CHAPTER 8

FUTURE TRAFFIC DEMAND FORECAST

8.1 ESTABLISHMENT OF CURRENT OD MATRIX

8.1.1 Traffic Analysis Zone

In general, traffic demand forecasting attempts to quantify the amount of travel on a road network. Demand for transportation is estimated based on socio economic activities and the supply of transportation is represented by the characteristics of road network. Demand should be estimated based on movement between areas. For this purpose a study area is divided into analysis units to enable to link information about activities, travel, and transportation to physical locations in a study area. The transportation analysis units are known as ‘Traffic Analysis Zone’.

Traffic analysis zones are specified according the following points:

- Balance between a size of zones and the density of network
- Availability of socio-economic indicators for model development
- Consideration of existing natural and administrative boundaries

Based on these aspects, the study team decided ‘Traffic Analysis Zone’ system as follows:

- The Study area is divided into 49 zones based on municipality and city for ARMM, Region X, and Region XII
- A province is applied for TAZ for outside the Study area in principle.
- Polloc port area is an independent TAZ.
- No traffic analysis zone is prepared for the islands in ARMM.
- The total number of TAZ is 115 zones in total.

The established TAZ is shown in **Table 8.1.1-1** and **Figure 8.1.1-1**.

TABLE 8.1.1-1 DEFINITION OF TRAFFIC ANALYSIS ZONE

Area		Province	Traffic Analysis Zone
Study Area	ARMM	Sharif Kabunsuan	2-8
		Maguindanao	9-17
		Lanao del Sur	30-49
	Region X	Lanao del Norte	74-81
		Misamis Oriental	82-91
		Bukidnon	92-100
	Region XII	Cotabato City	1
		North Cotabato	18-29
		Sultan Kudarat	50-57
		South Cotabato	58-68
		Sarangani	69-73
External Area			101-114
Special Area	Polloc Port		115

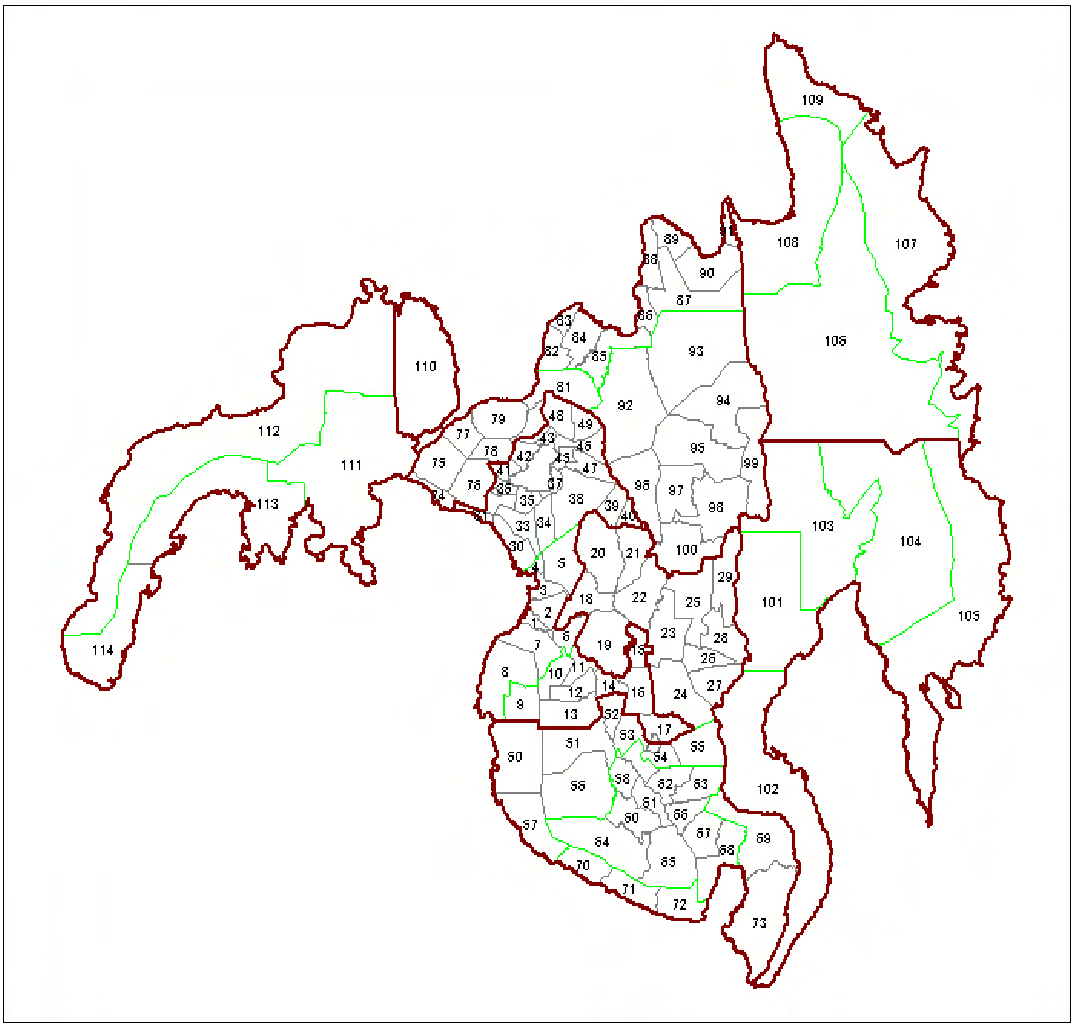


FIGURE 8.1.1-1 TRAFFIC ANALYSIS ZONE (TAZ)

8.1.2 Establishment of Current OD Matrix

1) Methodology

The process applied in this Study for establishing a current origin and destination (OD) matrix entails the following:

- A sample OD matrix is produced with the result of 'Roadside OD' interview survey.
- On the other hand, a network representing the existing situation for Mindanao Island.
- The sample OD matrix is adjusted as traffic flow on each road section will be the same by applying 'Entropy Maximization Model'.
- The adjusted OD matrix is assigned on the network and the assigned traffic volume is compared with the result of the traffic count survey so that the adequacy for traffic assignment simulation can be justified.

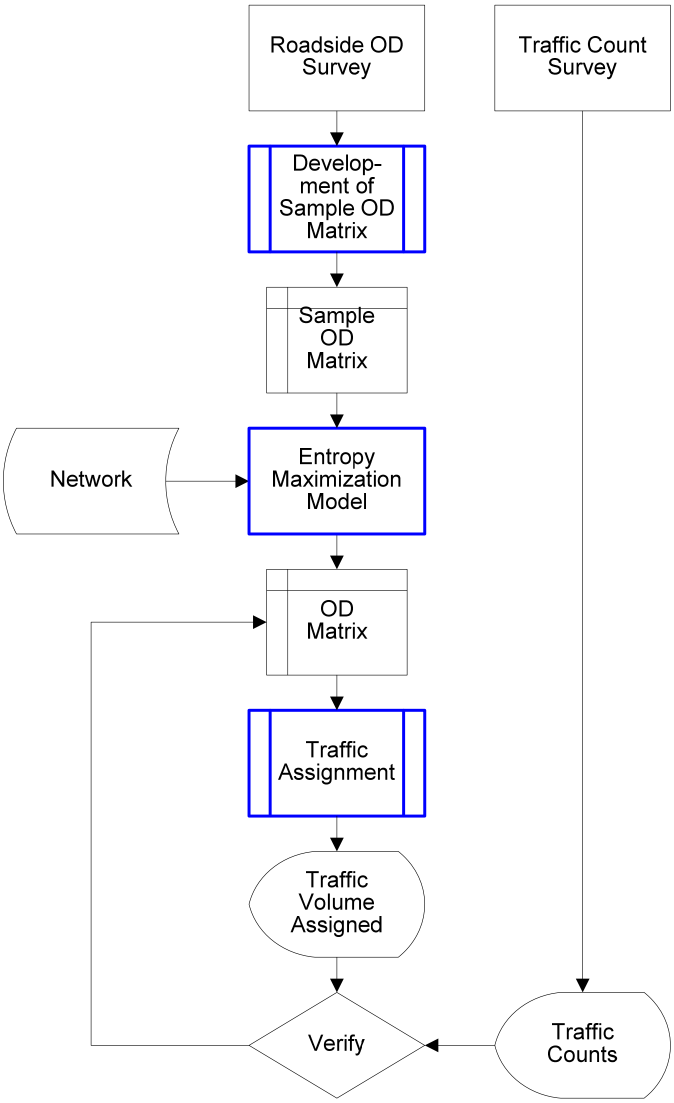


FIGURE 8.1.2-1 METHODOLOGY FOR CURRENT OD MATRIX ESTABLISHMENT

2) Traffic Survey

Outline of Traffic Survey

The Study team conducted the following two different transport surveys:

- Traffic count survey
- Roadside OD interview survey

Traffic Count Survey was carried out in order to count and classify motor vehicles at 37 locations and recording the data to determine the present traffic volume and traffic composition. OD survey was conducted to establish the present OD matrices at nine locations in terms of trips of passengers, commodities and vehicles.

FIGURE 8.1.2-2 LOCATIONS FOR TRAFFIC SURVEYS

Result of Traffic Count Survey

Table 8.1.2-1 shows the traffic volume in 12-hour count, 24-hour count, and AADT (Average Annual Daily Traffic). 24-hour count and AADT were estimated by applying an expansion factor at DPWH National's nearest survey station with the result of 12-hour count surveyed by this Study.

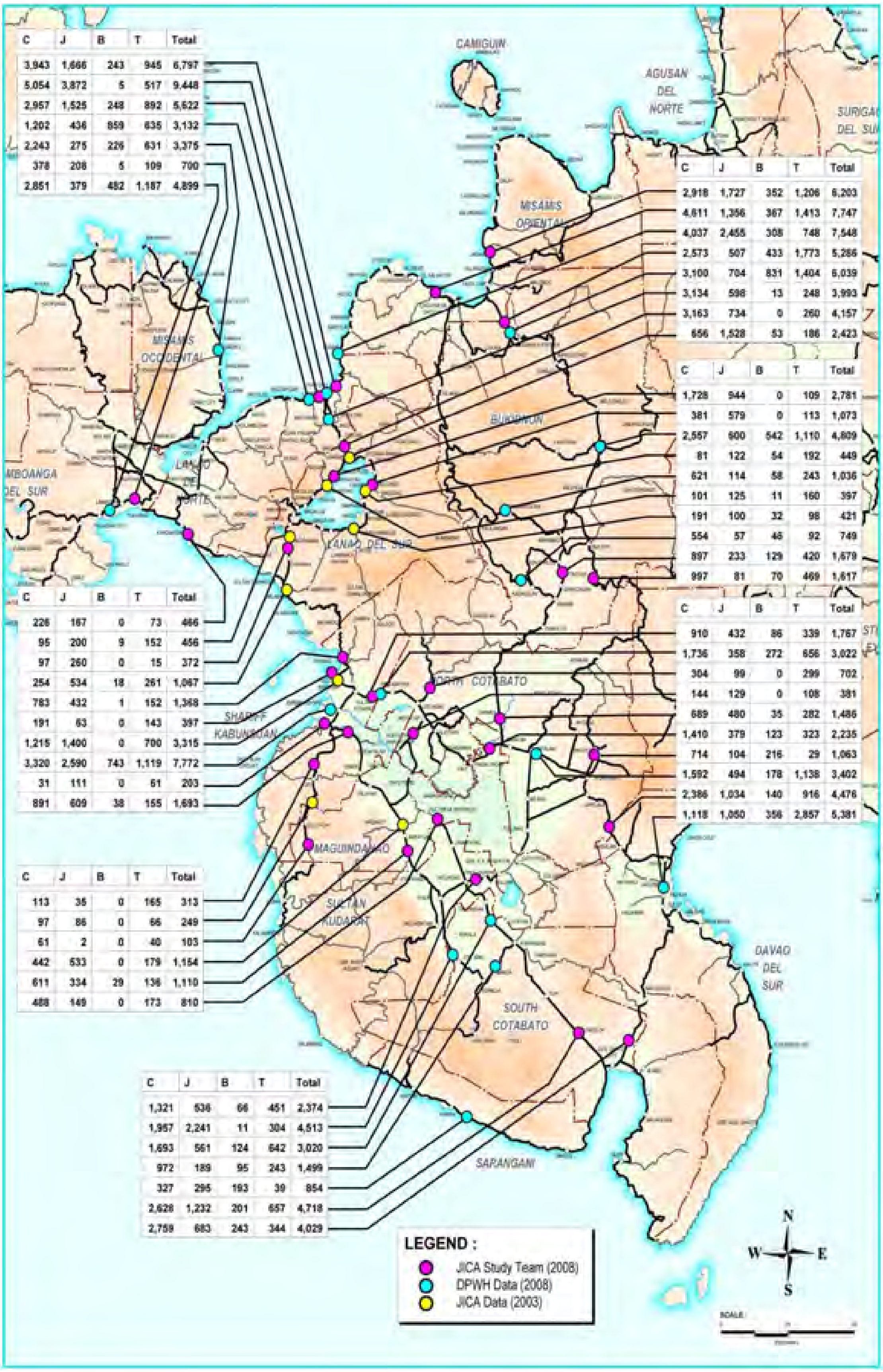
The traffic volume (AADT) per station is presented in **Figure 8.1.2-3**. Data of the DPWH National (2008) as well as JICA Study's data (2003) are also shown in the figure to appreciate traffic volume in other parts of the Study area.

The location where higher traffic volume was observed concentrates neighboring areas of large cities such as Cagayan de Oro City, Iligan City, and General Santos City. The traffic volume ranges between 4,000 and 7,500 in terms of AADT, in each location. On the other hand, AADT counted at the locations in neighborhood of Cotabato City is almost 1,500.

TABLE 8.1.2-1 TRAFFIC VOLUME IN THE STUDY AREA

Traffic Station No.	Road Direction	12-Hour Traffic Volume					24-Hour Traffic Volume					AADT				
		Car	Jeep	Bus	Truck	Total	Car	Jeep	Bus	Truck	Total	Car	Jeep	Bus	Truck	Total
1	Jasaan-Villanueva	2,133	1,399	239	935	4,706	3,055	1,770	328	1,462	6,615	2,918	1,727	352	1,205	6,202
2	Opol-El Salvador	3,368	1,099	249	1,082	5,798	4,829	1,390	343	1,689	8,251	4,611	1,356	367	1,412	7,746
3	Iligan - Linamon	3,167	1,636	101	636	5,540	4,159	2,082	248	1,120	7,609	3,943	1,666	243	945	6,797
4	Tagoloan-Manolo Fortich	1,879	411	287	1,175	3,752	2,694	520	395	1,852	5,461	2,573	507	433	1,772	5,285
5	Marawi-Saguiaran	2,491	684	0	193	3,368	3,336	918	0	319	4,573	3,163	734	0	259	4,156
6	Balindong-Marantao	1,351	920	0	78	2,349	1,822	1,179	0	137	3,138	1,728	944	0	109	2,781
7	Maguing-Molundo	300	539	0	86	925	402	723	0	142	1,267	381	579	0	113	1,073
8	Calanogas-Pagayawan	78	241	0	12	331	102	325	0	19	446	97	260	0	15	372
9	Tukuran - Karumatan	202	152	0	51	405	248	206	0	88	542	226	167	0	73	466
10	Labangan-Tukuran	289	155	4	106	554	341	199	6	134	680	378	208	5	110	701
11	Cotabato - Parang	561	437	1	156	1,155	652	539	1	192	1,384	783	432	1	153	1,369
12	Cotabato-Polloc	137	64	0	146	347	160	79	0	177	416	191	63	0	143	397
13	Pigcawayan - Cotabato	652	437	73	345	1,507	759	540	90	425	1,814	910	432	86	339	1,767
14	Libungan-Alamada	218	100	0	307	625	253	123	0	375	751	304	99	0	299	702
15	Cotabato-Kushiong	28	113	35	41	217	31	139	0	76	246	31	111	0	61	203
16	Cotabato - Upi	102	38	0	192	332	116	44	0	205	365	113	35	0	164	312
17	Upi-Lebak	55	2	0	50	107	62	2	0	50	114	61	2	0	40	103
18	Cotabato - DOS	814	619	39	177	1,649	902	761	45	194	1,902	891	609	38	155	1,693
19	Midsayap-Datu Piang	104	123	0	116	343	121	161	0	135	417	144	129	0	108	381
20	Ampatuan-Esperanza	555	363	31	154	1,103	625	418	33	171	1,247	611	334	29	136	1,110
21	Tacurong-Lambayong	443	162	0	209	814	500	186	0	216	902	488	149	0	172	809
22	Kabacan-Pagalungan	1,035	408	111	320	1,874	1,174	474	129	405	2,182	1,410	379	122	323	2,234
23	Carmen - Kabacan	506	516	32	279	1,333	575	599	37	352	1,563	689	480	35	282	1,486
24	Kitaotao-Dangcagan	628	224	89	299	1,240	747	280	128	517	1,672	897	233	129	420	1,679
25	Maramag-Quezon	689	78	48	317	1,132	830	98	69	528	1,525	997	81	70	469	1,617
26	Magpet-Kidapawan	504	111	1	192	808	595	130	1	243	969	715	104	216	29	1,064
27	Tacurong-Pres. Quirino	1,188	585	62	542	2,377	1,351	670	78	564	2,663	1,321	536	66	450	2,373
28	Gen. Santos - Polomolok	2,387	1,382	186	817	4,772	2,691	1,560	235	820	5,306	2,629	1,232	201	656	4,718
29	Bansalan - Makilala	1,387	1,094	134	864	3,479	1,988	1,293	148	1,145	4,574	2,386	1,034	140	915	4,475
30	Gen. Santos - Malungon	1,724	522	148	796	3,190	2,713	698	242	1,452	5,105	2,759	683	243	343	4,028
31	Isabela-Lamitan	1,138	299	305	528	2,270	1,386	430	386	848	3,050	1,208	345	309	677	2,539
32	Isabela-Maluso	870	270	119	402	1,661	1,059	396	147	653	2,255	923	317	117	522	1,879
33	Pasiagan-Patikul	515	359	0	434	1,308	627	517	0	740	1,884	546	414	0	592	1,552
34	Jolo-Indanan-Parang	107	395	0	288	790	130	569	0	490	1,189	114	455	0	391	960
35	Jolo-Talipao	75	598	0	95	768	91	861	0	159	1,111	80	689	0	127	896
36	Nalil-Bongao	79	89	0	31	199	96	128	0	52	276	84	103	0	41	228
37	Sanga Sanga-Bongao	104	81	0	38	223	126	117	0	64	307	110	93	0	52	255
38	Iligan - Linamon	2,375	1,498	164	597	4,634	3,119	1,906	254	1,052	6,331	2,957	1,525	248	892	5,622

Unit: vehicles



C	J	B	T	Total
3,943	1,666	243	945	6,797
5,054	3,872	5	517	9,448
2,957	1,525	248	892	5,622
1,202	436	859	635	3,132
2,243	275	226	631	3,375
378	208	5	109	700
2,851	379	482	1,187	4,899

C	J	B	T	Total
2,918	1,727	352	1,206	6,203
4,611	1,356	367	1,413	7,747
4,037	2,455	308	748	7,548
2,573	507	433	1,773	5,286
3,100	704	831	1,404	6,039
3,134	598	13	248	3,993
3,163	734	0	260	4,157
656	1,528	53	186	2,423

C	J	B	T	Total
1,728	944	0	109	2,781
381	579	0	113	1,073
2,557	600	542	1,110	4,809
81	122	54	192	449
621	114	58	243	1,036
101	125	11	160	397
191	100	32	98	421
554	57	46	92	749
897	233	129	420	1,679
997	81	70	469	1,617

C	J	B	T	Total
910	432	86	339	1,767
1,736	358	272	656	3,022
304	99	0	299	702
144	129	0	108	381
689	480	35	282	1,486
1,410	379	123	323	2,235
714	104	216	29	1,063
1,592	494	178	1,138	3,402
2,386	1,034	140	916	4,476
1,118	1,050	356	2,857	5,381

C	J	B	T	Total
226	167	0	73	466
95	200	9	152	456
97	260	0	15	372
254	534	18	261	1,067
783	432	1	152	1,368
191	63	0	143	397
1,215	1,400	0	700	3,315
3,320	2,590	743	1,119	7,772
31	111	0	61	203
891	609	38	155	1,693

C	J	B	T	Total
113	35	0	165	313
97	86	0	66	249
61	2	0	40	103
442	533	0	179	1,154
611	334	29	136	1,110
488	149	0	173	810

C	J	B	T	Total
1,321	536	66	451	2,374
1,957	2,241	11	304	4,513
1,693	561	124	642	3,020
972	189	95	243	1,499
327	295	193	39	854
2,628	1,232	201	657	4,718
2,759	683	243	344	4,029

FIGURE 8.1.2-3 RESULT OF TRAFFIC COUNT SURVEYS

3) Verification

The current OD matrix was estimated by using 'Entropy Maximization Model' so that it is necessary to check whether the OD matrix represents the current transport situation.

