Low-carbon Design for Intercity Passenger Transport Network of Turkey

Huseyin TIRTOM [a], Hiromichi YAMAGUCHI [b], Makoto OKUMURA [c], JinYoung KIM [d]

[a,c,d] *International Research Institute of Disaster Science, Tohoku University, Sendai, 980-8577,Japan;*
[b] *Graduate School of Engineering, Tohoku University ,Sendai, 980-8577, Japan*
[a] *tirtom@irides.tohoku.ac.jp* [b] *h-ymgc@plan.civil.tohoku.ac.jp*
[c]*mokmr@m.tohoku.ac.jp* [d] *kim.jinyoung@plan.civil.tohoku.ac.jp*

Keywords: multimodal, intercity passenger, network analysis, low-carbon

Abstract: Even with technological improvements in efficiency, transport sector emissions have been growing more in absolute terms than any other sector in the last decades due to the continuing growth of transport demand. Transport planners are being challenged to develop strategies to reduce CO_2 emissions in line with low-carbon targets without harming the total performance. One possible action among others is to set up a CO_2 upper limit. However, implying a limit without detailed analysis could potentially harm the performance of the network significantly and make some enthusiastic transport projects inefficient. Therefore, object of this study is to analyze the impact of low-carbon limit on the structure of intercity transport network of Turkey using multimodal planning model. Different levels of total CO_2 emissions limit to represent low-carbon targets were applied as a constraint in the model and resulting changes in the network structure to minimize total social cost were observed. Results indicate that at the low levels of CO_2 emissions limit, network response is foreseeable and necessary levels can be achieved by policies targeting a shift the air and bus to rail. But, at the further steps, major changes in the network structure might occur, causing loss of important links and decreased service levels.

Keywords: multimodal, intercity passenger, network analysis, MILP

1. INTRODUCTION

Recently, there is greater recognition of environmental problems in Turkey and sustainable development became a key policy issue. More strict regulations are enacted and Turkey became a party of the Kyoto Protocol in 2009. On the other hand, as accessing country to the European Union and OECD (Organization for Economic Cooperation and Development) member, Turkey is expected to take responsibilities and emission reduction commitments.[1)] In this respect, Turkish government prepared "National Climate Change Strategy" to reduce the growth of greenhouse gases in 2010. Main objective of the strategy is to tackle climate change without compromising sustainable development efforts, within the framework of international agreements. Transport sector is also given medium and long term targets such as; shifting from road transport to rail, air and sea transport modes by increasing capacity and strengthening infrastructure, promoting multimodal transport, promoting public transport modes in cities, using intelligent transport systems etc. [2)]

According to the Ministry of Environment and Forestry of Turkey, transport sector is responsible for the 18% of total CO_2 emissions in 2007. Although this number seems low comparing to the developed countries, increase rate is dangerously high in parallel with economic growth rate of the country. Total CO_2 emissions in Turkey caused by transport activities are 49,18 million tons in 2008. 80,6% of them is caused by road transport as the dominant mode. Share of air transport is relatively low (around 11%) but, it is the fastest growing transport mode in Turkey with the average rate of 15% per year. [3)] Although it is the most environmental friendly transport mode, share of rail transport is very low in Turkey (around 4%) due to the under-investment over years. But, recent High Speed Rail (HSR) projects aim to reverse this trend.

Consequently, transport planners are being challenged to develop strategies to reduce CO_2 emissions in the age of fast development. They should ensure continuous economic growth and design low-carbon network at the same time which is quite difficult. One possible action among others can be setting a CO_2 upper limit and redesigning network to keep emissions under this level. However, implying this kind of policies without detailed analysis could potentially harm the performance of the network significantly and make some enthusiastic HSR, highway and airport projects inefficient. In order to prevent unwanted outcomes and get maximum benefit from above policies, it has utmost importance to assess interactions and impacts on transport network with a holistic view. Therefore, this study intends to provide an analytical tool to analyze effects of CO_2 emission limits on the national transport network. To achieve this, optimal networks were developed for 5 CO_2 emission limits and changes in the network structures were analyzed using a multimodal transport planning model developed by authors[4)]. Accessibility change at each step was also calculated to assess impact of emission targets on different regions of the network.

The paper is organized as follows. In Section 2, multimodal planning model is explained. Network settings and data is given in Section 3. In Section 4, impact of CO_2 emission limits on the network structure and accessibility change are analyzed. Section 5 is the conclusion.

