An alternative model for the distribution of population

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Many thanks to:

D. Kotzinos
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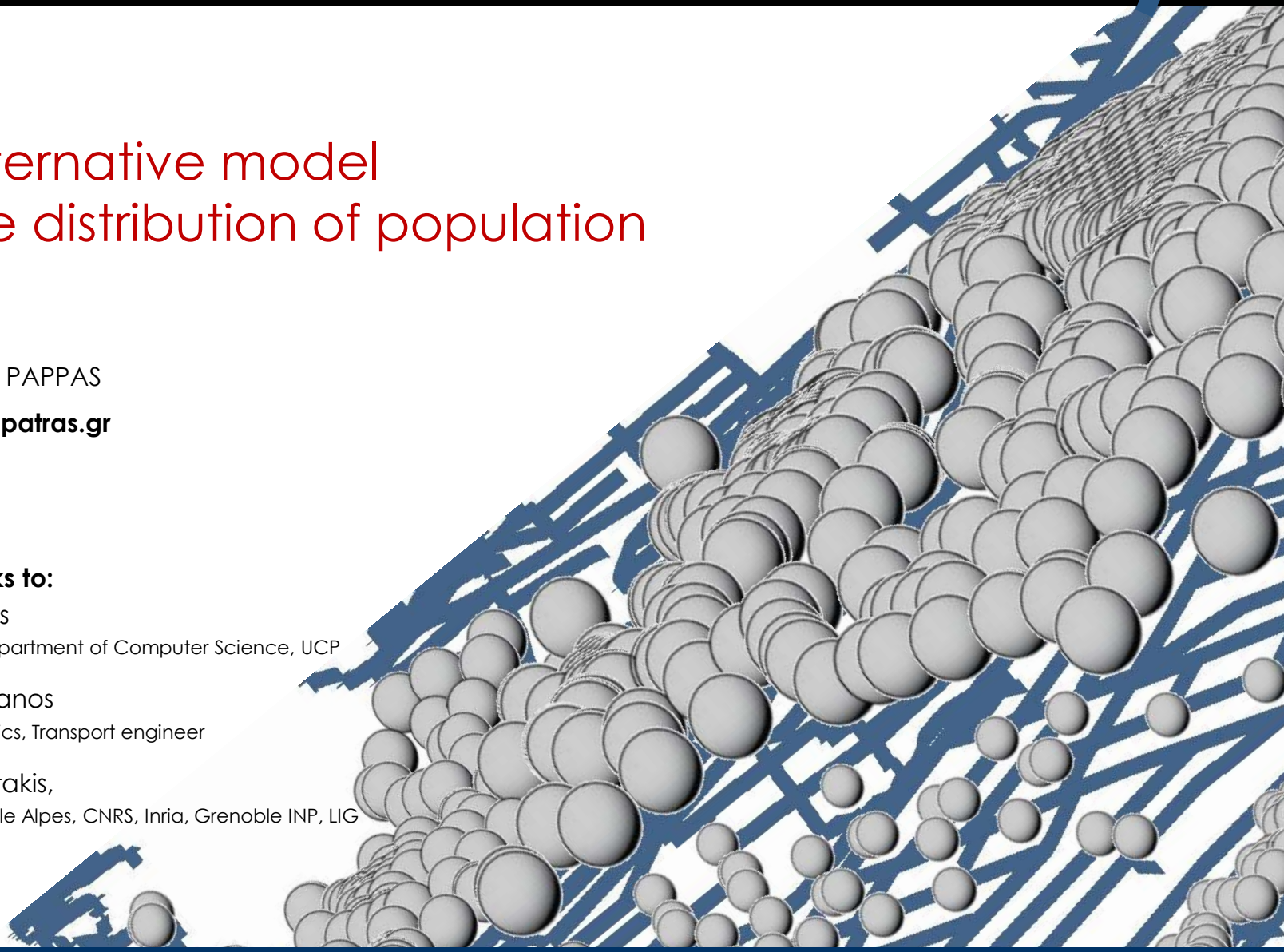
D. Sardelianos
Geoinformatics, Transport engineer

G. Arvanitakis,
Univ. Grenoble Alpes, CNRS, Inria, Grenoble INP, LIG



Laboratory of Urban and Regional Planning
Department of Architecture, School of Engineering, University of Patras

- The third largest University in Greece
- Founded in the city of Patras in 1964
- Start functioning in the academic year 1966 – 67
- 260Ha University campus
- 24 Departments organized in 5 Schools
- ~32.000 undergraduate students
- ~3.800 post-graduate students
- ~650 teaching stuff
- ~500 teaching and research assistants
- ~520 administrative / technical personnel

- a new Department, established in 1999
- ~600 undergraduate students
- ~40 teaching stuff (~20 visiting faculty)
- 10 research assistants
- 10 technical and administrative personnel
- two post-graduate programs
- Computer lab, Library, 5 studio halls, . . .

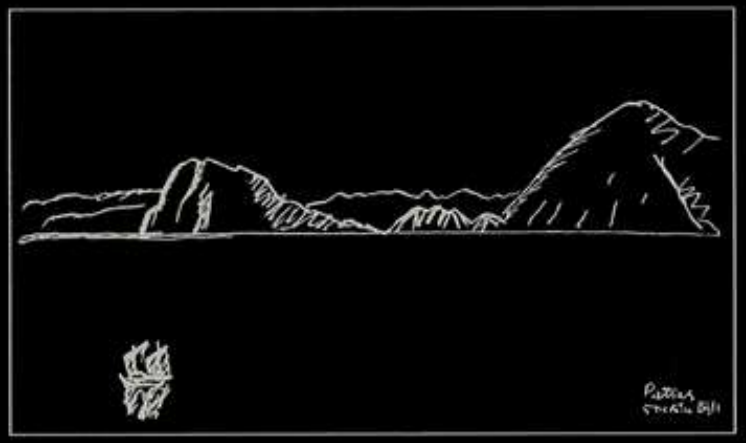
- The third urban complex in Greece
- ~250.000 inhabitants
- more than 4.000 years history
- Capital of Western Greece Region

Activities/Infrastructures:

- Port to Italy (West Gate)
- University of Patras
- Greek Open University
- University of Applied Sciences
- Science Park
- Industrial Park
- Regional Hospital
- . . .

Major problems:

- Deindustrialization
- Unemployment
- Traffic problems
- Quality of Urban Environment



Le Corbusier, 1911

Expansion and intensive development of the urban fabric

	PORT	CITY
1830 - 1870	Local Port	Urban development and formation at low rates
1870 - 1900	Port of Raisin	Rapid urban development and formation Economic growth
1900 - 1940	Port of Migration Commercial Port	Industrial stability Development of handicrafts / manufactures
1940 - 1950	2nd World War - Civil War	
1950 - 1970	Decline	Attempts for re-industrualization
1970 - 1995	Gate to Europe	Industrial decline (De-industrialization)
1995 - 2008	Node TEN-T	Turning to the tertiary sector
2009 +	A slow down	Economic crisis