The procedure of verification includes two steps: first, the current OD matrix is assigned on an existing network, second, the assigned traffic volume is compared with the result of the traffic count surveys at each corresponding location. This verification aims to check the accuracy of both the current OD matrix and an existing network modeled representing the existing transport situation. The detail of a network system will be discussed in Chapter 4.

Figure 8.1.2-4 exhibits the result of traffic assignment simulation. Traffic volume assigned is the sum of four types of vehicle: car, jeepney, bus, and truck, in terms of passenger car unit (pcu). And color indicates level of congestion (vehicle capacity ratio).

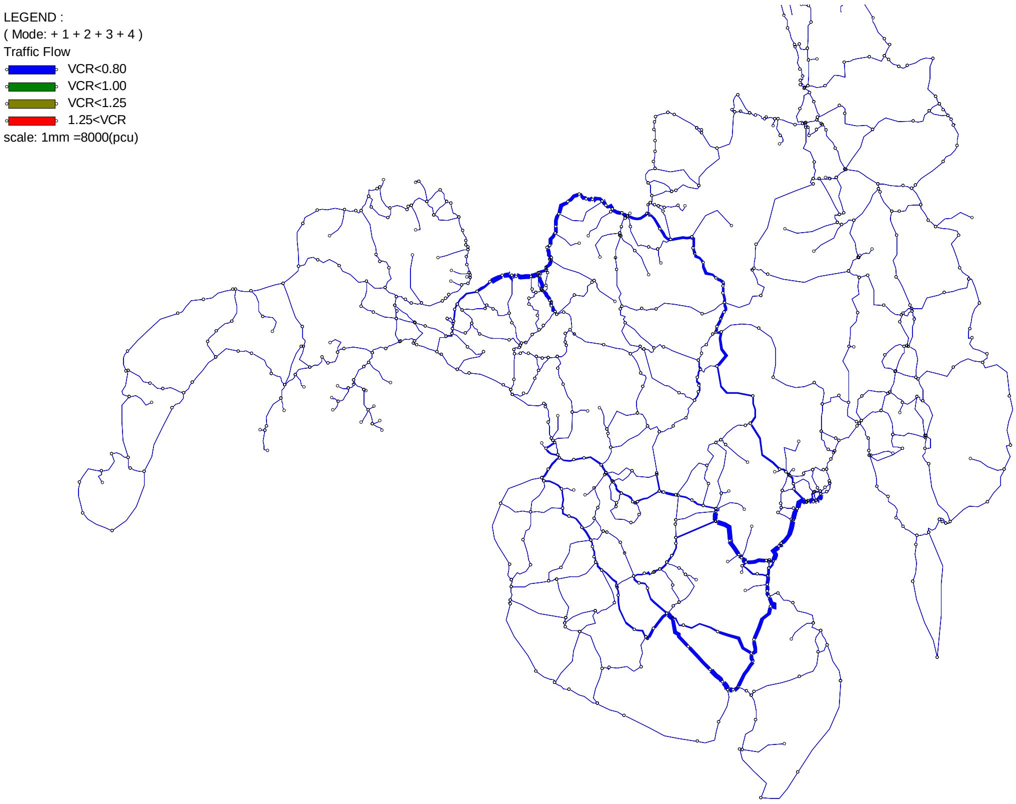
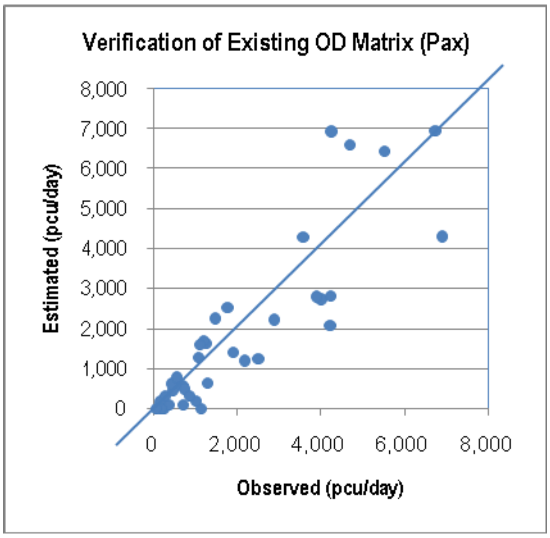


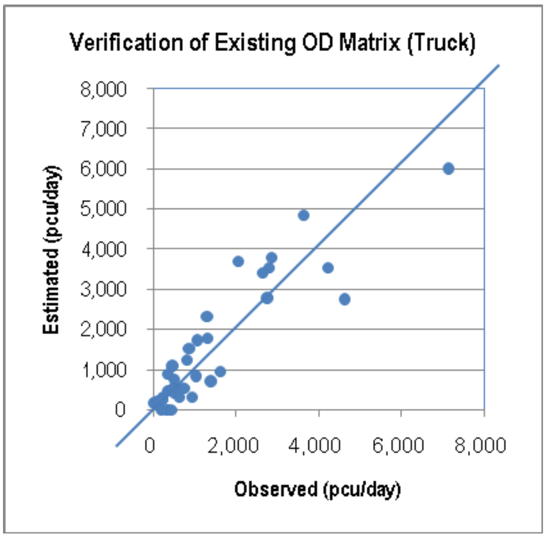
FIGURE 8.1.2-4 RESULT OF TRAFFIC ASSIGNMENT SIMULATION FOR EXISTING

Figure 8.1.2-5 shows the result of comparison between the traffic volumes assigned and observed in case of both passenger transport that includes car, jeepney, and bus, and cargo traffic. The result of traffic count survey was converted to traffic of pcu to compare with the result of assignment simulation.

The correlation coefficient is useful to be able to gauge the strength of the relationship between two variables, such as estimated and observed traffic volume in this case. A set of the correlation coefficient are 0.77 and 0.83 for passenger transport and cargo traffic, respectively. The correlation coefficient of passenger transport is relatively low than that for cargo transport. Although there are several locations indicating differences between estimated and observed, these values are tolerable.



Passengers r^2=0.77



Cargo Vehicle r^2=0.83

FIGURE 8.1.2-5 VERIFICATION BETWEEN SIMULATION RESULT AND TRAFFIC COUNTS OBSERVED

8.1.3 Existing Demand

In this section, the characteristics of the existing demand are discussed based on the current OD matrix produced in the previous section.

(1) Characteristic of Passenger Trips

<u>Trip Production and Attraction</u>

- **Figure 8.1.3-1** shows the passenger trip generation by TAZ, which is the number of trips producing from and attracting to each TAZ.
- The largest volume of trips generated at the area that includes Iligan City. Its volume is about 120 thousand trips / day.
- A number of passenger trips are often generated in the populated areas and big cities. The area of General Santos City, Cagayan de Oro City, and Cotabato City has relatively large volume of generated trips.

<u>Trip Distribution</u>

- The trip distribution of passenger demand is displayed in **Figure 8.1.3-2**.

- There is a strong link of demand between Cotabato Citye area and General Santos City area.
- Almost demand generating from the northern part of the Study area, such as Iligan City and Cagayan de Oro City, completes their trips inside the area and don’t reach Cotabato City area.

(2) Characteristic of Cargo Vehicle Trips

<u>Trip Production and Attraction</u>

- For the generation of cargo traffic, the area of General Santos City has the heaviest traffic and the number of traffic indicates about 3,300 vehicle / day, followed by the areas of Cagayan de Oro City and Iligan City. There are major ports which is terminal of cargo trips in these areas.
- Heavier volume of cargo traffic generation can be seen at Kidapawan area and Koronadal which are a capital of provinces.
- The cargo traffic generation is shown in **Figure 8.1.3-3**.

<u>Trip Distribution</u>

- The stronger relationship at north-south axis in the Study area can be seen compared with the passenger trip distribution. This is obvious that average trip length would be longer than that of passenger trips.
- There are heavy demand between Cotabato City and Iligan City and Cagayan de Oro City, and General Santos City.
- These are shown in **Figure 8.1.3-4**.

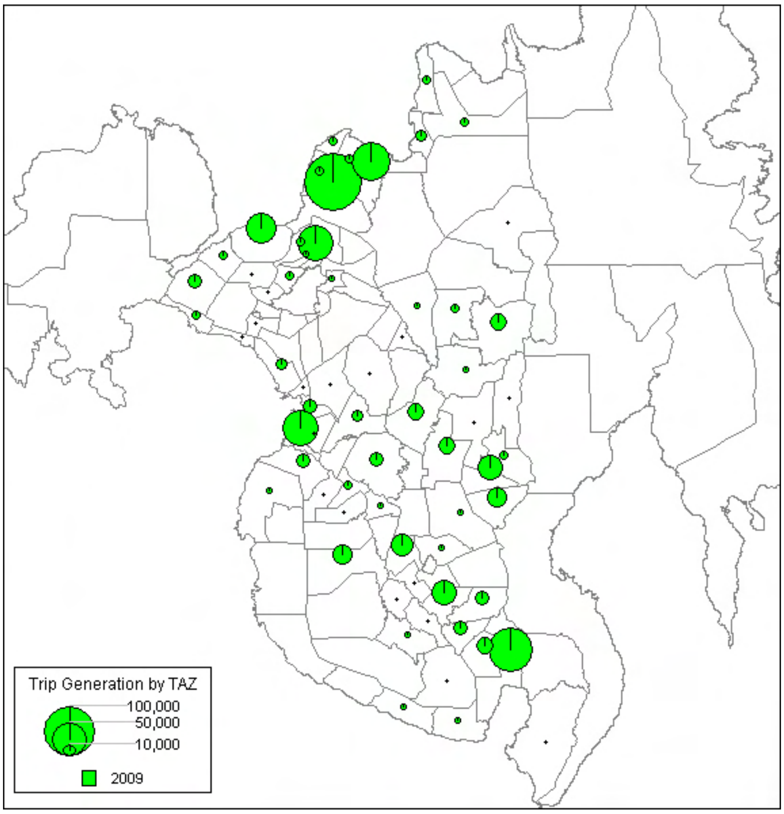


FIGURE 8.1.3-1 PASSENGER TRIP GENERATION (2009)

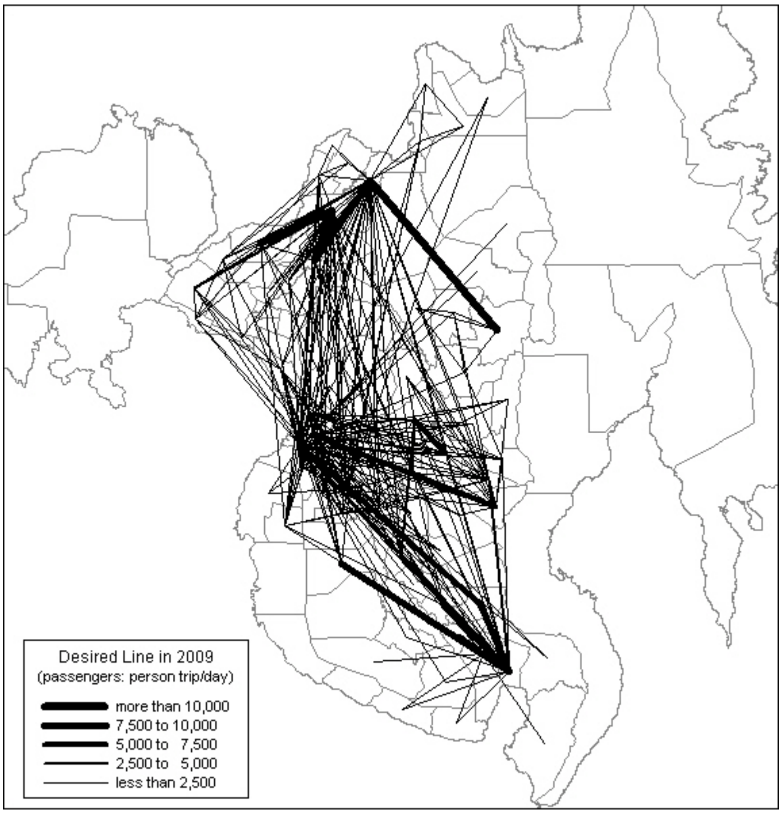


FIGURE 8.1.3-2 PASSENGER TRIP DISTRIBUTION (2009)

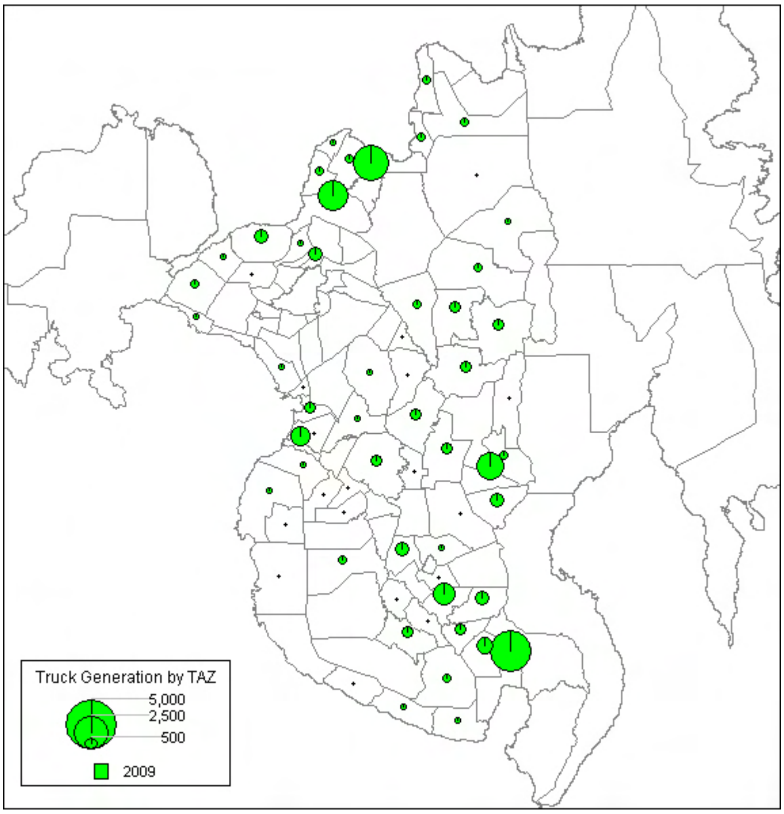


FIGURE 8.1.3-3 CARGO VEHICLE TRIP GENERATION (2009)

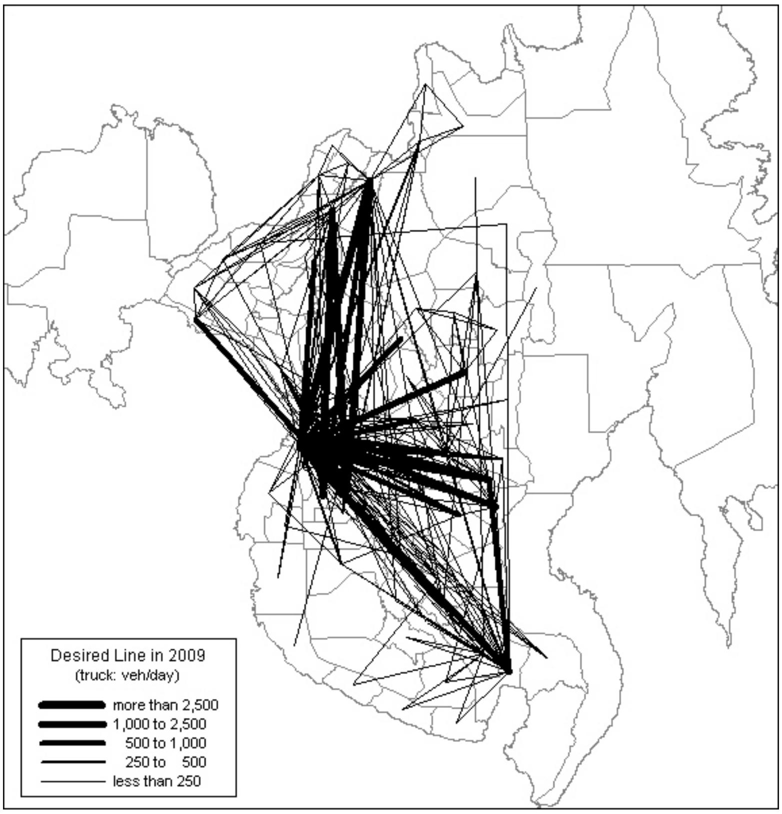


FIGURE 8.1.3-4 CARGO TRIP DISTRIBUTION (2009)

8.2 DEVELOPMENT OF DEMAND FORECAST MODELS

8.2.1 Basic Idea for Development

Basic idea for the development of forecasting models is as follows.

- Basically, forecasting the future traffic demand is done by applying the conventional four-step methodology; namely: trip generation and attraction model, trip distribution model, modal share model, and traffic assignment model.
- However, modal share model is not applied because it is not necessary to consider transferring between modes.
- Trip generation and attraction model, and trip distribution model should be developed for passenger trips and cargo traffic separately. Therefore, two different OD matrices will be estimated for the future.
- The future traffic demand is estimated at three years of 2015, 2020, and 2025.

The model development procedure is shown in the following figure.

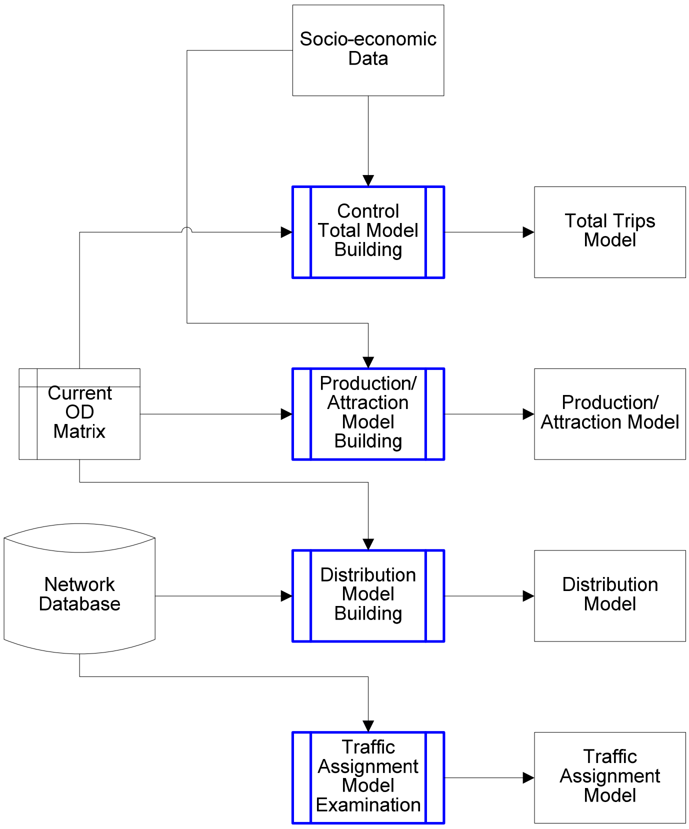


FIGURE 8.2.1-1 MODEL DEVELOPMENT PROCEDURE

8.2.2 Socio-Economic Data for Model Development

To develop trip generation models, population and cultivate area as a socio-economic indicator are prepared. The following describes the way to prepare the indicators by TAZ for the model development.

Population

As the results of CENSUS 2007, population by Province, City, Municipality, and Barangay is provided at Web site by National Statistics Office. The population data for Mindanao Island including the Study area was downloaded and it was aggregated into the traffic analysis zones.

Cultivate area

The cultivate area by type of crops was specified by enclosing with a polygon on GIS software platform. Then the area by type of crops and traffic analysis zone was measured with a function in the GIS software. The type of crops includes rice/corn, coconut, industrial crops, and grasses/shrubs.

The indicators prepared with the above-mentioned method are plotted by traffic analysis zone in **Figures 8.2.2-1** and **8.2.2-2**, and shown in **Table 8.2.2-1**.