2. MODEL

In this study, change of intercity transport network structure according to permitted total CO_2 emission levels will be analyzed using multimodal planning model, developed by Okumura et al.[4)] The model determines the most effective network structure, link frequencies and the number of passengers according to given line and mode parameters. It is formulated as a mixed integer linear programming model which tries to minimize a linear objective function, subject to several linear constraints. In this study, objective function is selected as minimizing total social cost to accommodate welfare of both passengers and operators. It is calculated as the summation of generalized cost of users and cost of operators as given in Equation (1). Generalized cost is the total travel time plus total transfer time expressed in monetary terms by multiplication of time value. Total operators cost represents the operation and maintenance costs incurred by the operators dependent on the existence of service and set frequency on each link. These costs are calculated according to unit values specific to unit seats prepared in each mode.

$$\min_{X,Y,B,A,Z,F} (GC + TOC) \tag{1}$$

In order to analyze low-carbon network with proposed multimodal planning model, an additional constraint is introduced to the original model to limit total CO_2 emissions generated by the network. This constraint is formulated in (2) below.

$$\sum_{ij}\sum_{m} c_{ij}^{m} F_{ij}^{m} \leq TCO_2 \tag{2}$$

Here, c_{ij}^m is the CO_2 factor for mode m on link ij, F_{ij}^m is the link frequency for mode m on link ij and TCO_2 is the limit for the total CO_2 emissions. CO_2 factors are calculated as unit CO_2 coefficients [5)] for each mode from Table 8 multiplied by length of the link ij. Hence, ranking of modes from most inferior to most environmentally friendly modes are Air > Bus > Rail > HSR. Rest of the model is given in Appendix I.

3. STUDY NETWORK

3.1 Existing Intercity Network of Turkey

Study network is limited to 11 cities in the central region of Turkey that covers most of the main transport arteries and majority of the intercity passenger traffic. 4 public transport modes (air, HSR, rail and bus) are included. There are 50 links in the network as shown in Figure 1 with city populations. HSR links between Bursa-Eskisehir, Eskisehir-Istanbul and Ankara-Sivas are still under construction but they are included in the analysis because they are expected to be operational in 2013-2014 period. Notable characteristic of Turkish intercity network is that rail network is scarce and two important cities (Bursa and Antalya) are not connected to the rail network. Therefore, road transport serves as the main travel mode in Turkey. Also necessary short cuts for rail between Ankara-Afyon, Ankara-Konya, Ankara-Sivas and Konya-Kayseri are missing. Turkish government intends to construct HSR in these sections in order to fill gaps in the rail network with yet to start projects. Although all the cities have airports, Afyon, Konya, Bursa and Eskisehir are excluded from the air network due to the low flight/passenger numbers.

