction at Khar Yalla, where many activities are done in limited space, where there is wastewater collection pipes. - Consideration of public transportation in the projects' design. - Rocky texture of the soil in some points could bring delays and additional costs. - Insecurity risks after the construction of engineering structures because they may attract people, such as drug users, mentally ill people, street hawkers, who can be a threat to users and pedestrians. - Limit of access to hospitals, schools, etc., during construction. - Possibility of the relocation of small businesses along Front de Terre. - Possibility of the relocation of the weekend market along Front de Terr. - Security risk for neighborhoods around the site resulting from traffic detour and the circulation of transport vehicles and big trucks. - Risk of conflicts of interests with the BRT project by CETUD (Executive Council of Urban Transport in Dakar).	- Projects are timely, so a solution of congestion is expected. - Consider same level installations with roundabouts or traffic lights for Aimé Césaire and Front de Terre/Bourguiba to avoid disrupting the BRT project. - Take public transportation into account. - Endeavor to shorten the duration of works. - Consult with ONAS (National Sanitation Office, Senegal) to have information on existing water networks and future extensions. - Prepare efficient system for the management of rainwater and regularly remove the sand to avoid flooding surrounding neighborhoods. - Take pedestrians' safety into account by physical measures and by regulation. - Prevent pedestrians from crossing, as traffic is supposed to increase on the VDN. - Put high-quality public lighting. - Involve local communities on time to predict risks of conflict and avoid eventual blunders. - Conduct a campaign to inform and sensitize the populations on inconveniences related to construction works. - Put in place speed humps and traffic signs for speed limits on by-pass roads and detours. - Try as much as possible to stay in present road reserves to avoid impacting private properties. - Plan a rainwater drainage channel near the junction. - Consider working with the municipality of Grand-Yoff, which plans to develop a 1000 m2 site in the area known as « zone du captage » and relocate the weekly market of Khar Yalla. - Find means to prevent big trucks from using the roads going through neighborhoods. - Think of traffic situation on secondary roads, which often create bottlenecks at junctions. - Work in harmony with CETUD to avoid overlaps between this project and the BRT (fast bus project).
Société MADS SARL	
- Concern about the fate of 1,500 people who earn their living in this market including high school and university students who make money from activities (This project is important and we are not against it).	- Plan technical options that would allow market space after the construction. - Find a temporary site to host the market during the construction phase.

Consultation with the nearby residents or business people has not been held so far. This consultation should be done in an appropriate manner in the next step in cooperation with AGEROUTE, the organization that is supposed to be the proponent of the project.

12.10.10 Further Steps

The analysis conducted at the IEE level in the Study clarified that the proposed sub-projects would create no major negative environmental impacts. Therefore, they are judged appropriate to proceed to

the next stage of the feasibility study.

A feasibility study will be held as the next step for this project and the studies to prepare the following two documents will be necessary:

- EIA
- ARAP

As for the ARAP, the following contents are required:

- Outline and background of project
- Legal framework on land acquisition and resettlement
- Scope of affected area and PAPs (based on property and land survey)
- Outline of socioeconomic profiles of PAPs (based on socioeconomic survey)
- Outline of resettlement and compensation policies
- Outline of entitlement matrix
- Institutional set-up
- Budgetary arrangement and implementation schedule
- Grievance redressing mechanism
- Public consultations and information disclosure
- Monitoring and evaluation

12.11 Prioritization of Sub-projects

12.11.1 Evaluation Method

For the prioritization of the five sub-projects on VDN and Front de Terre roads, a weighted point system or a multi-criteria analysis is applied for the evaluation of the five sub-projects that have been recommended in terms of the structure and traffic analysis, namely:

I-01: Improvement at SDE intersection on VDN (I-01e: at-grade improvement with traffic signals)
I-02: Improvement at Cité Keur Gorgui intersection on VDN (I-02c: flyover in the center)
I-03: Improvement at Aimé Césaire intersection on VDN (I-03: underpass)
I-04: Improvement at Khar Yalla intersection on Front de Terre (I-04a: flyover) and
I-05: Improvement at Bourguiba intersection on Front de Terre (I-05c: East-South flyover).

Although the economic feasibility of the investment is very important for evaluating the sub-projects, it is not the only criterion for determining the project priority. Besides economic feasibility, there should be several other viewpoints for evaluation, such as existing development policies, urgent need, scale of the sub-projects and consideration of the construction conditions including the environment.

Thus, a multi-criteria analysis with a weighted point system is applied for evaluating the sub-projects. The criteria are set out and grouped into the three major aspects, namely: necessity, effectiveness and construction conditions.

(a) Necessity: consistency with the latest Master Plan (PDUD 2025), existence of the Study and severity of the problems in terms of speed, traffic congestion and degree of saturation;
(b) Effectiveness: traffic volume, construction cost and EIRR;
(c) Construction conditions: construction period, noise/vibration, resettlement houses, aesthetic feature and maintenance.

Some of the criteria were also used for the selection of projects for pre-feasibility studies. For a multi-criteria analysis, these three aspects are considered with weights for the evaluation of each sub-project. The criteria under each aspect are described in the next section.

12.11.2 Multi-criteria Analysis

(1) Necessity (total 50 points)

Although all of the sub-projects must be relevant to the urban planning objectives for the development of the Study Area, the sub-projects that have been included as part of a necessary project in the existing transport master plan (i.e., PDUD 2025) or have been studied to some extent should be given points (10 points, respectively).

Moreover, the sub-projects that have severe local traffic problems should be given points (total 30 points) as urgent sub-projects. The score in terms of the local traffic problems is further divided into the following three quantitative indicators, each of which has a total of 10 points:

- Average speed (km/h): points calculated with a scale of 10 steps from the maximum value (zero points) down to the minimum value (10 points) of the average speeds in the two directions on the main roads (i.e., VDN or Front de Terre roads) observed at midday;
- Daily occurrence of traffic congestion (times/day): points calculated with a scale of 10 steps from zero up to the maximum value (10 points) of the number of occurrences of traffic congestion that is defined as a queue length of 100 meters or longer, observed on the main roads at every hour; and
- Degree of saturation: points calculated with a scale of 10 steps from zero up to the maximum value (10 points) of the degree of saturation based on the daily directional traffic volumes observed at the intersection, while no points are given if the degree of saturation is less than one.

(2) Effectiveness (total 50 points)

For the effectiveness of the sub-project, the projects that can more widely and greatly respond to people's needs may be given priority. As a proxy for the population of beneficiaries, the total traffic volume observed for 16 hours at each intersection may be used as an indicator of effectiveness, of which points are calculated with a scale of 10 steps, from zero up to the maximum value (20 points).

Furthermore, the sub-projects that are expected to bring a great economic return for the investment should be given priority and can be measured by an indicator of an EIRR, for which points are calculated with a scale of 10 steps, from zero up to the maximum value or 30% (smaller of the two) (20 points).

In addition, the construction cost is also included as a criterion under effectiveness, which indicates greater opportunity to implement other sub-projects at the same time under a limited budget, as the cost is smaller. The points are calculated with a scale of 10 steps, from the maximum value (zero points) down to the minimum value (10 points) of the construction cost.

(3) Construction Conditions (total 20 points)

Since construction is inevitable for the improvement of the current situation, the construction conditions cannot be modified once the improvement plan has been decided. However, these are included to consider the facility of the construction (through construction period, noise and vibration, households to be resettled and necessary maintenance), as well as the acceptance of the citizens

(through noise and vibration, households to be resettled and aesthetic features). The other two aspects, namely, necessity and effectiveness, should have greater weights for the overall evaluation and prioritization of the sub-projects. Thus, a total of 20 points are allocated to the aspect of construction conditions, with a maximum of four points for each of the following five criteria:

- Construction period (months): points calculated with a scale of four steps, from the maximum value (zero points) down to the minimum value (four points);
- Noise and vibration: zero points if it is heavy, two points if moderate and four points if rare;
- Households to be resettled: zero points if the number is 50 or more, two points if it is 10 or more (and less than 50) and four points if it is less than 10;
- Aesthetic features: zero points if a structure is planned on the ground and four points if not; and
- Maintenance: zero points if heavy maintenance is required, two points if it is moderate and four points if rare.

The above criteria and the scoring method are summarized in Table 12.20.1.

Table 12.11.1 Criteria and Scoring Method

Aspects	Weight	Criteria	Points System	
			Point	Method
Necessity	50	Consistency with the Master Plan	10	10, if part of the project road in PDUD 2025; 0, otherwise
		Existing study	10	10, if the Study exists; 0, otherwise
		Average speed	10	(Max. – value)/(Max. – Min.) * 10
		Daily occurrence of traffic congestion	10	(Value – Min.)/(Max. – Min.) * 10
		Degree of Saturation	10	(Value – Min.)/(Max. – Min.) * 10
Effectiveness	50	Traffic volume	20	Value / Max. * 20
		Construction cost	10	(1 - value / Max.) * 10
		EIRR	20	Value / Max. * 20
Construction Conditions	20	Construction period	4	(1 - value / Max.) * 4
		Noise and vibration	4	4, if rare; 2, if moderate; 0, if heavy
		Households to be resettled	4	4, if less than 10; 2, if 10 – 50; 0, if 50 or more
		Aesthetic features	4	0, if a structure on the ground; 4, otherwise
		Maintenance	4	4, if light; 2, if moderate; 0, if heavy

Note: 'Max.' is a maximum of all the sub-projects and 'Min.' is a minimum of all the sub-projects.
Sources: JICA Study Team

12.11.3 Evaluation Result

The five sub-projects are evaluated and scored through the multi-criteria analysis, based on the above-mentioned quantitative and qualitative criteria, as shown in Table 12.20.2. The sub-projects have been ranked according to the score and it is assumed that projects with higher total scores shall be prioritized. For earlier completion of the prioritized projects, it is hoped that the target implementation years will be properly scheduled and the necessary preparations will start as soon as possible.

Table 12.11.2 Evaluation Result: Intersection Improvement Project on VDN and Front de Terre

Sub-projects			Necessity (score = 50)										Sub Total
Location	Authority	Structure	Part of Project Road in PDUD2025*		Existing Study		Average Speed [km/h]		Daily Occurrence of Traffic Congestion		Degree of Saturation		
			Score =	10	Score =	10	Score =	10	Score =	10	Score =	10	50
1. SDE	AGEROUTE	At-grade	+	10		0	17.2	0	6	5	1.5	7	22
2. Cité Keur Gorgui	AGEROUTE	FO	+	10		0	17.6	0	1	1	1.8	9	20
3. Aimé Césaire	AGEROUTE	UP	+	10	+	10	13.9	3	0	0	2.1	10	33
4. Khar Yalla	AGEROUTE	FO		0		0	11.2	5	0	0	1.7	8	13
5. Bourguiba	AGEROUTE	FO		0		0	4.9	10	13	10	1.9	9	29

Note: * CETUD's latest transportation master plan

Sub-projects	Effectiveness (score = 50)						Sub Total
Location	Traffic Volume [PCU/16 hrs]		Construction Cost [billion FCFA]		EIRR [%]		
	Score =	20	Score =	10	Score =	20	50
1. SDE	54,886	20	1.2	10	90.6	20	50
2. Cité Keur Gorgui	50,842	19	14.9	5	21.6	14	38
3. Aimé Césaire	30,017	11	28.8	0	19.6	13	24
4. Khar Yalla	21,281	8	12.7	6	18.1	12	26
5. Bourguiba	31,071	11	14.0	5	17.4	12	28

Sub-projects	Construction Conditions (score = 20)										Sub Total	Total Score	Overall Ranking
Location	Construction Period		Noise and Vibration		Resettlement Households		Aesthetic Feature		Maintenance				
	Score =	4	Score =	4	Score =	4	Score =	4	Score =	4	20	120	
1. SDE	3	4	Moderate	2	0	4	At-grade	4	Moderate	2	16	88	1
2. Cité Keur Gorgui	24	2	Moderate	2	0	4	FO	0	Moderate	2	10	68	2
3. Aimé Césaire	36	1	Moderate	2	5	4	UP	4	Heavy	0	11	68	2
4. Khar Yalla	48	0	Moderate	2	4	4	FO	0	Moderate	2	8	48	5
5. Bourguiba	36	1	Moderate	2	4	4	FO	0	Moderate	2	9	66	4

Note: FO – flyover, UP – underpass
Source: JICA Study Team

Thus, the intersection improvement at SDE on VDN has been identified as a sub-project of the highest priority. While it involves at-grade improvement of the intersection, higher scores in effectiveness and facility in construction of the sub-project have given it top priority. Since the cost is relatively low, it will be probably implemented by the Senegalese side. Secondly, two sub-projects, namely, intersection improvements at Cité Keur Gorgui and Aimé Césaire on VDN road have been ranked second, and an intersection improvement at Bourguiba on Front de Terre road has been ranked fourth. However, their total scores are very close to each other, implying that all three sub-projects have the second priority. Selection of the sub-project(s) for immediate implementation out of these three sub-projects will be subject to discussions with the Senegalese side

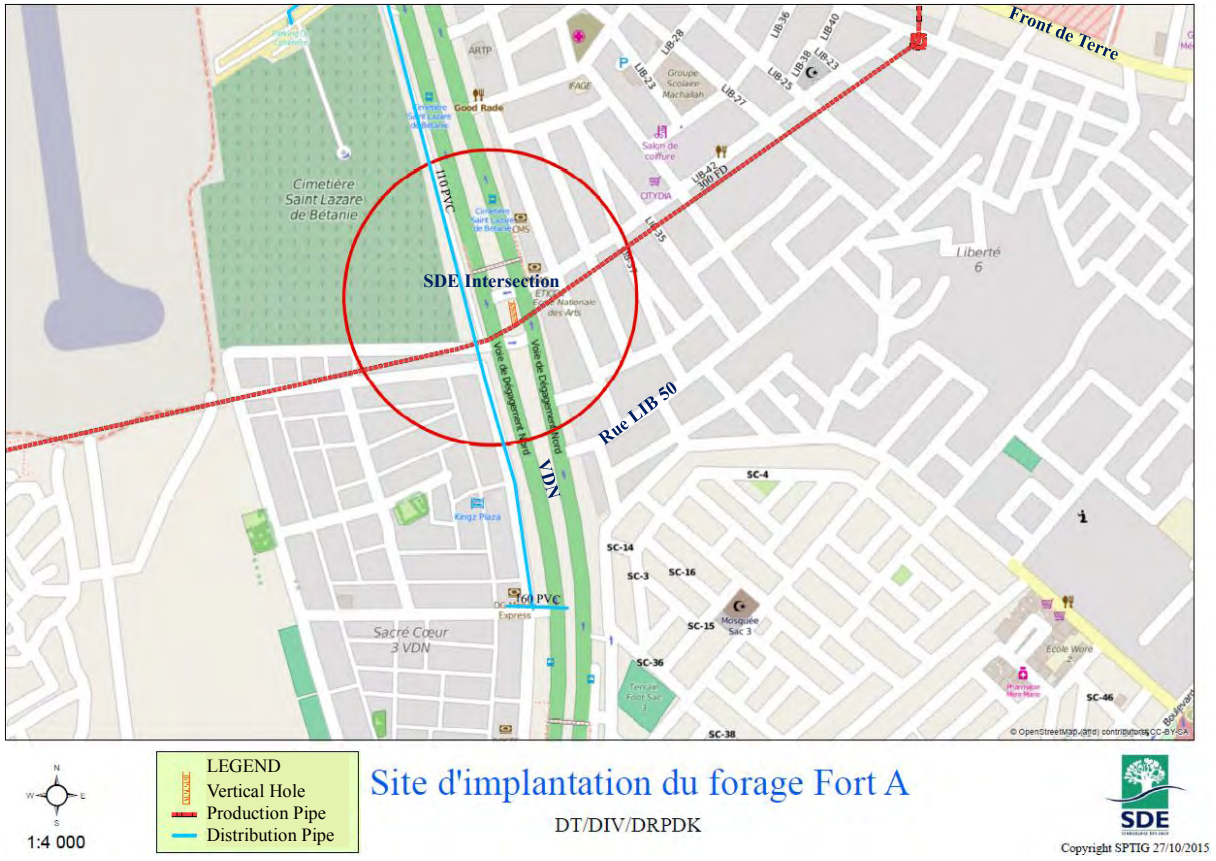
12.12 Conclusion and Recommendation

Out of the five sub-projects on VDN and Front de Terre, the intersection improvement at SDE on VDN (I-01e) has been identified as having the highest priority. It involves at-grade improvement of the intersection by installing traffic signals at four small cross-points and modifying the layout of the approach lanes, thereby achieving the low cost for improvement that could be immediately

implemented by the Senegalese side. However, the following issues should be noted for implementation:

- Since the length of the left-turn lanes on the crossing road is limited, the cycle of signalization at this intersection should be short enough to avoid spillback of the waiting queues;
- In Senegal, where roundabouts are generally preferred to traffic signals, it is not certain yet as to whether installation of traffic signals on an arterial road, such as VDN, will be customarily accepted, while the intersection is currently manually controlled by the police;
- If the installation of traffic signals cannot be realized for some reason, closure of the median and installation of U-turn lanes away from the intersection (I-01f) will be another alternative for at-grade improvement of the intersection. However, the same benefit may not be expected as for the installation of traffic signals; and
- This at-grade improvement is merely a temporary solution to the current traffic congestion. According to the traffic demand forecast, the intersection will be over-saturated again by around 2020.

In the medium- or long-term, a grade separation, such as a flyover (I-01a, I-01c) or an underpass (I-01b, I-01d), should be implemented for the SDE intersection. However, attention will have to be paid to the main large water pipes, as well as a vertical hole that exist around this intersection (Figure 12.21.1). Furthermore, as indicated in this figure, there are plans to develop the road named Rue LIB 50 as a major road connecting VDN and Front de Terre roads. Thus, it may be better to reconsider location of the grade separation itself for the future.



Source: SDE

Figure 12.12.1 Main Water Facilities Around SDE Intersection

Secondly, two sub-projects, namely, intersection improvements at Cité Keur Gorgui and Aimé Césaire on VDN road, have been ranked second. An intersection improvement at Bourguiba on Front de Terre road has been ranked fourth. However, their total scores are so close to each other, implying that all of these three sub-projects have the second priority. The selection of the sub-project(s) for immediate implementation out of these three sub-projects will be subject to discussions within the government in light of the available budget, along with a possibility of external funding.

Out of the five sub-project locations, traffic volume at the Cité Keur Gorgui intersection is the second largest after that of the SDE intersection. Hence, development of a flyover in the center of VDN road (I-02a) has been recommended as a result of the Study on the structure and design. However, before its implementation, an option of developing an elevated road in the center of VDN road (Figure 12.21.2) may be worth considering as a solution to the through traffic on VDN road, which was to be developed as a regional urban road serving longer-distance trips. This grand project will cost much more (approximately 220 billion FCFA) and it will take longer (about five years) than the individual sub-projects on VDN road. Meanwhile, the large median on VDN has been reserved originally for development of this elevated road.

The sub-project of improvement of the Aimé Césaire intersection on VDN road (I-03) is technically challenging due to the availability of limited ROW and the existence of an adjacent flyover and a nearby canal. Though all of these issues are to be solved with the proposed structure and design, the growing traffic

Source: JICA Study Team

Figure 12.12.2 Option of an Elevated Road on VDN

volume is a big issue since it is located at the South end of VDN road, while it is also considered as a North entrance to the central business district of Dakar. Apparently, this sub-project is expected to bring benefits by alleviating the current traffic congestion. However, the next intersection with a road named Rue de Zinguinchor (or more precisely, roundabout) located in the South may become another bottleneck. Thus, improvement of this roundabout by increasing the radius and area for smoother weaving of many turning movements should also be considered simultaneously for implementation of this sub-project.

Likewise, for the improvement of the Bourguiba intersection on Front de Terre road (I-05c), attention should be paid to increasing the capacity of the next interchange with the motorway (consisting, in fact, of multiple roundabouts) located in the East. Among others, since the section between Bourguiba and the next intersection will be part of the second BRT corridor that will run through this East-South flyover (I-05c), smooth traffic should be ensured in the further study on this sub-project.

CHAPTER 13 TRAFFIC IMPROVEMENT PROJECTS AROUND BAUX MARAÎCHERS BUS TERMINAL

13.1 Introduction

Baux Maraîchers is the main intercity bus terminal. In August 2014, it was relocated from Pompiers bus terminal in the center of Dakar. It now serves as a gateway to Dakar, with 780 intercity bus services to 480 destinations every day. This bus terminal was developed as part of the PAMU, financed by the World Bank and the government of Senegal. It aimed to not only centralize all the flux of intercity and international bus transport but also, to realize a hub of intermodal transfers in accordance with the evolution of the city of Dakar and its suburbs, especially Pikine and Guediawaye. The regional hub function of Dakar in West Africa is expected to be strengthened once Baux Maraîchers bus terminal is fully functional.

Thus, it has been developed at an ideal location, just beside the national road (RN1), toll motorway, and a commuter rail (PTB) station. For the convenience of the bus terminal users, it also has a connection with feeder transport such as DDD and AFTU buses. Furthermore, the passengers have been provided with sufficient travel information, such as signs, timetables, tariffs and platforms, as well as enough security through surveillance cameras.

However, since no traffic circulation plan has been developed, there is chronically heavy traffic congestion on the access road to the terminal. This seriously jeopardizes the punctuality of the intercity buses, as well as the accessibility to the terminal by the public and private feeder transport. CETUD has also recognized this problem and designated it as a priority project. Several physical improvement measures, such as the widening of the access road and construction of a grade separation or direct access ramps to RN1 or the motorway, as well as improvement measures in traffic management, such as one-way circulation and traffic regulation, have been set forth. However, none of these measures has been implemented yet.

Thus, this pre-feasibility study particularly targets the project that consists of the above-mentioned improvements. As a result of this project, the terminal is expected to recover its original function as one of the most successful intermodal terminals in Africa. This project is also in-line with one of the sustainable strategies for the urban master plan, that is, the enhancement of the intermodality between different modes of transport.

13.2 Current Situation

13.2.1 Location Map

Figure 13.2.1 shows a location map of the target area and the main facilities inside Baux Maraîchers bus terminal.

The main facilities inside the terminal based on site observation, information from CETUD and the terminal's website are briefly summarized, as follows:

- Two departure halls with the capacity of 144 spaces;
- One arrival hall with the capacity of 72 spaces;

- Two parking areas for intercity transport services which are on a rotating basis[1];
- One parking area for intercity transport services which are on a schedule basis[2];
- One parking area for international buses (for destinations Bamako, Abidjan, Cotonou, etc.);
- One zone for city transport vehicles, which is able to accommodate six buses, 22 minibuses, and 43 taxis for urban transport;
- One paid parking with the capacity of 72 spaces for private cars;
- Two service stations.

To comprehend the current situation in the target area, a number of traffic surveys were conducted. These surveys included the directional traffic count, signal phasing and traffic queue length at the intersection of NR1 and Rufisque Road. They also included a travel speed survey on certain road sections in the target area, a traffic count of the vehicles entering and exiting Baux Maraîchers bus terminal, and an OD interview survey of the vehicles exiting the terminal. The results from these surveys are presented in the following section.

[1] This is referred to as "Tour de Rôle" in French for which interurban taxis, vans, minibuses and buses are subscribed in order to queue at the departure halls. After the vehicle at the head of the queue is full, the following vehicle moves in to pick up passengers at the departure bay.

[2] This is referred to as "Horaire" in French, indicating the regular interurban transport services whose departure date and time are well determined. Their destinations include remote villages and towns.

Source: JICA Study Team, based on site investigation, information from CETUD and the website of Baux Maraîchers Bus Terminal (accessed on November 28th, 2015): (http://www.sentransco.com/index.php?option=com_content&view=article&id=165&Itemid=109)

Figure 13.2.1 Location Map of the Target Area and the Facilities Inside the Terminal

13.2.2 Directional Traffic Count Survey

Table 13.2.1 summarizes the traffic volumes at the two intersections that are located at both ends of the access road to Baux Maraîchers bus terminal. Figure 13.2.2 presents the traffic volume by the turning direction at the intersections. A more detailed description of the directional traffic count survey is presented in Appendix A, Section A.6.1.

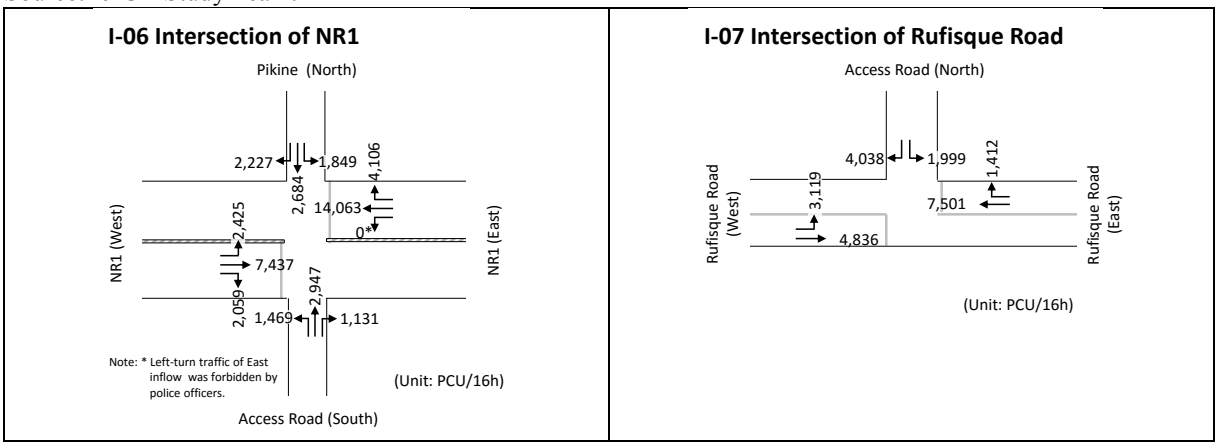
The traffic volume at the intersection of NR1 is relatively large and, within 16 hours, the passing

traffic volume exceeds 40,000 PCU. It is observed that the directions of the flyovers/underpasses, which are proposed as improvement alternatives at this sub-project location, match with the major directions of traffic flow.

Table 13.2.1 Traffic Volume at the Sub-project Locations

Code	Location	Traffic Volume (PCU/16hrs)					Flyover/ Underpass Direction
		From North	From South	From East	From West	Total	
I-06	Intersection of NR1	6,760	5,548	18,169	11,921	42,398	E-W
I-07	Intersection of Rufisque Road	6,037	-	8,913	7,955	22,905	-

Note: Shaded cells indicate the main traffic directions for which the flyovers/underpasses are proposed as improvement alternatives.
Source: JICA Study Team.



Source: JICA Study Team.

Figure 13.2.2 Directional Traffic Volume at the Sub-project Locations

13.2.3 Signal Phasing Survey

Following a signal phasing survey, the cycle lengths of the traffic signals at the two intersections located at both ends of the access road to Baux Maraîchers bus terminal are summarized in Table 13.2.2. At the intersection of NR1, the average cycle length is six minutes or more, causing excessive travel time delay. A more detailed description of the signal phasing survey is presented in Appendix A, Section A.6.1.

Table 13.2.2 Average Cycle Length at the Sub-project Locations

Code	Location	Feature	Cycle Length (sec)			Flyover/Underpass Direction
			Morning (6:00-9:00)	Noon (11:00-14:00)	Evening (17:00-20:00)	
I-06	Intersection of NR1	Unsignalized	507	362	358	E-W
I-07	Intersection of Rufisque Road	Unsignalized	-	-	-	-

Note: At the unsignalized intersections, the average cycle lengths of the manual control of traffic by police officers are adopted; at I-07, the police officers were not present during the period of the survey.
Source: JICA Study Team.

13.2.4 Travel Speed Survey

The average travel speed around the sub-project locations in the morning hours (6:00-9:00), noon hours (11:00-14:00) and evening hours (17:00-19:00) are presented in Table 13.2.3. Further detail of the travel speed survey is described in Appendix A, Section A.6.1.

In general, the average travel speeds are considerably low in the area around the bus terminal,

particularly along the access road. This results in excessive time delay for vehicles entering and exiting the terminal and the through traffic.

Table 13.2.3 Average Travel Speed at the Sub-project Locations

Code	Location	Direction	Average Travel Speed (km/h)			Flyover/ Underpass Direction
			Morning Hours (6:00-9:00)	Noon Hours (11:00-14:00)	Evening Hours (17:00-20:00)	
I-06	Intersection of NR1	From North	19.3	10.2	9.9	E-W
		From East	16.7	12.4	16.4	
		From South	11.5	5.6	6.4	
		From West	13.2	11.4	16.2	
I-07	Intersection of Rufisque Road	From North	10.1	7.2	6.9	-
		From East	32.8	24.9	28.0	
		From West	28.9	20.9	22.7	
I-08	Access road	From North	10.1	7.2	6.9	-
		From South	11.5	5.6	6.4	

Source: JICA Study Team.

13.2.5 Traffic Queue Length Survey

Table 13.2.4 shows the average queue length at the two intersections located at both ends of the access road. The intersection of NR1 (I-06) is observed to have a long queue, especially for the South inflow (i.e., the access road) and the West inflow, where the distance of traffic queue is over 100 meters during the noon hours and evening hours. Further detail of the queue length survey is described in Appendix A, Section A.6.1.

Table 13.2.4 Average Queue Length at the Sub-project Locations

Code	Location	Inflow Direction	Average Traffic Queue Length (m)			Flyover/ Underpass Direction
			Morning Hours (6:00-9:00)	Noon Hours (11:00-14:00)	Evening Hours (17:00-20:00)	
I-06	Intersection of NR1	From North	67	96	91	E-W
		From East	76	97	78	
		From South	97	129	147	
		From West	90	122	155	
I-07	Intersection of Rufisque Road	From North	8	15	3	-
		From East	-	-	-	
		From West	-	-	-	

Note: Shaded cells indicate the average queue length longer than 100m.
Source: JICA Study Team.

