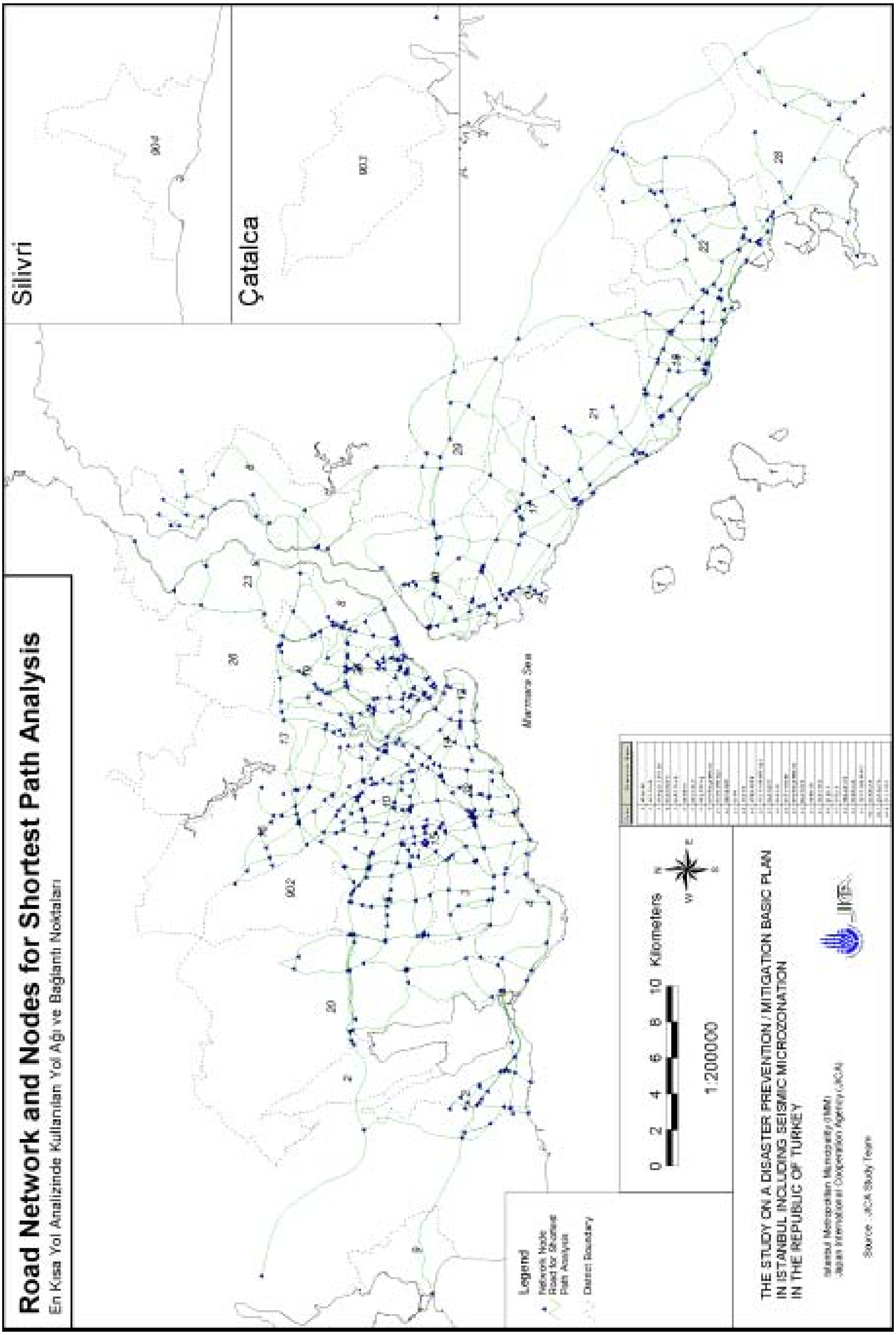

Figure 9.6.17 Road Network and Nodes for Shortest Path Analysis

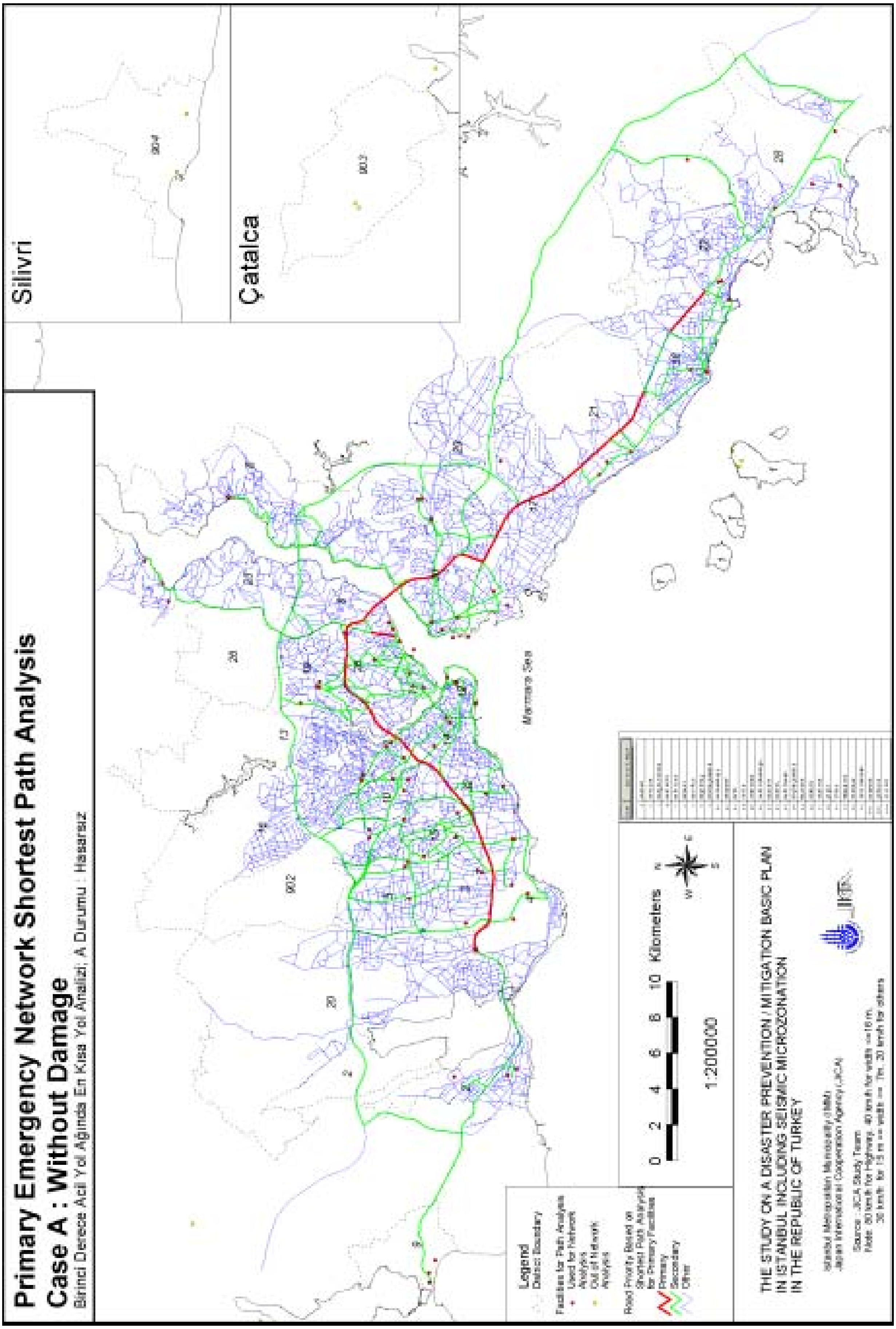

Figure 9.6.18 Primary Emergency Network Shortest Path Analysis Case A : Without Damage

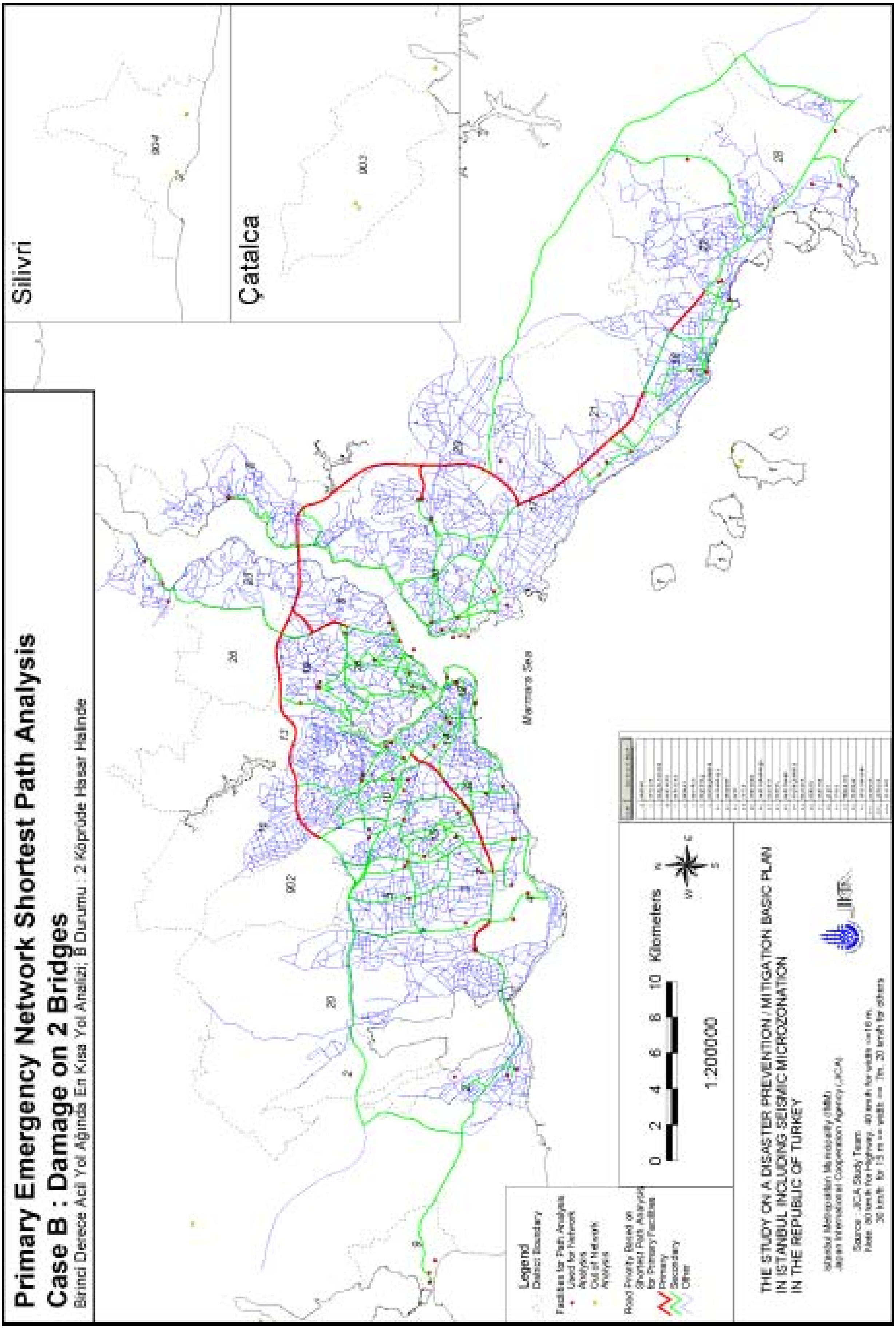

Figure 9.6.19 Primary Emergency Network Shortest Path Analysis Case B : Damage on 2 Bridges

