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A Novel Approach for Identifying the Locations of Potential Transit Rail Stations Using a GIS Based Model


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hEART 2014 - 3rd Symposium of the European Association for Research in Transportation

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Outline

- Motivation
- Background & Aim
- Methodology Framework
- Model Framework
- Case Study
- Sensitivity Analysis
- Conclusion

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Motivation

- Continuous growth of urban areas
  - increased need for mobility
  - traffic congestion on roads

- Transit rail network systems can :
  - relieve highway congestion,
  - decrease commute time,
  - reduce transport related air pollution,
  - provide quick and convenient services
  - improve economic activities

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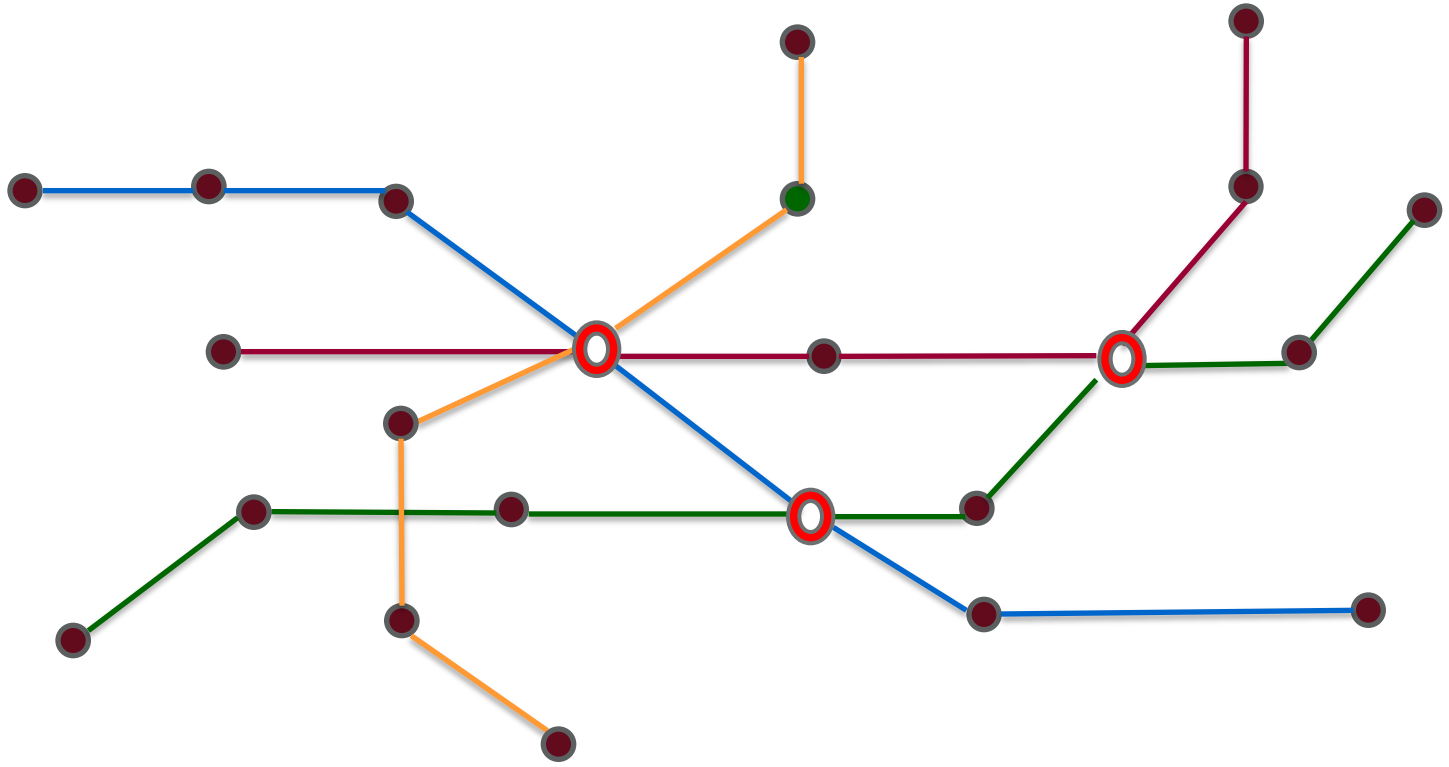
Transit Rail System Planning Aspects