13.2.6 Vehicle Count and Vehicle OD Survey at Baux Maraîchers Bus Terminal

Figure 13.2.3 reveals the directional traffic volume of vehicles entering and exiting the bus terminal over 17 hours from 5:00 to 22:00. Over 17 hours, there are 3,792 and 3,382 vehicles entering and leaving the bus terminal respectively through all entrances and exits.

The OD interview survey for vehicles leaving the bus terminal was simultaneously conducted at the two main exit gates, I-08-p1 and I-08-p2. This was done in order to establish the destinations that the vehicles are heading for and whether or not they use the motorway after leaving the bus terminal.

As shown in Figure 13.2.4, immediately after leaving the bus terminal's exits, 54% of the vehicles turned right towards the North, crossing a severely congested section of the access road to the intersection of NR1. Figure 13.2.5 adds that 21% of the exiting vehicles used the motorway for a section of their trip to their destinations. By grouping the vehicles' destinations into four large zones, Figure 13.2.6 indicates that the vehicles leaving the bus terminal are mainly Westbound and Eastbound, constituting 53% and 36% of the vehicles, respectively. A more detailed survey result can be found in

Appendix A, Section A.6.1.

Source: JICA Study Team.

Figure 13.2.3 Directional Traffic Volume of Vehicles Using the Bus Terminal

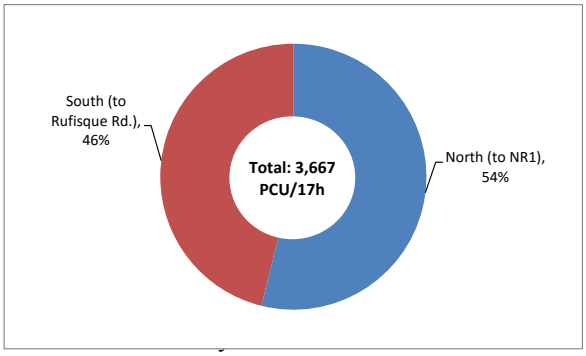


Figure 13.2.4 Share of Vehicle by Turning Direction

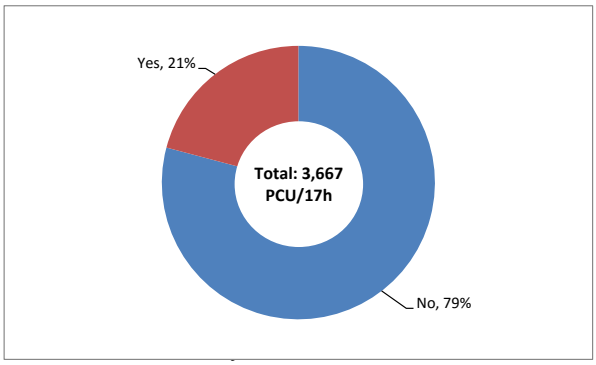
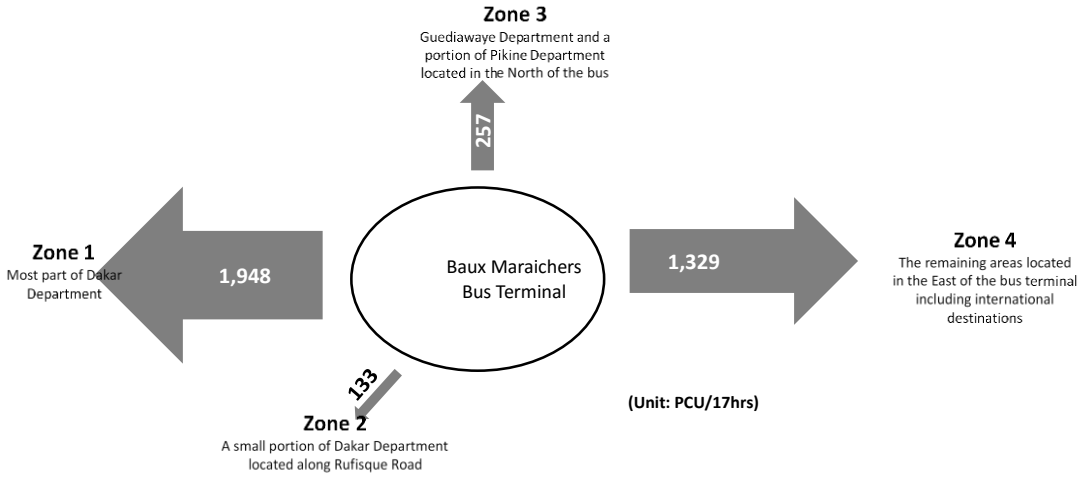


Figure 13.2.5 Share of Vehicle by Motorway Usage



Source: JICA Study Team.

Figure 13.2.6 Distribution by Destination of Vehicles Leaving the Bus Terminal

13.2.7 Summary of Issues

Based on the results of the traffic surveys conducted in the target area, Table 13.2.5 summarizes the

major traffic related issues that need to be tackled.

Table 13.2.5 Summary of the Traffic Related Issues

Location	Major Issues
Intersection of NR1	- High traffic volumes from the East and West inflows cause severe traffic congestion, resulting in low travel speed and long waiting queues on all of the approach roads. - Based on Figure 13.2.3 and Figure 13.2.4, the majority of vehicles from/to the terminal crossed this intersection. Therefore, it is necessary to immediately introduce proper congestion relief measures in order to save the important function of the terminal.
Intersection of Rufisque Road	- Traffic congestion was not observed at this intersection during the survey. - Nonetheless, the appropriate improvement of this intersection should not be neglected to ensure that it does not become a bottleneck in the future.
Access road	- While the spillback of waiting traffic queue on the South inflow of the intersection of NR1 indicates the occurrence of traffic congestion on the access road (see Table 13.2.4), the business activities of street vendors that occupy not only both of the sidewalks but also, some portion of the access road, significantly aggravate the road level of service, bringing the average travel speed to approximately 10km/h or lower (Table 13.2.3). - Improvement measures to increase the level of service of the access road are required.
Bus terminal	- The terminal currently has several entrances and exits. However, only one entrance, which serves the intercity buses/taxies, is located in the East side of the terminal along Rufisque Road. Other entrances and exits are located in the West side of the terminal on the already congested access road (Figure 13.2.3). - Under heavy traffic congestions at the intersection of NR1 and on the access road as described above, it is important to consider an alternate accesses to/from the terminal that enable vehicles to avoid the intersection of NR1 and the access road to reduce passengers' travel time. The possible alternatives that should be studied include: (i) improvement of access through PTB station entrance, such as the construction of a bus stop or parking facilities; and (ii) a direct motorway interchange to/from the terminal.

Source: JICA Study Team.

13.3 Proposed Alternatives for Improvement

To tackle the issues identified from the above-mentioned traffic surveys, a number of improvement alternatives or sub-projects to solve the present and anticipated future problems were proposed, as Table 13.3.1. This table also indicates the reference figure numbers for their respective designs that are presented later in Section 13.5. Based on these alternatives, the necessary analyses were conducted, as shown in the subsequent sections of this chapter.

The fundamental bases for proposing the alternatives for individual sub-project are summarized as follows.

(1) Improvement at the Intersection of NR1

The high traffic volumes from the East and West inflows cause severe traffic congestion, resulting in low travel speed and long waiting queues on all of the approach roads. It is observed that traffic congestion around this intersection significantly worsens the function of Baux Maraîchers bus terminal because the majority of vehicles to/from the terminal pass by this intersection (Figure 13.2.3 and Figure 13.2.4).

Considering the high traffic inflows from the East and West, which is the direction of NR1, two grade separation alternatives, i.e., the flyover and underpass, were proposed for this direction, as shown in Table 13.3.1. In addition, a traffic signal was also considered as an at-grade improvement alternative because the area is currently unsignalized. The U-turn lane is not taken into account because there are roundabouts located in a short distance both in the East and West of the intersection on NR1.

(2) Improvement at the Intersection of Rufisque Road

The access road connects Rufisque Road at an unsignalized T-junction. Traffic congestion was not observed at this intersection during the traffic survey. Nonetheless, the appropriate improvement of this intersection should not be neglected to ensure that a bottleneck at this intersection does not occur in the future.

A simple and low cost at-grade improvement, such as the preparation of a left-turn lane, road marking and road widening for a portion of the approach roads, are proposed for this intersection. The design of this improvement alternative is described in Section 13.5.

(3) Improvement of Access through PTB Station Entrance

The terminal currently has several entrances and exits. However, only one entrance, which serves the intercity buses/taxies, is located in the East side of the terminal along Rufisque Road. Other entrances and exits are located in the West side of the terminal on the access road, which is already congested (Figure 13.2.3).

Considering the heavy traffic congestions at the intersection of NR1 and on the access road, it is worth providing alternate accesses to/from the terminal that enable vehicles to avoid the intersection of NR1 and the access road. Taking advantage of the existing PTB station entrance and its surrounding available land, the constructions of bus stops and parking lots are expected to benefit some of the AFTU buses and taxis that are currently coming through the intersection of Rufisque Road and entering the bus terminal through entrance I-08-p3 (Figure 13.2.3). Among these vehicles, those coming from the West on Rufisque Road will be able to avoid the heavy congestion on the access road, which will save them time. Meanwhile, those coming from the East on the same road will be able to shorten their travel distance in addition to saving time.

The design of this improvement alternative is described in Section 13.5.

(4) Improvement of the Access Road

The access road is a two-lane two-way road, where street vendors occupy the sidewalks and a portion of its ROW. These street vendors aggravate the congestion that hinders both ordinary vehicles and buses.

Four improvement alternatives for the access road were proposed, as shown in Table 13.3.1. The alternatives I-08a, I-08b and I-08c are all about road widening from two lanes to four lanes. Section 13.5 discusses why and how these three alternatives were derived.

The alternative I-08d is a soft measure, aimed at introducing one-way traffic control in the Southbound direction. This is expected to increase the travel speed on the access road.

(5) Direct Motorway Interchange to/from the Terminal

This sub-project aims to provide dedicated access to/from the motorway so as to avoid the congestion on the access road and at the intersection of NR1, as mentioned above.

- For the direct motorway on-ramp, two (2) alternatives are proposed. Alternative I-09(1)a, which is located at the North side of the bus terminal, is an at-grade structure. Meanwhile, alternative I-09(1)b, which is located in the South side of the bus terminal, involves the construction of bridge structures crossing a portion of private land before merging with the motorway. The designs of the two alternatives of direct motorway on-ramp are presented in Section 13.5.

- For the direct motorway off-ramp, only one alternative is proposed. A discussion as to why and how the alternative was derived is also described in Section 13.5.

Table 13.3.1 Proposed Alternatives for Improvements

Alternatives / Sub-projects			Reference Figures
I-06a	A flyover at the intersection of NR1	Intersection of NR1	Figure 13.5.1
I-06b	An underpass at the intersection of NR1		
I-06c	Installation of traffic signals at the intersection of NR1		-
I-07(1)	Improvement at the intersection of Rufisque Road	Intersection of Rufisque Road	Figure 13.5.4
I-07(2)	Improvement of access through PTB station entrance	Along Rufisque Road near PTB station	Figure 13.5.5
I-08a	Widening of the access road to four lanes (reconstruction of the bridge)	Access road	Figure 13.5.6
I-08b	Widening of the access road to four lanes (both sides of the bridge)		
I-08c	Widening of the access road to four lanes (One side of the Bridge)		
I-08d	One-way traffic control on the access road		-
I-09(1)a	Direct motorway on-ramp from the terminal (Option 1 – North)	Direct motorway ramps	Figure 13.5.7
I-09(1)b	Direct motorway on-ramp from the terminal (Option 2 – South)		
I-09(2)	Direct motorway off-ramp to the terminal		Figure 13.5.8

Source: JICA Study Team.

13.4 Future Traffic Analysis

13.4.1 Travel Demand Forecast

The traffic demand forecast for the sub-project locations was conducted based on the results of the traffic survey presented in Section 13.2 and the demand forecasting model, which was developed in the latest study by CETUD on the BRT project in Dakar. Depending on the sub-project, the necessary adjustments were made, taking into consideration the socioeconomic framework (population and GRDP) and the car-ownership estimated by the JICA Study Team in the present project. Table 13.4.1 shows the forecasted traffic volume for the relevant sub-projects.

Table 13.4.1 Traffic Demand Forecast at the Sub-project Locations

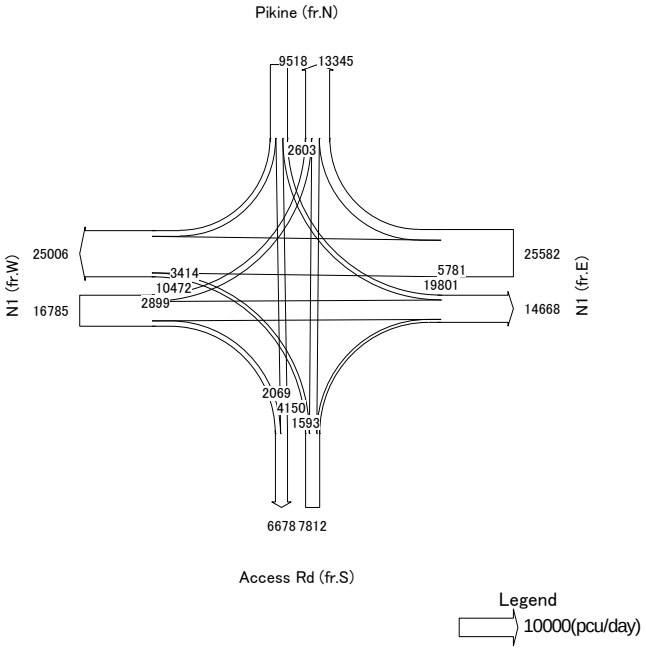
Code	Location	Daily Traffic Volume (PCU)			Growth 2025/2015	Growth 2035/2015	Flyover/ Underpass Direction
		2015 Existing	2025 Forecast	2035 Forecast			
I-06	Intersection of NR1	47,592	71,928	120,229	1.51	2.53	E-W
I-07	Intersection of Rufisque Road	23,038	42,474	70,810	1.84	3.07	-
I-08	Access road	14,277	24,716	40,333	1.73	2.83	-
I-09	Vehicles using the motorway	994	2,014	3,263	2.03	3.28	-

Source: JICA Study Team.

13.4.2 Traffic Analysis of the Sub-Projects

(1) Improvement at the Intersection of NR1 [I-06]

Figure 13.4.1 shows that the main traffic flow directions are the through traffics Eastbound and Westbound. During the directional traffic count survey, police officers banned the left-turn of the East inflow traffic. Traffic congestion around this intersection significantly weakens the function of Baux Maraîchers bus terminal as a regional hub.



Source: JICA Study Team.

Figure 13.4.1 Existing Directional Traffic Volume at Intersection of NR1

Possible improvement alternatives for this sub-project location are presented in Table 13.4.2. The grade separation alternatives I-06a and I-06b are respectively a flyover and an underpass, and the at-grade alternative I-06c is the installation of traffic signals.

The analysis result shown in Table 13.4.3 suggests that the installation of the traffic signal alone is not capable of solving the traffic congestion, even under the current traffic demand. This is because the degree of saturation is estimated to be 1.03. Additional measures, such as widening the approach road sections, specifically that of the NR1, are required to increase the intersection capacity to accommodate the excessive traffic volume on the approach roads, which are the East and West inflows. In addition, in the long-term, the construction of a grade separated intersection is a better alternative, as it is expected to not only improve the smooth traffic flow on NR1 but also, the functionality of Baux Maraîchers bus terminal.

In short, from the viewpoint of a traffic analysis, a grade separation structure is recommended for this intersection, as it is expected to significantly improve the function of the bus terminal.

Table 13.4.2 Improvement Alternatives for the Intersection of NR1

Alternatives for Improvement		Traffic Analysis
I-06a	A flyover at the intersection of NR1	√
I-06b	An underpass at the intersection of NR1	
I-06c	Installation of traffic signals at the intersection of NR1	√

Source: JICA Study Team.

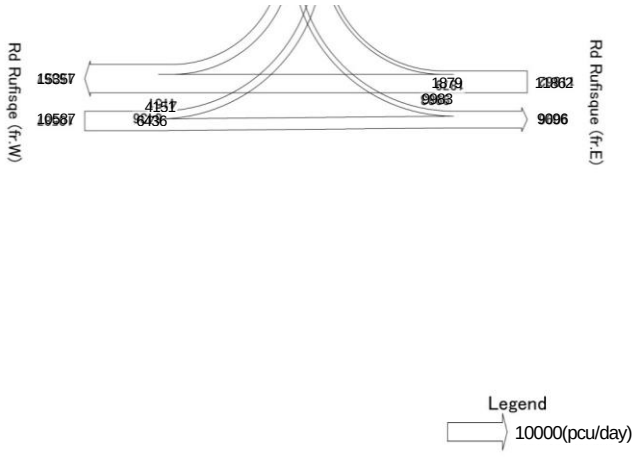
Table 13.4.3 Results of the Traffic Analysis for Improvement Alternatives at the Intersection of NR1

Year	Indicators	Improvement Alternatives		
		Existing	I-06a/I-06b	I-06c
2015	Degree of saturation	2.15	-	1.03
	Queue length (m)	363	-	242
2025	Degree of saturation	-	0.99	-
	Queue length (m)	-	146	-
2035	Degree of Saturation	-	1.76	-
	Queue length (m)	-	251	-

Source: JICA Study Team.

(2) Improvement at the Intersection of Rufisque Road [I-07(1)]

While through traffics Eastbound and Westbound constitute the main traffic flow direction, as shown in Figure 13.4.2, the traffic volume on the North approach road is also relatively high. At this sub-project location, the congestion is not often observed. Nonetheless, appropriate improvement of this intersection should not be neglected to ensure that bottleneck at this intersection does not occur in the future.



Source: JICA Study Team.

Figure 13.4.2 Existing Directional Traffic Volume at the Intersection of Rufisque Road

Only at-grade improvement, i.e., channelization, as shown in Figure 13.5.4, which involves the preparation of a left-turn lane, road marking and road widening for a portion of the approach roads, is proposed for this sub-project location. According to Table 13.4.4, this improvement alternative is expected to be suitable to this sub-project location until 2025.

For this reason, the at-grade improvement alternative that is discussed herein is recommended for the improvement at the intersection of Rufisque, in view of avoiding bottleneck that possibly hinders the function of the terminal.

Table 13.4.4 Results of the Traffic Analysis for the Improvement at the Intersection of Rufisque Road

Year	Indicators	Improvement Alternatives	
		Existing	I-07(1)
2015	Degree of saturation	0.78	-
	Queue length (m)	54	-
2025	Degree of saturation	-	1.01
	Queue length (m)	-	115
2035	Degree of saturation	-	1.77
	Queue length (m)	-	214

Source: JICA Study Team.

(3) Improvement of Access through PTB Station Entrance [I-07(2)]

This improvement alternative involves the provisions of bus stops or bays and parking lots at the entrance of PTB, as illustrated in Figure 13.5.5. This alternative is expected to benefit some of the

AFTU buses and taxis that are currently coming through the intersection of Rufisque Road and entering the bus terminal through entrance I-08-p3 (see Figure 13.2.3). Among these vehicles, those coming from the West on Rufisque Road will be able to avoid the heavy congestion on the access road, which means saving time. Meanwhile, those coming from the East on the same road will be able to shorten their travel distance, in addition to saving time. The change in the total travel time and cost by the aforementioned vehicles is used in the calculation of EIRR.

In fact, there are other benefits resulting from the improvement access through PTB station entrance that were not quantified in this study due to the limitation of the necessary data. For instance, this alternative is expected to save time for public transport users who need to transfer between buses and trains. Although the data were not available, it was observed during a site investigation that the existing PTB users and volume of transfer passenger between PTB and the bus are considerably small. By providing bus stop and parking facilities at the PTB station entrance, some buses, particularly the AFTU, and some taxis that currently access the terminal through I-08-p2 and I-08-p3 (as in Figure 13.1.3) can be re-routed/relocated to this new facility. This results in a shorter walking distance to the PTB station and reduced travel time as the buses and the taxis are not caught in traffic congestion along the access road. This contributes to the improvement of the transfer between PTB and buses. Moreover, a TER Dakar – AIBD planned by APIX, a Senegalese government agency for investment promotion and major projects, will operate through the PTB station. Therefore, the number of transfer passengers is expected to increase.

To sum up, this sub-project is recommended as it contributes to improving the access to/from the terminal and the transfer between buses and trains.

(4) Improvement of the Access Road [I-08]

Four improvement alternatives for the access road are described in Table 13.4.5. The alternatives I-08a, I-08b and I-08c are all about road widening but the differences lie in the treatment of the existing two-lane bridge, which is located in the middle section of the access road crossing over the motorway. Alternative I-08a refers to the case where the existing bridge is completely replaced by a new four-lane bridge. Alternative I-08b refers to the case where the existing bridge is kept, while expansion is made on both of its sides to make it a four-lane bridge. Alternative I-08c is similar to I-08b but the expansion is only made on the East side of the existing bridge. Figure 3.4.5 illustrates the outline drawings of the three alternatives I-08a, I-08b and I-08c. From a traffic flow viewpoint, vehicles using the access road are seen to equally benefit from any of the three alternatives of the road widening as their travel speed increases. However, the construction of these alternatives requires different techniques, which result in different costs. The estimated cost, which is shown later in Section 13.7.3, indicates that alternative I-08c is the cheapest option.

Alternative I-08d aims to introduce one-way traffic control in the Southbound direction, which is expected to considerably increase the travel speed. Under the current conditions, the Northbound traffic must make a detour but the available detour routes are of a long distance. It is estimated that only a small amount of travel time is saved against a drastic increase in the travel distance of the detoured vehicles. Therefore, alternative I-08d is inefficient and not economically viable, as shown later in Section 13.9.

Therefore, I-08c is recommended as it contributes to improving the service level of the access road and the function of the terminal. It also requires a relatively lower cost.

Table 13.4.5 Improvement Alternatives for the Access Road

Alternatives for Improvement	
I-08a	Widening of the access road to four lanes (reconstruction of the bridge)
I-08b	Widening of the access road to four lanes (both sides of the bridge)
I-08c	Widening of the access road to four lanes (one side of the bridge)
I-08d	One-way traffic control on the access road

Source: JICA Study Team.

(5) Direct Motorway On-ramp from the Terminal [I-09(1)]

The design shown in Figure 13.5.7 reveals that the direct motorway on-ramp is for intercity and international transport vehicles currently leaving the terminal through the exit I-08-p1 (see Figure 13.2.3). The vehicle OD interview conducted at I-08-p1 and I-08-p2 shows that the share of motorway usage is around 21% (i.e. around 770 vehicles per day). Out of this number, 497 vehicles are the intercity and international transport vehicles that depart from the terminal though the exit I-08-p1 alone. By providing the direct motorway on-ramp, the travel time that they currently spend from the terminal to the interchange can be saved.

Two alternatives for direct motorway on-ramp were studied, as shown in Table 13.4.6. The outline drawing of the motorway on-ramp is shown in Figure 13.5.7. Alternative I-09(1)a, which is located at the North side of the bus terminal, is an at-grade structure. It has a short distance as it directly connects the existing exit to the adjacent motorway. Another alternative, I-09(1)b, is located in the South side of the bus terminal, with a longer distance. This involves the construction of bridge structures and crosses a portion of private land before merging with the motorway. This results in a high cost, making it inferior to alternative I-09(1)a.

In conclusion, I-09(1)a is recommended as it contributes to the improvement of the terminal and requires a relatively lower cost.

Table 13.4.6 Alternatives for Direct Motorway On-ramp

Alternatives for Improvement	
I-09(1)a	Direct motorway on-ramp from the terminal (Option 1 – North)
I-09(1)b	Direct motorway on-ramp from the terminal (Option 2 – South)

Source: JICA Study Team.

(6) Direct Motorway Off-ramp to the Terminal [I-09(2)]

Similar to the on-ramp above, the off-ramp in Figure 13.5.8 is also designed for intercity and international transport vehicles. Assuming that the vehicles using the motorway after leaving the terminal also use it for the trip coming to the terminal, there are currently 497 vehicles per day. The travel time of these vehicles from the interchange to the terminal significantly reduces when a direct motorway off-ramp is provided.

Only one alternative for the direct motorway off-ramp is proposed, as indicated in Section 13.5. The structure design of the off-ramp is presented in Figure 13.5.8.

13.5 Road and Structure Design Alternatives for Improvements

The sub-projects and proposed corresponding alternatives involve the construction of grade separation structures, at-grade structures and soft measures to improve the traffic conditions around Baux Maraîchers bus terminal. Before comparing these alternatives, this section provides an insight into the technical issues of the structural design of each of the sub-projects and alternatives.

Table 13.5.1 summarizes the comparison of the alternatives that are proposed for each sub-project. The

geometric design criteria were based on the "Japanese Road Design Standard", as shown in Chapter 12, Table 12.4.3.

(1) Intersection of NR1 (I-06)

1) Grade Separation Alternatives (I-06a and I-06b)

A grade separation structure is considered in order to improve the operational function of the terminal. Based on the traffic survey, the traffic volume at this intersection is dominated by excessive inflows from the East and West. The left-turn of vehicles from the East was forbidden by police officers. The unclear shape of the intersection (lane configuration, marking, etc.) and the type of traffic control (manual control by police officers) were observed to affect the capacity of the intersection. Therefore, this alternative aims to eliminate the congestion of the intersection by providing a grade separation structure in the East-West direction.

The design criteria include the design speed V=40km/h and the lane composition two lanes x two directions for the main structure and one lane for each ramp.

For the planning of the grade separation structure, it is necessary to avoid the impact on private land and property. Therefore, it is necessary to design the structure within the ROW of NR1, which has the road width W=30m and four lanes. There is unused land available outside of the carriageway, which is possible to be used for the grade separation.

Therefore, the grade separation structure is designed with 3.6m x two lanes = 7.2m per direction (without shoulder) and one left-turn lane for the ramp at the intersection.

The control point is the distance of the weaving section between the existing motorway ramp and the intersection under study. As a result, 40km/h of the design speed and 7% of the maximum longitudinal gradient are applied.

For the grade separation structure, a flyover (I-06a) and a box-type underpass (I-06b) are considered. From the design criteria viewpoint, the flyover and underpass are almost similar because the existing road level is flat. However, the underpass needs pump facilities for drainage. Therefore, the underpass construction cost is higher. Road drainage is not a problem because the drainage channel underneath the existing sidewalk can be used.

An outline drawing of I-06a and I-06b is shown in Figure 13.5.1.

2) At-grade Alternative (I-06c)

This alternative aims to reduce traffic congestion and improve the traffic safety of the intersection by installing a traffic signal (I-06c), considering the revision of lane configuration and the reduction of traffic conflict points.

The setting of lane by traffic direction, the shorter distance between stop lines and the compact intersection area with installation of traffic signal enable this alternative to improve traffic safety and traffic capacity at the intersection. Moreover, it is possible to allow the left-turn of the East inflow, which is currently forbidden during most times of the day.

An outline drawing of I-06c is shown in Figure 13.5.3.

(2) Intersection of Rufisque Road (I-07(1))

This intersection was studied as an at-grade intersection. There is a level crossing with the railway (the current PTB frequency is 14 trains/day) near the intersection. However, there is a concern that an

at-grade intersection might become a problem, depending on the frequency of train operations in the future. The installation of a left-turn lane and road marking to widen the road with four lanes has been planned for this intersection. The planned access road has a design speed of V=50km/h, with two lanes in each direction, plus a left-turn lane. In the future, depending on the traffic volume, the left-turn lane will need to be reviewed.

Figure 13.5.4 illustrates the outline drawing of the improvement at the intersection of Rufisque Road (alternative I-07(1)).

(3) Improvement of Access through PTB Station Entrance (I-07(2))

Baux Maraîchers bus terminal has several entrances and exits. Except the only entrance, which is located in the East side of the terminal along Rufisque Road, the other entrances and exits are located in the West side of the terminal on the congested access road (see Figure 13.1.3). Taking advantage of the available land near the existing PTB station entrance, constructions of a bus stop and parking facilities are expected to reduce the traffic concentration on the access road at a certain level if some buses, particularly the AFTU, and some taxis that are currently getting in and out the terminal through I-08-p2 and I-08-p3 (as in Figure 13.1.3) are re-routed/relocated to the new facilities.

A parking lot for passengers to/from the PTB station and the bus terminal whose modes of access/egress are car or taxi, bus stops or bays for buses serving Rufisque Road (currently using the road side as bus stop), including the abovementioned re-routed/relocated buses, and the improvement of the sidewalk were studied. A parking lot plan has been planned to use the empty land area (~200m) between Rufisque Road and the railway. Then, a 30-meter wide area between the train station and the bus stop was reserved to be used as a plaza and the bus stop length was considered in order to accommodate 2~3 buses stopped in a line. The proposed number of bus stops or bays at this stage of study was not based on any estimated passenger demand and required operating headway, but it was assumed, taking into consideration the available land near the PTB station entrance and its function as a departure/arrival terminal. Generally, a bus from a particular bus line spends longer time at the departure bay than at a bus stop. Therefore, at least 2~3 bus bays is necessary at a terminal to accommodate the buses of other bus lines.

An outline drawing of the improvement of access through PTB station entrance, which includes all of the facilities mentioned above, is shown in Figure 13.5.5.