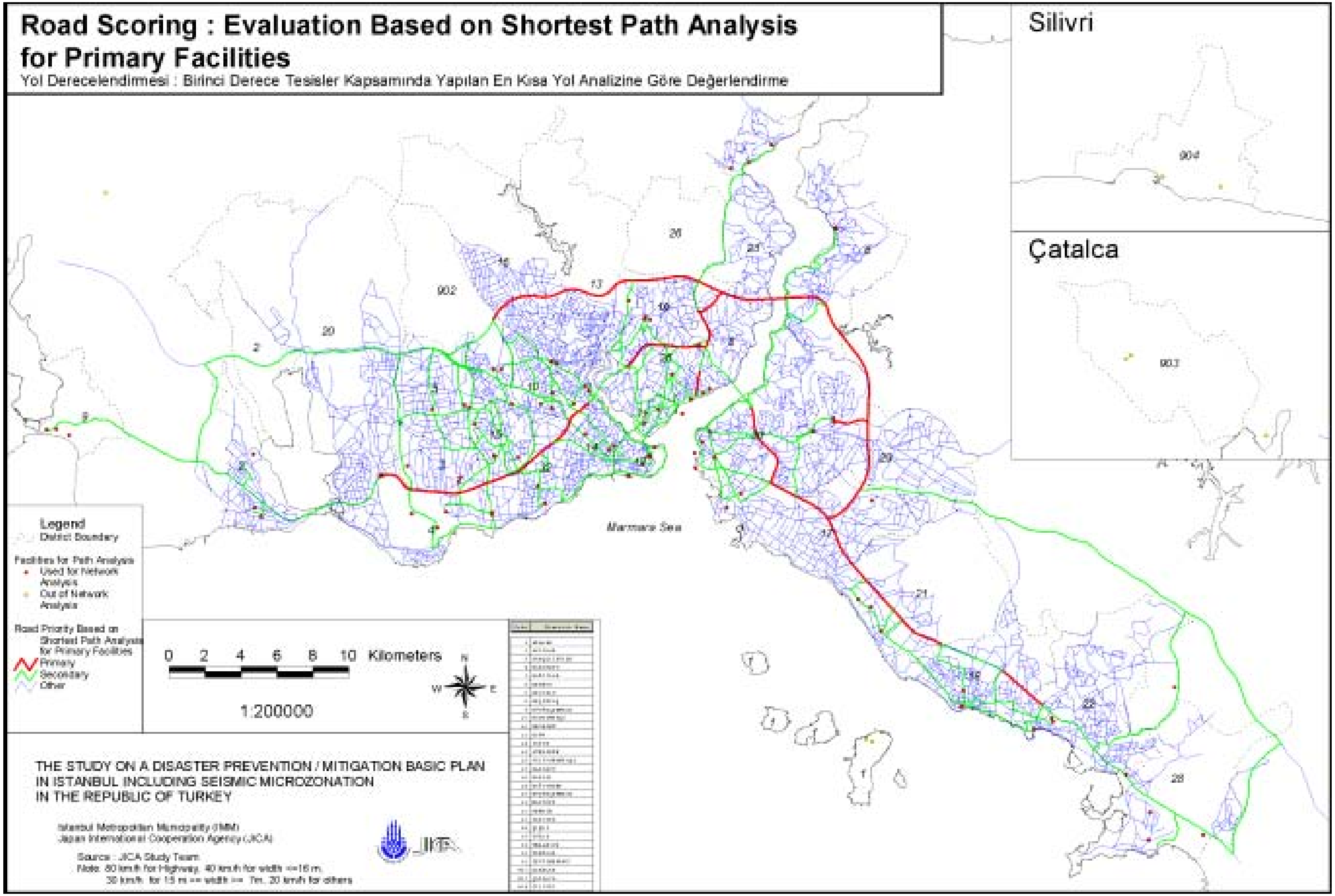

Figure 9.6.20 Road Scoring : Evaluation Based on Shortest Path Analysis for Primary Facilities

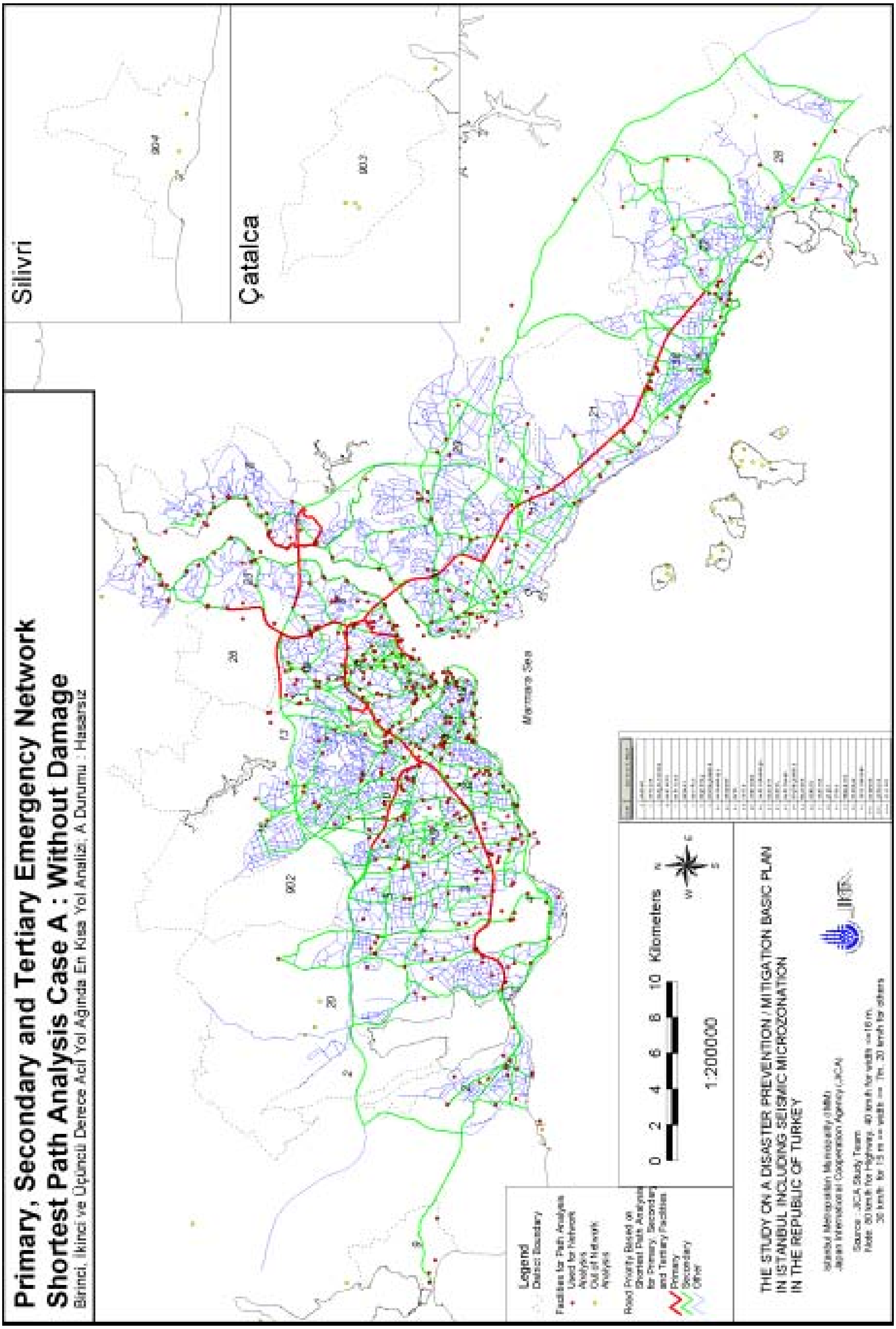

Figure 9.6.21 Primary, Secondary and Tertiary Emergency Network Shortest Path Analysis Case A : Without Damage