Mycenaean era **Roman era** **19th century**

Source: Maps Memories, Patras 2014

The first master plan in modern Greece, S. Voulgaris 1829

Spatial components

Natural environment

Building space

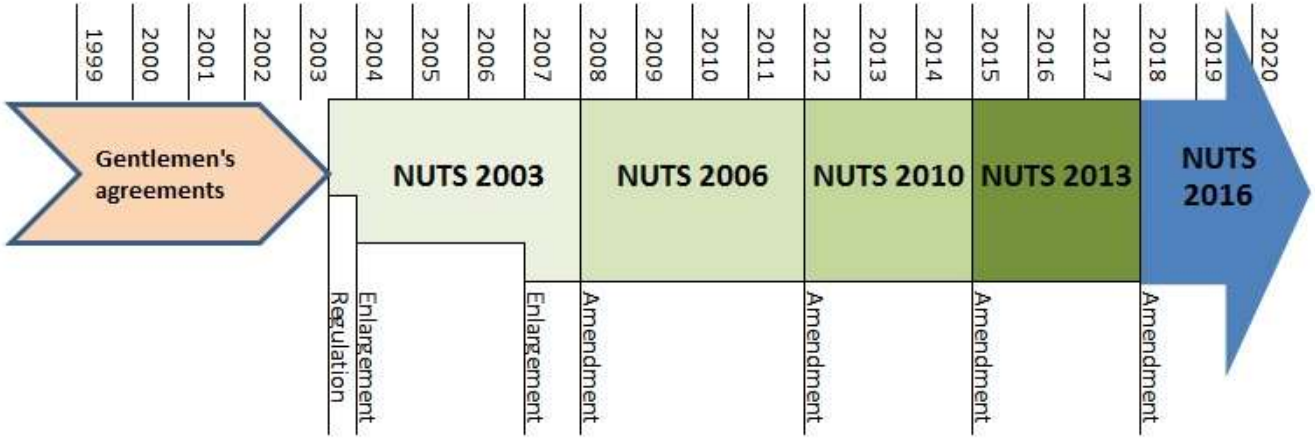
Population

Land Uses

Flows and utilities networks

Political Economy

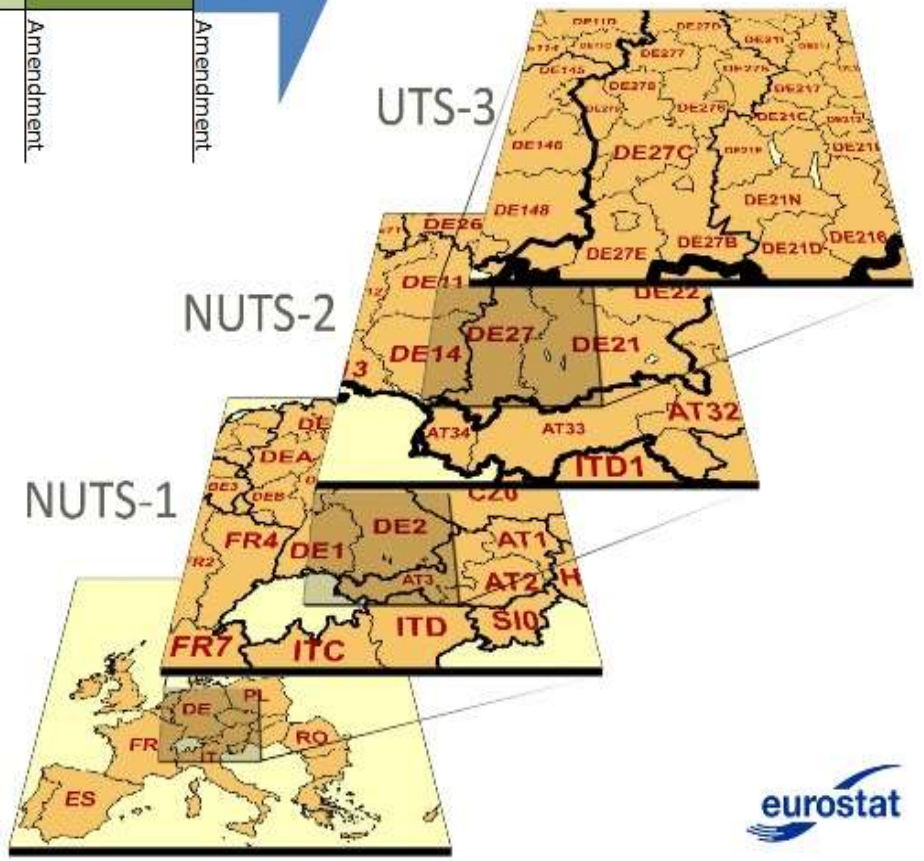
Photos: 1-vpappas, 2-http://www.telegraph.co.uk/, 3-http://en.wikipedia.org/wiki/Istanbul, 4-http://www.stadtentwicklung.berlin.de/, 5-http://www.vesti.la/, 6-http://www.ddstuffs.com/



NUTS 1: major socio-economic regions
NUTS 2: basic regions for the application of regional policies
NUTS 3: small regions for specific diagnoses

LAU: Local Administrative Units

LEVEL	MINIMUM	MAXIMUM
NUTS 1	3 million	7 million
NUTS 2	800 000	3 million
NUTS 3	150 000	800 000



source: http://ec.europa.eu/eurostat/web/nuts/history

Administrative division of France

NUTS0 **Country**

NUTS1 **Z.E.A.T. + DOM (14)**

NUTS2 **Regions + DOM (27)**

NUTS3 **Departments + DOM (101)**

LAU1 **Communes (35.462)**

. . .

. . . **Settlements (50.094 ?)**

DOM : Departement d' outre-Mer
Z.E.A.T. : Zone economique d' amenagement du territoire

source: http://ec.europa.eu/eurostat/web/nuts/national-structures-eu

NUTS0 Country

NUTS1 Developmental Regions (4)

NUTS2 Regions (13)

NUTS3 Groups of regional units / Prefectures (52)

LAU1 Municipalities (326)

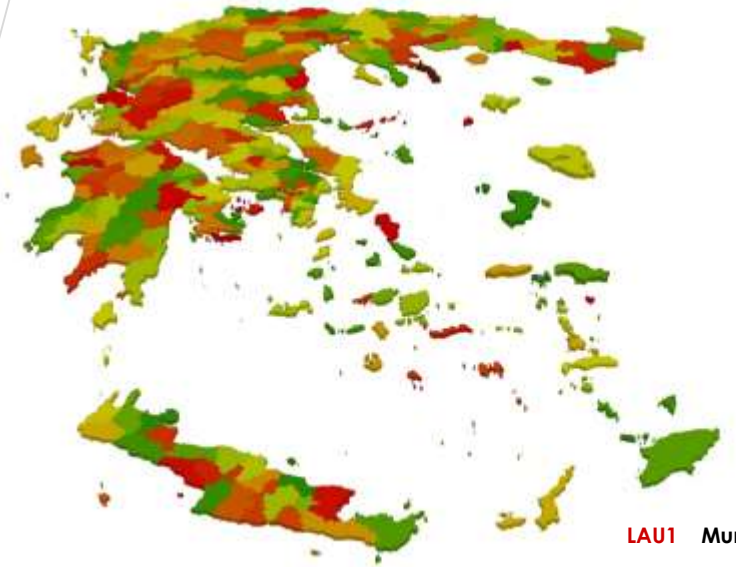
LAU2 Municipal units (1.034)

. . . Local units (6.134)