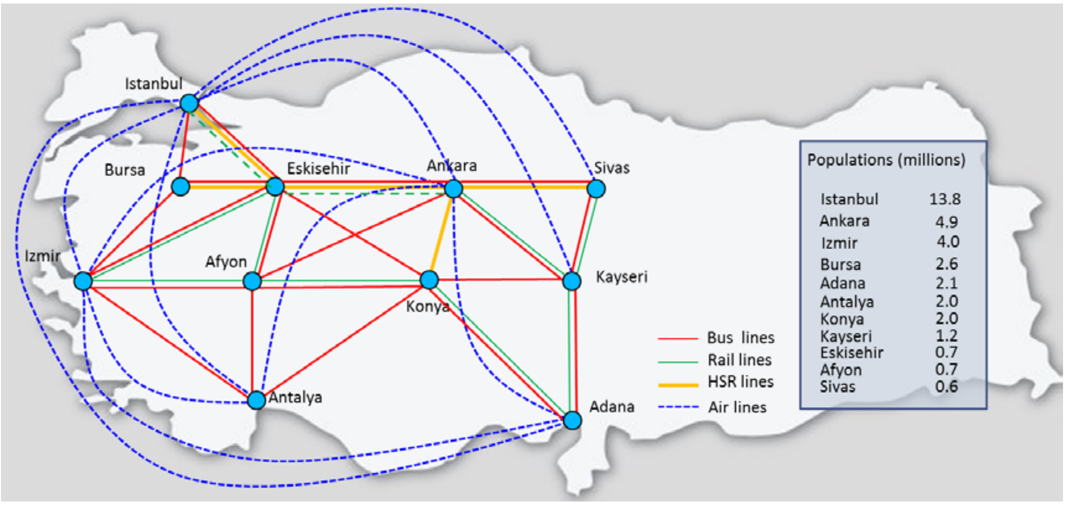


Figure 1 Study Network

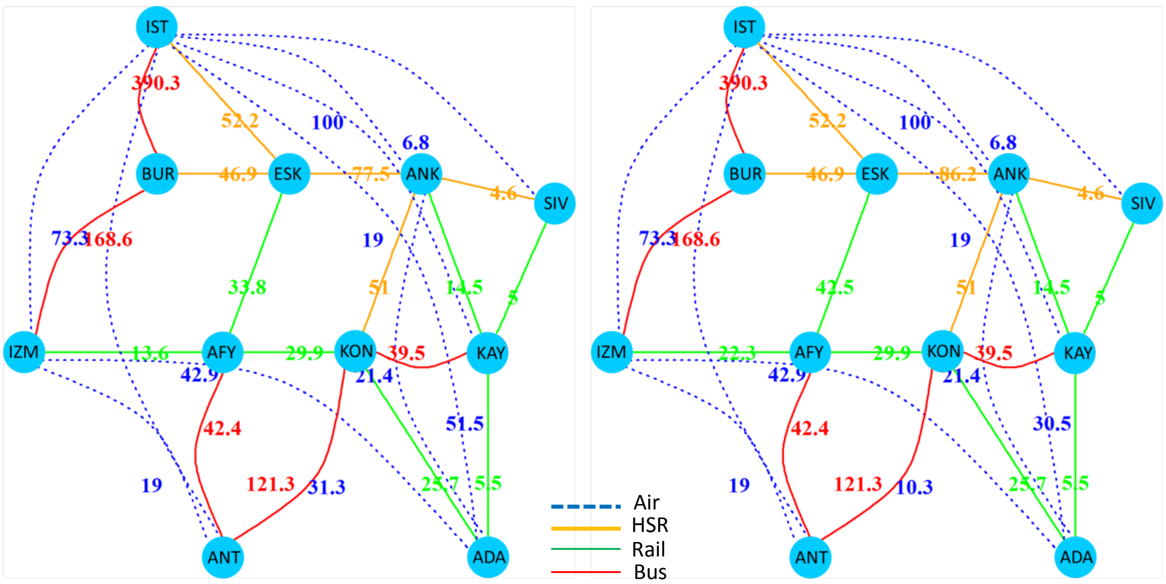
3.2 Data

Because of the fact that there was not any suitable observation data for OD traffic in Turkey at the time of study, artificially generated data by gravity model using city populations and distance between cities were used for the analysis. Link distances, travel times and fares are taken from actual data for the year 2012. Some generalizations were necessary for simplicity at the vehicle seat capacities and maximum link frequencies. OD data, transfer times, mode attributes and line parameters are given in Appendix II. Average value of time for Turkey is taken from a recent study [6] as 4.5 $/hour.

4. ANALYSIS

4.1 Impact of CO_2 Limit on Network Structure

For this analysis, changes in the network shape against different levels of CO_2 limit were observed, in order to find out behavior of the network. The network shown in Figure 2a with 5 HSR lines which is optimal solution network with no CO_2 restriction was selected as the base network and its total CO_2 emissions is 2,386,586 kg. This value was set as TCO_2 limit and it was decreased by 10% in 5 steps to represent different low-carbon targets. Resulting networks are shown in Figures 2b to 2f. Total travel time, total operator cost, total social cost and modal shares are also given in Table 1.