Table 13.5.1 Comparison of Alternatives

		I-06 Intersection of NR1			I-07(1) Improvement at the Intersection of Rufisque Road	I-07(2) Improvement of Access through PTB Station Entrance
		Grade Separation		Traffic Signal		
		Flyover	Underpass			
ID		I-06a	I-06b	I-06c	I-07(1)	I-07(2)
Outline of Planning		Congestion is severe at this intersection. Based on the traffic survey, the traffic volume at this intersection is dominated by excessive inflows from the East and from West. The left-turn of vehicles from the East was forbidden by police officers. The unclear shape of the intersection (lane configuration, marking, etc.) and type of traffic control (manual control by police officers) were observed to affect the capacity of the intersection. Therefore, this alternative aims to eliminate the congestion of the intersection by providing a grade separation structure in the East-West direction. The control point is the distance of the weaving section between the existing motorway ramp and the intersection under study.		Congestion is severe at this intersection. Based on the traffic survey, the traffic volume at this intersection is dominated by excessive inflows from the East and from West. The left-turn of vehicles from the East was forbidden by police officers. The unclear shape of the intersection (lane configuration, marking, etc.) and type of traffic control (manual control by police officers) were observed to affect the capacity of the intersection. This alternative aims to reduce traffic congestion and improve the traffic safety of the intersection by installing a traffic signal (I-06c), considering the revision of lane configuration and the reduction of traffic conflict points. This alternative also enables the left-turn of East inflow, which is currently prohibited during most times of the day.	This alternative aims to improve the traffic capacity and traffic safety of the intersection by the following method. - Install curbstone between the carriageway and sidewalk to enhance the unclear existing intersection sharp. - Solve the visibility of drivers by installing road marking and a left-turn lane.	In this alternative, a parking lot and bus stop are planned to promote transfer between private cars, buses and railway, which is expected to increase in service frequency in the future. The bus stop location was decided considering the existing pedestrian bridge, and the parking lot was placed besides it. The bus stop is planned to enable 2-3 buses stop in line.
Design Speed		V=40km/h		V=50km/h	V=50km/h	-
Number of Lanes		Grade separation two-lane x 2 Ramp one-lane x 2		Two-direction, four-lane + left-turn lane	Two-direction, four-lane Two-direction, two-lane + left-turn lane	-
Design Criteria	Minimum Radius	1200m		Straight line.	Straight line.	-
	Maximum Grade	7%		Level	Level	-
	Other	-	-	-	-	-
Length of Structure	Bridge	75m	-	-	-	-
	Box Culvert	-	75m	-	-	-
	Retaining Wall	325m	325m	-	-	-
Facility of Drainage		The existing drainage parallel to the side walk can be used.	Pump facilities for road drainage are required. The land beside the intersection can be used for installing the pumping station facilities, but the water flow terminal needs to be investigated.	The existing drainage parallel to the sidewalk can be used.	Not required.	Not required.
ROW	Compensation	Necessary compensation for the corner cut of the intersection. Number of compensation: two houses.		Planning within the ROW is possible.	Planning within the ROW is possible.	There is a simple building in the parking lot. Therefore, compensation for the relocation of this building is required.
	Land Acquisition	Necessary land acquisition for the corner cut.		No land acquisition.	No land acquisition.	Coordination with the owners of the land between the railway track and Rufisque road regarding the change of land use is required.
Judgment of the Plan		The control point is the distance of the weaving section from the existing motorway ramp. This plan adopts longitudinal gradient 7% and design speed 40km/h. Regardless of the above criteria, there is concern over the traffic operation of two-lanes of the main structure + two-lane of ramp as the distance is only 110m.		Sidewalk around the intersection and inside of ROW has been used for the material storage of roadside shops. Therefore, it is necessary to prohibit this type of usage to ensure sufficient sight distance and the safety of pedestrians.	This improves the traffic safety and capacity at the intersection. Traffic safety at railway crossing on the North side of should be taken into consideration.	The area of parking lot (number of parking vehicle) varies by possibility of land acquisition.
Relation to Other Facilities		There is no problem.		There is no problem.	Coordination between the intersection operation and railway crossing is required.	There is no problem.
Traffic Operations		Existing traffic volume: 42,398 PCU/16hrs Grade separation is necessary to cope with the congestion, as at-grade improvement is not a solution. Even with the grade separation, the degree of saturation will become 1.0 in 2025 and 1.76 in 2035 because the number of		Existing traffic volume: 42,398 PCU/16hrs The current degree of saturation is 2.1, and with installation of traffic signal, the degree of saturation remains 1.0. This means that it cannot solve the traffic congestion even under the existing traffic volume.	Existing traffic volume: 22,905 PCU/16hrs There is no concern over traffic congestion at this intersection (degree of saturation 0.78). However, the current intersection geometry, for instance, unclear marking, poses safety concern.	Existing traffic volume: 22,905 PCU/16hrszx It is observed that one bus is sufficient for the current passenger demand at this bus stop. However, three bus bays are planned, considering the expected increase in demand for railway and bus in the

	lanes is planned within the existing ROW. Therefore, it is necessary to consider the land acquisition in the future for road widening with the additional lane on the approach roads of the intersection.			However, the degree of saturation will become 1.0 in 2025 and 1.77 in 2035. Therefore, the future widening to four-lane with an additional lane at the intersection are needed.	future. Regarding the number of parking, parking spaces can accommodate 130 cars using the existing remnant land.
Workability	This requires large-scale traffic control during the construction.		This requires large-scale traffic control during the construction.	This requires large-scale traffic control during the construction	There is no particular problem.
Economy	This is superior to the underpass in economic efficiency.	The installation and maintenance of the drainage facilities (pumping stations) is required.	This is the lowest cost alternative compared with the flyover and underpass.	The construction cost is low; it is preferable in economic efficiency.	The construction cost is low; it is preferable in economic efficiency.
Cost (Million FCFA)	10,141	21,880	354	371	295
Evaluation	Good	Fair	Fair	Good*	Good*

Note: Shaded cells indicate that the alternatives are superior to others with regard to the attributes being compared; "*" indicates single alternative for the sub-project and shading of the cells is not made.
Source: JICA Study Team.

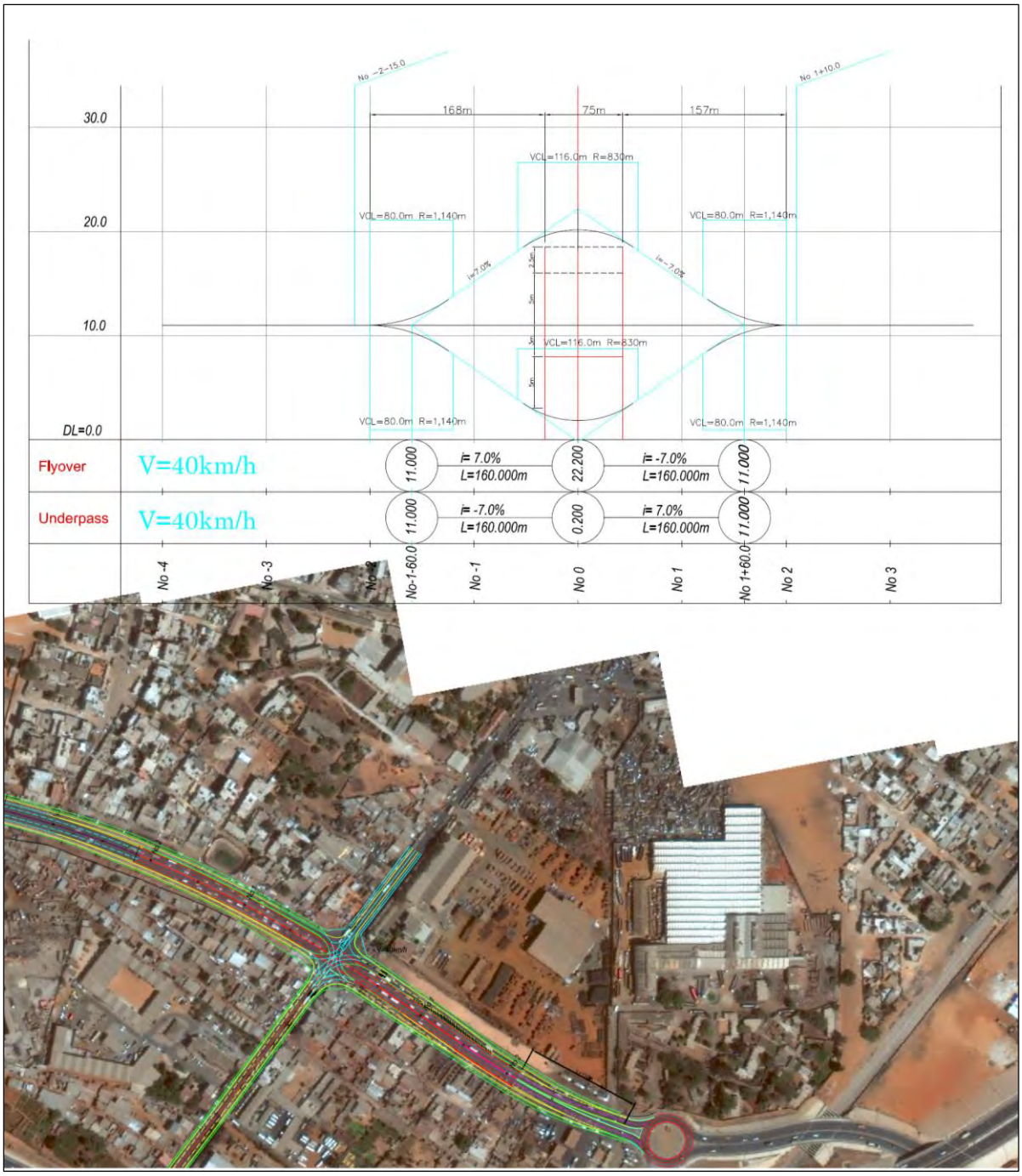
Table 13.5.1 Comparison of Alternatives (Continued)

		I-08 Improvement of the Access Road				I-09(1) Direct Motorway On-ramp from the Terminal		I-09(2) Direct Motorway Off-ramp to the Terminal
		Widening to Four Lanes			One-way Traffic Control			
		Reconstruction of the Bridge	Both Sides of the Bridge	One Side of the Bridge		(Option 1 – North)	Option 2 – South)	
ID		I-08a	I-08b	I-08c	I-08d	I-09(1)a	I-09(1)b	I-09(2)
Outline of Planning		In this alternative, the existing two-lane bridge is fully replaced by a new four-lane bridge. It requires a detour road and bridge during the construction period. Therefore, compensation is needed as leasehold and rebuilding is required.	Widening to four-lane in this alternative is as follows. - Remove both sidewalks of the existing bridge; - Widen the carriageway; - Construct new one-lane bridges on each side of the existing bridge. The new bridge can be constructed under the current traffic operation, considering traffic safety in spite of the removal of the sidewalk on the existing bridge.	Widening to four-lane in this alternative is as follows. - Remove one sidewalk of the existing bridge (East side); - Widen the carriageway and improve to two-lane per direction; - Construct a new bridge (two-lane + one side sidewalk) on the East side of the existing bridge. The new bridge can be constructed under the same traffic operation of the current situation and without removal work of the existing bridge.	This alternative changes the traffic operation from two-lane two-direction to two-lane one-direction. The intersection of NR1 is oversaturated and the queue spill back on the access road. To avoid traffic congestion, one-way traffic control is introduced for the access road.	A connection between the terminal and motorway is made via NR1 and the access road, which are always congested, causing inconvenience for users. Therefore, this alternative is planned to connect to the motorway by a direct on-ramp from the terminal. This alternative is planned by using the land in the North of the terminal.	A connection between the terminal and motorway is made via NR1 and the access road, which are always congested, causing inconvenience for users. Therefore, this alternative is planned to connect to the motorway by a direct on-ramp from the terminal. This alternative is planned using the stretch of land between the bus terminal and railway in the South of the terminal connecting to the motorway passing under the existing elevated access to the terminal and crossing over the railway.	A connection between the terminal and motorway is made via NR1 and the access road, which are always congested, causing inconvenience for users. Therefore, this alternative is planned to connect from the motorway by a direct off-ramp to the terminal. This alternative enables direct access to the existing arrival gate of the bus terminal.
Design Speed		V=40km/h	V=40km/h	V=40km/h	V=40km/h	V=40km/h	V=50km/h	V=40km/h
Number of Lanes		Two-direction, four-lane	Two-direction, four-lane	Two-direction, four-lane	One-direction, two-lane	Ramp one-lane	Ramp one-lane	Ramp one-lane
Design Criteria	Minimum Radius	200m	200m	200m	200m	100m	100m	100m
	Maximum Grade	7% (Current state)	7% (Current state)	7% (Current state)	7% (Current state)	0.3%	4%	8%
	Other	-	-	-	-	-	-	-
Length of Structure	Bridge	80m	80m	80m	-	-	89.3m	479.6m
	Box Culvert	-	-	-	-			
	Retaining Wall	140m	140m	140m	-	-	220m	397.9m
Facility of Drainage		Not required.	Not required.	Not required.	Not required.	Not required.	Not required.	Not required.
ROW	Compensation	Planning within the ROW is possible.	Land is required on both sides of road. Therefore, compensation for 11 properties is	Land is required on the East side of road. Therefore, compensation for three	Planning within the ROW is possible.	There is no problem.	There is no problem.	There is no problem.

			required.	properties is required.				
	Land Acquisition	Leased land for detour road (temporary bridge) is required during the construction.	Land widening is required by the construction method of the bridge section and its related structures.	Land widening is required by the construction method of the bridge section and its related structures.	No land acquisition.	No land acquisition.	The scrutiny of the railway land boundary could not be done. Therefore, coordination with the railway administration in the future is required.	There is private land between the bus terminal and the motorway. Therefore, coordination with the landowner is required.
Judgment of the Plan		There is no problem for the road structure for the re-erection of the bridge. The public awareness on ROW use is required.	With the widening plan to four lanes, traffic safety needs to be ensured. As the plan requires widening on both sides, land acquisition and compensation are necessary. The public awareness on ROW use is required.	With the widening plan to four lanes, traffic safety needs to be ensured. Land acquisition and compensation is required for the affected properties in the Northeast of the terminal. The public awareness on ROW use is required.	Some pedestrians and other commercial activities take place inside the ROW. Therefore, traffic safety is a concern. It is important to provide a proper sidewalk.	Installation of the destination guide board in front of the gate is required because the distance between the nose point and existing terminal exit is short.	The re-arrangement of the traffic direction inside the terminal is needed to enable all vehicles to access the planned on-ramp.	A long bridge is needed to cross over the motorway, other roads and railway because of the limited space for the construction. As a result, the construction cost becomes very high.
Relation to other Facilities		Coordination between the relevant agencies is required when the bridge crossing over the motorway is re-erected.	Coordination between the relevant agencies is required when the bridge crossing over the motorway is re-erected.	Coordination between the relevant agencies is required when the bridge crossing over the motorway is re-erected.	There is no problem.	The relocation of the existing drainage facilities is required. These drainage facilities will be use as a water flow terminal.	Regarding the crossing of the railway and the land, consultation and coordination with the relevant organizations is required.	Regarding the crossing of the railway and the land, consultation and coordination with the relevant organizations is required.
Traffic Operations		Existing traffic vol.: 12,191 PCU/16hrs Widening to four lanes is required because the current capacity is not sufficient.	Existing traffic vol.: 12,191 PCU/16hrs Widening to four lanes is required because the current capacity is not sufficient.	Existing traffic vol.: 12,191 PCU/16hrs Widening to four lanes is required because the current capacity is not sufficient.	Existing traffic vol.: 12,191 PCU/16hrs With the drastic increase of the travel distance because of the long detour against the little travel time saved, this alternative is inefficient and not economically viable.	-	-	-
Workability		It is necessary to have a large-scale traffic control on the motorway. This plan is the largest scale construction work among the alternatives.	It is necessary to have a traffic control of motorway. This plan is the most difficult construction work among the alternatives.	It is necessary to have traffic control of motorway. This plan is the smaller in scale of construction work, compared to alternatives I-08a and I-08b.	There is no particular problem. It is the simplest construction work among the alternatives.	There is no large-scale structure. Therefore, the construction work is simple.	It is large-scale construction work of a long viaduct, and it is also necessary to have the traffic control of the motorway and bus terminal.	It is large-scale construction work of a long viaduct, and it is also necessary to have the traffic control of the motorway and bus terminal.
Economy		This plan is inferior to the other alternatives, as it requires the highest cost.	It is more expensive than the alternative I-08c.	This plan has the lowest cost among the widening alternatives.	As construction cost is low, it is excellent in economic efficiency.	It is excellent in economic efficiency.	It is very expensive compared to I-09(1)a.	It is expensive because the elevated structure is large.
Cost (Million FCFA)		15,116	5,476	4,586	31	361	4,470	1,406
Evaluation		Poor	Fair	Good	Poor	Good	Poor	Good*

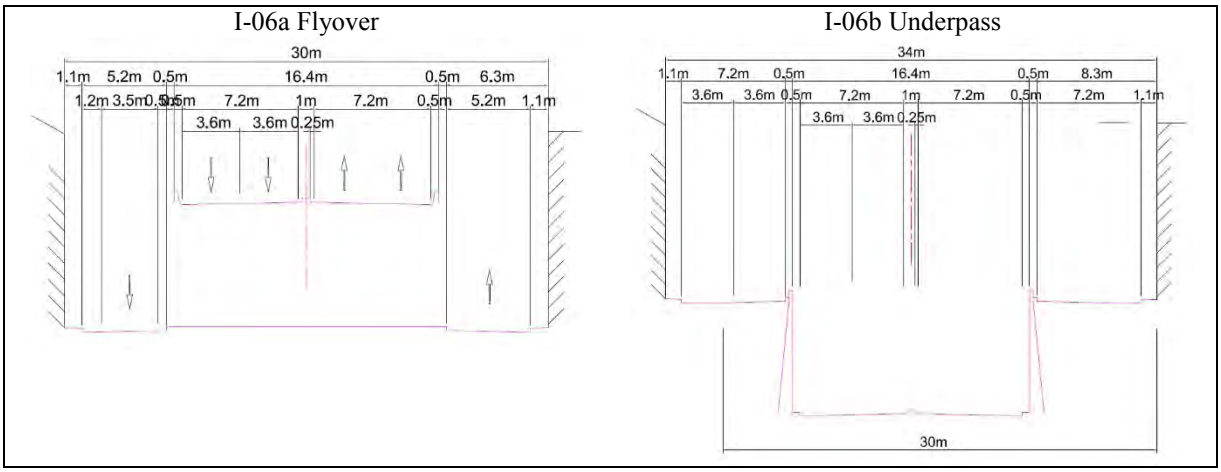
Note: Shaded cells indicate that the alternatives are superior to others with regards to the attributes being compared; "*" indicates single alternative for the sub-project and shading of the cells is not made.

Source: JICA Study Team.



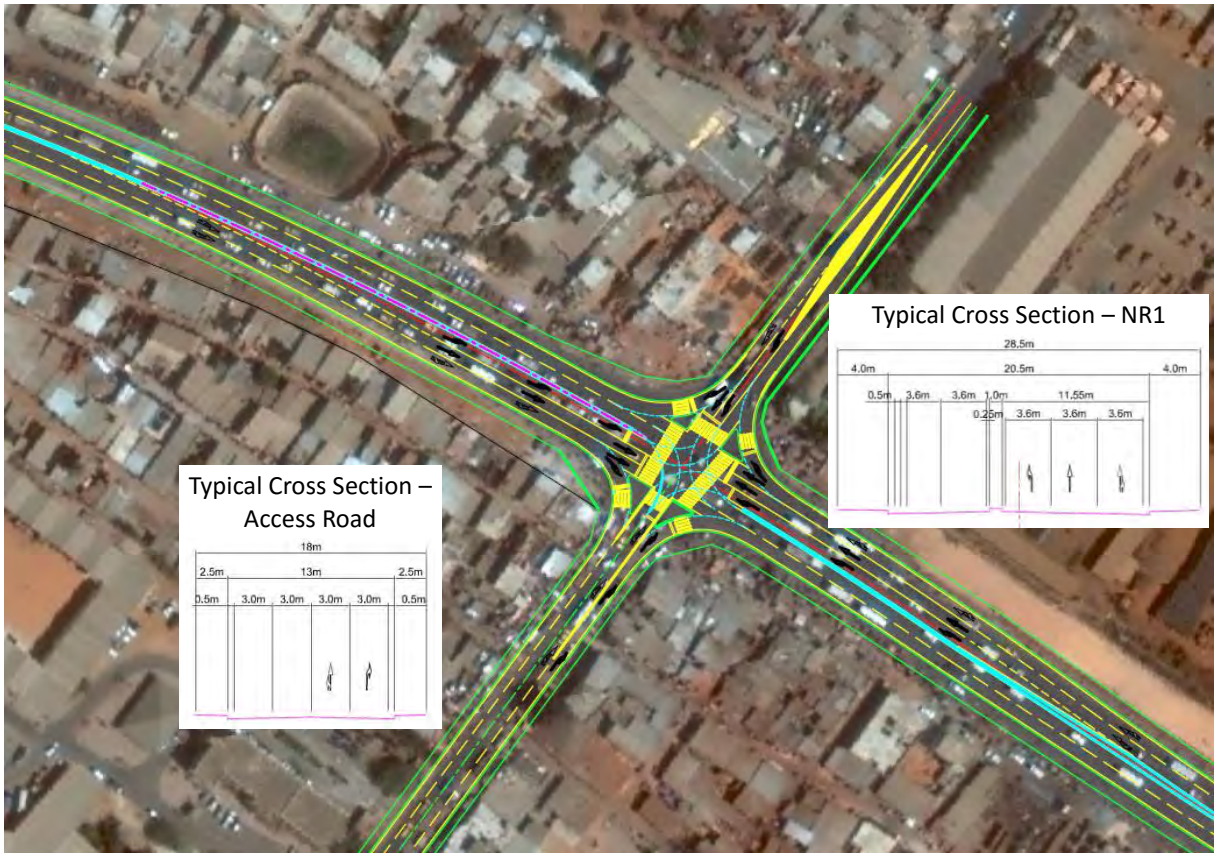
Source: JICA Study Team.

Figure 13.5.1 A Flyover and Underpass at Intersection of NR1 (I-06a, I-06b)



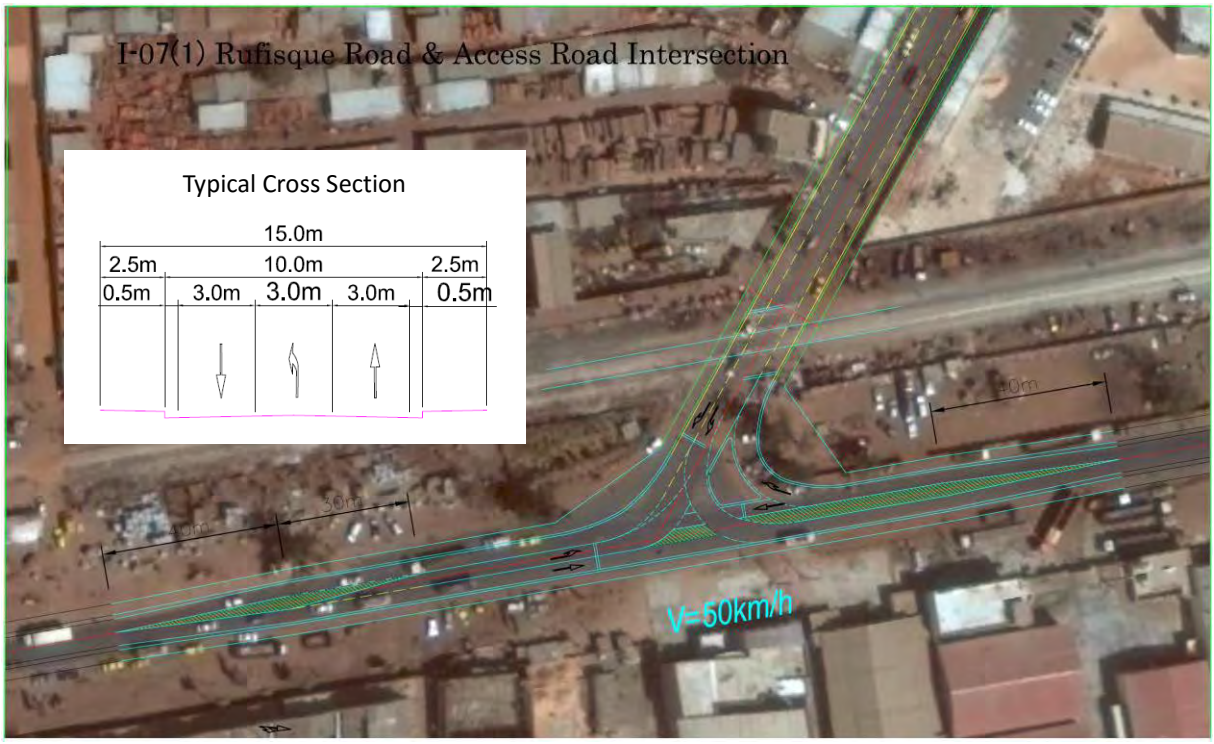
Source: JICA Study Team.

Figure 13.5.2 Typical Cross Section of the Flyover and Underpass at Intersection of NR1



Source: JICA Study Team.

Figure 13.5.3 Installation of a Traffic Signal at Intersection of NR1 (I-06c)



Source: JICA Study Team.

Figure 13.5.4 Improvement at the Intersection of Rufisque Road (I-07(1)))

Source: JICA Study Team.

Figure 13.5.5 Bus Stops and Parking Lot at PTB Station Entrance (I-07(2))

(4) Improvement of the Access Road (I-08)

1) Widening of the Access Road to Four Lanes (I-08a, I-08b, and I-08c)

The road connecting I-06 NR1 road and I-07 Rufisque Road is a two-lane road and is approximately 770m in length. The approximate ROW is: W=18m near the railway side, W=22m near the terminal entrance and W=23m from the expressway intersection to the North side of Rufisque Road. Additionally, it was considered to be an offset distance from the building's facade. Regarding widening the road to four lanes in the W=18m width, taking into consideration that the width of the existing sidewalk is the front road of the bus terminal, the following layout was adopted: four lanes x 3m=12m, 0.5m shoulder and 2.5m sidewalk on each side. The existing bridge, which has two lanes plus sidewalks, crosses over the existing expressway. It will be necessary to widen it to four lanes.

For the widening work of the bridges, there are three alternatives that can be used:

- Reconstruction of the bridge (I-08a): a four-lane bridge is newly constructed to replace the existing two-lane bridge;
- Construction of two additional one-lane bridges on both sides of the existing bridge (I-08b): both sidewalks of the existing bridge are removed and two one-lane bridges are constructed on both sides;
- Construction of an additional two-lane bridge on the East side of the existing bridge (I-08c): the sidewalk on the East side of the existing flyover is removed and an additional two-lane bridge is constructed.

The roadside land beyond the ROW of the access road, which is currently occupied for material storage, shops and other commercial purposes, needs to be regulated. For the alternative I-08a, a temporary detour road and bridge during the construction period is necessary. Therefore, land acquisition or lease will increase the overall cost. For the alternative I-08b, as it requires the construction of bridges on both sides, relocation and compensation will be an issue that needs to be further investigated. Similarly for the alternative (I-08c), which requires widening on the East side, relocation and compensation for the affected households will be subject to further investigation.

An outline drawing of widening the access road, along with the three alternatives for the widening of the bridge (I-08a, I-08b and I-08c), is shown in Figure 13.5.6.

2) One-way Traffic Control on the Access Road (I-08d)

The access road is currently a two-way two-lane road. There is a problem regarding traffic flow, especially the vehicles turning at the intersection of NR1 (the prohibited left-turn of East inflow). However, congestion has not been solved because the traffic volume passing this intersection is larger than the permissible intersection capacity. Therefore, contribution to solving traffic congestion by improvement alternatives, such as traffic signal and lane configuration within the existing ROW, as well as grade separation structure, remains a concern.

Therefore, this alternative aims to contribute to the reduction of traffic congestion at the intersection of NR1 without impacts caused by the necessity of widening the existing flyover above the motorway and the land use along the access road.

Under the one-way traffic control, the traffic will be diverted to other roads that need to be further analyzed both from the viewpoint of traffic flow and safety.

(5) Direct Motorway On-ramp from the Terminal l (I-09(1)a and I-09(1)b)

Two alternatives were considered for the on-ramp: using the land in the North of the bus terminal, mainly earthworks activities (I-09(1)a), or using the space on the drainage facility in the South along the border of the railway (I-09(1)b).