. . . **Settlements (13.554)**

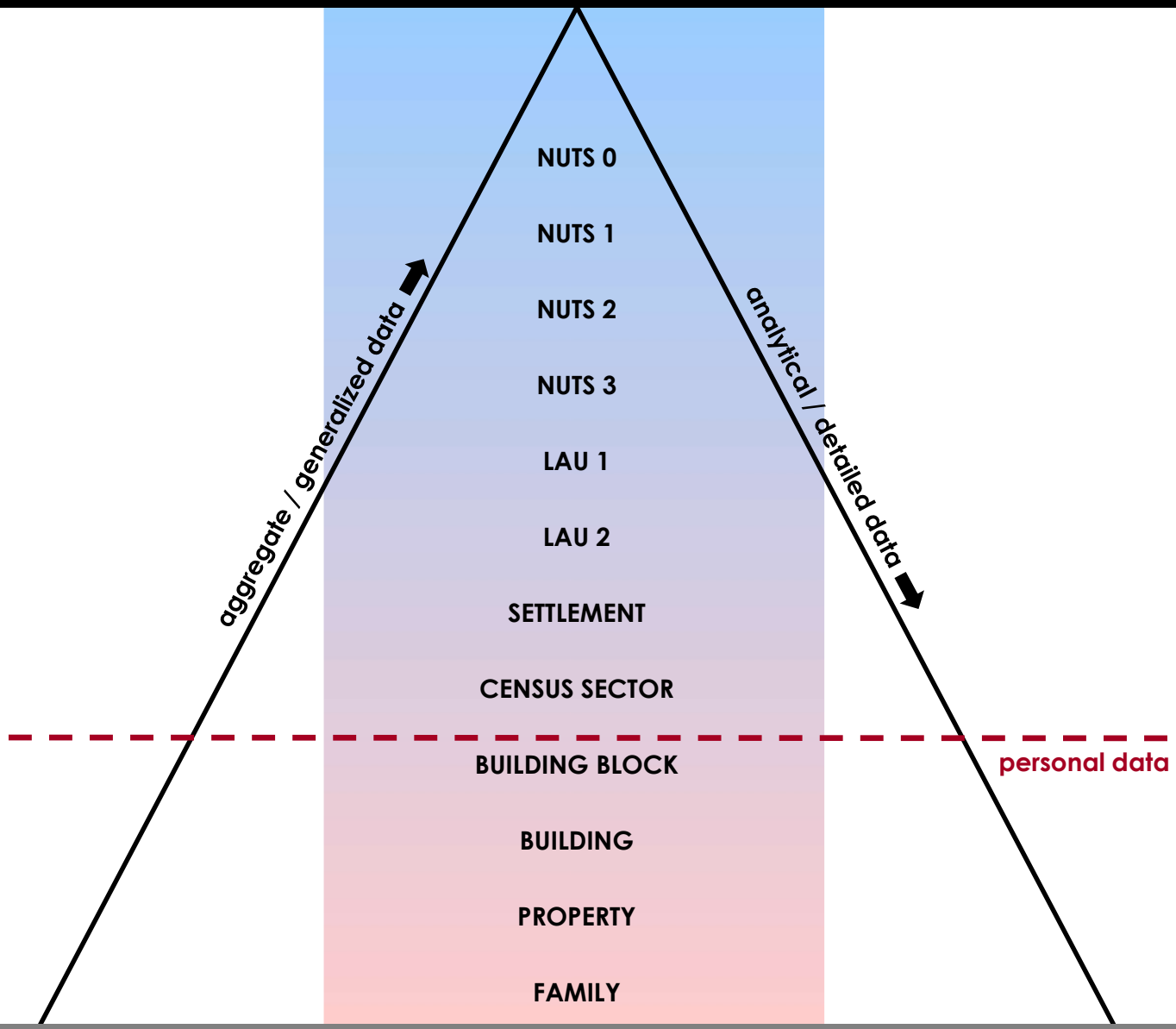
NUTS2 Regions (13)

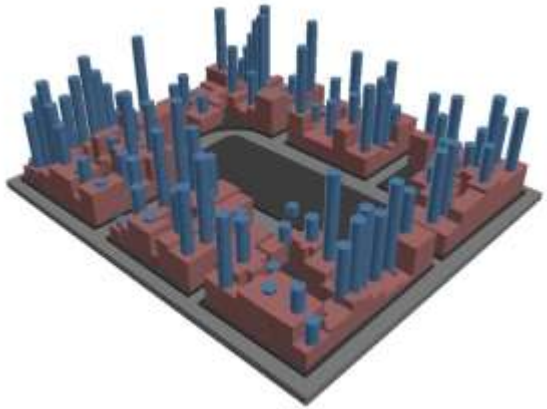
NUTS3 Regional units / Prefectures (75)



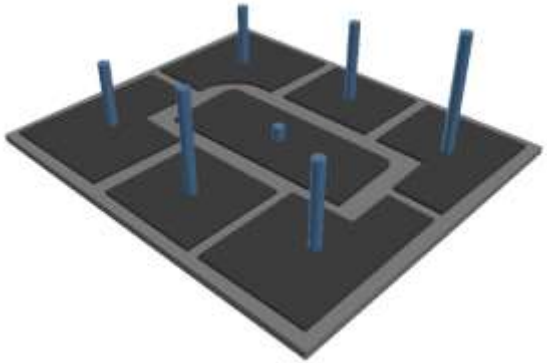
LAU1 Municipalities (326)

Statistical (population) data availability

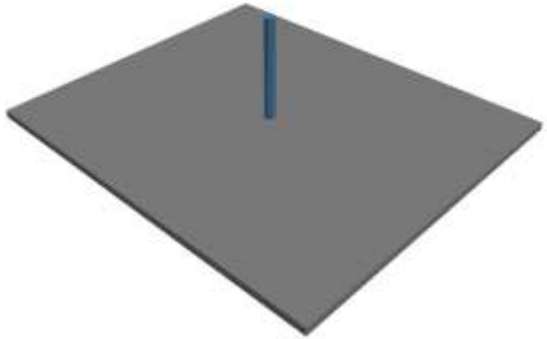




Buildings / Properties



Building plots



Census sectors

The population spatial models are depending mainly from the purpose, the scale and the data availability

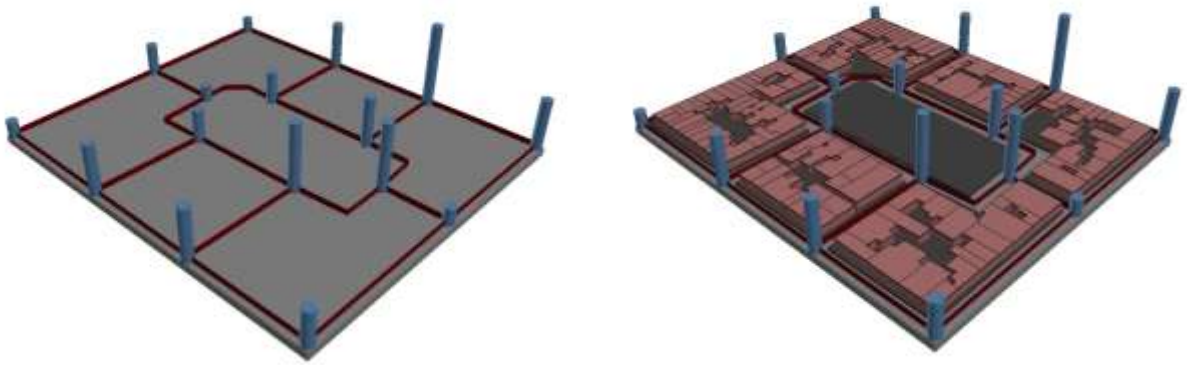
The research question

Settlements

Communities

Municipalities

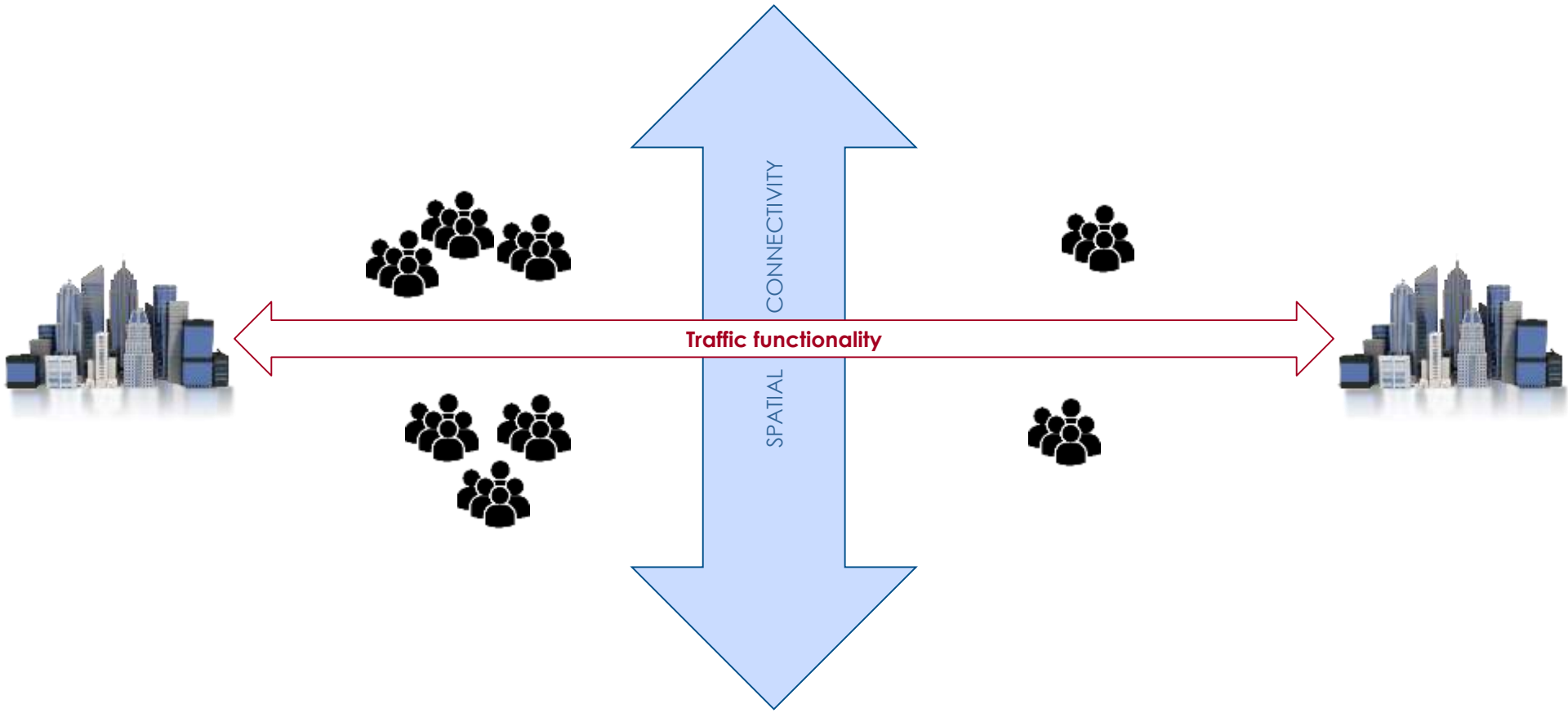
The population spatial models are depending mainly from the purpose, the scale and the data availability