-a- -b-

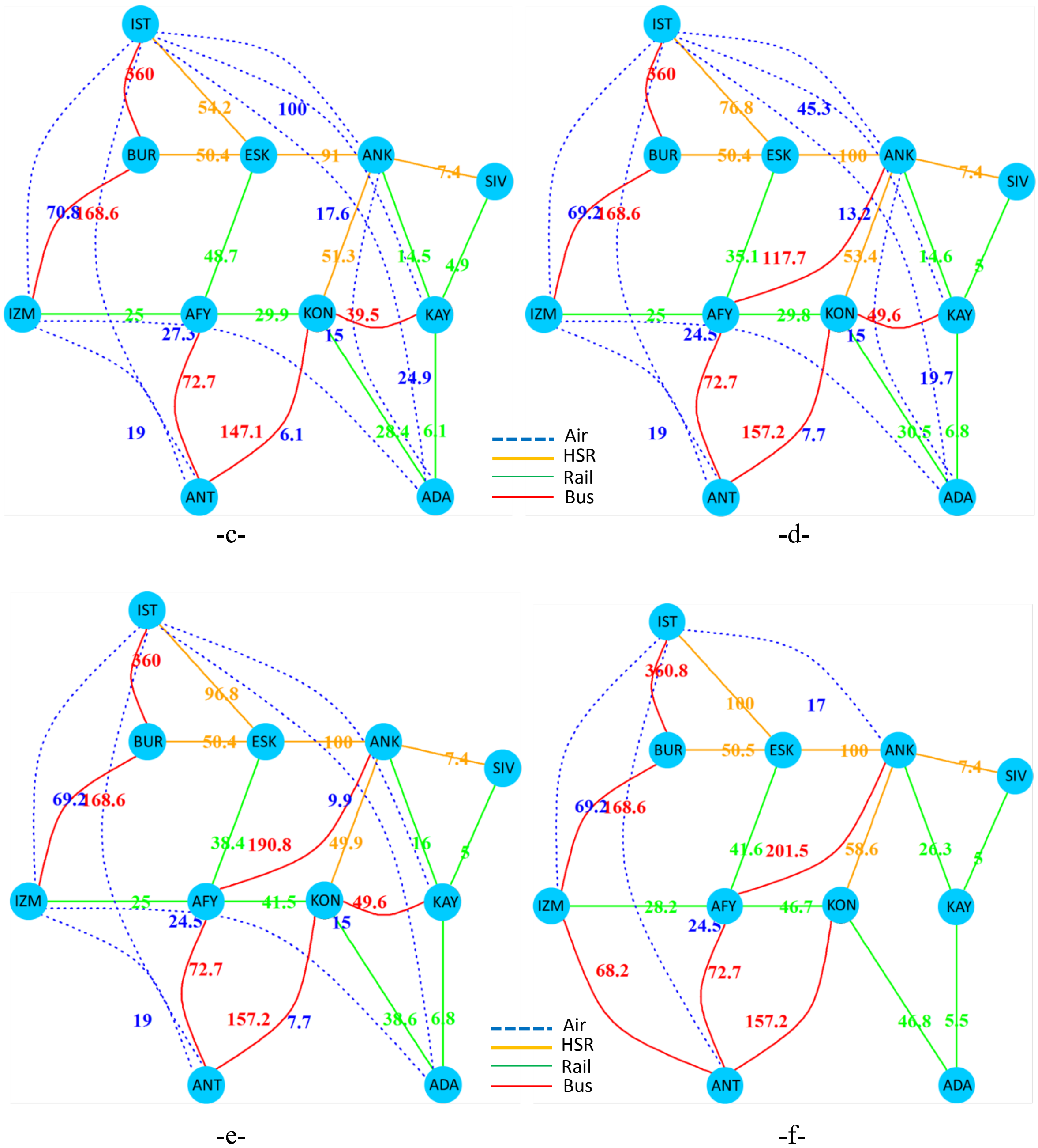


Figure 2. Line frequencies of the networks with a) No CO_2 limit, b) 10% emissions decrease, c) 20% emissions decrease, d) 30% emissions decrease, e) 40% emissions decrease, f) 50% emissions decrease,

Table 1. Results and Modal Shares

TCO2	Travel Time (hours/day)	Op.Cost ($/day)	Soc.Cost ($/day)	CO2 (kg/day)	% Rail	% Bus	% Air	% HSR
Base case	1,051,871	3,465,927	8,193,416	2,386,586	0.20	0.13	0.37	0.30
0.9*Base case	1,085,718	3,318,080	8,197,689	2,147,927	0.23	0.13	0.32	0.32
0.8*Base case	1,121,946	3,180,267	8,222,696	1,909,268	0.25	0.14	0.27	0.34
0.7*Base case	1,167,576	3,088,838	8,336,347	1,670,610	0.24	0.16	0.21	0.39
0.6*Base case	1,255,217	2,870,181	8,511,578	1,431,951	0.27	0.17	0.15	0.41
0.5*Base case	1,367,635	2,720,277	8,866,920	1,193,293	0.32	0.18	0.09	0.41

At the first step, TCO_2 limit is set as 10% lower than the base case. As it is expected, air mode was affected most due to the worst environmental performance and number of air passengers has decreased. In this case, air passengers between Izmir and Ankara who previously were using IZM-ADA-ANK air route, now shifted to IZM-AFY-ESK-ANK rail + HSR route, while number of bus users did not change in the network. Consequently, share of rail and HSR modes increased while air mode decreased by 5%. Total travel time and total social cost became worse as operation cost decreased due to the less usage of air.