1- Determination of station locations

2- Determination of line network linking the stations

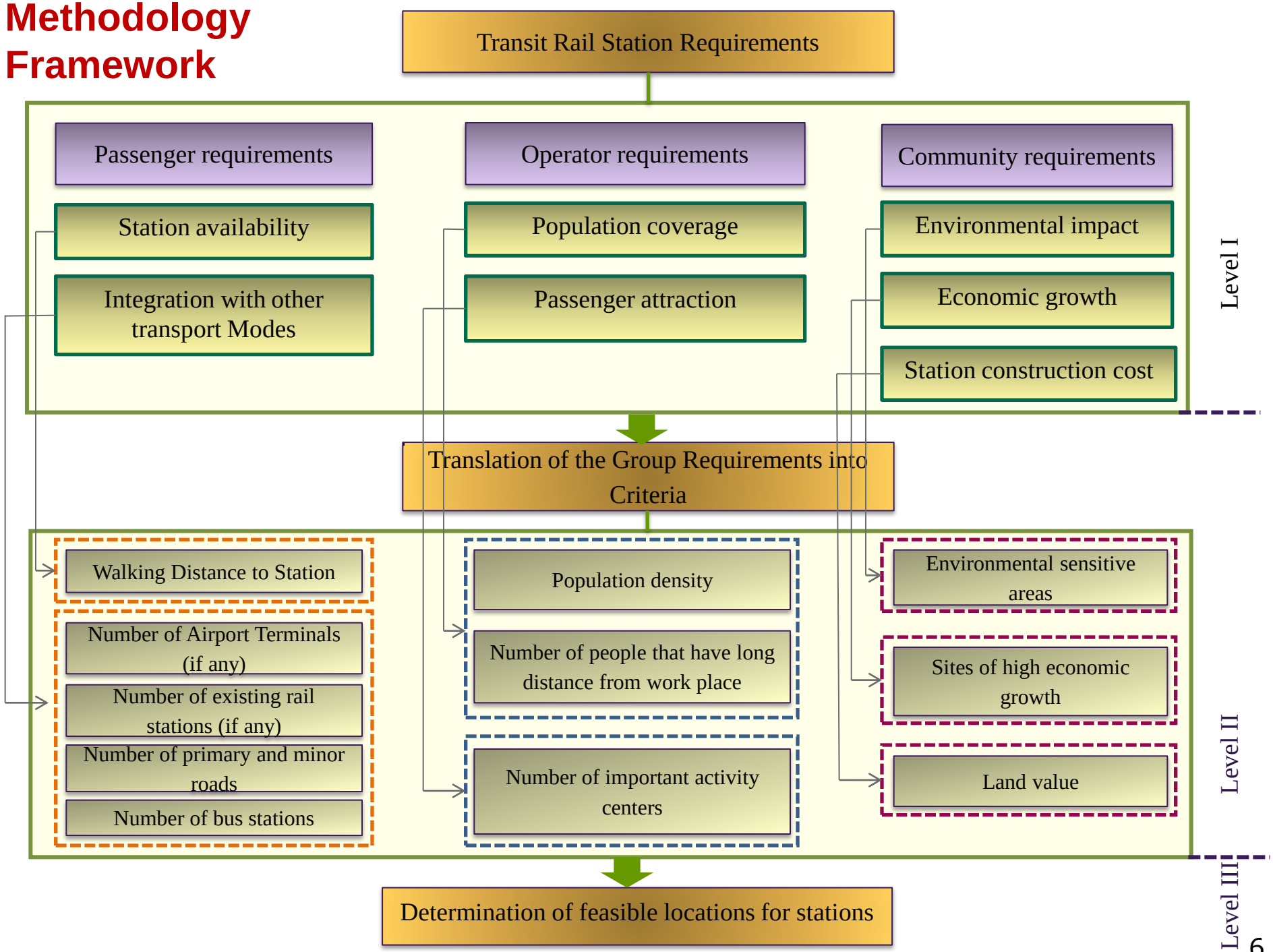


Research Background and Aim

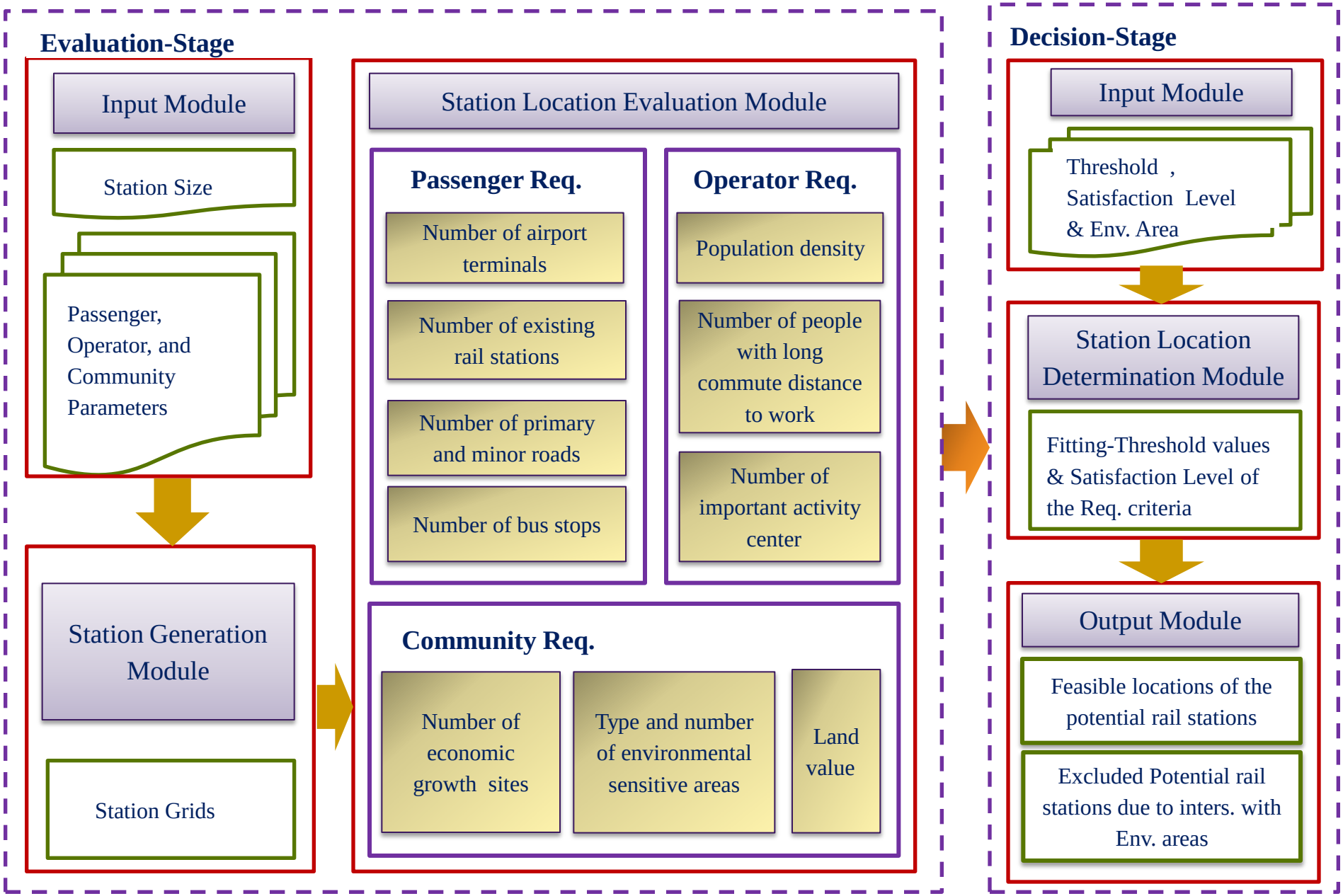
- Limitations of the current models for station location determination
  - Mainly consider a single objective for rail station planning
  - Rail line alignment determined before station location determination
  - Consider a single rail line with predetermined terminal stations

- Research contribution
  - Considers multiple objectives for rail station planning
  - Stations determined before line alignments
  - Considers multi rail lines with no need for predefined terminal stations