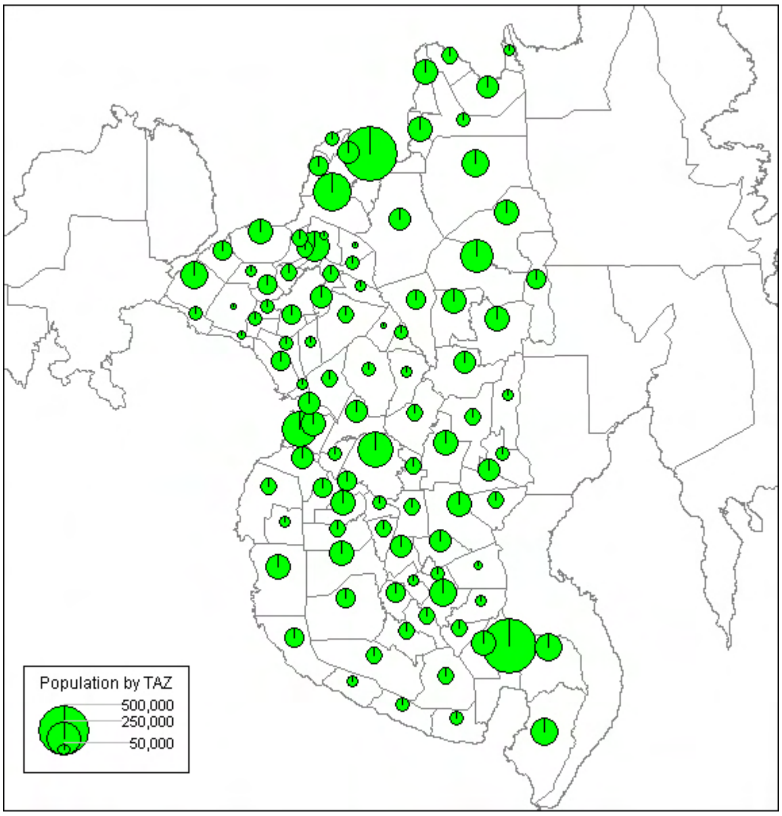


FIGURE 8.2.2-1 POPULATION BY TAZ (2007)

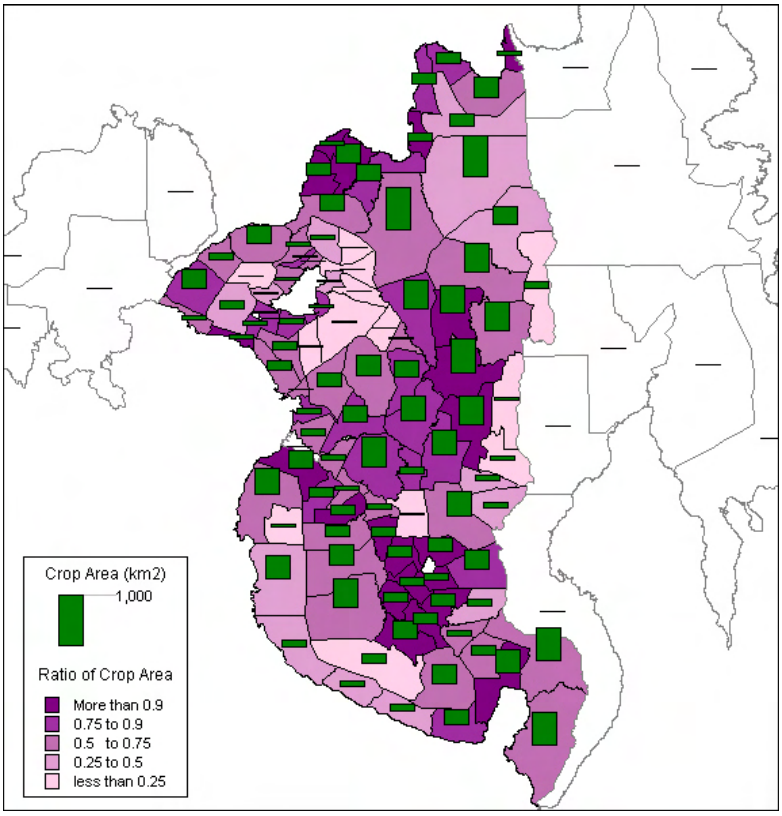


FIGURE 8.2.2-2 CROP AREA BY TAZ (2009)

TABLE 8.2.2-1 SOCIO-ECONOMIC INDICATORS FOR MODEL DEVELOPMENT BY TAZ

TAZ	Population (2007)	Rice/Corn (km2)	Coconut (km2)	Industrial Crops(km2)	Grasses/ Shrubs (km2)
1	259153	0	0	0	0
2	147065	31	52.6	0	77.9
3	102247	3.5	47.1	0	70.1
4	36319	0	35.4	0	2.9
5	64544	30.8	225.4	0	27.8
6	44533	108.7	12.5	0	0
7	103765	39.7	75.9	0	256
8	64413	97.5	73.1	0	363
9	32014	38.6	0	0	39.9
10	95207	25.6	50.2	0	126.1
11	95097	59.6	22.3	0	28.3
12	140147	126.4	11.3	0	80.2
13	66961	155.7	1.7	0	82.4
14	50740	94.9	4.6	0	22.7
15	64047	146	24.6	0	0.1
16	59470	44.4	0	0	19
17	107146	165.4	0	0	116.2
18	103318	161.8	19.4	0	149.6
19	252570	261.4	106.6	0	228
20	52165	87.7	23.2	0	305.2
21	36567	209.3	0	0	133.5
22	65670	235.7	0	0	266.6
23	140195	249.3	12.9	57.5	179.3
24	133480	255.6	73.8	5.3	172.2
25	66025	146.6	58.3	7.3	365.2
26	117610	14.7	84.7	21.2	0
27	71543	30.7	11	0	89.4
28	44114	29.9	34.9	0	30.9
29	38717	22.5	0	0	51.6
30	94043	0	179.8	0	25.4
31	23487	0	84.3	0	8.2
32	40221	2.5	19.4	0	70.3
33	41478	0	135.8	0	45.2
34	38949	8.6	0	0	46.2
35	81556	55.7	6.3	0	60.5
36	43418	17.4	0	0	45.5
37	103377	70.6	0	0	2.3
38	57304	17.8	0	0	31.2
39	13297	15.3	0	0	6.8
40	42186	34.2	0	0	28.3
41	89753	0	0	0	49.4
42	62370	0	0	0	67.9
43	177391	1.7	0	0	31
44	58066	3.7	0	0	41.7
45	63970	20.7	0	0	23.5
46	48573	26.2	0	0	4.9
47	29045	0.8	0	0	6.4
48	18916	59.9	0	0	47.6
49	11144	10.3	0	0	10.2
50	122402	70.4	97.5	0	293

TAZ	Population (2007)	Rice/Corn (km2)	Coconut (km2)	Industrial Crops(km2)	Grasses/ Shrubs (km2)
52	60372	203.4	0	0	0
53	116141	181.8	0	24.3	32.9
54	51640	99.8	0	0	53.1
55	23675	48.9	18.9	0	334.5
56	92301	167.6	0	0	423.9
57	77105	29.2	126	0	11.7
58	82470	172.7	0	0	47.4
59	35825	137.9	0	0	45.4
60	71513	233.8	0	0	125.3
61	73355	119.2	0	0	108.4
62	149621	181.5	0	0	79.9
63	34245	39.6	0	0	128.8
64	60401	102.1	3.7	0	105
65	70609	47.1	0	0	344.6
66	57779	111.7	0	0	23.7
67	131436	115.6	28.7	0	77.3
68	529542	109.6	38.5	0	322.1
69	167865	214.8	4.8	0	437.8
70	37054	28.7	60.2	0	50
71	53040	17	82.9	0	47.3
72	49274	30.2	36.8	0	244.2
73	168281	181.9	68.4	0	410.8
74	46004	19.6	25	0	59.3
75	169372	143.1	138.4	0	104.9
76	13999	0	39.5	0	143.1
77	81699	0	154.1	0	4.6
78	29945	0	0	0	36
79	127904	15.5	198.2	0	143.4
80	69360	57.4	18.3	0	38.3
81	308046	0	52.4	0	280.7
82	89918	0	100.3	0	163.3
83	45381	31.3	55.2	0	28.8
84	114152	23	97.5	0	262.6
85	553966	32.7	82.6	0	232.9
86	131124	0	49.8	0	123.1
87	43514	0	7.8	0	246.5
88	125361	5.6	129.3	0	111.9
89	58347	0	126.6	0	100.1
90	112247	1.1	296.9	0	133.9
91	28747	7.2	61.5	0	40.7
92	118743	127.7	2.3	0	715.3
93	165034	94.5	26.5	0	704
94	144065	155.5	0	0	212.5
95	214151	267.5	0	97.6	224.8
96	83246	263.9	0	6.5	319.6
97	146517	125.2	0	235.3	187.4
98	133331	104	0	160.5	304.4
99	77412	21.9	0	0	136.9
100	107785	273	0	10.9	405

8.2.3 Model Description

1) Total Trip Model

Trip production model is to estimate the future total number of person trips generated in the study area per day. There are three typical models commonly used:

- Trip rate model
- Growth rate model
- Functional model

In this Study, Growth rate model was applied for both passenger trips and cargo vehicle trips as follows:

<u>Passenger Trips</u>

$$G_p^t = G_p^{t-1} \times \alpha^t$$

Where, G_p^t : the number of passenger trips in the year of t

α^t : yearly growth rate in the period between the year of t – 1 and t (growth rate of GRDP per capita is employed.)

<u>Cargo Vehicle Trips</u>

$$G_c^t = G_c^{t-1} \times \beta^t$$

Where, G_c^t : the number of cargo vehicle trips in the year of t

β^t : yearly growth rate in the period between the year of t – 1 and t (growth rate of GRDP is employed.)

2) Trip Generation Model

Trip generation and attraction model is to estimate the number of trips generated from and attracted to each zone. This would have, generally, a close relationship with socioeconomic indicators such as population.

<u>Passenger Trips</u>

$$P_i = 53.21 \cdot x_i + 45570 \cdot D_i \quad (r^2=0.84)$$

Where, P_i : Passengers trip production of TAZ i

x_i : Population (1,000) of TAZ i

D_i : Dummy variable (=0, or 1) for TAZ i

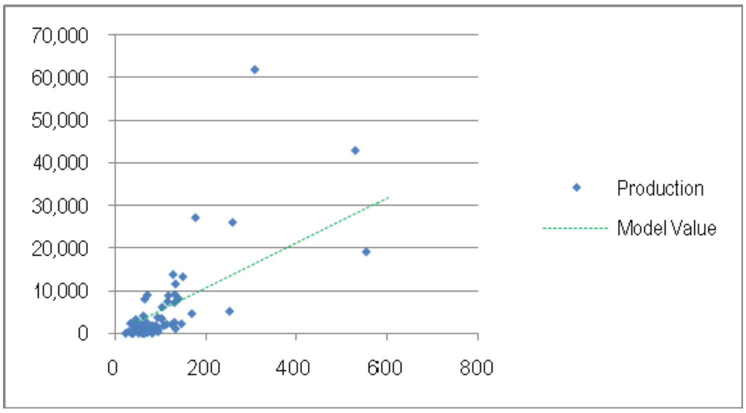


FIGURE 8.2.3-1 PASSENGER TRIP PRODUCTION AND POPULATION

$$A_j = 58.06 \cdot x_j + 38113 \cdot D_j \quad (r^2=0.82)$$

Where, A_j : Passengers trip attraction of TAZ j

x_j : Population (1,000) of TAZ j

D_j : Dummy variable (=0, or 1) for TAZ j

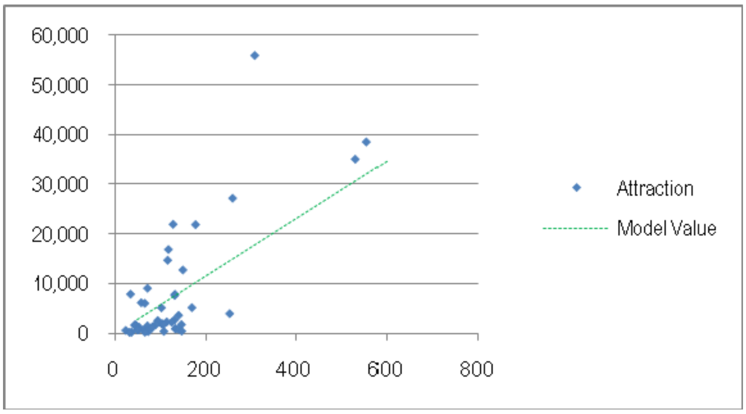


FIGURE 8.2.3-2 PASSENGER TRIP ATTRACTION AND POPULATION

Cargo Vehicle Trips

$$P_i = 2.412 \cdot x_i + 0.334 \cdot C_i - 68.0 \quad (r^2=0.84)$$

Where, P_i : Cargo vehicle trip production of TAZ i

x_i : Population (1,000) of TAZ i

C_i : Crop area (km^2) of TAZ i

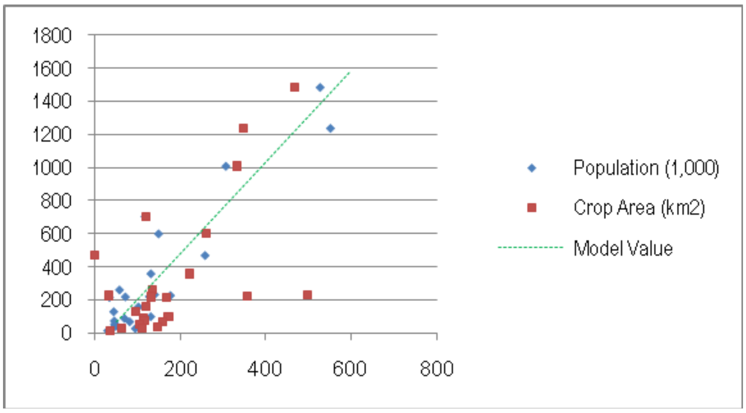


FIGURE 8.2.3-3 CARGO VEHICLE TRIP PRODUCTION AND SE INDICATORS

$$A_j = 2.606 \cdot x_j + 0.766 \cdot C_j - 172.4 \; (r^2=0.83)$$

Where, A_j : Cargo vehicle trip attraction of TAZ j

x_j : Population (1,000) of TAZ j

C_j : Crop area (km^2) of TAZ j

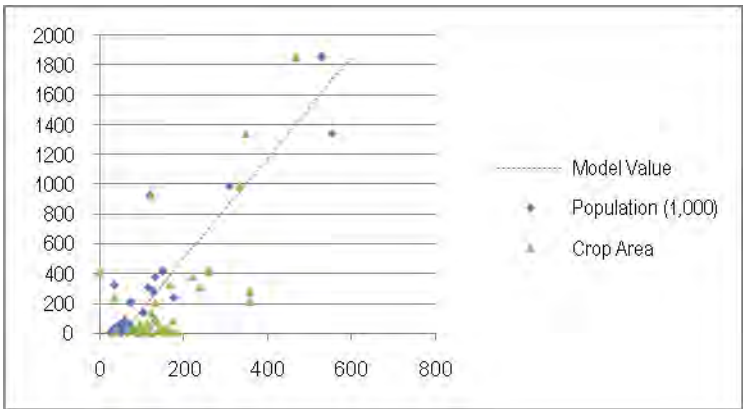


FIGURE 8.2.3-4 CARGO VEHICLE TRIP ATTRACTION AND SE INDICATORS

TABLE 8.2.3-1 PORT-RELATED TRAFFIC

Port	Volume Handled (1,000t/year)	Cargo Traffic Counted
General Santos	2,693.3	1,040
Iligan	319.9	945
Cagayan de Oro	4,264.2	4,392
Davao	4,160.0	3,773
Polloc	235.9	143

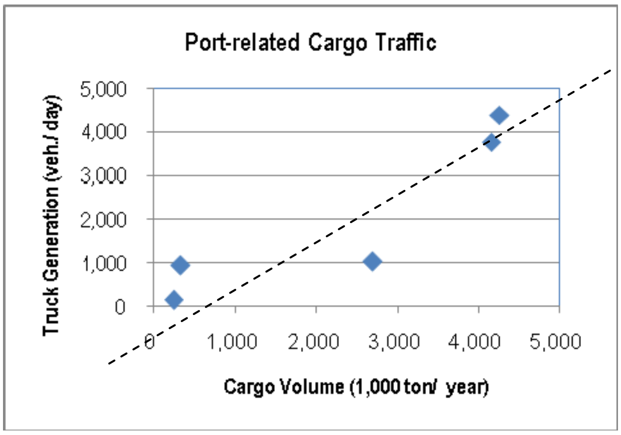


FIGURE 8.2.3-5 CARGO VEHICLE TRIP GENERATION AT PORT

3) Trip Distribution Model

Trip distribution model is to estimate the number of distributed trips by the combination of origin and destination (OD) zones, i.e., OD matrices, based on the trip generation and attraction by zone, which is described in the previous section.

The most widely used model for trip distribution is a Gravity model, which aims to estimate travel demand based on the relationship between trip production, trip attraction, and impedance function between zones such as a travel distance. This analysis resulted in the following formulas as a trip distribution model.

Passenger Trips

$$T_{ij} = 0.0525 \cdot \frac{P_i^{0.6156} \cdot A_j^{0.7660}}{D_{ij}^{0.7080}} \qquad (r^2=0.78)$$

Where, T_{ij} : Passenger trip distribution between TAZ i and j

P_i : Passenger trip production of TAZ i

A_j : Passenger trip attraction of TAZ j

D_{ij} : Travel distance between TAZ i and j

Cargo Vehicle Trips

$$T_{ij} = 0.1101 \cdot \frac{P_i^{0.5382} \cdot A_j^{0.5683}}{D_{ij}^{0.1220}} \qquad (r^2=0.75)$$

Where, T_{ij} : Cargo vehicle trip distribution between TAZ i and j

P_i : Cargo vehicle trip production of TAZ i

A_j : Cargo vehicle trip attraction of TAZ j

D_{ij} : Travel distance between TAZ i and j

Calibration of the Gravity model is accomplished by developing adjustment factors. The adjustment factors can be determined by comparing model output and observed data. The model formula is shown as follows.

$$T_{ij} = G_i \frac{A_j K_{ij} D_{ij}}{\sum_l A_{il} K_{il} D_{il}}$$

Where, Kij: Adjustment factor between existing and model value for the zone pair of i and j

The output of a distribution model is a set of elements that show the travel flow between each pair of zones. However, the row totals of distribution elements do not match with trip productions and the column totals of distribution elements do not match with trip attractions. Therefore, an iteration is done until satisfied that the totals match trip productions and attractions.

4) Assignment Model

JICA STRADA, which was developed by JICA, is used for traffic assignment simulation. This system provides two major types of highway assignment model, namely, incremental assignment and user equilibrium assignment.

The incremental assignment divides the input OD matrix data into several increments and assigns each increment to the minimum route where the generalized cost is the least. Once the increments are assigned, link cost of each link is calculated and the minimum route is found again for the next increments.

The user equilibrium assignment uses Wardrop's equal travel time principle for traffic assignment. This model can be expressed by the mathematical problem of optimization as follows.

$$\min . Z_p = \sum_a \int_0^{x_a} t_a(w)dw$$

subject to

$$\sum_k f_k^{rs} - Q_{rs} = 0$$

$$x_a = \sum_k \sum_{rs} \delta_{a,k}^{rs} f_k^{rs}$$

$$f_k^{rs} \geq 0$$

Where, f_k^{rs} : Traffic flow on the route k between the OD pair rs

Q_{rs} : OD trips between the OD pair rs

$t_a(x_a)$: Link cost function of the link a

x_a : Traffic flow on the link a

$\delta_{a,k}^{rs}$: dummy variable, which is [1] when the route k between the OD pair rs contains the link a, or [0] when the route does not.

For this Study, the user equilibrium model is applied.

8.3 DEVELOPMENT OF NETWORK DATABASE

8.3.1 General

This chapter presents detail regarding development of the future and base year highway network within the overall framework of the transport modeling process.

- The "beginning point" of network development is detailed study of mapping provided as a base map for tracing and overlapping.
- The Study team discussed the network hierarchy in terms of functional class and selected necessary links to be evaluated for the master plan network.
- Conversion of road information into GIS network files by the Study Team.
- Existing road surface situation was observed. Missing links were found and each road section was ranked by four levels of road condition.
- An existing network was produced by erasing missing links and adding existing road condition on the master plan network.

The network derivation process is shown in the following figure.