At the second step, TCO_2 limit is the 20% lower than the base case. Here, air link between Istanbul and Sivas was terminated and nearly all other air links have lost passengers. In this case, bus mode also benefited from decrease of air service and its share increased together with rail and HSR modes detriment to air mode.

At the third step, TCO_2 limit is the 30% lower than the base case. Again, air mode continued to lose passengers to HSR and rail. But, this time Eskisehir-Ankara HSR line reached its maximum capacity and became congested. This lead some passengers shift to the bus form HSR and a new bus link appeared between Afyon and Ankara. Air users between Adana and Izmir also increased slightly due to the decreased service levels of alternative rail route causing a 1% drop in the rail share.

At the fourth step, TCO_2 limit is the 40% lower than the base case. Air services between Istanbul-Ankara and Ankara-Adana were terminated and Eskisehir-Ankara HSR line continued to be only congested link in the network.

At the last step, TCO_2 limit is set to be half of the base case. All remaining air links except Istanbul-Izmir and Istanbul-Antalya sections were terminated even though those services are essential and convenient. A new bus link between Izmir and Antalya appeared to compensate the terminated air service. Interestingly, bus link between Konya and Kayseri also terminated together with Istanbul-Kayseri air service due to its feeder role. Those passengers shifted to KON-AFY-ESK-IST rail + HSR route, avoiding the congestion in the Istanbul-Eskisehir HSR link. Thus, air service between Istanbul and Ankara appeared again to cover the over capacitated HSR sections. Nonetheless, network has become dominated by rail and bus modes and share of air mode shrunk to the 9% while share of HSR stayed at 41% due to the capacity constraints.

Figure 3 shows the change of social cost and operators cost according to CO_2 levels, and total travel cost can be seen as the difference of the two. It is clear that operators cost decreased with the decrease of CO_2 caused by a shift from air, which has the highest unit operators cost to rail, a less costly mode. Similarly, social cost increased gradually with the CO_2 levels due to the increase in travel time. At the 4th and 5th steps slopes of lines become sharper due the major changes in the network shape i.e. necessary loss of air links and introduction of new bus links.

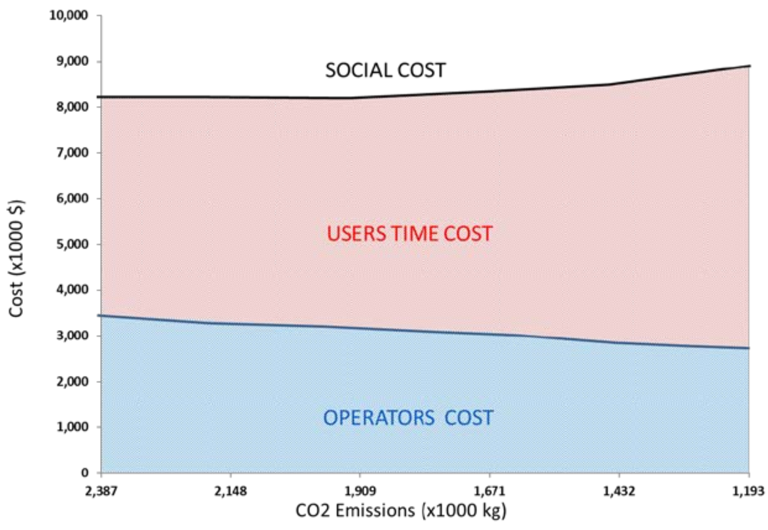


Figure 3 Social cost and Operators cost vs CO_2 emissions

4.2 Accessibility Analysis

In general terms, accessibility is defined as the ability to reach desired goods, services or destinations. Ultimate goal of a transport network is to provide enough level of accessibility to all users. Therefore, accessibility is considered to be a key indicator for network performance. When measured as node basis, accessibility also helps to assess regional differences. Due to the fact that each transport investment affects different parts of the network at different levels, it is important to take accessibility changes into account to preserve a well performing network for all users. Here, accessibility is measured based on generalized cost from the user perspective. Because of the fact that link traffic is represented according to origin zone in the model, total travel time and thus generalized cost of travel in regard to origin zone can be calculated easily. Table 2 below shows total generalized cost of travel for each node at 5 CO_2 limits, and Table 3 shows the percentage change according to the base case.