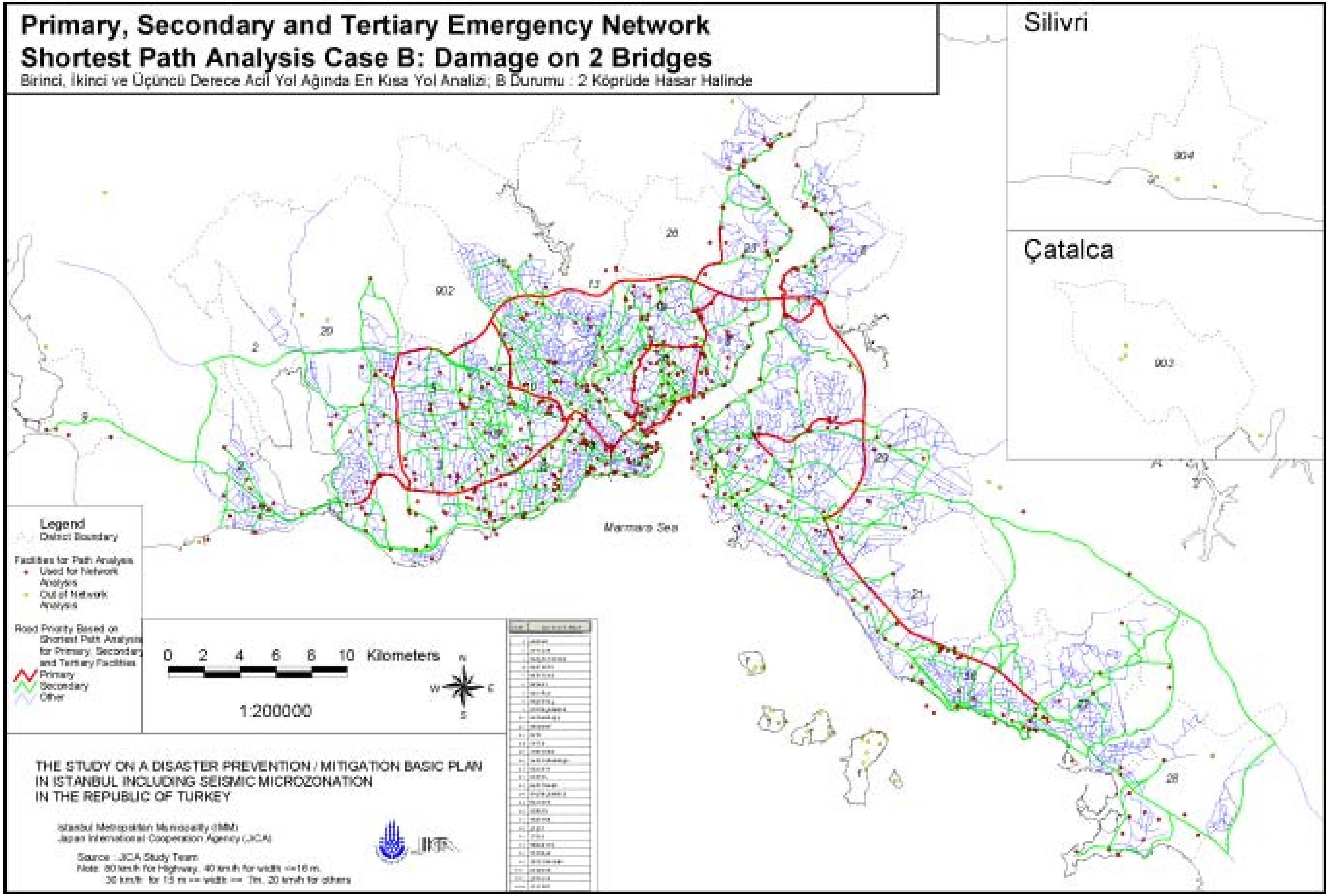

Figure 9.6.22 Primary, Secondary and Tertiary Emergency Network Shortest Path Analysis Case B: Damage on 2 Bridges

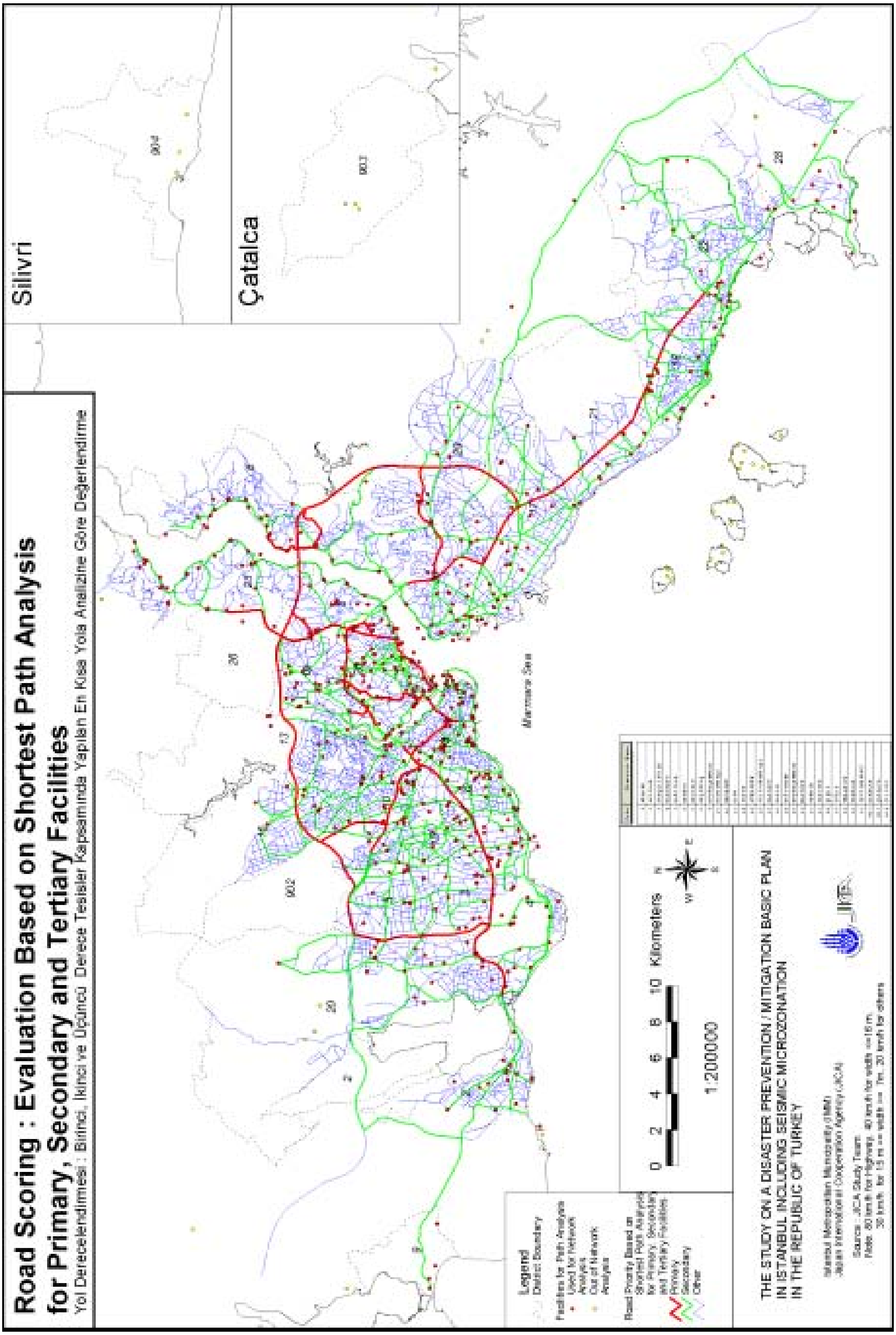

Figure 9.6.23 Road Scoring : Evaluation Based on Shortest Path Analysis for Primary, Secondary and Tertiary Facilities

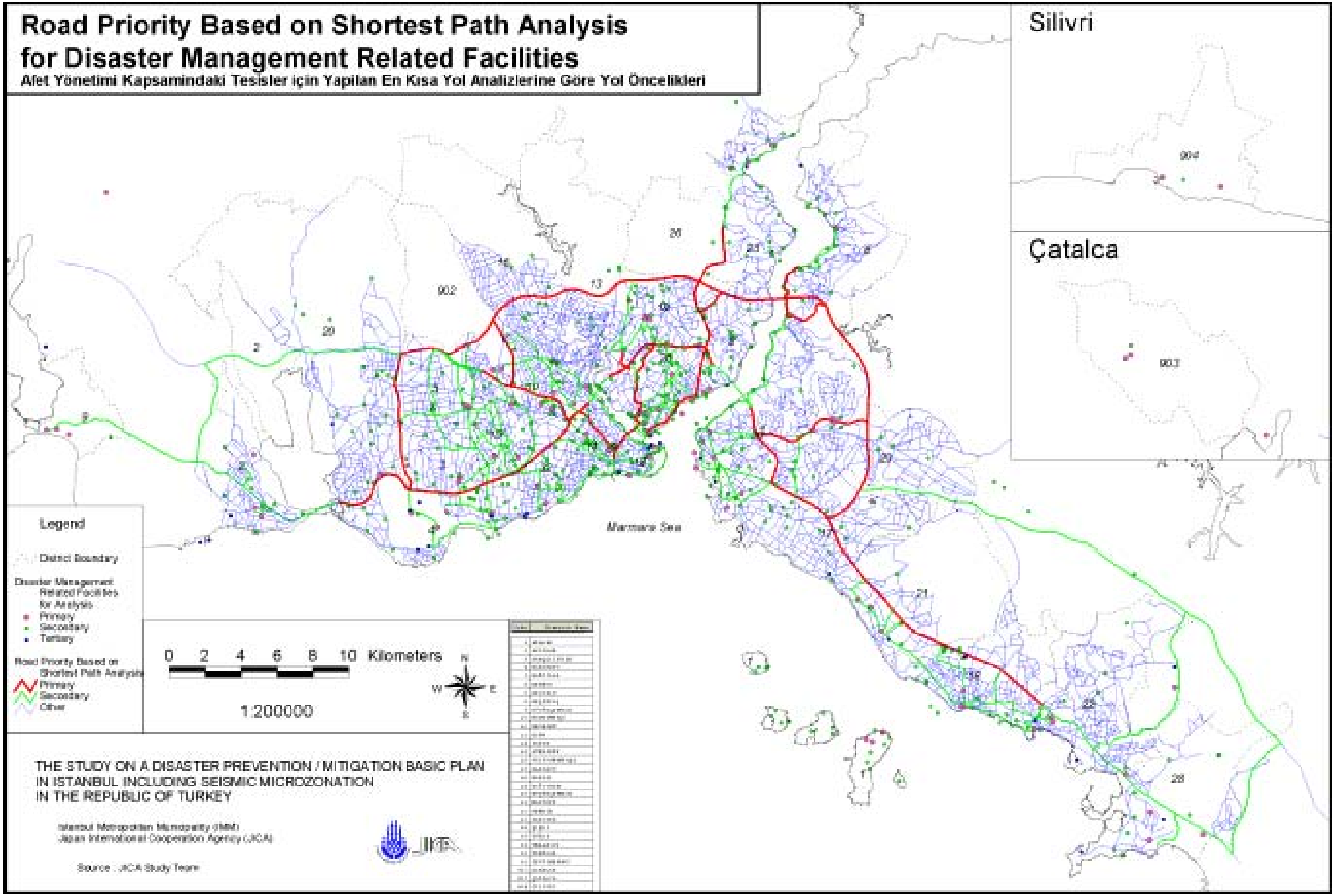

Figure 9.6.24 Road Priority Based on Shortest Path Analysis for Disaster Management Related Facilities

c. Importance Evaluation in Route and Section

IM, the integrated importance of routes and sections, is determined by applying the evaluation matrix shown in Table 9.6.4 to IA, the importance evaluation of routes and sections based on attributes, and to IN, the evaluation of routes and sections based on network characteristics. Based on the evaluation result, routes and sections are categorised as 3 classes: “most important,” “important,” and “general.”

Figure 9.6.25 shows the result of the importance evaluation of routes and sections based on such an evaluation matrix. Routes and sections of the roads in the surveyed area are categorised according to their importance as shown in

Figure 9.6.25. The result of the evaluation seems to be practical and reasonable: main loop lines, which are national traffic axes, and main radial lines connected to the loops are particularly important routes and sections. Thus, the most effective reinforcement and maintenance measures to protect roads from earthquake disasters become apparent by establishing a prioritisation order of the measures to protect bridges from earthquake disasters and road maintenance efforts. This order is based on the importance evaluation results of routes and sections.