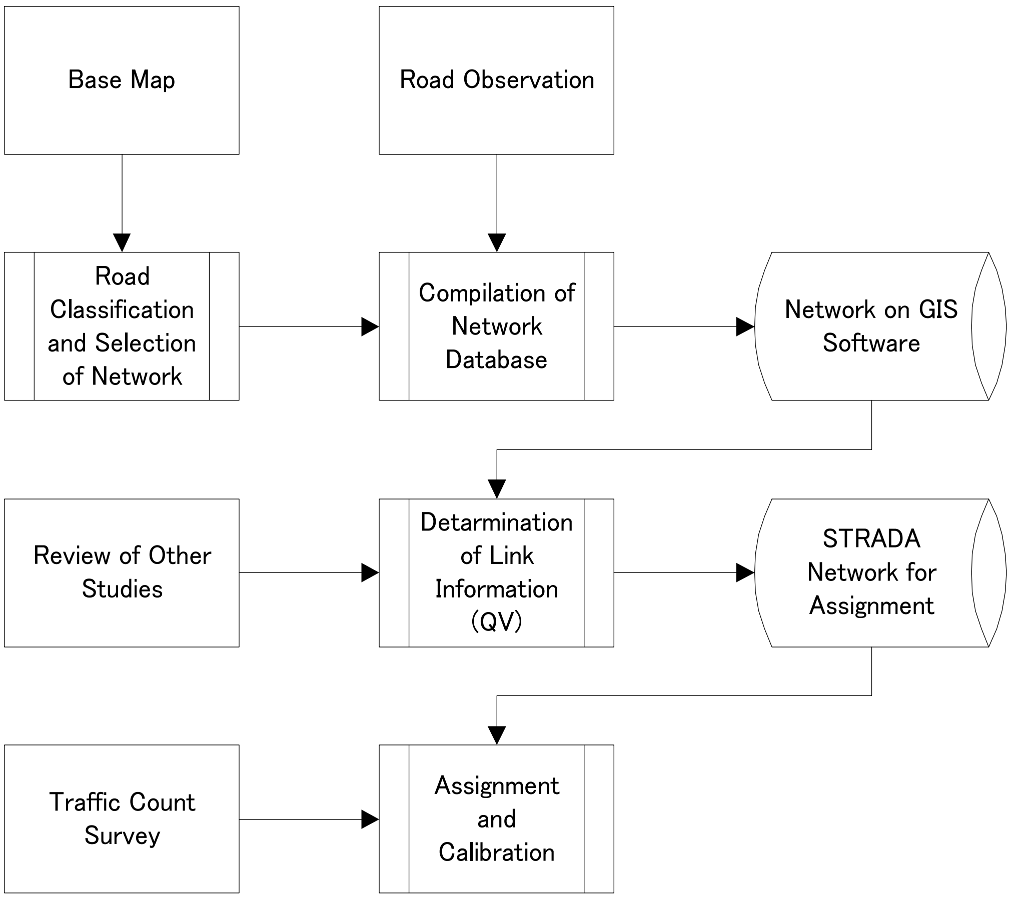


FIGURE 8.3.1-1 NETWORK DEVELOPMENT PROCESS

8.3.2 Future Network

1) Road Classification

Figure 4.2-1 shows the functional class defined by DPWH. This classification includes four classes: East-West Lateral road, North-South Backbone road, other road of strategic importance, and secondary road.

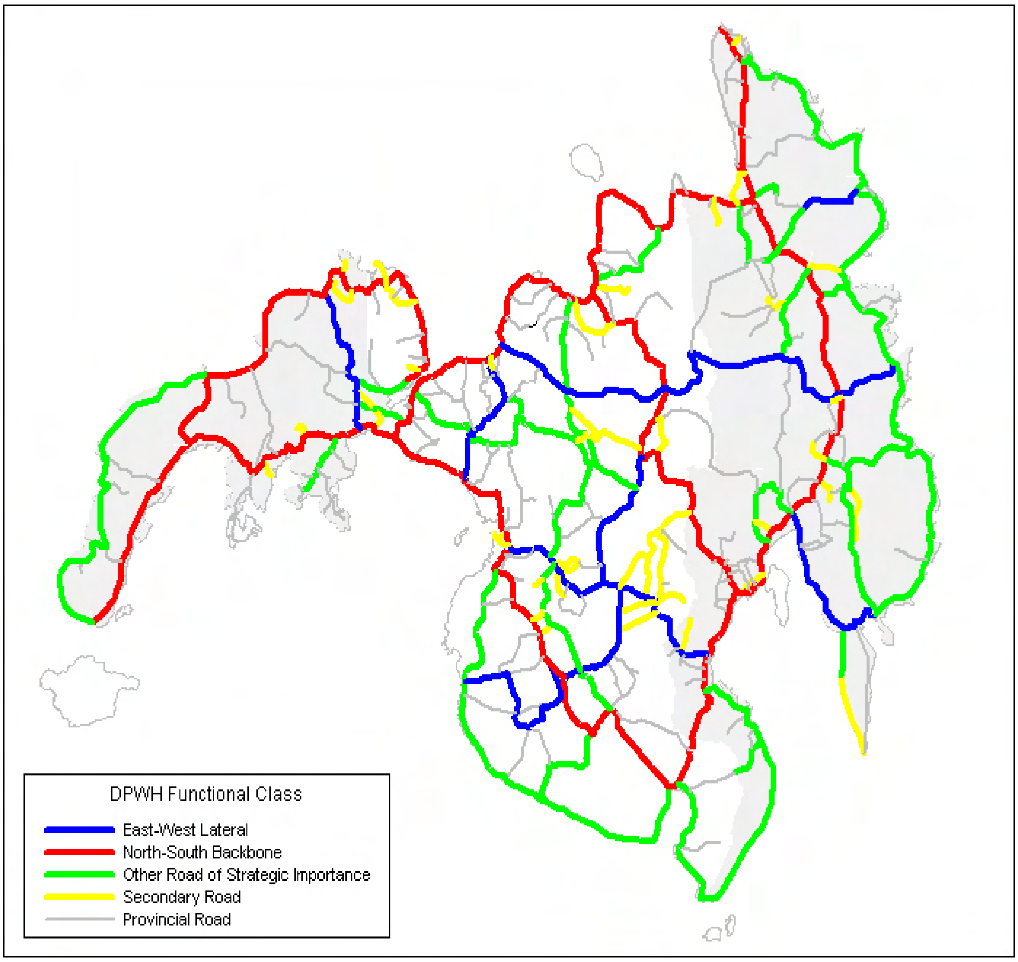


FIGURE 8.3.2-1 DPWH FUNCTIONAL CLASS

On the other hand, the Study team discussed and proposed other concept of road classification. The concept is simplified based on the DPWH functional class and consists of three categories: primary inter-city road, regional primary road, and regional secondary road. The proposed Master plan network is exhibited in **Figure 8.3.2-2**.

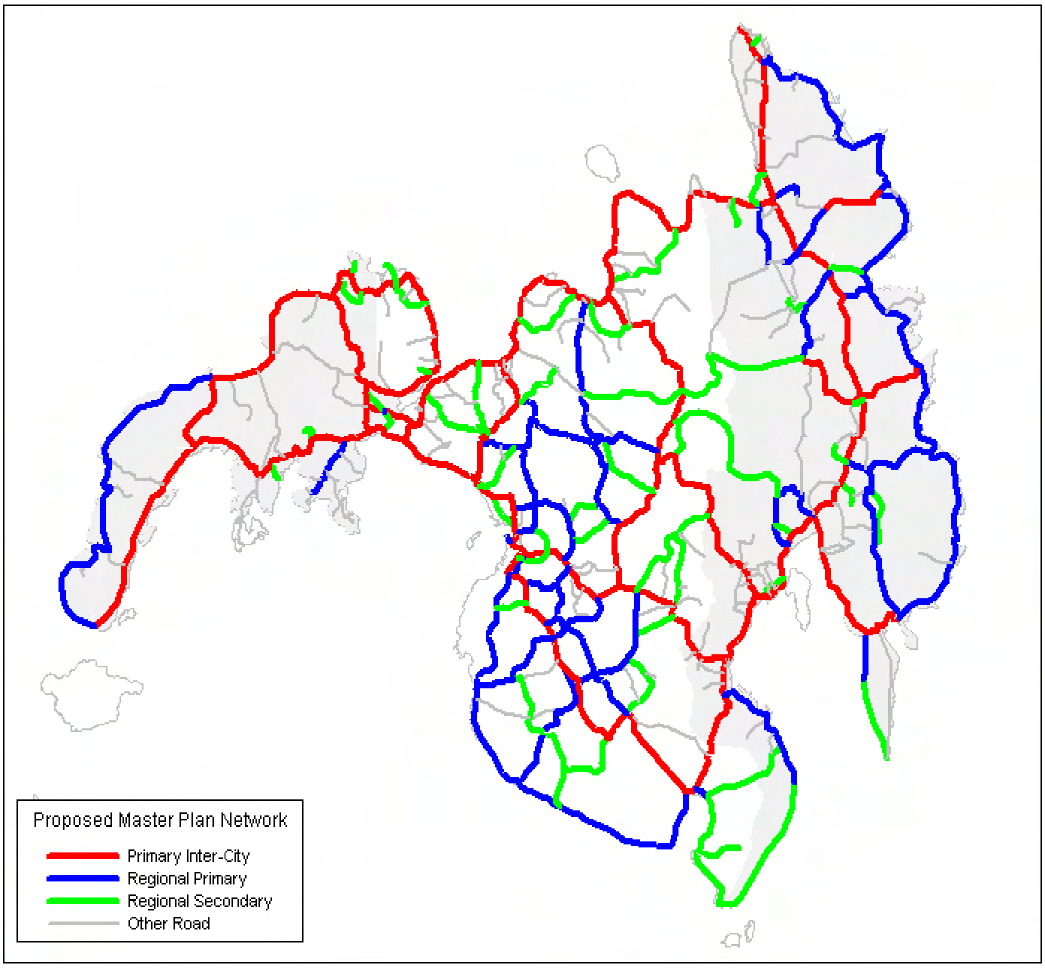


FIGURE 8.3.2-2 PROPOSED MASTER PLAN NETWORK

2) Definition of QV

Trip assignment is the procedure by which the minimum paths are searched and travel demand between each zone pair are loaded on the minimum paths. For searching the minimum paths, each link in the highway network should prepare link information such as travel speed and the relationship between travel speed and traffic volume. The Study team established these link information according road class as shown in **Table 8.3.2-1**.

TABLE 8.3.2-1 QV TABLE

Pavement	Road Class	No. of Lanes	Capacity (pcu/day)	Maximum Speed (km/h)
Paved	Primary Inter-City Road	2	19,000	70
	Regional Primary Road	2	18,000	60
	Regional Secondary Road	2	14,000	50
	Other Road	2	12,800	40
Unpaved (for Existing)		2	6,400	20

8.3.3 Existing Network

As mentioned in the earlier section, an existing network is produced by erasing missing links and updating link information in order to represent existing road surface condition on the Master plan network.

The location of missing links is shown in **Figure 8.3.3-1**, and observed road surface condition is displayed in **Figure 8.3.3-2**.

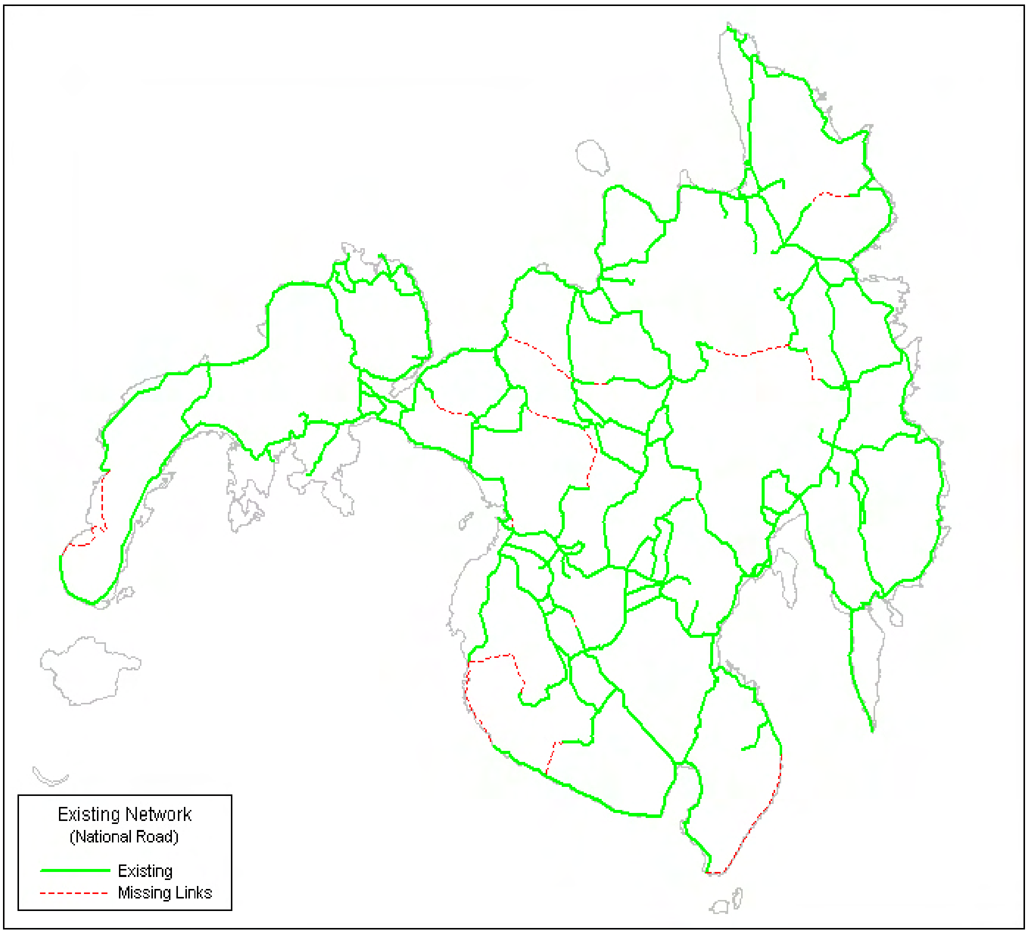


FIGURE 8.3.3-1 MISSING LINKS

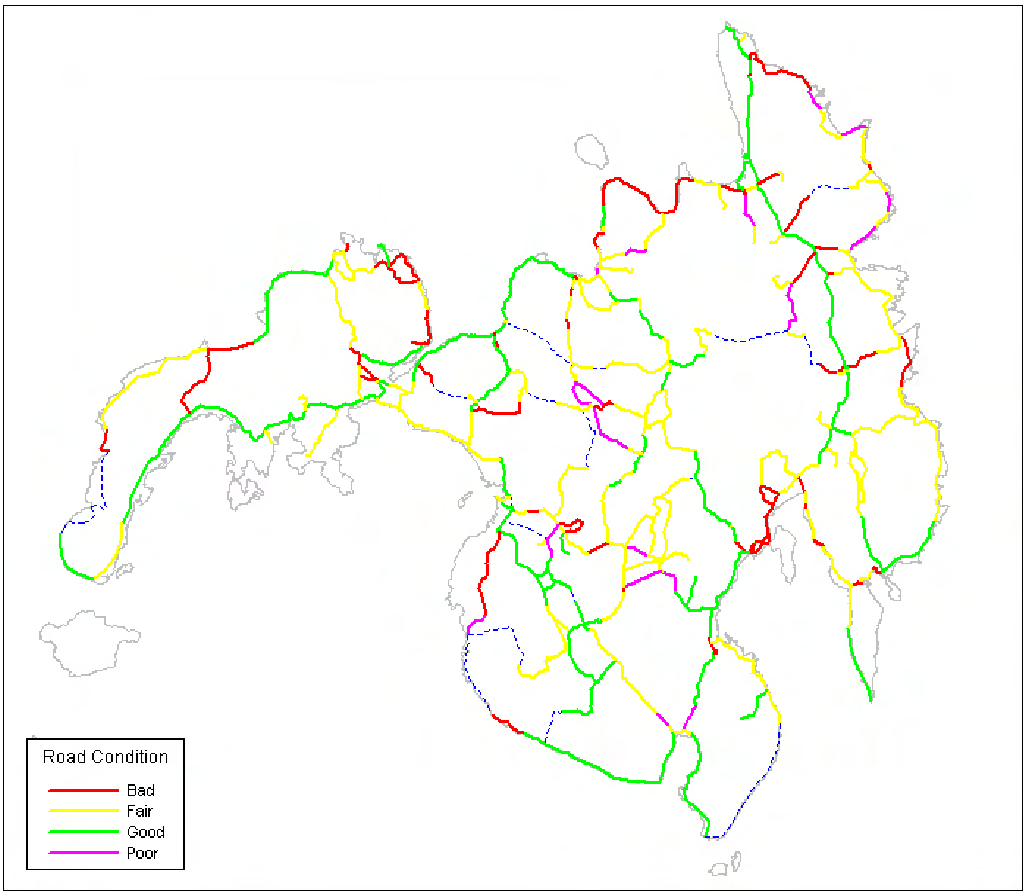


FIGURE 8.3.3-2 ROAD SURFACE CONDITION

8.4 FUTURE FRAMEWORK FOR FORECASTING

This chapter summarizes the future framework to be used for forecasting future demand. The future framework includes population and GRDP. The population is applied to estimate the future trip production and attraction for both passenger trips and cargo vehicle trips. GRDP and GRDP per capita are used to estimate the total number of trips in the Study area.

8.4.1 Assumption of Future Framework

Table 8.4.1-1 shows the future population by province for the years of 2015, 2020, and 2025, estimated by the Study team.

The population of the Study area is 11.3 million in 2007, and is estimated to be about 2.1 times at 16.8 million in 2025, while the population of ARMM is 4.1 million in 2007, and becomes at 6.2 million.

TABLE 8.4.1-1 FUTURE POPULATION OF STUDY AREA

Region / Province	2007	2015		2020		2025	
	Population	Estimated	Yearly Growth (%)	Estimated	Yearly Growth (%)	Estimated	Yearly Growth (%)
ARMM	*4,120,795*	*5,022,700*	*2.50*	*5,625,500*	*2.29*	*6,235,400*	*2.08*
Basilan	408,520	501,400	2.59	539,900	1.49	598,400	2.08
Lanao del Sur	1,138,544	1,338,300	2.04	1,468,300	1.87	1,627,500	2.08
Maguindanao	710,829	946,200	3.64	1,098,500	3.03	1,217,600	2.08
Shariff Kabunsuan	562,886	699,900	2.76	778,500	2.15	862,900	2.08
Sulu	849,670	970,700	1.68	1,055,500	1.69	1,169,900	2.08
Tawi-Tawi	450,346	566,200	2.90	684,800	3.88	759,100	2.08
Region X (Study Area only)	*3,339,464*	*3,968,300*	*2.18*	*4,409,300*	*2.13*	*4,887,400*	*2.08*
Bukidnon	1,190,284	1,430,400	2.32	1,623,000	2.56	1,799,000	2.08
Lanao del Norte	846,329	966,500	1.67	1,033,100	1.34	1,145,100	2.08
Misamis Oriental	1,302,851	1,571,400	2.37	1,753,200	2.21	1,943,300	2.08
Region XII	*3,829,081*	*4,589,400*	*2.29*	*5,113,300*	*2.19*	*5,667,700*	*2.08*
North Cotabato	1,121,974	1,310,100	1.96	1,432,600	1.80	1,587,900	2.08
Sarangani	475,514	554,900	1.95	610,900	1.94	677,200	2.08
South Cotabato	1,296,796	1,574,500	2.46	1,801,300	2.73	1,996,600	2.08
Sultan Kudarat	675,644	788,500	1.95	871,500	2.02	966,000	2.08
Cotabato City	259,153	361,400	4.24	397,000	1.90	440,000	2.08
Study Area Total	*11,289,340*	*13,580,400*	*2.34*	*15,148,100*	*2.21*	*16,790,500*	*2.08*

Table 8.4.1-2 summarizes the growth of the future GRDP, which is assumed by the Study team for the years of 2010, 2015, 2020, and 2025.

TABLE 8.4.1-2 FUTURE GRDP FOR THE STUDY AREA

Region	2007	2010		2015	2015	2020	2020	2025	2025
	GRDP	Estimated	Yearly Growth (%)	Estimated	Yearly Growth (%)	Estimated	Yearly Growth (%)	Estimated	Yearly Growth (%)
ARMM	*55,883*	*63,858*	*4.5*	*78,854*	*4.3*	*98,633*	*4.6*	*124,702*	*4.8*
Agriculture	26,315	30,116	4.6	37,351	4.4	46,769	4.6	59,124	4.8
Industry	8,320	9,909	6.0	12,647	5.0	16,925	6.0	22,863	6.2
Service	21,248	23,832	3.9	28,856	3.9	34,940	3.9	42,714	4.1
Region X	*310,185*	*373,152*	*6.4*	*504,065*	*6.2*	*672,146*	*5.9*	*892,969*	*5.8*
Agriculture	81,478	93,247	4.6	116,760	4.6	144,809	4.4	177,883	4.2
Industry	102,686	125,091	6.8	172,191	6.6	232,613	6.2	311,288	6.0
Service	126,021	154,814	7.1	215,113	6.8	294,724	6.5	403,798	6.5
Region XII	*220,321*	*255,266*	*5.0*	*323,350*	*4.8*	*413,375*	*5.0*	*526,503*	*5.0*
Agriculture	86,944	102,093	5.5	129,063	4.8	168,681	5.5	215,284	5.0
Industry	72,432	82,420	4.4	105,693	5.1	131,084	4.4	164,137	4.6
Service	60,945	70,753	5.1	88,594	4.6	113,610	5.1	147,082	5.3
Study Area Total	*586,389*	*692,276*	*5.7*	*906,269*	*5.5*	*1,184,154*	*5.5*	*1,544,174*	*5.5*

GRDP is an indicator which depicts a degree of economic activities in certain area. GRDP yearly growth rate is enough higher than the yearly growth rate of population. The growth of GRDP in Region X is relatively higher than the rest of the Study area, ARMM and Region XII, based on the assumption made by the Study team.

