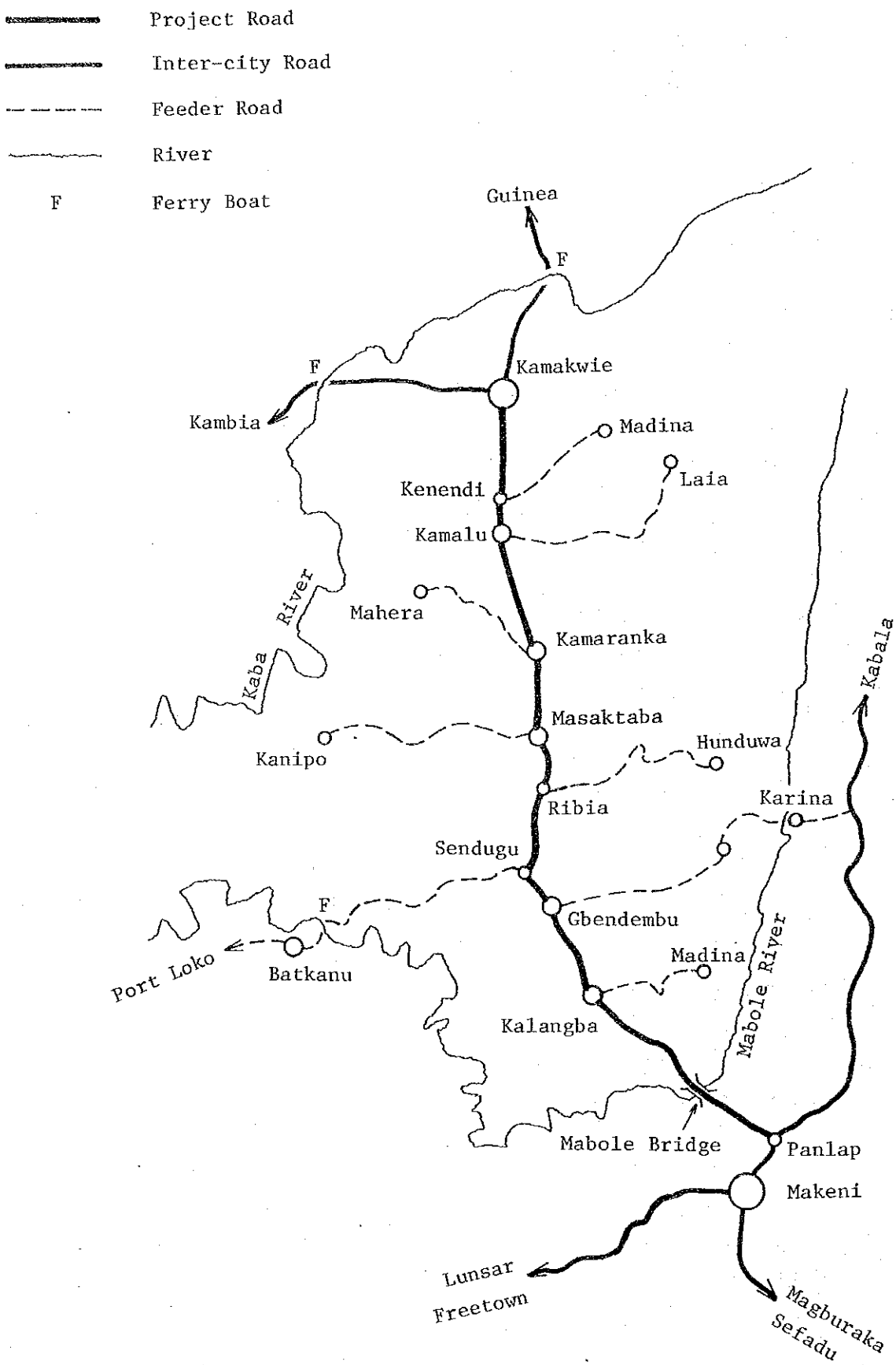


Fig. 3-1 Makeni - Kamakwie Road and Feeder Roads

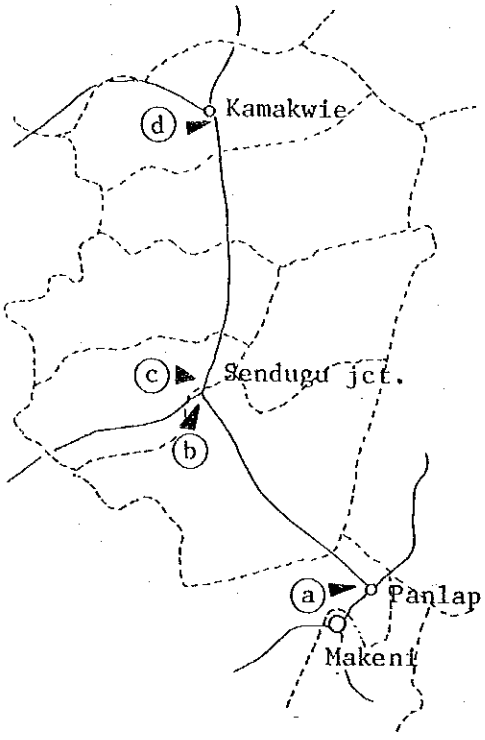


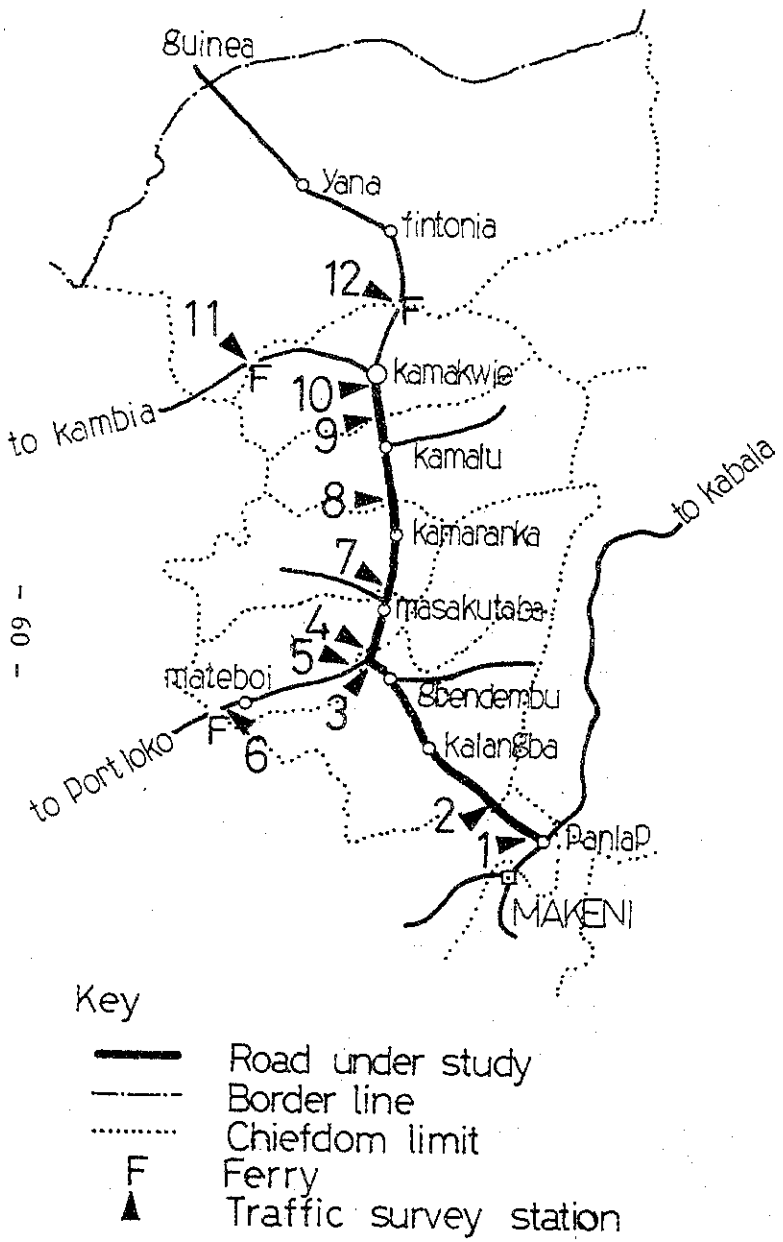
Table 3-1 Traffic Count Station by MOW on January, 1979

Station	Cars	Vans & Pickups	Trucks & Buses	Extra Heavy Vehicles	Total
ⓐ Panlap	38	85	40	28	191
ⓑ Sendugu jct.	9	23	41	-	73
ⓒ Sendugu jct.	10	27	36	-	73
ⓓ Kamakwie	20	34	32	7	93

Source: Statistics of MOW

Note: ◯ : Traffic Count Station by MOW
----: Chiefdom Boundary

(2) Traffic volume data in the rainy season were obtained for the first time by the Study Team as presented in Table 3-2, (see Fig. 3-2 for the survey schedule and traffic count stations).



Traffic Survey Schedule

Station No. and Location	September 25 Tue.	26 Wed.	27 Thu.	28 Fri.	29 Sat.	30 Sun.	October 1 Mon.	2 Tue.	4 Thu.
1. Panlap	OD	TC	TC*	TC	TC	TC	TC	-	-
2. Mabole	TC	-	-	-	-	-	-	-	-
3. Sendugu-jct.	OD	TC	TC	TC	TC	TC	TC	-	-
4. Sendugu-jct.	OD	TC	TC	TC	TC	TC	TC	-	-
5. Sendugu-jct.	OD	TC	TC	TC	TC	TC	TC	-	-
6. Batkanu-Ferry	OD	-	-	-	-	-	-	-	-
7. Masaktaba	OD	-	-	-	-	-	-	-	-
8. Bankabi	TC	-	-	-	-	-	-	-	-
9. Kenendi	OD	-	-	-	-	-	-	-	-
10. Kamakwie	OD	TC	TC*	TC	TC	TC	TC	-	-
11. Tompary-Ferry	-	-	-	-	-	-	-	OD	-
12. Kabba-Ferry	-	-	-	-	-	-	-	-	OD

TC=12 hours classified traffic counts
OD=Origin and destination survey
* =24 hours classified traffic counts

Source: JICA Mission

Fig. 3-2 Location of Traffic Survey Station

Table 3-2 Average Daily Traffic in the Rainy Season
Makeni - Kamakwie Road

Station	Cars	Vans	Pickups	Buses	Truck	Extra Heavy Vehicles	Total
1	21	29	16	20	13	17	116
2	20	28	15	20	13	15	111
3	5	19	14	17	5	11	71
4	4	18	11	15	6	11	65
5	3	8	2	5	2	3	23
6	0	1	0	3	0	0	4
7	3	13	9	15	9	12	61
8	3	13	10	15	9	3	53
9	8	21	11	22	9	0	71
10	8	25	10	22	9	4	78
11	2	13	6	1	1	8	31
12	1	9	4	0	0	5	19

Source: JICA Mission
Note: The above ADT data represent 12-hour traffic volumes adjusted to daily and weekly fluctuations. See Appendix for estimation (adjustment) method and other details.

(3) Average annual ADT (see table below) was obtained on the basis of the dry season ADT of (1) above and the rainy season ADT of (2) above.

Station # and Name	Cars	Vans & Pickups	Trucks & Buses	Extra-Heavy Vehicles	Total
1 (Panlap)	30	65	37	23	155
2 (Sendugu jct.)	7	28	32	11	78
3 (Sendugu jct.)	7	28	29	11	75
10 (Kamakwie)	14	35	32	6	87

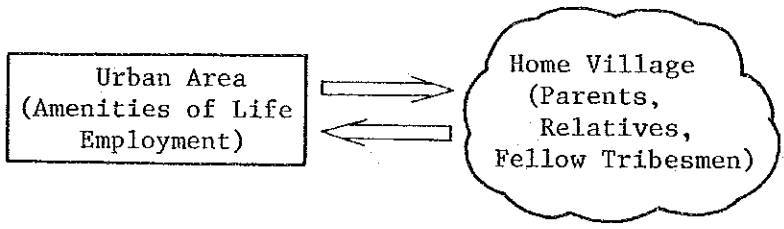
Source: JICA Mission

Panlap (Traffic Count Station 1, see Fig. 3-2) is the northern entrance to, and only a several miles from, Makeni, and traffic was nearly twice as heavy at Panlap as at other count stations. Traffic at Count Station 10, which is the south entrance to the "nucleus" city in the north, Kamakwie, was the greatest after Panlap.

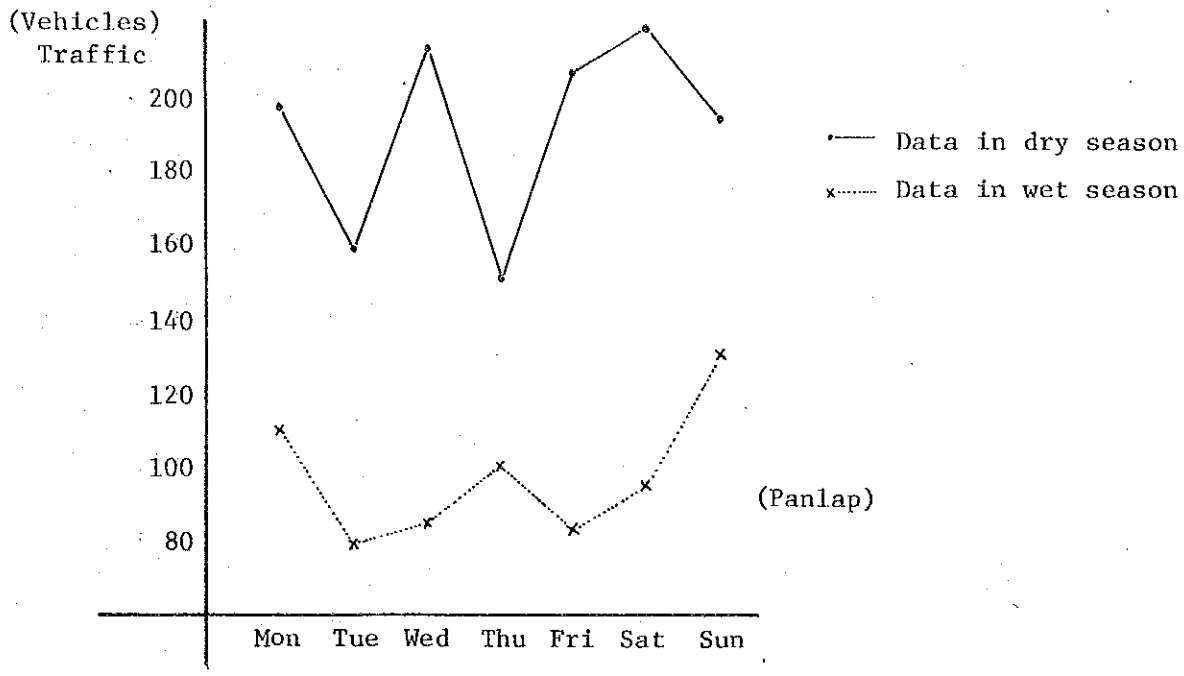
3) Current Traffic Characteristics

(1) Daily and Weekly Fluctuations

Traffic volume fluctuations at major points on the Makeni - Kamakwie Road are shown in Figs. 3-3 and 3-4. The "variation in week" graphs show that the traffic volume increases over weekends. Interview findings suggest that this is because those who live and work in Makeni return to their home villages over weekends.



The "variation in day" graphs indicate that at Panlap, down traffic is heavy in weekday mornings and up traffic is heavy in weekday evenings, while at Kamakwie, up traffic is heavy in weekday mornings and down traffic is heavy in weekday evenings. As it was revealed through an interview survey at various villages, this is because urban residents living in cities for the "amenities of life" flow out of Makeni and Kamakwie every morning to go to work on farms and return to the city in the evening.



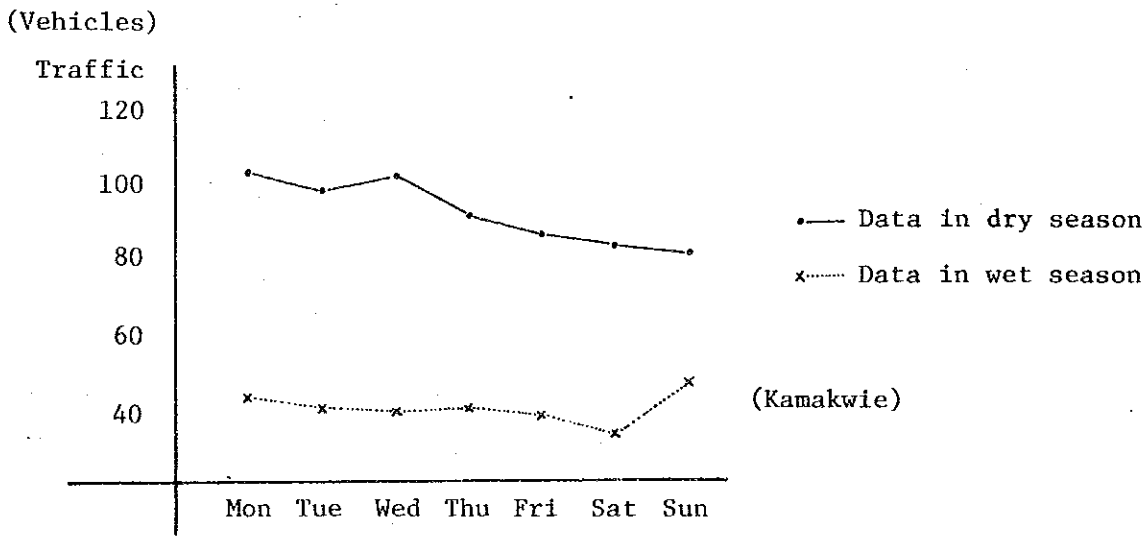
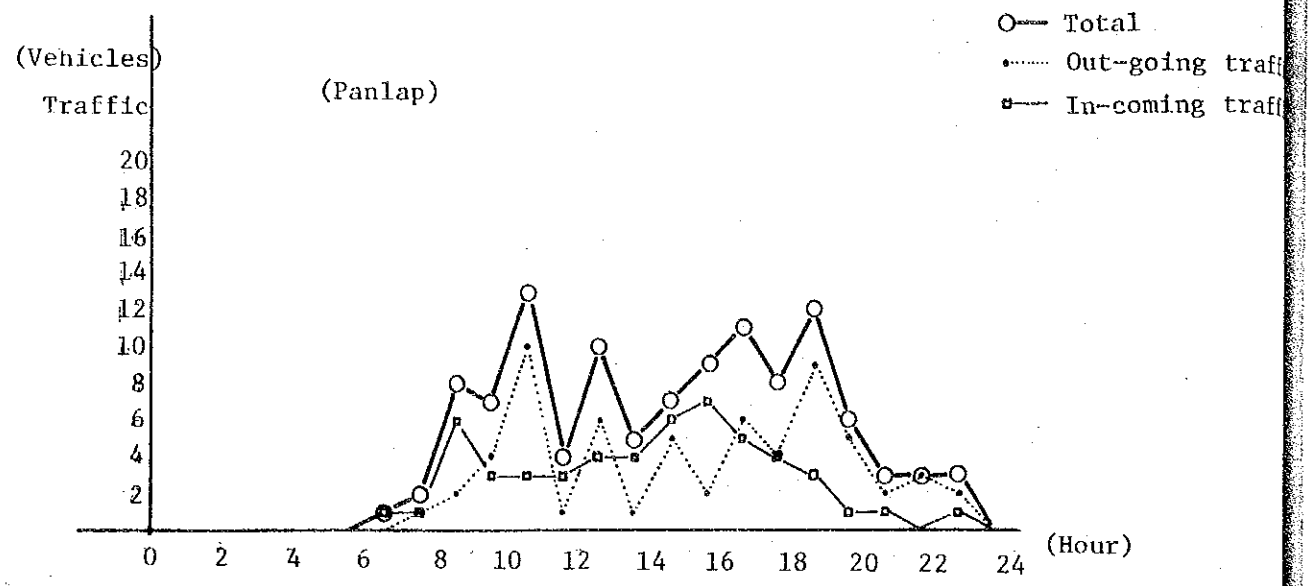


Fig. 3-3 Traffic Variation in Week

Source: MOW Statistics
(Data in dry season)
JICA Mission
(Data in wet season)

Note: Traffic in dry season is daily traffic.
Traffic in wet season is 12 hours traffic.