Methodology Framework



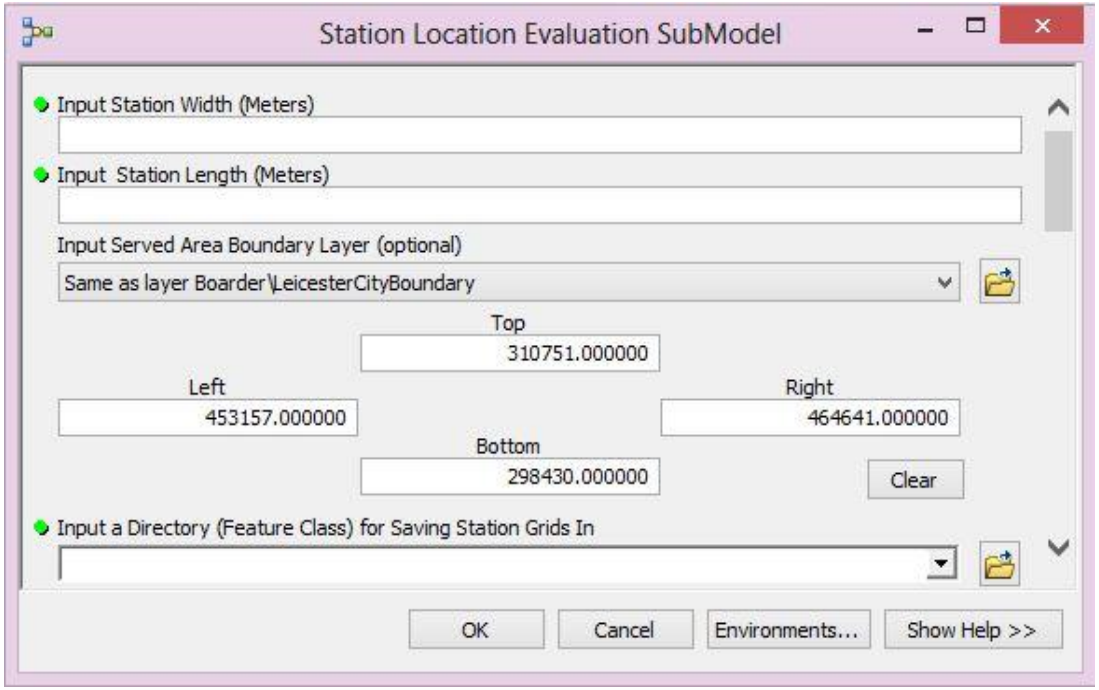
Level III – Determination of Feasible Station Locations



Evaluation-Stage (1/3)

1- Input Module: this is employed by transit rail planners (users) to input and adjust various planning parameters which include

a) Station Size



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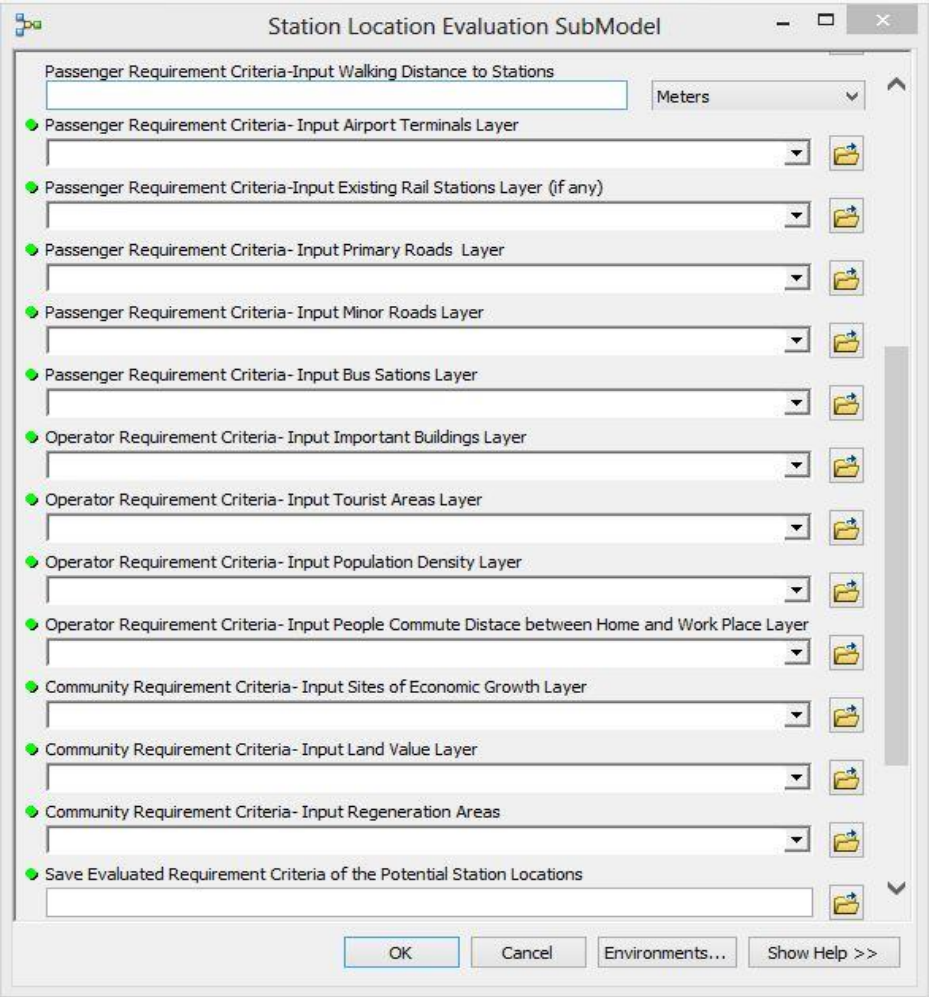
Evaluation-Stage (1/3)

b) Three stakeholders parameters:

- Passenger Parameters
- Operator Parameters
- Community Parameters



Evaluation-Stage (2 &3 /3)

2- Station Generation Module:

- Divides the study area into grids (G_i) based on the station size inputs
- Creates a layer (Ω_s) for stations.