8.4.2 Zonal Indicators

The future passenger and cargo vehicle trip generation can be estimated by inputting the population and crop area in the trip generation models. The trip generation is estimated for each TAZ so that input data should be prepared for each TAZ.

Population

The framework for the population in each province discussed in the previous section is broken down into TAZ in proportion with the ratio of existing population in TAZ to the population of a province. This is based on an idea that the urban structure in a province does not drastically change in the future.

Crop Area

The framework for crop area is not analyzed so that the same way to break down cannot be applied as applied for population. The future crop area is estimated by applying the following formula.

$$A_i^t = A_i^{t-1} \times (1 + r)$$

Where, A_i^t : crop area of zone i in the year of t (km^2)

r : yearly growth rate of GRDP in the period between the year of t – 1 and t

The zonal indicators for forecasting the future trip generation are estimated for only the Study area including ARMM, Region X, and Region XII. The trip generation outside the Study area is estimated by multiplying the growth rate of population with the existing trip generation for passenger trips and by multiplying the growth rate of GRDP with the existing cargo vehicle trip generation for cargo trips.

8.5 FUTURE DEMAND FORECASTING

The forecast results of the travel demand are presented in this section. While the previous chapter explains the outline of the forecast models, this chapter describes the demand forecast results at each step.

8.5.1 Total Number of Trips Produced

The first step of forecasting procedure is to estimate the number of total trip generated in the Study area. As shown in **Table 8.5.1-1**, the total number of passenger trips is estimated at 589.5 thousand and that of cargo vehicle trips at

25.2 thousand in 2025. This estimation was done by multiplying a growth rate with the total number of trips in 2009.

TABLE 8.5.1-1 TOTAL TRIP GENERATION IN THE FUTURE

Year	Passenger (person trips)	Yearly Growth Rate (%)	Cargo (vehicle trips)	Yearly Growth Rate (%)
2009	354,500		10,700	
2010	365,800	3.18	11,300	5.69
2015	427,800	3.18	14,800	5.59
2020	501,100	3.21	19,300	5.49
2025	589,500	3.30	25,200	5.45

8.5.2 Trip Generation by TAZ

Next, the trip production and attraction of each traffic analysis zone (TAZ) are calculated by using the models described in the previous chapter, and the above total number of trip generation is distributed into each TAZ, in proportion with the model value for the trip production and attraction.

Figure 8.5.2-1 shows the increase of population by TAZ, which affect the increase of trip production and attraction. **Figures 8.5.2-2** and **8.5.2-3** display the future passenger trip generation in 2025, which is the sum of trip production and attraction, and the future cargo vehicle trip generation in 2025, respectively.

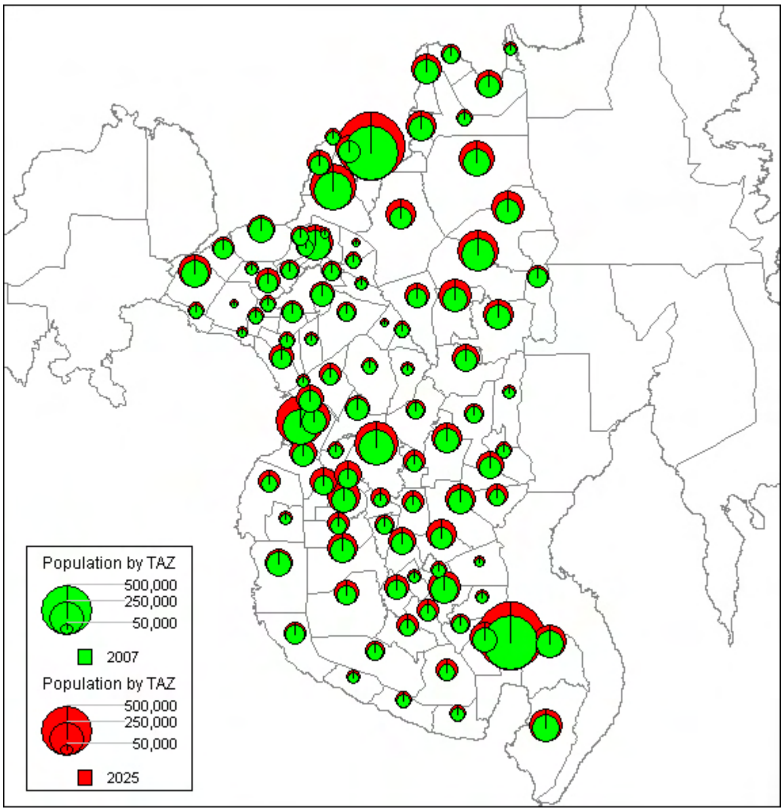


FIGURE 8.5.2-1 INCREASE OF POPULATION

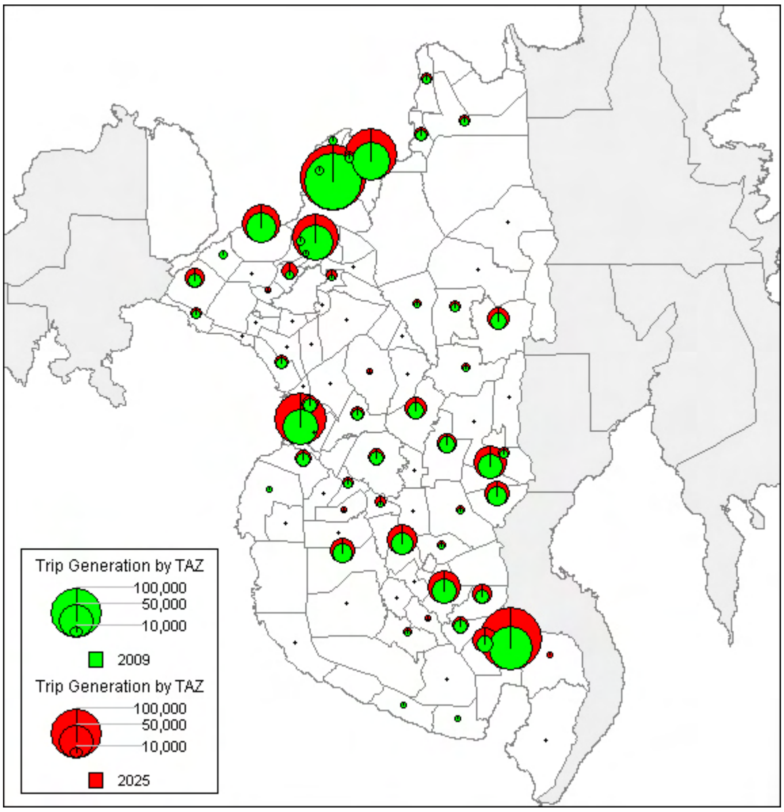


FIGURE 8.5.2-2 FUTURE PASSENGER TRIP GENERATION IN 2025

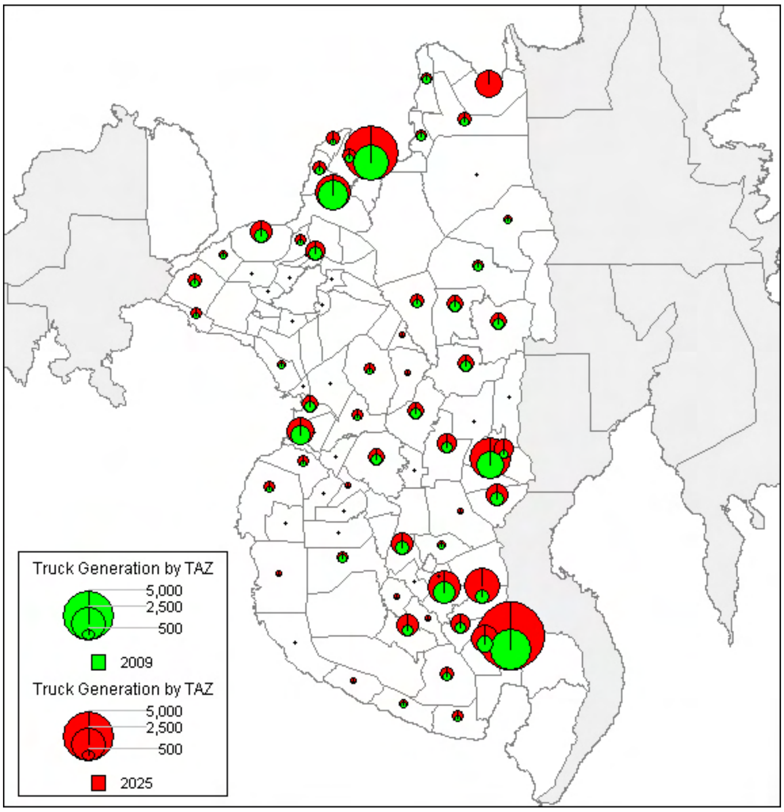


FIGURE 8.5.2-3 FUTURE CARGO VEHICLE TRIP GENERATION IN 2025

8.5.3 Trip Distribution

The trip production and attraction distributed to each TAZ are next distributed into the elements of the OD matrix by using the trip distribution model.

Figures 8.5.3-1 and **8.5.3-2** are plots of 'Desire Lines', the width of its lines precisely corresponds to the travel demand between a pair of two TAZ. It seems that the travel demand becomes larger and their destination, or origin, spreads in all direction in the Study area in the future, compared with the 'Desire Lines' for the existing travel demand described in **Figures 8.1.3-2** and **8.1.3-4**.

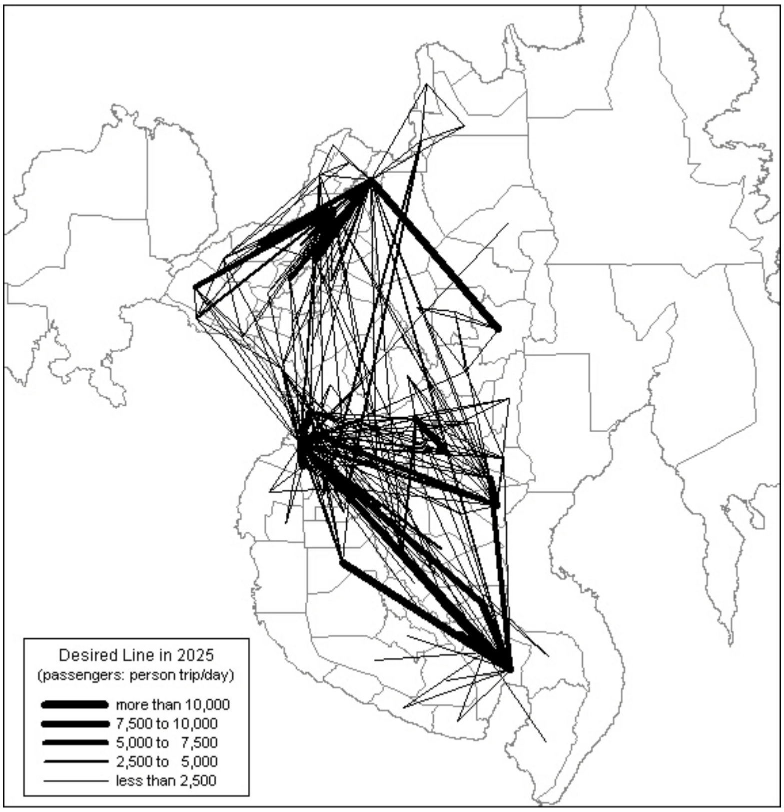


FIGURE 8.5.3-1 PASSENGER TRIP DISTRIBUTION IN 2025

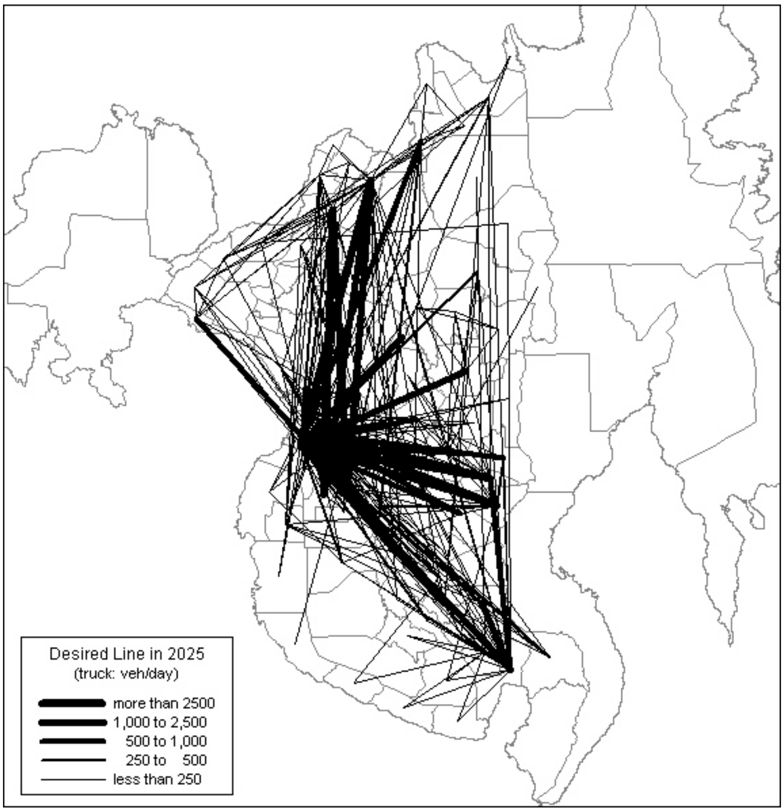


FIGURE 8.5.3-2 CARGO VEHICLE TRIP DISTRIBUTION IN 2025

8.5.4 Traffic Assignment

1) Assignment Cases

Traffic volume by road section in the future can be estimated by traffic assignment model. Traffic assignment model searches the minimum paths in a network and assigns an OD demand between a pair of traffic zones on the minimum paths. That is, the calculation requires a network and an OD matrix as an input data.

The cases of calculation analyzed in this section are described in **Table 8.5.4-1**.

- Existing Case
  assigns the existing OD matrix on the existing highway network. This will be the basis with that the change of other alternatives can be evaluated.

- Do Nothing Case
  assigns the future OD matrix on the existing highway network. This is an imaginary case, which can realize direct implications about the necessity of road construction and improvement to meet the future demand.

- Master Plan Case
  assigns the future OD matrix on the future highway network (Master Plan network). This can check whether the master plan network meets the future travel demand and whether the mobility benefits of road users are maintained in the future.

TABLE 8.5.4-1 FORECASTING CASE

Case	Travel Demand	Network
Existing Case	2009 OD	Existing Network
Do Nothing Case	2025 OD	Existing Network
Master Plan Case	2025 OD	Proposed Master Plan Network

2) Assignment Model

For traffic assignment, ‘User Equilibrium Assignment’ model is employed in this Study. ‘Incremental Assignment’ model searches the minimum paths and load OD demand on the paths. Therefore, final result of this model would sometimes cause the concentration of traffic on major roads beyond a reasonable number. On the other hand, ‘User Equilibrium Assignment’ model can provide results under equilibrium conditions that the total travel cost (all trips) is logically minimized. As a consequence, all routes between any origin-destination pair have equal and minimum costs.

3) Impact of Master Plan Network

Before the assigned traffic volume of each link is analyzed, an impact of the Road Improvement Master Plan is measured by comparing network performance indicators of ‘Do Nothing Case’ and ‘Master Plan Case’.

Table 8.5.4-2 summarizes the network performance indicators by traffic assignment case. The performance indicators of highway network include daily travel distance (pcu-km), daily travel time (pcu-hour), average travel speed, and average congestion (Demand Capacity Ratio). The following formulas describe the definition of each indicator.

Total travel distance: $TTD = \sum_k V_k \cdot l_k$

Total travel time: $TTT = \sum_k V_k \cdot \frac{l_k}{s_k}$

Total capacity distance: $TCD = \sum_k Q_k \cdot l_k$

Average travel speed: $ATS = \frac{TTD}{TTT}$

Demand capacity ratio: $DCR = \frac{TTD}{TCD}$

Where, V_k : assigned traffic volume on link k

l_k : length of link k

s_k : average travel speed of assigned traffic on link k

Q_k : capacity of link k in terms of pcu

The impact of Road Improvement Master Plan can be summarized as follows:

- Total travel distance of ‘Master Plan Case’ indicates 22.0, which is 2.8 times longer than that of existing.
- Total travel time of ‘Master Plan Case’ becomes 2.2 times longer than that of existing.
- The total travel distance of ‘Master Plan Case’ indicates 22.0 million pcu*km. By comparing this value with that of ‘Do Nothing Case’, travel distance is shortened by 7%. This implicates that 7% of wasteful detour travel may be improved.
- The impact on the improvement of travel time is more remarkable than travel distance. It would be improved by 23% (330.6 thousand for ‘Master Plan Case’ and 429.6 thousand for ‘Do Nothing Case’)
- Average travel speed indicates the improvement of about 20%.

TABLE 8.5.4-2 NETWORK PERFORMANCE BY CASE

Indicators	Existing Case	Do Nothing Case	Master Plan Case
Total Travel Distance (1,000km*pcu)	8,031.0	23,711.5	22,021.2
Total Travel Time (1,000hrs*pcu)	147.2	429.6	330.6
Total Capacity Distance (1,000km*pcu)	151,841.5	151,841.5	173,345.0
Average Travel Speed (km/h)	54.6	55.2	66.6
Demand Capacity Ratio	0.05	0.16	0.13

Table 8.5.4-3 shows the comparison of average travel time among Cotabato City, Cagayan de Oro City, and General Santos City.

- Average travel time between Cotabato City and General Santos City may worsen by 38% in 2025 if any development plan is carried out ('Do Nothing Case').
- On the other hand, if Master Plan is introduced, average travel time between Cotabato City and General Santos City is improved by 59%, which means travel time becomes a half.
- In the case of average travel time between Cotabato City and Cagayan de Oro City, 'Do Nothing Case' indicates 13.8% and it will be improved by 37% for 'Master Plan Case'.

TABLE 8.5.4-3 AVERAGE TRAVEL TIME BETWEEN MAJOR CITIES

	Cotabato - General Santos		Cotabato - Cagayan de Oro		General Santos - Cagayan de Oro	
	Average Travel Time (hour)	Ratio (%)	Average Travel Time (hour)	Ratio (%)	Average Travel Time (hour)	Ratio (%)
Existing Case	4.77		6.23		8.98	
Do Nothing Case	6.59	38.2	7.09	13.8	11.48	27.8
Master Plan Case	3.76	-59.3	4.77	-37.2	7.34	-46.1

The result of traffic assignment for 'Do Nothing Case' and 'Master Plan Case' are illustrated in **Figures 8.5.4-1** and **8.5.4-2**, respectively.