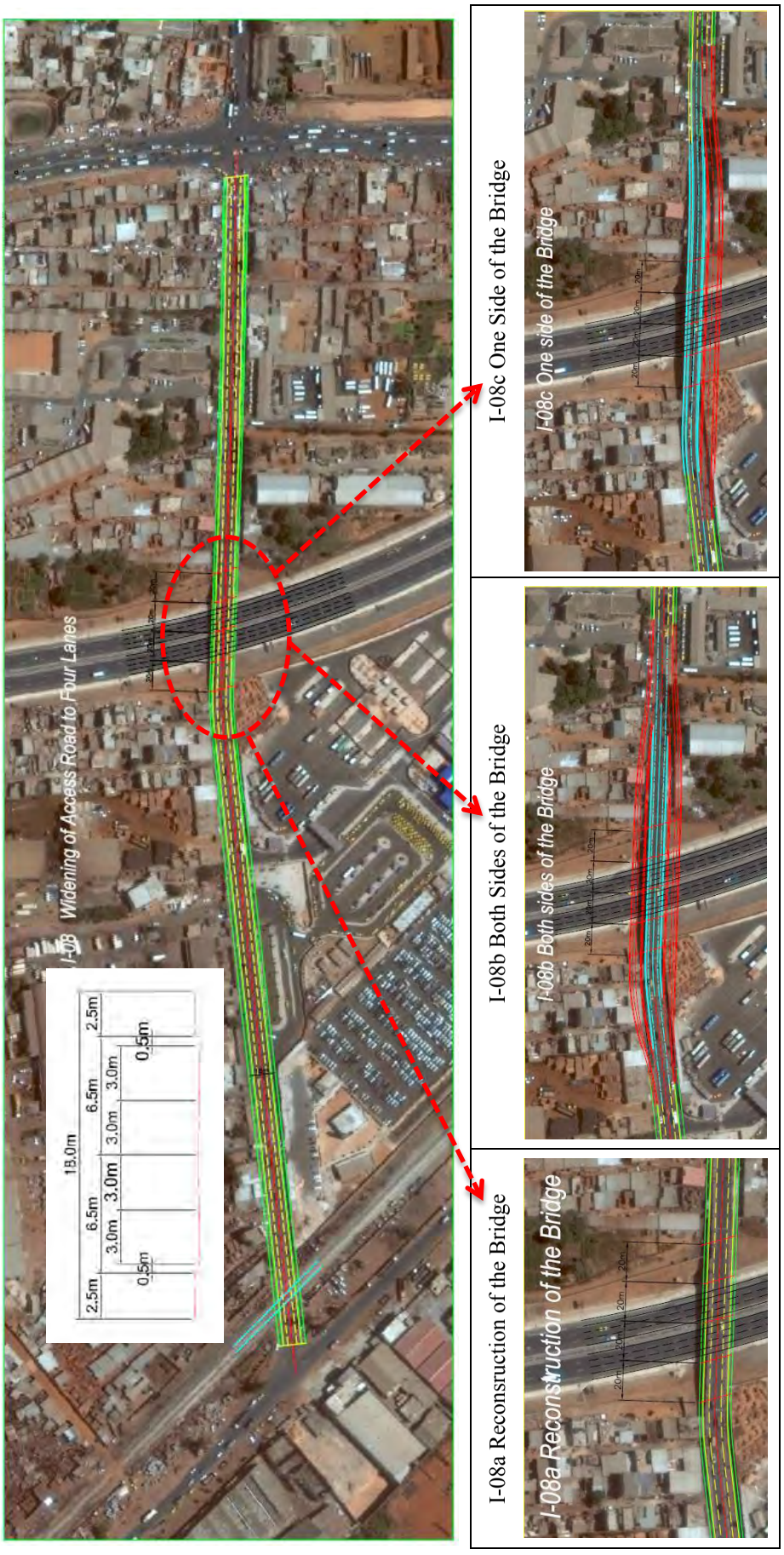
The first alternative (I-09(1)a) has a smaller ramp (350m) and does not require large structures so the construction process is easier and the project cost is lower. The second alternative (I-09(1)b) requires confirmation with the railway operator to use the border land and the ramp has the length of 1 km. Thus, bridges are necessary in order to cross the railway. Therefore, the construction is more complex and its cost is more expensive.

Figure 13.5.7 shows the outline drawings of the direct motorway on-ramp from the terminal, which includes the two alternatives, i.e., on-ramp in the North of the terminal and on-ramp in the South of the terminal.

(6) Direct Motorway Off-ramp to the Terminal (I-09(2))

The planned off-ramp crosses the existing road, the expressway and the railway, and the vertical alignment ends at the current terminal entrance. The ramp has a total length of 750m but more than half of this is composed of bridges (460+20=480m) to cross each point. The design speed of V=40km/h was adopted for the one-lane ramp, considering the relation between the radius of the horizontal S curve and the vertical alignment i=8% from the terminal to the expressway crossing section. The ramp width W=5.5m was defined, considering light and heavy vehicles.

An outline drawing of the off-ramp is shown in Figure 13.5.8.



Source: JICA Study Team.

Figure 13.5.6 Widening of the Access Road to Four Lanes (I-08a, I-08b, I-08c)

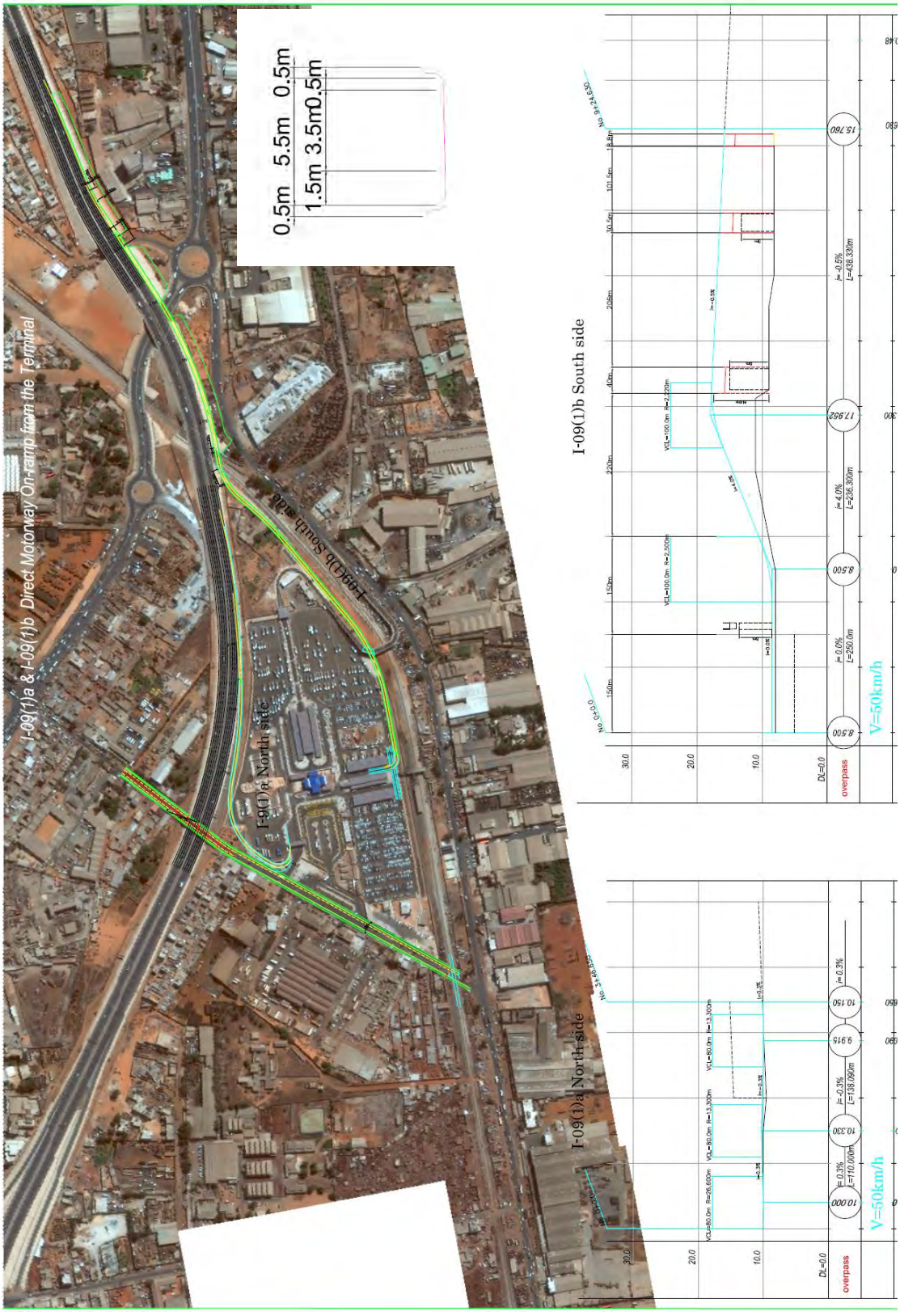
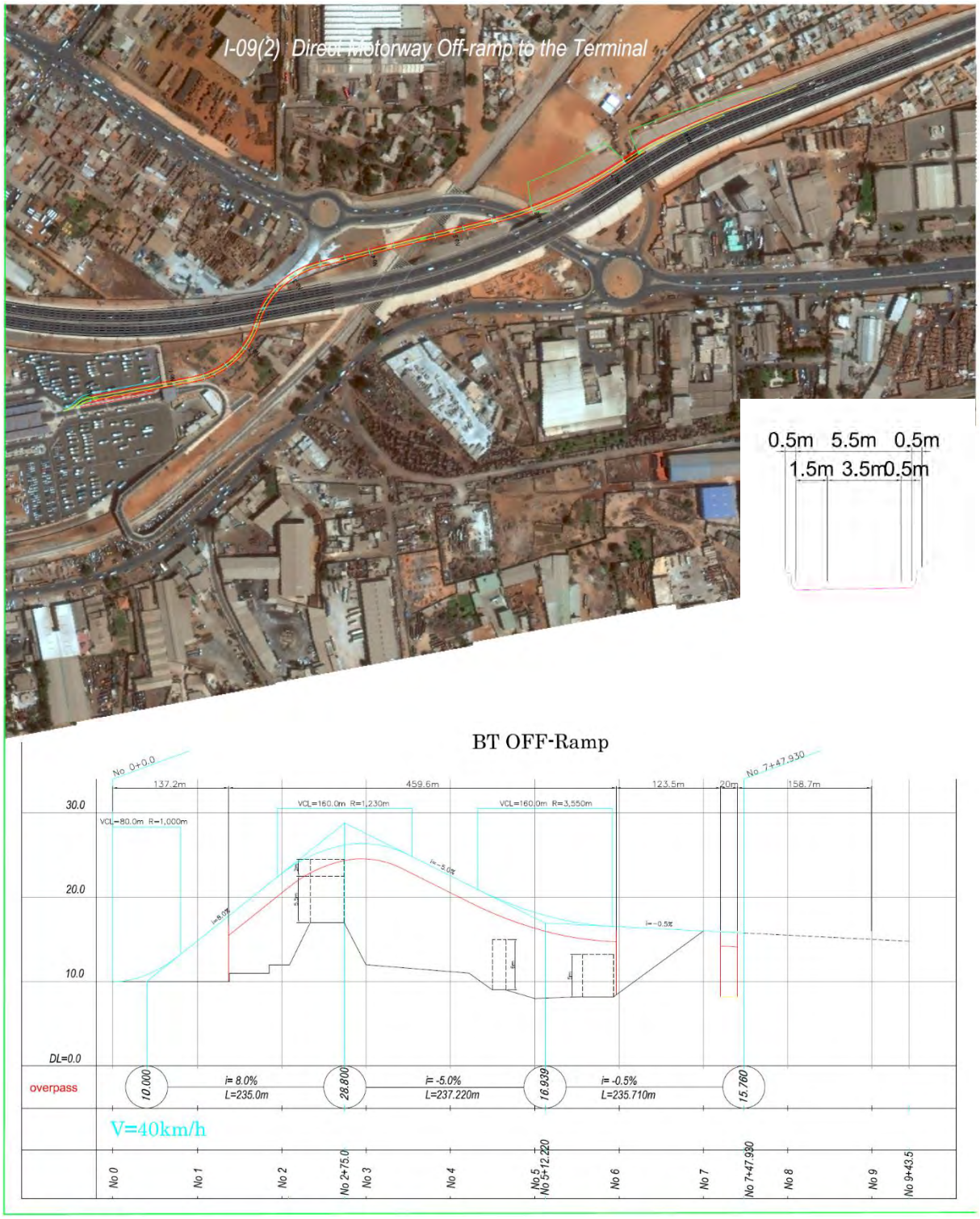


Figure 13.5.7 Direct Motorway On-ramp from the Terminal (I-09(1)a, I-09(1)b)

Source: JICA Study Team.



Source: JICA Study Team.

Figure 13.5.8 Direct Motorway Off-ramp to the Terminal (I-09(2))

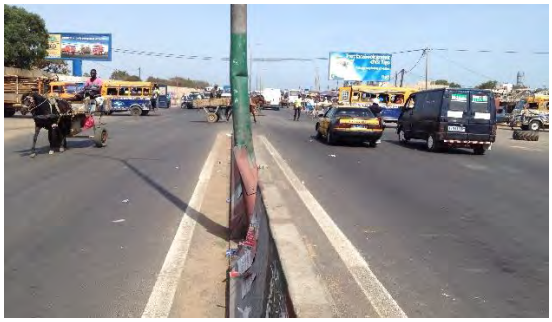
13.6 Construction Plan

13.6.1 Characteristics of the Project Site

(1) Intersection of NR1 (I-06)

This intersection is the crossing between NR1, which is characterized by heavy traffic, and the access

road of Baux Maraîchers bus terminal. Therefore, a construction method that has minimum impact on the traffic flow is desired.


View from the West side


View from the shoulder on the West side


View from the East side


View from the NR-1 to the access road

Source: JICA Study Team.

Figure 13.6.1 Situation of the Intersection of NR-1 (I-06)

(2) Access Road (I-08)

This is a two-lane road with factories and shops on both sides. However, it has the ROW that is able to accommodate four lanes. If the access road is widened to four lanes, the bottleneck will be at the existing two-lane bridge crossing over the motorway. Any construction work related to this bridge could have a significant impact on the traffic of the motorway. Therefore, a construction method that minimizes the blockage of the motorway traffic is necessary.

Situation of the access road


Approach to the bridge crossing over the motorway

Source: JICA Study Team.

Figure 13.6.2 Situation of the Access Road (I-08)

(3) Others (I-07, I-09)

Since they involve small construction works, problems are not particularly considered.

Intersection of Rufisque Road (I-07(1))

Rufisque road around PTB station entrance (I-07(2))

Construction plan site for the on-ramp in the North (I-09(1)a)

Construction plan site for the on-ramp in the South (I-09(1)b) and the off-ramp (I-09(2))

Source: JICA Study Team.

Figure 13.6.3 Situation of Other Sub-Project Locations

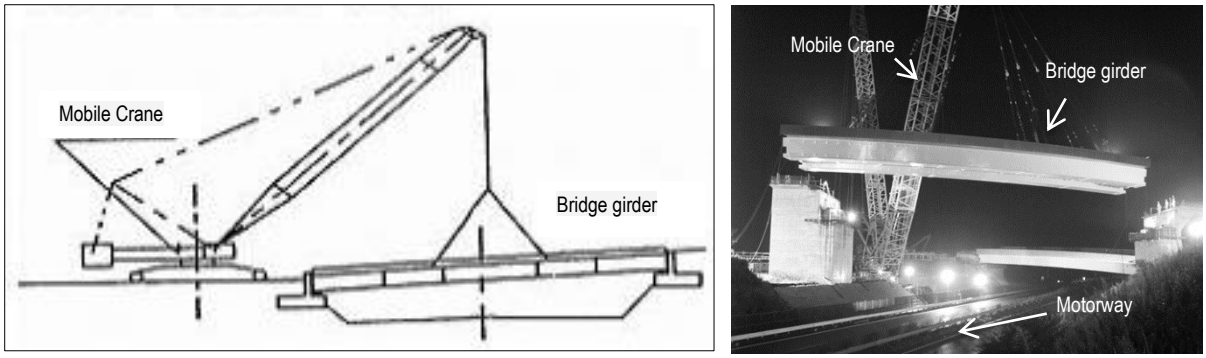
13.6.2 New Construction Technology

The new construction technologies that can be applied have already been described in Chapter 12, Section 12.6.2. In this section, only the erection method that can be applied for the motorway is described.

The large block erection method by a large crane enables the installation of the bridge girder, assembled at a factory or near the construction site over the existing motorway, with minimum impact on the traffic. This has the following advantages:

- Minimizes the closure time of the existing expressway (between half-day and one day). Therefore, there is no big impact on the traffic of the expressway.
- Shortening the construction period.

Therefore, it is efficient to adopt the large block erection method for the bridge construction on the heavy traffic motorway, which cannot be closed for a long time. The possible application of the new construction technology in the context of the above-mentioned construction sites is summarized in Table 13.6.1. Figure 13.6.4 shows the large block erection method by a large crane, together with an example of its application on a motorway.



Source: Left picture – Homepage of Japan Bridge Association; Right picture – Japan Federation of Construction Management Engineers Association.

Figure 13.6.4 Large Block Erection Method by a Large Crane

Table 13.6.1 New Construction Technology Method and Its Application

New Technology	Application	Suppression of Land	Suppression of Noise	Suppression of Vibration	Shortening of Construction Period	Maintenance and Repair	Application
Steel pipe press pile	Pile foundation	—	○	○	—	—	I-06, I-07, I-09 Flyover
Steel sheet pipe press pile	Retaining wall	○	○	○	○	—	I-06 Underpass
Panel bridge	Bridge	—	○	—	○	○	I-06 Underpass
H-shaped steel bridge	Bridge	○	—	○	—	○	I-06, I-07, I-09 Flyover
Large block erection method by large cranes	Bridge	—	—	—	○	—	I-07

Source: JICA Study Team.

13.7 Project Cost Estimate

13.7.1 Conditions of the Cost Estimate

The same conditions described in Chapter 12, Section 12.7.1 are adopted.

13.7.2 Unit Cost for the Pre-feasibility Study

The same unit costs described in Chapter 12, Section 12.7.2 are adopted.

13.7.3 Cost Estimate for the Preliminary Design

The results of the cost estimation for the traffic improvement project around Baux Maraîchers bus terminal are shown in Table 13.7.1.

Table 13.7.1 Result of the Cost Estimation for the Traffic Improvement Project around Baux Maraîchers Bus Terminal

Unit: Million FCFA

	I-06		I-07		I-08				I-09	
	East-West Flyover/ Underpass	Traffic Signal on NR1	Intersection Improvement at Rufisque Road	Improvement of Access Through PTB Station	Widening of the Access Road to Four Lanes			One-way Traffic Regulation	On-ramp	Off-ramp
					Reconstruction of the Bridge	Both sides of the Bridge	One side of the Bridge			
ID	***I-06a***	—	—	—	—	—	—	—	***I-09(1)b***	***I-09(2)***
Flyover	10,141	—	—	—	—	—	—	—	4,470	1,406
ID	***I-06b***	—	—	—	—	—	—	—	—	—
Underpass	21,880	—	—	—	—	—	—	—	—	—
ID	—	***I-06c***	***I-07(1)***	***I-07(2)***	***I-08a***	***I-08b***	***I-08c***	***I-08d***	***I-09(1)a***	—
At-grade	—	354	371	295	15,116	5,476	4,586	31	361	—

Source: JICA Study Team.

(1) Improvement at the Intersection of NR1 (I-06)

The results of the cost estimation are shown in Table 13.7.2, which can be summarized as follows.

1) Construction Cost (E)

The construction costs with price escalation and contingencies are estimated to be 7,692 million FCFA for the flyover (I-06a) plan, 16,410 million FCFA for the underpass (I-06b) plan and 268 million FCFA for the traffic signal installation (I-06c) plan.

2) Engineering Service Cost (F)

The engineering service costs with price escalation and contingencies are estimated to be 806 million FCFA for the flyover (I-06a) plan, 1,908 million FCFA for the underpass (I-06b) plan and 28 million FCFA for the traffic signal installation (I-06c) plan.

3) Project Cost

The total project costs, including compensation (land acquisition and others), administration cost, tax, interest and commission charge, are estimated to be 10,141 million FCFA for the flyover (I-06a) plan, 21,880 million FCFA for the underpass (I-06b) plan and 354 million FCFA for the traffic signal installation (I-06c) plan.

Table 13.7.2 Summary of the Estimated Cost for Improvement at Intersection of NR1

	ID	Description	Amount (Million FCFA)	Remark
Flyover East-West	***I-06a***	Construction Cost	7,692	Include price escalation and contingency
		Engineering Cost	806	Include price escalation and contingency
		Project Cost	10,141	Include compensation, administration cost, tax, interest and commission charge
Underpass East-West	***I-06b***	Construction Cost	16,410	Include price escalation and contingency
		Engineering Cost	1,908	Include price escalation and contingency
		Project Cost	21,880	Include compensation, administration cost, tax, interest and commission charge
Traffic Signal Installation	***I-06c***	Construction Cost	268	Include price escalation and contingency
		Engineering Cost	28	Include price escalation and contingency
		Project Cost	354	Include compensation, administration cost, tax, interest and commission charge

Source: JICA Study Team.

Table 13.7.3 Result of the Cost Estimation for the Improvement at the Intersection of NR1

Alternative	ID	Description		Unit Price (FCFA)	Unit	Quantity	Amount (FCFA)	Remark
Flyover East-West	*I-06a*	Preparation Work		650,800,000	ls	1	650,800,000	
		Bridge Work		2,581,300	m2	1,080	2,787,804,000	Small Number Main I-Girder＋Synthetic Floor Bridge
		Retaining Wall Work		548,600	m2	3,250	1,782,950,000	Terre Armee Method
		Earth Work	Filling	10,400	m3	25,025	260,260,000	
		Pavement Work	Bridge Part	180,700	t	32	5,782,400	
			Earth Work Part	60,300	m2	16,810	1,013.727,925	
			Sidewalk	19,000	m2	3,450	65,550,000	
		Incidental Work		32,540,000	ls	1	32,540,000	
		Subtotal (A)					6,599,314,325	
		Price Escalation (B)					725,924,576	11% of (A)
		Subtotal (C)＝(A)＋(B)					7,325,238,901	
		Contingency (D)					366,261,945	5% of (C)
		Construction Cost (E)＝(C)＋(D)					7,691,500,846	
		Engineering Service (F)					659,931,433	10% of (A)
		Price Escalation (G)					72,592,458	11% of (F)
		Contingency (H)					73,252,389	5% of ((F)＋(G))
		Engineering Cost (I)＝(F)＋(G)＋(H)					805,776,280	
		Compensation Cost (J)					0	
		Administration Cost (K)					80,577,628	10% of (I)
		Tax (L)					1,529,509,883	18% of ((E)＋(I))
		Interest (M)					25,491,831	0.5% of ((E)＋(I))
		Commitment Charge (N)					8,497,277	0.1% of ((E)＋(I))
		Project Cost (E)＋(I)＋(J)＋(K)＋(L)＋(M)＋(N)					10,141,353,745	
Underpass East-West	*I-06b*	Preparation Work		1,336,300,000	ls	1	1,336,300,000	
		Box Culvert Work		9,679,800	m	75	725,985,000	
		Retaining Wall Work		15,702,700	m	650	10,206,755,000	Steel pipe sheet pile press-fit method
		Earth Work	Cutting	5,200	m3	25,025	130,130,000	
		Pavement Work	Box Culvert Part	180,700	t	32	5,782,400	
			Earth Work Part	60,300	m2	16,810	1,013.727,925	
			Side Walk	19,000	m2	3,450	65,550,000	
		Incidental Work		66,810,000	ls	1	66,810,000	
		Drainage Facility Work		2,077,915,900	ls	1	2,077,915,900	
		Subtotal (A)					15,628,856,225	
		Price Escalation (B)						11% of (A)
		Subtotal (C)＝(A)＋(B)					15,628,856,225	
		Contingency (D)					781,442,811	5% of (C)
		Construction Cost (E)＝(C)＋(D)					16,410,299,036	
		Engineering Service (F)					1,562,885,623	10% of (A)
		Price Escalation (G)					171,917,419	11% of (F)
		Contingency (H)					173,480,304	5% of ((F)＋(G))
		Engineering Cost (I)＝(F)＋(G)＋(H)					1,908,283,346	
		Compensation Cost (J)					0	
		Administration Cost (K)					190,828,335	10% of (I)
		Tax (L)					3,297,344,829	18% of ((E)＋(I))
		Interest (M)					54,955,747	0.5% of ((E)＋(I))
		Commitment Charge (N)					18,318,582	0.1% of ((E)＋(I))
		Project Cost (E)＋(I)＋(J)＋(K)＋(L)＋(M)＋(N)					21,880,029,875	
Traffic Signal Installation	*I-06c*	Preparation Work		22,700,000	ls	1	22,700,000	
		Signal Work		206,501,000	ls	1	206,501,000	Four-leg intersection
		Incidental Work		1,140,000	ls	1	1,140,000	
		Subtotal (A)					230,341,000	
		Price Escalation (B)					25,337,510	11% of (A)
		Subtotal (C)＝(A)＋(B)					255,678,510	
		Contingency (D)					12,783,926	5% of (C)
		Construction Cost (E)＝(C)＋(D)					268,462,436	
		Engineering Service (F)					23,034,100	10% of (A)
		Price Escalation (G)					2,533,751	11% of (F)
		Contingency (H)					2,556,785	5% of ((F)＋(G))
		Engineering Cost (I)＝(F)＋(G)＋(H)					28,124,636	
		Compensation Cost (J)					0	
		Administration Cost (K)					2,812,464	10% of (I)

		Tax (L)	53,385,673	18% of ((E)+(I))
		Interest (M)	889,761	0.5% of ((E)+(I))
		Commitment Charge (N)	296,587	0.1% of ((E)+(I))
		Project Cost (E)+(I)+(J)+(K)+(L)+(M)+(N)	353,971,557	

Source: JICA Study Team.

(2) Improvement at the Intersection of Rufisque Road and Improvement of the Access Through PTB Station Entrance

The results of the cost estimation are shown in Table 13.7.4, which can be summarized as follows.

1) Construction Cost (E)

The construction cost with price escalation and contingencies is estimated to be 282 million FCFA for the improvement at the intersection of Rufisque Road (I-07(1)) and 224 million FCFA for the improvement of the PTB station entrance (I-07(2)).

2) Engineering Service Cost (F)

The engineering service cost with price escalation and contingencies is estimated to be 30 million FCFA for the improvement at the intersection of Rufisque Road (I-07(1)) and 23 million FCFA for the improvement of the PTB station entrance (I-07(2)).

3) Project Cost

The total project cost, including compensation (land acquisition and others), administration cost, tax, interest and commission charge, is estimated to be 371 million FCFA for the improvement at the intersection of Rufisque Road (I-07(1)) and 295 million FCFA for the improvement of the PTB station entrance (I-07(2)).

Table 13.7.4 Summary of the Estimated Cost for the Improvement at the Intersection of Rufisque Road and Improvement of the Access through PTB Station Entrance

	ID	Description	Amount (Million FCFA)	Remark
Improvement at Intersection of Rufisque Road	***I-07(1)***	Construction Cost	282	Include price escalation and contingency
		Engineering Cost	30	Include price escalation and contingency
		Project Cost	371	Include compensation, administration cost, tax, interest and commission charge
Improvement of Access Through PTB Station Entrance	***I-07(2)***	Construction Cost	224	Include price escalation and contingency
		Engineering Cost	23	Include price escalation and contingency
		Project Cost	295	Include compensation, administration cost, tax, interest and commission charge

Source: JICA Study Team.

Table 13.7.5 Result of the Cost Estimation for the Improvement at the Intersection of Rufisque Road and Improvement of the Access Through PTB Station Entrance

	ID	Description)		Unit Price (FCFA)	Unit	Quantity	Amount (FCFA)	Remark
Improvement at the Intersection of Rufisque Road	*I-07(1)*	Preparation Work		23,800,000	ls	1	23,800,000	
		Pavement Work	Earth Work Part	60,300	m2	3,121	188,202,330	
			Sidewalk	19,000	m2	1,499	28,481,532	
		Incidental Work		1,190,000	ls	1	1,190,000	
		Subtotal (A)					241,673,862	
		Price Escalation (B)					26,584,125	11% of (A)
		Subtotal (C)=(A)+(B)					268,257,987	
		Contingency (D)					13,412,899	5% of (C)
		Construction Cost (E)=(C)+(D)					281,670,886	
		Engineering Service (F)					24,167,386	10% of (A)
		Price Escalation (G)					2,658,412	11% of (F)
		Contingency (H)					2,682,580	5% of ((F)+(G))
		Engineering Cost (I)=(F)+(G)+(H)					29,508,378	
		Compensation Cost (J)					0	
		Administration Cost (K)					2,950,838	10% of (I)
		Tax (L)					56,012,268	18% of ((E)+(I))
		Interest (M)					933,538	0.5% of ((E)+(I))
		Commitment Charge (N)					311,179	0.1% of ((E)+(I))
		Project Cost (E)+(I)+(J)+(K)+(L)+(M)+(N)					371,387,087	
Improvement of Access through PTB Station Entrance	*I-07(2)*	Preparation Work		18,900,000	ls	1	18,900,000	
		Pavement Work	Bus Stop	60,300	m2	158	9,497,250	
			Sidewalk	19,000	m2	1,043	19,815,100	
			Parking	30,150	m2	4,630	139,608,851	
		Fence Work		12,000	m	253	3,035,760	
		Incidental Work		950,000	ls	1	950,000	
		Subtotal (A)					191,806,961	
		Price Escalation (B)					21,098,766	11% of (A)
		Subtotal (C)=(A)+(B)					212,905,727	
		Contingency (D)					10,645,286	5% of (C)
		Construction Cost (E)=(C)+(D)					223,551,013	
		Engineering Service (F)					19,180,696	10% of (A)
		Price Escalation (G)					2,109,877	11% of (F)
		Contingency (H)					2,129,057	5% of ((F)+(G))
		Engineering Cost (I)=(F)+(G)+(H)					23,419,630	
		Compensation Cost (J)					0	
		Administration Cost (K)					2,341,963	10% of (I)
		Tax (L)					44,454,716	18% of ((E)+(I))
		Interest (M)					740,912	0.5% of ((E)+(I))
		Commitment Charge (N)					246,971	0.1% of ((E)+(I))
		Project Cost (E)+(I)+(J)+(K)+(L)+(M)+(N)					294,755,205	

Source: JICA Study Team.

(3) Improvement of the Access Road

The results of the cost estimation are shown in Table 13.7.6, which can be summarized as follows.

1) Construction Cost (E)

The construction cost with price escalation and contingencies is estimated 11,465 million FCFA for the widening of the access road to four lanes (reconstruction of the bridge) (I-08a), 4,146 million FCFA for the widening of the access road to four lanes (both sides of the bridge) (I-08b), 3,470 million FCFA for the widening of the access road to four lanes (one side of the bridge) (I-08c) and 24 million FCFA for the one-way traffic control on the access road (I-08d).