3- Station Location Evaluation Module:

- Evaluates the locations of the station grids generated with respect to the:

  a- Passenger requirements

  b- Operator requirements

  c- Community requirements

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Evaluation-Stage Output

Table

Station_Location_Evaluation

OID *	Shape *	Rail_Station	Primary_Roads	Minor_Road	Bus_Stop	Pop_Dens	Long_Distance	Important_Building	Tourist_Area	LandValue	Development_Project	Regeneration_Areas
1878	Polygon	1	24	105	16	21.121016	246.070583	18	<Null>	66.882437	2	1
1879	Polygon	1	24	112	15	27.255444	299.336093	21	<Null>	66.076342	2	1
1880	Polygon	1	15	128	17	32.786933	348.533909	22	<Null>	65.544067	2	1
2085	Polygon	1	26	147	45	13.720133	146.305292	18	<Null>	54.752431	2	1
2086	Polygon	1	27	143	38	14.07032	151.573933	17	<Null>	55.69769	2	1
2087	Polygon	1	26	135	26	14.153523	152.756796	16	<Null>	57.440139	2	1
2088	Polygon	1	21	129	21	15.892578	165.426995	15	<Null>	58.532339	2	1
2089	Polygon	1	20	113	16	20.537627	198.665476	14	<Null>	58.944232	2	1
2663	Polygon	<Null>	24	93	33	14.779471	154.316389	16	<Null>	58.966277	2	1
2664	Polygon	<Null>	25	89	27	18.558676	186.212653	13	<Null>	56.219129	2	1
2665	Polygon	<Null>	26	98	21	22.577298	216.651985	12	<Null>	53.510345	2	1
2666	Polygon	<Null>	27	102	16	27.051599	251.036682	10	<Null>	50.763958	2	1
2667	Polygon	<Null>	28	102	16	31.703506	289.546943	10	<Null>	48.211968	2	1
2668	Polygon	<Null>	28	100	17	36.197305	327.384099	10	<Null>	45.844531	2	1
2669	Polygon	<Null>	29	100	18	40.364387	362.754683	10	<Null>	43.608158	2	1
2844	Polygon	<Null>	13	44	14	21.517979	269.489711	9	<Null>	69.935544	2	<Null>
2845	Polygon	<Null>	16	52	15	27.416764	338.36154	10	<Null>	68.048699	2	<Null>
2846	Polygon	<Null>	19	58	14	32.612603	398.633076	11	<Null>	65.951537	2	<Null>
2847	Polygon	<Null>	21	66	15	37.472927	453.212895	11	<Null>	63.744952	2	<Null>
2848	Polygon	<Null>	22	67	15	42.514938	509.655262	11	<Null>	61.535432	2	<Null>
2849	Polygon	<Null>	23	73	17	47.771728	566.632737	11	<Null>	59.52087	2	<Null>
2850	Polygon	<Null>	24	79	15	53.391798	624.435733	12	<Null>	57.586208	2	<Null>
2851	Polygon	<Null>	24	80	16	58.955269	680.850201	11	<Null>	55.664891	2	<Null>
2852	Polygon	<Null>	24	84	16	63.861688	733.01234	12	<Null>	54.092052	2	<Null>
2853	Polygon	<Null>	25	94	17	68.878601	790.008143	9	<Null>	53.112495	2	<Null>
2854	Polygon	<Null>	24	98	16	73.597298	843.504534	10	<Null>	52.329727	2	<Null>
3021	Polygon	<Null>	4	33	8	21.04442	291.157073	11	<Null>	75.726881	2	<Null>
3022	Polygon	<Null>	3	35	8	29.547464	406.823889	13	<Null>	75.611451	2	<Null>
3023	Polygon	<Null>	9	40	11	38.148132	523.438691	14	<Null>	75.237565	2	<Null>
3024	Polygon	<Null>	15	50	12	45.387323	619.001021	15	<Null>	74.392364	2	<Null>
3025	Polygon	<Null>	17	51	11	50.869387	688.191019	14	<Null>	73.15416	2	<Null>
3026	Polygon	<Null>	20	51	13	55.895425	748.913306	12	<Null>	71.661327	2	<Null>
3027	Polygon	<Null>	22	60	15	61.069743	811.026052	14	<Null>	70.634897	2	<Null>
3028	Polygon	<Null>	24	66	14	66.858366	881.699879	14	<Null>	70.895131	2	<Null>
3029	Polygon	<Null>	25	68	14	73.033662	954.975603	16	<Null>	71.41909	2	<Null>
3030	Polygon	<Null>	26	70	14	79.373855	1030.065877	13	<Null>	72.261307	2	<Null>
3031	Polygon	<Null>	27	79	13	86.256915	1113.534493	12	<Null>	73.245027	2	<Null>

1 (0 out of 4566 Selected)