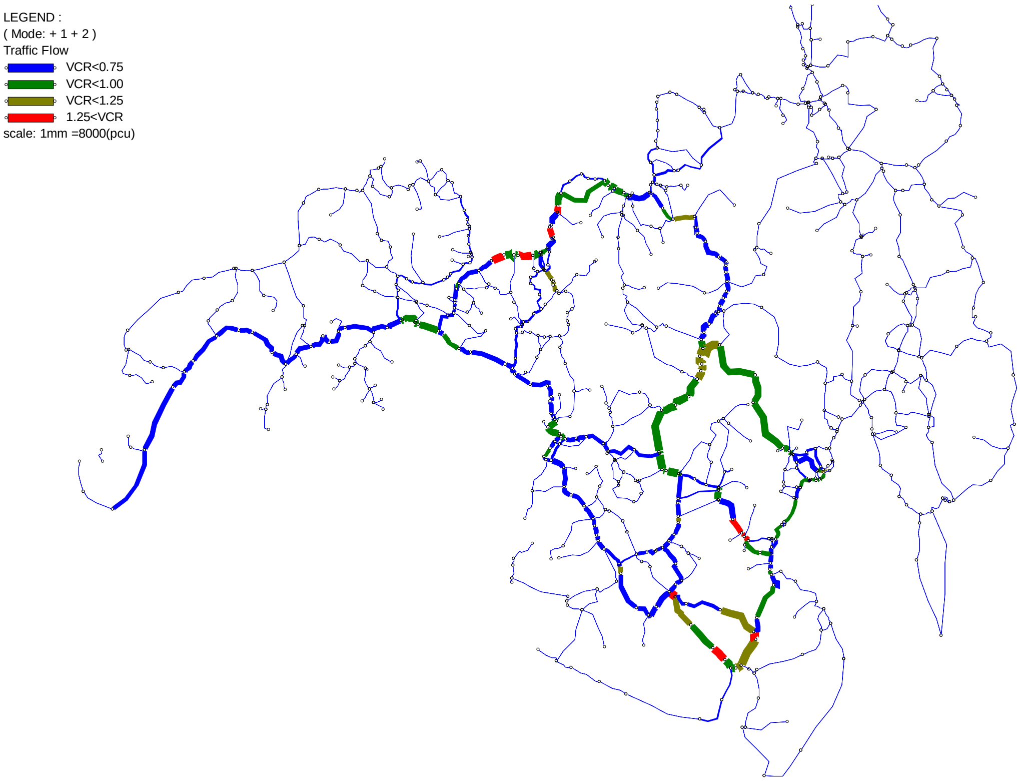


FIGURE 8.5.4-1 RESULT OF TRAFFIC ASSIGNMENT OF DO NOTHING CASE IN 2025

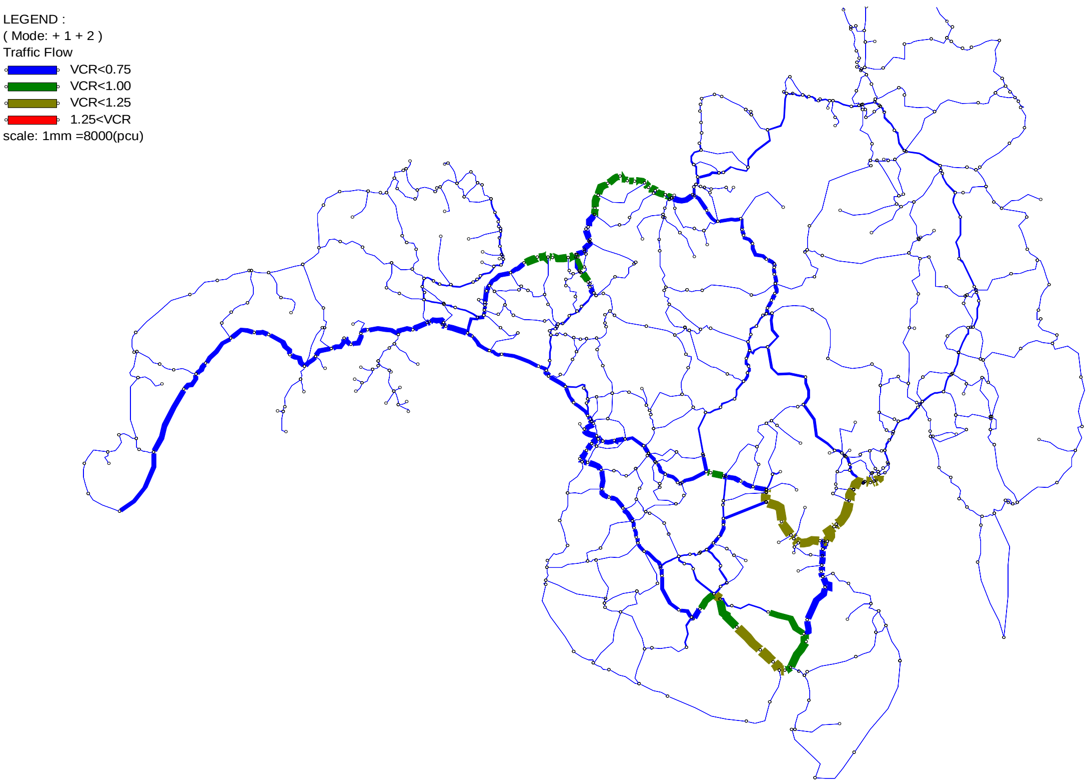


FIGURE 8.5.4-2 RESULT OF TRAFFIC ASSIGNMENT OF MASTER PLAN CASE IN 2025

4) Traffic Volume Estimated by Road Section

The traffic volume on major road section of Master Plan network in 2025 is summarized in **Table 8.5.4-4**. An ID of each road section is specified in **Figure 8.5.4-3**.

TABLE 8.5.4-4 TRAFFIC VOLUME ASSIGNED BY ROAD SECTION

ID	Road Name	Link Name	Capacity (pcu)	Traffic Volume Assigned (pcu)			VCR	Truck Rate (%)	Average Speed (km/h)
				Private Car	Truck	Total			
L1-1	Iligan-Marawi Rd.	AR1-24B	19,000	10,991	2,330	13,321	0.70	17.5	69.5
L1-2	Marawi-Malabang Rd.	AR1-25A	19,000	1,008	870	1,878	0.10	46.3	70.0
L1-3	Marawi-Masiu Rd.	AR1-23C	18,000	2,286	1,010	3,296	0.18	30.6	60.0
L1-4	Mulondo-Wao Rd.	AR1-22C	18,000	1,055	523	1,578	0.09	33.1	60.0
L2-1	Cotabato-Malabang-Lanao del Norte Rd.	AR1-21E	19,000	563	8,143	8,706	0.46	93.5	69.9
L2-2	Marawi-Malabang Rd.	AR1-25J	19,000	989	1,010	1,999	0.11	50.5	70.0
L2-3	Masiu-Ganassi Rd.	AR1-23I	18,000	132	423	555	0.03	76.2	60.0
L2-4	Ganassi-Tubod Rd.	AR1-26	14,000	307	338	645	0.05	52.4	50.0
L2p-1	Border of SK-Butig-Lumbayanague	AR2-61B	18,000	1,071	1,001	2,072	0.12	48.3	60.0
L2p-2	Marawi-Marabang Rd.	AR1-65C	14,000	25	23	48	0.00	47.9	50.0
SK-1	Davao-Cotabato Rd.	AR2-23A	19,000	2,329	5,152	7,481	0.39	68.9	69.9
SK-2	WYE Length Davao-Cotabato Rd.								
SK-3	Cotabato-Lanao Rd.	AR2-21G	19,000	429	3,634	4,063	0.21	89.4	70.0
SK-4	Salimbao-Delta Bridge Rd.								
SK-5	Lamsan-Simuay Jct. Rd.	AR2-21C	12,800	0	0	0	0.00	-	40.0
SK-6	Simuay-Landsan-Prang Rd.	AR2-61C	18,000	415	713	1,128	0.06	63.2	60.0
SK-7	Landsan-Polloc Rd.	AR2-28	18,000	0	373	373	0.02	100.0	60.0
SK-8	Parang Wharf Rd.	AR2-27	19,000	3,008	9,604	12,612	0.66	76.1	69.6
SK-9	Marbel-Ala-Cotabato Rd.	AR2-22F	19,000	5,046	4,308	9,354	0.49	46.1	69.9
SK-10	Awang-Upi-Lebak Rd.	AR2-24A	18,000	261	1,955	2,216	0.12	88.2	60.0
SKp-4		AR2-61E	14,000	1,260	443	1,703	0.12	26.0	60.0
M-1	Marbel-Ala-Cotabato Rd.	AR2-22D	19,000	4,995	4,253	9,248	0.49	46.0	69.9
M-2	Awang-Upi-Lebak Rd.	AR2-24B	18,000	226	1,290	1,516	0.08	85.1	60.0
M-3	Dulawan-Marbel Rd.	AR2-25D	18,000	1,153	551	1,704	0.09	32.3	60.0

The result of traffic assignment for the whole Study area is shown in **Figure 8.5.4-4**. Unit of numbers is 100 pcu per day.

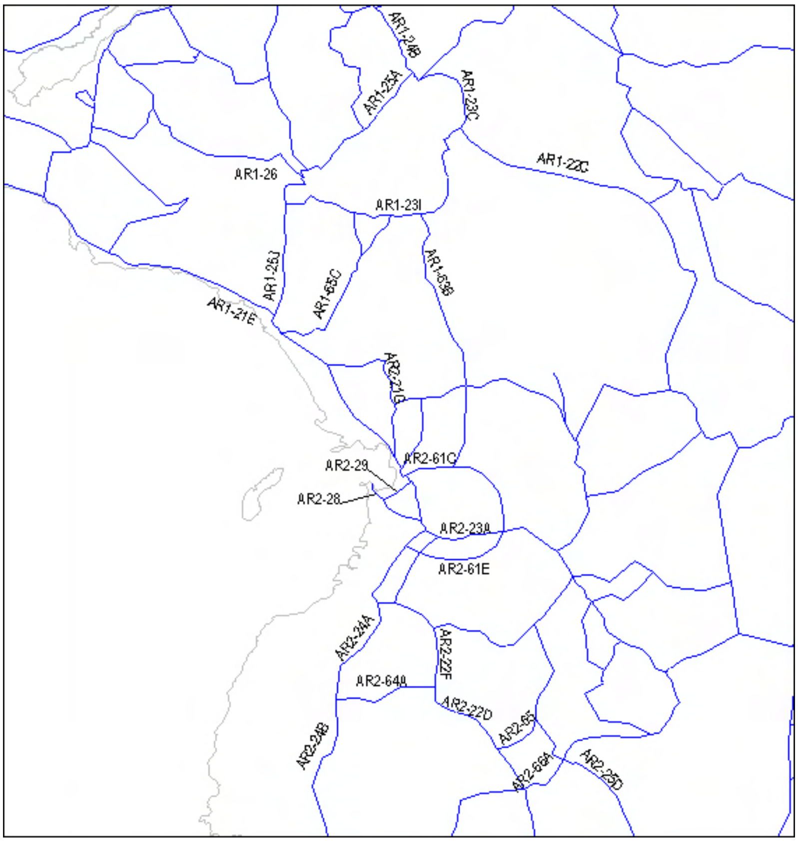


FIGURE 8.5.4-3 LINK NAME OF EACH ROAD SECTION

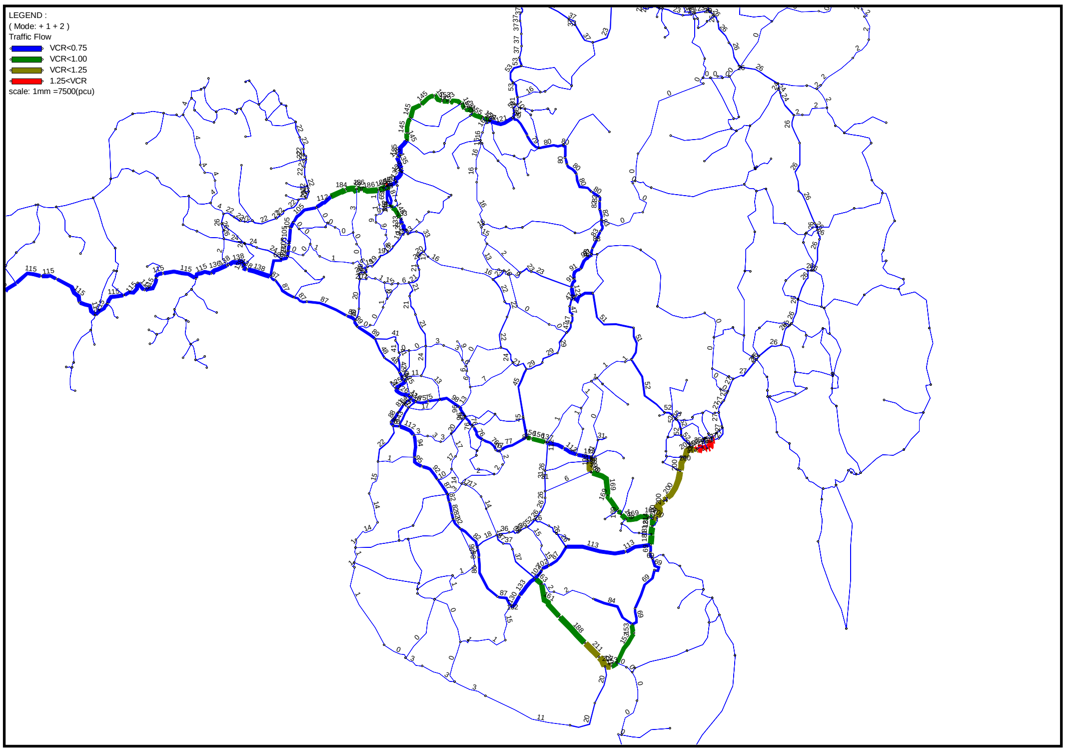


FIGURE 8.5.4-4 TRAFFIC ASSIGNMENT RESULT OF MASTER PLAN CASE IN 2025

CHAPTER 9

ROAD MAINTENANCE IMPROVEMENT PLAN

9.1 ROAD MAINTENANCE PROBLEMS AND ISSUES

Maintenance of National Roads in the ARMM has not been fully executed due to several problems and issues regarding implementation system. Therefore, road conditions in the ARMM area are not usually ensured. Poor road maintenance implementation causes the decrease in durability of road facilities as well as an increase in the number of traffic-related accidents. Consequently, road maintenance cost increases with a relative loss in economic benefits such vehicle operation cost and travel time saving cost.

Based on the results of data analysis and information collected, and discussion with counterparts and related agencies concerned, the following four (4) viewpoints of problems and issues of the maintenance on the National Road are examined;

1) road maintenance budget
2) road maintenance manpower
3) road maintenance equipment
4) road maintenance implementation organization

9.1.1 Road Maintenance Budget Problems and Issues

The detailed Annual Maintenance Budget allocated in 2008 to each District Engineering Office (DEO) and Area Equipment Service Office (AESO) are presented in Chapter 3.5. The total Annual Maintenance Budget allocated to (in) ARMM is about PhP 220,357,000 while total National Road length to be maintained is about 951 km long as shown in **Table 9.1.1-1**. Therefore, annual maintenance budget per km is about PhP 230,000/km.

The JICA Study Team roughly estimated the maintenance cost of the following;

- Gravel Road
- PCC Pavement in very bad condition
- PCC Pavement in bad condition
- PCC Pavement in fair condition

As a result, maintenance cost required for maintenance of gravel road is about PhP 799,000/km, while maintenance cost of very bad, bad and fair conditions of PCC is about PhP 775,000/km, PhP 562,000/km, and PhP 454,000/km respectively as shown in Table **9.1.1-2** to **Table 9.1.1-5**.

TABLE 9.1.1-1 TOTAL MAINTENANCE BUDGET IN ARMM BY FUND (IN 2008)

Items	Total Maintenance Budget in ARMM (Pesos) *(a)*	Road Length(km) *(b)*	Maintenance Budget/km (Pesos) *((a)/(b))*	Remarks
Fund by GAA	**110,581,600**	**951**	**116,279**	**Base Cost=68,691**
Fund by MVUC	**109,776,000**	**951**	**115,432**	
Total	**220,357,600**	**951**	**231,711**	

Source: DPWH-National and DPWH-ARMM

TABLE 9.1.1-2 MAINTENANCE COST REQUIRED FOR GRAVEL ROAD

	Minimum Maintenance Cost for Unpaved Road per Km						
Working Items	Morking Activity	Quantities Caluclation	Unit	Quantity	Unit Cost	Cost/km (Pesos)	Implement Frequency
Surface (Gravel)	Cut and Excavat	6.0*1,000*0.20/10	m3	120	30.6	3,672	1-Time/10-Y
	Fill &Compact	6.0*1,000/10	m2	600	653.6	392,160	1-Time/10-Y
	Grading	6.0*1,000*2	m2	12,000	1.3	15,600	2-Times/Y
	Replacement of Base	6.0*1,000*0.6/10	m2	360	214	77,040	1-Time/10Y
	Replacemant of Sub-Base	6.0*1,000*0.6/10	m2	360	214	77,040	1-Time/10Y
Dranage	Clean Side Ditch	1,000*2*2*0.5	m	2,000	19	38,000	2-Times/Y
	Culvert Cleaning	1*15*2	m	30	76.5	2,295	2-Times/Y
	Sweep & Clean Canal	100*2	m	200	19	3,800	2-Times/Y
Shoulder	Cut and Excavat	1.5*1,000*2*0.2/10	m3	60	30.6	1,836	1-Time/10-Y
	Fill &Compact	1,5*1,000*2/10	m2	300	476.0	142,800	1-Time/10-Y
	Grading	1.5*1,000*2*2	m2	6,000	1.6	9,600	2-Times/Y
Road Side Feature	Vegetation	3*1,000*2*2	m2	12,000	1.9	22,800	2-Times/Y
	Erosion Repar	Unit	km	1	10,000	10,000	1-Time/5-Y
	Road Side Fasility	Unit	km	1	1,000	1,000	1-Time/Y
Traffic Service	Traffic Sign	Unit	km	1	440	440	1-Times/Y
	Center Line	Unit	km	1	440	440	1-Times/Y
	Traffic Bourd	Unit	km	1	440	440	1-Times/Y
	Guardrail	Unit	km	1	440	440	1-Times/Y
	Total					799,403	

Source: JICA Study Team

TABLE 9.1.1-3 MAINTENANCE COST REQUIRED FOR PCC IN VERY BAD CONDITION

Minimum Maintenance Cost for PCC Pavement Road per Km (Very Bad Pavement Condition Case)							
Working Items	Morking Activity	Quantities Caluclation	Unit	Quantity	Unit Cost	Cost/km (Pesos)	Implement Frequency
Pavement (PCC)	Patching of Surface	6.5*1,000*2	m2	13,000	1.2	15,600	2-Times/Y
	Crack & Joint Sealing	6.5*1,000*2	m2	13,000	2.4	31,200	2-Times/Y
	Replacement of PCC	6.5*1,000*0.6/10	m2	390	1,021	398,190	1-Time/10Y
	Replacement of Base	6.5*1,000*0.6/10	m2	390	214	83,460	1-Time/10Y
	Replacemant of Sub-Base	6.5*1,000*0.6/10	m2	390	214	83,460	1-Time/10Y
	Cut & Excanate	6.5*1,000*0.6*0.5/10	m3	195	30.6	5,967	1-Time/10Y
Dranage	Clean Side Ditch	1,000*2*2*0.5	m	2,000	19	38,000	2-Times/Y
	Culvert Cleaning	1*15*2	m	30	76.5	2,295	2-Times/Y
	Sweep & Clean Canal	100*2	m	200	19	3,800	2-Times/Y
Shoulder	Cut and Excavat	1.5*1,000*2*0.2/10	m3	60	30.6	1,836	1-Time/10-Y
	Fill &Compact	1,5*1,000*2/10*0.5	m2	150	476.0	71,400	1-Time/10-Y
	Grading	1.5*1,000*2*2*0.5	m2	3,000	1.6	4,800	2-Times/Y
						0	
Road Side Feature	Vegetation	3*1,000*2*2	m2	12,000	1.9	22,800	2-Times/Y
	Erosion Repar	Unit	km	1	10,000	10,000	1-Time/5-Y
	Road Side Fasility	Unit	km	1	1,000	1,000	1-Time/Y
						0	
Traffic Service	Traffic Sign	Unit	km	1	440	440	1-Times/Y
	Center Line	Unit	km	1	440	440	1-Times/Y
	Traffic Bourd	Unit	km	1	440	440	1-Times/Y
	Guardrail	Unit	km	1	440	440	1-Times/Y
	Total					775,568	

Source: JICA Study Team

TABLE 9.1.1-4 MAINTENANCE COST REQUIRED FOR PCC IN BAD CONDITION

Minimum Maintenance Cost for PCC Pavement Road per Km (Bad Pavement Condition Case)							
Working Items	Morking Activity	Quantities Caluclation	Unit	Quantity	Unit Cost	Cost/km (Pesos)	Implement Frequency
Pavement (PCC)	Patching of Surface	6.5*1,000*2	m2	13,000	0.6	7,800	2-Times/Y
	Crack & Joint Sealing	6.5*1,000*2	m2	13,000	1.2	15,600	2-Times/Y
	Replacement of PCC	6.5*1,000*0.4/10	m2	260	1,021	265,460	1-Time/10Y
	Replacement of Base	6.5*1,000*0.4/10	m2	260	214	55,640	1-Time/10Y
	Replacemant of Sub-Base	6.5*1,000*0.4/10	m2	260	214	55,640	1-Time/10Y
	Cut & Excanate	6.5*1,000*0.4*0.5/10	m3	130	30.6	3,978	1-Time/10Y
Dranage	Clean Side Ditch	1,000*2*2*0.5	m	2,000	19	38,000	2-Times/Y
	Culvert Cleaning	1*15*2	m	30	76.5	2,295	2-Times/Y
	Sweep & Clean Canal	100*2	m	200	19	3,800	2-Times/Y
Shoulder	Cut and Excavat	1.5*1,000*2*0.2/10	m3	60	30.6	1,836	1-Time/10-Y
	Fill &Compact	1,5*1,000*2/10*0.5	m2	150	476.0	71,400	1-Time/10-Y
	Grading	1.5*1,000*2*2*0.5	m2	3,000	1.6	4,800	2-Times/Y
Road Side Feature	Vegetation	3*1,000*2*2	m2	12,000	1.9	22,800	2-Times/Y
	Erosion Repar	Unit	km	1	10,000	10,000	1-Time/5-Y
	Road Side Fasility	Unit	km	1	1,000	1,000	1-Time/Y
Traffic Service	Traffic Sign	Unit	km	1	440	440	1-Times/Y
	Center Line	Unit	km	1	440	440	1-Times/Y
	Traffic Bourd	Unit	km	1	440	440	1-Times/Y
	Guardrail	Unit	km	1	440	440	1-Times/Y
	Total					561,809	

Source: JICA Study Team

TABLE 9.1.1-5 MAINTENANCE COST REQUIRED FOR PCC IN FAIR CONDITION

Minimum Maintenance Cost for PCC Pavement Road per Km (Fiar Pavement Condition Case)							
Working Items	Morking Activity	Quantities Caluclation	Unit	Quantity	Unit Cost	Cost/km (Pesos)	Implement Frequency
Pavement (PCC)	Patching of Surface	6.5*1,000*2	m2	13,000	0.3	3,900	2-Times/Y
	Crack & Joint Sealing	6.5*1,000*2	m2	13,000	0.6	7,800	2-Times/Y
	Replacement of PCC	6.5*1,000*0.3/10	m2	195	1,021	199,095	1-Time/10Y
	Replacement of Base	6.5*1,000*0.3/10	m2	195	214	41,730	1-Time/10Y
	Replacemant of Sub-Base	6.5*1,000*0.3/10	m2	195	214	41,730	1-Time/10Y
	Cut & Excanate	6.5*1,000*0.3*0.5/10	m3	80	30.6	2,433	1-Time/10Y
Dranage	Clean Side Ditch	1,000*2*2*0.5	m	2,000	19	38,000	2-Times/Y
	Culvert Cleaning	1*15*2	m	30	76.5	2,295	2-Times/Y
	Sweep & Clean Canal	100*2	m	200	19	3,800	2-Times/Y
Shoulder	Cut and Excavat	1.5*1,000*2*0.2/10	m3	60	30.6	1,836	1-Time/10-Y
	Fill &Compact	1,5*1,000*2/10*0.5	m2	150	476.0	71,400	1-Time/10-Y
	Grading	1.5*1,000*2*2*0.5	m2	3,000	1.6	4,800	2-Times/Y
Road Side Feature	Vegetation	3*1,000*2*2	m2	12,000	1.9	22,800	2-Times/Y
	Erosion Repar	Unit	km	1	10,000	10,000	1-Time/5-Y
	Road Side Fasility	Unit	km	1	1,000	1,000	1-Time/Y
Traffic Service	Traffic Sign	Unit	km	1	440	440	1-Times/Y
	Center Line	Unit	km	1	440	440	1-Times/Y
	Traffic Bourd	Unit	km	1	440	440	1-Times/Y
	Guardrail	Unit	km	1	440	440	1-Times/Y
	Total					454,379	

Source: JICA Study Team

Results of the estimated maintenance cost were compared with the 2008 maintenance budget (see **Table 9.1.1-6**). Ideal road maintenance budget needs to be 2 or 3 times more than the 2008 budget.