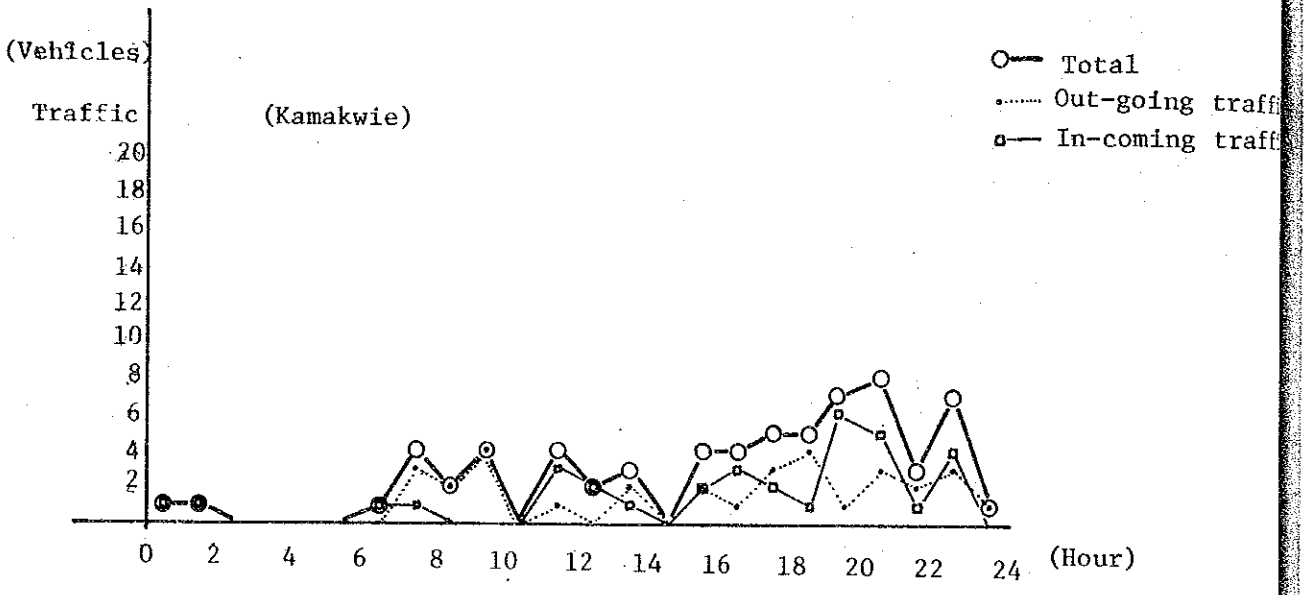


Fig. 3-4 Traffic Variation in Day

Source: Traffic Survey by JICA Mission

Note: This figure shows variations of weekdays only.

Makeni and Kamakwie, which have large populations and can be called cities, are actually "villages where a large number of people live close to each other" and are not matured cities* in the sense that Freetown, Tokyo, and Osaka are. A characteristic of Kamakwie is that traffic continues late into the night because of motorcars on a long drive coming in from Freetown or Makeni (for instance, a car leaving Makeni at dark would arrive in Kamakwie at about 8 P.M.).

(2) Traffic Origin/Destination

A traffic origin/destination survey (O-D survey**) was conducted to understand from where to where people move on the Road. The O-D table presented in Fig. 3-5 shows that traffic generation and termination incidence are high in Makeni, Kamakwie, the Gbendembu-Gowahun Chiefdom (where two towns - Kalangba and Gbendembu - are located), and the Gbanti-Kamaranka Chiefdom (where Kamalu town exists).

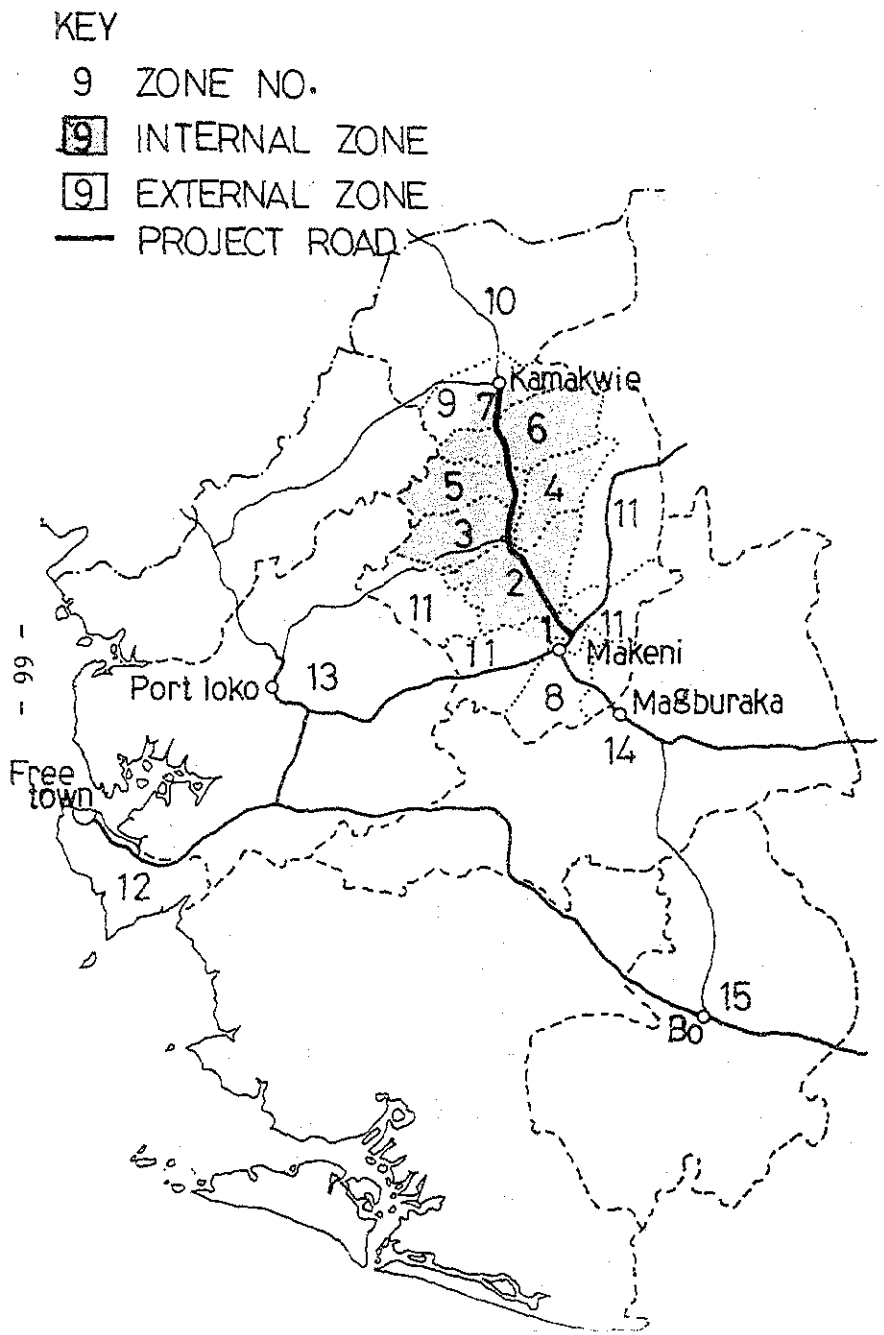
In O-D, the Makeni - Kamakwie traffic accounts for 20% of the total number of trips on the Road.

(3) Passenger and Goods

In the O-D survey, drivers were questioned on the number of passengers, the rate of goods carried to capacity, trip purpose, and so forth (see Table 3-3).

* In matured cities, commuters travel toward the city in the morning and away from the city in the evening. Road traffic congestion is quite serious in Freetown in rush hours.

** O-D surveys, which are conducted by stopping traffic and interviewing the drivers, reveal the exact origin and destination of each trip, number of passengers, and other detailed information. See Appendix I for O-D table by type of motorcar.



	Internal Zone							External Zone								Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1.		3						1			2					6
2.	5	2						7	2			3				19
3.					2			3	2							7
4.																-
5.						2		5				5	1			13
6.					3		2	2	4			1				12
7.						1			2							3
8.	2	7	5		5				15							34
9.		1	1		2	4	2	9				1	1	1		22
10.																-
11.																-
12.		3				1			1							5
13.									1							1
14.																-
15.									2							2
Total	7	16	6	-	12	8	4	27	29	-	2	10	2	1	-	124

1. Makari Gbanti Chiefdom
2. Gbendembu Gowahun Chiefdom
3. Sanda Tenraran Chiefdom
4. Magbaiamba Chiefdom
5. Gbanti Kamaranka Chiefdom
6. Sanda Loko Chiefdom
7. Area Adjacent to the Project Road of Sela Limba Chiefdom
8. Bombali Sebora Chiefdom
9. Sela-Limba Chiefdom Excluding Zone 7
10. Tambaka Chiefdom
11. Bombali District Except Above Zone
12. Western Area (Freetown)
13. Port Loko District
14. Tonkolili District
15. Bo District

Fig. 3-5 Origin-Destination (O-D) Matrix by Vehicle Trip on September 1979

Source: JICA Mission

Table 3-3 Traffic Characteristics

Characteristics	Passenger Car	Light Vehicle		Heavy Vehicle		Extra Heavy Vehicle
		Van	Pickup	Bus	Truck	
Average number of passengers per vehicle	4.1	15.5	6.6	18.6	3.2	1.5
Average rate of load (%)	-	-	50	-	40	75
Average rate of pay-load (t)	-	-	0.9	-	1.1	5.8
Principal purpose of trip	Business	Serve passenger	Agricul-tural activity & business	Serve passenger	Agricul-tural activity & business	Business
Make/model	Datsun-1300, Toyota 1600, Mazda 1600	Datsun 1500, Mazda 1600, Mazda 1800, (Loading capacity 1.0-2.0t)		Mazda 2000, Toyota 2000, Toyota Mini Bus (Loading capacity 2.5-3.0t)		Bedford, Toyota Dyna (Loading capacity 5-12t)

Source: JICA Mission

Average numbers of passengers indicated by the O-D survey were 4.1 (82% of capacity of 5) for passenger cars, 15.5 (78% of capacity of 20) for vans, and 18.6 (74% of capacity of 20) for small buses (remodeled middle-size trucks). These rates are very high compared with the 1.35* for passenger cars in Japan.

Goods loading rates were 50% for small trucks, 40% for middle-size trucks, and 75% for large trucks. The rates for the former two are rather low and it is assumed that goods transport is not a major purpose of the operation of these trucks. On the other hand, the rate for large trucks is high, suggesting that the road surface condition is surprisingly good and allows the carriage of a large quantity of goods on a truck.

Trip purposes indicated by the O-D survey were "business" for passenger cars and large trucks, "passenger transport" for vans and small buses, and "business and agricultural activities" for small and middle-size trucks. Thus, it was revealed that while passenger cars, vans, small buses, and large trucks are being used for their originally-intended purposes, small and medium trucks are used not only for goods transport but also for other purposes.

(4) Trip Generation Rate

In addition to the above O-D survey, a home interview survey was conducted by having investigators visit each household for an interview.

Average trip generation rate indicated by the home interview survey was 0.06 trips per person per day, which is still low compared with 2.5 to 3 trips per person per day in Japan.

* Source: "Current Status and Future of Urban Traffic in Hiroshima"

Table 3-4 Trip Rate

Name of Town	Number of Sample Household	Trip Rate/ Person.Day
Panlap	5	0.183
Kalangba	11	0.043
Gbandembu	15	0.016
Kamaranka	10	0.060
Kamalu	9	0.044
Average	50	0.060

Source: JICA Mission

Pedestrian range is the maximum distance persons go afoot, beyond which they would utilize a motorcar. The home interview survey revealed a pedestrian range of two to three miles (see Fig. 3-6).

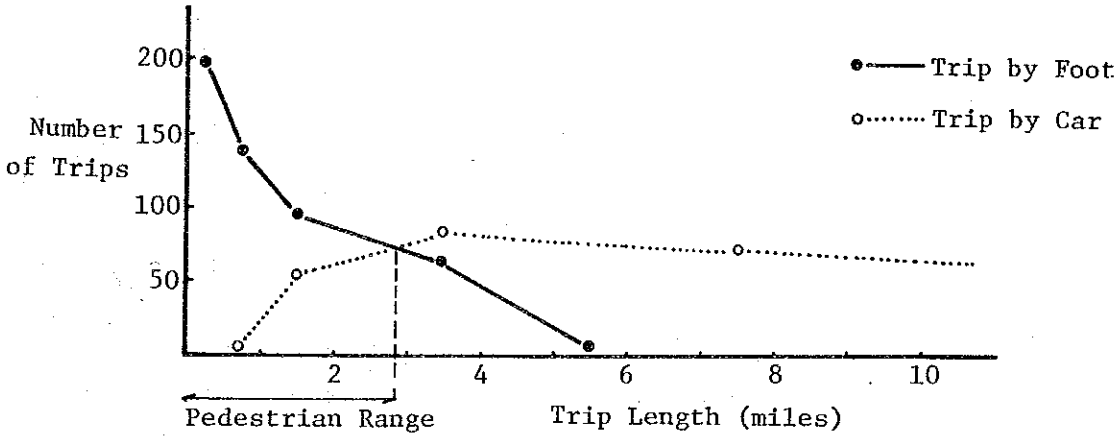


Fig. 3-6 Pedestrian Range

Source: JICA Mission

(5) Fares

Passenger fares are always negotiated between the passenger and the driver (of taxicabs and remodeled buses) in the absence of a fixed tariff. The Road Transport Corporation (RTC) buses and the mini-buses (called "poda poda") which serve in Freetown, however, have fixed tariffs as follows:

RTC:	Within Freetown	0.10-0.20 Le
	Freetown - Makeni	3.50 Le
	Freetown - Bo	4.00 Le
	Freetwon - Guinea (Conakry)	10.00 Le
Mini-bus (poda poda):		
	Within Freetown	10 ¢ per person per trip

An interview survey resulted in the following estimation of negotiated taxi and remodeled bus fares:

Distance	One-way Fare (Per Person Per Trip)
Up to 2 miles	0.20 Le
2 - 8 miles	0.50
10 - 20 miles	1.00
50 miles	2.00
100 miles	3.00

Source: JICA Mission

As a side information, taxi and remodeled bus fares are 2 Le for Makeni - Kamakwie (53 miles), 3 Le for Makeni - Freetown (115 miles), and 4 Le for Makeni - Kabala (76 miles). It should be noted that these fares are for passengers sharing rides, and the fare becomes very high when a passenger rides alone. Also, taxi drivers try to avoid bad roads and, therefore, it appears that almost no taxicabs are operated on the Makeni -

Kabala Road and, in wet seasons, the Makeni - Kamakwie Road.

Goods fares are also negotiated. According to carriers, the carlot rate is from 30 to 50 cents per mile per ton. This means fares of 3 Le for a bag (50 kilogrammes) of cement from Freetown to Kamakwie (about 170 miles), 1.0 Le for a bag of groundnuts and 0.50 Le for a bag of corn (wheat), both from Kamakwie to Makeni.

(6) Operation Speed*

In 1971, maximum speed limits were established in Sierra Leone at 20 miles per hour in city areas and 30 miles per hour out of cities. These speed limits are little enforced, however, and most drivers drive at maximum capacity of the vehicle at present: passenger cars are driven at a speed of 60 to 70 miles per hour on 4-lane and 2-lane expressways, about 55 miles per hour on well-paved 2-lane roads, and about 40 miles per hour on paved but inferior 2-lane roads. Large trucks are driven at some 15% lower speed than passenger cars. On the Makeni - Kamakwie Road, passenger cars move at a speed of 20 to 30 miles per hour.

(7) Cattle Movement

Cattle droving by walking cattle-herders represent 20% - 30% (according to the Veterinary Division in Panlap) of total cattle movement (approximately 8,000 cattle-trips per year) on the Makeni - Kamakwie Road. In order to eliminate the droving of about 2,500 cattle per year (less than 30% of the 8,000) from this road, approximately 150 truck-trips will be required if each 7-ton truck can carry 10 to 17 cattle (50 to 85 sheep or goats; according to said Division).

* The indicated speeds are clocked sectional speeds.

4) Road Development Activities in the Project Area

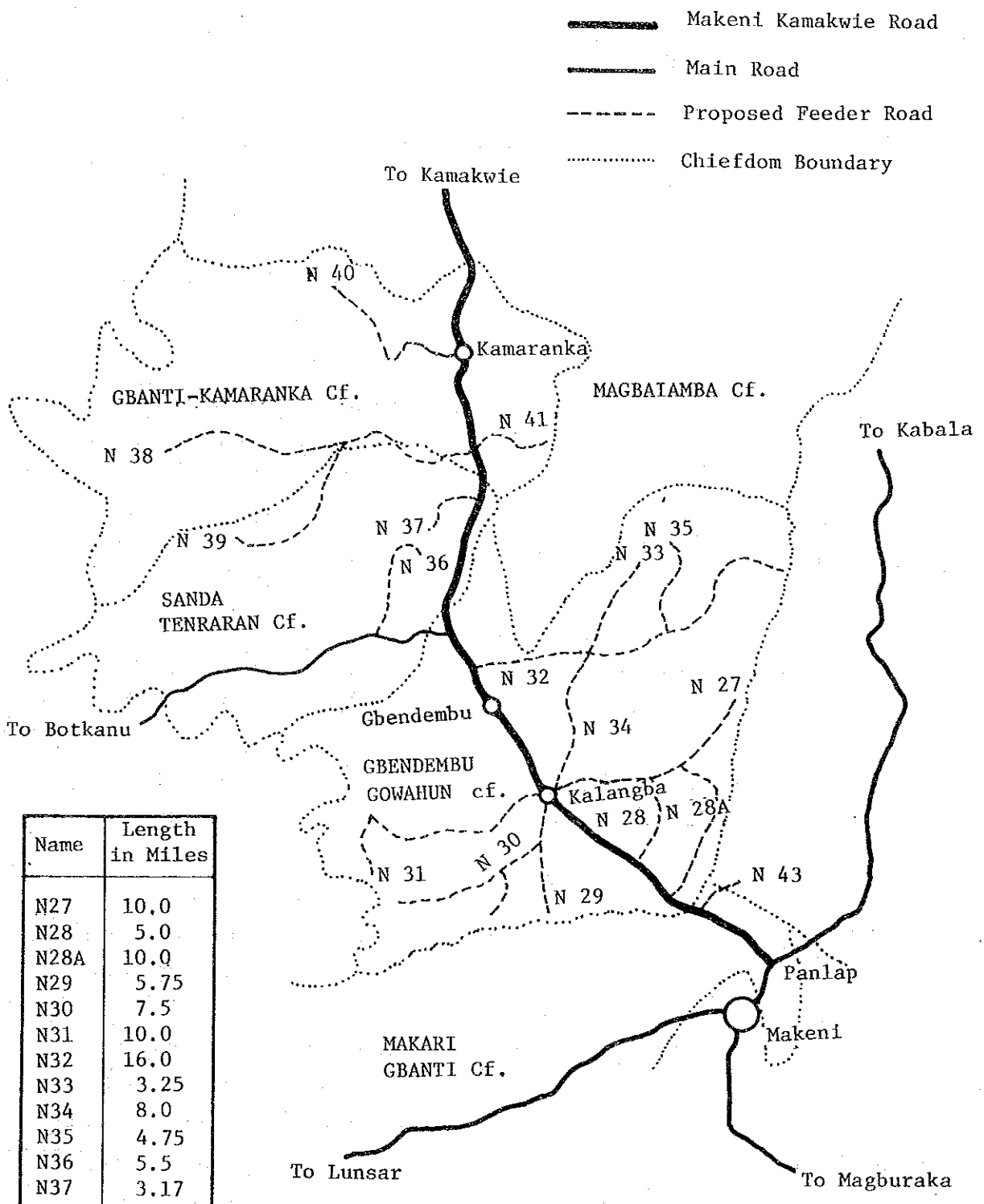
Feeder road development projects are currently being implemented under the Northern Area Integrated Agricultural Development Programme (NAIADP); the projects cover some of the Project Area, ie. Makari Gbanti, Gbendembu Gowahun, Sanda Tenraran, and Gbanti Kamaranka Chiefdoms. In addition, it is expected that the next extension of the IADP project will be implemented by the Food and Agriculture Organization (FAO) of the United Nations and will cover the entire Project Area.

The Cooperative American Relief Everywhere (CARE), which is in charge of the feeder road construction, has adopted the Class IV specification of the National Road Standard of Sierra Leone for the feeder roads (some modifications are authorized depending on the function of the road), as follows:

Design traffic speed	25 MPH (about 40 Km/H)
Minimum radius	300 feet (about 90 meters)
Maximum gradient	15%
Road width	16 feet (about 4.9 meters)

The unit feeder road construction cost (total project cost) is estimated at approximately 30,000 Le/mile (4.3 million yen/Km).

Note: A table of feeder road projects now being implemented by NAIADP is presented in Appendix.



Name	Length in Miles
N27	10.0
N28	5.0
N28A	10.0
N29	5.75
N30	7.5
N31	10.0
N32	16.0
N33	3.25
N34	8.0
N35	4.75
N36	5.5
N37	3.17
N38	13.25
N39	7.0
N40	7.5
N41	3.75
N43	3.75
Total	124.17

Fig. 3-7 Proposed Feeder Roads for 1978-81 in IADP

Source: NAIADP Makeni Office

3.2 Road Inventory Survey

A road inventory survey was conducted for an accurate understanding of the existing conditions (surface, width, vertical and horizontal alignments, and location and shape of culverts and bridges) of the Makeni - Kamakwie Road.

1) Alignment

The existing road, most of which goes through plateaus and dales, shows fairly good horizontal and vertical alignments on the whole. Alignments are good generally in the plateaus, but in the vicinity of villages in dales sight distance is sometimes inadequate due to steep gradients and horizontal curvatures of a small radius.

Between Panlap and Matehun (17 miles), some sections do not satisfy the geometric design standard, but the rest have good vertical and horizontal alignments. Both vertical and horizontal alignments are favourable between Matehun and Kaimpo (28 miles). Between Kaimpo and Kamakwie, the road goes through a mountainous terrain, and alignments and sight distance are inadequate near rivers and creeks.

The existing road appears to have been constructed in consistency with the local topography in order to minimize the number of cuttings and embankments. Therefore, alignments are particularly poor in portions cutting through ridges and embankments in dales, where gradients are short and varying. Because the horizontal alignments have been so designed as to minimize the amount of earthwork, some horizontal curvatures are of a very small radius and the alignments often have little continuity and harmony with each other.

Simply put, the existing road was constructed mostly manually with little attention to alignment, when traffic volume was very small, and, therefore, both vertical and horizontal alignments not only fail to meet the geometric design standard but also lack harmony.