2) Engineering Service Cost (F)

The engineering service cost with price escalation and contingencies is estimated 1,201 million FCFA for the widening of the access road to four lanes (reconstruction of the bridge) (I-08a), 434 million FCFA for the widening of the access road to four lanes (both sides of the bridge) (I-08b), 364 million FCFA for the widening of the access road to four lanes (one side of the bridge) (I-08c) and 3 million FCFA for the one-way traffic control on the access road (I-08d).

3) Project Cost

The total project cost including compensation (land acquisition and others), administration cost, tax, interest and commission charge is estimated to be 15,116 million FCFA for the widening of the access road to four lanes (reconstruction of the bridge) (I-08a), 5,476 million FCFA for the widening of the access road to four lanes (both sides of the bridge) (I-08b), 4,585 million FCFA for the widening of the access road to four lanes (one side of the bridge) (I-08c) and 31 million FCFA for the one-way traffic control on the access road (I-08d).

Table 13.7.6 Summary of the Estimated Cost for Widening of the Access Road to Four Lanes

	ID	Description	Amount (Million FCFA)	Remark
Widening of the access road to four lanes (reconstruction of the bridge)	***I-08a***	Construction Cost	11,465	Include price escalation and contingency
		Engineering Cost	1,201	Include price escalation and contingency
		Project Cost	15,116	Include compensation, administration cost, tax, interest and commission charge
Widening of the access road to four lanes (both sides of the bridge)	***I-08b***	Construction Cost	4,146	Include price escalation and contingency
		Engineering Cost	434	Include price escalation and contingency
		Project Cost	5,476	Include compensation, administration cost, tax, interest and commission charge
Widening of the access road to four lanes (one side of the bridge)	***I-08c***	Construction Cost	3,470	Include price escalation and contingency
		Engineering Cost	364	Include price escalation and contingency
		Project Cost	4,586	Include compensation, administration cost, tax, interest and commission charge
One-way traffic control on the access road	***I-08d***	Construction Cost	24	Include price escalation and contingency
		Engineering Cost	3	Include price escalation and contingency
		Project Cost	31	Include compensation, administration cost, tax, interest and commission charge

Source: JICA Study Team.

Table 13.7.7 Result of the Cost Estimation for the Widening of the Access Road to Four Lanes

Alternative	ID	Description		Unit Price (FCFA)	Unit	Quantity	Amount (FCFA)	Remark
Widening of the access road to four lanes (reconstruction of the bridge)	*I-08a*	Preparation Work		970,000,000	ls	1	970,000,000	
		Demolish Work	Existing Bridge	1,290,650	m2	960	1,239,024,000	Steel Box Girder Bridge
		Bridge Work	New Bridge	3,226,600	t	1,280	4,130,048,000	Including Detour Work
		Temporary Work	Temporary Bridge	3,226,600	m2	960	3,097,536,000	
		Pavement Work	Bridge	180,700	m2	38	6,866,600	
			Earth Work Part	60,300	is	5,259	317,111,067	
			Sidewalk	19,000	m2	1,454	27,618,210	
		Incidental Work		48,500,000	ls	1	48,500,000	
		Subtotal (A)					9,836,703,877	
		Price Escalation (B)					1,082,037,426	(A)の 11%
		Subtotal (C)＝(A)＋(B)					10,918,741,303	
		Contingency (D)					545,937,065	(C)の 5%
		Construction Cost (E)＝(C)＋(D)					11,464,678,368	
		Engineering Service (F)					983,670,388	10% of (A)
		Price Escalation (G)					108,203,743	(F)の 11%
		Contingency (H)					109,187,413	(F)＋(G)の 5%
		Engineering Cost (I)＝(F)＋(G)＋(H)					1,201,061,544	
		Compensation Cost (J)					0	
		Administration Cost (K)					120,106,154	10% of (I)
		Tax (L)					2,279,833,184	18% of ((E)＋(I))
		Interest (M)					37,997,220	0.5% of ((E)＋(I))
		Commitment Charge (N)					12,665,740	0.1% of ((E)＋(I))
		Project Cost (E)＋(I)＋(J)＋(K)＋(L)＋(M)＋(N)					15,116,342,210	
Widening of the access road to four lanes (both sides of the bridge)	*I-08b*	Preparation Work		350,800,000	ls	1	350,800,000	
		Bridge Work	New Bridge	3,226,600	m2	880	2,839,408,000	
		Pavement Work	Bridge	180,700	t	26	4,698,200	Steel Box Girder Bridge
			Earth Work Part	60,300	m2	5,259	317,111,067	
			Sidewalk	19,000	m2	1,454	27,618,210	
		Incidental Work		17,540,000	is	1	17,540,000	
		Subtotal (A)					3,557,175,477	
		Price Escalation (B)					391,289,302	(A)の 11%
		Subtotal (C)＝(A)＋(B)					3,948,464,779	
		Contingency (D)					197,423,239	(C)の 5%
		Construction Cost (E)＝(C)＋(D)					4,145,888,018	
		Engineering Service (F)					355,717,548	10% of (A)
		Price Escalation (G)					39,128,930	(F)の 11%
		Contingency (H)					39,484,648	(F)＋(G)の 5%
		Engineering Cost (I)＝(F)＋(G)＋(H)					434,331,126	
		Compensation Cost (J)					10,000,000	
		Administration Cost (K)					43,433,113	10% of (I)
		Tax (L)					824,439,446	18% of ((E)＋(I))
		Interest (M)					13,740,657	0.5% of ((E)＋(I))
		Commitment Charge (N)					4,580,219	0.1% of ((E)＋(I))
		Project Cost (E)＋(I)＋(J)＋(K)＋(L)＋(M)＋(N)					5,476,412,579	
Widening of the access road to four lanes (one side of the bridge)	*I-08c*	Preparation Work		293,600,000	ls	1	293,600,000	
		Bridge Work	New Bridge	3,226,600	m2	720	2,323,152,000	Steel Box Girder Bridge
		Pavement Work	Bridge	180,700	t	21	3,794,700	
			Earth Work Part	60,300	m2	5,259	317,111,067	
			Sidewalk	19,000	m2	1,334	25,338,210	
		Incidental Work		14,680,000	is	1	14,680,000	
		Subtotal (A)					2,977,675,977	
		Price Escalation (B)					327,544,357	(A)の 11%
		Sun Total (C)＝(A)＋(B)					3,305,220,334	
		Contingency (D)					165,261,017	(C)の 5%
		Construction Cost (E)＝(C)＋(D)					3,470,481,351	
		Engineering Service (F)					297,767,598	10% of (A)
		Price Escalation (G)					32,754,436	(F)の 11%
		Contingency (H)					33,052,203	(F)＋(G)の 5%
		Engineering Cost (I)＝(F)＋(G)＋(H)					363,574,237	
		Compensation Cost (J)					10,000,000	
		Administration Cost (K)					36,357,424	10% of (I)

		Tax (L)					690,130,006	18% of ((E)+(I))
		Interest (M)					11,502,167	0.5% of ((E)+(I))
		Commitment Charge (N)					3,834,056	0.1% of ((E)+(I))
		Project Cost (E)+(I)+(J)+(K)+(L)+(M)+(N)					4,585,879,241	
One-way traffic control on the access road	***I-08d***	Preparation Work		2,000,000	ls	1	2,000,000	
		Road Marking Work		4,800	m2	1,500	7,200,000	L-500m,W=0.15m
		Installation Work of Traffic Sign		1,118,600	no.	10	11,186,000	φ600
		Incidental Work		100,000	ls	1	100,000	
		Subtotal (A)					20,486,000	
		Price Escalation (B)					2,253,460	(A)の 11%
		Sun Total (C)=(A)+(B)					22,739,460	
		Contingency (D)					1,13.7,973	(C)の 5%
		Construction Cost (E)=(C)+(D)					23,876,433	
		Engineering Service (F)					2,048,600	10% of (A)
		Price Escalation (G)					225,346	(F)の 11%
		Contingency (H)					227,395	(F)+(G)の 5%
		Engineering Cost (I)=(F)+(G)+(H)					2,501,341	
		Compensation Cost (J)					0	
		Administration Cost (K)					250,134	10% of (I)
		Tax (L)					4,747,999	18% of ((E)+(I))
		Interest (M)					79,133	0.5% of ((E)+(I))
		Commitment Charge (N)					26,378	0.1% of ((E)+(I))
		Project Cost (E)+(I)+(J)+(K)+(L)+(M)+(N)					31,481,418	

Source: JICA Study Team.

(4) Direct Motorway Interchange to/from the Terminal

The results of the cost estimation for the direct motorway interchange to/from the terminal are shown in Table 13.7.8, which can be summarized as follows.

1) Construction Cost (E)

The construction costs with price escalation and contingencies are estimated to be 10,664 million FCFA for the off-ramp (I-09(2)), 274 million FCFA for the on-ramp North (I-09(1)a) plan and 3,390 million FCFA for the on-ramp south (I-09(1)b) plan.

2) Engineering Service Cost (F)

The engineering service costs with price escalation and contingencies are estimated to be 1,117 million FCFA for the off-ramp (I-09(2)), approximately 29 million FCFA for the on-ramp North (I-09(1)a) plan and approximately 355 million FCFA for the on-ramp south (I-09(1)b) plan.

3) Project Cost

The total project costs including compensation (land acquisition and others), administration cost, tax, interest and commission charge are estimated to be 14,061 million FCFA for the off-ramp (I-09(2), 361 million FCFA for the on-ramp North (I-09(1)a) plan and 4,470 million FCFA for the on-ramp South (I-09(1)b) plan.

Table 13.7.8 Summary of the Estimated Cost for the Direct Motorway Interchange

	ID	Description	Amount (Million FCFA)	Remark
Off-ramp	***I-09(1)a***	Construction Cost	10,664	Include price escalation and contingency
		Engineering Cost	1,117	Include price escalation and contingency
		Project Cost	14,061	Include compensation, administration cost, tax, interest and commission charge
On-ramp North	***I-09(1)b***	Construction Cost	274	Include price escalation and contingency
		Engineering Cost	29	Include price escalation and contingency
		Project Cost	361	Include compensation, administration cost, tax, interest and commission charge
On-ramp South	***I-09(2)***	Construction Cost	3,390	Include price escalation and contingency
		Engineering Cost	355	Include price escalation and contingency
		Project Cost	4,470	Include compensation, administration cost, tax, interest and commission charge

Source: JICA Study Team.

Table 13.7.9 Result of the Cost Estimation for the Direct Motorway Interchange to the Terminal

Alternative	ID	Description		Unit Price (FCFA)	Unit	Quantity	Amount (FCFA)	Remark
Off-ramp	***I-09(2)***	Preparation Work		887,200,000	ls	1	887,200,000	
		Bridge Work		2,581,300	m2	2,638	6,808,953,140	Panel Bridge
		Retaining Wall Work		548,600	m2	1,990	1,091,439,700	Terre Armee Method
		Earth Work	Filling	10,400	m3	485	5,045,040	
		Pavement Work	Bridge Part	180,700	t	79	14,275,300	
			Earth Work Part	60,300	m2	2,417	145,727,010	
		Incidental Work		44,360,000	ls	1	44,360,000	
		Subtotal (A)					9,149,968,919	
		Price Escalation (B)					1,006,496,581	11% of (A)
		Construction Cost (C)=(A)+(B)					10,156,465,500	
		Contingency (D)					507,823,275	5% of (C)
		Construction Cost (E)=(C)+(D)					10,664,288,775	
		Engineering Service (F)					914,996,892	10% of (A)
		Price Escalation (G)					100,649,658	11% of (F)
		Contingency (H)					101,564,655	5% of ((F)+(G))
		Engineering Cost (I)=(F)+(G)+(H)					1,117,211,205	
		Compensation Cost (J)					0	
		Administration Cost (K)					111,721,121	10% of (I)
		Tax (L)					2,120,669,996	18% of ((E)+(I))
		Interest (M)					35,344,500	0.5% of ((E)+(I))
		Commitment Charge (N)					11,781,500	0.1% of ((E)+(I))
		Project Cost (E)+(I)+(J)+(K)+(L)+(M)+(N)					14,061,017,097	
On-ramp North	***I-09(1)a***	Preparation Work		23,100,000	ls	1	23,100,000	
		Earth Work	Filling	10,400	m3	1,620	16,848,000	
		Pavement Work	Earth Work Part	60,300	m2	3,211	193,593,150	
		Incidental Work		1,160,000	ls	1	1,160,000	
		Subtotal (A)					234,701,150	
		Price Escalation (B)					25,817,127	11% of (A)
		Subtotal (C)=(A)+(B)					260,518,277	
		Contingency (D)					13,025,914	5% of (C)
		Construction Cost (E)=(C)+(D)					273,544,191	
		Engineering Service (F)					23,470,115	10% of (A)
		Price Escalation (G)					2,581,713	11% of (F)
		Contingency (H)					2,605,183	5% of ((F)+(G))
		Engineering Cost (I)=(F)+(G)+(H)					28,657,011	
		Compensation Cost (J)					0	
		Administration Cost (K)					2,865,701	10% of (I)
		Tax (L)					54,396,216	18% of ((E)+(I))
		Interest (M)					906,604	0.5% of ((E)+(I))
		Commitment Charge (N)					302,201	0.1% of ((E)+(I))

		Project Cost (E)+(I)+(J)+(K)+(L)+(M)+(N)					360,671,924	
On-ramp South	*I-09(1)b*	Preparation Work		282,000,000	ls	1	282,000,000	
		Bridge Work		2,581,300	m2	491	1,267,805,495	Panel Bridge
		Retaining Wall Work		548,600	m2	1,760	965,536,000	Terre Armee Method
		Earth Work	Filling	10,400	m3	7,144	74,292,400	
		Pavement Work	Bridge Part	180,700	t	15	2,710,500	
			Earth Work Part	60,300	m2	4,206	253,636,875	
		Incidental Work		14,100,000	ls	1	14,100,000	
		Subtotal (A)					2,908,716,018	
		Price Escalation (B)					319,958,762	11% of (A)
		Sun Total (C)=(A)+(B)					3,228,674,780	
		Contingency (D)					161,433,739	5% of (C)
		Construction Cost (E)=(C)+(D)					3,390,108,519	
		Engineering Service (F)					290,871,602	10% of (A)
		Price Escalation (G)					31,995,876	11% of (F)
		Contingency (H)					32,286,748	5% of ((F)+(G))
		Engineering Cost (I)=(F)+(G)+(H)					355,154,226	
		Compensation Cost (J)					0	
		Administration Cost (K)					35,515,423	10% of (I)
		Tax (L)					674,147,294	18% of ((E)+(I))
		Interest (M)					11,235,788	0.5% of ((E)+(I))
		Commitment Charge (N)					3,745,263	0.1% of ((E)+(I))
		Project Cost (E)+(I)+(J)+(K)+(L)+(M)+(N)					4,469,906,513	

Source: JICA Study Team.

13.7.4 Maintenance Cost

A periodic inspection is carried out every year. The cost of this is assumed to be 1% of the construction costs per year. A large-scale repair is carried out every 10 years. The cost of this is assumed to be 10% of the construction costs.

13.8 Implementation Program

13.8.1 Possible Loan Assistance

This pre-F/S was conducted assuming a possibility of lending by international partners including assistance from JICA.

From start to completion, the scheme of the project is shown in Table 13.8.1.

Table 13.8.1 Possible Scheme

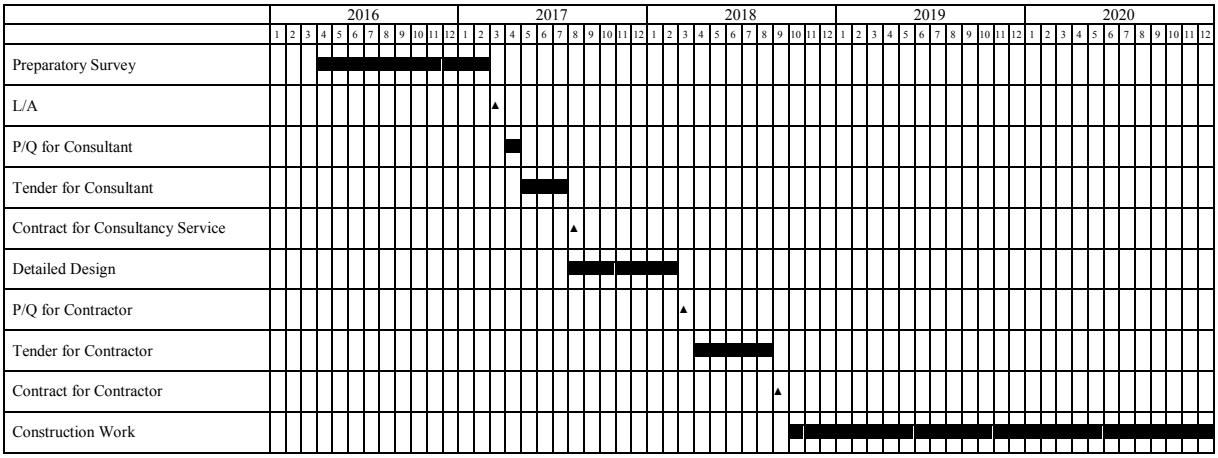
	Consultant	Contractor
Outline Design	Preparatory Survey	-
Detailed Design	Loan Assistance	-
Tender	Loan Assistance	-
Supervising / Construction Work	Loan Assistance	Loan Assistance

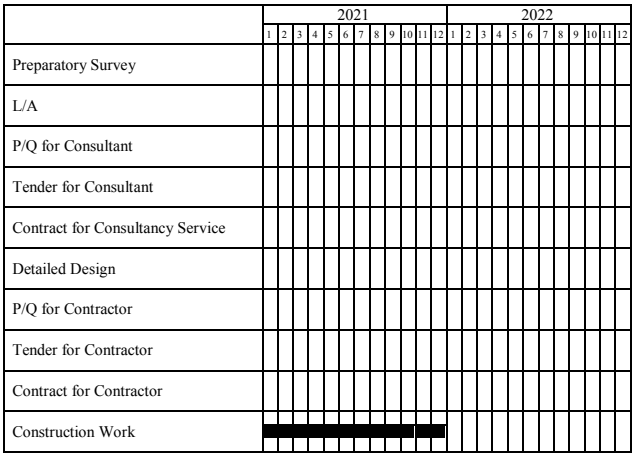
Source: JICA Study Team.

13.8.2 Implementation Schedule

Assuming international financing cooperation, the improvement project around Baux Maraîchers Bus Terminal is shown in Table 13.8.2.

Table 13.8.2 Implementation Schedule for the Improvement Project Around Baux Maraîchers Bus Terminal





Source: JICA Study Team.

13.9 Economic Analysis

13.9.1 Presumptions

The costs and benefits are calculated as the differences between "with" and "without" the traffic improvement project (the project). The with/without comparison attempts to measure the incremental benefits of the project. This approach can account for changes in production that would occur without the project.

Presumptions of an economic analysis of the project are shown in Table 13.9.1. The economic cost in an economic analysis is used for the purpose of deducting transfer payments such as tax and interests. This conversion is commonly done by applying the standard conversion factor. The standard conversion factor that is applicable to the present economic analysis is set at 0.85 as a typical value that is applied to projects in developing countries.

Table 13.9.1 Presumptions of the Economic Analysis

Item	Preconditions	Remarks
Project life (evaluation period)	30 years after construction	Commencement of investment: 2016, Opening: 2021
Exchange rate	EURO (€) = FCFA659,95/€ US Dollar (USD) = FCFA594.04/USD	BCEAO Rate
Social discount rate (opportunity cost of capital)	12 %	
Economic price	85% of financial price	

Source: JICA Study Team.

13.9.2 Cost

As shown in Table 13.9.2, the economic cost was estimated by (i) deducting the government taxes and other items from the financial cost and (ii) applying a conversion factor of 0.85 to the rest of the financial cost. Maintenance costs are also added to the economic cost. Operation and maintenance (O&M) and renewal costs are assumed as Table 13.9.3 indicates.

Table 13.9.2 Estimated Economic Cost

Unit: million FCFA

	Sub-projects/Alternatives	Financial Cost	Economic Cost
I-06a	A flyover at the intersection of NR1	10,141	7,226
I-06b	An underpass at the intersection of NR1	21,880	17,113
I-06c	Installation of traffic signals at the intersection of NR1	354	252
I-07(1)	Improvement at the intersection of Rufisque Road	371	265
I-07(2)	Improvement of access through PTB station entrance	295	210
I-08a	Widening of the access road to four lanes (reconstruction of the bridge)	15,116	10,771
I-08b	Widening of the access road to four lanes (both sides of the bridge)	5,476	3,895
I-08c	Widening of the access road to four lanes (one side of the bridge)	4,586	3,260
I-08d	One-way traffic control on the access road	31	22
I-09(1)a	Direct motorway on-ramp from the terminal (Option 1)	361	257
I-09(1)b	Direct motorway on-ramp from the terminal (Option 2)	4,470	3,185
I-09(2)	Direct motorway off-ramp to the terminal	14,061	10,019

Source: JICA Study Team.

Table 13.9.3 Operation and Maintenance Cost and Renewal Cost for Economic Analysis

Item	Cost	Remarks
O&M cost	1% of construction cost	Every year
Renewal cost	10% of construction cost	Every 10 years

Source: JICA Study Team.

13.9.3 Traffic Volume

The traffic volume on the project road is estimated, as shown in Section 13.4.1.

13.9.4 Benefits

The savings in VOC and TTC are taken as the benefits of the project.

(1) VOC

The VOC is calculated by the type of vehicle in the two scenarios: with the project and without the project. The VOC covers the fuel cost, lubricant cost, maintenance costs of the vehicles including the purchase of tires, driver cost, etc. In this analysis, the unit values of the VOC are estimated by studies of past road projects in Senegal, as shown in Table 13.9.4. A unit amount of savings in VOC is estimated for savings in 1 km per one car after completion of the project. Saving in VOC is the difference between VOC of travel speed without the project and VOC of travel speed with the project. The total savings in VOC (FCFA per car) are estimated by multiplying the saving in VOC, the distance of the road and the standard conversion factor.

Table 13.9.4 Vehicle Operating Costs by Travel Speed

Unit: FCFA/km/vehicle

Travel Speed	Passenger Car	Small Bus	Large Bus	Small Truck	Large Truck
10 km/h	292.0	340.6	1,044.8	733.8	1,231.0
20 km/h	233.5	301.4	924.5	648.5	1,011.0
30 km/h	211.9	283.7	870.5	605.1	882.1
40 km/h	203.0	274.7	842.7	581.1	804.5
50 km/h	200.7	271.0	831.3	569.9	765.7
60 km/h	201.3	270.5	829.8	567.2	753.9

Source: JICA Study Team based on related studies by AGEROUTE, such as "Etude Economiques de la Rehabilitation des Troncons Routiers Nioro-Keur Ayip (RN4) et Passy-Sokone (RN5) (2010)" and "Eude sur les Couts et Conditions d'Exploitation des Vehicules de Transport Public de Voyageurs au Senegal Pour une Tarification Optimale" (2014).

(2) TTC

Savings in travel time costs are based on the assumption that saving time would be used for other productive activities. The unit price (or average hourly output) of the other activities is estimated for a passenger by the type of vehicle and working/non-working hours. Table 13.9.5 shows the travel time costs.

Table 13.9.5 Travel Time Costs

Item		Unit	Passenger car	Bus
Unit price of passenger	Working hours	FCFA/hour/person	626.2	313.1
	Nonworking hours	FCFA /hour/person	187.9	93.9
	% of workers to total passenger	%	30	30
	Average price (a)	FCFA /hour/person	319.4	159.7
Average number of passengers *(b)		Person/car	2.5	30
Travel time cost (c) = (a) X (c)		FCFA /hour/car	798.4	4,790.4

Source: JICA Study Team.

13.9.5 Estimate of the Economic Internal Rate of Return

Based on the costs and benefits calculated as explained above, the EIRR and the ENPV at a discount rate of 12% has been calculated, as Table 13.9.6 shows.

The results of the several alternatives of the project are judged economically viable as the calculated EIRR exceeds 12%, which is considered to be a threshold to judge the project viability in developing countries.

The benefit-cost streams of the main alternatives are given in Appendix B.2.

Table 13.9.6 EIRR and ENPV by the Alternatives

	Sub-projects/Alternatives	EIRR (%)	ENPV (FCFA million)	Remarks
I-06a	A flyover at the intersection of NR1	17.4	3,859	
I-06b	An underpass at the intersection of NR1	9.1	-3,704	
I-06c	Installation of traffic signals at the intersection of NR1	83.1	300	Project life: three years Opening: 2018
I-07(1)	Improvement at the intersection of Rufisque Road	49.9	953	Opening: 2018
I-07(2)	Improvement of access through PTB station entrance	34.2	411	Opening: 2018
I-08a	Widening of the access road to four lanes (reconstruction of the bridge)	10.2	-1,305	
I-08b	Widening of the access road to four lanes (both sides of the bridge)	23.3	3,954	
I-08c	Widening of the access road to four lanes (one side of the bridge)	26.3	4,440	
I-08d	One-way traffic control on the access road	N.A.	-5,149	Opening: 2018
I-09(1) a	Direct motorway on-ramp from the terminal (Option 1 North)	42.7	1,014	
I-09(1) b	Direct motorway on-ramp from the terminal (Option 2 South)	5.2	-1,225	
I-09(2)	Direct motorway off-ramp to the terminal	N.A.	-7,268	

Source: JICA Study Team.

13.9.6 Sensitivity Analysis

A sensitivity analysis has been conducted on the EIRR by changing the conditions with the variation on economic benefits and costs, and the results are shown in Table 13.9.7. Table 13.9.7 indicates the sensitivity analysis results of the main alternatives, with EIRRs more than 12%. The results indicated that, in any case, the EIRR value would exceed 12%.

Table 13.9.7 Sensitivity Analysis of EIRR

I-06a A Flyover at the Intersection of NR1

		Benefits				
		80%	**90%**	**100%**	**110%**	**120%**
Costs	**120%**	13.2%	14.3%	15.4%	16.4%	17.4%
	110%	14.0%	15.2%	16.3%	17.4%	18.4%
	100%	15.0%	16.2%	17.4%	18.5%	19.5%
	90%	16.1%	17.4%	18.6%	19.7%	20.8%
	80%	17.4%	18.7%	20.0%	21.2%	22.4%

T-06c Installation of Traffic Signals at the Intersection of NR1

		Benefits				
		80%	**90%**	**100%**	**110%**	**120%**
Costs	**120%**	45.3%	55.1%	64.7%	74.0%	83.1%
	110%	52.5%	62.9%	73.1%	83.1%	92.8%
	100%	60.9%	72.1%	83.1%	93.8%	104.3%
	90%	70.9%	83.1%	95.0%	106.6%	118.1%
	80%	83.1%	96.5%	109.5%	122.3%	134.9%

I-07(1) Improvement at the Intersection of Rufisque Road

		Benefits				
		80%	**90%**	**100%**	**110%**	**120%**
Costs	**120%**	34.9%	38.7%	42.4%	46.2%	49.9%
	110%	37.6%	41.7%	45.8%	49.9%	54.0%
	100%	40.9%	45.4%	49.9%	54.4%	58.8%
	90%	44.9%	49.9%	54.9%	59.8%	64.7%
	80%	49.9%	55.5%	61.1%	66.6%	72.1%

I-07(2) Improvement of Access Through PTB Station Entrance

		Benefits				
		80%	**90%**	**100%**	**110%**	**120%**
Costs	**120%**	23.9%	26.6%	29.1%	31.7%	34.2%
	110%	25.8%	28.7%	31.5%	34.2%	37.0%
	100%	28.1%	31.2%	34.2%	37.3%	40.3%
	90%	30.8%	34.2%	37.6%	40.9%	44.3%
	80%	34.2%	38.0%	41.8%	45.5%	49.2%

I-08b Widening of the Access Road to Four Lanes (Both Sides of the Bridge)

		Benefits				
		80%	**90%**	**100%**	**110%**	**120%**
Costs	**120%**	17.3%	18.9%	20.4%	21.9%	23.3%
	110%	18.5%	20.2%	21.8%	23.3%	24.7%
	100%	19.8%	21.6%	23.3%	24.9%	26.4%
	90%	21.4%	23.3%	25.0%	26.7%	28.3%
	80%	23.3%	25.3%	27.1%	28.9%	30.6%

I-08c Widening of the Access Road to Four Lanes (One Side of the Bridge)

		Benefits				
		80%	**90%**	**100%**	**110%**	**120%**
Costs	**120%**	19.8%	21.5%	23.2%	24.8%	26.3%
	110%	21.1%	22.9%	24.6%	26.3%	27.9%
	100%	22.5%	24.5%	26.3%	28.0%	29.7%
	90%	24.3%	26.3%	28.2%	30.1%	31.8%
	80%	26.3%	28.5%	30.5%	32.5%	34.3%

I-09(1) Direct Motorway On-ramp from the Terminal

		Benefits				
		80%	**90%**	**100%**	**110%**	**120%**
Costs	**120%**	33.4%	35.9%	38.3%	40.5%	42.7%
	110%	35.2%	37.9%	40.3%	42.7%	44.9%
	100%	37.4%	40.1%	42.7%	45.1%	47.5%
	90%	39.8%	42.7%	45.4%	48.0%	50.4%
	80%	42.7%	45.7%	48.6%	51.2%	53.8%

Source: JICA Study Team.

13.10 Environmental and Social Considerations

13.10.1 Present Environmental and Social Conditions

(1) Physical Conditions

The geology of the region of Dakar usually belongs to one of the following geological formations:

- Volcanic rocks of Tertiary and Quaternary (head of the peninsula)
- Quaternary deposits (Niayes zones)
- Limestone and marl of the Middle Eocene (Tertiary and Secondary) (the rest of the Dakar region)

Continental dunes occupy most of the region of Dakar and the soil is poor in terms of organic material, and is subject to wind erosion and run-off water.