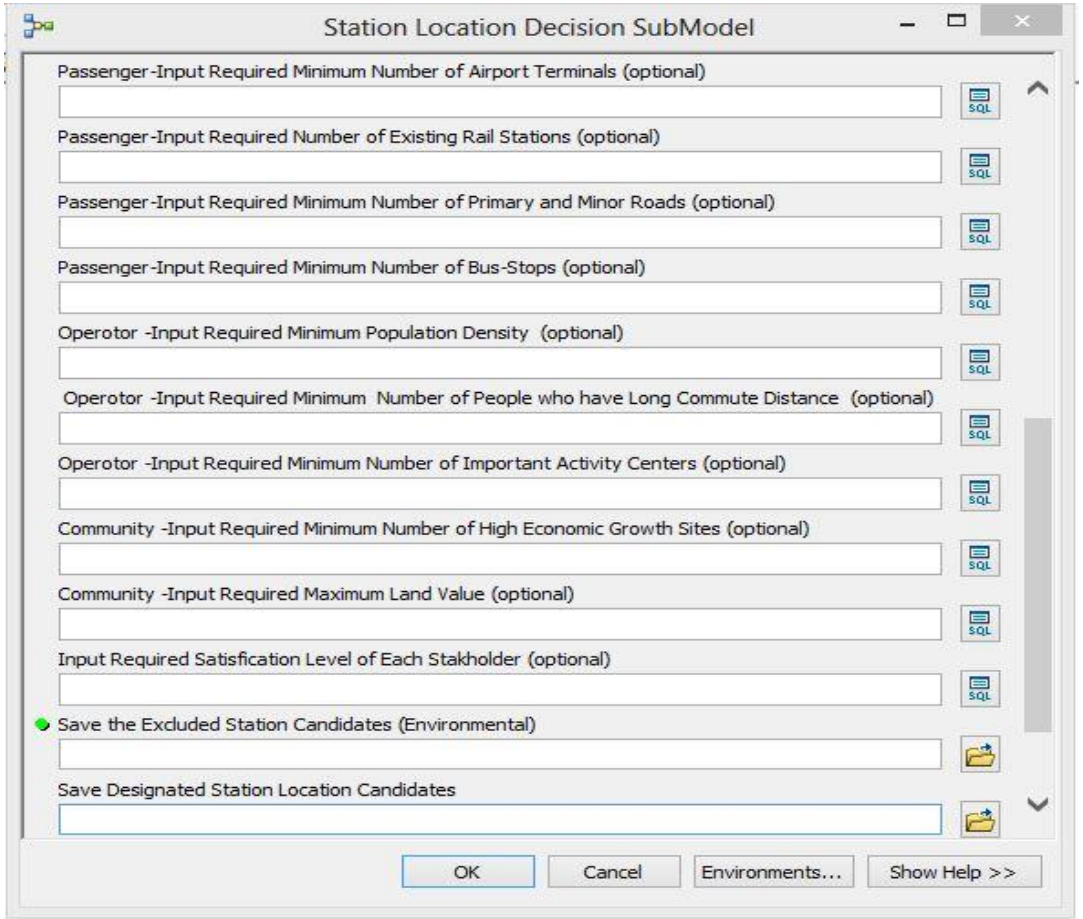
Station_Location_Evaluation

Decision-Stage (1/3)

1- Input Module: this is employed by transit rail planners (users) to input and adjust various planning parameters which include :

a) Threshold values

b) Satisfaction level



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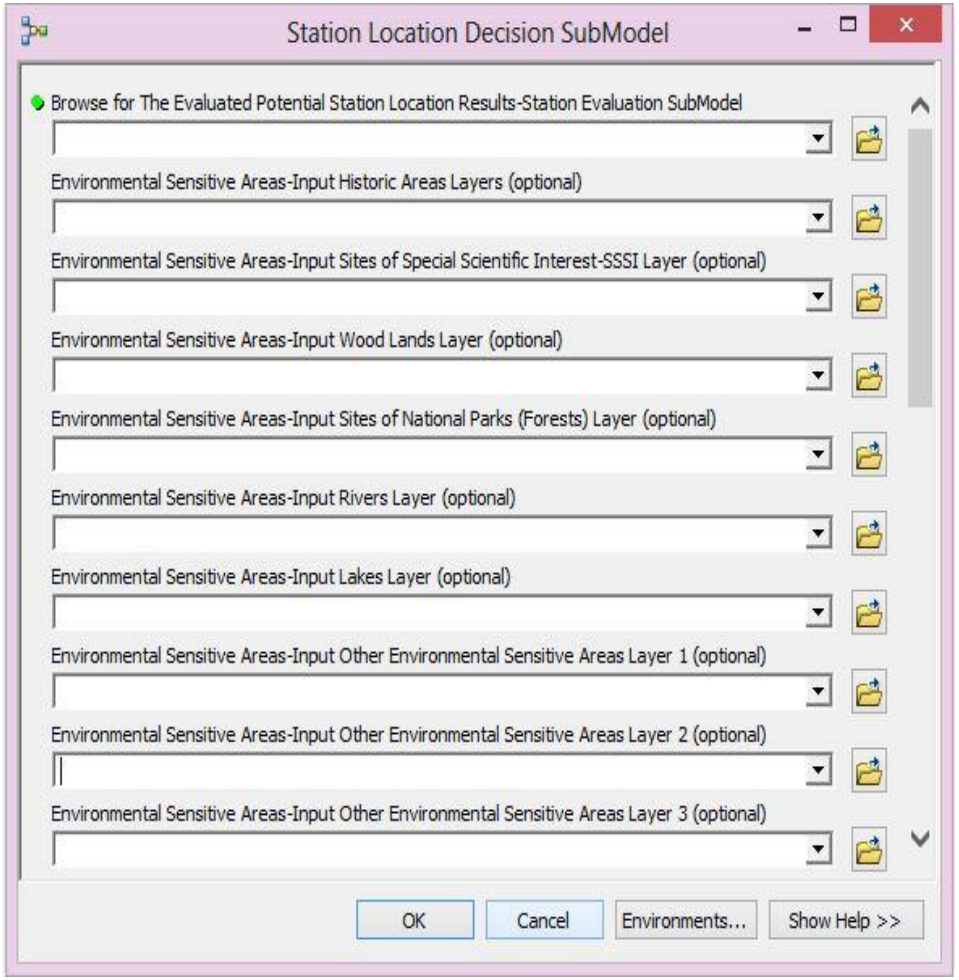
Decision-Stage (1/3)

c) Environmental Sensitive Areas



Decision-Stage (2/3)

2- Station Location Determination Module: consists of three subroutines:

a) Environmental Sensitive Area Exclusion ( ):

- Find Stn_Grid intersect from Env. Sensitive areas and Exclude

$$\Omega_f = \Omega_s \cap \Omega_i$$

b) Station Location Assessment ( ):

- Compare Stn_Grid_Requirement to Threshold Values
- Assign binary values to Stn_Grid

c) Station Location Determination( ):

- Aggregate weights of the requirement criteria satisfied by Stn_Grid
- Determine Stn_Grid that meet Satisfaction level