Table 9.6.4 Evaluation Matrix of Importance of Route and Section

		Importance Based on Network Characteristic I_N		
		Very Important	Important	Relatively Important
Importance Based on Attribute I_A	Very Important	Primary		
	Important		Secondary	
	Relatively Important			Other

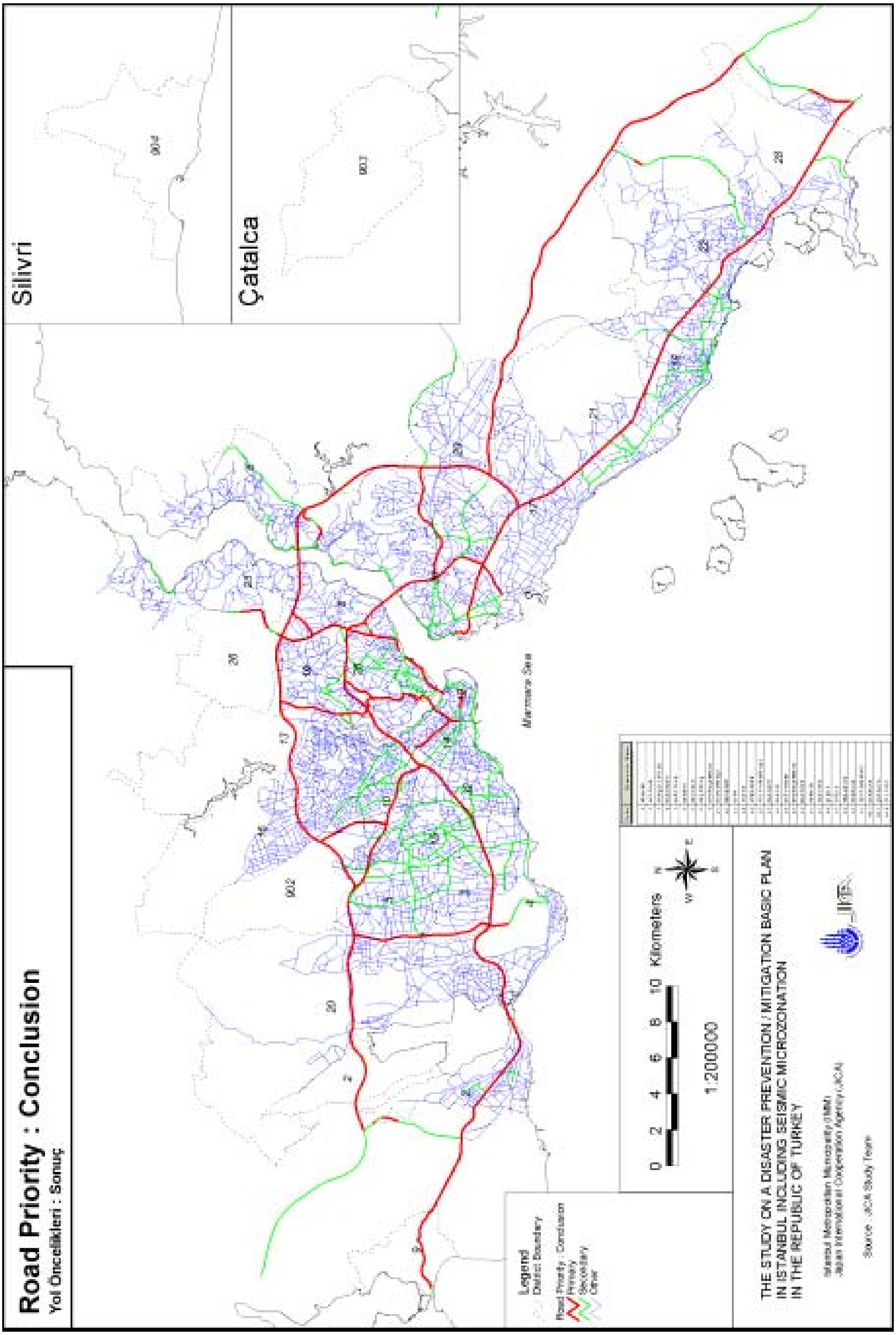

Figure 9.6.25 Road Priority : Conclusion

(2) Impact Evaluation of Bridge Collapse

Evaluation Method

In regard to the earthquake resistance of bridges, two types of bridges were extracted in section 9.5 Bridges as those that should be subject to earthquake-proof measures: 1) “bridges which will possibly collapse” and 2) “bridges built on alluvium having PGA >= 300g and piers longer than 10m.”In this regard, to begin with, the prioritisation of earthquake-proof measures for these two types of bridges is evaluated. Then, the impact when the bridges are damaged is evaluated.

The extent of the impact when a bridge is damaged is evaluated by the extended influence caused by its collapse and/or the significantly damaged substructure of the bridge. The factors taken into consideration are whether there are long or large bridges on the main road and how the sites under the bridges are utilised. In this regard, the extent of the impact due to the bridge’s damage, as well as the importance of the relevant routes and sections, are taken into consideration. The score for these factors are shown in section 9.5 Bridges, which have been extracted as the ones that require earthquake-proof measures, and the strength of the impact of a bridge collapse is expressed by the total sum of the products obtained by multiplying these scores, or points, by the weight coefficients. Namely, E, the impact of a bridge collapse, is expressed by the following formula:

$$E = \sum_{k=1}^{m} \sigma_k \cdot Y_k$$

E : The Bridge is an Impact when Struck

σ_k : Weight Coefficient of Factor k

Y_k : Points in Evaluation of Factor k

The higher the value of E, the larger the impact caused by a bridge’s collapse. In evaluating its degree or extent, the impact is categorised into 3 groups, “extremely large,” “large” and “general,” referring to the histogram of the points E as shown in Table 9.6.5.

Shown in Table 9.6.6 are the factors, their total scores, or points, and the weight coefficients for individual factors used in the calculation of Impact E.

Table 9.6.5 Importance evaluation matrix on earthquake disaster prevention of bridge

		Importance of Earthquake-Proof Measures		
		Very Important	Important	Relatively Important
Impact when struck	Extremely Large	Very Important		
	Large		Important	
	General			Relatively Important

Table 9.6.6 Factor of Impact and Weight of Points in Evaluation

Factor			Points in Evaluation Xj	Weight Coefficient Wj
Type of Road Bridge	Long Bridge on Main Line	The importance in the route and the section is the most important.	3	10
		The importance in the route and the section is important.	2	
		The importance in the route and the section is general.	1	
		Others	0.5	
Railway Bridge	Long Bridge on Main Line	Traveler Line	2	10
Type Under Bridge	Road	The importance in the route and the section is the most important.	3	5
		The importance in the route and the section is important.	2	
		The importance in the route and the section is general.	1	
		Others	0.5	
	Railway		2	

<u>Evaluation Result</u>

<u>Priority Evaluation based on Necessity of Earthquake-Proof Measures</u>

Table 9.6.7 and Table 9.6.8 show the prioritisation evaluation matrixcs based on the need for earthquake-proof measures for “ bridges which will possibly collapse” and “bridges built on alluvium having PGA >= 300g and piers longer than 10m.” The figures in Table

9.6.7 are the number of bridges studied. There are 4 bridges having first priority with regards to need for earthquake-proof measures, 17 bridges with second priority, and 6 bridges with third priority..

Table 9.6.7 Priority based on Necessityof Earthquake-Proof measures

		Judge1-1 ;Dropping Bridges		
		1	2	3
Judge1-2 ; Pier	1	4	2	2
	2	0	0	37
	3	15	4	Rest of Bridges

Impact Evaluation of Bridge Collaps

Figure 9.6.26 is a histogram showing the resulting impact whenbridges suffer earthquake damage. The degrees of impact are grouped into 3 classes, “extremely large,” ”large” and “general,” which are also shown in **Figure 9.6.26**.

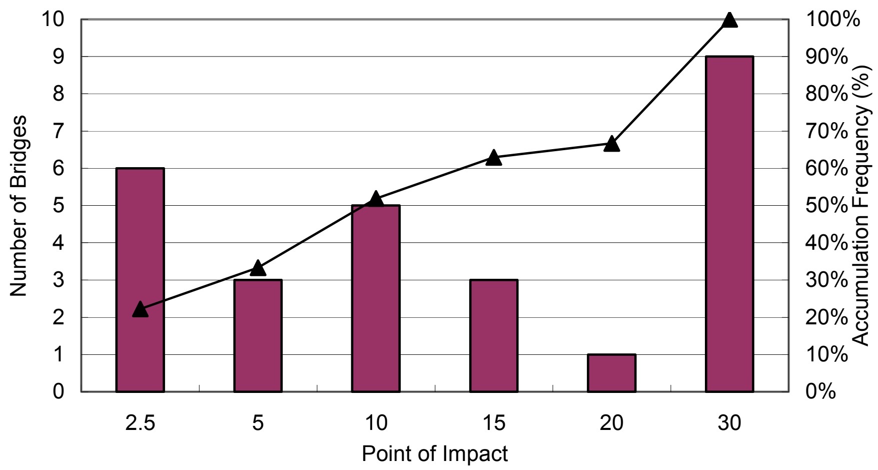

Figure 9.6.26 Distribution of Point of Impact by Bridge Collapse

Table 9.6.8 Earthquake-Proof Evaluation and Priority Evaluation of Bridges

ID	BRIDGE _NO	Dropping Bridges			Pier			Earthquake-Proof	Impact of collapse		Priority
		Evaluation_ A	Evaluation_ C	Judge1-1	10m or more	PGA_GAL_ model_C	Judge1-2	Judge1	Score	Judge2	
94	1	B	B	2	1	333.5	1	2	30	1	1
223	52	A	A	1	1	480.1	1	1	30	1	1
103	55	B	B	2	1	325.1	1	2	30	1	1
95	57	A	A	1	1	456.4	1	1	30	1	1
89	58	A	A	1	1	473.6	1	1	30	1	1
88	89	A	A	1	0	475.5	3	2	20	2	2
143	188	A	A	1	1	479.3	1	1	30	1	1
157	190	A	A	1	0	326.9	3	2	2.5	3	3
114	191	A	A	1	0	352	3	2	5	3	3
262	AK3	C	A	2	0	473.2	3	3	2.5	3	3
264	AK4	C	A	2	0	471.4	3	3	2.5	3	3
265	AK5	A	A	1	0	476.1	3	2	2.5	3	3
308	MT110	A	A	1	0	329.2	3	2	15	2	2
310	MT112	A	A	1	0	328.4	3	2	15	2	2
349	MT86	A	A	1	0	476	3	2	30	1	1
350	MT87	A	A	1	0	476	3	2	30	1	1
351	MT88	A	A	1	0	476	3	2	15	2	2
355	MT94	A	A	1	0	419.4	3	2	30	1	1
380	T28A	A	A	1	0	413.2	3	2	10	2	2
381	T28B	A	A	1	0	413.2	3	2	10	2	2
384	T30	B	B	2	0	479.5	3	3	2.5	3	3
386	T33	A	A	1	0	302.6	3	2	2.5	3	3
388	T4	A	A	1	0	402.4	3	2	5	3	3
389	T5	A	A	1	0	493.8	3	2	10	2	2
434	UAS17	C	B	2	0	470.4	3	3	10	2	3
279	M1-3-A	C	C	3	1	307.6	1	3	10	2	3
455	YIM5	C	C	3	1	379.9	1	3	5	3	3

Then, the results of the prioritisation evaluation based on the need for earthquake-proof measures and the impact when bridges are damaged are evaluated by means of the matrices shown in Table 9.6.9 and Figure 9.6.27. The bridges classified as having high priority for earthquake-proof measures and causing an extremely strong impact when damaged are those that are on the main loops, spanning valleys, etc.