Table 2 Total generalized cost of travel ($) for each node for 5 CO_2 limits

	Base Case	90%	80%	70%	60%	50%
Istanbul	761,999	761,999	775,529	836,355	925,627	1,061,297
Bursa	658,155	658,155	669,023	677,607	705,126	678,893
Izmir	476,663	552,750	581,649	589,301	600,400	729,259
Eskisehir	220,837	220,837	220,837	226,610	229,590	228,606
Afyon	521,322	521,322	521,322	529,011	529,011	529,011
Antalya	281,394	281,394	320,375	333,332	333,332	410,020
Ankara	643,458	719,518	739,587	811,042	937,776	918,867
Konya	442,562	442,562	442,562	442,562	496,909	481,755
Sivas	62,275	62,275	84,370	84,564	85,413	85,413
Kayseri	232,254	232,254	235,542	253,260	268,273	339,678
Adana	426,543	426,543	451,633	463,865	529,940	683,844
Total	4,727,462	4,879,609	5,042,429	5,247,508	5,641,397	6,146,643

Table 3 Percentage change of accessibility for each node for 5 CO_2 limits

	Base Case	90%	80%	70%	60%	50%
Istanbul	761,999	0.0	1.8	9.8	21.5	39.3
Bursa	658,155	0.0	1.7	3.0	7.1	3.2
Izmir	476,663	16.0	22.0	23.6	26.0	53.0
Eskisehir	220,837	0.0	0.0	2.6	4.0	3.5
Afyon	521,322	0.0	0.0	1.5	1.5	1.5
Antalya	281,394	0.0	13.9	18.5	18.5	45.7
Ankara	643,458	11.8	14.9	26.0	45.7	42.8
Konya	442,562	0.0	0.0	0.0	12.3	8.9
Sivas	62,275	0.0	35.5	35.8	37.2	37.2
Kayseri	232,254	0.0	1.4	9.0	15.5	46.3
Adana	426,543	0.0	5.9	8.7	24.2	60.3

It is obvious from Table 3 that some parts of the network affected seriously from decreased CO_2 levels while in other parts change were insignificant. Especially for central nodes like Bursa, Eskisehir, Afyon and Konya changes were below 10% even at the 50% CO_2 reduction. Some cities like Izmir and Ankara were affected starting at the first step and impact increased gradually while for other cities like Adana and Istanbul, impact was lesser at first steps but increased sharply at the last two cases. This analysis indicates that changes in one part of the network affect other parts at different levels. Therefore, it is important to assess possible accessibility changes for every part of the network at decision making process of transport investments.

5. CONCLUSION

In conclusion, impact of low-carbon limit on the intercity transport network of Turkey was analyzed using the multimodal planning model. In order to find out impact of possible climate change tackles on transport network, different levels of CO_2 emissions limits were applied and resulting optimal networks were assessed. Moreover, accessibility changes caused by different CO_2 limits were also analyzed. It was found that, tight CO_2 limit in order to achieve a carbon-efficient network increases travel times and so total social cost. On the other hand, operators cost decreases continuously due to the less unit costs of bus and rail modes than air. Interestingly, at some steps, there might be some unexpected situations such as an increase in the air passengers or appearance of a new bus service due to the need of compensation of a terminated link or congestion. By these results, it can be implied that setting though CO_2 emissions limits causes the present network structure lose some critical links, diminishing its performance and then, we must endure inconvenient and ineffective network structure. Therefore, it is necessary to analyze all possible scenarios, considering interactions between modes in order to achieve a well-balanced network to satisfy both social cost and low-carbon criteria.

For future studies, instead of applying a certain threshold for CO_2 emissions, different scenarios can be prepared and analyzed using our model. Also, population trajectories can be taken into account for a target year.

REFERENCES

1) Baloglu, H. (2009). Sustainable Development and Climate Change Policies: Situation of Turkey as an Accessing Country to the EU (Doctoral dissertation, Universität Wien).

2) Republic of Turkey Climate Change Strategy 2010-2020 (2010), General Directorate of Environmental Management Climate Change Department, Ankara

3) Babalik-Sutcliffe, E. (2010). Assessment Report for Current Situation of Transport Sector (In Turkish)

4) Okumura M., Tirtom H., Yamaguchi H. (2012), Planning Model of Optimal Modal-Mix in Intercity Passenger Transportation. Proceedings of LTLGB 2012

5) Kato, H., Shibahara, N., Osada, M., & Hayashi, Y. (2005). A life cycle assessment for evaluating environmental impacts of inter-regional high-speed mass transit projects. Journal of the Eastern Asia Society for Transportation Studies, 6, 3211-3224.