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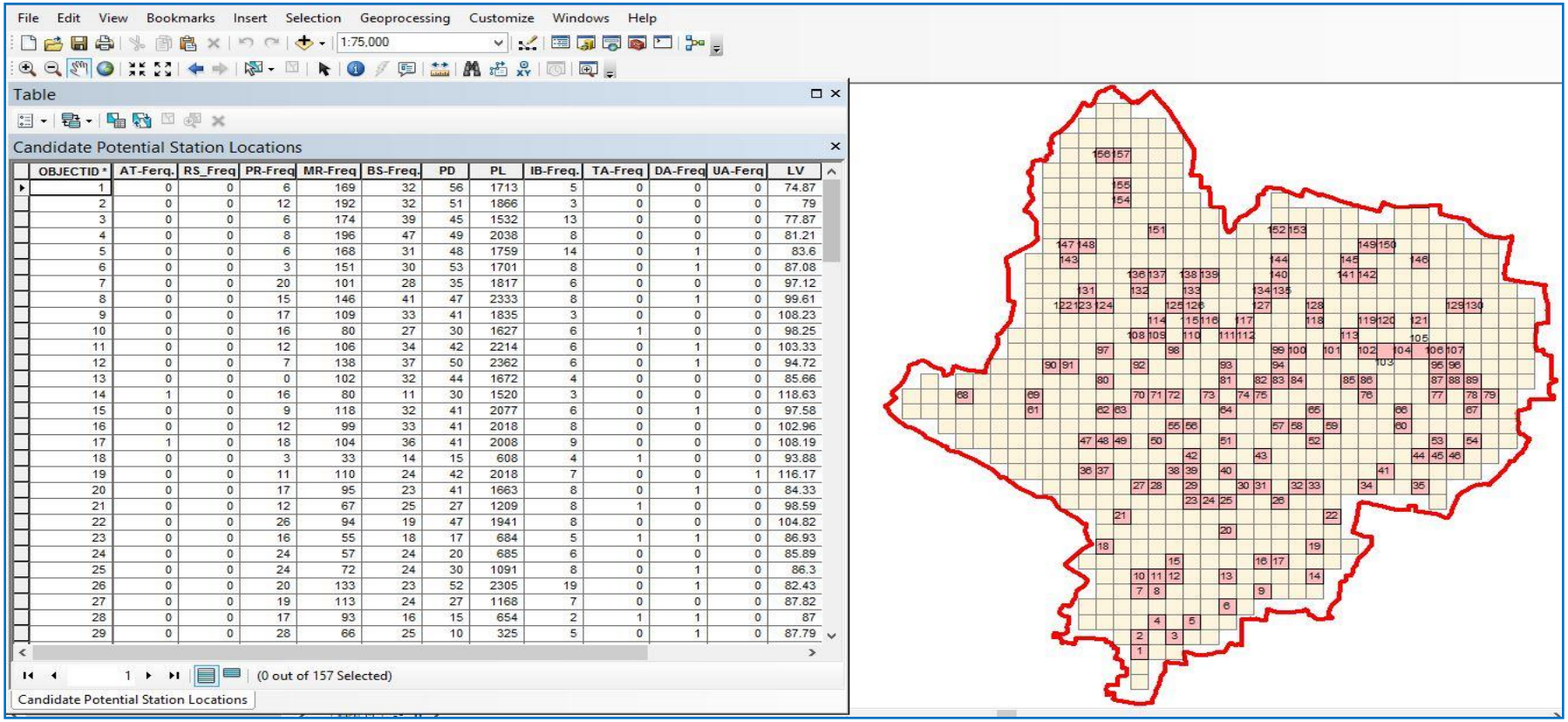
Decision-Stage (3/3)

3. Output Module



The Model Output

Case Study

Table 1: Input data and output results of the applied case study, Leicester City

Input Data		**Output Results**	
Station Size	50 m for width 300 m for length	Station Grids	**4566**
		Feasible Station Location	**1031**
Threshold values	50^{th} percentiles of all the Requirement criteria	Excluded Stations due to Intersection with Env. Areas	**475**
Satisfaction Level	More than 50% of each stakeholder	Excluded Feasible Stations due to Intersection with Env. Areas	**60**

Sensitivity Analysis

Three categories of sensitivity analysis were carried out:

1. Impact of the requirement criteria threshold values.
2. Impact of the requirement criteria collectively at the stakeholder Level.
3. Impact of the requirement criteria individually at the stakeholder Level.

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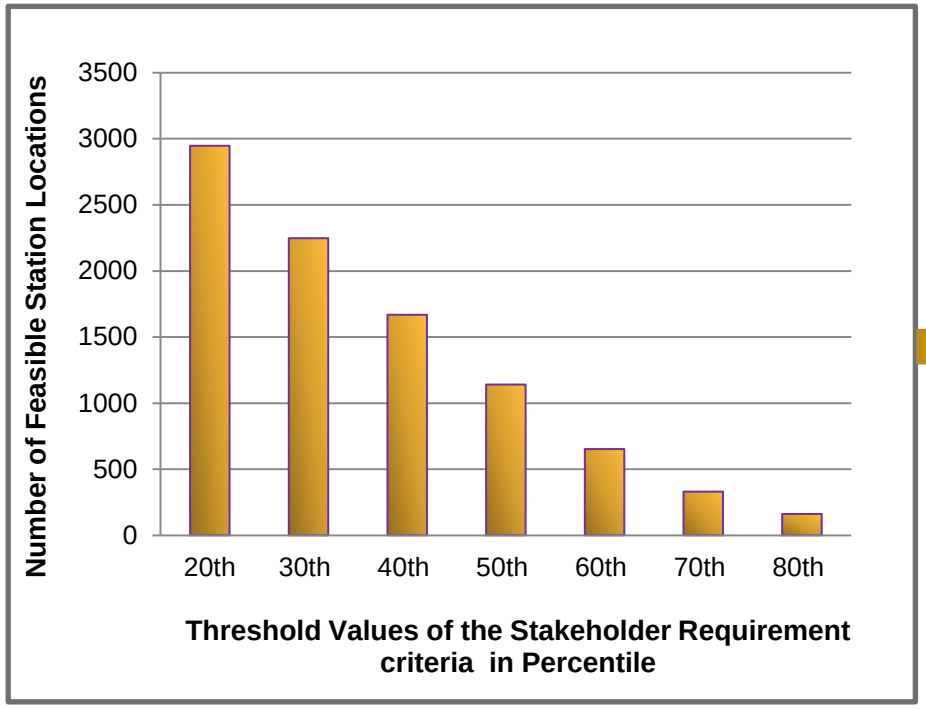
Sensitivity Analysis

1- Impact of the requirement criteria threshold values



Threshold Value (Percentiles)	No. of Feasible Stations	Percentage Change
20th	2946	-43.4
30th	2247	
40th	1668	
50th	1140	
60th	652	-80
70th	330	
80th	161	

Number of Feasible Station Locations with Different Threshold Values of the Requirement Criteria
Data sources: British Ordnance Survey and Leicester Council