TABLE 9.1.1-6 COMPARISON OF BUDGET AND MAINTENANCE COST

	(a) Budget in 2008 (GAA+MVUC)	(b) Estimated Maintenance Cost			
		Gravel Road	PCC in Fair Condition	PCC in Bad Condition	PCC in Very Bad Condition
Budget/Maintenance Cost (per Km/Year)	231,711	799,000	454,000	562,000	776,000
b/a	-	3.4	2.0	2.4	3.3

Source: JICA Study Team

One of the problems and issues of road maintenance in ARMM is extreme shortage of Annual Maintenance Budget, although drastic increase of such may not be expected considering Philippine's financial conditions.

9.1.2 Road Maintenance Equipments Problems and Issues

As previously mentioned, the road maintenance equipments are maintained by the Area Equipment Service Office (AESO). At present, major maintenance equipments are presented in **Table 9.1.2-1**. There are only one or two Road Graders and Dump Trucks in each AESO and most of them are non-operational.

TABLE 9.1.2-1 LIST OF MAINTENANCE EQUIPMENTS

Items	Maguindanao (I+II) AESO	Lanao del Sur (I) AESO	Lanao del Sur (II) AESO	Sulu AESO	Tawi – Tawi AESO	Total
Road Length to be Maintained	247 km	146 km	161 km	170 km	227 km	951 km
Major Equipment for Maintenance Works						
1) Air Compressor	0	0	0	3	1	4
2)Pavement Breaker	0	0	0	0	0	0
3) Concrete Cutter	0	0	0	0	0	0
4) Concrete Mixer	0	2	0	1	2	5
5) Crusher	0	0	0	1	0	1
6) Truck Crane	0	0	0	0	1	1
7) Excavator	1	1	0	1	1	4
8) Service Car	4	3	0	8	1	16
9) Dump Truck	3	3	1	4	4	15
10)Water Tank Truck	0	0	0	0	3	3
11)Trailer	0	0	0	0	2	2
12)Bulldozer	1	1	0	0	0	2
13)Loader	1	2	2	1	0	6
14)Road Grader	2	2	1	2	3	10
15)Roller	0	0	0	1	0	1
16)Lane Marker	0	0	0	0	0	0
17)Vibrator	0	1	0	1	3	5
18)Compactor	0	0	0	5	2	7
19) Grass Cutter	0	0	0	0	0	0
20) Hammer	0	0	0	0	1	1

Source: DPWH-ARMM

Based on the conditions of maintenance equipment, the problems and issues are as follows;

1) There is an extreme shortage in the number of operational maintenance equipments and spare parts.
2) An increase in the number of non-operational maintenance equipments is expected when the existing budget conditions is continued.
3) Proper implementation of road maintenance is not conducted due to shortage in the number of operational maintenance equipments and spare parts.
4) Proper road maintenance may be carried out by providing additional maintenance equipments which may be rented from private companies.

9.1.3 Manpower Problems and Issues

As previously mentioned, maintenance works of the National Road in ARMM is executed by the District Engineering Office (DEO) and Area Equipment Service Office (AESO). A total of 478 staff is working at these two offices, of which 345 belong to the DEO and 133 to the AESO (see **Table 9.1.3-1**).

TABLE 9.1.3-1 NUMBER OF STAFF IN DEO AND AESO

Name of Province	Name of DEO	Name of AESO	No. of Staff in DEO	No. of Staff in AESO	Total (person)
Shariff Kabunsuan	Shariff Kabunsuan	---------------------	41	---------	41
Maguindanao	Maguindanao	Maguindanao	32	41	73
Lanao del Sur	Lanao del Sur (I)	Lanao del Sur (I)	73	37	110
	Lanao del Sur(II)	Lanao del Sur(II)	20	0	20
Sulu	Sulu (I)	Sulu	75	41	116
	Sulu (II)	-----------------------	45	----------	45
Tawi-Tawi	Tawi-Tawi	Tawi-Tawi	59	14	73
Basilan	Baselan	------------------------	0	----------	---------
Total			345	133	478

Source: DPWH-ARMM

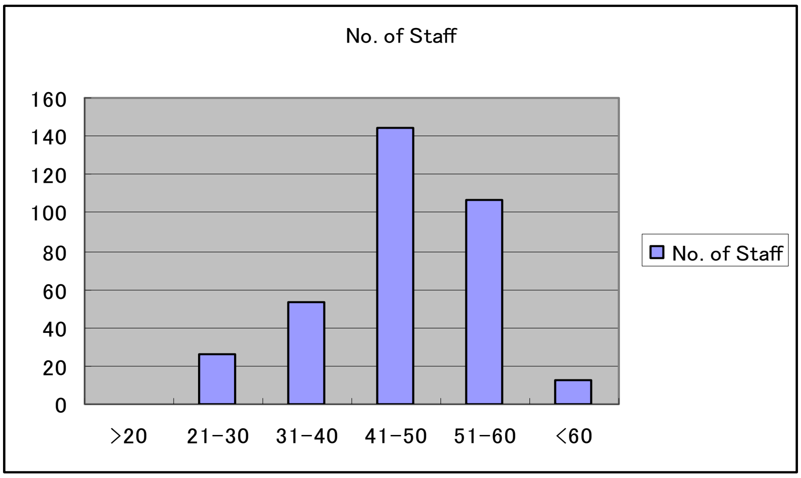
Number of staff in DEO by age group is shown in **Table 9.1.3-2** and **Figure 9.1.3-1**. The 21 to 30 years old age bracket occupies 7.5% of the total number of staff in the DEOs while 15.4% is occupied by 31 to 40 years old employees. Highest percentage is occupied by the 41 to 50 years old age group, recorded at 41.7% , whereas the 51 to 60 years old and 60 and above groups occupy 31.0% and 4.4%, respectively.

The average age of DEO staff is observed to be 47 to 48 years old, quite higher compared with private companies. ARMM retirement age is 65 years old. Basing from the data, about 35% of the total staff will be retired from service after 10 years. Consequently, about 50% will be retired in 20 years time, thus technology transfer on maintenance works to younger generation becomes important.

TABLE 9.1.3-2 NUMBER OF STAFF IN DEO BY AGE GROUP

Age of Staff	Shariff Maguin	Lanao I+II	Sulu (I)	Sulu (II)	Tawi Tawi	Basilan	Total (Person)
Less 20	0	0	0	0	0	0	0
21-30	5	2	3	16	0	0	26 (7.5%)
31-40	13	15	9	15	5	0	53 (15.4%)
41-50	31	38	35	3	25	0	144 (41.7%)
51-60	19	35	24	0	26	0	107 (31.0%)
Over 60	5	3	2	0	3	0	13 (4.4%)
			2 Vacant				2
Total	73	93	73	45	59	0	345 (100%)

Source: DPWH-ARMM



Source: DPWH-ARMM

FIGURE 9.1.3-1 NUMBER OF STAFF IN DEO BY AGE GROUP

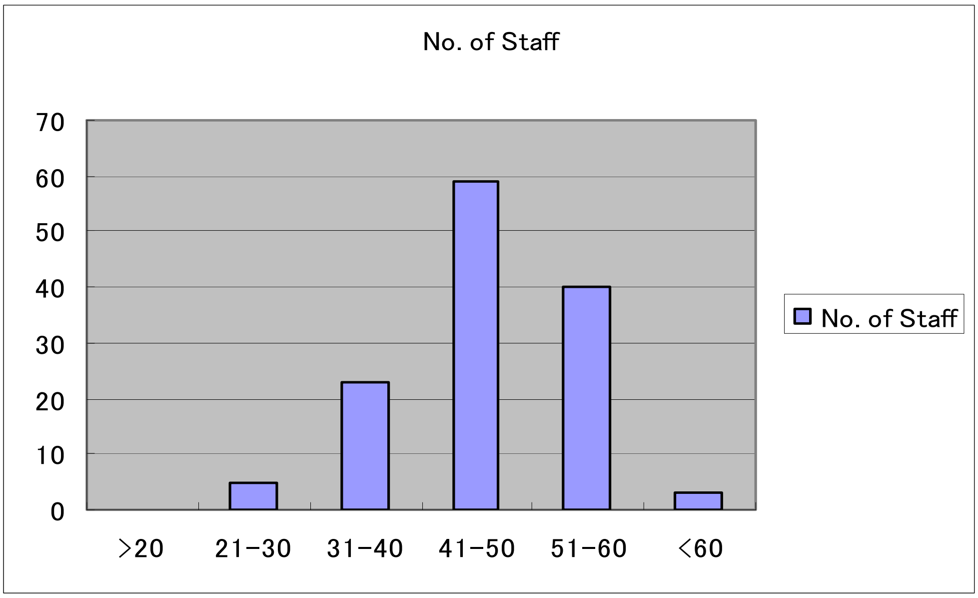
Number of staff in AESO by age group is shown in **Table 9.1.3-3** and **Figure 9.1.3-2**. 3.8 % of the total number of AESO staff is occupied by the 21 to 30 years old age group whereas 31 to 40 years old employees occupy 17.7 %. Similar with the DEO scenario, AESO staff at the 41 to 50 years old age bracket occupies the highest proportion at 45.4% while 51 to 60 years old and 60 and above age groups occupy 30.8% and 2.3%, respectively.

The average age of AESO staff is observed to be about 46 to 47 years old, almost the same as DEO staff age. About 35% of the total staff is expected to retire from service after 10 years while about 50% will be retired in 20 years.

TABLE 9.1.3-3 NUMBER OF STAFF IN AESO BY AGE GROUP

Age of Staff	Maguindanao	Lanao del Sur	Sulu	Tawi Tawi	Basilan	Total (Person)
Less 20	0	0	0	0	0	0
21-30	2	3	0	0	0	5 (3.8%)
31-40	9	19	5	3	0	23 (17.7%)
41-50	20	8	16	4	0	59 (45.4%)
51-60	7	0	19	6	0	40 (30.8%)
Over 60	2		0	1	0	3 (2.3%)
	1-Vacant	1-Vacant	1-Vacant			3-Vacant
Total	40	36	40	14	0	133 (100%)

Source: DPWH-ARMM



Source: DPWH-ARMM

FIGURE 9.1.3-2 NUMBER OF STAFF IN AESO BY AGE GROUP

Taking into account the above conditions, the problems and issues of maintenance manpower are as follows;

1) Staffs aged 40 years old and above occupy a major proportion of the total number of DEO and AESO staff, which is about 77%.
2) Within 20 years, over 50% of total number of staffs will be retired.
3) Technology transfer on road maintenance method to younger generation is important in order to ensure proper maintenance.

9.1.4 Road Maintenance Implementation Organization Problem and Issues

As previously mentioned, each DEO and AESO has almost the same organizational structures. The average number of staff in each section or division of DEO and AESO is presented in **Table 9.1.4-1** and **Table 9.1.4-2** respectively. However, the actual number of staff of each section and division is different from the standard.

Sufficient road and bridge inspection survey and the preparation of database have not been conducted. This is the major limitation of the technical aspect of road maintenance activities in ARMM due to inadequate road condition database. Therefore, effective planning and programming, scheduling and design works for road maintenance implementation becomes difficult. This is one of the causes of disruption on the sufficient functional road maintenance activities. Limitations on the existing maintenance activities such as road and bridge inspection, database, planning and design should be improved as soon as possible.

TABLE 9.1.4-1 AVERAGE NUMBER OF STAFF IN DEO

Director	Assist Director	Section	Division	No. of Staff
Director				1
	Assist. Director			2
		Administrative	Chief	1
			Designate	1
			Supply Officer	2
			Security Guard	3
			Driver	2
		Maintenance	Chief	1
			Supervisor	2
			Engineer	8
			Plumber	1
			Painter	1
			Well Drilling	1
		Construction	Chief	1
			Engineer	4
		Planning	Chief	1
			Engineer	2
			Instrument Man	1
			Clerk	3
		Comptrollership	Chief	1
			Acting Account	1
			Budget Office	1
			Acting Cashier	1
		Building Code	Chief	1
			Engineer	2
			Electrician	1
		Material	Chief	1
			Engineer	4
Total				50

Source: JICA Study Team based on DPWH-ARMM data

TABLE 9.1.4-2 AVERAGE NUMBER OF STAFF IN AESO

Director	Section	Unit	No. of Staff
Director			2
	Planning & Const.	Chief	1
		Equipment	1
		Mechanic	1
		Utility	1
	Administrative	Officer	2
		Personnel	3
		Security Service	2
		Accounting	3
		Supply	4
	Repair Bay	Chief	1
		Mechanic (II)	4
		Mechanic (I)	8
		Operator	1
		Electrician	1
		Metal Worker	1
		Painter	1
		Document	1
		Clerk	2
Total			40

Source: JICA Study Team based on DPWH-ARMM data

In addition to above, following sections will be required to reinforce maintenance activities;

1) Inspection and Database section
2) Design and Supervision section
3) Equipment section in the future
4) Contract section in the future

Considering the above mentioned conditions, the problems and issues for maintenance organization structure are pointed out as follows;

1) The numbers of staff and organizational structure for road and bridge inventory survey are very weak. Therefore, there is no sufficient road condition data.
2) The numbers of staff and organizational structure for the preparation of database activities are very weak. Therefore, there is no sufficient road condition data by database.
3) The number of staff and organizational structure for the preparation of planning and design are very weak. Therefore, it is very difficult to prepare the proper plan and program.

9.2 ROAD MAINTENANCE IMPROVEMENT SCENARIOS

9.2.1 General

1) Planning Goal and Policy

Road maintenance works are carried out to provide good condition of road facilities to road users, to preserve road assets, to reduce traffic costs, to decrease traffic-related accidents and to maximize usage of existing road facilities. In the long run, sufficient road maintenance activities save overall road development cost as well as contribute to increase the economic benefits. Therefore, road maintenance works are vital and quite important since it encompasses economic, technical and financial aspects.

Considering the importance of road maintenance works, the **"Creation or Establishment of Sustainable Maintenance System"** is identified as the planning policy and goal in this maintenance study.

2) Identification of Maintenance Implementation Scenario

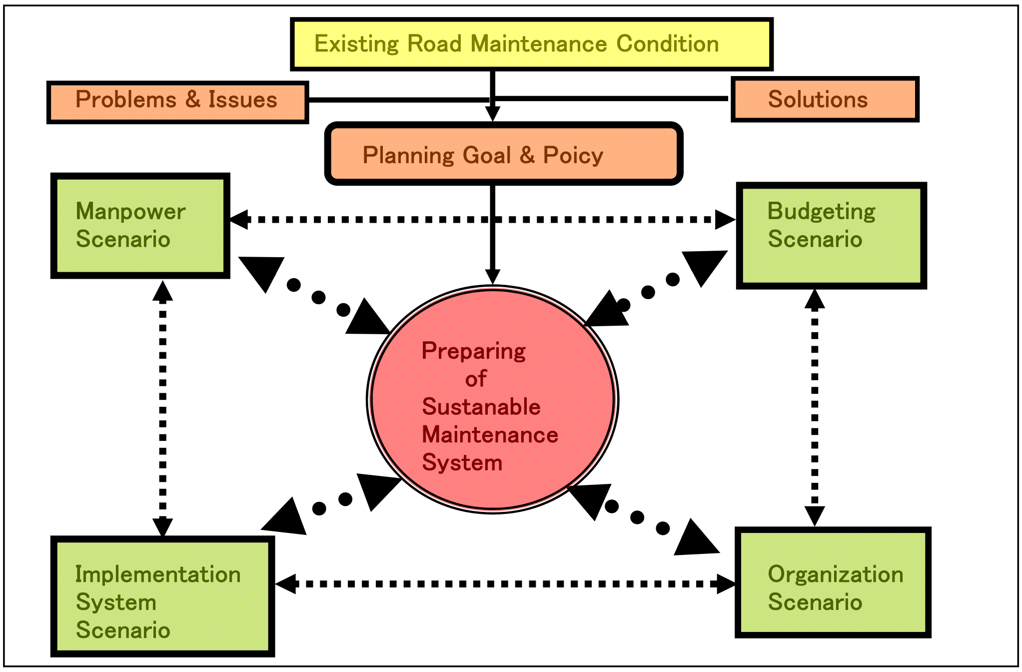
The road maintenance improvement scenarios are identified based on the solution to the existing problems and issues mentioned in Chapter 9.1, as well as in consideration of the planning policy and goal of maintenance systems mentioned above.

The major problems and issues are summarized, and the main solutions to problems are presented in **Table 9.2.1-1**. Considering the existing maintenance problems and issues, four (4) scenarios are identified as shown in **Table 9.2.1-1** and **Figure 9.2.1-1**. The detailed descriptions of each scenario identified are presented in the following sections.

TABLE 9.2.1-1 RELATIONSHIP BETWEEN MAINTENANCE PROBLEMS AND SCENARIOS

Viewpoints	Major Problems & Issues	Solutions	Scenario
1.Budget	Limited Budget	Proper prioritization of maintenance activities	Scenario-1
	No drastic increase expected	Selection of activity	
	Limited activities	Prepare basic data	
	Bad pavement condition		
2. Manpower	Imbalance of staff age	Reformation of staff	Scenario-2
	No technology transfer		
	Weak technical capability		
3.Maintenance Equipment	Decreasing No. of equipment in operational condition	MBC system introduced	Scenario-3
	Decreasing No. of spare parts	Decrease of MBA	
	Limited Budget		
	No expect procurement		
4. Organization	Decreasing No. of equipment	Restructuring	Scenario-4
	Decreasing No. of staffs		

Source: JICA Study Team



Source: JICA Study Team

FIGURE 9.2.1-1 GENERAL IDEA OF MAINTENANCE IMPROVEMENT SCENARIO

9.2.2 Scenario -1: Maintenance Activities under Limited Maintenance Budget

Considering the socio-economic conditions, existing road conditions, historical maintenance activities, and maintenance budgeting condition of ARMM, the following three (3) approaches for implementation of maintenance activities under the limited budget allocation are proposed as the Scenario-1;

Step 1: Within two (2) years, the road and bridge inspection works/ activities and the preparation of database activities on the road and bridge condition are reinforced as priority maintenance works.

Step 2: During the ten (10) year period, the routine maintenance activities are reinforced/ increased gradually as the main activities for road maintenance.