Table 9.6.9 Importance Evaluation of Bridge

		Judge1 ; Importance of Earthquake-Proof Measures		
		Very Important	Importanct	Relatively Important
Judge2 ; Impact when Struck	Extremely Large	52, 57, 58, 188	1, 55, MT86, MT87	
	Large		89, MT110, MT112, MT88, MT94,T28A, T28B, T5	M1-3-A
	General		190, AK5, T33, T4	AK3, AK4, T30, UAS17,YIM5

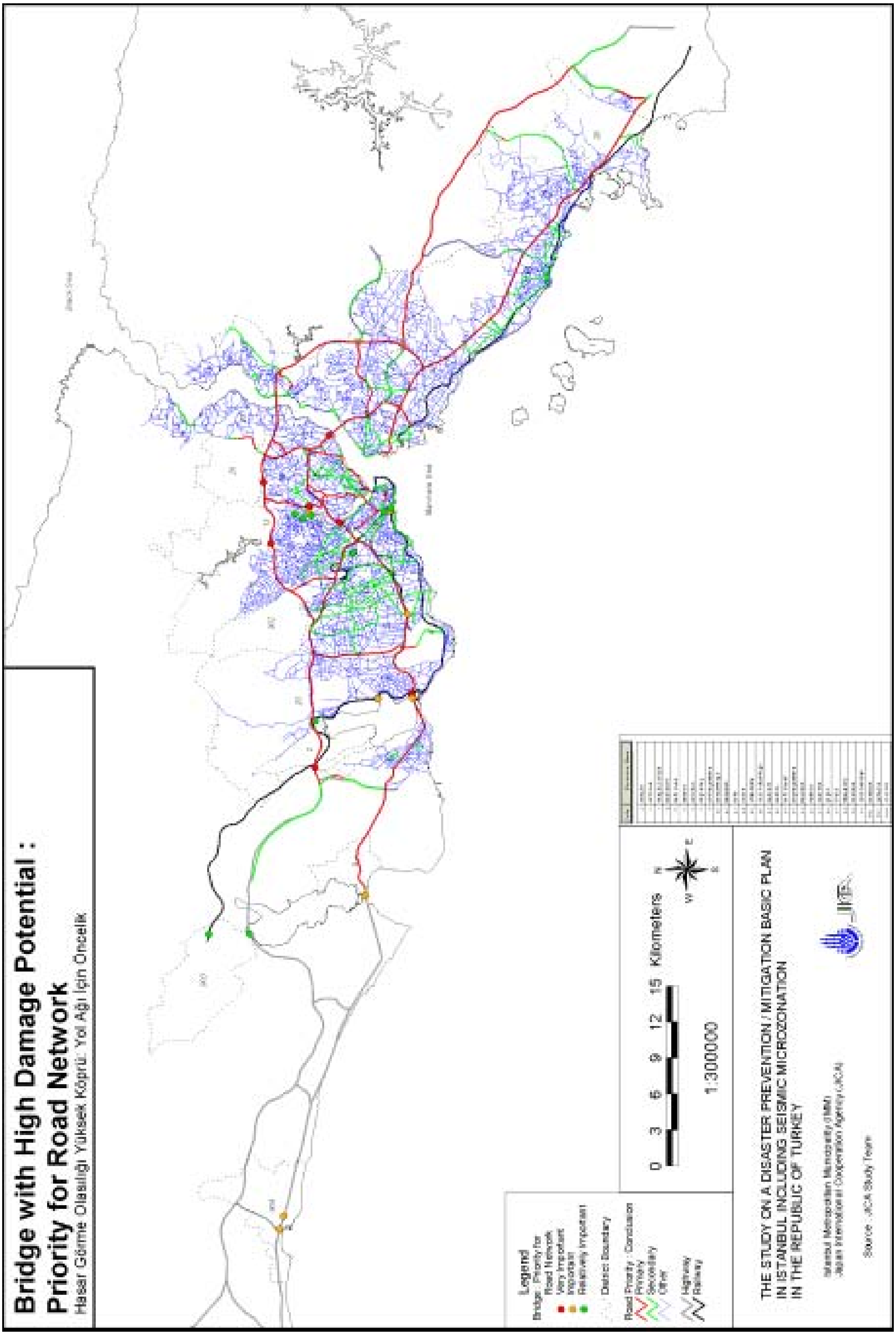

Figure 9.6.27 Bridge with High Damage Potential : Priority for Road Network

(3) Importance Evaluation on Earthquake Disaster Prevention of Road and Bridge

As understood from the evaluation results described above, the main loop lines and main radial lines connected to them can be regarded as the most important roads in the area studied. As explained previously, these loop and radial lines are the routes that form the national traffic axes, and the evaluation results reflect the actual traffic situation in general. The routes that have been extracted as secondarily important are the roads in the modernised city that are actually functioning as primary urban traffic, and the evaluation result reflects their actual traffic situation in general, too.

The importance evaluation of roads considers earthquake disaster prevention. As described above, the evaluation results generally coincide with the forms, operations, and functions of actual roads. It is desirable, therefore, that road maintenance work and earthquake-proof during normal times and in preparing against earthquakes be proceeded with according to the prioritised order identified by the importance evaluation.

Then, the prioritised order regarding earthquake-proof measures for bridges is established from the results of the importance evaluations of road networks and bridges. Also taking into consideration the impact suffered when bridges are damaged by an earthquake, the importance of bridges needing earthquake reinforcement was evaluated and results are shown in Table 9.6.10. Roads and bridges are collectively evaluated by means of the matrix shown in Table 9.6.11, which was prepared based on the above result and the importance of routes and sections. Namely, the priority of earthquake-proof measures for bridges is decided based on this evaluation's result.

Table 9.6.10 Importance Evaluation of Bridge

Importance of Bridge	Bridge No.		Number of Bridges
	Height of Pier H>=10m	Height of Pier H<10m	
Most Importance	52, 57, 58, 188, 1, 55	MT86, MT87, MT94	9
Importance		89, MT110, MT112, MT88, T28A, T28B, T5	7
General	M1-3-A, YIM5	190, 191, AK5, T33, T4, UAS17, AK3, AK4, T30	11

Collectively shown in Figure 9.6.28 is the evaluation result from the matrix in Table 9.6.11 and the result of the importance evaluation of road network. The highest priority regarding need for earthquake-proof measures for bridges is given when the importance of the bridge is high and that of the road is high. Table 9.6.12 shows the 5 levels of priority regarding earthquake-proof measures, and each level includes about 6 bridges. The most effective result for disaster prevention is achieved when earthquake reinforcement is systematically implemented based on this obtained priority order.

Table 9.6.11 Importance Evaluation on Earthquake Disaster Prevention

		Importance in Route and Section		
		Primary	Secondary	Other
Importance Evaluation of Bridge	Very Important	Primary		
	Important		Secondary	
	Relatively Important			Teritary

Table 9.6.12 Priority Level of Earthquake-Proof Measures

Stage of measures	Bridge No.	Number of Bridges
1	52, 57, 58, 188	4
2	MT86, MT87, MT94, 1, 55	5
3	89, MT110, MT112, MT88, T28A, T28B, T5	7
4	190, 191, UAS17, M1-3-A, AK5, T33, T4	7
5	YIM5, AK3, AK4, T30	4

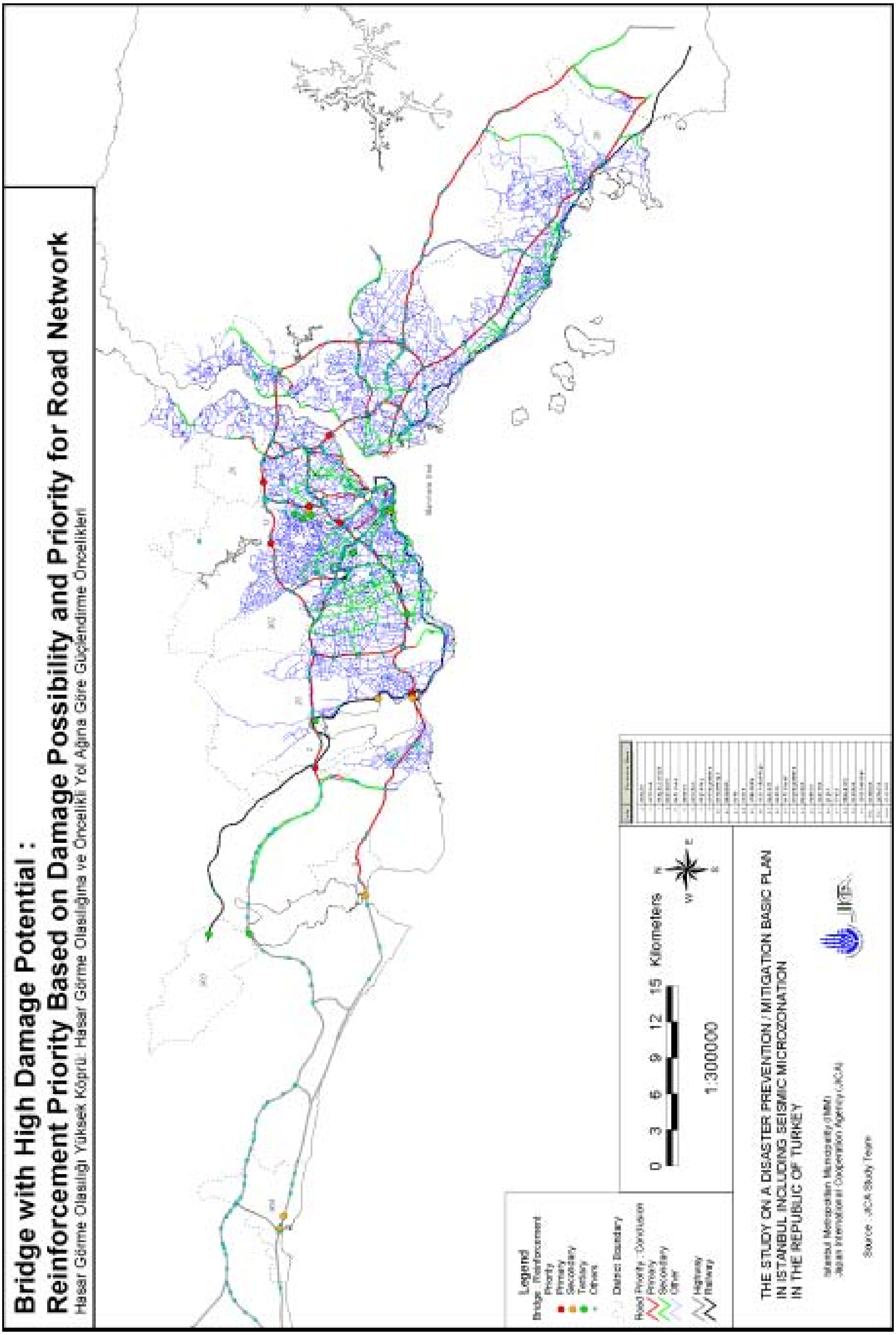

Figure 9.6.28 Bridge with High Damage Potential : Reinforcement Priority Based on Damage Possibility and Priority for Road Network