Table 3-5 Number of Horizontal Curves in the Specified Range

(Unit: Number)

Radius (ft)	Intersection Angle			Total
	0°≦IA<30°	30°≦IA<60°	60°≦IA<90°	
- 250	-	-	8	8
250 - 500	3	26	72	101
500 - 800	2	21	33	56
800 - 1,100	-	4	11	15
1,100 - 1,600	2	16	13	31
1,600 - 2,300	24	65	23	112
2,300 - 3,000	77	35	6	118
3,000 - 4,000	6	3	-	9

Source: JICA Mission

Table 3-6 Length of Grade Lines in the Specified Range

(Unit: Miles)

Gradient (%)	Length of Grade Lines (ft)						Total
	300	700	1,000	1,300	1,700	2,000	
0-1	2.8	5.1	5.5	2.0	0.5	0.3	16.2
1-2	0.4	0.7	0.7	0.2	0.5	-	2.5
2-3	1.4	3.0	3.2	1.8	0.5	-	9.9
3-4	1.0	2.7	2.0	1.1	0.2	-	7.0
4-5	1.1	1.8	1.5	0.5	0.1	-	9.2
5-6	1.1	1.7	1.4	0.4	0.1	-	0.5
6-7	1.2	1.7	1.9	0.7	0.7	-	6.2
7-8	0.1	0.1	0.1	-	-	-	0.3
8-9	0.2	0.3	0.1	0.2	-	-	0.8
9-10	0.1	0.2	-	-	0.2	-	0.5
Total	9.4	17.3	16.4	6.9	2.8	0.3	53.1

Source: JICA Mission

2) Cross Section

The existing road varies in width by location. It is generally narrow (from 10 to 20 feet) in cut or embanked parts, wide (20 to 30 feet) on plateaus where embankment need not be very high and cutting very deep, and very wide (about 40 feet) in villages.

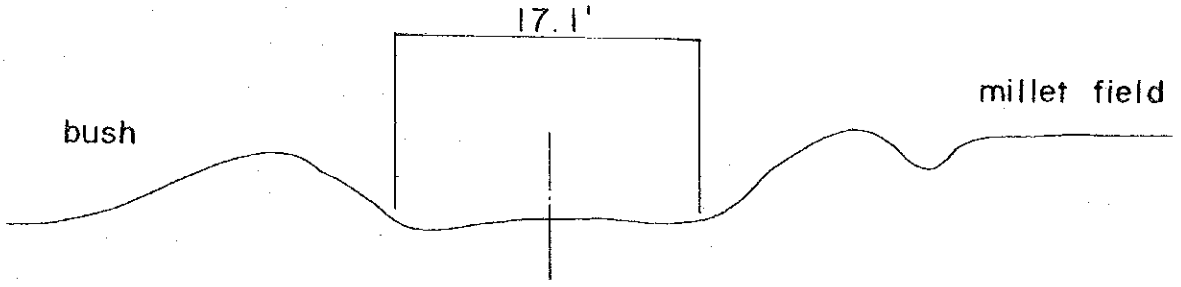
Hardly any side ditches were installed. Naked ditches found in some village areas are believed to be of little effect.

Slope gradients are very steep (vertical:horizontal, 1:0.2 to 1:0.4) in cut parts, but the slopes are relatively stable because the cutting is not very deep (about 7 feet at most). Embankments are not high (about 10 feet at maximum) and are stable with a gradient of 1:1.5.

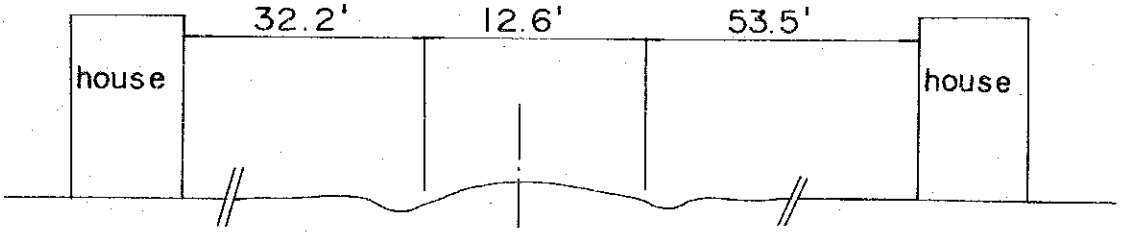
3) Surface

The existing road has generally good surface conditions throughout its extension. The surface soil is silty clay with a gravel content and most of the surface have been compacted by the cumulative load of traffic. The gravel content varies by location and is generally high in plateaus and low in lowlands. Where the road declines from a plateau toward a lowland, rainwater flows down over the road surface because of the lack of side ditches, and creates water channels, washes gravels out, and thus devastates the road surface.

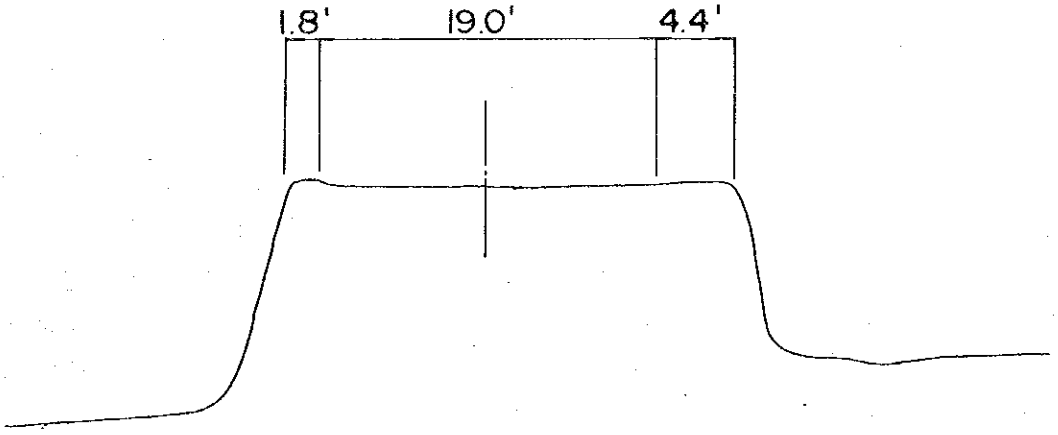
In some lowland sections where the road runs by rice paddies, such as in the Tambianu - Maiyata Section, water has soaked into the road from the side, softening the road surface. In the lowland section between Makali and Kemedi, water has soaked into the road from the sides, submerging the clayey soil and softening the road down to the sub-grade.



CUT STA. 7+50



VILLAGE STA. 6+00 (MAFURÉ-NJALA)



BANK STA. 5+00 (MABOLE BRIDGE)

Fig. 3-8 EXISTING TYPICAL CROSS SECTION (ft.)

SCALE 1 : 125

4) Culvert

The existing road has a total of 13 bridge culverts and 144 pipe culverts. The width of bridge culverts is usually about 12 feet, with the largest about 20 feet. Most of the pipe culverts are of 2-foot diameter, and two or three pipe culverts are placed together at 19 locations where the discharge volume is high. Bridge culverts are made of reinforced concrete but are believed to be inadequate for future loads. All of the 2-foot diameter pipe culverts and most of the other pipe culverts are reinforced concrete pipe or corrugated pipe.

Some 2-foot pipes are filled with mud, having almost no room for discharge. Pipes were merely buried in place, and inlets and outlets are being little cared for. Foundation work for pipe installation is not believed to have been done thoroughly, since some pipes have subsided at the middle of road at some locations. Generally speaking, however, the pipe culverts are believed to be in good condition due to the sub-grade of silty sand clay with gravel content, which is quite firm.

3.3 Bridge Inventory Survey

The existing road has a total of 24 bridges. Their width vary from 10 feet to about 14 feet. Most of them are of single span, but some are of multiple span. With the exception of the Mabole Bridge, the bridges are made of either reinforced concrete slabs or plates laid over I section steel girders supported by gravity abutments or wooden crossbeams and wooden plates placed over the girder where vehicle tyres pass. Bridges in the first half of the road (from Panlap) are of reinforced concrete slabs, and those in the latter half are of wooden slabs.

All of these bridges in the present condition will be inadequate for future traffic. Inquiry with local inhabitants revealed that all of these

Table 3-7 List of Existing Bridge Culverts and Multiple Pipe Culverts

Location Km	Mile	Type	D x N (ft)	Width (ft)	Length (ft)	Height (ft)	W.D.	W.L. (ft)
3 + 40	2.1	P.C.	2' x 3	-	19'0"	-	L	0'4"
6 + 60	4.1	P.C.	2'6" x 2	-	31'8"	-	R	-
7 + 60	4.7	P.C.	2' x 3	-	18'4"	-	R	3'4"
9 + 40	5.9	BRC	-	12'10"	9'8"	3'4"	L	1'0"
10 + 10	6.3	P.C.	2' x 2	-	11'0"	-	L	0'4"
10 + 90	6.8	BRC	12'10"	12'	14'7"	7'5"	L	1'0"
18 + 90	11.8	P.C.	2' x 2	-	21'2"	-	R	1'8"
23 + 40	14.6	P.C.	2' x 5	-	18'6"	-	L	0'4"
23 + 80	14.9	P.C.	2' x 3	-	17'6"	-	L	0'4"
32 + 00	20.0	BRC	-	15'9"	10'6"	4'11"	R	0'4"
32 + 60	20.4	BRC	-	17'5"	13'1"	5'1"		
35 + 40	22.1	P.C.	2' x 2	-	17'8"	-	R	-
35 + 90	22.4	BRC	-	13'11"	12'2"	7'11"	R	1'0"
37 + 40	23.3	BRC	-	13'9"	12'2"	3'0"	L	0'4"
40 + 90	25.6	P.C.	2' x 2	-	19'0"	-	L	1'0"
42 + 00	26.3	P.C.	2'6" x 2	-	21'4"	-	L	-
43 + 90	27.4	BRC	-	13'11"	11'4"	2'4"	L	-
44 + 60	27.9	BRC	-	13'11"	12'10"	6'8"	L	0'4"
47 + 10	29.4	BRC	-	14'1"	8'0"	2'10"	R	-
49 + 60	31.0	BRC	-	13'9"	8'0"	1'0"	R	-
51 + 60	32.3	P.C.	2' x 2	-	17'10"	-	R	0'4"
52 + 30	32.7	P.C.	2' x 2	-	23'10"	-	R	0'4"
52 + 60	32.9	P.C.	2' x 2	-	18'0"	-	R	-
53 + 30	33.3	BRC	-	13'11"	9'2"	4'10"	R	-
55 + 00	34.4	P.C.	2' x 2	-	14'4"	-	R	-
55 + 60	34.8	P.C.	2' x 2	-	18'0"	-	R	-
58 + 70	36.7	P.C.	2' x 3	-	18'0"	-	L	-
60 + 40	37.8	P.C.	2' x 2	-	18'2"	-	R	-
61 + 50	38.4	BRC	-	13'9"	11'6"	5'1"	L	-
62 + 90	39.3	P.C.	2' x 2	-	18'4"	-	L	-
67 + 40	42.1	BRC	-	13'11"	14'9"	6'6"	L	-
74 + 40	46.5	BRC	-	20'2"	9'0"	3'11"	L	-
76 + 20	47.6	P.C.	2' x 3	-	23'10"	-	L	-

Source: JICA Mission

Note: P.C.: Pipe culvert
BRC: Bridge culvert
D x N: Diameter x Number of pipes
W.D.: Water direction
H.W.L.: Highest water level from the BRC elevation

bridges have never been flooded and, therefore, are believed to have sufficient discharge area even during floods.

The Mabole Bridge is a 5-span bridge with a length of 332.2 feet and a width of 14.9 feet including sidewalks. It has gravity abutments of reinforced concrete, column type piers, plate girders, and a superstructure of reinforced concrete slab. The bridge in its present condition is estimated to withstand a load of up to about 20,000 pounds, as calculated from its strength. Abutments and piers are expected to have an allowable stress sufficient to support a vehicle weight of 20,000 pounds and the weight of the superstructure.

The foundations of all these bridges including the one over the Mabole are direct foundations and show no evidence of subsidence.

Table 3-8 List of Existing Bridges

Location		Span	Width (ft)	Length (ft)	Height (ft)	W.D.	W.H.L. (ft)	Remarks
Km	Mile							
5 + 30	3.3	1	10'11"	17'6"	10'6"	L	-	-
5 + 90	3.7	2	11'1"	53'4"	12'2"	R	-	-
8 + 00	5.0	5	14'9"	332'2"	36'1"	L	-	-
13 + 20	8.3	1	11'1"	32'2"	14'1"	L	0'4"	-
16 + 20	10.1	1	11'0"	15'1"	16'11"	L	0'4"	-
17 + 00	10.6	1	10'8"	19'7"	13'1"	L	-	-
22 + 20	13.9	1	11'1"	32'8"	12'6"	L	-	-
26 + 30	16.4	2	11'0"	50'6"	15'9"	L	-	W
27 + 20	17.0	3	11'0"	96'2"	32'10"	L	-	-
27 + 70	17.3	1	11'0"	17'7"	12'6"	L	-	-
30 + 20	18.9	1	11'0"	17'8"	10'6"	L	0'4"	-
32 + 00	20.0	1	15'9"	10'6"	13'9"	L	0'8"	-
34 + 00	21.3	1	11'0"	27'5"	13'9"	L	-	-
35 + 10	21.9	1	16'1"	27'8"	13'3"	L	-	-
43 + 10	26.6	2	13'11"	61'8"	19'4"	L	-	W
45 + 40	28.4	1	11'0"	28'3"	15'11"	L	-	W
49 + 00	30.6	1	10'0"	18'1"	7'10"	L	0'4"	W
51 + 20	32.0	1	13'11"	31'6"	16'1"	L	0'4"	W
57 + 00	35.7	1	13'11"	21'6"	7'3"	L	0'4"	W
60 + 30	37.7	3	13'11"	93'6"	20'4"	L	-	W
64 + 10	40.0	1	15'7"	21'0"	5'11"	L	0'4"	W
64 + 80	40.5	1	13'11"	25'3"	9'6"	L	0'4"	W
67 + 00	41.9	2	13'11"	52'8"	14'9"	L	-	W
74 + 20	46.4	4	13'9"	108'11"	28'10"	L	-	W

Source : JICA Mission

Note : H.W.L.: Highest water level from the bridge elevation
W : Wooden slab

3.4 Topographical Survey

1) Purpose

Sections where alignment needs to be improved have been identified based on road and bridge inventory surveys, and subjected to the following surveys in order to determine route location and to facilitate road and bridge designing.

2) Topographical Survey

A topographical survey was conducted covering a total extension of 19.5 miles (31.5 kilometers) in order to make a topographical map at a scale of 1:1,250, as shown in Appendix N. An open traverse survey was conducted first at each survey point and, based on this, an offset survey was conducted.

3) Profile Survey

The centre line of the existing road in the sections where the topographical survey was conducted was subjected to a profile survey. As for bench mark, the temporary altitude at each point was used as the margin height.

4) Cross Section Survey

A cross section survey was made for a width of 50 feet (15 metres) along the centre line at intervals of 100 feet (90 metres) in the section where the topographical survey was made.

5) River Cross Section Survey

Rivers over which major structures (bridges, culverts) currently exist have been surveyed for cross section. At each location, a river cross section survey was conducted at three points: on the road center

line, 100 feet (30 metres) upstream, and 100 feet (30 metres) downstream.

6) The results of these surveys have been translated into the following drawings and included in Appendix N:

	Scale
Plan	1 : 1,250
Profile	1 : 1,250 (horizontal)
	1 : 6,250 (vertical)
Cross Section	1 : 200
River Cross Section	1 : 200

3.5 Climate Study

1) Rainfall

The Project Area belongs to a typical tropical area with fairly distinct rainy and dry seasons. The rainy season is claimed to last from May to October, but rainfall is particularly heavy in July, August, and September.

As shown in Appendix O, average-year precipitation in Makeni is about 120 inches. Of the total annual precipitation, 85% occur in the rainy season and 60% in July to September. Maximum daily rainfall in Makeni is over five inches, indicating the occurrence of concentrated rainfalls.

2) Temperature

Temperature is high in Makeni, with a mean maximum of 80°F to 90°F. Temperature varies little throughout the year but is slightly lower in the rainy season than in dry. The mean minimum also varies little between 60°F and 70°F throughout the year.

Table 3-9 Mean Maximum and Minimum Temperatures at Makeni (1970-1979)

(Unit: °F)

Month	Maximum	Minimum
January	91.5	65.9
February	94.5	69.7
March	95.9	70.1
April	95.4	71.9
May	93.3	72.5
June	89.5	72.1
July	86.1	71.6
August	86.2	71.1
September	87.0	71.6
October	88.8	73.1
November	89.0	73.4
December	89.8	67.0

Table 3-10 Relative Humidity at Makeni (1970-1979)

(Unit: %)

Month	At 9:00	At 15:00
January	82.3	52.2
February	85.1	48.3
March	80.0	47.6
April	80.9	48.9
May	85.4	62.1
June	87.4	69.5
July	90.6	72.8
August	92.0	74.3
September	90.3	71.0
October	86.6	65.8
November	87.8	65.3
December	85.4	58.7

Source: Table 3-9,10: Sierra Leone Meteorological Service

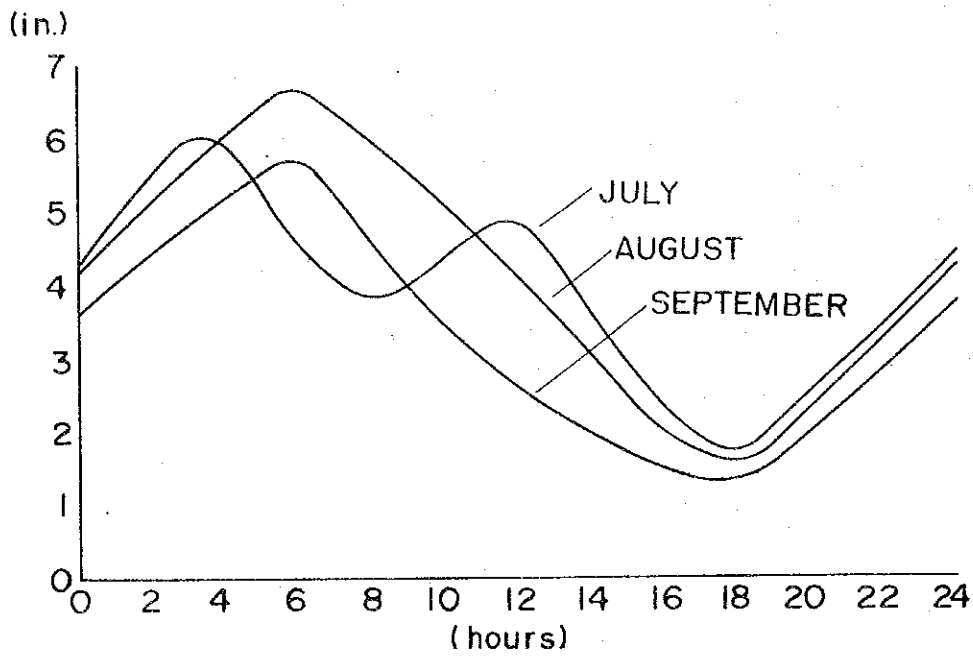


Fig. 3-9 SMOOTHED OUT CURVES FOR HOURLY RAINFALL AT LUNGI

Source : Fig.3-9,10,11: Rainfall in Sierra Leone, December, 1973.