The synthesis of the different pedological studies undertaken in the Cap Vert peninsula show the existence of four main types of soils:

- Undeveloped mineral soils at the level of the white dunes
- Hydromorphic clay soils or sand-clay soils or "deck" soils
- Sandy ferruginous tropical soils slightly leached or "Dior"
- Saline soils

(2) Biological Conditions

The areas that are concerned with the project are artificialized and do not have flora or an ecosystem.

(3) Social Conditions

The Bountou Pikine intersection, the intersection of the NR1 and the access road belong to Dalifort commune, with a population of 30,418, Pikine Department.

The area around the Bountou Pikine intersection is busy with dense traffic. There is neither a residential area nor sensitive infrastructure, such as clinics or schools, in the neighborhood.

(4) Air Quality

Two air samples (one near the Bountou Pikine intersection and one on the access road) were taken and analyzed for SOx, NOx, PM 2.5 and PM 10. The results are shown in Table 13.10.1 and Table 13.10.2. The air quality standards of WHO and Senegal are shown in Table 13.10.3.

Table 13.10.1 Concentration of NOx and SOx at and near the Bountou Pikine Intersection

		NOx	NO	SO2
Bountou Pikine	At the intersection	5ppm or 10.28 mg/m³	5 ppm or 6.7mg/m³	< 1 ppm
	On the access road	2 ppm or 4.11 mg/m³	2ppm or 2.68 mg/m³	< 1 ppm

Source: Prestige Cabinet Council.

As for NO_2, the measured values highly exceed the WHO hourly standard, 40-50μg/m^3 or 0.04 mg/ m^3, in both sites. The SO_2 concentrations did not exceed 1 ppm and, therefore, could not be detected because of the limit of the analyzer. However, this does not mean that levels lower than 1 ppm do not cause health problems, as the daily standard of both WHO and NS-05-62 of Senegal is 125 ug / m^3 or 0.125 mg / m³.

Table 13.10.2 Concentration of PM 2.5 and PM10 at and near the Intersections

Measurement Site		Concentration of PM 2.5 (μg/m³)	Concentration of PM 10 (μg/m³)
Bountou Pikine	At the intersection	11.89	54.26
	On the access road	35.81	74.03

Source: Prestige Cabinet Council.

As for PM 2.5, the value is higher than the WHO daily standard, 10μg/m3, at both sites. As for PM 10.0, the values are higher than the WHO daily standard, 20μg/m3, at both measurement sites.

A remarkable point is that the concentration is higher on the access road than at the intersection, for both PM 2.5 and PM 10. This means that the pollution observed on the access road is not necessarily due to traffic volume and it may be caused by other factors.

Table 13.10.3 Standards for Key Pollutants

Pollutant		**Maximum Value Limit**	
		WHO Instructions	**NS-05-62 (Senegal)**
Sulphur dioxide (SO2) (in μg/m3)	Annual	500	-
	Daily	125	125
	Hourly	50	50
Nitrogen dioxide (NO2) (in μg/m3)	Annual	200	200
	Hourly	40-50	40
Particles <2.5 μm (PM2.5) (in μg/m3)	Annual	25	-
	Daily	10	-
Particles <10μm (PM10) (in μg/m3)	Annual	50	260
	Daily	20	80
(For reference only)			
(O3) (in μg/m3)	Hourly	150-200	-
	8 hours	120	120
Carbon monoxide (CO) (in μg/m3)	Hourly	30 000	-
	8 hours	10 000	30 000 (24h)

Source: WHO and NS-05-62 (Senegal regulation).

The noise and vibration were measured at the same sites as air and the results are shown in Table 13.10.4. As for noise, the maximum thresholds are 55-60 dB, so the noise levels of both sites exceed the thresholds.

Table 13.10.4 Noise and Vibration at and near the Intersections

Measurement Site		Noise (dB)	Vibration (dB)
Bountou Pikine	At the intersection	67.9	73.6
	On the access road	79.6	81.9

Source: Prestige Cabinet Council.

(5) Groundwater Quality

(Please refer to 12.10.1 (5)).

13.10.2 Related Laws and Regulations

(Please refer to 12.10.2).

13.10.3 Studies on Alternatives

The alternatives for the improvement plan of each component are compared from environmental and social perspectives.

For the NR1 intersection improvement, there are two alternatives – the flyover and underpass. The construction period for the flyover alternative is shorter, therefore the period of nuisance and inconvenience caused by the project is also shorter. This is an advantage for nearby residents. Needless to say, it is desirable to reduce the number of buildings to be resettled and this point is always considered when alternatives are prepared.

The alternative I-09(1)b for the on-ramp to the motorway may involve compensation for the private land to be used for the on-ramp construction, while the alternative I-09(1)a will not have such an issue.

It is anticipated that, during construction, there will be no differences in the environmental impact of the three alternatives for the bridge expansion for the access road to the Baux Maraîchers bus terminal (I-08a, I-08b, I-08c). Although the one-way traffic control solution would reduce the negative environmental impact on the access road area, the overall impact, including the surrounding area, would be greater, taking into consideration that there would be long detours for Northbound traffic.

As for the 'without project' case, no cost and no impact by the project are anticipated. However, the conditions of difficulty of movement will continue, resulting in the loss of time and energy, as well as worsening environmental conditions such as air quality and noise.

13.10.4 Scoping

The scoping results are shown in Table 13.10.5. The items evaluated as B- or C were included in the TOR for the IEE.

Table 13.10.5 Scoping Results

	Item	Evaluation		Reason
		CP	OP	
Pollution				
1	Air pollution	B-	D	CP: There may be pollution to some extent because of equipment operation. OP: No additional air pollution is expected because traffic is improved.
2	Water pollution	B-	D	CP: There may be pollution to some extent because of equipment operation. OP: There is no pollution source.
3	Waste	B-	D	CP: Waste soil or waste material may occur. OP: There is no pollution source.
4	Soil contamination	B-	D	CP: There may be pollution because of oil spill. OP: There is no pollution source.
5	Noise and vibration	B-	D	CP: There may be some noise and vibration because of equipment operation. OP: No additional noise and vibration is expected.
6	Ground subsidence	D	D	Construction work that may cause ground subsidence is not included.
7	Offensive odor	D	D	Construction work that may cause offensive odor is not included.
8	Bottom sediment	D	D	No river system is included in and around the projects.
Natural Environment				
9	Protected area	D	D	There is no protected area in and around the projects.
10	Flora, fauna and biodiversity	D	D	There is no flora or fauna.
11	Hydrological situation	D	D	There is no hydrological system nearby.
12	Topography and geographical features	D	D	Large change to topography and geographical features is not planned.
Social Environment				
13	Involuntary resettlement and land acquisition	B-	B-	Several buildings (mainly business entities) may be resettled.
14	Poor people	D	D	There are no activities to affect them.
15	Indigenous and	D	D	There are no indigenous and ethnic people nearby.

	Item	Evaluation		Reason
		CP	OP	
	ethnic people			
16	Local economy such as employment and livelihood, etc.	B+	B+	CP: There may be positive impact because of inflow of workers. OP: There may be positive impact on local economy because people can save time due to reduced traffic congestion.
17	Land use and utilization of local resources	C	C	Part of land use may be restricted.
18	Water use	D	D	There will be no activities that may affect this item.
19	Social infrastructure and social service	D	D	There will be no activities that may affect this item.
20	Social institutions such as local decision making system, etc.	D	D	There will be no activities that may affect this item.
21	Misdistribution of benefit and damage	C	C	There may be misdistribution because beneficiaries are car users from outside, not the nearby residents.
22	Local conflict of interests	C	C	There may be conflict because limited people will be negatively affected.
23	Cultural heritage	D	D	There is no cultural heritage in and around the project area.
24	Landscape	D	B+	CP: Landscape is changed but not always worse. OP: Landscape will be improved because of less traffic congestion.
25	Gender	D	D	There will be no activities that may affect this item.
26	Children's rights	D	D	There will be no activities that may affect this item.
27	Hazards (risk) Infectious diseases such as HIV/AIDS	C	C	Senegal has low rate of HIV/AIDS, but impact not known.
28	Working conditions including security for workers	B-	D	CP: Working conditions may be bad, if proper consideration is not made. OP: There are no construction workers, though limited number of maintenance staff work.
29	Accidents	B-	B+	CP: There may be accidents, if the proper consideration is not given. OP: Traffic accidents may be reduced because of smooth transportation.
30	Impacts on broad area; climate change	D	D	Construction work is limited to part of the roads and not large. Therefore, no impact is expected.

Note: A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: Extent of positive/negative impact is unknown (a further examination is needed, and the impact could be clarified as the Study progresses).
D: No impact is expected.
CP: Pre-construction and construction period.
OP: Operation period.

Source: JICA Study Team.

13.10.5 Anticipated Environment Impact

The following negative impacts can be anticipated. These are common among the three intersections.

(1) Before and During Construction

1) Air

- Dust by soil excavation, land clearance and ground leveling pollutes air environment.
- Pollution is caused by emissions from transportation in soil excavation, land clearance, ground leveling, etc., from the working equipment and machinery.
- The main pollutants are SOx, NOx, CO, etc.

2) Water

- Waste water is generated from the cleaning and maintenance of the machinery. The main pollutants are COD, oil and grease, and SS.
- Human waste is generated by the workers' use of toilets.
- Domestic waste water is generated by the workers.
- The main pollutants are BOD5, COD, SS, NH3 N and P.
- If not treated properly, these kinds of waste water may pollute soil and groundwater.

3) Waste

- Construction waste, such as pebbles, sand, cement, wood, and paint, etc., is generated in the construction site.
- Hazardous solid wastes are generated including oil, grease, glue, paint, paint containers, gasoline and batteries. Judging from some practical experience, hazardous solid waste occupies about 5% of construction waste.

4) Soil

- Waste water, washing waste water from washing of equipment and waste raised above may contaminate the soil.

5) Noise and Vibration

- Ground leveling, soil excavation and construction work generate noise through the operation of heavy equipment. Generally, noise (8 m distance from the site) is estimated to be 86-98 dB and the acceptable level is about 60 dB. If no measures are taken, the noise will cause discomfort to the nearby residents.
- The vibration sources are heavy machinery and vehicles, such as bulldozers, trucks, etc., and the vibration level of all kinds of machinery is estimated as 64-71 dB at the point 30m away from the sources. The general standard is 75 dB.

6) Involuntary Resettlement and Land Acquisition

- Three business entities or residences are required to be resettled at the NR1 intersection under the most probable plan at present.
- The survey on land ownership is not covered by the IEE because it is judged to be carried out when the design is finalized.

7) Social Infrastructure

- Excavation may disrupt the underground infrastructure, such as electric cables, telegraphic wires, water pipes or sewerage pipes, provided by SDE, SENELEC and SONATEL, etc., resulting in inconvenience for the nearby residents.
- The mobility for motorists, cyclists and pedestrians may be reduced because of traffic overload on alternative ways and detours.

8) Misdistribution of Benefit and Damage

- Beneficiaries are mainly car users. They can drive more comfortably and can save time.

- On the other hand, the residents may suffer from inconvenience due to road closure, the partial loss of business activities, air/noise pollution and other negative impacts during the construction period.

9) Risk of Infectious Diseases (HIV/AIDS)

- There may be the appearance and spread of STDs as a consequence of the arrival of workers and their interactions with the communities.

10) Working Conditions Including Security for Workers

- If the working environment is bad or some of the workers neglect the working rules, it can cause fatigue, dizziness, etc., while working.

11) Accidents

- The number of vehicles going in and out of the construction area will be increased, which may increase traffic accidents.
- Accidents may be caused due to the negligence of workers, lack of protective equipment or lack of awareness of the strict compliance with the safety rules of construction workers.

(2) During Operation

Involuntary Resettlement and Land Acquisition

- The quality of life of the people who are resettled may be worsened if the proper compensation and rehabilitation is not carried out.

(3) Summary of the Project's Impact

The anticipated impact can be summarized as shown in Table 13.10.6.

Table 13.10.6 Summary of Anticipated Impacts

	Item	Evaluation		Description of Impact
		CP	OP	
Pollution				
1	Air pollution	B-	D	CP: Pollution is caused from working equipment and machinery. OP: No additional air pollution is expected because traffic is improved.
2	Water pollution	B-	D	CP: Waste water is generated from the cleaning and maintenance of machinery and human activities. OP: There is no pollution source.
3	Waste	B-	D	CP: Construction waste is generated, part of which is hazardous waste. OP: There is no pollution source.
4	Soil contamination	B-	D	CP: Waste water and waste may contaminate soil. OP: There is no pollution source.
5	Noise and vibration	B-	D	CP: Construction work causes noise and vibration. OP: No additional noise and vibration is expected.
Social Environment				
6	Involuntary resettlement and land acquisition	B-	B-	CP: Some business entities or residences are required to be resettled. Some street occupants are required to be moved. OP: The quality of life of the people who are resettled may be worsened.
7	Social infrastructure	B-	D	CP: Electric cable, telegraphic wire, water pipe, etc., may be disrupted, resulting in inconvenience. Mobility is reduced in detours. OP: There is no impact after construction.
8	Misdistribution of benefit and damage	B-	D	CP: Residents may suffer from inconvenience, loss, etc. OP: Residents do not suffer from inconvenience, loss, etc.
9	Local conflict of interests	D	D	Judging from similar works in Dakar, it is not expected.
10	Risk of infectious diseases (HIV/AIDS)	B-	D	CP: Sexually transmitted diseases (STDs) may be brought by the workers. OP: There are no construction workers.
11	Working conditions including security for workers	B-	D	CP: It may cause fatigue, dizziness, etc., if working conditions are bad. OP: There are no construction workers, though limited number of maintenance staff work.
12	Accidents	B-	B+	CP: Construction vehicles may increase traffic accidents. Accidents may be caused due to the negligence of workers. OP: Traffic accidents may be reduced because of smooth transportation.

Note: A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
D: No impact is expected.
CP: Pre-construction and construction period.
OP: Operation period

Source: JICA Study Team.

13.10.6 Proposed Mitigation Measures

Mitigation measures to be taken against the anticipated negative impacts described above are explained below. The contractor of the construction work is responsible for all of the measures and is required to implement them all.

(1) Before and During Construction

1) General

- Conducting training sessions for all of the workers before starting work on the site to raise awareness of the environmental and social management, and to sensitize the personnel of the contractor.
- Tailoring the contents of the above-mentioned training for each target group.
- Sensitizing the surrounding communities, including nearby public institutions (schools, health centers, water points, etc.), and common places (markets, places of worship, etc.)

2) Air

- Limiting the speed of trucks that are involved in transporting the materials to 30 km /h.
- Spraying the work surfaces and deviations of areas.
- Proceeding with trucks with tarpaulin carrying materials, such as laterite, sand and gravel, to minimize the dispersion of fines.
- Supplying dust masks to site staff.
- Giving information and prior sensitization of the local population.
- Raising awareness of truck drivers for a smooth discharge of materials.

3) Water

- Establishing mobile toilet facilities in the yards.
- Providing a paved area for the washing and maintenance of gear with an oil separator.

4) Waste

- Collecting waste separately by type and value (form boards falls, iron scrap, etc.).
- Preparing a special yard of waste to be delivered by an approved company for treatment.
- Storing hazardous substances in sealed containers in secure storage areas to be protected.
- Handling hazardous substances under constant surveillance.
- Collecting hazardous waste (waste oil, used batteries, oil filters, contaminated rags, etc.) in sealed containers and storing them in paved areas that are protected from the weather, to be treated later by a licensed treatment company.

5) Soil

- Providing a paved area for the washing and maintenance of gear with an oil separator.
- Storing the oil products on a concrete pad to minimize all forms of degradation and pollution of soil and groundwater.

6) Noise and Vibration

- Installing noise isolation devices into the machines with high noise levels such as excavators, compressors, excavator, etc.
- Using appropriate noise protection gears (helmet, ear plugs) to avoid the noise impact to the workers.

7) Involuntary Resettlement and Land Acquisition

- Holding consultations with the owners/users of the buildings to be resettled, explaining what kinds of compensation and rehabilitation support can be provided.
- Holding consultations with the vendors and other stakeholders, showing what kinds of compensation can be (or cannot be) provided.

8) Social Infrastructure

- Making efforts to reduce the impact on the residents with coordination with related organization such as SDE, SENELEC and SONATEL, etc., resulting in inconvenience for the nearby residents.
- Arranging the layout and operation of alternative ways and detours to not affect the mobility of the people.
- Explain the alternative ways and detours asking for residents' understanding.

9) Risk of Infectious Diseases (HIV/AIDS)

- Raising awareness of construction workers and other related people.

10) Misdistribution of Benefit and Damage

- Holding stakeholder meetings with the nearby residents, providing all of the information, such as the schedule, kinds of anticipated impacts, and asking for their understanding and cooperation.
- Providing compensation or solatium for their loss or inconvenience.

11) Working Conditions Including Security for Workers

- Equipping the workers with suitable safety equipment (safety shoes, helmets, face masks and earmuffs, gloves, etc.).
- Training workers about workplace safety in construction.

12) Accident

- Keeping a proper work schedule to avoid fatigue.
- Training workers about workplace safety in construction.

(2) During Operation

Involuntary Resettlement and Land Acquisition

- Regularly conducting monitoring as scheduled and taking prompt actions if improper conditions are found.

13.10.7 Proposed Monitoring Plan

Monitoring the measures to be taken against the anticipated negative impacts described above is explained in Table 13.10.7. A consultant hired by the project owner can conduct the monitoring. The project owner will be responsible for all of the monitoring results and can instruct the contractor to improve the way that the mitigation measures are conducted, if a problem is found in the monitoring results.

Table 13.10.7 Monitoring Plan

Environmental Item	Method of Monitoring (with index, if any)	Monitoring Place	Frequency
Pre-construction and Construction Period			
Air pollution	To check whether the respective mitigation measures are followed or not	Construction site	Once/week (irregularly)
Water pollution	-	-	-
Waste	To check whether respective mitigation measures are followed or not.	Construction site	Once/week (irregularly)
Soil contamination	To check whether respective mitigation measures are followed or not.	Construction site	Once/week (irregularly)
Noise and vibration	To check whether respective mitigation measures are followed or not.	Construction site	Once/week (irregularly)
Involuntary resettlement	As the ARAP, to be prepared, requires (stakeholder meetings, interviews etc. may be used)		
Social infrastructure	To have opportunities to hear residents' opinions/requests/grievances on the project through meetings/interviews as often as possible		
Misdistribution of benefit and damage	To have opportunities to hear residents' opinions/requests/grievances on the project through meetings/interviews as often as possible		
Risk of infectious diseases	To check that the education program is properly held	Construction site	When construction starts and once/twice a month
Working conditions including security for workers	To check whether the respective mitigation measures are followed or not	Construction site	Once/week (irregularly)
Accidents	a. To check whether the respective mitigation measures are followed or not b. To keep the records of accidents and analyze them to learn lessons	Construction site	Once/week (irregularly) Once/week (regularly)
Operation Period			
Involuntary resettlement	As the ARAP, to be prepared, requires (stakeholder meetings, interviews, etc. may be used)		

Note: ARAP: Abbreviated Resettlement Action Plan (to be prepared with F/S).
Source: JICA Study Team.

13.10.8 Resettlement Policy Framework

(1) General

The layout of the improvement plan for the intersection sometimes laps over part of the existing buildings, though efforts were made to avoid overlapping and to minimize the number of such buildings. Therefore, some buildings have to be moved.

There is one more group of people that have to be moved. They are the street vendors and street occupants on the walkways or ROW at and around the intersections. These people are not usually categorized as displaced people but this section includes them.

(2) Laws in Senegal

The laws in Senegal are as presented in Chapter 12.

(3) World Bank Manual and Guidelines

The World Bank Manual and Guidelines are as presented in Chapter 12.

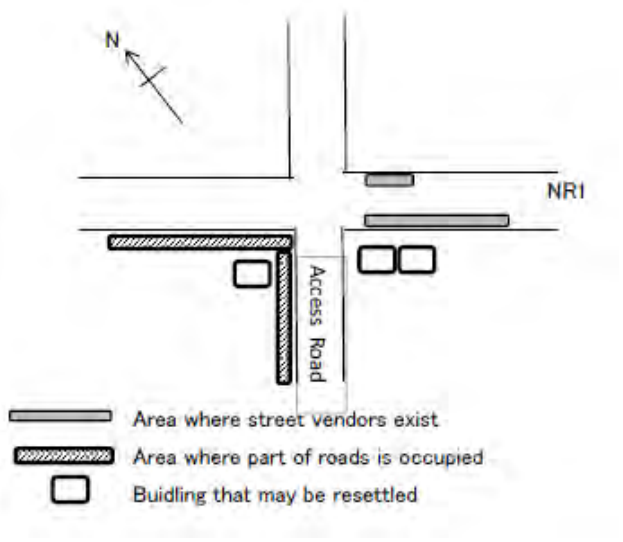
(4) Comparison of the Policies

The comparison made in Chapter 12 applies in the same manner.

(5) Present Conditions of the People to be affected

1) Owners/ Users of the Buildings to be resettled

At the present stage, it is estimated that three buildings are to be resettled. However, it should be noted that this estimation is based on readily accessible maps and is not always exact. The buildings concerned are commercial and business entities that are located at or near the corner of the NR1 intersection. These are all small-scale ones, therefore, the number of PAPs will not be big.



Source: JICA Study Team.

Figure 13.10.1 Rough Sketch of the Intersection

2) Street Vendors

Some street vendors exist on both of the sidewalks of NR1. The number of vendors is considered to be between 10 and 20.

3) Other Road Occupants

There are many furniture makers, wood traders, etc., around the intersection. Many of these shops occupy the road side in front of their own shops as their working places or storage, mainly at the South side of NR1 and West side of the access road.

The approximate locations of those above-mentioned buildings/areas are shown in Figure 13.10.1.

(6) Entitlement Matrix

The following entitlement matrix is proposed, considering all of the above conditions. The street vendors and the related people of the weekly market are not covered by OP 4.12. However, to have an amicable relationship, it is suggested that some kind of compensation is provided.

Table 13.10.8 Entitlement Matrix

Potential Impact	Categories of People	Compensation or Support to be Given	Law/Guidelines to be Based on
Land loss	- Individual person who owns the land that they occupy. - Legal entity that owns the same.	- Compensation of a property of the same value plus transaction fees or cash, depending on the market price. - Support for resettlement.	- The January 22nd, 2001 Constitution: - Law 76 – 67 of July 2nd, 1976 - Law n° 64 – 46 of June 17th, 1964. - Decree n° 64 – 573 of July 30th, 1964 - Law 76 – 66 of July 2nd, 1966 - Decree n° 81 – 557 of May 21st, 1981. - Decree 91-838 of August 22nd 1991
Facility Loss	- Individual person who owns a fixed facility (e.g., building, shop, warehouse, billboard). - Legal entity that owns the same.	- Compensation of a structure of equal value or in cash at the replacement cost without depreciation. - Support for resettlement.	- The January 22nd, 2001 Constitution. - Law 76 – 67 of July 2nd, 1976 - Law n° 64 – 46 of June 17th, 1964 - Decree n° 64 – 573 of July 30th, 1964 - Law 76 – 66 of July 2nd, 1966 - Decree n° 81 – 557 of May21st, 1981 - Decree 91-838 of 22sdAugust 1991
Income Loss (formal sector such as shop owner)	- Individual person who occupies a business place, or losing their income source. - Legal entity who occupies a business place, or losing their income source (local authorities, companies).	- Compensation for income loss for a period to be determined according to the impact severity and the estimated time necessary to recover the livelihood. - Support for resettlement.	- O.P 4.12 of World Bank.
Income Loss (informal sector such as street vendors)	- Vendor with an official site license. - Vendor without an official site license.	- Alternative site and compensation. - Alternative site or transition allowance.	- Involuntary Resettlement Sourcebook, WB.

Source: JICA Study Team.

As for the road occupants, mainly furniture shops, a survey on landownership of the occupied land should first be carried out. If it belongs to the furniture shops (in this case, they are not occupants), legally-defined procures of land acquisition and resettlement will be taken. If the land belongs to AGEROUTE, the occupants will be asked to give over the land. However, in this case, provision of an alternative site is not appropriate. Therefore, meetings among stakeholders will be required if a kind of compensation or solatium will be given to them.

13.10.9 Consultation with Stakeholders

Consultation with the stakeholders, mainly relevant governmental agencies and municipalities shown below, was held. Their main views are summarized in Table 12.9.10.

- DUA
- CETUD
- DTT

- Municipality of Pikine

Table 13.10.9 Summary of Opinions of the Relevant Organizations

Concern	Expectation/Recommendation
- Traffic disruption and the change of habits of users whose movements will be made more difficult during the construction. - Income loss of street workers due to their relocation (service stations, canteens, wood sellers, aprons and window dresser, car parks, etc.). - Loss of tax income that were paid because of the occupation of public roads. - Impact on "Paak Lambaye" (main market for wood in Dakar), located near NR1 intersection. - Probable flood, if the work takes place in the rainy season. - Nuisances related to noise and dust that are likely to disturb the local residents settled on the edge of the ROW. - Presence of large machines during construction.	- Integrate technical options that are more consistent with the standards of road development. - Analyze the impact on the entry and exit movements of Dakar. - Take public transportation into account. - Involve LTD in the planning process. - Endeavor to shorten the duration of works. - Develop traffic plans that allow accessibility to commercial and industrial structures in the area. - Consider phasing the work by area to avoid locking up all access roads. - Avoid working during the rainy season, as the department of Pikine is very vulnerable to flooding. - Consider relocating those who lose business places, and provide decent compensations to rights holders. - Work with the City of Pikine, Dalifort town, Pikine West town and Pikine East town throughout the whole process as Baux Maraîchers bus station is located in the Municipality of Dalifort, but the access roads are in Pikine West town and Pikine East town. - Cooperate with the Town Council of Pikine to explore the possibility of enhancing the existing municipal area to use it as a temporary resettlement site.

Consultation with the nearby residents or business people has not been held so far. The consultation with these people should be done in an appropriate manner in the next step in cooperation with AGEROUTE, the organization that is supposed to be the proponent of the project.

13.10.10 Further Steps

The further steps presented in Chapter 12 apply in the same manner.

13.11 Prioritization of the Sub-projects

13.11.1 Evaluation Method

For the prioritization of the following six sub-projects around Baux Maraîchers bus terminal, a weighted point system or a multi-criteria analysis is applied for the evaluation of the sub-projects:

- I-06: Improvement at the intersection of NR1 (I-06a: Eastwest flyover),
- I-07(1): Improvement at the intersection of Rufisque Road,
- I-07(2): Improvement of access from Rufisque Road through PTB station entrance,
- I-08: Widening of the access road to four lanes (I-08c: new bridge on one side),
- I-09(1): Direct motorway on-ramp from the terminal (I-09(1)a: Option 1), and
- I-09(2): Direct motorway off-ramp to the terminal.

As with the prioritization of the sub-projects of the intersection improvement, the evaluation should consider multiple viewpoints such as existing development policies, urgent need, the economic feasibility of the investment, the scale of the sub-projects and consideration of the construction conditions including the environment. The same criteria are set forth and grouped into three major aspects: namely, necessity, effectiveness and construction conditions.

13.11.2 Multi-criteria Analysis

The criteria for prioritization have been fully described earlier in Section 12.10.2. In particular, this section includes differences in the definition for the criteria under each aspect.

(1) Necessity (total 50 points)

First, the sub-projects where roads have been included as part of a necessary project in PDUD 2025 or the sub-projects that have been studied to some extent should be given points (10 points, respectively).

Then, the score in terms of the local traffic problems is further divided into the following three quantitative indicators, each of which has a total of 10 points:

- Average speed (km/h): points calculated with a scale of 10 steps from the maximum value (0 point) down to the minimum value (10 points) of the average speeds in the two directions on the main roads observed at midday.
- Daily occurrence of traffic congestion (times / day): points calculated with a scale of 10 steps from zero up to the maximum value (10 points) of the number of occurrences of traffic congestion that is defined as a queue length of 100 meters or longer observed on the main roads at every hour.
- Degree of saturation: points calculated with a scale of 10 steps from zero up to the maximum value (10 points) of the degree of saturation, based on the daily directional traffic volumes observed at the intersection or on the main road. No points are given if the degree of saturation is less than 1.0.

For the evaluation of the sub-projects of direct motorway on- and off-ramps from/to the terminal (I-09) in terms of necessity, the aforementioned main road refers to the access road between NR1 and Rufisque Road. This is because the primary objective is to establish smoother access between the bus terminal and motorway by avoiding the traffic on the existing access road.

(2) Effectiveness (total 50 points)

As a proxy for the population of beneficiaries, the total traffic volume observed for 16 hours at each intersection may be used as an indicator of effectiveness, of which the points are calculated with a scale of 10 steps from zero up to the maximum value (20 points).

Furthermore, the sub-projects are measured by an indicator of an EIRR, of which the points are calculated with a scale of 10 steps from zero up to the maximum value or 30% (smaller of the two) (20 points).

In addition, the construction cost is also included as a criterion under effectiveness. The points are calculated with a scale of 10 steps from the maximum value (0 points) down to the minimum value (10 points) of the construction cost.

(3) Construction Conditions (total 20 points)

In order to consider the facility of the construction, as well as acceptance by the citizens, a total of 20 points are allocated for the aspect of construction conditions, with a maximum of four points for each of the following five criteria:

- Construction period (months): points calculated with a scale of four steps from the maximum value (0 points) down to the minimum value (4 points);
- Noise and vibration: 0 points if it is heavy, 2 points if moderate and 4 points if rare.

- Households to be resettled: 0 points if the number is 50 or more, 2 points if it is 10 or more (and less than 50) and 4 points if it is less than 10.
- Aesthetic feature: 0 points if a structure is planned on the ground and 4 points if not.
- Maintenance: 0 points if heavy maintenance is required, 2 points if it is moderate and 4 points if rare.