a model based on nodes

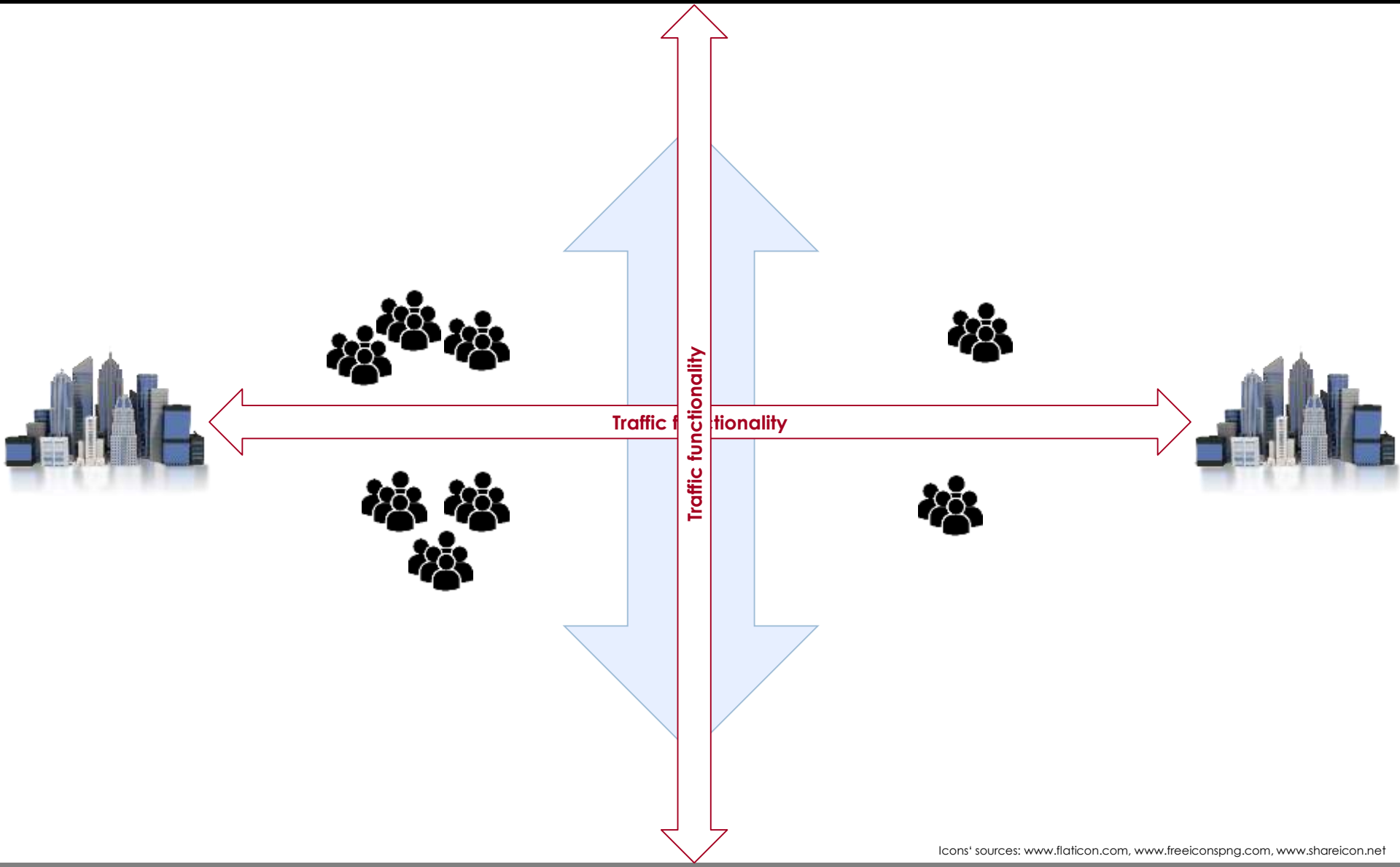
The population spatial models are depending mainly from the purpose, the scale and the data availability

Traffic functionality vs. Spatial connectivity



Icons' sources: www.flaticon.com, www.freeiconspng.com, www.shareicon.net

Traffic functionality vs. Spatial connectivity



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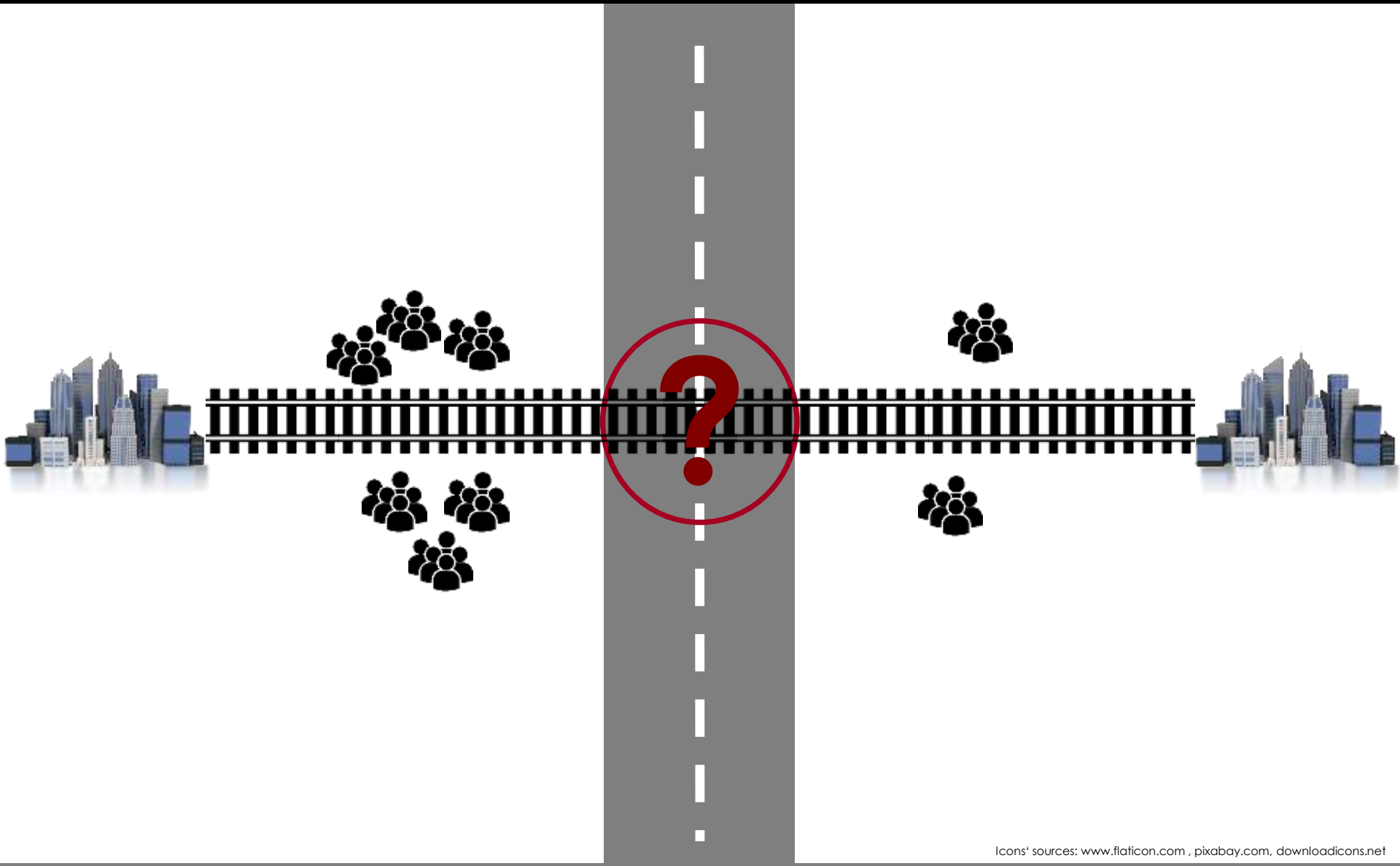
The spatial connectivity is implemented through transport systems