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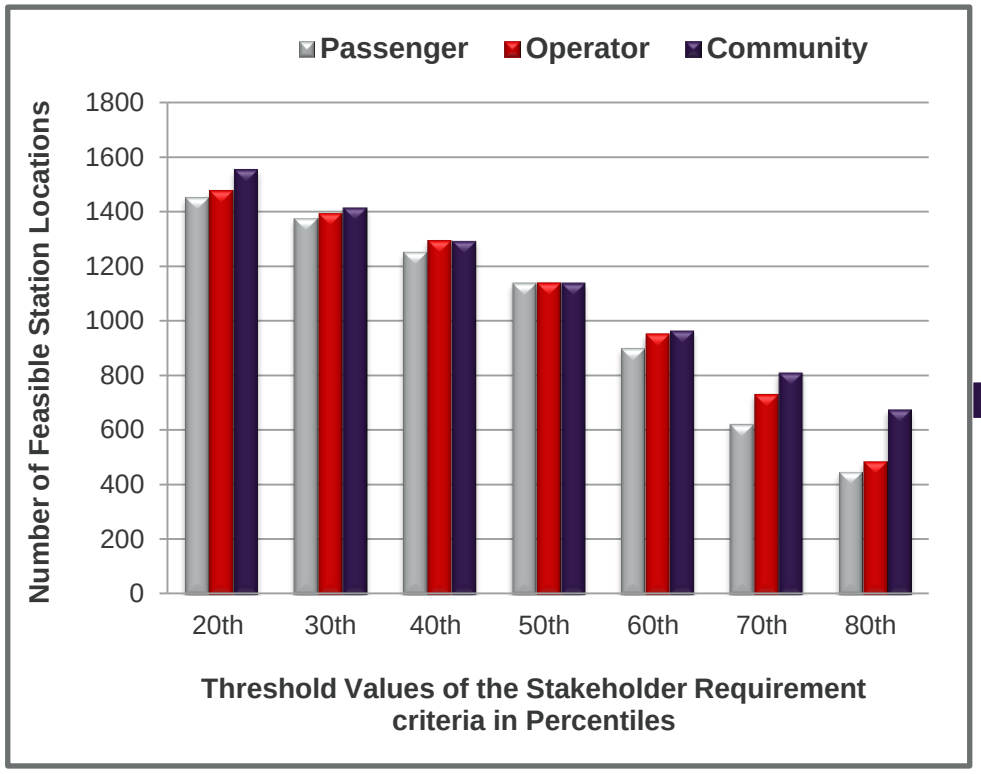
Sensitivity Analysis

2- Impact of the requirement criteria collectively at the stakeholder Level



Threshold Value (Percentiles)	Passenger %Change	Operator %Change	Community %Change
20th	0.0	0.0	0.0
30th	5.2	5.6	8.9
40th	13.7	12.4	16.8
50th	21.5	22.9	26.7
60th	37.9	35.5	37.9
70th	57.1	50.4	47.7
80th	69.0	67.1	56.5

Number of Feasible Station Locations with Different Threshold Values of the Three Stakeholder Requirements

Data sources: British Ordnance Survey and Leicester Council

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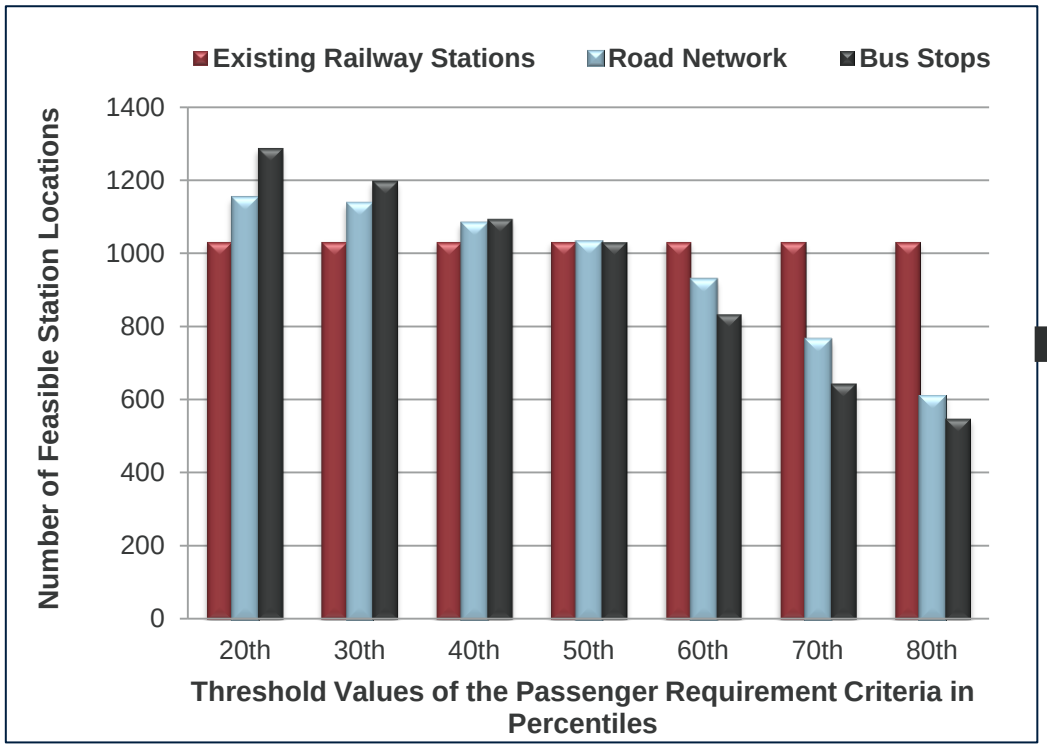
Sensitivity Analysis

3- Impact of the requirement criteria individually at the stakeholder Level

a- Passenger Requirements



Threshold Value (Percentiles)	Railway %Change	Road Network %Change	Bus Stops %Change
20th	0	0.0	0.0
30th	0	1.3	7.0
40th	0	6.0	15.0
50th	0	10.4	20.0
60th	0	19.4	35.2
70th	0	33.5	49.9
80th	0	47.0	57.4

Number of Feasible Station Locations with Different Threshold Values of the Passenger Requirements