13.11.3 Evaluation Result

The six sub-projects are evaluated and scored through the multi-criteria analysis, based on the above-mentioned quantitative and qualitative criteria, as shown in Table 13.11.1. The sub-projects have been ranked according to the score, and it is assumed that projects with the higher total scores shall be prioritized. For earlier completion of the prioritized projects, it is hoped that the target implementation years will be properly scheduled and the necessary preparations will be started as soon as possible.

Table 13.11.1 Evaluation Result: Traffic Improvement Project Around Baux Maraîchers Bus Terminal

Sub-Projects			Necessity (score = 50)										Sub Total
Location or Item	Authority	Structure	Part of the Project Road in PDUD2025*		Existing Study		Average Speed [km/h]		Daily Occurrence of Traffic Congestion		Degree of Saturation		
			score =	10	score =	10	score =	10	score =	10	score =	10	50
I-06. Improvement at the intersection of NR1	AGEROUTE	FO	+	10	+	10	13.1	10	17	10	2.1	10	50
I-07(1). Improvement at the intersection of Rufisque Road	AGEROUTE	At-grade	+	10		0	20.8	0	4	2	0.8	0	12
I-07(2). Improvement of access through PTB station entrance	CETUD	At-grade		0		0	20.8	0	4	2	0.8	0	2
I-08. Widening of the access road to four lanes	AGEROUTE	At-grade + bridge		0		0	13.9	9	10	6	1.2	6	21
I-09(1). Direct motorway on-ramp from the terminal	AGEROUTE	At-grade		0	+	10	13.9	9	10	6	1.2	6	31
I-09(2). Direct motorway off-ramp to the terminal	AGEROUTE	FO		0	+	10	13.9	9	10	6	1.2	6	31

* CETUD's latest transportation master plan.

Sub-projects	Effectiveness (score = 50)						Sub Total
Location or Item	Traffic Volume [PCU/16 hrs]		Construction Cost [Billion FCFA]		EIRR [%]		
	score =	20	score =	10	score =	20	50
I-06. Improvement at the intersection of NR1	42,398	20	10.1	0	17.4	12	32
I-07(1). Improvement at the intersection of Rufisque Road	22,905	11	0.4	10	49.9	20	41
I-07(2). Improvement of access through PTB station entrance	22,905	11	0.3	10	34.2	20	41
I-08. Widening of the access road to four lanes	12,191	6	4.6	6	26.3	14	30
I-09(1). Direct motorway on-ramp from the terminal	12,191	6	0.4	10	42.7	18	36
I-09(2). Direct motorway off-ramp to the terminal	12,191	6	1.4	9	-	0	15

Sub-projects	Construction Conditions (score = 20)										Sub Total	Total Score	Overall Ranking
Location or Item	Construction Period		Noise and Vibration		Resettlement Households		Aesthetic Feature		Maintenance				
	Score =	4	Score =	4	Score =	4	Score =	4	Score =	4	20	120	
I-06. Improvement at the intersection of NR1	24	2	Moderate	2	2	4	FO	0	Moderate	2	10	92	1
I-07(1). Improvement at the intersection of Rufisque Road	3	4	Rare	4	0	4	At-grade	4	Light	4	20	73	3
I-07(2). Improvement of access through PTB station entrance	3	4	Rare	4	0	4	At-grade	4	Light	4	20	63	5
I-08. Widening of the access road to four lanes	18	2	Moderate	2	25	2	Widening	4	Light	4	14	65	4
I-09(1). Direct motorway on-ramp from the terminal	6	3	Rare	4	0	4	At-grade	4	Light	4	19	86	2
I-09(2). Direct motorway off-ramp to the terminal	18	2	Rare	4	0	4	FO	0	Moderate	2	12	58	6*

Note: * The sub-project will not have enough economic viability; FO – flyover, UP – underpass.
Source: JICA Study Team.

Thus, the intersection improvement with an East-West flyover at the intersection of NR1 (I-06a) has been identified as a sub-project of the highest priority for the improvement of the bus terminal. Higher scores, especially in terms of its necessity, including the urgency of the traffic problems around this intersection, have made this sub-project a top priority among the improvement alternatives for the bus terminal. While implementation should be under the authority of AGEROUTE, funding could be sought through international donors as it involves a considerable cost.

Secondly, the sub-project of the development of a direct motorway on-ramp from the terminal (I-09(1)a) takes second priority. This is mostly due to its higher scores in effectiveness and facility in construction. Then, the sub-project of improvement at the intersection of Rufisque Road (I-07(1)) takes third priority, followed by the sub-project of improvement of access from Rufisque Road through PTB station entrance (I-07(2)) and the sub-project of widening the access road to four lanes, including an additional bridge on a side (I-08c), in this order. Meanwhile, the sub-project of development of a direct motorway off-ramp to the terminal (I-09(2)) will not have enough economic viability and has been ranked lowest.

13.12 Conclusion and Recommendation

Out of the six sub-projects for traffic improvement around Baux Maraîchers bus terminal, the intersection improvement with an East-West flyover at the intersection of NR1 (I-06a) has been identified as the sub-project with the highest priority. Since this intersection has already been well over saturated, even under the current condition that a left-turn movement from NR1 to the access road is prohibited, the grade separation for East-West traffic has been proposed as the only solution for alleviating the traffic congestion. While the bus terminal is managed by CETUD, the implementation of this sub-project should be under the authority of AGEROUTE. Funding could be sought through international donors as it involves a considerable amount of the cost. Meanwhile, the following issues should be noted for implementation:

- There is a roundabout 350 meters to the East of the intersection, and merging between the flyover traffic and the side road traffic must be completed before the roundabout. This may result in slower traffic than the design speed.
- Though the currently prohibited left-turns from the East to the South will be permitted after the completion of this sub-project, the implementation of this sub-project may be even more effective with simultaneous implementation of widening the access road to four lanes (I-08c).

Then, the sub-project of the development of a direct motorway on-ramp from the bus terminal (I-09(1)a) is given second priority. It is a way out directly from the bus terminal to the motorway, and this sub-project is expected to bring great benefit to the intercity public transport by ensuring smooth traffic flow onto the motorway. While this on-ramp is dedicated to the public transport, sharing it with general traffic could be possible and it should be well discussed, along with its benefits and negative impact.

As for the sub-project of the improvement at the intersection of Rufisque Road (I-07(1)), which takes third priority, the at-grade improvement of the intersection with traffic signals is expected to increase the capacity of the intersection and secure the smooth traffic flow on Rufisque Road, which is an alternative route to the NR1 route. This will also enhance the safety around the intersection including the nearby railway crossing of which signalization should also be coordinated with this intersection. However, if frequent train operations become a hindrance to the vehicular traffic and its safety, the grade separation of this intersection and the railway will be necessary in the long run.

As for the sub-project of widening the access road to four lanes, including an additional bridge on a side (I-08c), though it takes fourth priority out of the six sub-projects for improvement of the access traffic to the bus terminal, it is expected to directly improve the access to the bus terminal by widening the access road, which has enough ROW. Furthermore, as mentioned earlier, it may be better to be implemented concurrently with the sub-project of the intersection improvement with an East-West flyover at the intersection of NR1 (I-06a) in order to achieve a multiplier effect. The issue may be the availability of the space for the additional bridge(s) over the motorway. While the reconstruction of the bridge (I-08a) would cost much more and hinder the traffic both on the motorway and the access road during the construction period, lower-cost options of an additional two-lane bridge on the East side of the existing one (I-08c) or additional one-lane bridges on both sides (I-08b) will need to acquire part of the private land that is outside the existing ROW. Though the former seems to involve less expropriation, further discussion may be necessary for the implementation of this sub-project.

The sub-project of the improvement of access from Rufisque Road through PTB station entrance (I-07(2)) takes fifth priority because of its relatively smaller number of beneficiaries, which are limited to local bus and taxi users. However, of all the six sub-projects, it has the highest score in terms of effectiveness, since a greater return on the investment could be expected and the cost is relatively small.

CHAPTER 14 COMPARATIVE ANALYSIS OF PROPER WASTE TREATMENT ALTERNATIVES FOCUSING ON WASTE-TO-ENERGY SYSTEM

14.1 Introduction

(1) Background

In the Study Area, several issues on solid waste management have been revealed. These issues correspond to the rapidly increasing urban population and waste amount. Since there have been no sanitary landfills until now, the current disposal sites are operated in an open-dumping way, which has caused serious social and environmental problems. The limitation of available lands is another issue to consider. It is not easy to identify a proper landfill site, as there has been strong opposition by the public to the Sindia landfill operation. Even if the operation of the Sindia landfill is recommenced, its lifespan is only estimated to be 15 years. These challenges have been reflected in the stronger needs of proper waste management, such as sanitary treatment and waste reduction in the Study Area. In this context, the JICA Study Team has analyzed various options of solid waste management, with a main focus on the potentiality of the Waste to Energy System as one of the solutions.

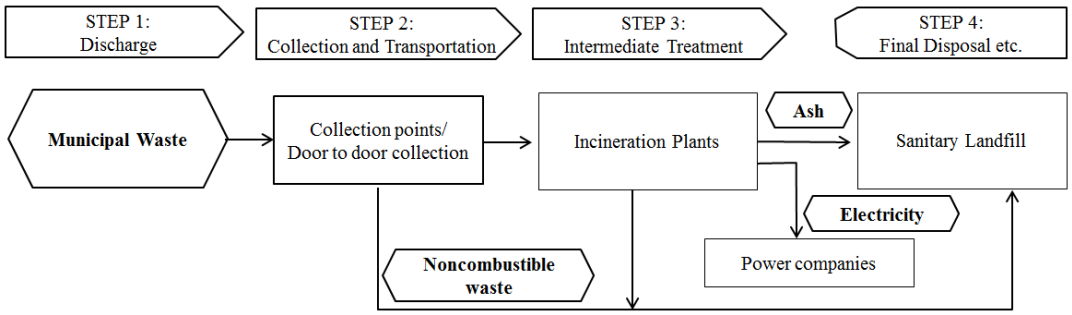
The Waste to Energy System, or incineration, has been widely adopted as an intermediate treatment, prior to the final disposal. The main advantages of incineration are listed as follows:

- Final disposal can be conducted in a more sanitary way.
- Significant reduction of waste volume can be attained. The lifespan of landfill sites can be prolonged significantly because the waste can be reduced by incineration to 10% in weight and approximately 5% in volume.

Under the process of incineration, flue gas with a large amount of thermal energy is produced. The Waste to Energy System is a method of producing electricity (and available heat) for the livelihood of municipal residents by the efficient recovery of the generated thermal energy in the gas in incineration plants. This method is different from conventional power plants. The primary role of incineration is the reduction of waste volume, while the electricity generation portion is subordinate.

However, the Waste to Energy System is very effective at increasing the investment efficiency for waste disposal and environmental protection by the installation of the equipment that provide additional value to the incineration plants.

The flow of the Waste to Energy System is shown in Figure 14.1.1.



Source: JICA Study Team.

Figure 14.1.1 Flow of the Waste to Energy System (Example)

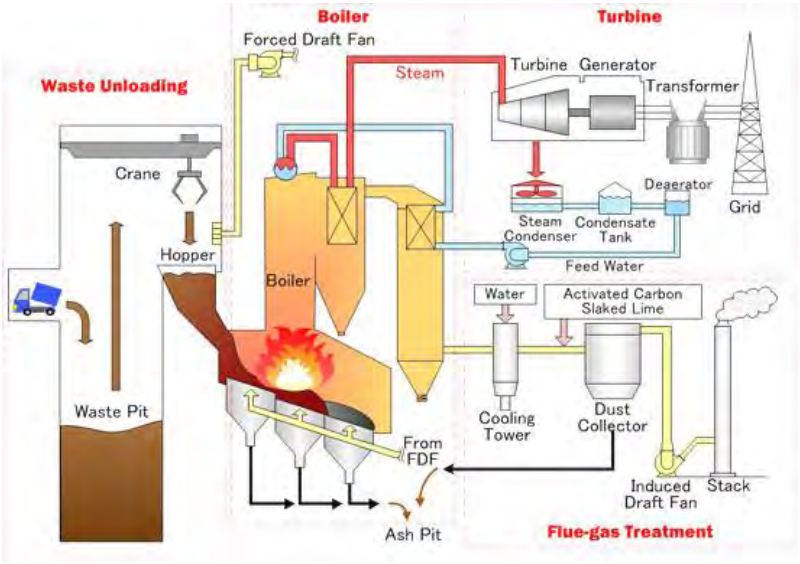
(2) Features of Waste to Energy System

The salient features of the Waste to Energy System are as follows:

- Payment for the fuel for electric power generation is not necessary because the combustible waste itself is the fuel.
- The plants can be stably operated all year round because the variation in the daily waste generation amount is relatively small.
- The electricity needed for the operation of an incineration plant can be supplied by the additional generating equipment. Income can be obtained from the sale of the surplus electricity.
- The construction cost of new transmission lines can be reduced by constructing the plants close to high power demand areas.
- There are some harmful components in the flue gas and ash because municipal waste can contain miscellaneous substances. Thus, the plants should have effective equipment to eliminate those harmful components, so that the emissions into the atmosphere and surrounding environment can be reduced almost completely.
- Since a large amount of organic waste and paper refuse consists of types of biomass, the Waste to Energy plants are considered to be renewable energy resources. This concept has been accepted worldwide.
- Moreover, as combustible materials, such as waste woods and waste pieces of plastic in industrial waste, can be incinerated in the same way, a volume reduction of those materials and an increase in output power can be obtained as a result.
- Additionally, mixed combustion with an inexpensive low-grade coal like lignite is possible and a larger electricity generation capacity can be planned, independent of the restricted amount of waste.

14.2 Outline of the Waste to Energy Facilities

A typical system of Waste to Energy facilities is shown in Figure 14.2.1.



Source: www.yokogawa.com

Figure 14.2.1 Typical System of Waste to Energy Plant

- The incoming waste is stored temporarily in a waste pit of the incineration plant.
- Using a grab bucket, the waste is thrown into the stoker (furnace) of a boiler to incinerate through a hopper at a time interval that is required for continuous and stable incineration.
- In order to effectively incinerate the waste containing a lot of moisture, unique technologies are employed in the design of the stoker. Each incineration plant manufacturer has developed its own technology.
- At a high temperature, the flue gas heats up water tube lattices at the upper part of a boiler to generate hot steam.
- The high-pressure steam produced is supplied to a steam turbine in a generator room to generate electricity.
- The steam is condensed by an air-cooled steam condenser and supplied to the boiler cyclically.
- The flue gas from the boiler is decontaminated or cleaned by a series of gas processing units, such as a dust collector, and is released from a stack.

14.3 Waste to Be Incinerated Under the Waste to Energy System

14.3.1 Total Amount of Municipal Waste

The generation amount of total municipal waste is estimated to be 1,581 ton/day. This estimation was calculated based on the current incoming waste amount at the existing landfill. The industrial waste and medical waste were excluded from the total incoming waste (1,700 ton/day): 6% and 1% of all the incoming waste, respectively.

14.3.2 Waste to Be Incinerated Under the Waste to Energy System

(1) Type of Waste to Be Incinerated under the Waste to Energy System

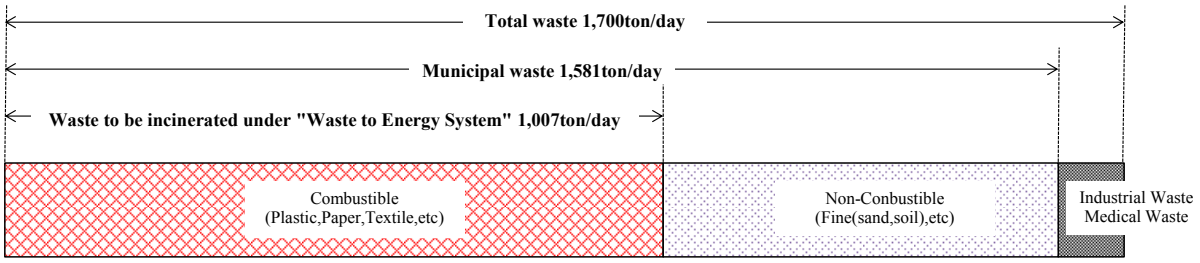
In the analysis of the Waste to Energy System, it is necessary to identify what types of waste can be treated by incineration. The target waste for the Waste to Energy System was determined according to the following policies:

- Metals such as iron and aluminum were excluded because incineration only treats combustible waste.
- Fine materials were also excluded because they do not contribute to waste reduction or calorific generation.
- All of the other wastes, except the waste mentioned above, are considered wastes that are suitable for incineration.

(2) Characteristics of Waste to Be Incinerated under the Waste to Energy System

The amount of waste to be incinerated by the Waste to Energy System is 1,007 ton/day. This was calculated based on the results of the waste composition survey. The amounts of fine materials and metal were subtracted from the total incoming waste (1,581 ton/day).

The breakdown of the waste amount in the Study Area is shown in Figure 14.3.1 and 14.3.2. The amount and composition of waste to be incinerated under the Waste to Energy System is shown in Table 14.3.1.



Source: JICA Study Team.

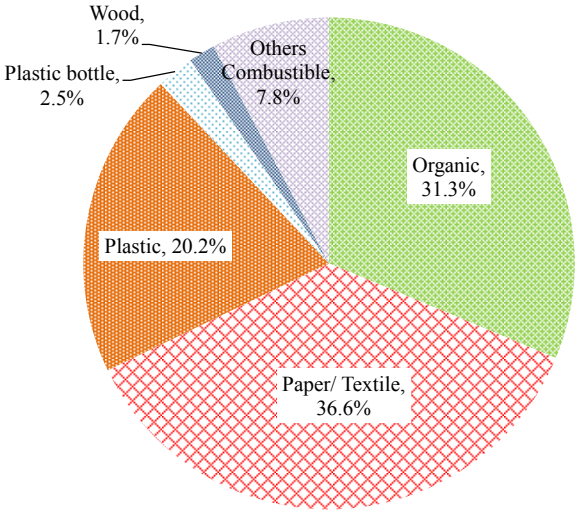
Figure 14.3.1 Breakdown of the Waste Amount in the Study Area

Table 14.3.1 Amount and Composition of Waste to Be Incinerated Under the Waste to Energy System

Item	Percentage (%)	Amount (ton/day)
Organic	31.3	315
Paper/ Textile	36.6	368
Plastic	20.2	203
Plastic bottle	2.5	25
Wood	1.7	18
Other combustible	7.8	78
Total	**100**	**1,007**

Note: 1) The waste composition survey was conducted from October 7th to 13th, 2015 under the guidance of the JICA Study Team.
2) "Other combustible" includes any other burnable waste, which is not categorized as "Organic", ""Paper/Textile", ""Plastic", "Plastic bottle" and "Wood".

Source: JICA Study Team.



Source: JICA Study Team.

Figure 14.3.2 Composition of Waste to Be Incinerated by the Waste to Energy System

(3) Three Components of Target Waste for the Waste to Energy System

Three components were measured in order to confirm the efficiency of waste incineration. Assuming that the majority of "Ash" is originated from fine materials, the percentage of "Ash" was considered to be 5.0%. The remaining 95% was apportioned between "Moisture" and "Combustible". The results of the calculation are shown in Table 14.3.2.

Table 14.3.2 Three Components (the portion of Ash is assumed as 5%)

Item	Moisture	Combustible	Ash	Total
Percentage	43.0%	52.0%	5.0%	100%

Source: JICA Study Team.

(4) Calorific Values of Target Waste for the Waste to Energy System

The calorific values were calculated and analyzed according to two methods: 1) estimation by three components, 2) estimation by waste composition. The results of the calculation are shown in Tables 14.3.3 and 14.3.4.

Estimation by three components

The following formula was utilized in order to calculate the lower calorific value, based on the three components. The results of the estimation are shown in Table 14.3.3.

$Hl = \alpha B - 25W$
(Hl: Lower calorific value, α: 190 ~ 230, B: Combustible [%], W: Moisture [%])

Table 14.3.3 Estimation of the Calorific Value (by three components)

Item	Range (kJ/kg)	Intermediate Value (kJ/kg)	Range (kcal/kg)	Intermediate Value (kcal/kg)
Calorific value	8,805~ 10,885	9,845	2,106~ 2,604	2,355

Note: 1) 1 cal = 4.18 J.
2) All of the data were rounded to integers.
Source: JICA Study Team.

Estimation by waste composition

The following formula was utilized in order to calculate the lower calorific value, based on the waste composition. The results of the estimation are shown in Table 14.3.4.

$Hl = \beta(B - P) + \gamma P - 25W$
(Hl: Lower calorific value, β: 180～190, γ: 310～340,
B: Combustible [%], P: Plastic [%], W: Moisture [%])

Table 14.3.4 Estimation of Calorific Value (by waste composition)

Item	Range (kJ/kg)	Intermediate Value (kJ/kg)	Range (kcal/kg)	Intermediate Value (kcal/kg)
Calorific value	10,962~ 11,893	11,427	2,622~ 2,845	2,734

Note: 1) 1 cal = 4.18 J.
2) All of the data were rounded to integers.
Source: JICA Study Team.

Based on the results of the two types of calculation, the calorific values are estimated to be 2,100-2,800 kcal/kg, which is higher than those in Japan. It was judged that the calorific values are sufficient to introduce an electric power generation system.

14.4 Evaluation of the Waste to Energy System

14.4.1 Evaluation Criteria

The following six criteria were taken into account for the evaluation of the Waste to Energy System:

(a) Pollution control/ Sanitary treatment
(b) Final disposal amount
(c) Greenhouse gas reduction (CO2 emission)
(d) Investment efficiency
(e) Necessity of waste segregation
(f) Operation and maintenance of the facilities

The prerequisites for the evaluation are shown in Table 14.4.1.

Table 14.4.1 Prerequisites for Evaluation

Item	Description
Annual waste amount treated by incineration	367,555 ton/year (1,007 ton/day×365 day/year)
Capacity of incineration plants	1,200 ton/day (600 ton/day x 2 plants)
Annual operational days	310 days (85% of facility operational rate)
Three components of target waste	Moisture 43.0% Combustible 52.0% Ash 5.0%
Calorific values	2,100~2,800 kcal/kg (8,800~11,700kJ/kg)

Source: JICA Study Team.

14.4.2 Pollution Control/ Sanitary Treatment

The current Mbeubeuss disposal site has been managed in an open-dumping way. Since it is not sanitarily operated, the surrounding residents have made complaints about the improper operation.

On the other hand, in terms of sanitary treatment, the Waste to Energy System contributes significantly to the stability and detoxification of the waste by incinerating waste at a high temperature.

Pollution by flue gas can be avoided by setting up gas control standards and installing gas treatment facilities. Apart from flue gas, regulations for waste water, bad odor, noise and vibration pollution should be developed to keep them under control.

Flying ash, a part of the incineration residue, needs to be treated by chemicals because it contains heavy metals and can contaminate groundwater. It will be disposed at a landfill with sufficient safeguards, after chemical treatment and dissolution tests.

14.4.3 Final Disposal Amount

The final disposal amount was calculated for both the current system and the Waste to Energy System. The results of the calculation are shown in Table 14.4.2.

In general, by introducing incineration plants, the waste amount is reduced by 1/10 on a weight basis and by 1/20 on a volume basis. Compared with the current system, a 74% reduction of the final disposal amount is expected, while the lifespan is prolonged 3.8 times by introducing the Waste to Energy System. The Waste to Energy System is effective under the constraints where a final disposal site is difficult to find.

Table 14.4.2 Comparison of Final Disposal Amount

Item	Unit	Current System (Mbeubeuss Landfill)/ Sanitary Landfill System (*1)	Waste to Energy System
Final disposal amount produced by intermediate treatment	ton/day	0	101
	m^3/day	0	67
Final disposal amount directly brought to the landfill	ton/day	1,581	574
	m^3/day	1,715	372
Total final disposal amount	ton/day	1,581	674
	m^3/day	1,715	439

Note: 1) The final disposal amount of the "Current system" is the same as that of the "Sanitary landfill system".
Source: JICA Study Team.

14.4.4 Greenhouse Gas Reduction (CO_2 Emission)

The CO_2 emission was calculated in terms of the prevention of global warming. The results of the calculation are shown in Table 14.4.3.

The Waste to Energy System makes it possible to reduce 85% of CO_2 emission, compared with the current system. A lot of methane gas was emitted from the current Mbeubeuss landfill by the anaerobic reaction of the organic waste. Methane gas has a bigger global warming potential, 25 times that of CO_2, and is not preferable to avoid global warming. On the other hand, the Waste to Energy System generates CO_2 by the incineration of plastic waste. However, since the CO_2 is deducted by the electric power generation, the Waste to Energy System is effective from the viewpoint of global warming prevention.

Table 14.4.3 Comparison of CO_2 Emission Amounts

	Item	Unit	Current System (Mbeubeuss Landfill)	Sanitary Landfill System	Waste to Energy System
Greenhouse Gas Through Landfill	CH_4 originated by organic waste	CH_4/day	46	23	0
	CH_4 originated by paper/ textile	CH_4/day	53	27	0
	CH_4 originated by wood	CH_4/day	3	1	0
	Total CH_4 generated by the current system	CH_4/day	101	51	0
	Total CO_2 generated by the current system	**CO_2/day**	**2,525**	**1263**	**0**
Greenhouse Gas Through Incineration	CO_2 generated by incineration (Plastic waste)	CO_2/day	0	0	631
	CH_4 generated by incineration	CO_2/day	0	0	0
	N_2O generated by incineration	CO_2/day	0	0	17
	CO_2 reduction by electricity power generation	CO_2/day	0	0	- 270
	Total CO_2 generated by the Waste to Energy System	**CO_2/day**	**0**	**0**	**379**
Total CO_2 emission amount		**CO_2/day**	**2,525**	**1,263**	**379**

Source: JICA Study Team.

14.4.5 Investment Efficiency

(1) Prerequisites for Estimation

The prerequisites for estimation are described as follows:

1) Construction Cost

According to the interview survey with the Japanese plant makers, the construction cost was set at 75-125 million FCFA/ton. This amount does not include the land price.

2) Operation and Maintenance Cost (Annual Base)

Utility cost

The utility cost consists of water use and chemicals for flue gas treatment and was set at 500 FCFA/ton, based on the interview survey with the Japanese plant makers.

Labor cost

The number of necessary personnel for the operation was estimated as 40 people and the unit labor cost was set at 10 million FCFA/person/year.

Maintenance cost

The annual maintenance cost to maintain the facilities was fixed at 3% of the total construction cost.

Sales of electricity

Unit in-house electricity usage: 120kW/waste ton

Unit electricity generation: 400kW～800kW/waste ton

Unit sales price of electricity: 118 FCFA/kWh (based on the average sales price of electricity)

(2) Results of the Investment Efficiency Analysis

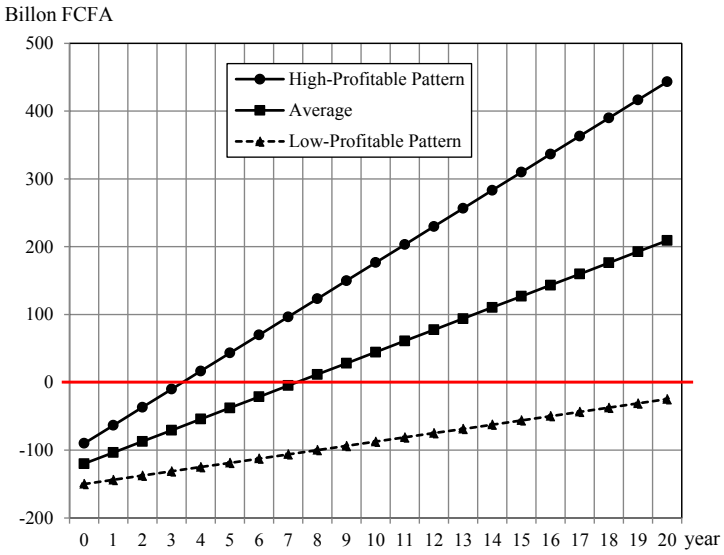
The results of the investment efficiency analysis are shown in Table 14.4.4.

The annual revenue from the Waste to Energy System is calculated by subtracting "(2) Total operation and maintenance cost" from "(3) Sales of electricity", which is 6.24 - 26.64 billion FCFA/year. This indicates that the recovery time of the construction cost is approximately 3 - 24 years. The range of the recovery time is relatively large under this estimation because of the fluctuation in unit construction cost and power generation amount. The patterns of cost recovery are shown in Figure 14.4.1.

Table 14.4.4 Results of the Investment Efficiency Analysis

Item	Unit	Cost
(1) Total construction cost	billion FCFA	90~150
(2) Total operation and maintenance cost	billion FCFA /year	4.96~6.76
2.1 Utility cost	billion FCFA /year	1.86
2.2 Labor cost	billion FCFA /year	0.40
2.3 Maintenance	billion FCFA /year	2.70~4.50
(3) Sales of electricity	billion FCFA /year	13.0~31.6
Annual balance: (3) – (2)	billion FCFA /year	6.24~26.64

Source: JICA Study Team.



Source: JICA Study Team.

Figure 14.4.1 Patterns of Cost Recovery

14.4.6 Necessity of Waste Segregation

Waste segregation is essential for the Waste to Energy System because incinerations only treat combustible waste. There are three ways to separate waste: 1) Waste separation at the source, 2) Waste separation at the incineration facilities and 3) Waste separation at the sorting centers.

(1) Waste Separation at the Source

Residents cooperate with separating the waste into combustible and noncombustible waste. The advantages are:

- Separation at the incineration facilities is not necessary and it becomes easier to incinerate the waste. In addition, waste reduction by separating fine materials is recommended.
- Waste separation can help to raise public awareness.

On the other hand, the following points are a matter of concern:

- It should be examined whether the residents can fully cooperate with waste separation at the source.
- The collection rates may go down because of waste separation. When the residents separate the waste into combustible and noncombustible waste, the waste collection vehicles usually require more trips to the landfill.