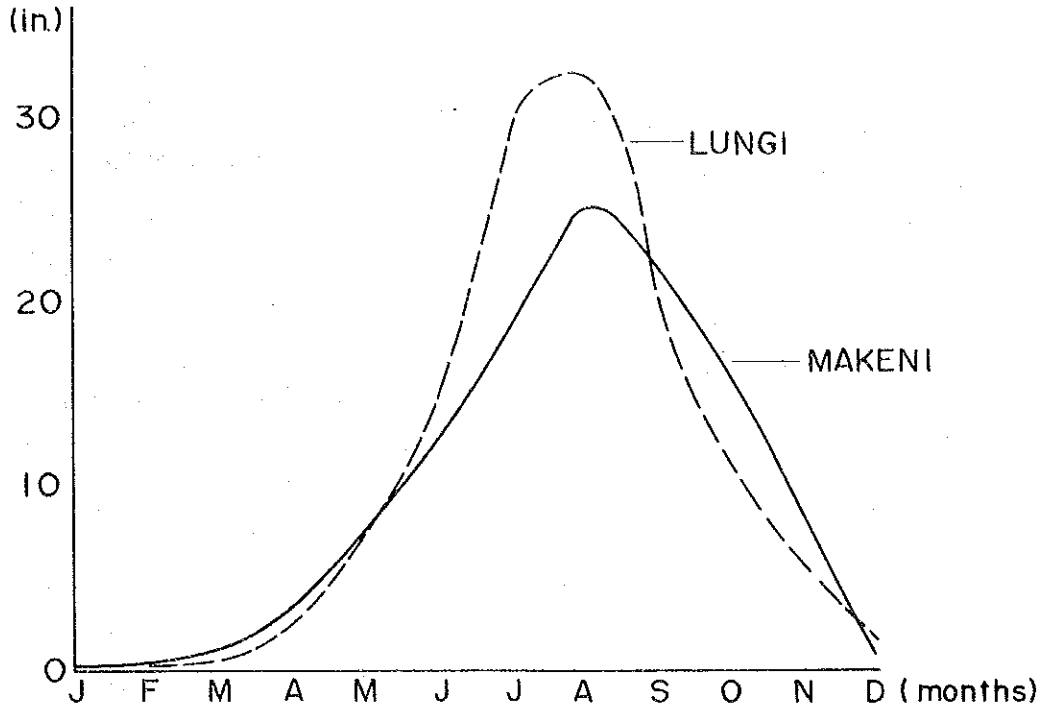


Fig. 3-10 MONTHLY VARIATION OF RAINFALL

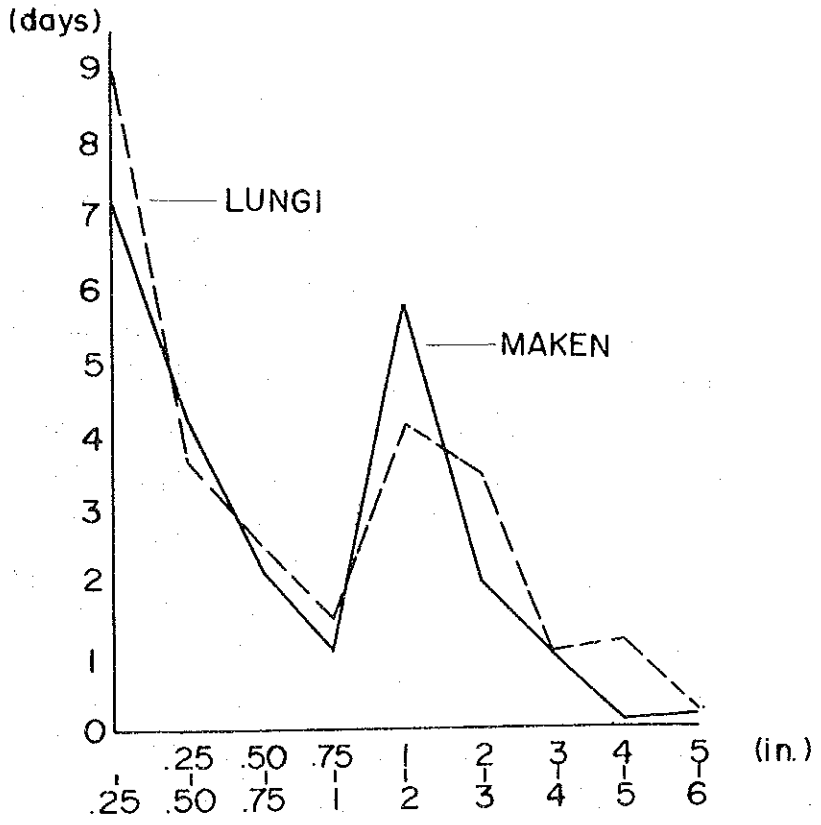


Fig. 3-11 AVERAG NUMBER OF DAYS WITH RAINFALL IN THE SPECIFIED RANGE IN AUGUST

3) Humidity

Maximum humidity in Makeni ranges from 80% to 90%, sometimes exceeding 90% in the rainy season. Minimum humidity is from 50% to 70%, indicating that the air is quite damp even in the dry season.

4) Rainy Days

As shown in Appendix O, it rains 14 to 25 days each month during the rainy season, and nearly everyday from July to September. In the dry season, it rains only up to four days a month.

5) Daylight Hours

The duration of daylight is six to seven hours per day from July to September and is about eight hours in the dry season, as shown in Appendix O. The difference in daylight hours is little between dry and wet seasons.

3.6 Soil Survey

1) Purpose

A soil survey was made to evaluate the suitability of sub-grade soil, aggregates for bridge foundation, concrete, and pavement, and embankment materials to facilitate the designing of the road, pavement, and bridge foundations and the formulation of construction work schedule. The survey at this stage will offer basic data for preliminary design and provide a guideline for detailed soil survey for detailed design and, therefore, should be conducted with adequate care.

2) Survey Outline

Samples were collected at ten locations where the soil represented the section or area. For the purpose of the Mabole Bridge foundation designing, the bearing layer was confirmed by auger boring at

the bridge construction site.

The survey included physical tests (specific gravity, optimum moisture content, sieve analysis test, liquid limit, plasticity index), a field CBR test, and, at the Mabole Bridge construction site, a bearing layer confirmation by auger boring.

These tests were conducted in laboratory and in the field according to BS 1377 and ASSHO T-180.

3) Survey Findings

The survey findings are summarized in Table 3-11, and described in detail in Appendix P-1. The typical base soil of the existing road is silty sand clay with some gravel content and falls under A-2-7 by the ASSHO Soil Classification, with the exceptions of Sample No. 4 collected near Gbendembu which is silty sand falling under A-2-6 by the same classification, and Sample No. 8 from near Kamalu which is clay soil falling under A-6.

For the upgrading of the existing road, the sub-grade soil must have adequate properties for the purpose: generally 50% or less fine aggregate, a plasticity index of 30 or less, and 5% or higher soaked CBR. The fine aggregate proportion of the existing road soil is only about 44% at most (in the vicinity of Makali) and is usually from 20 to 40%. The plasticity index is from 30 to 10, and the CBR can be expected to be at least 25. These indicate that the soil can be used satisfactorily as the base soil for the upgrading of the existing road surface. However, Sample No. 9 and the surrounding soil are silty clay with a high plasticity index and have a higher fine aggregate proportion than elsewhere. The deterioration of CBR and workability can possibly be caused by water penetration from roadside into the sub-base course and this must be prevented by the installation of an impervious layer.

Field CBR Test

The Field CBR Test, conducted to evaluate the bearing capacity of the existing road surface, indicated a very high value, due to compacting under cumulative vehicle load, in all areas except for the vicinity of Makali. This shows that the existing road surface can be used adequately as a roadbed. Even the soil in the vicinity of Makali, with a lower CBR value than elsewhere, is not soft ground. The existing road surface in this area can also be used as a roadbed with a proper impervious layer.

Auger Boring at Mabole Bridge Site

As shown in Appendix P-2, the substructural foundation layer bearing was tested at the Mabole Bridge construction site by auger boring, and the presence of bedrock was confirmed at a depth of 10 to 25 feet. An outcrop of rocks was observed on the river bank near the site, and local inhabitants indicated an outcrop of rocks in the riverbed in the dry season. Based on the foregoing, it is believed that a bearing layer with rock foundation exists in the riverbed not deeper than 10 feet.

Defraction Survey

Prior to conducting a defraction survey of the existing road surface by the Benkelman Beam, a 7-ton dump truck was driven over the surface at a very low speed for a naked eye observation of the changes in the road surface. In view of the very little change observed - the defraction being less than 1/5 of an inch - it was judged that the Benkelman Beam Survey would be unnecessary and that there would be no trouble caused by defraction.

Table 3-11 Summary of Soil Test

Sample Number	Location	Natural Moisture Content	Specific Gravity	Particle Size Distribution			Consistency				Compaction					Report
		%	Sp.G	Gravel	Sand	Fines	LL %	PL %	PI %	L.S.	MDD lb/ft^3	MDD mg/m^3	OMC %	C.B.R.	Sub-group	
1	Panlap (o mile)	8.4	2.77	68	12	20	43	30	13	7	123	1.97	12.3	43	A-2-7	Gravel sand silty clay
2	Mabole (5.1 miles)	4.5	2.77	47	28	25	45	28	17	10	126	2.02	9.0	160	A-2-7	"
3	Mafure (10.8 miles)	11.2	2.68	57	21	22	47	30	17	6	128	2.05	9.2	130	A-2-7	"
4	Gbendembu (19.7 miles)	15.3	2.69	1	72	27	40	22	18	10	117	1.88	10.8	98	A-2-6	Sandy soil
5	Magbandani (22.0 miles)	11.9	2.78	69	11	20	41	27	14	8	129	2.07	10.8	100	A-2-7	Gravel sand silty clay
6	Masaktaba (30.7 miles)	34.8	2.72	50	26	24	48	22	26	12	117	1.88	12.0	74	A-2-7	"
7	Kamaranka (35.9 miles)	16.5	2.65	51	27	22	63	33	30	12	109	1.75	13.2	87	A-2-7	"
8	Kamalu (44.8 miles)	13.2	2.52	54	16	30	53	30	23	10	128	2.05	11.3	26	A-2-7	"
9	Makali (46.1 miles)	23.9	2.65	7	49	44	37	19	18	10	111	1.78	14.6	46	A-6	Clayey soil
10	Kamakwie (53.1 miles)	11.1	2.64	64	15	21	45	26	19	10	120	1.92	15.2	50	A-2-7	Gravel sand silty clay

Source : JICA Mission

3.7 Construction Material Survey

1) Embankment Material

Because earth from cutting will be used for embankment in nearby locations as a principle, the existing roadside soil was tested for a field CBR value and findings were favourable, as stated before. The natural topsoil of the roadside soil, however, is "laterite", a residual iron soil formed by the decomposition under high temperature and high humidity of organic matter accumulated on the soil surface. It is therefore inferior as embankment material. Suitable embankment material can be obtained along the existing road if the topsoil of the entire extension is either spoiled or thrown into lower parts of the embankment.

2) Selected Material

Silty clay with relatively high gravel and sand contents are to be obtained from embankment material borrow pits and used as sub-base course material and back fill for structure.

3) Crushed Stones

A field survey indicated the possibility of developing new quarries at three locations for obtaining crushed stones for use in structure and base course work.

a) Matehun area, 17 miles from Panlap
b) Area 1 mile from the Batkanu Road, near Gbendembu
c) Makuta area near Kamaranka

The quarry must not only have the required stones but must also have sufficient land space for a storage yard and the construction of a crushing plant, and it is important that the hauling distance to the job site is short.

The Matehun area has a sufficient deposit of stones and offers easy quarrying; therefore it is the most suitable. The second possibility is Makuta, in view of the hauling distance, but the cost of obtaining crushed stones might be somewhat higher due to a degree of topsoil and the necessity of constructing an access road. Whether both locations should be developed or limited to one location should be decided before detailed designing, by comparing hauling distance and development cost. However, two quarries are assumed for the time being.

The stone available at the above locations is granite. Generally speaking, an angular aggregate with a maximum diameter of 2 inches, a minimum adjusted CBR of 20%, and an abrasion loss of 50% or less by the Los Angeles Abrasion Test, is desirable for base course use. Some granite crush into flat pieces, and therefore have a high abrasion loss. Such unsuitable materials should be taken out before use.

4) Gravel and Sand

Both gravel and sand can be obtained from major rivers on the route. (As Figure 3-12 shows, major rivers cross the road at suitable intervals and insure short hauling distances.) These materials were indicated by surveys conducted so far to be suitable for concrete materials in terms of particle size, but detailed surveys should be conducted at the time of detailed designing.

5) Water

Water will be obtained from major rivers. Although water is not available throughout the year from all the rivers, since precipitation varies greatly between the rainy and dry seasons, local inhabitants witness that the major rivers indicated in Figure 3-12 have water even in the dry season. The quality of the water should be tested in detail at the time of designing, but as far as naked eye observation

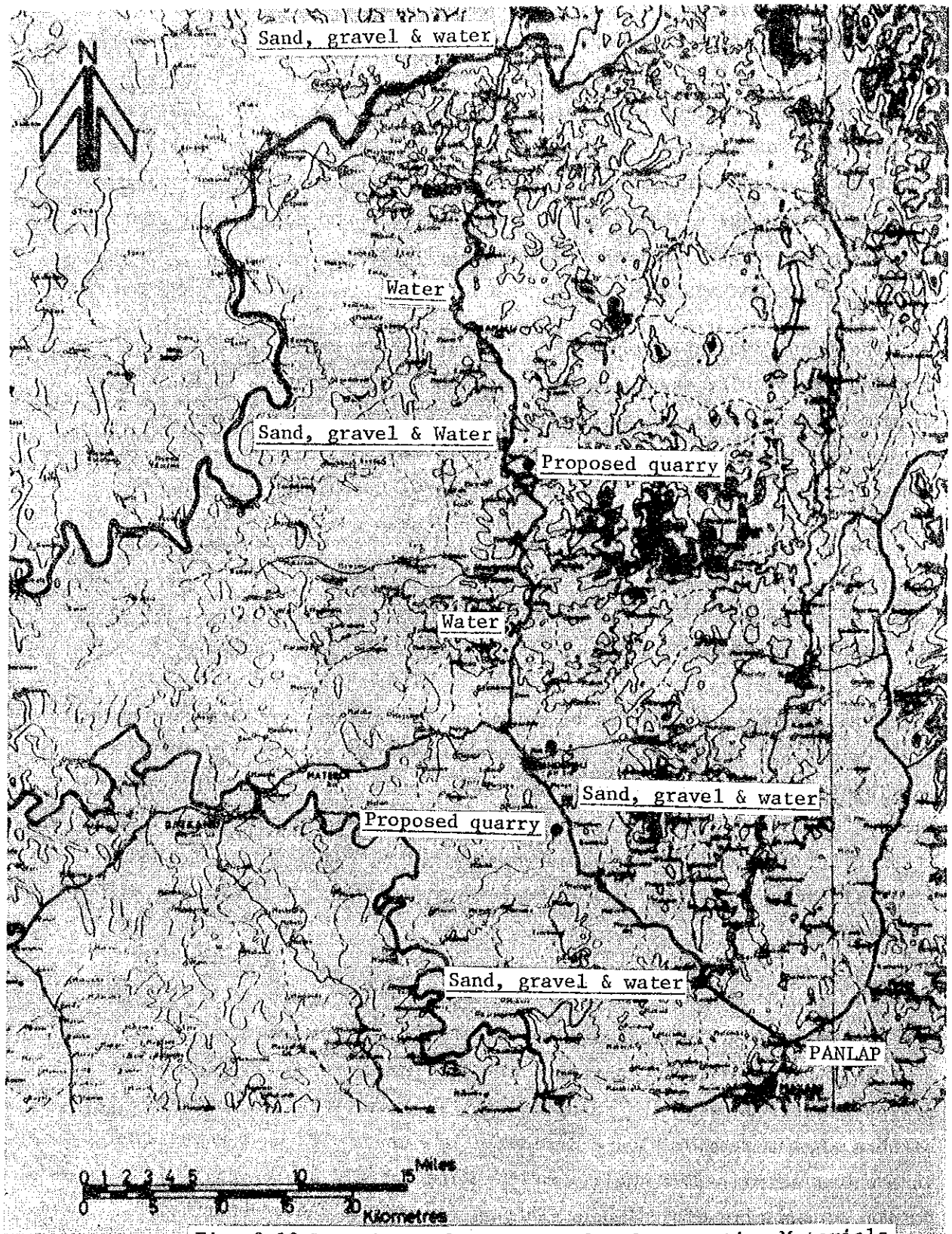


Fig. 3-12 Locations of Resources for Construction Materials

Source : JICA Mission

is concerned, the water is free of impurities and is usable for construction purposes.

3.8 Hydrological Analysis

1) Purpose

The Project Road crosses the Mabole and many other rivers and creeks, and therefore has a number of bridges and culverts. These structures must have sufficient discharge areas to accomodate the volume of discharge during floods if the road is to be upgraded to an all-weather road. Because the discharge area of existing structures is insufficient to handle the proposed discharge volume, new bridges, box culverts, and pipe culverts with sufficient areas must be installed as a part of the improvement work. The purpose of the hydrological analysis is to determine the necessary discharge area size by estimating the proposed discharge volume based on data obtained through a field survey.

2) Method

The size of the discharge area can be determined by a number of methods, but the available material can affect the result greatly. Basic data used for this analysis is the daily rainfall recorded in Makeni at one end of the Project Road. Based on this, the maximum average hourly rainfall is estimated for each of the major rivers and creeks for the estimation of discharge volume. In addition, the cross section of these rivers and creeks was measured, and local inhabitants were interviewed on water level during floods. The proposed discharge volume and the proposed discharge area size were determined through comparing the above two types of information through the process indicated by the flow chart in Figure 3-13.

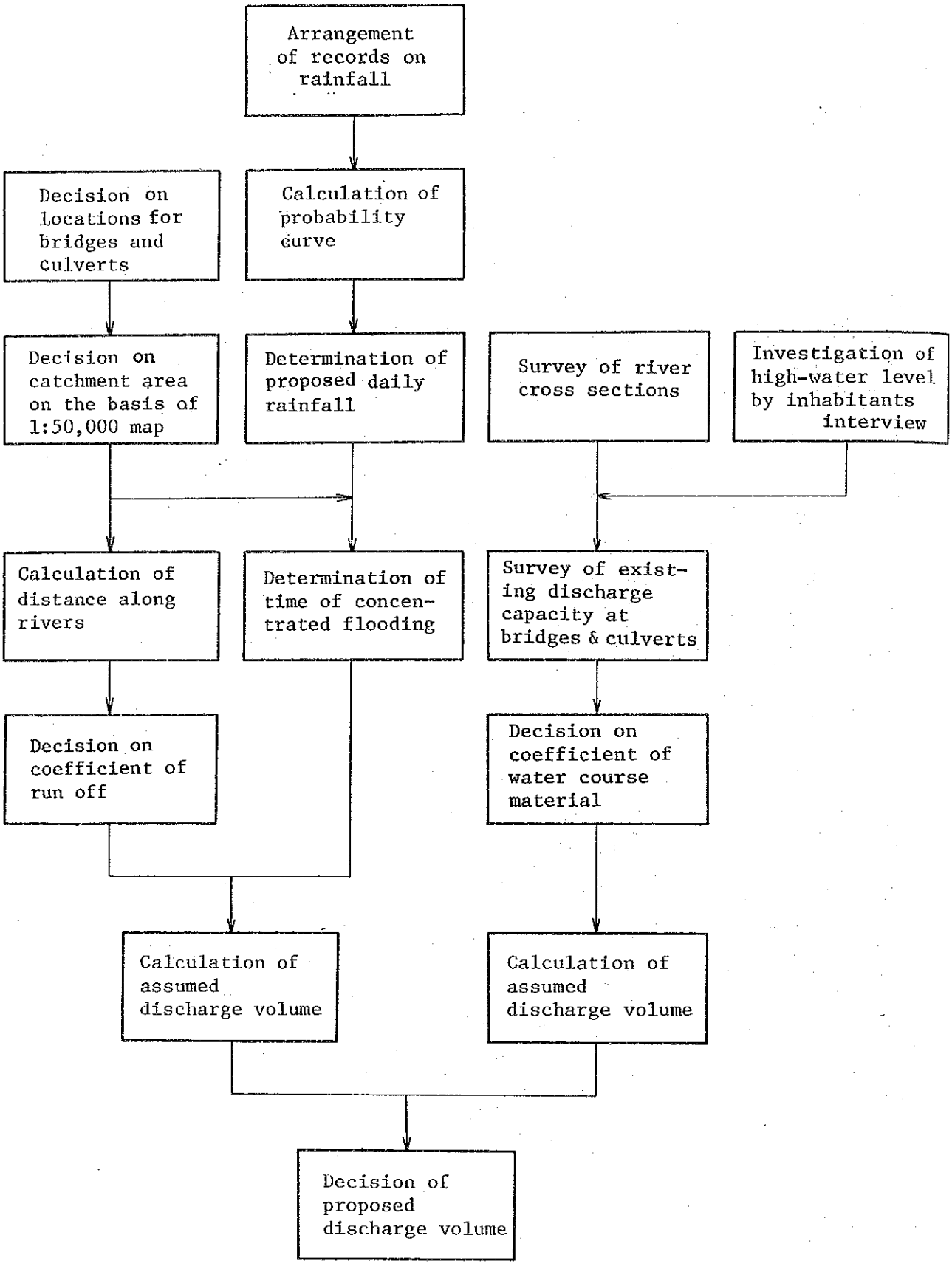


Fig. 3-13 Flow Chart of Hydrological Analysis

3) Estimation Result

Calculations for the estimated discharge volume and the discharge capacity of existing bridges and culverts are described in detail in Appendix Q. In view of the types and precision of the data used for these calculations following the flow chart, the calculated value of the proposed discharge volume was adjusted realistically with reference to the high-water level indicated by the inhabitants. The discharge volume of catchment areas where small-diameter pipe culverts are to be installed was not calculated.

The discharge area size of bridges and culverts was decided based on the proposed discharge volume. The proposed discharge volumes of major rivers and creeks are listed in Table 3-12.