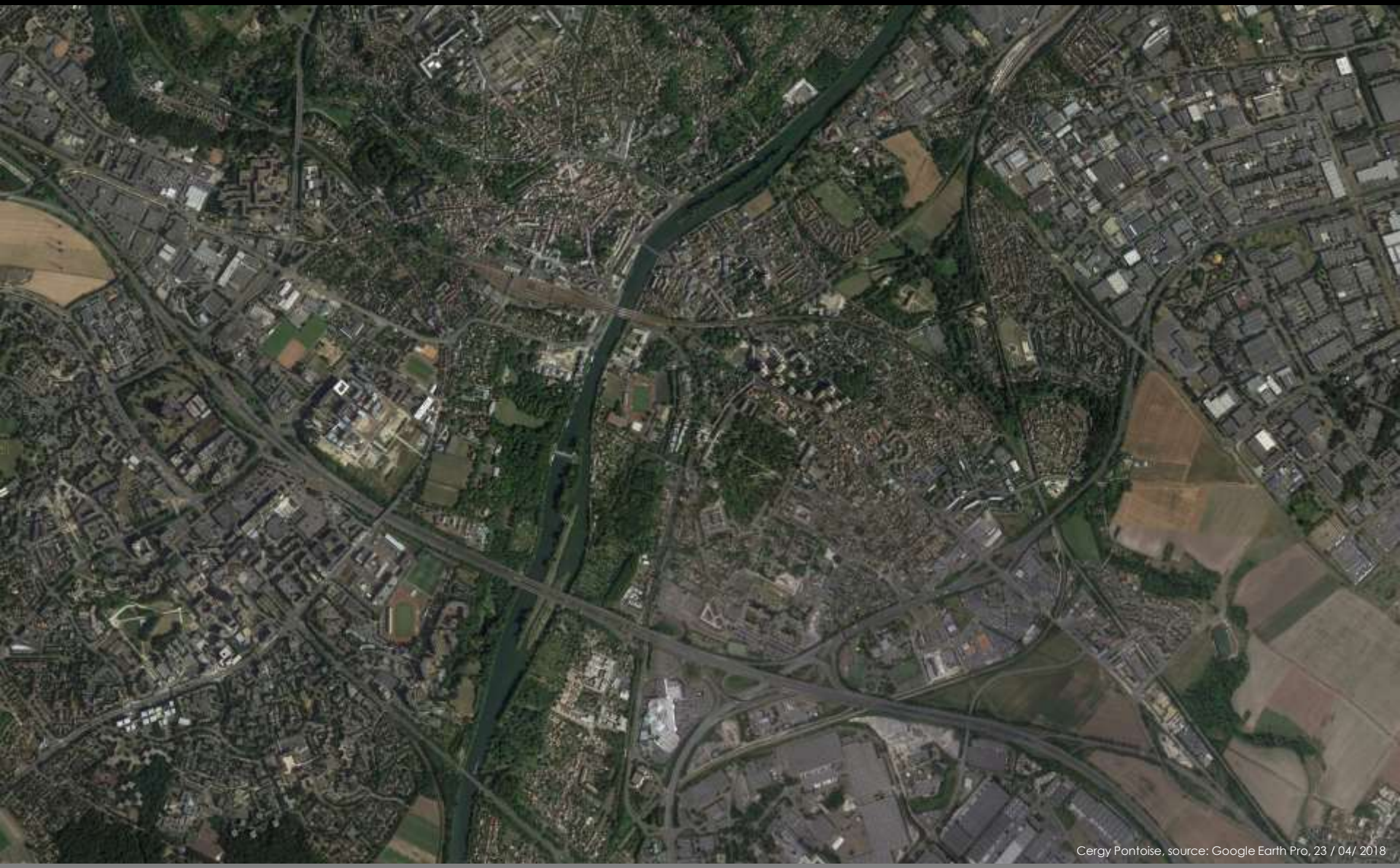
Traffic functionality vs. Spatial connectivity



Icons' sources: www.flaticon.com , pixabay.com, downloadicons.net

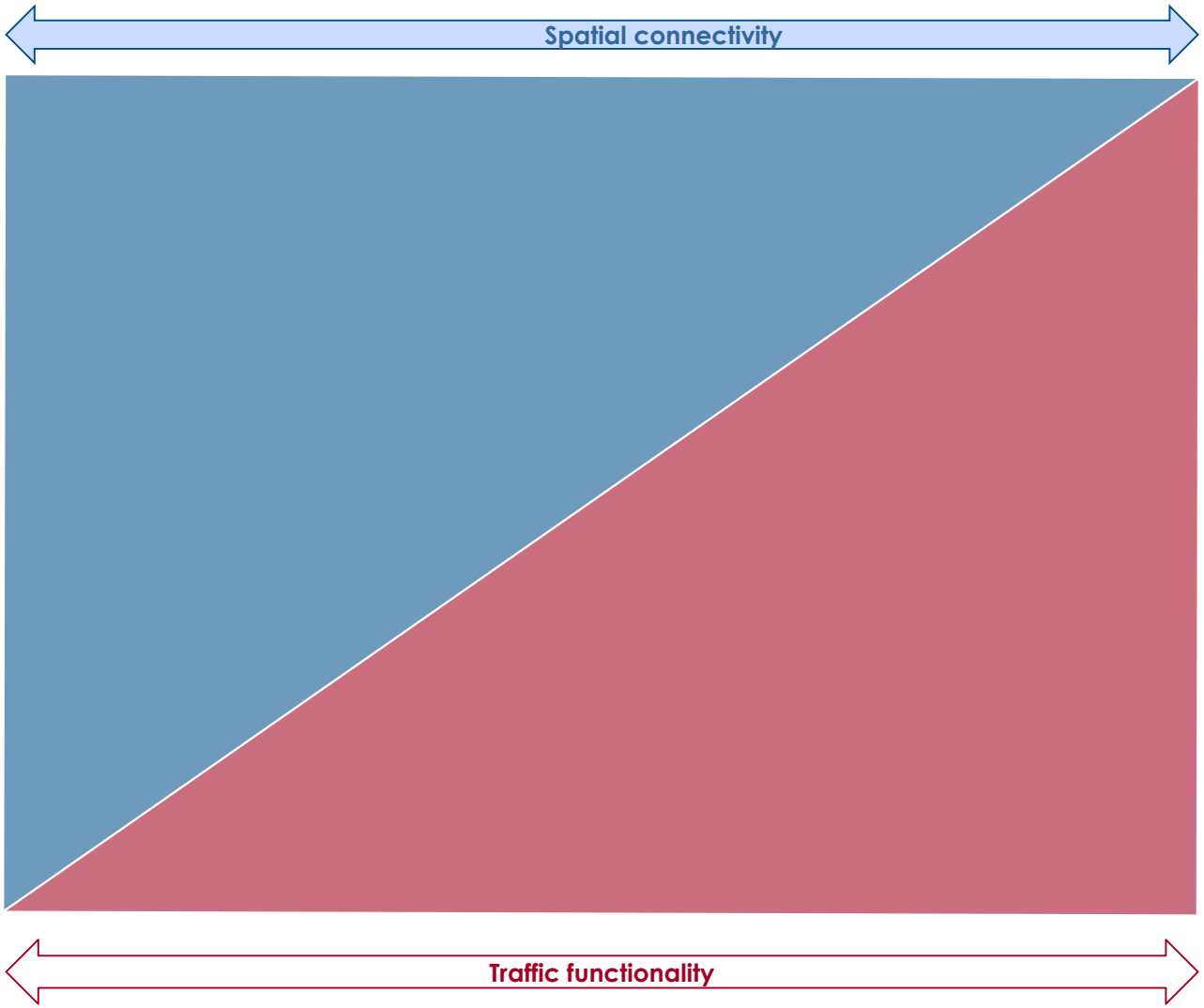
Conflicts / Problems if different transport systems