9.6.3. Estimation of Probable Road Blockage by Collapsed Buildings

Roads have both a traffic function and a space function, and serve for traffic of automobiles and walking persons, as access to various facilities along the roads or as spaces to accommodate infrastructures (for power supply, telephones, gases, etc.) under normal circumstances. On the other hand, in case of emergency like a disastrous earthquake, they serve for traffic of emergency vehicles and as spaces for evacuation or prevention of fire spreading. Therefore, arrangement for preventing roads from being blocked is required to secure an adequate road function in case of emergency. Especially in the City of Istanbul, roads are the most important transportation medium to support a function as a metropolis. Therefore, it is desirous to estimate in advance to what extent a road function can be secured in case of emergency and to promote a plan for arrangement of roads and urban areas in the future based on the result of estimation. From this point of view, the estimation of probable road blockage due to collapsed buildings will be discussed based on an estimate on probable damages to the buildings. The term of "road blockage" in this report is defined as a case where a passage wider than three (3) meters cannot be secured to allow the smallest vehicles to go through after the buildings, etc. are collapsed (Figure 9.6.29).

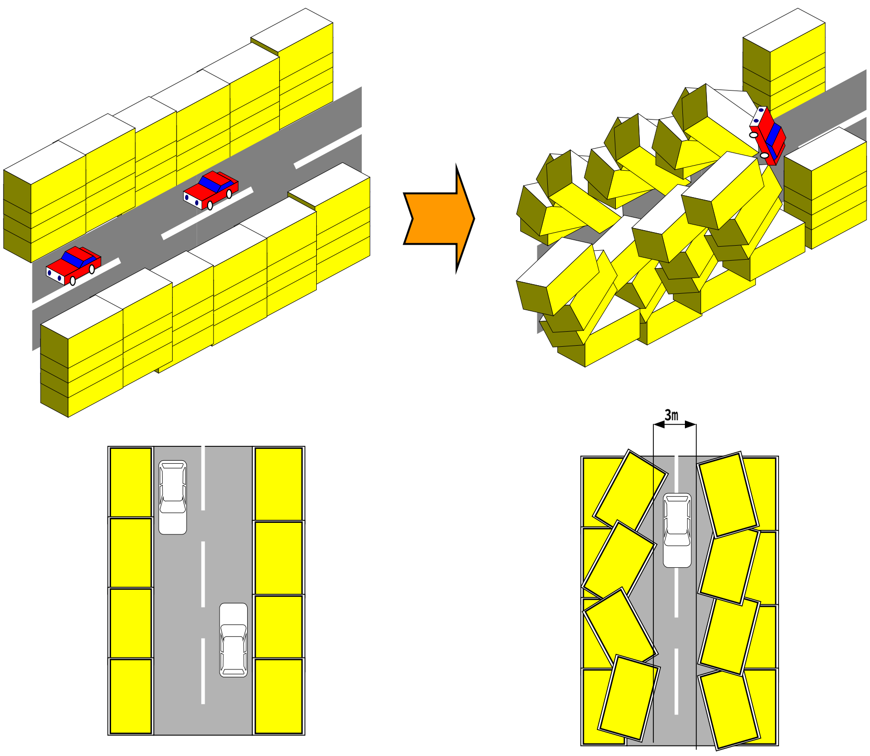

Figure 9.6.29 Definition of Road Blockage

(1) Estimation Procedures of Probable Road Blockage

It is possible to estimate whether a road will be blocked by buildings collapsed as a result of a disastrous earthquake or not from various factors such as conditions of the buildings, width of the collapsed buildings and conditions of the roads and routes. In other words, various factors as shown in Figure 9.6.30 are related.

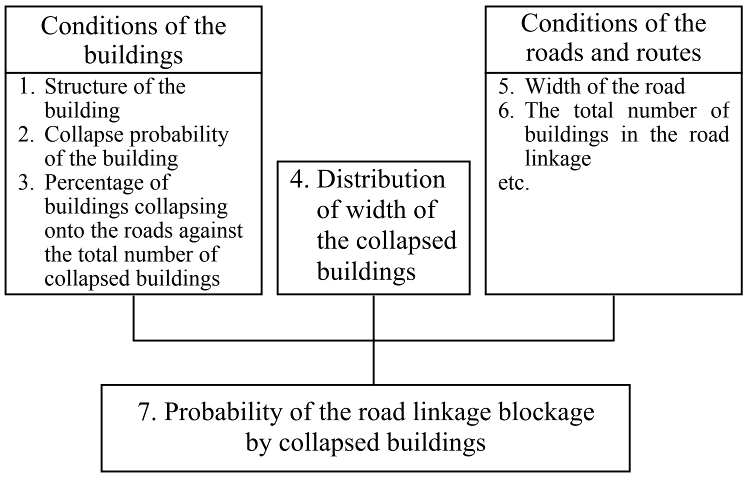

Figure 9.6.30 Factor of Road Blockage

The probability of the road blockage can be estimated by hypothesizing some conditions and the corresponding values for each of the above-mentioned factors. We set the following conditions and values herein to estimate the road blockage probability.

- The road blockage probability will be estimated for each grid of 500 meters square.
- The building collapse probability in each grid of 500 meters square shall be in the case of Model-C earthquake motion.
- The probability of buildings collapsing onto the roads will be hypothesized as 100%.
- Roads as an object of this report are ones of 2 to 6 meters, 7 to 15 meters and of 16 meters or more, as already classified.
- Road linkage shall be a total extension of the roads in a grid of 500 meters square, and buildings are hypothesized to connect to the routes.

In other words,

- The probability of buildings collapsing onto roads is equal to the building collapse probability in a grid of 500 meters square × 1.0.

- The probability of buildings on both sides of the roads collapsing onto the roads is equal to the second power of the collapsing probability of buildings in a grid of 500 meters square multiplied by 1.0.
- The width of a passage that the smallest vehicles can go through after building collapse is hypothesized as 3 meters.
- The probability that a sum of the width of collapsed buildings exceeds the width of remaining road is hypothesized to be 98% for roads of 2 to 6 meters wide, 11% for roads of 7 to 15 meters wide and 0.3% for roads wider than 16 meters respectively from the cases obtained in the Kobe Earthquake

(2) Estimation of Road Blockage Probability of Each Road Type

a. Road Blockage Probability of Roads of 2 to 6 Meters Wide

Estimates of the road blockage probability of roads of 2 to 6 meters wide are shown in Figure 9.6.31. Areas where the road blockage probability is estimated higher than 50% are supposed to be south of the European side and the Asian side. These areas are heavily inhabited areas and road blockage occurs at an area where the building collapse probability is estimated high. Such narrow roads are developed in areas where buildings stand close together, and they are being used as street. Therefore, it is worried that the road blockage caused by collapsed buildings may give serious difficulties to evacuation and rescue activities.

b. Road Blockage Probability of Roads of 7 to 15 Meters Wide

Estimates of the road blockage probability of roads of 7 to 15 meters wide are shown in Figure 9.6.32. Areas where the road blockage probability is estimated higher than 50% are supposed to be a part of the European side. Although roads of 7 to 15 meters wide have neither a function of principal road nor a function of a wide network, they have access to the principal roads and are placed inside and around the residential areas. Therefore, access to the living quarters and others will become difficult and some areas will be isolated, if roads having such functions were blocked.

c. Road Blockage Probability of Roads of 16 Meters Wide or More

Estimates of the road blockage probability of roads of 16 meters wide or more are shown in Figure 9.6.33. Roads over 16 meters in width are supposed to hardly encounter road blockage due to collapsed buildings. Therefore, such roads are supposed to have little possibility of encountering difficulties for transit of vehicles, even if buildings fell down onto roads.