6) Dogan M (2012), Passenger Time Value for Konya Province in the context of Ankara-Konya High Speed Railway Project (in Turkish). Akademik Bakis Dergisi,

APPENDIX I

Model formulation
Objective function is given in Equation (1)-(3). Equations (4)-(7) show the constraints to preserve the traffic amount while Equations (8)-(9) show the constraints for incoming and outgoing frequencies to prevent exceeding link users than link capacity. Equation (10) is the sustainability condition and it states that in order to provide a service on a link, certain number of passengers are necessary to cover operating costs. Finally, Equation (10) gives the calculation of total CO_2 emissions in the network. Variables and parameters of resulting MILP model are explained in Table 4 and Table 5. This model was constructed and solved by R using lpSolve package, an open source mixed integer programming tool.

Objective function:

$$\min_{X,Y,B,A,Z,F} (GC + TOC) \tag{1}$$

$$GC = v * (\sum_{ij} \sum_{m} t_{ij}^{m} + \sum_{n} \sum_{mm`} \tau_{n}^{mm`}) \tag{2}$$

$$TOC = \sum_{ij} \sum_{m} (u_{ij}^{m}\ h^{m} F_{ij}^{m} + d_{ij}^{m} Z_{ij}^{m}) \tag{3}$$

Constraints:

$$\sum_{i \in N^{-}(n)} X_{in}^{km} = A_{n}^{km} + \sum_{m' \in M} Y_{n}^{kmm'} \quad \forall n \in N, \forall k \in K, \forall m \in M \tag{4}$$

$$\sum_{m} A_{n}^{km} = T_{kn} \quad \forall n \in N, \forall k \in K \tag{5}$$

$$B_{n}^{m} + \sum_{m' \in M} Y_{n}^{km'm} = \sum_{j \in N^{+}(n)} X_{nj}^{km} \quad \forall n \in N, \forall k \in K, \forall m \in M \tag{6}$$

$$\sum_{l \in K} T_{nl} = \sum_{m \in M} B_{n}^{m} \quad \forall n \in K \tag{7}$$

$$F_{ij}^{m} \leq g^{m} Z_{ij}^{m} \qquad \forall (i,j) \times m \in A \tag{8}$$

$$\sum_{k} X_{ij}^{km} \leq h^{m} F_{ij}^{m} \qquad \forall (i,j) \times m \in A \tag{9}$$

$$f_{ij}^{m} \sum_{k} X_{ij}^{km} \geq d_{ij}^{m} Z_{ij}^{m} + e_{ij}^{m} F_{ij}^{m} \quad \forall (i,j) \times m \in A \tag{10}$$

$$X_{ij}^{km} \geq 0,\ Y_{n}^{kmm'} \geq 0,\ B_{k}^{m} \geq 0,\ A_{n}^{km} \geq 0 \tag{11}$$

$$Z_{ij}^{m} = \{0,1\},\ F_{ij}^{m} \geq 0 \tag{12}$$

Table 4: Model variables

Variable	Explanation
X_{ij}^{km}	Traffic amount on a link between nodes i, j by mode *m* originated from node *k*
$Y_{n}^{kmm'}$	Amount of transit passengers from mode *m* to *m*`at node *n* coming from origin node k
B_{k}^{m}	Trips originated from node *k* using mode *m*
A_{n}^{km}	OD trips between k and *n* using mode *m*
T_{kn}	Total OD demand between nodes k and n
Z_{ij}^{m}	Binary value {0,1} for existence of service on a link between nodes i, j for mode *m*
F_{ij}^{m}	Frequency on a link between nodes i, j for mode *m*
TCO^{2}	Total CO_2 emissions

Table 5: Model Parameters

Parameter	Explanation
h^{m}, g^{m}	Seat capacity and max. operable frequency of mode *m*
d_{ij}^{m}, e_{ij}^{m}	Fixed and variable cost of maintaining service on an link between nodes i, j (with unit of passenger numbers)
f_{ij}^{m}	Link fare between nodes i, j for mode m
v	Value of time
t_{ij}^{m}	Link travel time between nodes i, j for mode *m*
$\tau_{n}^{mm`}$	Transfer time at node n between modes m and m`
c_{ij}^{m}	CO_2 emissions per unit frequency operation between nodes *i, j* for mode *m*

APPENDIX II

OD Data and Mode Parameters

Table 6. OD Data (daily average)