(2) Waste Separation at the Incineration Facilities

Sorting machines at the incineration facilities should separate fine materials. Bag breaking machines may be necessary, since the residents sometimes put fine materials into plastic bags. The following is an example of the sorting methods:

Bag breaking machines/manual removal of noncombustible waste – Removal of fine materials by screening – Manual separation of recyclable waste.

(3) Waste Separation at the Sorting Centers

Another option to separate waste is to utilize the sorting centers. In this way, only the combustible waste is transported to the incineration facilities. Currently, the Mbao sorting and transfer center, which could be used for the separation of fine materials and any recyclables, such as aluminum and iron, is under construction.

14.4.7 Operation and Maintenance of the Facilities

Since the Waste to Energy System has never been introduced in Senegal, it is important to judge whether the operation and maintenance can be carried out properly. The operation of incineration plants is very complicated, involving facility operation, maintenance and inspection, as well as the procurement of proper machines. Therefore, in the case of Japan, most of the local governments outsource the operation to private companies, except in some bigger cities. It is more desirable and realistic for the Senegalese government to entrust the operation to a plant maker or the subcontracting companies. Currently, waste collection is outsourced to private companies and the same system can be applicable to the Waste to Energy System. By entrusting a set of operations, such as facility operation, inspection and procurement, the whole process becomes easier.

On the other hand, if the Senegalese government does operate the plants, guidance by a plant maker would be essential for at least several years. It is recommended that some staff members from a plant maker should be stationed permanently to help with machine maintenance, facility planning and countermeasures for emergency accidents, etc. From the overall viewpoint, operation by the Senegalese government would be difficult, even though some workers, such as waste separators at the incineration facilities, could be locally hired.

14.5 Remaining Issues to Be Solved

14.5.1 Criteria for Construction Candidate Sites

The construction site for the Waste to Energy plant should satisfy the following conditions:

- The site should be stable in terms of geology.
- The ground level of the site should be high without any risks of flood.
- The site should be close to the waste generation source.

- The power lines around the site should be developed.
- The residents around the site should have reached an agreement on the Waste to Energy System.
- The site should have no limitations to development such as a national park.
- The site area should be more than 6 ha, which is the minimum area required for construction of an incineration plant with the capacity of 1,200 ton/day.

14.5.2 Environmental Impact Assessment and Related Legislation

In the construction of waste-related facilities, an environmental impact assessment ("EIA" hereafter) should be conducted, according to Senegalese law. Consultation and discussion with the agency in charge of EIA, the Direction of Environment and Classified Establishment, Ministry of Environment and Sustainable Development, should be held.

The level of EIA is divided into two categories: any projects classified as category one are considered to have clear impacts on the environment, while any projects of category two have limited impact on the environment with some mitigation measures. The category that Waste to Energy plants are in should be identified according to Senegalese regulations.

In order to introduce the Waste to Energy System, the standards for flue gas emission and incineration residue disposal should be developed. In addition, the following legislation needs to be established and complied with:

- Laws on pollution control (air, water, noise, vibration and bad odor, etc.)
- Laws on occupational safety and health
- Laws on the power generation business
- Laws on city planning
- Laws on forest and natural parks
- Laws on cultural property conservation

14.5.3 Cooperation with Residents

Any waste-related facilities may be considered to be a nuisance. For example, residents may picture negative images such as "The air is polluted by flue gas", "Waste collection vehicles often come to our areas", "Dirty" and "Stinky". Since these images can cause the suspension of the construction and operation, the government should secure sufficient time to explain the safety and benefits of incineration plants. It is important to closely cooperate with knowledgeable scholars and local influential persons, in addition to the governmental officers in charge of waste management.

14.5.4 Coordination with Power Companies

SENELEC is one of the candidate companies that can purchase the electricity from the Waste to Energy plant. The following points should be taken into consideration:

- The unit sales price of electricity should be discussed and determined. The unit sales price was set at 118 FCFA/kWh under the current estimation above, which is higher than the price in Japan.
- The conditions to fix the sales price of electricity should be discussed. The power generation amount can be flexible, due to the fluctuations of calorific values and operational conditions.

- The fluctuation in the sales price of electricity should be minimized because the total construction process of the Waste to Energy System, from preparation through to final construction, is long.

14.5.5 Coordination with Stakeholders

Since the construction cost is high, understanding and coordination at a national level are essential. It may take a long time to coordinate all of the stakeholders including the consultation with residents.

Waste pickers are also stakeholders, many of who work at Mbeubeuss landfill to collect and sell recyclable waste. A waste picker association has been established. This association buys the collected valuables from waste pickers and sells them to buyers of recyclables. The Waste to Energy System may reduce their income resources by incinerating plastic and PET bottles, etc. On the other hand, employment opportunities can be provided for waste pickers in the process of manual waste separation.

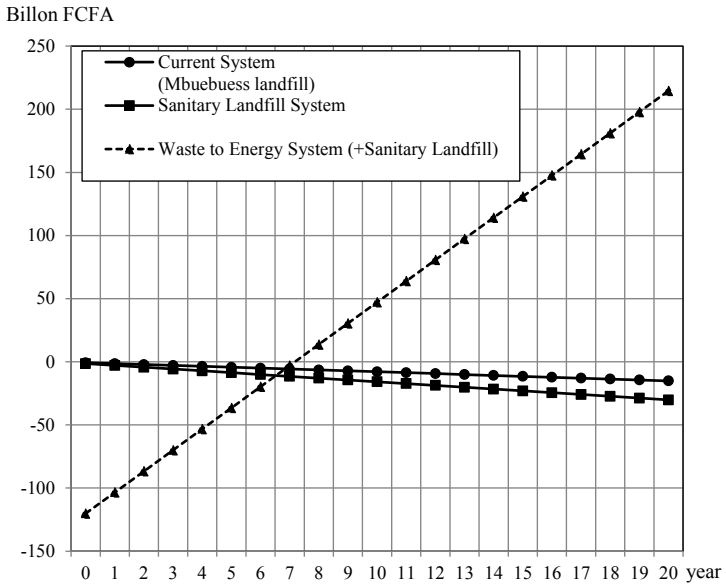
14.5.6 Risk Management of the System

There are some potential risks to be taken into consideration: 1) fluctuation of waste generation amount and quality, 2) transition of related legislations, such as flue gas standards and sales price, 3) opposition by residents and 4) failure to make a contract with a plant operator. These risks should be properly managed to make the system more sustainable.

14.6 Conclusions and Recommendations

The comparison of waste management systems in the Study Area is summarized in Table 14.6.1. The Waste to Energy System (and sanitary landfill) can be considered as the best option to solve the existing issues on waste management in the Study Area.

It was also found that the Waste to Energy System has advantages from an environmental viewpoint, such as the reduction of the final disposal amount and greenhouse gas. While the Waste to Energy System could be an expensive option, the estimation showed that the large amount of revenue from the sales of electricity could compensate for it (Figure 14.6.1). The power sales revenue could be sufficient to recover the construction cost. The power sales revenue could be sufficient to recover the construction cost in 3~24 years. In addition, the maintenance cost of the landfills will be saved, due to the reduction in the landfilling waste amount.



Note: 1) The cost of a landfill only includes the operation cost in the estimation because the landfill has already been constructed and the construction cost is not required.
2) The cost of the Waste to Energy System includes the construction and operation and maintenance cost.
3) The average value of the electricity generation amount is applied for the comparison of the investment efficiency above.

Source: JICA Study Team.

Figure 14.6.1 Comparison of Investment Efficiency

On the other hand, as mentioned in Section 14.4 “Remaining Issues to be Solved”, there are some challenges that still need to be tackled. This is because the Waste to Energy System is a new technology for not only Senegal but also, the Sub-Saharan countries.

It is strongly recommended that, based on the results of this analysis, a feasibility study on the Waste to Energy System be conducted with the collaboration of a plant manufacturer.

Table 14.6.1 Comparison of the Waste Management Systems in the Study Area

No.	Item	1. Current System (Mbeubeuss landfill)	2. Sanitary Landfill System	3. Waste to Energy System (+Sanitary Landfill)
(1)	Pollution control/ Sanitary treatment	*(Baseline)* • Significant environmental impacts are observed.	• The environmental impacts can be mitigated.	• The risk of pollution by the plants would be limited under the proper treatment system.
(2)	Final disposal amount	*(Baseline)*	• The same as the baseline.	• The final disposal amount is reduced by 74% (volume-based) and 57% (weight-based).
(3)	Greenhouse gas reduction (CO_2 emission)	*(Baseline)* • A large amount of CH_4 is emitted.	• The amount of greenhouse gas is reduced by 50%.	• The amount of greenhouse gas is reduced by 85%.
(4)	Investment efficiency	*(Baseline)* • There is no need for investment.	• Investment to construct a new landfill will become necessary in 15 years.	• The construction cost will be recovered by the sales of electricity, even though the construction cost of incineration plants is relatively high. • The urgent construction of additional landfills is not necessary. • Power generation can supplement coal fired power generation, contributing to a reduction in coal imports.
(5)	Necessity of waste segregation	*(Baseline)*	• The same as the baseline.	• The segregation of combustible waste is required.
(6)	Operation and maintenance	*(Baseline)*	• Some technical workers are needed.	• Highly skilled workers are essential.
(7)	Other aspects	• Strong opposition by the residents has occurred.	• Agreement with the residents is necessary.	• Agreement with the residents is necessary. • The coordination with related stakeholders is indispensable (areas of waste management, finance and electricity, etc.).

Source: JICA Study Team.

CHAPTER 15 POLICY PACKAGE AND ACTION PLAN FOR DUA

15.1 Investment Requirement-Budget Balance

The following summarizes the balance of the investment requirements for realizing the 2035 Master Plan and the availability of public funds for investment.

Table 15.1.1 Balance of Fund Requirement for 2035 Master Plan and Budget Availability

Item	Amount
a. Budget for capital expenditure by the government in 2015	962,186 million FCFA
b. Total requirement for public investment for the 2035 Master Plan	2,555,476 million FCFA
c. Annual average requirement for public investment for the 2035 Master Plan (b./20 years)	127,774 million FCFA
d. Proportion of public investment for the 2035 Master Plan to capital expenditure (c/a)	13%

Source: JICA Study Team.

The investment requirement is obtained from the estimates of broad investment requirements presented in Section 7.9.

The fund availability is obtained from the budget of the Senegalese government in 2015, focusing on the capital expenditure at 962,186 million FCFA, comprising 557,186 million FCFA from internal source and 405,000 million FCFA from an external source, as shown below.

Table 15.1.2 Budget of Senegalese Government

Item	In million FCFA	%
Internal resources		
Public debt	598,010	21.5
Personnel expenditure	510,000	18.4
Other current expenditures	706,586	25.4
Capital expenditure	557,186	20.1
Subtotal	*2,371,782*	*85.4*
External resources		
Capital expenditure	405,000	14.6
Subtotal	*405,000*	*14.6*
Total	**2,776,782**	**100.0**

Source: Loi de finances pour l'année 2015
(http://www.finances.gouv.sn/index.php/finances/lfi/loi-de-finances-2015).

Based on the comparison above, the requirement for public funds in order to realize the 2035 Master Plan, accounting for 13% of the 2015 budget for capital expenditure, is broadly judged to be within an affordable range of the government capital expenditure budget. For private investment, the Senegalese government needs to ensure the conditions of investment required by the private sector, maintaining an appropriate balance with serving the public interest.

15.2 Policy Package for the 2035 Master Plan

A set of proposed measures for realizing the 2035 Master Plan presented until Chapter 14 are organized into a policy package, as shown in table 15.2.1. Various measures are classified into the

following eight categories. The policies from the first to seventh category follow the seven objectives for achieving the "City of Hospitality" vision presented in Chapter 6. One category is added to indicate a set of activities contributing to strengthening the technical foundation in various areas. It comprises technical studies and surveys and capacity development activities.

- Comfortable environment creation policy
- Easy communication policy
- Innovative creation policy
- Urban development management policy
- Environmental management policy
- Inclusiveness enhancement policy
- Broad view application policy
- Technical foundation building policy

15.3 Action Plan for DUA

The following are the immediate tasks that DUA will need to undertake.

Formalization process of the 2035 Master Plan and the Daga Kholpa Detailed Plan

DUA will take the necessary actions for the approval process including the following events:

- Preparation of regulatory conditions for the 2035 Master Plan and the Daga Kholpa detailed plan
- Approval by the stakeholders including communes and regional committees
- Approval of SEA report by DEEC
- Approval and proclamation of the 2035 Master Plan and the Daga Kholpa detailed plan by President
- Transmission of the approved plans to national archives for security purposes

DUA is subsequently recommended to move on to the next stage of disseminating the 2035 Master Plan and the Daga Kholpa detailed plan to all of the stakeholders through undertaking the following activities:

- Preparation and printing of the documents summarizing the 2035 Master Plan and the Daga Kholpa detailed plan for distribution.
- Preparation and printing of explanation documents for distribution.
- Holding seminars and workshops to present and distribute the documents for the central government ministries and organizations, local governments and the private sector.
- Support of the central government ministries and organizations and local governments in aligning their policies and plans within the framework of the 2035 Master Plan and the Daga Kholpa detailed plan.

Pre-feasibility study

DUA is recommended to take the following actions:

- To communicate with the relevant ministries and organizations in charge of transportation and solid waste management such as AGEROUTE, CETUD, Ministry of Environment and CADAK-CAR and reach an agreement on promoting the projects to the next stage.
- To secure funds for the next stage studies.
- To support the undertaking of feasibility studies for the transportation projects.

- To support the undertaking of a detailed study on the optimum waste management system including waste-to-power project in consideration of the important factors that would affect the viability of the project such as the price of electricity and the interest of private producers of incineration and power generation plants.

Capacity development at institutional, organizational and individual levels

DUA is recommended to take actions to develop the technical and managerial skills of the DUA officers according to the proposed capacity development plan as a short-term priority.

Promotion of the Master Plan 2035 policy package

DUA will propose to the government the creation of a platform for implementing the 2035 Master Plan Policy Package. DUA could function as the secretariat for this platform. The platform will be the venue to promote cooperation and coordination of the activities by different ministries, organizations and local governments within the framework of Master Plan 2035 Policy Package, paying due attention to sustainability enhancement.

A unique characteristic of the proposed policy package is its integration of the sustainability enhancement perspective. The improvement of the urban environment in the Study Area should be promoted not only depending on the conventional approach of expanding the physical capacity of facilities following demand, but also by implementing non-structural measures such as controlling demand itself and dealing with natural disasters resiliently. An example of non-structural measures from a macroscopic view would be the creation of compact and self-reliant urban spaces. It will contribute to restraining CO_2 emission, thus enhancing the fundamental sustainability of the Study Area from the global environmental perspective.

This kind of approach would be more effective by consolidating the efforts by different ministries and organizations than implementing it separately. It is proposed that DUA functions as the secretariat in promoting the Master Plan 2035 Policy Package, while the core part of the Senegalese government oversees the overall implementation of the policy package, especially from the sustainability perspective.

Table 15.2.1 Policy Packages for 2035 Master Plan (1/5)

Policy	Components	Actions	Organizations and Ministries: Responsible Organizations & Ministries	Organizations and Ministries: Relevant Organizations & Ministries	Remarks
1. Comfortable Environment Creation Policy	1.1 Urban Infrastructures	Water supply service expansion and rehabilitation	SONES	MHA	in terms of both quantity and quality
		Construction and rehabilitation of substations, transmission lines and distribution lines	SENELEC	MEDER	Rehabilitation especially in built-up areas
		Construction of thermal power plants (in Senegal)	Private	MEDER (SENELEC)	
		Construction of public utility conduits	Local administration	SENELEC, SONES, ONAS, DUA	
		Construction, expansion and rehabilitation of sewage treatment plants and sewer networks	ONAS	MHA	
		Construction and expansion of septage treatment plants	ONAS	MHA	
		Solid waste collection service improvement	CADAK-CAR, PNGD	MESD MEDD	
		Improvement of intermediate solid waste treatment system	CADAK-CAR, PNGD	MESD MEDD	Including waste-to-energy system as an option, use of Mbao sorting center
		Sanitary land fill establishment	CADAK-CAR, PNGD	MESD MEDD	Including reopening of Sindia Sanitary Landfill site
		Drainage facilities construction	ADM, ONAS	MHA, local adiministrations	Extreme storm events of 10-year return period as the criteria
		Countermeasures for coastal erosion in priority areas	DEEC	MHA, local adiministrations	
	1.2 Non-structural measures for urban services and disaster risk reduction	Community-led urban disaster risk reduction	DPC, DARZI	Local administrations	
		Disaster Information sharing and dissemination	DPC, DARZI	Local administrations	Integrated information management, early warning, improved operation of disaster risk management center
		Application of Flood Management Area concept to land use planning	DUA, ADM	MHA	Integration into PUDs
		Hazard map preparation and distribution	ADM, DGPRE, ONAS	MHA, local adiministrations	
	1.3 Law and order	Crime reduction initiative	Community	Police, local governments, DUA	DUA to contribute in promoting CPTED (crime prevention through environmental design)
	1.4 Amenity	Parks/open space promotion	Local governments	DUA	

Table 15.2.1 Policy Packages for 2035 Master Plan (2/5)

Policy	Components	Actions	Organizations and Ministries		Remarks
			Responsible Organizations & Ministries	Relevant Organizations & Ministries	
2. Easy Communication Policy	2.1 Transportation infrastructure	Intersections improvement	AGEROUTE	CETUD, MOT	
		Roads improvement and development	AGEROUTE	CETUD, MOT	
		Railway development	ANCF, private sector	CETUD, PTB, APIX, MOT	
		BRT development	CETUD, private sector	AGEROUTE, MOT	
		BHLS development	CETUD, private sector	AGEROUTE, MOT	
		Ferry services	ANAM, private sector	CETUD, PAD, MOT	
	2.2 Transportation demand control	Non-structural measures promotion	CETUD	AGEROUTE, local administrations	road pricing, park and ride, share-ride, non-motorized transportation modes, traffic management, easier inter-modal transfer, illegal park restrition etc.
	2.3 Logistics infastructure	Dakar Port access improvement	AGEROUTE	PAD	
		Expansion of Dakar Port	PAD	ANAM, MFME	
		Logistic facilities development	PAD, APIX, private logistic companies	PAD, APIX, private logistic companies	
		Secondary port development	ANAM	MFME	
	2.4 ICT	ICT business promotion	Private sector	MIPIPDTE, MPT	
		e-government promotion	Prime Minister's Office, MIPIPDTE	Ministries, central organzations, local administrations	

Source: JICA Study Team

Table 15.2.1 Policy Packages for 2035 Master Plan (3/5)

Policy	Components	Actions	Organizations and Ministries		Remarks
			Responsible Organizations & Ministries	Relevant Organizations & Ministries	
3. Innovative Creation Policy	3.1 Primary sector	Niaye agriculture promotion	MAER	Local administrations	
		Fishery promotion	MFME	Local administrations	
	3.2 Secondary Sector	Industry relocation	MOIM, APROZI	MOC, ADEPME, DCCI	
		Industrial park creation in DISEZ	APIX	PSE-BSO, APROSI, MOIM	
		Craft industry promotion	MOC	MIPIPDTE	
	3.3 Tertiary sector	Urban tourism products development	MTTA	Local administrations, MPIPDTE, ASTP	
		Rural tourism products development	MTTA	Local administrations, MPIPDTE, ASTP, MAER	
		Resort tourism products development	MTTA	Local administrations, SAPCO, MPIPDTE, ASTP	
	3.4 Investment promotion	FDI promotion initiative	MIPIPDTE	APIX	FDI: foreign direct investment
4. Urban Development Mnagement Policy	4.1 Urban planning and implementation	Awareness raising on master plan for people and private sector	DUA	Local administrations	
		Technical, institutional and and legal supporting tools development for enhancing master plan's effectiveness	DUA	Local administrations	
		Awareness raising on master plan for ministries, central organizations and local governments	DUA	Ministries, central organizations, local administrations	

Source: JICA Study Team

Table 15.2.1 Policy Packages for 2035 Master Plan (4/5)

Policy	Components	Actions	Organizations and Ministries		Remarks
			Responsible Organizations & Ministries	Relevant Organizations & Ministries	
5. Environmental Management Policy	5.1 Regional environment	Reuse of treated wastewater for gardening	SONES	MHA	To suppress wasteful water use
		Campaign on saving water use	SONES	MHA	
		Awareness campaign on use of hygienic toilets	ONAS, SNH	MHA, MHSA	
		Promotion of proper waste discharge and waste segregation at source	CADAK-CAR, PNGD	MEF, MEDD	Promotion of three Rs (reduction, reuse and recycling)
		Campaign on saving electricity use	SENELEC	MEDER	To suppress wasteful electricity use
		Pollution control enhancement	MHSA	Private sector	
	5.2 Global environment	Compact and self-sustained city development	DUA, line ministries, central organizations, private sector	Local governments, APIX, SICAP	CO^2 reduction by reduced number and distance of trips
		Public transportation promotion	CETUD	AGEROUTE, private operators	Highly related with 2.1 Urban Infrastructure
		Low-head hydro-power development	New public entity	MEDER, ANER, ASER	A new public entity needs to be established.
6. Inclusiveness Enhancement Policy	6.1 Livelihood	Promoting small scale operations in agriculture, industry and service	MOC	Local administrations	
	6.2 Institutional arrangement	Tax system reform to reduce income disparity	MEF	-	
		Social insurance expansion	MEF	-	
	6.3 Public transportation	Enhancement of public transportation services for irregular settlements	CETUD, private sector	MOT	
	6.4 Vulnerable group	Gender mainstreaming initiative	MWFC	Local administrations	
7. Broad View Application Policy	7.1 Regional cooperation	Cooperation on sustainability enhancement within ECOWAS and UEMOA framework	MFASA	DUA	

Source: JICA Study Team

Table 15.2.1 Policy Packages for 2035 Master Plan (5/5)

Policy	Components	Actions	Organizations and Ministries		Remarks
			Responsible Organizations & Ministries	Relevant Organizations & Ministries	
8. Technical foundation building policy	Studies/surveys	Dakar Port master plan preparation	PAD	ANAM, MFME	
		Study on water tariff	SONES	MHA	
		Preparation of sewerage development master plans for Rufisque, Diamniadio and Daga Kholpa	ONAS	MHA	
		Detailed study on electricity transmission and distribution systems in the existing city area of Dakar	SENELEC	MEDER	
		Study on low-head hydropower development in Senegal	ANER	MEDER	
		Updating of Rufisque drainage master plan	ONAS	MHA, local administrations	
		Preparation of urban drainage master plans for Diamniadio and Daga Kholpa	ONAS, ADM	MHA, local administrations	
		Preparation of a comprehensive coastal management plan	DUA, DEEC	MHA, local administrations	
	Capacity development	Capacity development on PDU and PUD preparation	DUA	Local administrations	
		Technical upgrading for reducing non-revenue water (leakage detection etc.)	SONES	MHA	
		Capacity development for dealing with emergency disaster situations for different levels of government	DPC, DARZI	Local administrations	
		Capacity development on Flood Management Area application	DUA, ADM	MHA	
		Meteo-hydrological monitoring system strengthening	ANACIM, DGPRE	DPC, MHA	

Source: JICA Study Team

CHAPTER 16 CONCLUSION AND RECOMMENDATIONS

16.1 Conclusion

Existing condition and issues

The stakeholder meetings, the social survey, a series of technical coordination committee meetings and steering committee meetings and the findings by the JICA Study Team clarified a number of problems of the Study Area. These include chronic traffic congestion; unsanitary condition due to insufficient sanitation; sewerage and solid waste management infrastructures, especially in the unplanned residential areas; increasing urban disaster risks, such as flood and coastal erosion; and economic hardships such as low income and unemployment. In addition to these problems directly affecting people, there are also more macroscopic problems such as the environmental problem – the reduction of environmentally sensitive areas and farmlands and pollution by industries.

There are a number of reasons for this situation. A rapid increase of population is a fundamental factor that is exacerbating the problems, not only the social increase by inflow of rural population into Dakar, but also, the natural increase of the existing population in the Study Area. The existing mono-polar urban structure with most of the business and commercial functions concentrated in Plateau has resulted in heavy chronic traffic congestion during morning and evening peak hours and growing burden on infrastructures. Financial and technical limitations on the part of the Senegalese government have made it difficult for them to tackle these issues swiftly and effectively. While the ongoing master plan for 2025 proposed the transformation of the existing mono-polar structure to a multi-polar one by designating the seven urban poles, its effect has been limited to Diamniadio development. This is because it is difficult for the government to develop all the seven poles at the same time. The master plan for 2025 also encouraged the conversion of environmentally and socially important green spaces and farmlands to residential areas, especially in Nyaye. The sustainability diagnosis conducted in the Study made a comprehensive assessment of the Study Area from the sustainability perspective, covering all of the aspects mentioned above. It was found that the sustainability of the Study Area is low.

The estimate of the population made for the Study Area indicates that its population will almost double in 20 years: 3,206 thousand in 2013 to 6,084 thousand in 2035. The problematic situation will continue to deteriorate unless proper measures begin to be implemented in a swift manner.

2035 Master Plan

The Study proposes a vision of the Study Area as “A City of Hospitality”, integrating the views of all of the stakeholders. Seven objectives are proposed to realize this vision: comfortable environment creation objective, easy communication objective, innovative creation objective, urban development management objective, environmental management objective, inclusiveness enhancement objective and broad view application objective. A set of strategies to realize these objectives are developed and an action plan is proposed in the form of “Policy Package”.

It is recommended that the spatial development of the Study Area is guided according to the land use plan for 2035. This is characterized by a multi-polar structure with Plateau, Diamniadio and Daga Kholpa as the urban poles and other major urban areas as the urban centers. This multi-polar structure is under a clearer urban hierarchy, with the self-contained function of these urban poles, as well as the

preservation of green areas and farm lands surrounding the urban areas and transportation network linking these urban poles and other urban areas.

Plans are proposed in each sector including both structural measures and non-structural measures. In terms of urban management, the Study proposes measures to enhance the people's recognition of the master plan, to strengthen the tools for the master plan preparation and implementation, and to enhance the recognition of the central government organizations and local government to the master plan. In terms of capacity development, the Study proposes the development of the capacity of DUA first and then to expand the capacity development to local governments. The role of DUA is proposed to be shifted from the present direct involvement in planning and control towards policy and strategy formulation, standardization and support in capacity development. The inputs by the SEA were integrated in all this process.

Detailed Plan for Daga Kholpa

As a means to realize the 2035 Master Plan, Daga Khopa was selected as the target area for the detailed plan preparation out of 10 candidate areas. A detailed plan was prepared for an area of 3,981 hectares to accommodate a population of 211 thousand estimated in 2035, through collaborative efforts by the DUA planning team comprising 17 members and the JICA Study Team. The basic concept of the Daga Kholpa detailed plan is the coexistence of modernity and tradition. This is characterized by a land use pattern that allows both the traditional villages and modern urban area with multiple functions of commerce, business, logistic, cultural, recreational and residential to coexist.

Pre-feasibility study

Pre-feasibility studies were conducted also as a means to realize the 2035 Master Plan. There are two packages: one for a combination of two transportation related projects, *Intersection Improvement Project on VDN and Fronte de Terre* and *Traffic Improvement Project around Baux Maraicher Bus Terminal,* and the other for a *Comparative Analysis of Solid Waste Disposal System Focusing on Waste-to-Energy system*.

It was preliminarily clarified that the transportation related projects are technically and economically viable. Therefore, they are proposed to be promoted to the next stage of the feasibility study for a more precise evaluation or directly to the implementation stage.

The solid waste project places emphasis on analyzing the possibility of a waste-to-energy solution, which is the method for utilizing the energy created by incinerating solid wastes for power generation. In this sense, it is rather a detailed analysis at the master plan level than a pre-feasibility level. As a result of the analysis on technical, financial, environmental and social aspects, it is judged that this option could be viable. On this basis, the Study proposes that the waste-to-power solution is considered as a subject for further detailed assessment.

Investment requirement and 2035 Master Plan policy package

The magnitude of investment required to realize the 2035 Master Plan is broadly estimated to be 7,255 FCFA billion in total in 20 years until 2035, comprising 4,700 FCFA billion (65%) by private investment and 2,555 FCFA billion (35%) by public investment. The annual average public investment required is 128 FCFA billion per year, which is about 13% of the capital expenditure budget of the Senegalese government in 2015. The level of required public investment is, therefore, considered to be within an affordable level of the government investment budget. The Senegalese government will need to improve the investment environment of the Study Area both in physical and institutional aspects to realize the level of private investment mentioned above.

The proposals presented up to Chapter 14 are grouped into eight policy packages as follows:

- Comfortable environment creation policy
- Easy communication policy
- Innovative creation policy
- Urban development management policy
- Environmental management policy
- Inclusive enhancement policy
- Broad view application policy
- Technical foundation building policy

It is recommended that the relevant organizations and ministries align the actions proposed by the Study in their own development plans and programs and take actions towards implementation.

16.2 Recommendations

It is recommended that DUA take actions swiftly towards the realization of the 2035 Master Plan according to the action plan presented in Chapter 15. The following are the key actions:

- Formalization of the 2035 Master Plan and Daga Kholpa detailed plan
- Promotion of the transportation projects, for which the pre-feasibility study was conducted, to the next stage either a more detailed study or directly to implementation
- Promotion of a detailed study on the waste-to-energy solution on a regional basis including Senegal and neighboring countries suffering from the same problem of solid waste management
- Establishment of a capacity development system within DUA according to the proposed capacity development plan
- Creation of a platform for sharing and disseminating the 2035 Master Plan with and to relevant government ministries, organizations and local governments, especially to align their activities within the framework of the 2035 Master Plan and promote the sustainability enhancement initiative.