Traffic functionality vs. Spatial connectivity



Cergy Pontoise, source: Google Earth Pro, 23 / 04/ 2018

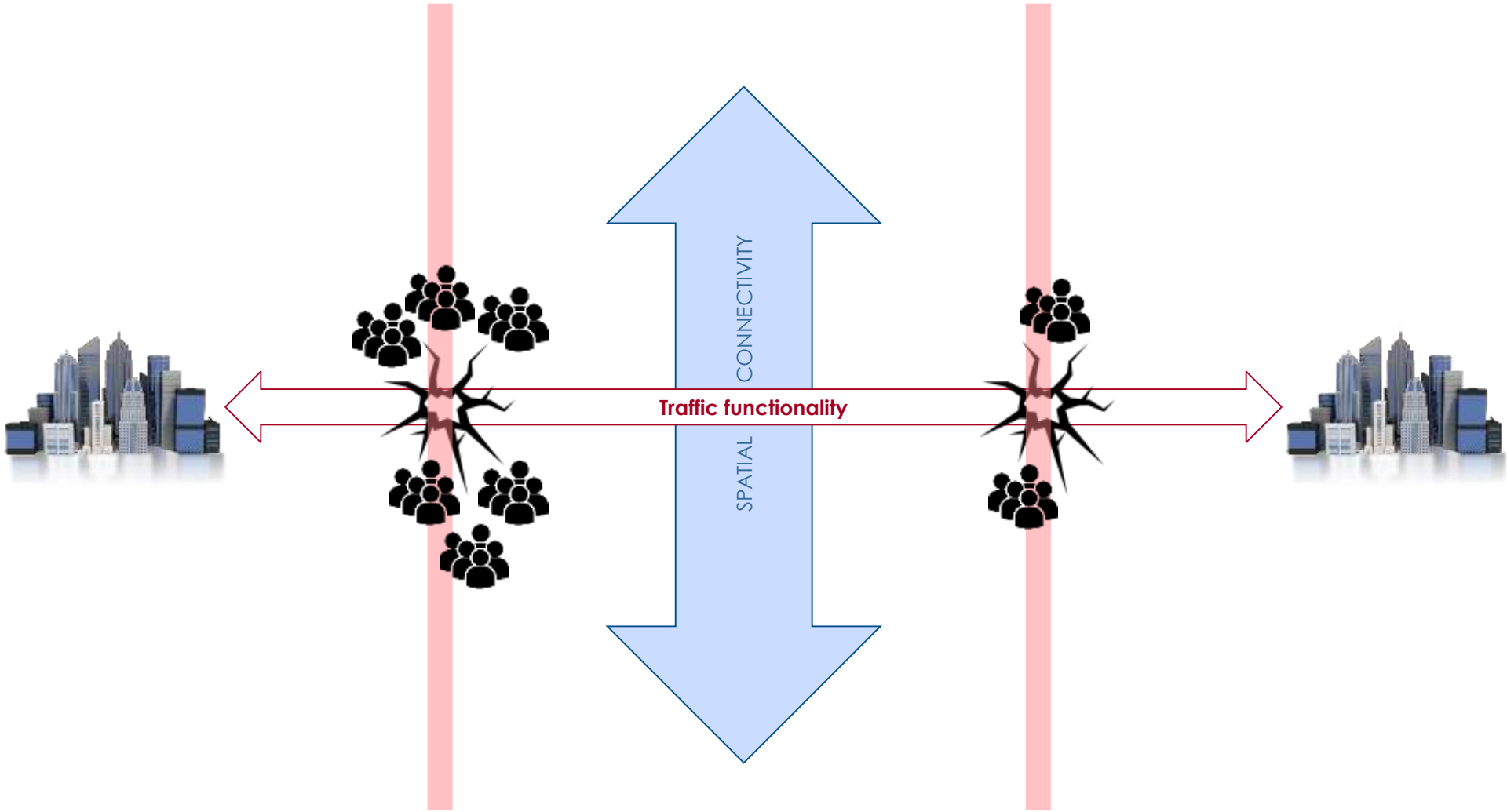
Traffic functionality vs. Spatial connectivity



Icons' sources: www.flaticon.com

Spatial connectivity has a negative relation with traffic functionality and the determinant is not only the cost

Traffic functionality vs. Spatial connectivity

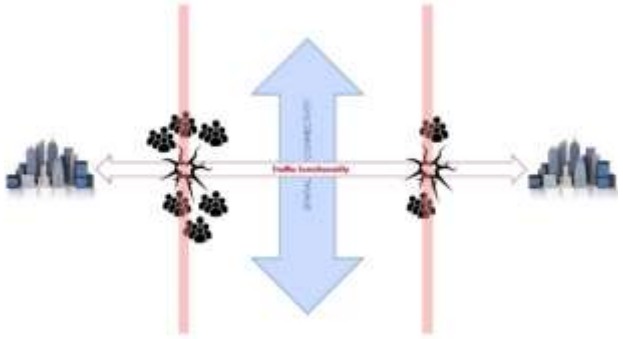


Icons' sources: www.flaticon.com, www.freeiconspng.com, www.shareicon.net

The contribution of each cross (junction, link, etc.) is proportional to the population that will potentially use it (attracted population)

Rating / Validation models

- Traffic volumes
- Risk of intersection (based on various parameters)
- Number of accidents
- Cost of action (maintenance / upgrade / construction)
- Cost of total network
- . . .



For examples for railway networks (plain junctions):

- The addition of automated luminous signals and automated protected bars reduces the accidents by 50 %
- The increase of road traffic volumes by 50% increases also the accidents by 15 %
- The increase of rail traffic volumes by 50% increases also the accidents by 12 %
- The increase of railroad lines (from single to double) increases the accidents by 10 %

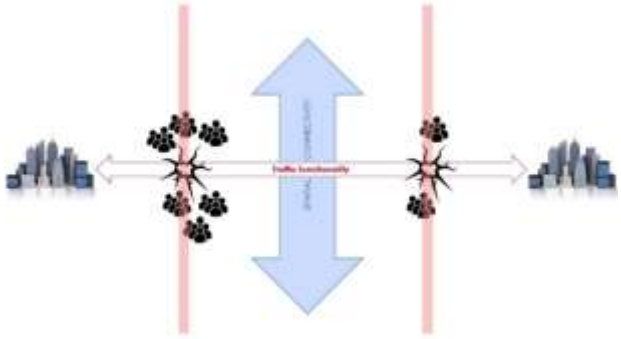
Note: The above figures are from the Hellenic reality