O/D	Istanbul	Bursa	Izmir	Eskisehir	Afyon	Antalya	Ankara	Konya	Sivas	Kayseri	Adana	Total
Istanbul	0	16560	11415	7425	3480	4035	21705	4770	810	2175	2475	74850
Bursa	16560	0	7755	7095	1860	1395	6765	1755	180	525	600	44490
Izmir	11415	7755	0	1380	2010	3135	4380	2055	180	495	780	33585
Eskisehir	7425	7095	1380	0	1935	645	5355	1080	75	240	255	25485
Afyon	3480	1860	2010	1935	0	1305	3930	2175	60	225	7710	24690
Antalya	4035	1395	3135	645	1305	0	2550	3030	135	465	1050	17745
Ankara	21705	6765	4380	5355	3930	2550	0	9885	1185	4590	3255	63600
Konya	4770	1755	2055	1080	2175	3030	9885	0	345	1815	2580	29490
Sivas	810	180	180	75	60	135	1185	345	0	1590	390	4950
Kayseri	2175	525	495	240	225	465	4590	1815	1590	0	1815	13935
Adana	2475	600	780	255	7710	1050	3255	2580	390	1815	0	20910
Total	74850	44490	33585	25485	24690	17745	63600	29490	4950	13935	20910	353730

Table 7. Transfer Times

Modes	Transfer times (min)
Rail to Rail	20
Rail to Air	100
Rail to Bus	40
Air to Air	60
Air to Bus	100
Bus to Bus	20

Table 8. Mode attributes

Modes	Vehicle Capacities (passengers)	CO_2 Emissions ($grCO_2$/pass-km)
Rail	400	5
HSR	400	3.9
Air	165	34
Bus	54	9

Table 9. Line Parameters

Links	Travel Time (min)				Length (km)				Unit Fare (TL)			
	Rail	Bus	Air	HSR	Rail	Bus	Air	HSR	Rail	Bus	Air	HSR
Istanbul-Eskisehir	-	283	-	91	-	330	-	303	-	44	-	55
Istanbul-Bursa	-	208	-	-	-	243	-	-	-	32	-	-
Bursa-Eskisehir	-	140	-	62	-	162	-	208	-	30	-	40
Bursa-Izmir	-	275	-	-	-	321	-	-	-	43	-	-
Izmir-Eskisehir	381	353	-	-	571	412	-	-	36	55	-	-
Izmir-Afyon	281	277	-	-	422	323	-	-	26	43	-	-
Izmir-Antalya	-	380	-	-	-	443	-	-	-	60	-	-
Eskisehir-Ankara	-	200	-	69	-	233	-	230	-	32	-	40
Eskisehir-Konya	-	-	-	-	-	335	-	-	-	100	-	-
Eskisehir-Afyon	108	125	-	-	162	146	-	-	12	25	-	-
Afyon-Ankara	-	220	-	-	-	257	-	-	-	35	-	-
Afyon-Konya	181	191	-	-	272	223	-	-	18	30	-	-
Afyon-Antalya	-	247	-	-	-	288	-	-	-	40	-	-
Antalya-Konya	-	277	-	-	-	323	-	-	-	44	-	-
Ankara-Sivas	-	380	-	118	-	443	-	393	-	60	-	60
Ankara-Kayseri	254	273	-	-	381	319	-	-	24	43	-	-
Ankara-Konya	-	221	-	64	-	258	-	212	-	35	-	40
Konya-Kayseri	-	280	-	-	-	327	-	-	-	44	-	-
Konya-Adana	247	305	-	-	370	356	-	-	24	48	-	-
Sivas-Kayseri	149	166	-	-	223	194	-	-	14	26	-	-
Kayseri-Adana	216	285	-	-	324	333	-	-	20	45	-	-
Istanbul-Adana	-	-	120	-	-	-	707	-	-	-	110	-
Istanbul-Izmir	-	-	70	-	-	-	330	-	-	-	100	-
Istanbul-Antalya	-	-	65	-	-	-	483	-	-	-	100	-
Istanbul-Ankara	-	-	90	-	-	-	350	-	-	-	100	-
Istanbul-Kayseri	-	-	80	-	-	-	977	-	-	-	110	-
Istanbul-Sivas	-	-	95	-	-	-	694	-	-	-	100	-
Izmir-Ankara	-	-	70	-	-	-	521	-	-	-	100	-
Izmir-Adana	-	-	85	-	-	-	736	-	-	-	110	-
Izmir-Antalya	-	-	65	-	-	-	356	-	-	-	100	-
Ankara-Antalya	-	-	70	-	-	-	386	-	-	-	100	-
Ankara-Adana	-	-	60	-	-	-	389	-	-	-	100	-