Table 3-12 Proposed Discharge Volume and Assumed Velocity

Location Km	Mile	Place	Discharge Cu.Yd/sec	Velocity Yd/sec
3+40	2.1	Yoni	9.4	3.9
5+30	3.3	Wari	100.8	6.7
6+00	3.7		174.1	6.7
8+00	5.0	Manegre	2,785.1	5.5
9+40	5.9	Mafure	15.6	5.6
10+90	6.8		44.7	5.2
13+20	8.3	Tembianu	149.6	7.5
16+20	10.1		32.1	5.2
17+00	10.6	Mafure	48.4	6.3
22+20	13.9	Makambi	67.6	4.1
23+40	14.5		20.6	5.6
26+30	16.4	Matehun	174.1	5.3
27+20	17.0	Mabanguru	396.6	6.3
27+70	17.3		40.7	4.6
30+20	18.9		43.5	5.2
32+00	20.0	Gbendembu	21.5	5.2
32+60	20.4		30.4	5.2
34+00	21.3		108.6	4.8
35+10	21.9	Magbandan	132.8	5.3
35+90	22.4		30.2	5.2
37+40	23.3		12.6	4.0
43+10	26.6	Makwabe	306.1	6.5
43+90	27.4		6.4	3.2
44+60	27.9		17.9	5.2
45+40	28.4	Ribia	87.3	6.3
47+10	29.4		9.8	4.0
49+00	30.6		11.5	4.0
49+60	31.0	Masaktaba	63.0	6.5
51+20	32.0		180.2	5.3
53+30	33.3		22.0	5.2
57+00	35.7		46.8	6.3
58+10	36.1		38.1	5.2
60+30	37.7	Gbimti	338.9	5.6
61+50	38.4		22.1	5.2
64+10	40.0		27.7	3.4
64+80	40.5		62.2	4.0
67+00	41.9	Makeli	189.4	4.7
67+40	42.1		47.3	6.3
74+20	46.4	Makali	654.8	6.4
76+30	47.4		30.9	5.2

Source: JICA Mission

PART 11

PLANNING FOR THE PROJECT

CHAPTER 4 PLAN METHODOLOGY

CHAPTER 5 FUTURE IMAGE OF THE PROJECT AREA

CHAPTER 6 FUTURE TRAFFIC VOLUME FORECAST

CHAPTER 7 ALTERNATIVE ROAD DEVELOPMENT PLANS

CHAPTER 8 PRELIMINARY DESIGN

CHAPTER 9 CONSTRUCTION SCHEDULE

CHAPTER 10 PROJECT ASSESSMENT

CHAPTER 4

PLAN METHODOLOGY

4.1 Basic Approach

For the formulation of the road construction Project, the approach, procedure, and output arrangements have been adopted as explained below.

a) The construction or improvement of a road will have desirable effects on the Project Area for years to come, and future socio-economic pictures should be different with and without project implementation. The present Study attempts to draw a future picture of the agricultural sector, which is believed to receive the strongest impact from this Project within the Project Area (Chapter 5).

b) The future traffic volume on the Project Road is forecast on the basis of various traffic and transport data of Sierra Leone, particularly those which pertain to the Project Area, and on the future picture of the Area of a) above (Chapter 6).

c) The design standards of the road which will be adequate to service the forecast volume of future traffic are established, and a number of alternative plans are proposed, with the topography, climate, geology, and the location of villages in the Project Area and the current conditions of the Project Road in consideration (Chapter 7).

d) The preliminary designing is accomplished on the basis of feasible alternative(s) and the construction work schedule, maintenance/control programmes are established, and the cost of each alternative is estimated (Chapters 8 and 9).

e) The estimated cost is compared against the expected benefits from the Project Road improvement to see if each alternative has worth economically, while hard-to-quantify impacts will also be taken into consideration to facilitate an overall feasibility assessment of the Project (Chapter 10).

The process through these steps involves roughly four sectors: agriculture, transport, road engineering, and economic analysis. Experts in these sectors will collaborate with each other in following the process.

4.2 Agricultural Forecast

The major work of forecast in the agriculture sector is to estimate and compare future production quantities and values (in terms of value-added) with and without the Project, following the procedure shown in Fig. 4-1. Major assumptions are:

a) That the Road is completed in 1985, producing impacts on agriculture starting in 1986,

b) That, with or without the Project, the Area population increase rate and agricultural productivity (harvest per unit of land) will vary, and the average number of labour force per household, cultivation land area size, crop pattern, livestock population, and per capita average of agricultural product consumption will remain constant,

c) That the base year for the estimation is 1978 and that 1978 prices are used to calculate the value and cost of production.

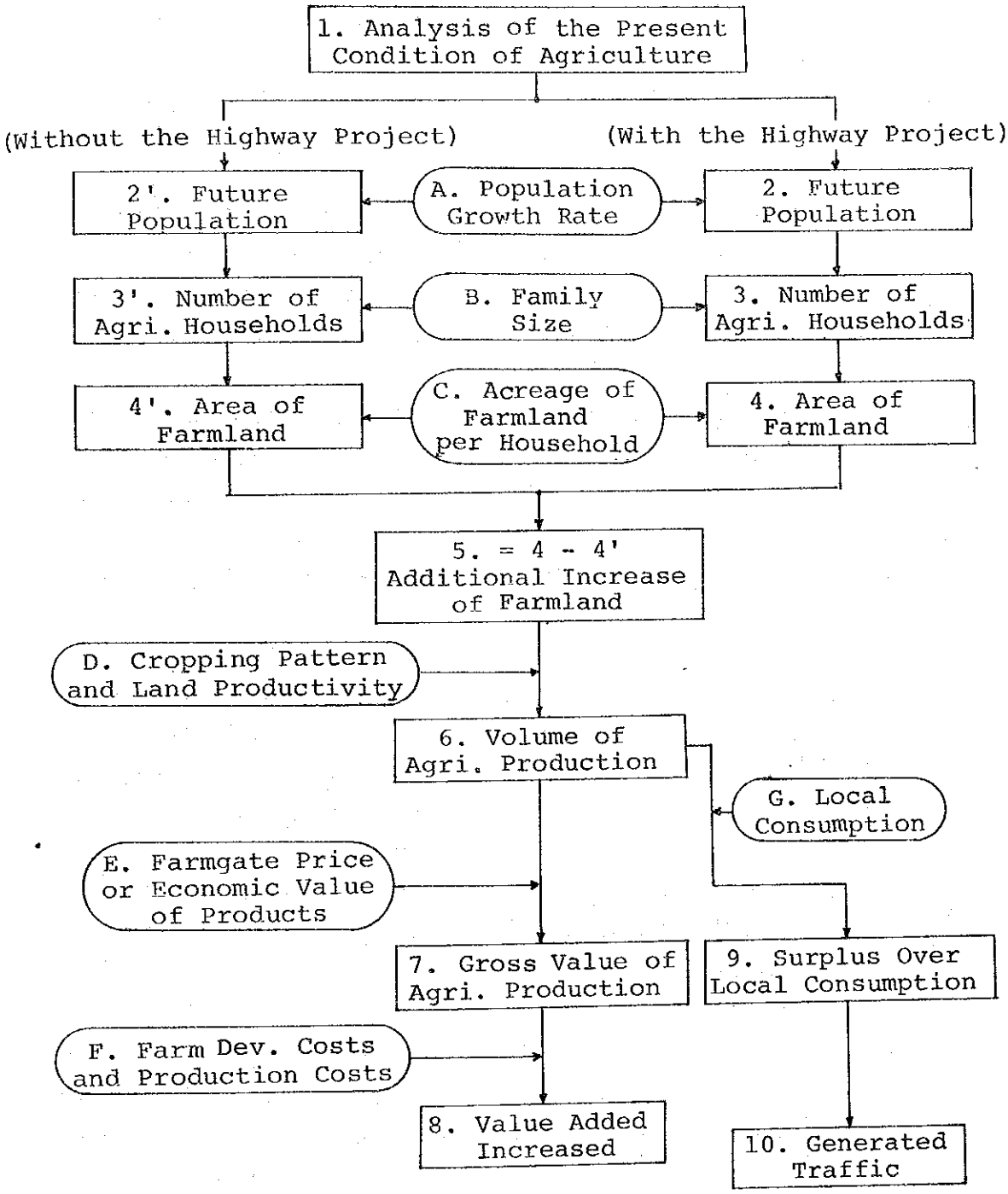


Fig. 4-1 Forecasting Procedure for the Future Agricultural Development in the Project Area

4.3 Traffic Forecast

While the method of traffic forecast is discussed in detail in Chapter 6, the basic thinking is as follows:

a) Traffic forecasts are made for passengers (carried by passenger cars, vans and buses) and goods (carried by pickup trucks, medium-size trucks, and extra-heavy vehicles) separately, not taking into consideration mixed (passenger and goods) carriage.

b) Passenger trip increases are caused by Area population growth and rise in propensity to ride a car (number of motorcar trips per person).

c) The composition ratio of passenger cars will rise and the composition will change in the future.

d) For goods traffic, only the shipment of surplus agricultural products of the Area to markets outside the Area and the transit traffic of livestock are considered. The delivery of industrial products into the Area (which will represent the return trip of the shipment of agricultural products) and intra-area truck trips as a result of agricultural activities are disregarded. (These assumptions will tend to understate the economic benefits of the Project, thereby preventing the danger of mistaking a low feasibility project for a high.)

e) The present composition of goods transport vehicles by vehicle type and loading rate are considered to remain constant in the future.

4.4 Road Designing and Programming

Basic policies which govern this Road Project programming are as follows:

a) Since the Project Road will be a trunk road and an international road by nature, it is to be designed as an all-season (passable throughout the year) paved road.

b) In view of the existing conditions of the Project Road, village distribution, and economy of construction, the effective utilization of the existing Project Road or its improvement, as opposed to the construction of an entirely new road, is to be given first consideration.

c) Locally procured materials are to be utilized efficiently in the interest of economy.

d) The design and the method of construction work which are commensurate with or appropriate to the construction and maintenance capabilities available in Sierra Leone will be used.

Road designing requires an overall judgement (informed judgement) of various conditions, and the designing process involves much trial-and-error rather than deductive reasoning. The work of designing can be simply summarized as follows:

a) An inventory of the existing road condition is taken, and the nature, topography, and society along the road and other design environments are analyzed.

b) The required road specification standard is established on the basis of an overall understanding/assessment of future traffic and the nature of the road.

c) The sections of the existing road which do not conform to the established specifications are identified, and the kind and scope of improvement are studied.

d) The required improvement work is designed, giving full consideration to the design environment (river flux, soil, topography, materials)

as understood under a) above.

e) Based on the design, the work quantity is surveyed, and the construction cost is estimated by multiplying the unit construction cost by the quantity. The total construction cost is divided into a local currency portion and a foreign exchange portion.

f) The construction work schedule (timetable) is established on the basis of the required completion data and the number of workable days (with the rainy season in consideration).

4.5 Economic Assessment

The economy of a project is basically assessed by a quantitative comparison of project cost and the benefit from the project. Usually, the cost and the benefit do not occur at the same time and, therefore, must be converted into the current value in the base year (applying the DCF method).

Estimation of the benefit is made through a with-and-without comparison. Also, items whose market value is not believed to reflect their true economic value must be appropriately adjusted (by applying a shadow price). See Chapter 5 for details.

CHAPTER 5

FUTURE IMAGE OF THE PROJECT AREA

CHAPTER 5

FUTURE IMAGE OF THE PROJECT AREA

In this Chapter, the future population and agricultural production in the Project Area will be predicted. Heretofore, the population increase rate and economic activities have been low in the Project Area, and agricultural production has almost never exceeded the self-sufficiency level. Data on the society and economy are generally unavailable, the statistics of two censuses (1963 and 1974) being the only available data on population and the data of the 1970/71 agricultural census, on agriculture. The projection method of forecast, under which the past trend is extented toward the future, may not be used in the absence of records. Consequently, the future image of the Project Area is to be obtained chiefly through (1) the comparison of the Area with advanced agricultural areas in Sierra Leone, (2) the review of target values of past development projects, and (3) discussions with pertinent officials of the Ministry of Agriculture and Natural Resources.

5.1 Future Population

Between 1963 and 1977, the population of Sierra Leone increased at a fairly high average annual rate of 2.1%. It is assumed that this rate has since risen, based on the findings of a number of sample surveys made subsequently, and the Government of Sierra Leone used a high 2.6% for its National Development Plan, 1974/75 - 1978/79. Accelerated population increases, however, will result in a decline in personal income, an aggravation of the unemployment problem, and an inadequate social capital in regions unless the regions are developed in a balanced manner and the economy accomplishes real growth in pace with the population increase. Otherwise, a rapid population swell alone will constitute a serious hindrance to national development. The Government is taking a serious view of this and is making efforts for the extension of family planning (birth control). Thus, it is believed reasonable

to assume that the 2.6% level of population increase will not last long but will gradually diminish (by about 0.1% in five years) back to about 2.1% by the year 2010. If so, average population increase rate for the future thirty years will be 2.35% per year.

In the Project Area, on the other hand, population increased at an yearly average of 1.2% between the two censuses, which was substantially lower than the national average, suggesting population outflow from this Area. Although it is very difficult to forecast how this situation will change in the future, there is no doubt that, in view of the unemployment and housing shortage in the capital area and the dim prospect of diamond mining in the Kono District (areas into which rural population is moving), the importance of a policy to discourage rural population outflow will increase. The implementation of this Project will help restrain population outflow from the Project Area, because:

a) Agricultural crops will have marketability and any surplus products can result in an income increase; as a result, farmers will be encouraged to stay on the farm.

b) Communications will be facilitated by the better road, making agricultural extension activities easier and accelerating the spread of improved farming techniques, thereby further supporting the farmers' income increase.

c) The improvement of access to the urban service (commercial, leisure, educational, and medical) facilities of Freetown, Makeni, and so forth will result in a decrease of urban-rural gaps in the "amenities of life."

Based on the above observations, the following assumptions are used for the forecast of future population in the Project Area:

a) Without the Project, the average population increase rate will remain constant at 1.2% per annum.

b) With the Project, population outflow will not be discontinued but will be reduced substantially, and population increase, approaching the natural increase level (of 2.35%), will reach about 2.0% per annum after 1985.

c) The population of each chiefdom in the Project Area will continue to increase at the same pace as before (and, therefore, chiefdom populations will be obtained by extending past trends and the aggregate will be adjusted in conformity with the Area population increase rate of b) above).

d) The agricultural population will be 90% of the Area population (based on the 1970/71 Agricultural Census).

e) With or without the Project, the number of persons per farming household will be 6.4 (based on the same data as d).

The future population and the number of farming households in the Project Area, as estimated under these assumptions, are presented in Tables 5-1 and 5-2. Forecasts for the year 2010 are a population of 192,000 and 27,000 farming households in total with the Project, which are 23% greater than the 156,000 and 22,000 estimated without the Project. Because the closed population (that which assumes no social increase/decrease) of the Project Area is about 215,000, about 23,000 people will flow out of the Area by 2010 even with Project implementation.

5.2 Agricultural Prospects

Agricultural development is making smooth progress in the four chiefdoms covered by the IADP Programme. In the three southern chiefdoms not yet covered by the Programme, agricultural development will also be accomplished as in the four southern chiefdoms when the expanded IADP Programme is executed. The completion of the Makeni - Kamakwie Road will result in an improvement of the effects of the IADP Project, as the efficiency of extension activities will rise, the range of farming materials distribution will be extended, and the

Table 5-1 Future Population of the Project Area

(1) With the Road Project

	1978	1985	1990	2000	2010
Makari Gbanti	5,546	6,518	7,561	10,154	13,603
Pendenbu Gowahun	25,169	26,861	29,084	34,032	39,722
Sanda Tenraran	17,104	19,559	22,247	28,730	37,009
Gbanti Kamaranka	16,439	17,787	19,450	23,215	27,638
Magbaiamba	5,300	5,501	5,839	6,566	7,366
Sanda Loko	13,832	14,558	15,607	17,904	20,487
Sela Limba	23,724	26,575	29,785	37,348	46,713
Total	107,112	117,359	129,574	157,949	192,537

(2) Without the Road Project

	1978	1985	1990	2000	2010
Makari Gbanti	5,546	6,467	7,212	8,952	11,085
Pendenbu Gowahun	25,169	26,651	27,742	30,003	32,368
Sanda Tenraran	17,104	19,405	21,220	25,329	30,157
Gbanti Kamaranka	16,437	17,648	18,553	20,466	22,521
Magbaiamba	5,300	5,458	5,570	5,789	6,002
Sanda Loko	13,832	14,444	14,887	15,784	16,694
Sela Limba	23,724	26,366	28,411	32,927	38,064
Total	107,112	116,439	123,594	139,251	156,891

Source : JICA Mission

Table 5-2 Number of Farming Households of the Project Area

(1) With the Road Project

	1978	1985	1990	2000	2010
Makari Gbanti	780	917	1,063	1,428	1,913
Pendenbu Gowahun	3,539	3,777	4,090	4,786	5,586
Sanda Tenraran	2,405	2,750	3,129	4,040	5,204
Gbanti Kamaranka	2,311	2,501	2,735	3,265	3,887
Magbaiamba	745	774	821	923	1,036
Sanda Loko	1,945	2,047	2,195	2,518	2,881
Sela Limba	3,336	3,737	4,189	5,252	6,569
Total	15,063	16,504	18,221	22,212	27,076

(2) Without the Road Project

	1978	1985	1990	2000	2010
Makari Gbanti	780	909	1,014	1,259	1,559
Pendenbu Gowahun	3,539	3,748	3,901	4,219	4,552
Sanda Tenraran	2,405	2,729	2,984	3,562	4,241
Gbanti Kamaranka	2,311	2,482	2,609	2,878	3,167
Magbaiamba	745	768	783	814	844
Sanda Loko	1,945	2,031	2,094	2,220	2,348
Sela Limba	3,336	3,708	3,995	4,530	5,353
Total	15,063	16,374	17,380	19,582	22,063

Source : JICA Mission

scope of products procurement will expand. Thus, greater crop yield rates will be obtained with the Project than without. By assuming that the Project Road is completed in 1985 and that the useful life of the Road will be 25 years, agricultural production is forecast for the year 2010 (when the useful life of the road will have just expired).

Furthermore, the following assumptions and procedures were used for the forecast:

1) Crop Production Forecast

(1) Forecast of Cultivation Land by Region and by Crop

a) Cultivation land area size increase is estimated on the basis of population growth and in accordance with the process given in 2.3 - 4). That is, under the assumption that the average family size, the ratio of farming households to total households, and the average farm land size per farming family will remain constant in the future, future cultivation land area size is estimated as presented in Table 5-3.

b) The additional farm land needed due to population increase will be reclaimed.

c) Planting rates of cash crops, such as paddy rice, groundnut, tobacco, and orange, will increase, and rates of upland rice, maize, millet, Guinea corn, cassava, and sweet potato will decrease proportionally. Changes in planting rates for each chiefdom are shown in Table 5-4.

d) Planting rates will remain constant with or without the Project.

(2) Future Agricultural Production Improvement

The harvest quantity of major agricultural products, particularly of rice, will be much improved through the efforts of the Ministry of Agriculture and the IADP due to variety, fertilization and agronomic

Table 5-3 Acreage of Future Farmland

(1) With the Road Project

(Unit: Acre)

	1978	1985	1990	2000	2010
Makari Gbanti	3,744	4,400	5,104	6,854	9,182
Pendenbu Gowahun	16,989	18,131	19,632	22,971	26,812
Sanda Tenraran	11,545	13,202	15,017	19,393	24,981
Gbanti Kamaranka	11,095	12,006	13,129	15,670	18,656
Magbaiamba	3,577	3,713	3,941	4,432	4,972
Sanda Loko	9,337	9,827	10,535	12,085	13,829
Sela Limba	16,014	17,938	20,105	25,210	31,531
Total	72,301	79,218	87,462	106,615	129,963

(2) Without the Road Project

	1978	1985	1990	2000	2010
Makari Gbanti	3,744	4,365	4,868	6,043	7,482
Pendenbu Gowahun	16,989	17,989	18,726	20,252	21,848
Sanda Tenraran	11,545	13,099	14,324	17,097	20,356
Gbanti Kamaranka	11,095	11,912	12,523	13,815	15,202
Magbaiamba	3,577	3,684	3,760	3,908	4,051
Sanda Loko	9,337	9,750	10,049	10,655	11,268
Sela Limba	16,014	17,797	19,177	22,225	25,693
Total	72,301	78,596	83,426	93,995	105,902

Source : JICA Mission

Table 5-4 Percentage of Cropping Area in 1978 and 2010

Year	1978		2010	
Type	A	B	A	B
Swamp rice	10.0%	7.4%	12.5%	9.1%
Upland rice	55.0	54.2	50.5	49.7
Maize	3.0	4.0	2.5	3.0
Guinea corn	1.0	1.0	0.5	0.5
Millet	2.0	3.6	1.0	2.6
Cassava	2.5	1.9	1.5	0.9
Sweet potato	1.5	1.5	1.0	1.0
Groundnuts	19.0	19.2	22.0	24.0
Tobacco	2.0	4.0	3.0	5.0
Orange	2.5	1.9	4.0	2.9
Mango	1.0	0.6	1.0	0.6
Banana	0.5	0.7	0.5	0.7
Total	100.0	100.0	100.0	100.0

Note : Type A: Makari Gbanti, Pendenbu Gowahum, Sanda Tenraran, Gbanti Kamaranka
Type B: Magbaiamba, Senda Loko, Sela Limba

Source : Estimated by the JICA Mission based on the results of the Agricultural Census in 1970/71

techniques improvement, extension, and disease/pest control. Various improvements to be accomplished will include the achievement of faster ripening.

As for paddy rice, the currently cultivated low-yielding Oryza glaberrima will be gradually replaced by high-yielding and better-tasting varieties. The Agricultural Experimentation Station encourages the use of CP4 and RH2 for paddy rice and Rok 3 and Loc 23 for upland rice. The Station is promoting the use of fertilizers and recommends 110 pounds of composite fertilizer (20-20-0) and 110 pounds of urea for paddy rice and 110 pounds of composite fertilizer and 40 pounds of urea for upland rice. Frequent vermin attacks, particularly of nightwalkers, are damaging to upland rice. Spraying a 1,000-time diluted malathon is recommended for blight control. The improvement of crops other than rice has progressed little but such improvement efforts will be intensified in the future.

(3) Future Yield per Acre

a) Without the Project, the yield of each crop per acre is assumed to increase on a linear curve from the level estimated by IADP.

b) With the Project, the same yield per acre as without the Project is assumed for 1985, the starting year, and maximum yield per acre with the Project has been estimated at 8% to 20% higher than the yield without the Project. These different "with the project" increments in yield per acre have reference to the situations in other various West African countries and reflect predicted future increases in crop production. The future yield per acre is shown by crop in Table 5-5.

c) It is assumed that the yield of newly reclaimed land in the first year of cultivation will be 30% of the average normal yield of the same year, and will be 60% in the second year, and 100% in the third.

d) Yield rates of each fruit in the initial years of plantation are assumed as presented in Table 5-6.