Photo source: www.pinterest.com

Only empirical Rating / Validation models

Usually the emphasis is on traffic functionality

The main parameter is to reduce the crossings



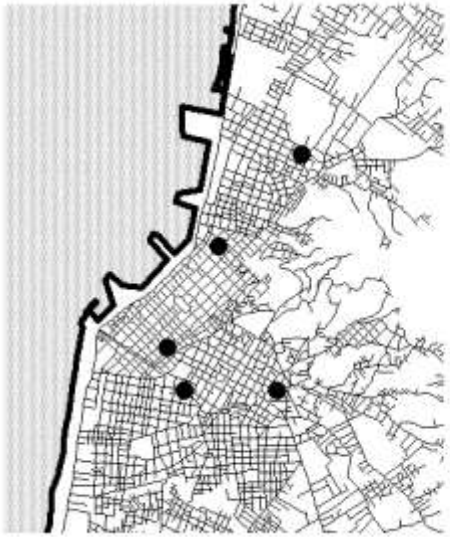
For potential (existing) crossings:

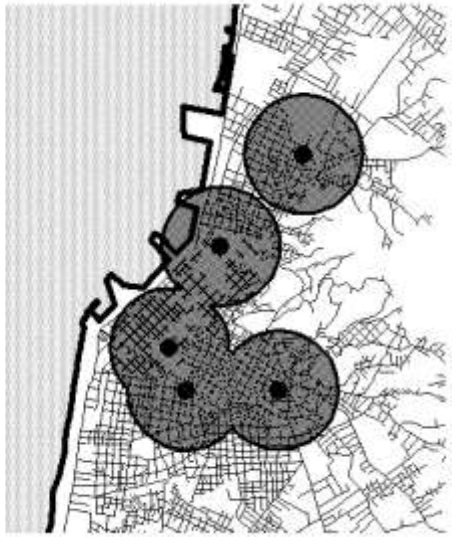
- **Influence zone (service area)**
- **Calculation of the population in service area**
- **Attractiveness (routes at less cost)**

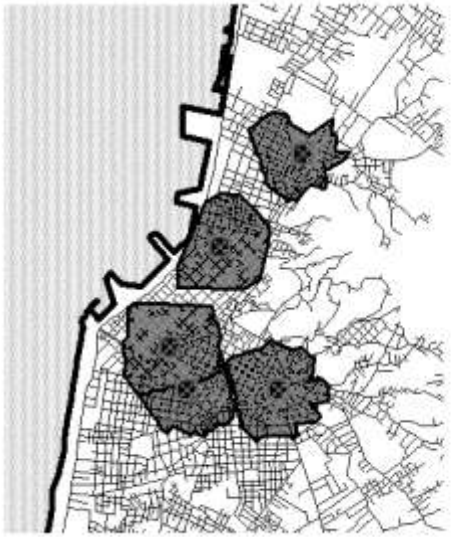
- **Evaluation matrix (scale, weights, etc.)**
- **Creating scenarios**

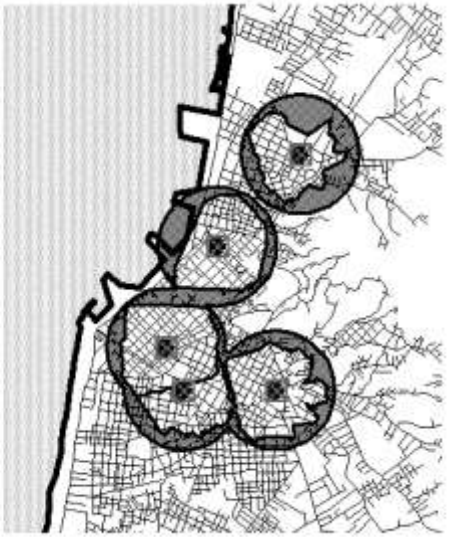
Photo source: https://www.flickr.com/photos/jeffs4653/11946449776

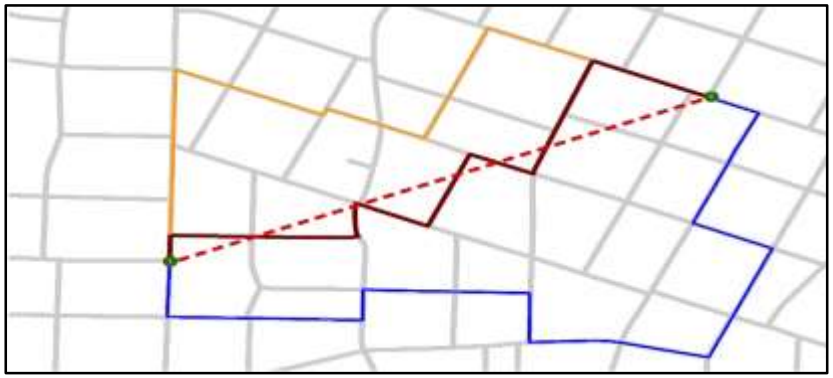
The meaning of distance











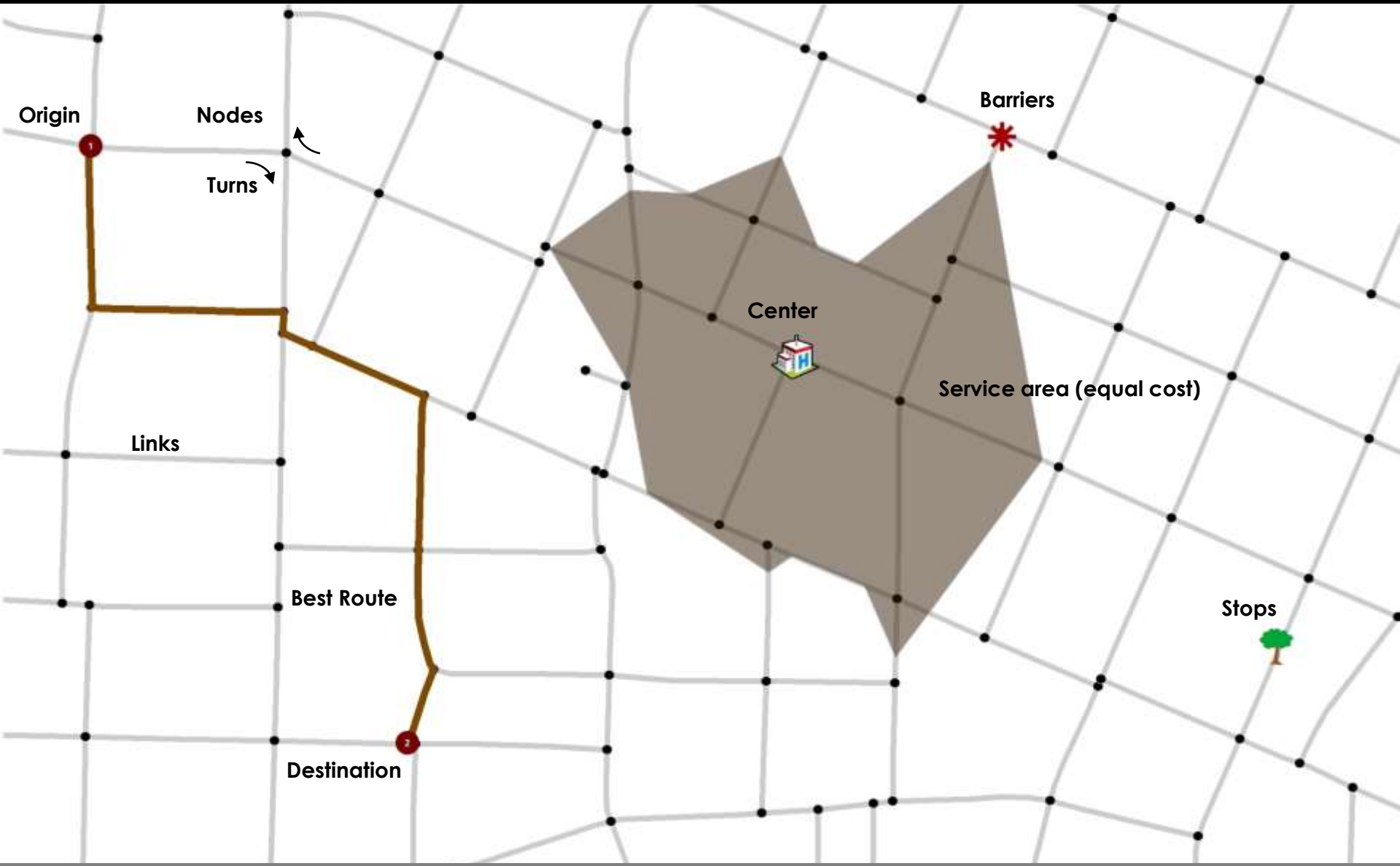
$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}.$$