According to the data of Bureau of Maintenance (BOM), the major routine maintenance activities are identified as follows;

a) Pothole patching, sealing of cracks on pavement
b) Grading and patching of shoulders
c) Drainage cleaning and clearing
d) Roadside and feature maintenance; vegetation control, road sign and guardrail cleaning and repainting.
e) Road marking maintenance
f) Bridge maintenance; cleaning of bridge decks, shelves framework and drainage, spot repainting.

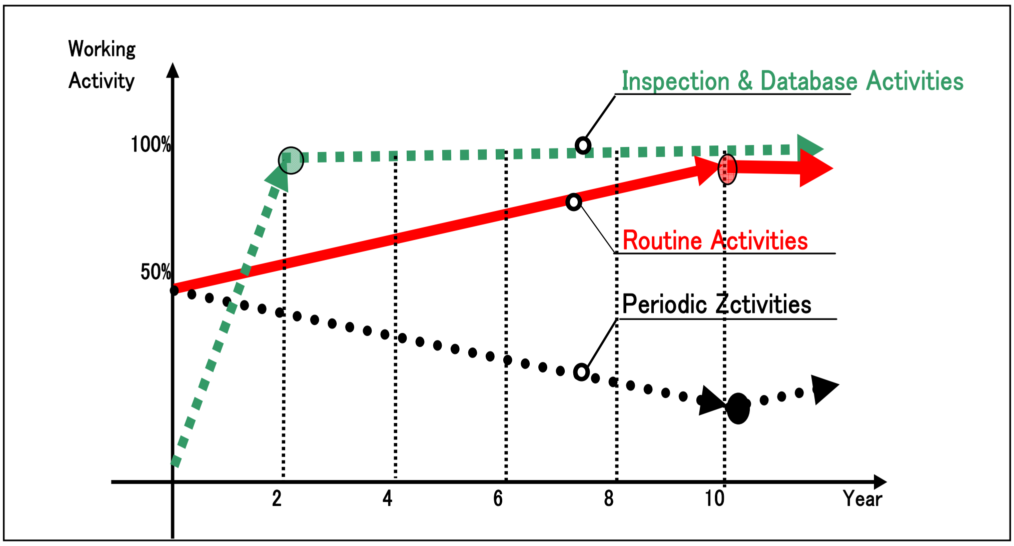
Step 3: During the ten (10) year period, the periodic maintenance activities are restrained/ decreased gradually, in accordance with the allocated maintenance budget and a decrease in the number of maintenance equipment operated.

Whereas, road sections in very bad conditions are improved by capital outlay budget in the next 10 years, DPWH-ARMM should do its best to increase capital outlay budget.

According to the data of Bureau of Maintenance (BOM), the major periodic maintenance activities are identified as follows;

g) Large area resealing of pavement
h) Re-gravelling of shoulders
i) On bridges, parapet repairs, deck sealing, repairs to scour protection, re-painting

The general image of Scenario-1 is presented in **Figure 9.2.2-1.**



Source: JICA Study Team

FIGURE 9.2.2-1 SCENARIO FOR MAINTENANCE ACTIVITIES UNDER LIMITED BUDGET

9.2.3 Scenario -2: Reformation of Maintenance Manpower

The composition of age group of staff is unbalanced, and the average age of staffs in District Engineering Office (DEO) and Area Equipment Service Office (AESO) is estimated to be about 47 to 48 years old.

Considering the maintenance technology transfer aspects, maintenance activities, and maintenance budget allocation, the following reformation of maintenance manpower conditions are proposed as the Scenario -2;

1) At present, the average age of staffs in EDO and AESO is estimated to be about 47 to 48 years old. The average age of staff will need to be decreased gradually.

2) By year 2015, the average age of DEO and AESO staffs is reformed to about the early 40's age bracket.

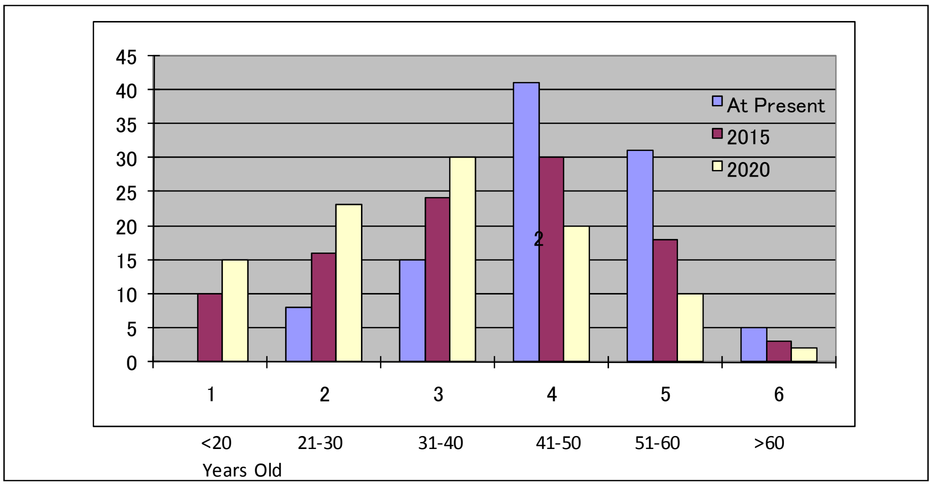
3) By year 2020, the average age of DEO and AESO staffs is reformed to about the late 30's age bracket.

The general image of above mentioned Scenario-2 for the reformation of maintenance manpower is presented in **Table 9.2.3-1** and **Figure 9.2.3-1**.

TABLE 9.2.3-1 AGE COMPOSITION OF MAINTENANCE MANPOWER

Age of Staff	Year		
	2008	2015	2020
< 20	0 %	10 %	15 %
21-30	8 %	16 %	23 %
31-40	15 %	24 %	30 %
41-50	41 %	30 %	20 %
51-60	31 %	18 %	10 %
> 60	5 %	3 %	2 %
Total (100%)	100%	100%	100%

Source: JICA Study Team



Source: JICA Study Team

FIGURE 9.2.3-1 AGE COMPOSITION PERCENTAGE BY YEAR

9.2.4 Scenario -3: Implementation System of Maintenance Activities

There are two (2) maintenance implementation systems in the Philippines; the Maintenance by Administration (MBA) and the Maintenance by Contractor (MBC). At present, the road and bridge maintenance activity in ARMM is implemented by only MBA. However, the implementation of maintenance works by other regions such as Region X and XII adopts both MBA and MBC.

Since there is very limited number of operational maintenance equipments in the AESOs, the number of operational maintenance equipments and spare parts is expected to gradually decrease. Furthermore, procurement of new maintenance equipments is not feasible due to shortage in maintenance budget allocation.

Taking into account the number of maintenance equipment and their conditions, the following four (4) reformations of maintenance implementation system are proposed;

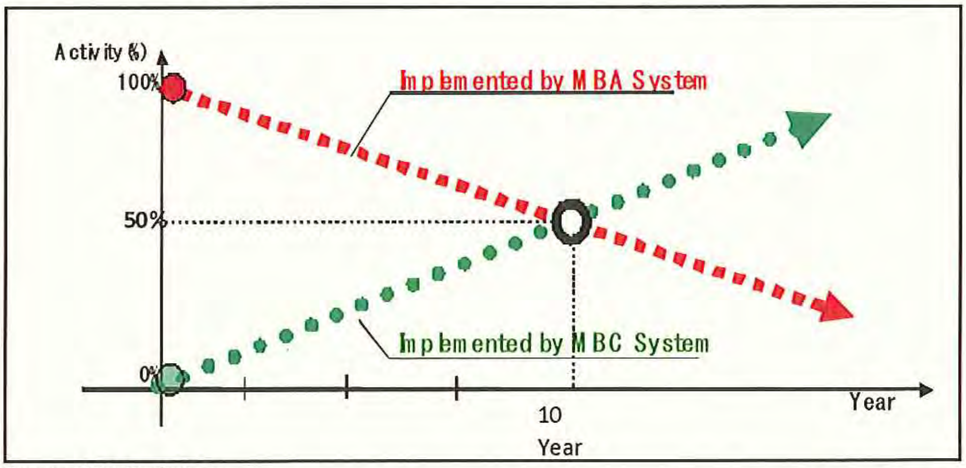
1) The percentage share of MBA is to be decreased gradually.

2) The percentage share of MBC is to be increased gradually.

3) During the ten (10) year period, 50% of total maintenance activities are implemented by MBA and the remaining 50% by MBC system.

4) During the fifteen (15) year period, 30% of total maintenance activities are implemented by MBA system and the remaining 70% are MBC.

The general image of Scenario-3 is presented in **Figure 9.2.4-1**.



Source: JICA Study Team

FIGURE 9.2.4-1 SCENARIO - 3 FOR INTRODUCTION OF MBC

9.2.5 Scenario -4 : Restructuring of Maintenance Implementation Organization

National road maintenance works for a total road length of 995 km has been implemented by a total of 345 staffs of seven (7) DEOs and 133 staffs of the four (4) AESOs.

In the future, the total number of staffs needed for the whole implementation of maintenance works may be increased gradually, according to the reinforcement of the existing maintenance activities and also the expansion of bad pavement condition road segments. Number of staff needed for the management of maintenance equipment may be decreased gradually as the number of operational equipments decrease due to limited budget and introduction of MBC.

Considering above mentioned conditions, the following four (4) approaches for the restructuring of organization are proposed;

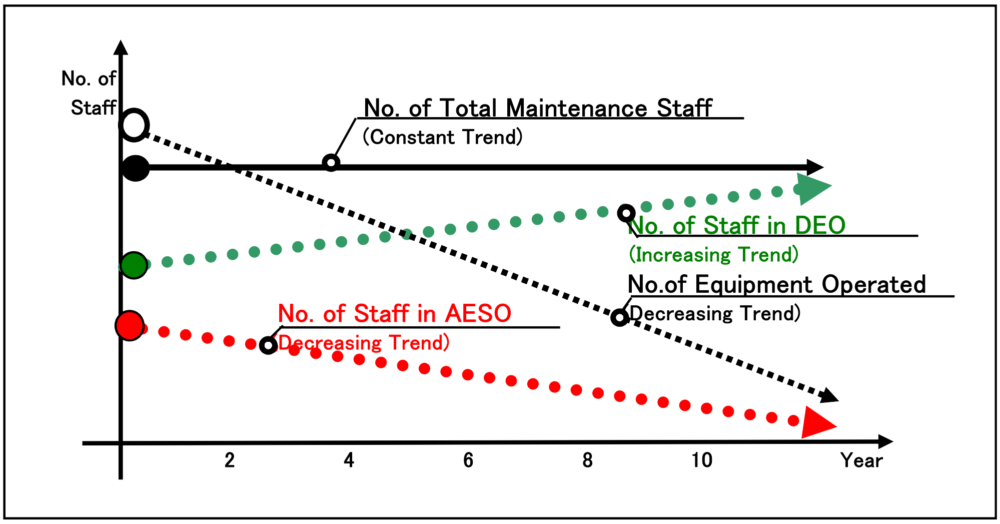
Approach 1: The total number of staff needed for the overall maintenance works in the future is kept at constant.

Approach 2: The numbers of staff in DEO is to be increased gradually, according to the reinforcement of maintenance activities in the future.

Approach 3: The numbers of staff in AESO is to be decreased gradually, in accordance with the decrease in the number of maintenance equipments and increase of MBC.

Approach 4: The number of staff taken out from the AESO is to be transferred to the DEO, in accordance with the above mentioned approaches.

The general image of the Scenario-4 is presented in **Figure 9.2.5-1**.



Source: JICA Study Team

FIGURE 9.2.5-1 SCENARIO - 4 FOR RESTRUCTURING OF ORGANIZATION

9.3 ROAD MAINTENANCE LEVEL AND PRIORITY OF MAINTENANCE ACTIVITIES

9.3.1 Road Maintenance Level

Road maintenance level by maintenance activity is shown in **Table 9.3.1-1,** which also shows demarcation of MBA and MBC.

TABLE 9.3.1-1 ROAD MAINTENANCE LEVEL

Elements	Type	Maintenance Activities	DPWH Classification	Requirement Criteria	Proposed Maintenance Level	Proposed Demarcation
Carriageway	PCC	Crack and Joint Sealing	Routine	By Condition	Good= 110 liters/km Fair= 210 liters/km Bad= 245 liters/km	MBA
		Temporary Patching	Routine	By Condition	Good, Fair = 0 Bad = 0 V. Bad = 40 clm/km	MBA
		Patching	Routine Special	By Condition	Good = 0 Fair = 5.2 cu.m/km Bad = 14.4 cu.m/km	MBC (or MBA)
		Replacement of Concrete Pavement	Routine/ Special	By Condition	Good, Fair = 0 Bad = 45 sq.m/km	MBC
		Resurfacing of Bit. Pavement (Overlay)	Periodic	By Condition	Fair to Bad	MBC
	AC	Sealing	Routine	By Condition	Good = 105 liters/km Fair = 260 liters/km Bad = 350 liters/km	MBA
		Temporary Patching	Routine	By Condition	Good, Fair = 0 Bad = 0	MBA

					V. Bad = 40 cl m/km	
		Patching	Routine	By Condition	Good = 4.25 cu.m/km Fair = 11.0 cu.m/km Bad = 13.5 cu.m/km	MBC (or MBA)
		Replacement of Bituminous Pavement	Routine	By Condition	Good = 0 Fair = 0 Bad = 100 sq.m/km	MBC
		Resurfacing of Bit. Pavement (Overlay)	Periodic	By Condition	Fair to Bad	MBC
	Gravel Earth	Patching	Routine	By Condition	160 cu.m/km	MBC (or MBA)
		Grading	Routine	By Frequency	6 times a year and as needed	MBA
		Regravelling	Periodic	By Frequency	Once in 3 years	MBC or MBA
		Upgrading Unpaved Roads to Bituminous Roads Specially in Mountain Sections	Special		As needed	MBC
Shoulder	PCC	Include PCC shoulder on Carriageway Activities	Routine	By Condition	1.0 cu.m/km	MBA
	AC	Already included on carriageway activities	Routine	By Condition	1.0 cu.m/km	MBA
	Gravel Earth	Patching	Routine	By Condition	10 cu.m/km	MBC (or MBA)
		Grading	Routine	By Frequency	2 times a year	MBA
		Regravelling	Periodic	By Frequency	Once in 5 years	MBC or MBA
		Replacement of Shoulder Material	Periodic	By Condition	40 cu.m/km	MBC (or MBA)
Drainage	Side Ditches	Ditch Cleaning	Routine	By Frequency	2 times a year and as needed	MBA
	Concrete/ Riprap	Repair of Lined Ditches	Routine	-	As needed	MBA
		Cleaning Gutters	Routine	-	As needed	MBA
		Sweeping and Cleaning of Curb in Urban Areas	Routine	-	As needed	MBA
		Cleaning of Covered Canal	Routine	By Frequency	4 times a year and as needed	MBA
	Earth	Cutting New Ditches Over 100 Meters Long in Rock	Special	-	As needed	MBC
	RCPC/ RCBC	Culvert Cleaning	Routine	By Frequency	2 times a year and as needed	MBA
		Machine Clearing Minor Drainage Structure	Routine	-	As needed	MBA
		Digging Inlet and/or Outlet Channel within the Road Right-of-Way		-	As needed	MBA
		Repair to Lateral Drainage Lines (Storm Drains)	Routine	-	As needed	MBA
		Installation of New Culvert Lines Near/ Parallel to Old/ Existing Non-Functioning Culvert	Routine	-	As needed	MBC
		Complete	Routine	-	As needed	MBC

		Replacement of Old/Existing Culvert Lines				
		Repair of Underdrains	Routine	-	As needed	MBA
		Repair of Spillways and other Overflow Structures	Routine	-	As needed	MBA
		Installing New Cross Drainage Pipe Culvert at New Locations	Special	-	As needed	MBC
		Digging Outlet Channels Outside the Road Right-of-Way	Special	-	As needed	MBC or MBA
	Others	Repair and/or Replacement of Minor Structure	Routine	-	As needed	MBC or MBA
Bridge		Cleaning Bridges	Routine	By Frequency	Once a year	MBC or MBA
		Patching Concrete Decks	Routine	By Condition	-	MBA
		Repairs to Concrete Bridges	Routine	By Condition	-	MBA
		Repairs to Steel Bridges	Routine	By Condition	-	MBA
		Repairs to Bailey Bridges	Routine	By Condition	-	MBA
		Repairs to Timber Bridges	Routine	By Condition	-	MBA
		Reconstruction of Temporary Bridges	Special	-	As needed	MBA
		Replacement of Damaged Permanent Bridge with Temporary Bridge	Special	-	As needed	MBA
		Reconstruction of Structural Elements of Permanent Bridges	Special	-	As needed	MBA
		Construction of Major Detours for Roads and Bridges	Special	-	As needed	MBA
		Replacing Timber Decks	Periodic	-	As needed	MBA
		Bridge Repainting	Periodic	-	As needed	MBC
		Providing Bituminous Wearing Course on Bridge Decks	Special	-	As needed	MBC
		Replacement of Bailey Panels	Special	-	As needed	MBA
Roadside Features	Urban/ Rural	Vegetation Control	Routine	By Frequency	4 times a year = 525 pass m/km	MBC or MBA
		Erosion Repair and Control on Roadside	Routine	-	As needed	MBA
		Repair to Major Roadside Structures	Routine	-	As needed	MBA (or MBC)
		Other Roadside Maintenance such	Routine	-	As needed	MBC (or MBA)

		as Painting for Beautification, Maintain Plants				
		Repair of Curbs and Sidewalks	Routine	-	As needed	MBA
		Street Cleaning	Routine	-	As needed	MBA
		Construct New Slope Protection Structure	Special	-	As needed	MBC
		Sodding Slopes	Special	-	As needed	MBC (or MBA)
Traffic	Road Markers	Centerline and Lane Line Repainting (Manuel or by machine)	Routine Special	By Frequency	Twice a year @ 500 m/km	MBC (or MBA)
		Repainting Channelization Curbs for Traffic Control Purpose	Routine	-	As needed	MBC (or MBA)
		Repainting Edgelines	Routine	By Frequency	Twice a year	MBC (or MBA)
		Repainting Pedestrian Crosswalks Approach to Islands, Stop Lines and Pavement Messages	Routine	-	As needed	MBC (or MBA)
	Traffic Sign	Sign Maintenance	Routine		50% of total no. of signs (once a year)	MBA
		Sight Distance Mowing and Clearing Vegetation to Improve Sign Visibility	Routine	Once a year	Covered by Vegetation Control	MBA or MBC
		Washing and Cleaning Traffic Signs, Hazard Marker and Guardrails	Routine	By Frequency	Once a year	MBA
		Traffic Signal Light Maintenance	Routine		As needed	MBA
		Removal of Unauthorized Signs	Routine		As needed	MBA
		Placing New Traffic Signs at New Location	Special		As needed	MBA
		Placing New Km Post and Culvert Marker	Special		As needed	MBA
	Guardrails	Guardrail Maintenance	Routine	Once a year	25% total length of guardrail a year	MBA
		Sight Distance Mowing and Clearing Vegetation to Improve Guardrail Visibility	Routine	By Frequency	Covered by Vegetation Control	MBA or MBC
		Washing and Cleaning of Guardrails	Routine	By Frequency	Once a year	MBA
		Installation of New Guardrails	Special	-	As needed	MBC

	Islands	Maintenance of Pedestrian and Vehicular Island	Routine	-	As needed	MBA
Emergency Works		Initial Response to Emergencies (Roads)	Routine	-	As needed	MBA
		Initial Response to Emergencies (Bridges)	Routine	-	As needed	MBA
		Emergency Projects	Routine	-	As needed	MBC or MBA
Supervision Support and Overhead		Production of Bituminous Premix	Routine	-	As needed	MBA
		Other Materials Production/ Handling	Routine	-	As needed	MBA
		Indirect Cost Work or Expenses	Routine	-	As needed	MBA
		Other Work or Expenses	Routine	-	As needed	MBA
		Foreman Supervision	Routine	-	As needed	MBA
		Unproductive Time	Routine	-	-	MBA
		Motorized Equipment Training	Routine	-	-	MBA

9.3.2 Priority of Maintenance Activities

Since the maintenance budget is far below actual requirements and maintenance level proposed in **Section 9.3.1** could not be achieved, therefore DPWH shall select priority maintenance activities focusing on the following aspects;

PRIORITY MAINTENANCE ACTIVITIES

- Maintenance of paved carriageways shall be given top priority to protect past capital investment.
- Road maintenance of roads serving higher traffic volume shall be given higher priority than those serving less traffic.
- Maintenance of gravel/earth roads in very bad condition shall be given the lowest priority which are usually beyond economically maintainable condition. Instead, DPWH-ARMM should plan the capital investment for such roads to fundamentally improve the condition.
- Among routine maintenance works, cleaning of pipe-culverts, box-culverts and side ditches shall be given top priority, so that the pavement can be protected.
- Frequency of shoulder maintenance, roadside features and traffic/guide signs can be reduced.