Table 5-5 Yield of Crop per Acre

(Unit: lbs)

		1978	2000
Swamp rice	Without the Project	1,300	2,500
	With the Project	1,300	2,800
		1978	2005
Upland rice	Without the Project	1,000	1,600
	With the Project	1,000	1,800
		1978	2005
Maize	Without the Project	900	1,500
	With the Project	900	1,800
		1978	2005
Guinea corn	Without the Project	1,500	2,000
	With the Project	1,500	2,300
		1978	2005
Millet	Without the Project	1,300	2,000
	With the Project	1,300	2,300
		1978	2005
Cassava	Without the Project	4,500	6,000
	With the Project	4,500	7,200
		1978	2005
Sweet potato	Without the Project	2,900	3,500
	With the Project	2,900	4,000
		1978	2005
Groundnuts	Without the Project	1,000	1,500
	With the Project	1,000	1,700
		1978	2000
Tobacco	Without the Project	1,100	1,200
	With the Project	1,100	1,300
		1978	2010
Orange	Without the Project	9,000	12,000
	With the Project	9,000	13,200
		1978	2010
Mango	Without the Project	4,400	5,000
	With the Project	4,400	5,500
		1978	2010
Banana	Without the Project	2,900	3,800
	With the Project	2,900	4,200

Source : JICA Mission

Table 5-6 Yield Rates of Fruits in Initial Years of Plantation

	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	7th Year	8th Year
Orange	0 %	0 %	0 %	0 %	30 %	60 %	100 %	100 %
Mango	0	0	0	0	30	30	60	100
Banana	0	30	60	100	100	100	100	100

Source : JICA Mission

e) For simplicity, no regional difference is considered for yield per acre.

f) Various crop production volumes in the Project Area from 1978 through 2010 are estimated in Table 5-7.

2) Future Livestock Population

The followings are assumed for the forecast of the number of livestock animals to be raised in the Project Area in the future:

a) The quantity of average meat consumption per capita in Sierra Leone will change little in the future, and the total meat consumption will increase only in proportion to population increase. Thus, livestock population will also rise in direct proportion to population increase.

b) The composition of livestock animals will remain constant in the future.

The yearly total number of livestock animals to be shipped to the market is estimated for the years up to 2010 in Table 5-7. Those shipped to the market will amount to 30% of the total number raised.

3) Future Agricultural Development Potential

The total cultivated land, with the Project, of 129,960 acres in the Project Area in the terminal year of the Plan will be very realistic because it will be only 20% of the total arable land of 635,140 acres in the Area as indicated by Table 2-2.

Table 5-7 Agricultural Production Forecast

(1) With the Road Project

	Unit	1978	1985	1990	2000	2010
Swamp rice	(1,000 lbs)	8,421	11,292	16,354	30,412	30,554
Upland rice	"	39,534	52,344	63,117	89,754	115,246
Maize	"	2,212	3,304	3,851	5,133	6,221
Guinea corn	"	1,085	1,136	1,265	1,494	1,512
Millet	"	2,482	2,764	3,262	4,298	4,839
Cassava	"	7,353	7,751	8,881	110,96	11,916
Sweet potato	"	3,145	3,612	3,954	4,682	5,174
Groundnuts	"	13,795	17,061	21,897	34,825	48,970
Tobacco	"	2,227	2,491	3,083	4,662	6,186
Orange	"	14,706	34,540	36,364	45,327	43,984
Mango	"	2,672	2,794	4,135'	5,005	4,788
Banana	"	1,216	1,922	2,439	2,595	2,567
Cattle	(head)	4,241	4,601	5,049	6,091	7,369
Sheep	"	1,523	1,653	1,813	2,188	2,647
Goats	"	2,697	2,926	3,210	3,873	4,686

(2) Without the Road Project

	Unit	1978	1985	1990	2000	2010
Swamp rice	(1,000 lbs)	8,421	11,265	14,933	24,144	29,024
Upland rice	"	39,534	52,219	58,535	72,611	84,195
Maize	"	2,212	3,296	3,510	3,951	4,261
Guinea corn	"	1,085	1,134	1,166	1,188	1,081
Millet	"	2,482	2,758	2,997	3,410	3,459
Cassava	"	7,353	7,733	8,070	8,522	8,162
Sweet potato	"	3,145	3,604	3,668	3,755	3,721
Groundnuts	"	13,795	17,020	20,228	27,974	35,512
Tobacco	"	2,227	2,485	2,880	3,826	4,693
Orange	"	14,706	34,540	35,377	35,531	32,807
Mango	"	2,672	2,794	4,040	3,938	3,726
Banana	"	1,216	1,922	1,959	1,994	1,959
Cattle	(head)	4,241	4,565	4,816	5,370	6,005
Sheep	"	1,523	1,640	1,730	1,929	2,157
Goats	"	2,697	2,903	3,062	3,415	3,819

Source : JICA Mission

As for paddy rice, which is cultivated chiefly in lowlands and in dales, new paddies may be reclaimed from the existing forests. If so, the 8,390 acres which will be additionally needed (which is the difference between the current situation and that in the termination year of the Plan) amounts to only 6% of the total forest area of 140,160 acres. Therefore, it may be assumed that the reclamation of additional 8,390 acres of paddies will be possible (however no data on the percent of forest land suitable for conversion to rice paddies were available).

4) Future Surplus Agricultural Products

Future surplus agricultural products are conceived to be the balance of future consumption deducted from future production, as shown in Table 5-9 and 5-10. Average annual consumptions of agricultural products per person estimated for 1978 and the terminal year of the Plan, 2010, are shown in Table 5-8.

Table 5-8 Per Capita Consumption of Agro-Products

Year	1978	2010
Rice	220 lbs	264 lbs
Meat	6	6
Maize	20.6	23.1
Guinea Corn	10.1	7.6
Millet	23.1	23.2
Cassava	68.6	61.3
Sweet Potato	29.2	27.1
Groundnut	22.0	22.0

Source: JICA Mission

The tobacco and fruit consumption is assumed to remain at the 1978 level. The total quantity of grains (rice, maize, Guinea corn, millet) is reduced by 10% (5% for seed and 5% for store ullage) in arriving at the shipment volume.

5) Future Agro-Related Industries

Given that the future agricultural production, consumption, and surplus in the Project Area are as heretofore discussed, future production increases will result in the requirement of storage, polishing, and other facilities for agriculture products, particularly grains. The fruit-processing capacity will also have to be expanded.

Livestock inflow from Guinea and the northern part of the Project Area and surplus livestock in the Area will total to 24,000 cattle, 10,000 sheep, and 12,600 goats, with the Project in the target year of 2010. The economy has poor facilities for transporting these livestock to major cities alive, and it is desirable that a slaughterhouse be constructed in Makeni. It is reported that a slaughterhouse with a capacity to handle 25 animals per hour is currently being planned for Makeni.

Table 5-9 Local Consumption of Agro-Products

(1) With the Road Project

	Unit	1978	1985	1990	2000	2010
Rice (Paddy)	(1,000 lbs)	36,253	41,459	47,145	60,810	78,200
Maize	"	2,207	2,482	2,791	3,525	4,448
Guinea corn	"	1,082	1,121	1,187	1,324	1,463
Millet	"	2,472	2,714	2,998	3,659	4,467
Cassava	"	7,348	7,863	8,534	10,043	11,803
Sweet potato	"	3,128	3,373	3,682	4,384	5,218
Groundnuts	"	2,356	2,582	2,851	3,475	4,236
Tobacco	"	0	0	0	0	0
Orange	"	2,941	6,908	7,273	9,065	8,797
Mango	"	1,336	1,397	2,067	2,502	2,394
Banana	"	851	1,345	1,708	1,816	1,797
Cattle	(head)	2,892	3,169	3,498	4,265	5,199
Sheep	"	1,392	1,526	1,684	2,053	2,503
Goats	"	1,500	1,643	1,814	2,211	2,696

(2) Without the Road Project

	Unit	1978	1985	1990	2000	2010
Rice (Paddy)	(1,000 lbs)	36,253	41,134	44,969	53,612	63,772
Maize	"	2,207	2,462	2,662	3,108	3,624
Guinea corn	"	1,082	1,112	1,132	1,167	1,192
Millet	"	2,472	2,692	2,860	3,226	3,640
Cassava	"	7,348	7,802	8,140	8,854	9,617
Sweet potato	"	3,128	3,347	3,512	3,865	4,252
Groundnuts	"	2,356	2,562	2,719	3,064	3,452
Tobacco	"	0	0	0	0	0
Orange	"	2,941	6,908	7,075	7,106	6,561
Mango	"	1,336	1,397	2,020	1,969	1,863
Banana	"	851	1,345	1,372	1,396	1,371
Cattle	(head)	2,892	3,144	3,337	3,760	4,236
Sheep	"	1,392	1,514	1,607	1,810	2,040
Goats	"	1,500	1,630	1,730	1,950	2,196

Source : JICA Mission

Table 5-10 Production Surplus of Agro-Products over Local Consumption

(1) With the Road Project

	Unit	1978	1985	1990	2000	2010
Rice (Paddy)	(1,000 lbs)	11,702	22,177	32,326	59,355	76,600
Maize	"	6	823	1,061	1,607	1,773
Guinea corn	"	3	15	78	171	49
Millet	"	7	51	264	638	372
Cassava	"	5	-112	347	1,053	113
Sweet potato	"	17	239	273	298	-44
Groundnuts	"	11,438	14,479	19,047	31,350	44,734
Tobacco	"	2,227	2,491	3,083	4,662	6,186
Orange	"	11,764	27,632	29,091	36,262	35,187
Mango	"	1,336	1,397	2,067	2,502	2,394
Banana	"	365	577	732	778	770
Cattle	(head)	1,349	1,432	1,550	1,826	2,171
Sheep	"	131	127	129	134	144
Goats	"	1,197	1,283	1,396	1,662	1,991

(2) Without the Road Project

	Unit	1978	1985	1990	2000	2010
Rice (Paddy)	(1,000 lbs)	11,702	22,350	28,499	43,143	49,498
Maize	"	6	834	849	843	637
Guinea corn	"	3	21	34	21	-111
Millet	"	7	66	137	184	-181
Cassava	"	5	-69	-70	-332	-1,455
Sweet potato	"	17	257	156	-110	-531
Groundnuts	"	11,438	14,458	17,509	24,910	32,060
Tobacco	"	2,227	2,485	2,880	3,826	4,693
Orange	"	11,764	27,632	28,302	27,424	26,246
Mango	"	1,336	1,397	2,020	1,969	1,863
Banana	"	365	577	588	598	588
Cattle	(head)	1,349	1,421	1,478	1,610	1,769
Sheep	"	131	126	123	118	117
Goat	"	1,187	1,273	1,332	1,465	1,622

Source : JICA Mission

CHAPTER 6

FUTURE TRAFFIC VOLUME FORECAST

CHAPTER 6

FUTURE TRAFFIC VOLUME FORECAST

6.1 Forecast Method

1) Review of Forecast Method

Future traffic volume on a road may be forecast either by the projection method or the theoretical method. Under the projection method, the historical data (recorded traffic volume) is extended or projected toward the future. The theoretical method is also referred to as a three-stage method, and involves (1) the forecast of traffic volume to be generated in the future based on population and other basic indicators, (2) distributed traffic volume forecast by a gravity model or other appropriate means, and (3) the allocation of forecast traffic volume through simulation.

The projection method is simple and practical, while the theoretical method -- although it requires an analysis of a large volume of data and is complicated -- guarantees a more scientific forecast.

Both the projection and theoretical methods are used for the present Study. That is, the passenger traffic volume is forecast by the projection method, and the goods traffic volume is forecast by the theoretical method, for the following reasons:

a) Basic socio-economic data sufficiently reliable for a theoretical method forecast could not be obtained.

b) The annual traffic volume calculated on the basis of the data of traffic surveys taken only twice a year is too unreliable in view of seasonal fluctuations (due to different harvesting times) in the flow of agricultural products, which are very important in the case of feeder roads which go through one of the most important

agricultural areas of the nation. Therefore, it was decided that the goods traffic volume will be forecast through a quantity estimation of agricultural products, quantity flow estimation, and translation of these estimates to traffic volume under the theoretical method.

c) As for passenger traffic, which represents routine trips, it was judged that the future traffic volume can be forecast accurately by the projection method, using data obtained through traffic surveys taken once in the dry season and once in the wet season. Furthermore, a simulation for allocation is unnecessary because the number of trips is still small (see the present O-D table) and the road network is simple, and the projection method was believed to offer the required precision.

2) Forecast Method

Passenger traffic and goods traffic are forecast separately as follows:

For passenger traffic, the total number of passengers at the present is projected toward the future, based on the rates of population and GDP growth, and then allocated to each type of vehicle, namely, passenger cars, vans, and remodeled (truck) buses, which is believed to be used for passenger transport.

For goods traffic, the flow of surplus agricultural products as estimated under "6-1. The Future of Agricultre" in Chapter 6 is allocated to pick-up trucks, medium-size trucks, and large trucks, which are believed to be used for goods transport.

In addition, normal traffic volumes, development (induced) traffic volumes, and diverted traffic volumes of both passengers and goods are estimated for a benefit estimation which is a part of economic assessment.

Normal traffic is that which can be attributed to natural increases in population and economic activities, assuming no change in physical conditions of the existing roads (ie. assuming no road construction or improvement).

Development (induced) traffic represents the increment beyond and above normal traffic and is that which is induced by the reduction in travel time, development in roadside areas, and other consequences of a road construction/improvement.

Diverted traffic is that which is diverted from competing road(s) to a newly constructed or improved road.

The process of the future traffic volume forecast is shown by a flow chart in Fig. 6-1.

6.2 Forecast Result

1) Passenger Traffic

Forecast assumptions and the estimation process are explained below.

a) Annual average daily passenger traffic (passenger AADT) is assumed to be 1.5 times greater than the ADT of the wet season.

b) The number of passengers in the future is expected to increase by a rate of 4.2% per annum if the road project is not carried out. This figure is arrived at by multiplying the rate of population increase (1.2%) by the increase rate of propensity to ride a car (3%). If the project is carried out, the rate of passenger increase will be 5.1% (1.02 x 1.03).

Fig. 6-1 Traffic Forecast Flow Chart

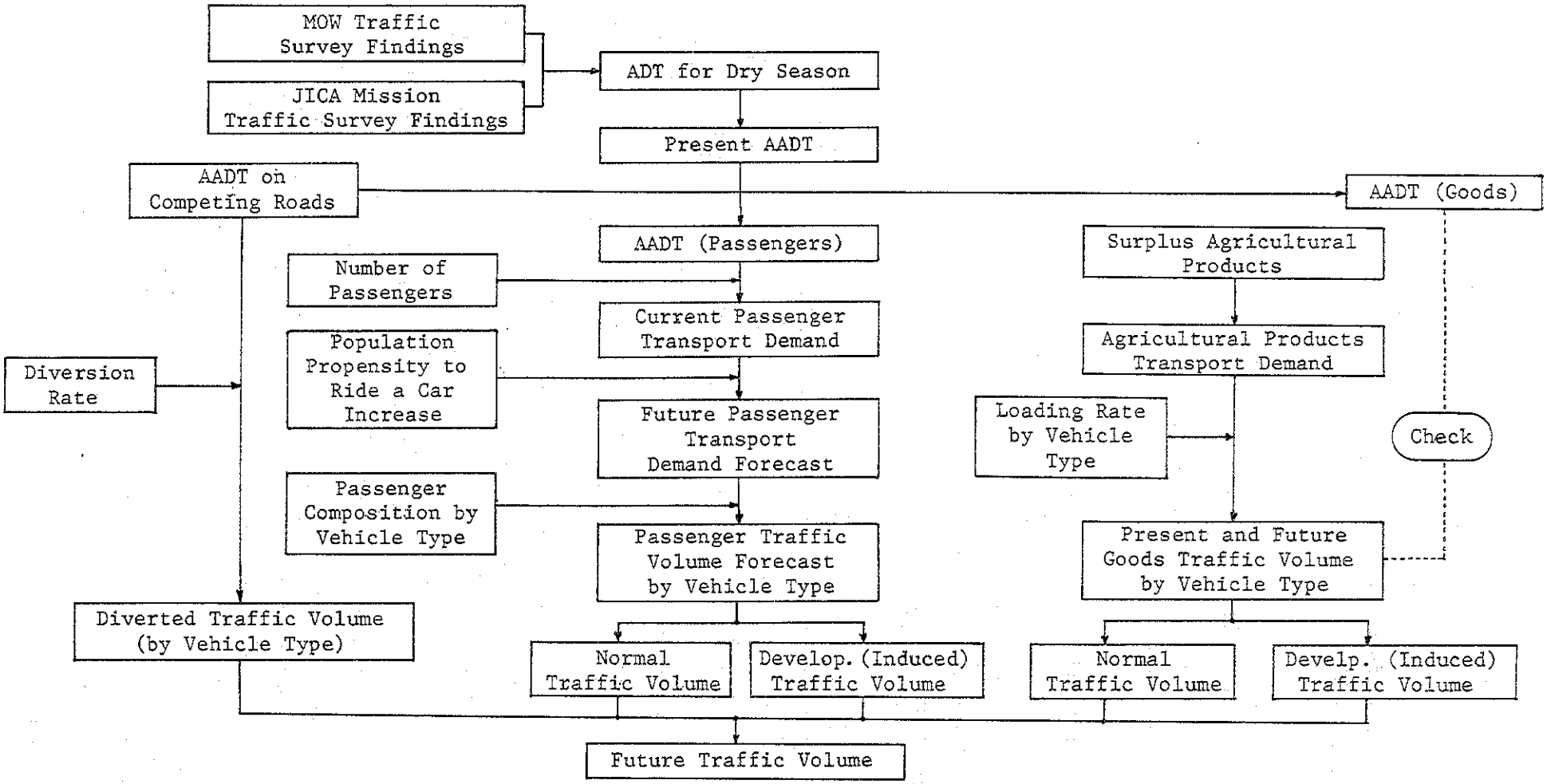


Table 6-1 Annual Average Daily Passenger Traffic

Section	Car	Van	Bus	Total
Panlap - Mabole	31	43	30	104
Mabole - Sandugu	19	35	28	82
Sendugu - Masakutaba	6	24	25	55
Masakutaba - Bankabi	4	20	23	47
Bankabi - Kenendi	8	26	28	62
Kenendi - Kamakwie	12	35	33	80

Source: JICA Mission

Note: Passenger traffic (ADT) in dry season (Ministry of Public Works Survey) was two times that in wet season (JICA Mission Survey). Based on this, it has been assumed that annual average daily traffic (AADT) is 1.5 times the average daily traffic (ADT) in wet season.

* A propensity to ride a car is calculated by the rate of frequency of trip generation by people. Increase in this propensity is first estimated at 5.6%, based on the recorded annual traffic increase throughout the nation of 7.83% and the annual population increase of 2.1%: (1.0783 ÷ 1.021 = 1.056)

However, because it is believed that the average number of passengers per vehicle will decrease, passenger increase will not be in direct proportion to traffic increase. Thus, the indicated 3.7% is adjusted downward to 3% for a more realistic propensity to ride a car estimation.

c) The number of passengers per vehicle is assumed to remain constant in the future.

d) The composition of vehicle types is assumed to change in the future (when this Project is implemented).

Section	1979*1			2010*2		
	Car	Van	Bus	Car	Ban	Bus
Panlap - Mabole	30	42	28	50	30	20
Mabole - Sendugu	30	41	29	50	30	20
Sendugu - Masaktaba	10	47	43	20	40	40
Masaktaba - Bankabi	9	43	48	20	40	40
Bankabi - Kenendi	15	42	43	30	35	35
Kenendi - Kamakwie	15	45	40	30	35	35

Source: JICA Mission

Note: *1 From Table 6-1

*2 Estimates (The rate of passenger cars to total passenger carrying vehicles has already reached 70% on inter-city trunk roads and 80% in downtown areas in Sierra Leone.)

Compositions for interval years is estimated by linear curves.

e) The development (induced) passenger traffic volume corresponds to the difference between the traffic volume with the implementation of this Project and that without.