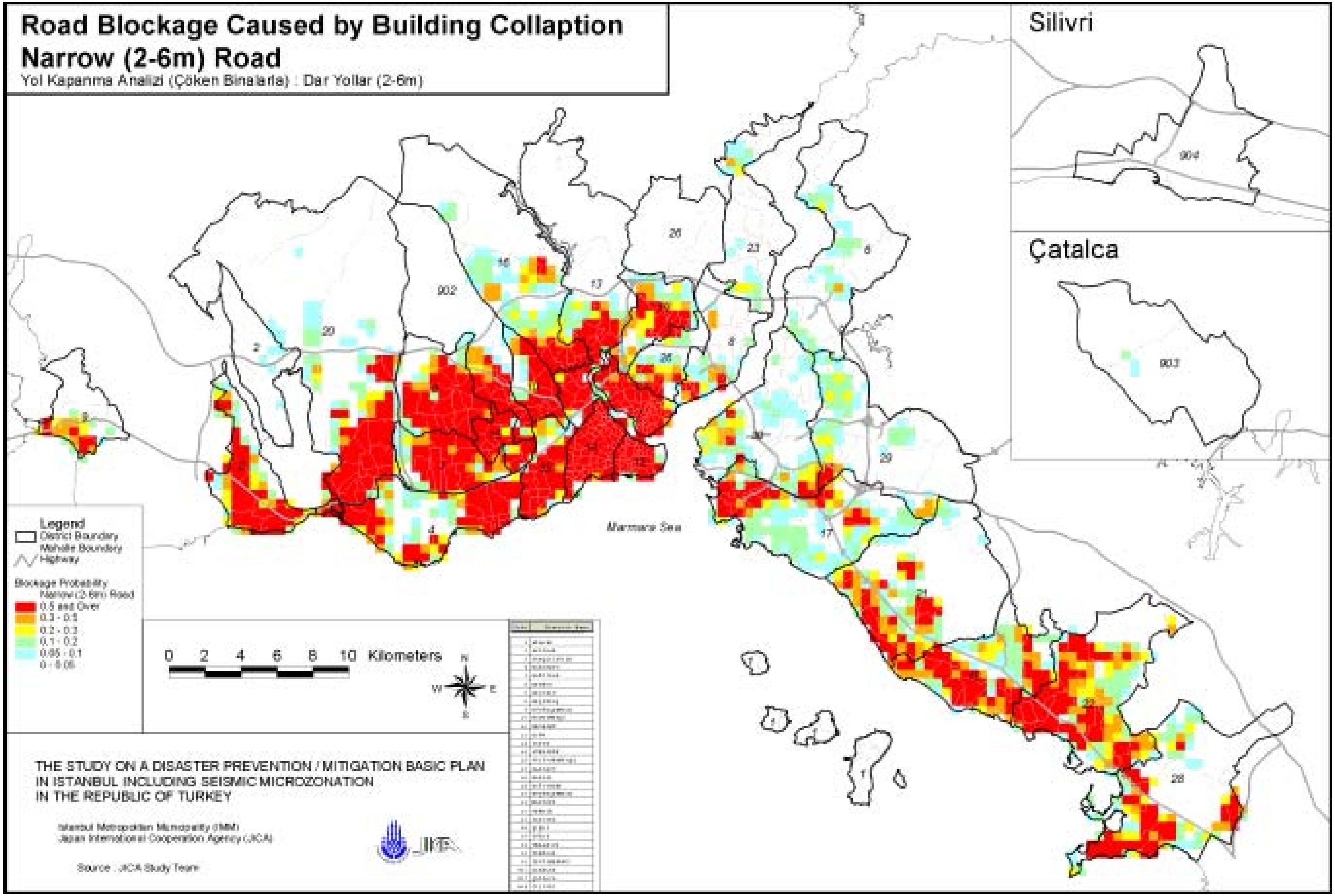

Figure 9.6.31 Road Blockage Caused by Building Collaption Narrow (2-6m) Road

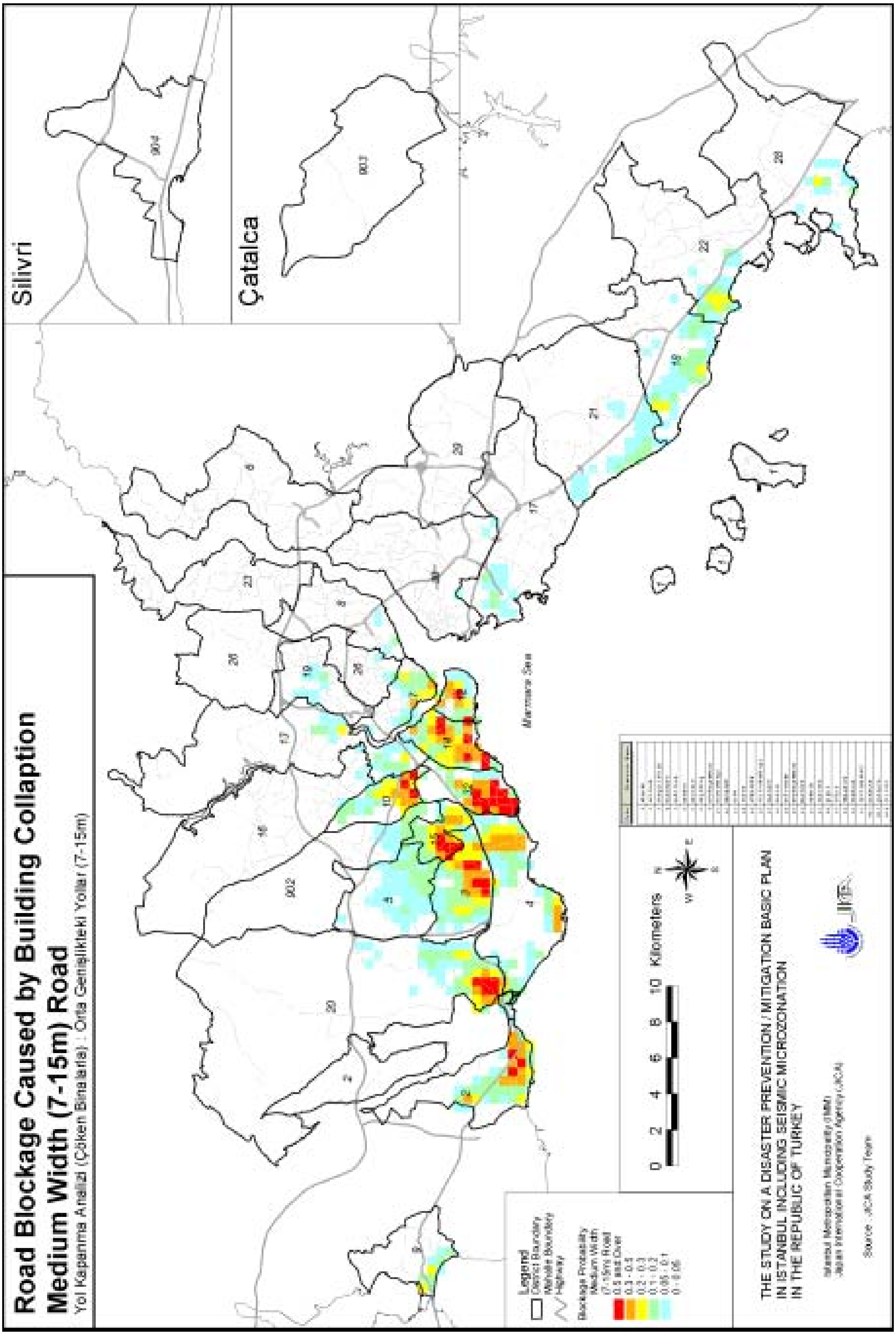

Figure 9.6.32 Road Blockage Caused by Building Collaption Medium Width (7-15m) Road

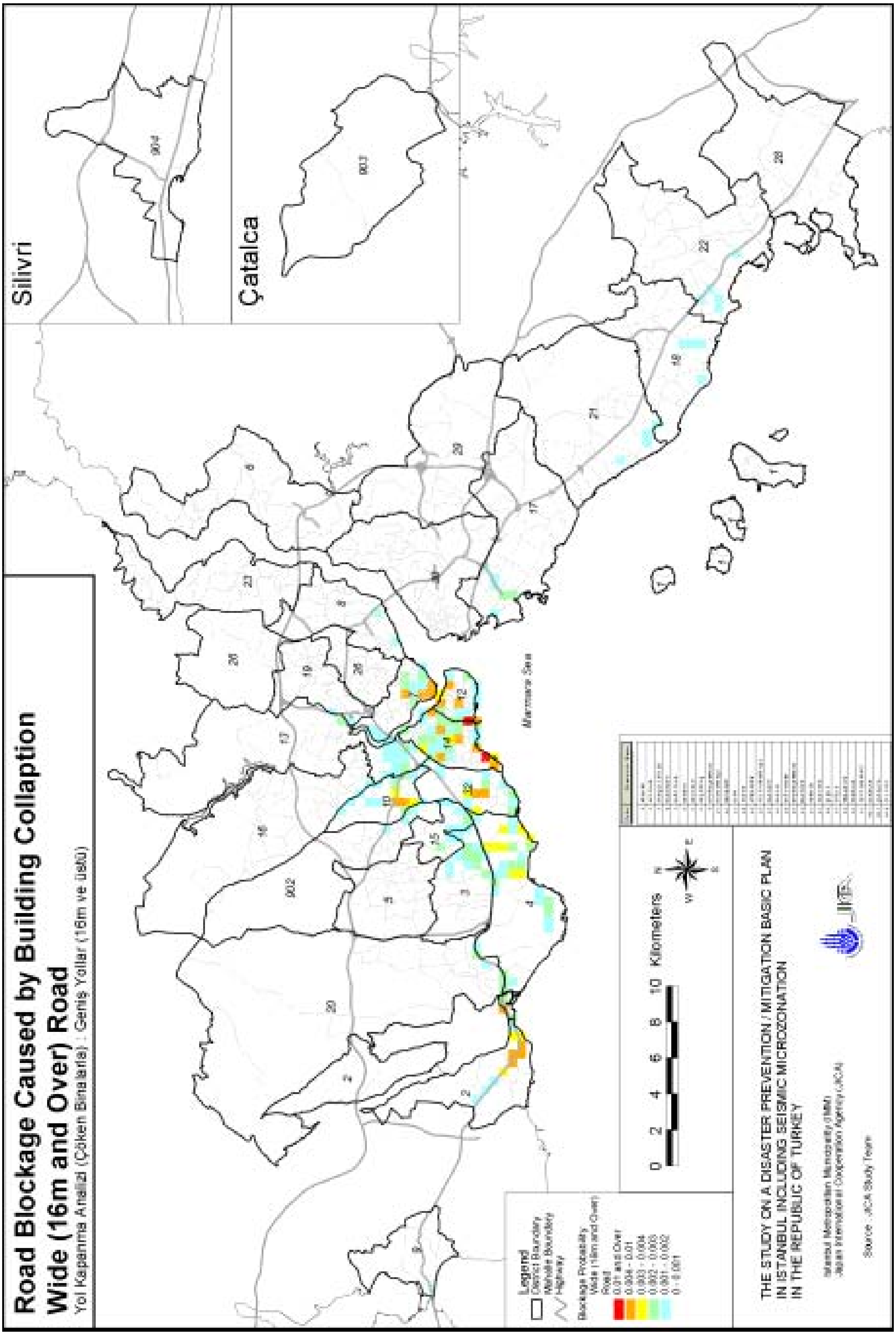

Figure 9.6.33 Road Blockage Caused by Building Collaption Wide (16m and Over) Road

(3) Presumption of Isolation District According to Road Blockage

Possibility of isolation especially by road blockage was assessed based on the results obtained from the estimates of road blockage due to collapsed buildings as above-mentioned. Estimation results were sorted to four indices, namely “Very risky”, “Risky”, “Slightly risky” and “Low risk”. Relations between indices and road blockage assessment were estimated as follows:

Table 9.6.13 Relation between Index and Road Blockage of Evaluation

Risk of isolation	State of road blockage	
	Road of 2–6 meters wide	Road of 7-15 meters wide
Very risky	Most of roads are blocked.	-
	Blockage probability is higher than 50%.	No road of 7-15 meters wide exists.
	Blockage probability is higher than 50%.	Blockage probability is higher than 50%.
Risky	Blockage probability is higher than 50%.	Blockage probability is 30 to 50% or higher.
Slightly risky	Blockage probability is 30 to 50% or higher.	No road of 7-15 meters wide exists
	Blockage probability is higher than 50%.	Blockage probability is 10 to 20% or higher.
Low risk	Other than above-mentioned	Other than above-mentioned

Areas that are supposed to be isolated by road blockage are shown in Figure 9.6.34, based on the assessment indices shown in Table 9.6.13. According to this assessment, many areas on the south of the European side are supposed to be isolated. In such areas that are isolated by road blockage, remarkable difficulties will be encountered in evacuation and rescue activities, removal of collapsed buildings and transportation of commodities. Therefore, a new policy on road arrangement and improvement of land utilization will be required to reduce a risk of isolation.