Data sources: British Ordnance Survey and Leicester Council

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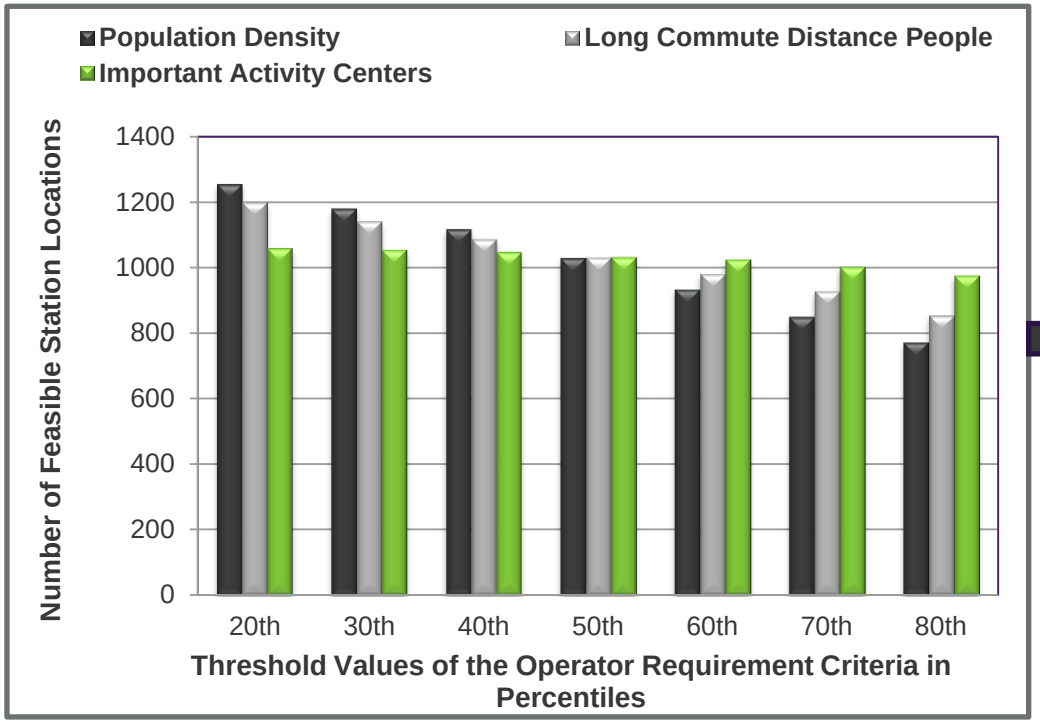
Sensitivity Analysis

3- Impact of the requirement criteria individually at the stakeholder Level

b- Operator Requirements



Threshold Value (Percentiles)	Population Density %Change	Long Commute Dist. People %Change	Important Building %Change
20th	0.0	0.0	0.0
30th	6.0	4.8	0.5
40th	10.9	9.4	1.1
50th	17.9	14.0	2.6
60th	25.6	18.2	3.2
70th	32.2	22.6	5.4
80th	38	29	8

Number of Feasible Station Locations with Different Threshold Values of the Operator Requirements

Data sources: British Ordnance Survey and Leicester Council

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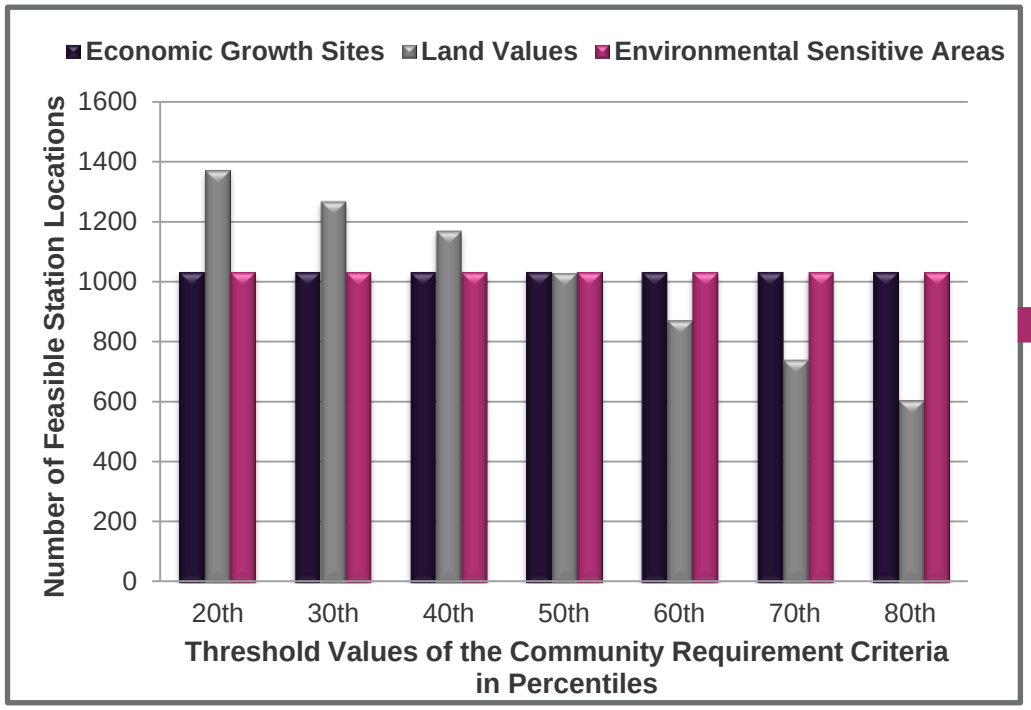
Sensitivity Analysis

3- Impact of the requirement criteria individually at the stakeholder Level

c- Community Requirements



Threshold Value (Percentiles)	Economic Growth %Change	Land Values %Change	Env. Areas %Change
20th	0.0	0.0	0.0
30th	0.0	7.6	0.0
40th	0.0	14.7	0.0
50th	0.0	24.9	0.0
60th	0.0	36.4	0.0
70th	0.0	45.9	0.0
80th	0.0	55.8	0.0

Number of Feasible Station Locations with Different Threshold Values of the Community Requirements

Data sources: British Ordnance Survey and Leicester Council

Conclusion

The proposed methodology can :

(1) simultaneously consider multiple requirements and constraints.

(2) incorporate both quantifiable and non-quantifiable requirement criteria.

(3) find solution in large scale regions with complex topographies,

(4) be expanded to include generation of the rail line network .

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Acknowledgments

The authors wish to thank the following agencies for providing the required datasets:

- British Ordnance Survey
- UK data service
- Leicester City Council for providing the required datasets , and

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