2) Goods Traffic

Forecast assumptions and the estimation process are explained below:

a) Loading rate is assumed to remain constant in the future:

Pickup trucks 50%
Medium-size trucks 40%
Large (extra-heavy) trucks 75%

b) Therefore, average load is estimated as follows

	Average Load	Average Capacity
Pickup trucks	0.9 tons	1.8 tons
Medium-size trucks	1.1	2.7
Large (extra-heavy) trucks	5.8	7.7

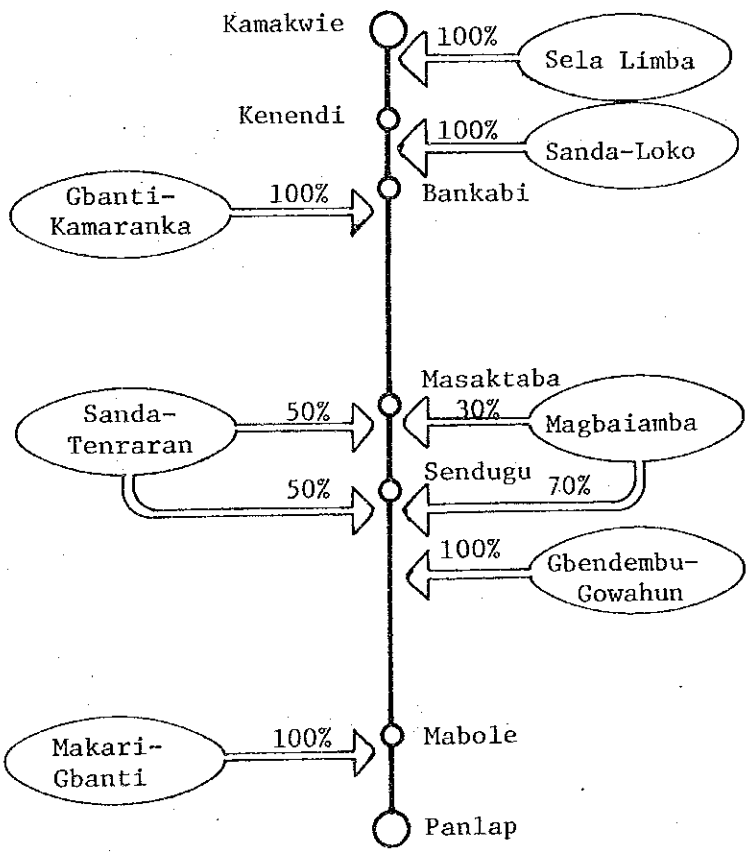
c) Composition of vehicle types is assumed to remain constant in the future:

Pickup trucks	40%
Medium-size trucks	30%
Large (extra-heavy) trucks	30%

d) Based on the above assumptions, the agricultural products shipment is distributed by weight as follows:

Pickup trucks	15%
Medium-size turcks	15%
Large (extra-heavy) trucks	70%

e) It is assumed that the shipment of agricultural products from each chiefdom will be accomplished as shown in the figure below.

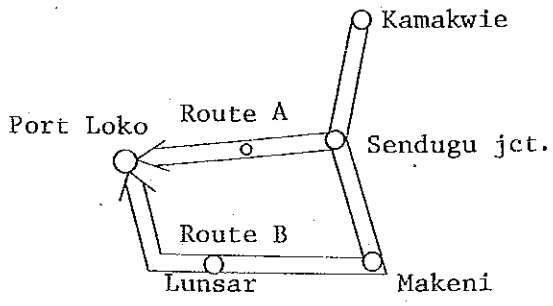


f) It is assumed that the number of cattle presently walked (herded) represents 25% of total cattle transport and that the entire cattle transport will be by truck after the completion of this Project.

3) Diverted Traffic

Upon the completion of this Project, traffic diversion is possible from two routes. One starts from Sendugu Junction (approximately mid-point on the Project Road), goes through Batkanu, and ends at Port Loko. According to the O-D survey and interview survey findings, traffic on this route is only four to six vehicles per day (25% vans, 75% remodeled buses) in the wet season, almost all of which are for passenger transport between Kamakwie and Port Loko. For traffic between Kamakwie and Port Loko, two routes are available between Sendugu Junction and Port Loko: one which passes Batkanu (Route A) and one which goes through Makeni and Lunsar (Route B). (Kamakwie - Port Loko traffic on Route B uses the entire extension of the Project Road.) In view of the fact that the time distance by Route B is 20 minutes shorter than by Route A presently, and 60 minutes shorter upon completion of the Project Road, it appears that Route A is used to serve passenger transport demands of roadside villages. Thus, it is believed that the current traffic on this route will divert substantially to the Project Road upon its completion.

Assuming a 50% diversion rate, it is estimated that one half of the current traffic on the Sendugu-Batkanu - Port Loko Road will divert to the Project Road. The forecast result of this diverted traffic is shown in Table 6-4.



Another possible diversion to the Project Road, which is an international road leading to Guinea, will be from the Trunk Sierra Leone - Guinea Inter-

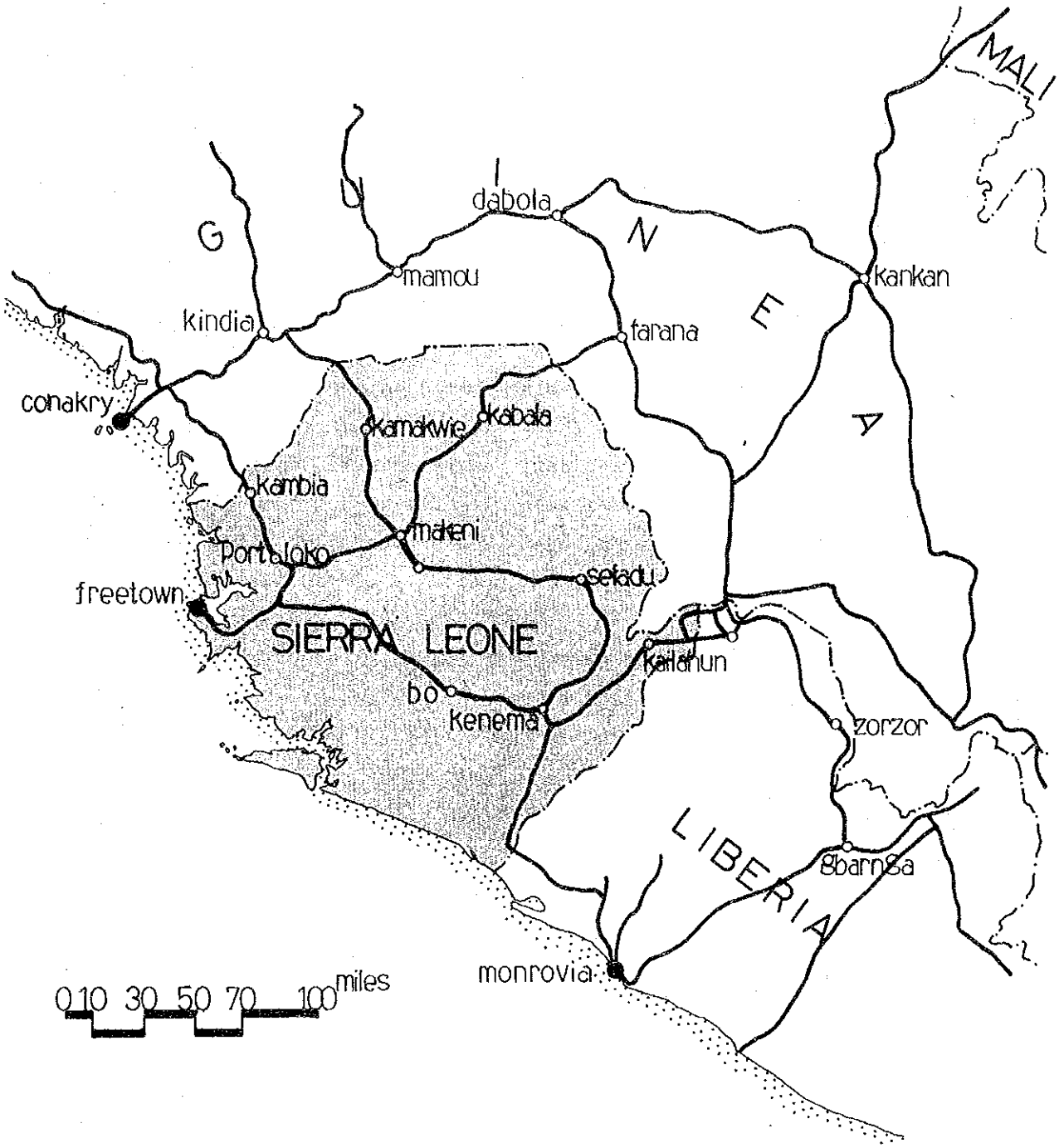


Fig. 6-2 Sierra Leone & Her Neighbours

Source: "Sierra Leone in Maps", J.I. Clarke

State Highway (Freetown - Port Loko - Kambia - Conakry) (See Fig. 6-2). The diversion volume of this international traffic will largely depend upon the future quality of the road from Kamakwie to the Guinea border and of the road continuing in Guinea beyond the border. However, the only possible diversion will be a small volume of traffic transporting agricultural products from Northern Guinea in view of the distance between the capitals of the two nations. Therefore, the international traffic diversion is disregarded.

4) Future Traffic Forecast

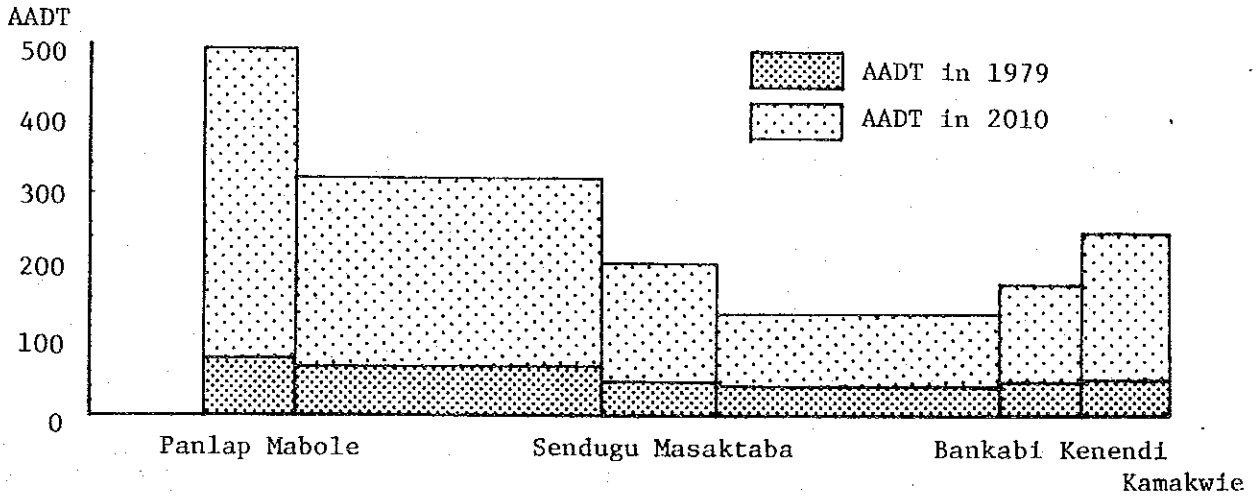
The forecast of future traffic volume based on the foregoing information is shown in Table 6-2. For the Panlap - Mabole section, where traffic is the heaviest, an average daily traffic of 995 vehicles is expected in the year 2010. This will be slightly higher than the current traffic on the Makeni - Lunsa - Magburaka Road. (Forecast values are presented in detail in Appendix L.)

The future traffic forecast by vehicle type presented in Table 6-3 shows that passenger cars represent a large proportion of the total traffic. This is particularly true in the vicinity of Makeni and Kamakwie.

The future traffic forecast is classified into normal traffic, diverted traffic, and development (induced) traffic in Table 6-4.

Table 6-2 Total Traffic Forecast

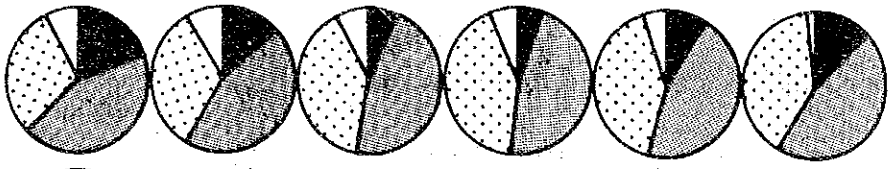
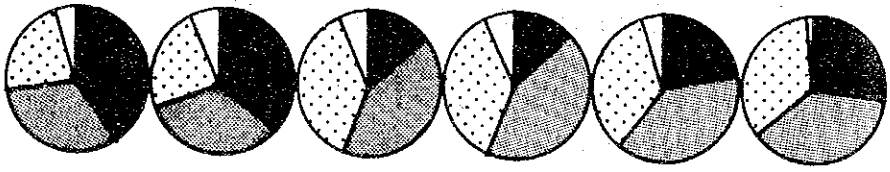
SECTION	1979	1985	1990	1995	2000	2005	2010
1 Panlap-Mabole	160	240	321	432	572	758	995
2 Mabole-Sendugu	135	204	260	333	419	524	643
3 Sendugu-Masaktaba	94	130	165	212	268	336	414
4 Masaktaba-Bankabi	81	106	131	162	197	237	280
5 Bankabi-Kenendi	94	125	155	195	241	297	360
6 Kenendi-Kamakwie	101	135	175	228	296	384	498



Distance (Miles)		5.0	17.4	5.2	16.2	4.3	5.0
AADT	1979	160	135	94	81	94	101
	2010	995	643	414	280	360	498
AADT(2010)/ AADT(1979)		6.2	4.8	4.4	3.5	3.8	4.9

Source: JICA Mission

Table 6-3 Composition of Future Traffic by Vehicle Type

Year	Vehicle Type	Panlap Mabole	Mabole Sendugu	Sendugu Masaktaba	Masaktaba Bankabi	Bankabi Kenendi	Kenendi Kamakwie
AADT in 1979	Car	31	19	6	4	8	12
	Van & Pickup	69	60	43	37	42	47
	Truck & Bus	47	45	37	34	38	40
	E.H.V.	12	11	7	5	5	2
AADT in 2010	Car	394	223	57	35	79	132
	Van & Pickup	326	219	171	117	136	182
	Truck & Bus	223	152	154	102	122	171
	E.H.V.	47	44	27	21	18	7
Vehicle Structure	1979						
	2010						

Note:

- Car
- Van & Pickup
- Truck & Bus
- E.H.V. (Extra Heavy Vehicle)

Source: JICA Mission

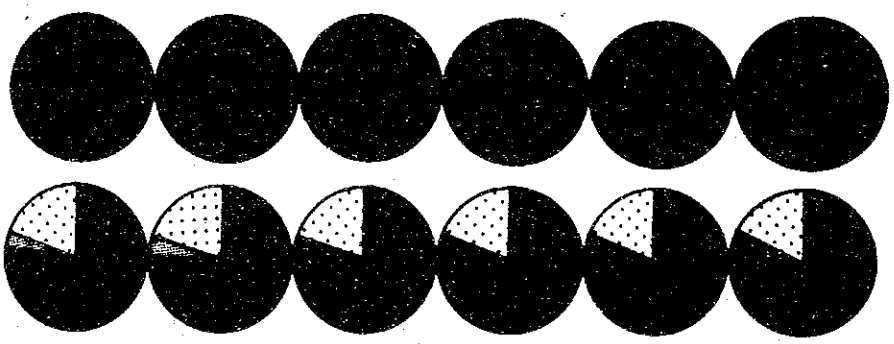
Table 6-4 Future Traffic by Generation Category

Year	Traffic Type	Panlap Mabole	Mabole Sendugu	Sendugu Masaktaba	Masaktaba Bankabi	Bankabi Kenendi	Kanendi Kamakwie
AADT in 1979	Normal	160	135	95	81	94	101
	Diverted	-	-	-	-	-	-
	Developed	-	-	-	-	-	-
AADT in 2010	Normal	772	486	332	226	293	410
	Diverted	32	32	-	-	-	-
	Developed	193	126	83	54	68	89

Traffic Type Structure

1979

2010



Note: Normal Traffic
Diverted Traffic
Development Traffic

Source: JICA Mission

CHAPTER 7

ALTERNATIVE ROAD DEVELOPMENT PLANS

CHAPTER 7

ALTERNATIVE ROAD DEVELOPMENT PLANS

7.1 Basic Thinking

The upgrading of the existing Project Road to a paved all-weather 2-lane international highway linking with Guinea will make it a trunk of the northern road network and an important supplement to the national road network of Sierra Leone and will be a precondition to the successful accomplishment of regional development, particularly in the area of agriculture. The Road should be upgraded to conform with the Class I Road Standard of Sierra Leone, with a design speed of 50 miles (80 kilometers) per hour.

The achievement of maximum effects with minimum investment will be a most important consideration to plan formulation.

In addition to the road construction cost, the cost of subsequent road maintenance, for a safe and pleasant usage at minimum running cost, should not be overlooked.

The effects of a road project on the society depends largely on the route of the road. However, in view of the fact that feeder roads are being developed in the Project Area, the Project Road may somewhat deviate from the existing road route without greatly affecting the progress of development projects in the Project Area.

Staged construction should also be considered as a possible means of improving investment effects of this Project. Because future traffic volume fluctuation over time is estimated to be greater than sectional fluctuation, the road may be upgraded only to a level adequate to serve existing demand, and further improved as demand increases in the future. In staged construction, however, care should be used to minimize possible repetition of

earthwork, bridge work, and other structural construction. Also, the disadvantage of repeated nuisance to roadside inhabitants (traffic hindrance, temporary impairment of road safety, etc.) should be taken consideration.

The length of this Project's construction period will vary, depending on the alternative adopted. Construction of a new road inevitably involves a number of uncertainties, such as work on a poor ground which may not be pre-designed, and is usually delayed by unforeseen causes, such as damage of earthwork by cataracts. A new road construction usually takes longer than a comparable upgrading work.

Based on the above observations, the following alternative plans were selected for comparative assessment.

7.2 Alternative Plan A

The first consideration to follow the above basic thinking would be, in view of the cost and the preservation of the current level of service, the upgrading of the existing road to conform with a given standard by improving all inferior alignments, bridges, culverts, and road width so as to satisfy the standard.

Whether or not bypass roads to detour villages are necessary should be studied and decided on the basis of the volume of traffic and village conditions. The existing road has adequate traffic capacity. Although the existing road route has sufficient lateral clearances in villages, where houses are located away from the road, additional lanes, sidewalks, guardrails, and curbs should be provided so that through-traffic, pedestrians, and stopping traffic can be separated to assure safety and a smooth flow of traffic. Therefore, no bypasses will be needed.

This alternative, then, may be summarized as follows:

(1) The existing road will be used to the maximum extent.

(2) Inferior alignments and widths will be improved to satisfy the Class I Road Standard of the Sierra Leone Road Classification.

(3) All bridges, culverts, and other structures will be newly constructed.

(4) Pavement will be used throughout the entire road extension.

The sections which need upgrading in order to satisfy these points have been indicated in Fig. 7-1 and described in detail in Appendix S-1. A summary of the upgrading work is given in Table 7-1.

Table 7-1 Aspects of Alternative Plan A

Items		Description
Design Criteria	Classification	Class I
	Design speed	50 m.p.h.
	Carriage way	22 ft
	Shoulder width	5 ft
	Surface course	2-Coat surface dressing
Conditions for Improvement	Widening Section	36.6 mile
	Re-alignment, Horizontal	13.1 mile
	Re-alignment, Vertical	3.4 mile
	Total Distance	53.1 mile
Construction Period		1983 - 1985

Source: JICA mission

7.3 Alternative Plan B

This alternative will consider a staged construction work for a higher investment effect. It will differ from Alternative A only in that the road will be first upgraded to satisfy the Class II (design speed of 40 miles per hour) Standard of the Sierra Leone Road Classification

and, ten years later, to satisfy the Class I Standard (design speed of 50 miles per hour). A staged construction is liable to result in unnecessary investment duplications, unless care is used. Under this alternative, out of the road sections which currently do not satisfy the Class I Standard (that is, the same sections as those indicated under Alternative A), those which do not satisfy Class II are identified, selected, and upgraded to Class I. Then, all the sections with unimproved alignments will meet at least Class II. All bridges and box culverts located in these sections are to be upgraded to Class I.

In the section to be worked on in the second stage, the only duplicated jobs will be pavement and work on pipe culverts. In the second stage, some pipe culverts will have to be moved in accordance with the shifting of the road route, but temporary work, cofferdam work, and work on other structures will not be repeated.

The timing of work on the Mabole Bridge has been considered for this alternative. This bridge will not withstand the traffic load expected in the future. Using the yield strength of superstructure materials as their allowable strength, this bridge will withstand a vehicle load of up to 20,000 pounds, but this does not ensure complete safety.

Therefore, the bridge should be reconstructed in 1995; until then, the existing bridge should be used with a proper traffic-weight control.

This alternative is summarized as follows:

(1) The upgrading will be first up to the Class II Standard (design speed, 40 miles per hour) and 10 years after the initial improvement (which will be 1995), to Class I.

(2) The first-stage work will be to upgrade to the Class I Standard all the sections which do not presently satisfy the Class II Standard and the bridges and box culverts in other sections.

(3) Those subject to the second work stage will be only the sections

which do not satisfy the Class II Standard and which contain only pipe culverts.

(4) The new Maboie Bridge will be constructed in the second stage. Until the time of its completion, up traffic and down traffic will have to be alternated on one lane and restricted by weight.

(5) Bridges, culverts, and other structures will be newly installed.

(6) The entire road extension will be paved.

Based on the above, sections to be upgraded have been indicated in Figure 7-1 and described in Appendix S-2. Alternative B improvement work is outlined in Table 7-2.

Table 7-2 Aspects of Alternative Plan B

Items		Description	
		First Stage	Second Stage
Design Criteria	Classification	Class II or Class I	Class I
	Design Speed	40 m.p.h or 50 m.p.h	50 m.p.h
	Carriage way	20 ft or 22 ft	22 ft
	Shoulder width	3 ft or 5 ft	5 ft
	Surface course	2-Coat	2-Coat
Conditions for Improvement	Widening section	37.3 mile	-
	Re-alignment, Horizontal	13.3 mile	3.1 mile
	Re-alignment, Vertical	2.5 mile	1.8 mile
	Total distance	53.1 mile	
Construction Period		1983 - 1985	1995 - 1996

Source: JICA mission

7.4 Alternative Plan C

Alternative C envisages the continued use of the existing road as is, and the construction of a new road on a different route. The new road is to be constructed as a Class I road with a design speed of 50 miles per hour one to six miles to the left (as seen from the starting point of the Project) of the existing route, utilizing relatively flat land. Therefore, the new road will reach Makeni without going through Panlap. The advantage of this alternative will be the construction of a new road without hindering the existing traffic, which will use the existing road while the new road is being constructed. The construction cost of this new road will, needless to say, be greater than the cost of upgrading the existing road.