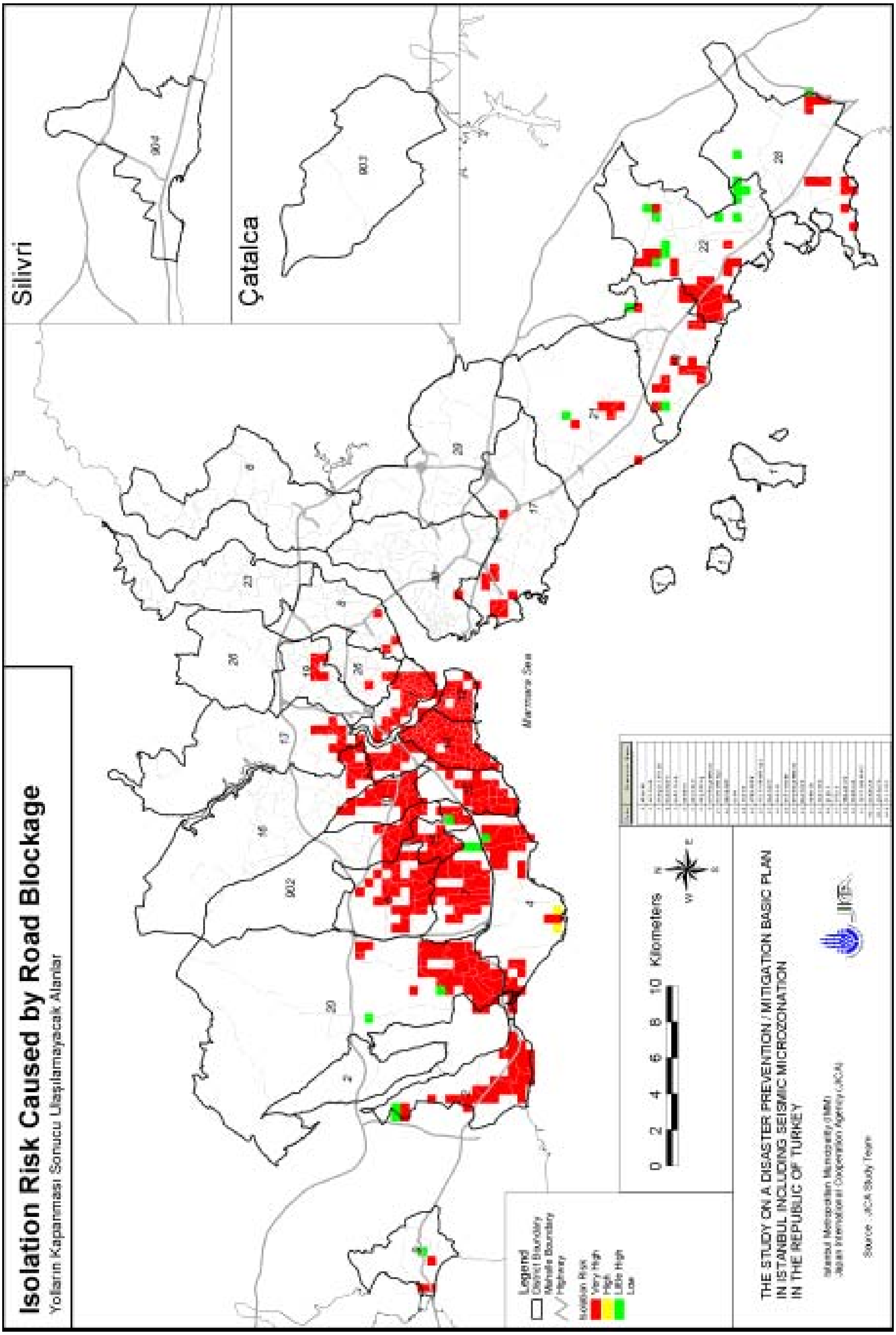

Figure 9.6.34 Estimated Isolated Area by Road Blockage

9.6.4. Considering Earthquake Resistance in Road Development Efforts

This section explains how earthquake resistance should be considered in future road development. These suggestions have been derived from the results of the road network importance evaluation and the study on the influence of road blockades caused by the collapse of roadside buildings.

(1) Layout of road network

Ahighly reliable road network should meet the following two conditions:

1) The road system should have redundant capacity in its network: this means the construction of the road system should have high redundancy, which secures the reliability of the system in terms of connecting traffic by providing alternative routes in an emergency. Road structures, such as bridges, that are earthquake resistant preserve the function of the road system even when hit by an earthquake or when experiencing some other emergency.

2) Roads should have redundant capacity in cross sectional layout: this capacity contributes to the higher reliability of respective road sections. Namely, the least necessary road function should be secured even when roadside buildings have collapsed due to an earthquake.

From the above two viewpoints, how the road system in future should be is explained in the following:

a. Road system network with redundant capacity

Based on the layout of the current road network and the previously described results of the importance evaluation, it is recommended to improve the road system as follows:

- Two highways, which run east and west and form the main loop, and other highways, which run north and south and form radial lines connecting the main loop, are the so-called “national traffic axes.” These axes provide the functions of alliance, connection and interchange. These highways have sufficient width and function as principal roads covering a wide area. However, because the national highway (E5), which horizontally connects east and west at the southern part of the European side, is also utilised by inner-city traffic, it is necessary to plan another route to separate the national traffic axes and city traffic.

- The above is also assumed from the analysis result of the road network for the case when an earthquake strikes. Namely, it is noted that, after an earthquake, the traffic flow on the European would be extremely concentrated on the southern part of the main loop (E5 to O-1), causing a large-scale traffic jam. The analysis presented here is based on the traffic flow between principal facilities, which are important duringrelief and emergency restoration periods. However, because such roads are also utilised for emergency escape, it is necessary to construct additional roads to help avoid traffic jams when the area is struck by an earthquake.
- As understood from the results of the importance evaluation, 1st degree roads designated by IMM are main roads constituting the road network in the area. While most of them are wide enough to fulfill their required functions, some of them are narrow in width. Therefore, in the sections where road width is insufficient, it is necessary to plan the securing of sufficient road width and to construct additional roads.
- Roads are linear systems with structures such as bridges, etc. located along their lengths. Particularly, in constituting important road networks, some bridges require earthquake resistant or disaster preventive mesures. However, it is difficult to implement all of these earthquake resistant measures at the same time because of practical construction work schedules and budget constraints. Therefore, as pointed out previously, it is necessary to carry out the measures against earthquake according to the level of importance of each measure and a well-planned time schedule. While only bridges are targeted in this study, it is desirable to conduct similar studies on other structures, such as retaining walls, etc., in the future.
- Building debris and other waste materials produced by disasters can exacerbate traffic conditions. In terms of easing traffic conditions during early stages and other subsequent restoration activities, it is very important to treat and dispose of the waste produced by the earthquake as early as possible. Therefore, it is necessary to previously designate a road or set up a route that is not part of the ordinary road network for the treatment and disposal of the disaster.
- According to the analysis results onfrequency of road network utilisation, the activities during relief and emergency restoration periods primarily utilise the existing roads that connect principal facilities. It is also anticipated that traffic during these periods will be concentrated along main loop lines and radial lines connected to them. Regarding the treatment and transportation of disaster waste, one proposed option is to secure seaside dumps for disposal of the waste by means of marine transportation. Thus, because comparatively less traffic concentration is expected along seaside roads after

an earthquake and since some harbor facilities already exist, it is desirable to develop roads and harbor facilities as follows:

- To reinforce existing roads running north and south and connecting principal roads at seaside (to secure enough road width, etc.).
- To construct new facilities, which are capable of temporary accumulation and shipping of the disaster waste, in the existing main harbors.
- To transport the disaster waste from the temporary dump to the site for waste treatment and disposal via seaways.
- While it is not clear at this moment where the location for the final treatment and disposal of waste will be, an abandoned coal mine on the coast of the Black Sea is thought to be a candidate site for it. Though details about the abandoned mine are not known, it is thought effective to transport the waste by sea to the harbor facility near the mine and then to the mine by dump trucks, etc.

b. Development of roads with redundant capacity in cross-sectional layout:

Regarding road blockages caused by the collapse of roadside buildings, it has been presumed that risk is highest for sections having roads narrow in width. In sections where the density of narrow roads is high and buildings stand close together, isolation of sections caused by road blockages is expected as well. Therefore, in order to prevent road blockages caused by the collapse of roadside buildings, the development of road such as those described below is necessary:

- It is necessary to secure that roads have sufficient width in order to avoid road blockages. What has been learned from the experiences in the earthquake that struck the southern part of Hyogo Prefecture is that at least 11 to 12m of road width is necessary to ensure that, even with the collapse of a roadside building, the minimum road width of 3m can be counted on for vehicular traffic to be able to pass through. And it is desirable that the roads, which are used for emergency escape and transportation of relief supplies, have cross sectional layout with redundant capacity for pedestrians and automobile traffic in an emergency.
- Very narrow roads having only 2 to 6m in width should be improved, taking the current utilisation of roadside land into consideration as well. It is most desirable to develop an urban district into an area where roads and buildings are earthquake resistant through redevelopment of densely built–up areas.

- In Istanbul, many cars park on the streets in the urban district. Even when roads have redundant capacity in their cross-sectional layout, it is expected that the cars on the streets will disturb relief and restoration activities. Therefore, it is necessary to construct public parking facilities (for example, large-scale underground parking facilities), in addition to working on the improvement of roads and urban districts.

Regarding the reliability of road systems, the hierarchy of road networks is considered to be another important factor in addition to the 2 items explained above. In Istanbul, road networks such as the national traffic axes system, inner-city traffic system and inner-section traffic system are seen according to their functions. Currently, however, the national traffic axes and inner-city traffic systems are combined in a mixed-up manner, and the inner-city traffic system is formed by random networks. Therefore, the construction of road networks having hierarchy has to be taken into consideration in the development of road networks in the future.

(2) Alliance with marine traffic after an earthquake

As Istanbul is surrounded by sea, marine traffic plays an important role in the transportation of materials and movement of people even during ordinary times. Once the areas are hit by an earthquake, it is expected that very crowded roads due to concentrated traffic will significantly disturb restoration activities and transportation of relief materials. Therefore, it is thought that an alliance between road and marine traffic is important for relief of concentrated road traffic, better transportation of relief supplies, and the transportation of disaster waste previously mentioned. From this point of view, it is necessary to develop harbor facilities, which can be responsible for transportation of goods, and roads leading to the harbors, based on a well-planned schedule.

Harbor facilities, which are bases for marine traffic, are also effective as disaster prevention centres. This subject is discussed in Section9.7., “Port and Harbors.”