This alternative is summarized as follows:

(1) The new road will be developed on a new route directly connecting Makeni and Kamakwie.

(2) The road will be a Class I road with a design speed of 50 miles per hour.

(3) The road will be constructed in one stage, and all earthworks, bridges, and other structures will be newly constructed.

The route of Alternative C's new road is shown in Fig. 7-1 and described in detail in Appendix S-3. A summary of this alternative is given in Table 7-3.

Table 7-3 Aspects of Alternative Plan C

Items		Description
Design Criteria	Classification	Class I
	Design Speed	50 m.p.h
	Carriage way	22 ft
	Shoulder width	5 ft
	Surface course	2-Coat surface dressing
Condition for Construction	Total distance	48.9 mile
Construction Period		1983 - 1986

JICA Mission

7.5 Comparison of Alternatives

Of these alternatives, the one which will best meet the Project purpose must be identified, based on an overall comparative study. Not only the construction cost but the entire cost, including maintenance expense, should be compared against economic benefits; technological aspects should also be considered.

The amount of investment fund immediately required will be less for the staged construction under Alternative B than for the one-stage construction under Alternative A. The cost of upgrading under Alternative A will, however, be less than the cost of the new route development under Alternative C. Alternative B will require less initial investment than Alternative A, but the cost of a second stage construction is usually comparatively high. Investment effects of the one-stage construction and the two-stage construction should be compared by economic assessment. In addition to the aspects of the construction itself, Alternative B will be disadvantageous in that it will cause hindrance to the local inhabitants and traffic twice, rather than once.

Alternative C will permit the construction of a desirable road with well-balanced alignments, while in the case of upgrading work, such ele-

ments as service to local villages and access roads will much restrict the formation of a desirably shaped road. The direct road between Makeni and Kamakwie under Alternative C will be about 4.2 miles (about 8%) shorter than the roads under Alternatives A and B, but will require approximately 35% (22,500,000 Leones) greater cost than the other two, as estimated in Appendix. As opposed to the existing road, which runs through villages, the new road, which is to be positioned one to six miles away from the existing road, will have to be connected to the villages by feeder roads with resultant reduced services to the inhabitants. In view of its higher (by as much as 35%) construction cost, it is believed that an economic assessment, if done, will not prove Alternative C to be more favourable than Alternatives A and B.

Based on the above comparisons, Alternatives A and B are considered as the only candidates which should be subjected to an economic assessment for final selection. Therefore, subsequent discussions in this report will be limited to Alternatives A and B.

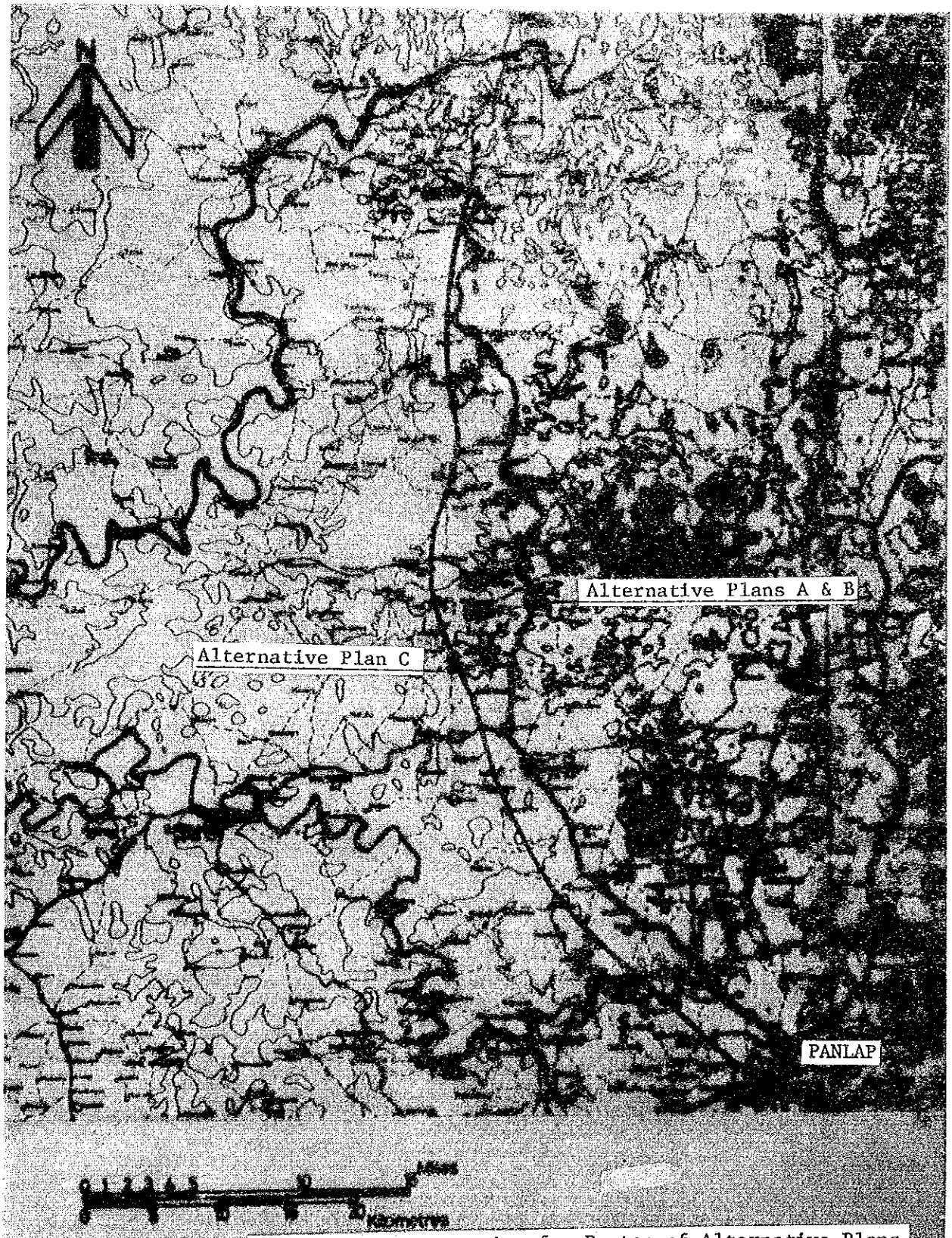


Fig. 7-1 Illustration for Routes of Alternative Plans

CHAPTER 8

PRELIMINARY DESIGN

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8.1 Fundamental Philosophy

1) Purpose

In order to assess the technical feasibility of Alternatives A and B and to identify difficulties and matters of caution for detailed designing, a preliminary design is to be drawn for each of the alternatives. Also, construction and maintenance costs will be estimated on the basis of the preliminary design and used for an economic feasibility study.

2) Design Standard and Design Speed

The design standard and design speed of the Road are the most important elements in the determination of road function and design criteria. The Project Road must be able to handle the volume of traffic to be generated by agricultural development projects envisaged for the roadside areas, and also must be in harmony with the existing road network. Furthermore, when extended beyond Kamakwie toward the east in the future, this road will become an international highway reaching the Guinea border. Therefore, the existing road is to be upgraded to a level conforming with the Class I Standard of the Sierra Leone Road Classification, with a design speed of 50 miles per hour.

3) Improvement Method

Important elements that should be considered for any road improvement work are the minimization of construction cost and the maximization of service to roadside inhabitants. The alignment and the kind and method of construction work should be so selected that the same level of upgrading can be accomplished with minimum expense. So that through-traffic can

travel smoothly and safely, bypass roads should also be installed. Pedestrian traffic should be separated from through-traffic for safety. However, the installation of bypass roads will necessitate the construction of access roads in order to maintain service to the village. Since future traffic will be limited on this Road and in the interest of construction cost and service to the village, bypass roads will not be installed. However, in order to assure the smooth flow of through-traffic and the safety of pedestrians in the village, the through-traffic and pedestrian traffic must be separated by additional lane(s), sidewalks(s), gaurdrails and curbs.

4) Bridges and Culverts

The bridges and culverts of the existing road failed to conform to the road standard in terms of width, proposed height and load-bearing capacity, and therefore, must be either reinforced or replaced. In view of the reinforcement cost comparable to the construction cost of new structures and of future maintenance cost, replacement would be more advantageous. Therefore, existing bridges and culverts are to be demolished and newly constructed.

The construction of new bridges, box culverts, and pipe culverts will be necessary at 180 locations throughout the Project Road. The necessary discharge area size and installation height vary by location, but attempting to construct these structures to meet local requirements only will entail designing a large number of different shapes and will result in a relatively high construction cost and a longer construction period. Therefore, these structures are to be standardized to a maximum extent in the interest of construction cost and period.

5) Pavement Design

Pavement design should take into consideration materials available from roadside areas, the existing road surface condition, and future traffic volume. The very well-compacted existing road is to be used as the sub-

grade. Materials obtainable from nearby areas will be the most economical pavement material for base and sub-base course.

Of possible paving methods, such as surface dressing, asphalt macadam and asphalt concrete, surface dressing is believed to be the most suitable in view of future traffic, materials and workability.

8.2 Alignment Plan

1) Design Standard

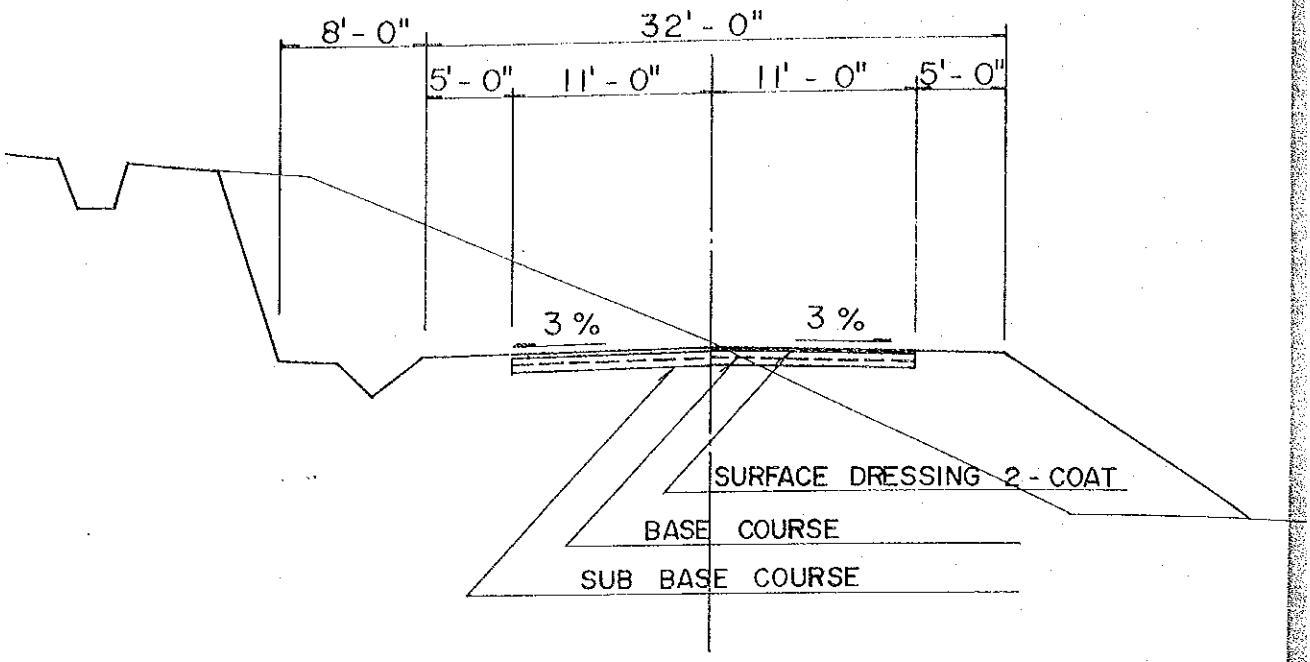
The existing road is to be upgraded to satisfy the Class I Standard of the Sierra Leone Road Classification, as stated earlier. Sierra Leone recently established such design standard in consideration of the yearly increasing traffic volume and other conditions present in the nation. With regards to details not set forth by said standards, design specification of this Project has been determined as presented in the next table with reference to the following specification*:

Table 8-1 Geometric Design Standard

Road Classification		I	II	Remarks
Design Horizontal Alignment	Speed (m.p.h.)	50	40	
	Minimum radius (ft)	1,000	600	
	Min. curve length (ft)	500	350	I A 7°
	Max. superelevation rate (%)	6	6	
Vertical Alignment	Max. gradient (%)	6	7	
	Max. length for maximum grade (ft)	1,800	-	
	Min. vertical curve length (ft)	10,000	5,000	Crest
	-ditto- (ft)	7,000	3,000	Sag
Stopping Cross Section	Sight distance (ft)	400	250	
	Carriage way (ft)	22	20	
	Shoulder width (ft)	5	3	
	Bridge section width (ft)	22	22	Kurb-kurb

Source: General Geometric Standard in Sierra Leone

* "A Policy on Geometic Design of Rural Highways" - American Association of State Highway of Officials



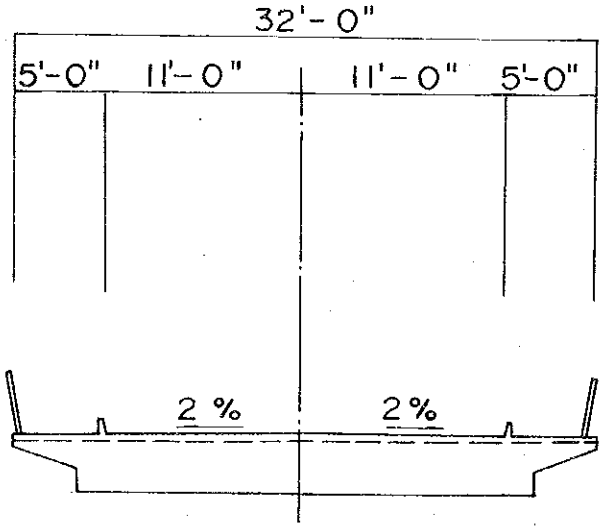


Fig. 8-1 TYPICAL CROSS SECTION

2) Basic Philosophy

The improvement of existing alignments should be carefully determined not only in conformity with the design criteria but also with consideration of their effects on safe and smooth traffic flow and construction cost.

At the time of preliminary designing, road sections needing improvement in alignment were identified based on the following basic thinking:

a) The improved alignments should be as consistent with the local topography as possible. Smooth alignment following the natural contour offers greater traffic safety and tends to minimize construction and maintenance costs.

b) The continuity of alignment should be emphasized. When horizontal curves of a small radius occur after a long tangent, a curve with a large radius should be installed as approach.

c) The construction of a road through an undulating plateau in close conformity with the topography will result in a vertical alignment with frequent sags and crests. These roads with numerous hidden dips, sometimes called the "roller-coaster" alignment, should be avoided as much as possible for traffic safety.

d) Both vertical and horizontal alignments should be as moderate as possible near a junction, where an adequate sight distance should be available and the stop and start of vehicles should be easy, to preventing traffic accidents where the traffic flow cross each other.

e) Generally, horizontal and vertical alignments should maintain a proper balance with each other. The combination of these alignments should provide a proper compound gradient. As favourable a combination of vertical and horizontal alignments should be sought for, in due consideration of construction cost increase. The insertion of a horizontal curve with a small radius and of the reverse

point of an S-curve should be avoided at the tops and bottoms of vertical curves. In the case of a horizontal curve with a small intersection angle, the length of the curve should be as long as possible in order to prevent the curve from appearing "kinked." Broken-back grade lines (two horizontal curves in the same direction separated by a short sectional tangent grade) should be avoided.

8.3 Earthwork Design

1) Embankment and Cutting Work

The maximum use of earth produced by cutting for embankment purposes is a principle of this Project. As studied earlier, borrowed earth is to be used when hauling distance is otherwise excessive. The topsoil, which is laterite unsuitable for embankment, is to be spoiled down to about 1 foot.

In the re-alignment sections, trees are to be felled in order to assure an adequate sight distance, and the construction site should be cleared and grubbed for earthwork stability.

A French drain and an impervious layer are to be installed for embankments in marshes and dales. Embankment slope gradient is to be 1:1.5, and cutting slope gradient is to be decided between 1:0.2 and 1:0.4, depending on soil conditions. High embankments and deep cuttings are to be avoided as a rule, but when inevitable, beam steps are to be placed.

2) Slope Protection

Slope protection should be limited for embankments and cuttings where necessary, provided that riprap pitching is done on embankment slopes in approaches to bridges and culverts and on cuttings where soil is easily collapsible.

3) Drainage Design

Surface draining, slope draining, and adjacent-area draining are possible. In surface draining, water is drained by the vertical and horizontal curves of the road into roadside ditches. Because the Project Road will generally have two lanes except at junctions, surface draining can be accomplished only on shoulders. Roadside ditches are to be naked ditches, and are to be installed as necessary.

In cutting parts, shoulder-side ditches will be installed in order to prevent water-flow from the adjacent area into the slope. These ditches are to be constructed as naked ditches to drain water into rivers and creeks. Generally, no drainage structures will be installed at the toe of a slope in embankment sections, provided that naked side ditches are installed where water otherwise remains at the foot of the embankment. No special drainage facilities will be installed on slopes, but when a shoulder-side ditch has to be connected to a side ditch in cutting sections, a verticle ditch is to be installed.

8.4 Culvert Design

A large number of culverts presently exist because the Project Road runs through flat lands and hills crossing numerous rivers and creeks. Upon the upgrading work, these culverts are to be replaced in accordance with the new road plan. When culverts with a discharge area size adequate to the proposed discharge volume of each river, as calculated in Section 3.8, have been installed, the function of the currently divided water channels will be restored.

The cross section of each culvert is determined by the proposed height of road surface at the cross point, proposed discharge volume, and the river shape. However, to design a large number of different culverts would complicate construction work, and make construction cost relatively high and construction period unnecessarily long. Therefore, the standard culvert types as described in Tables 8-2, 8-3 have been selected for use.

Five types of box culverts with the most economical square cross section have been selected, with minimum size of 5 feet and maximum size of 10 feet. Three types of pipe culverts with a diameter of 3 feet, 4 feet, and 5 feet have been selected.

Table 8-2 Standard Types for Box Culverts

Standard Types	Size		Protective covering depth	Discharge capacity volume
	Width	Height		
Type A	5 ft	5 ft	Min. 1- 1"	7 cub. Yd.
B	7 ft	7 ft	-ditto-	15 cub. Yd.
C	10 ft	10 ft	-ditto-	45 cub. Yd.
D	13 ft	13 ft	-ditto-	97 cub. Yd.
E [Type C double (10+10) ft]		10 ft	-ditto-	102 cub. Yd.

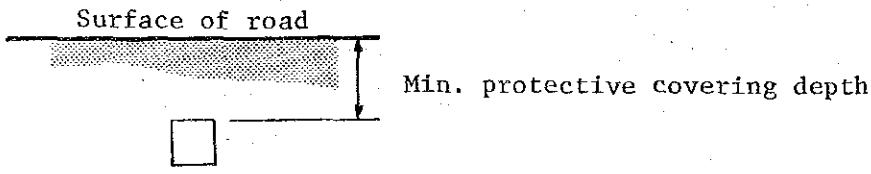
Source: JICA Mission

Table 8-3 Standard Types for Pipe Culverts

Standard types	Size diameter	Protective covering depth	Discharge capacity volume
Type A	Ø 3 ft	Min. 2 ft	2 cub. Yd.
B	Ø 4 ft	-ditto-	3 cub. Yd.
C	Ø 5 ft	-ditto-	5 cub. Yd.

Source: JICA Mission

Note:



The installation of standard types of box and pipe culverts to accomodate the proposed discharge volume of each river is summarized in Table 8-4. Of the total 159 culverts, only the major ones are included in Table 8-4. Standard designs of all box and pipe culverts are presented in a separate Appendix S-5.

Table 8-4 List of Proposed Box Culverts to be Installed

Location		Type	Length (feet)	Water Direction
Km	Miles			
3 + 20	2.20	7 ft x 7 ft	82	L
5 + 30	3.30	10 ft x 10 ft	35	L
9 + 40	5.90	7 ft x 7 ft	35	L
10 + 90	6.80	10 ft x 10 ft	72	L
16 + 20	10.10	10 ft x 10 ft	35	L
17 + 00	10.60	13 ft x 13 ft	35	L
23 + 40	14.60	7 ft x 7 ft	35	L
27 + 70	17.30	13 ft x 13 ft	35	L
30 + 20	18.90	13 ft x 13 ft	35	L
32 + 00	20.00	10 ft x 10 ft	52	L
32 + 60	20.40	10 ft x 10 ft	35	R
35 + 90	22.40	10 ft x 10 ft	35	R
37 + 40	23.30	10 ft x 10 ft	35	L
44 + 00	27.50	5 ft x 5 ft	35	L
45 + 20	28.30	10 ft x 10 ft	72	L
47 + 10	29.40	7 ft x 7 ft	92	R
49 + 00	30.60	7 ft x 7 ft	35	R
49 + 60	31.00	13 ft x 13 ft	72	L
53 + 70	33.60	10 ft x 10 ft	35	R
57 + 00	35.70	13 ft x 13 ft	42	L
58 + 10	36.10	10 ft x 10 ft	102	L
62 + 10	38.80	10 ft x 10 ft	35	L
67 + 40	42.10	13 ft x 13 ft	35	L
74 + 40	46.50	7 ft x 7 ft	35	L
76 + 30	47.70	10 ft x 10 ft	132	L

Note: Water direction "R" means that water flows from left side to right side of the road toward Kamakwie.

Source: JICA Mission