Euclid

D = abs(x1–x2) + abs(y1–y2)

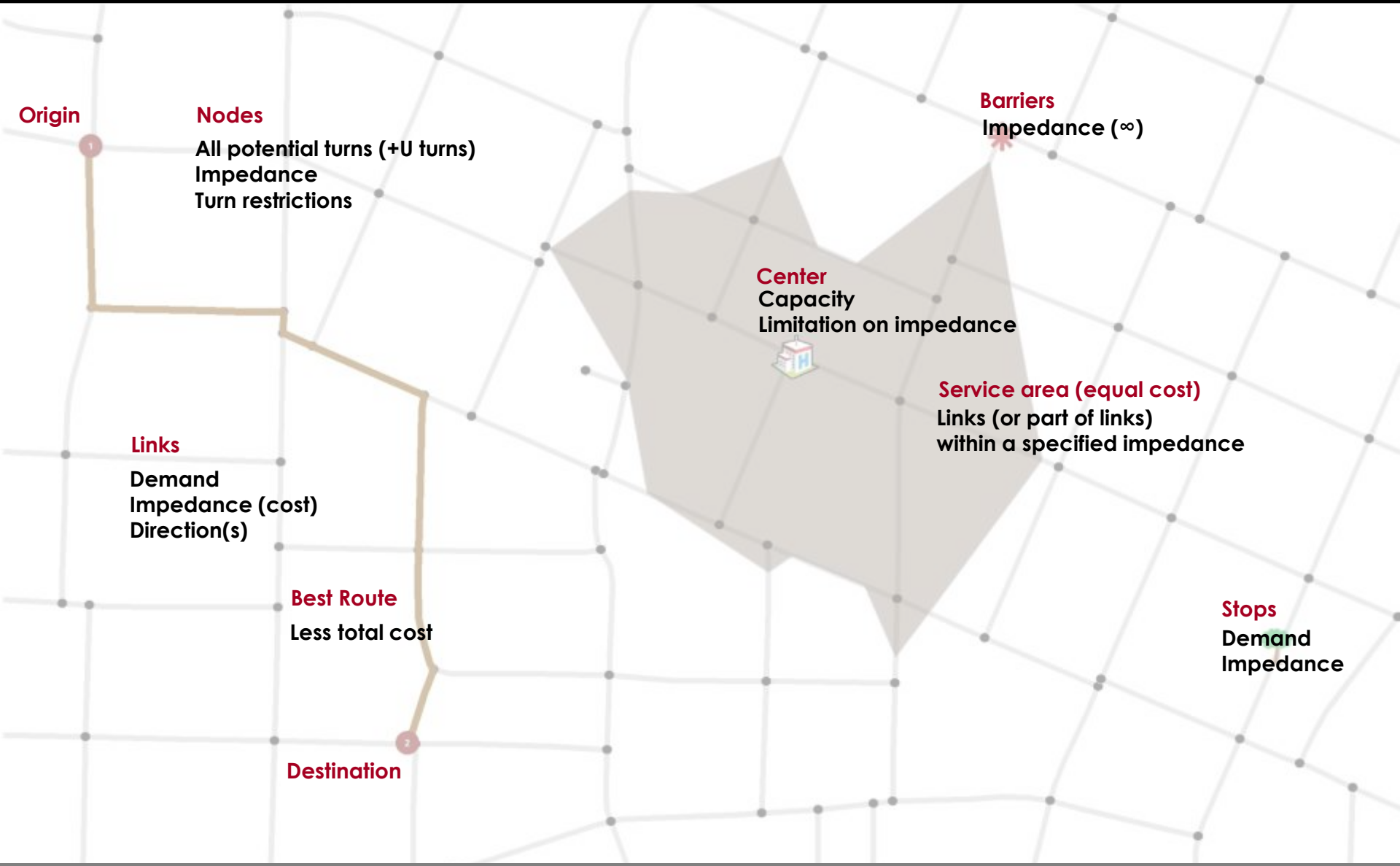
Manhattan

Main elements of a Network dataset



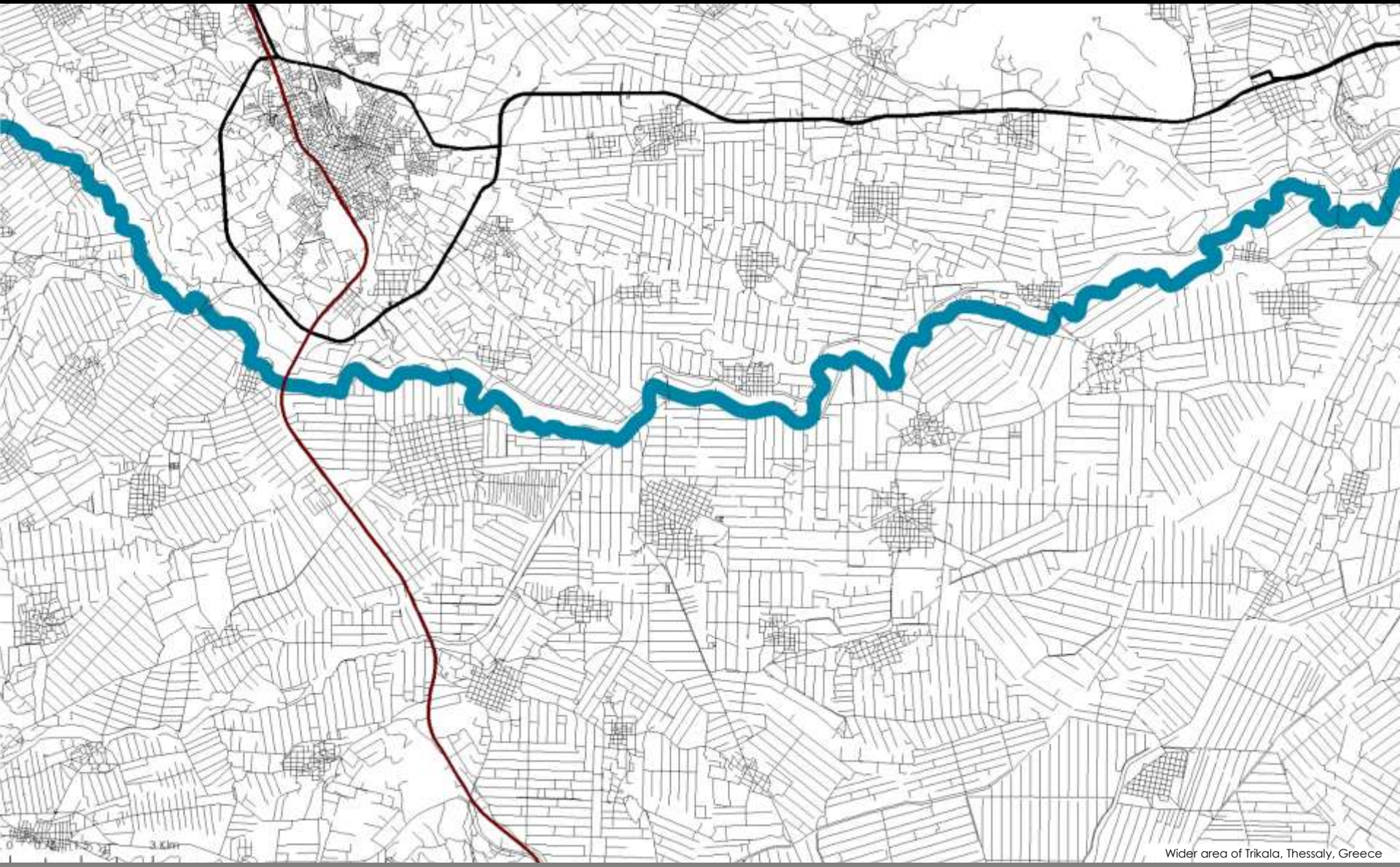
Resources flow on links (edges, channels, pipes, etc.)

Main elements of a Network dataset



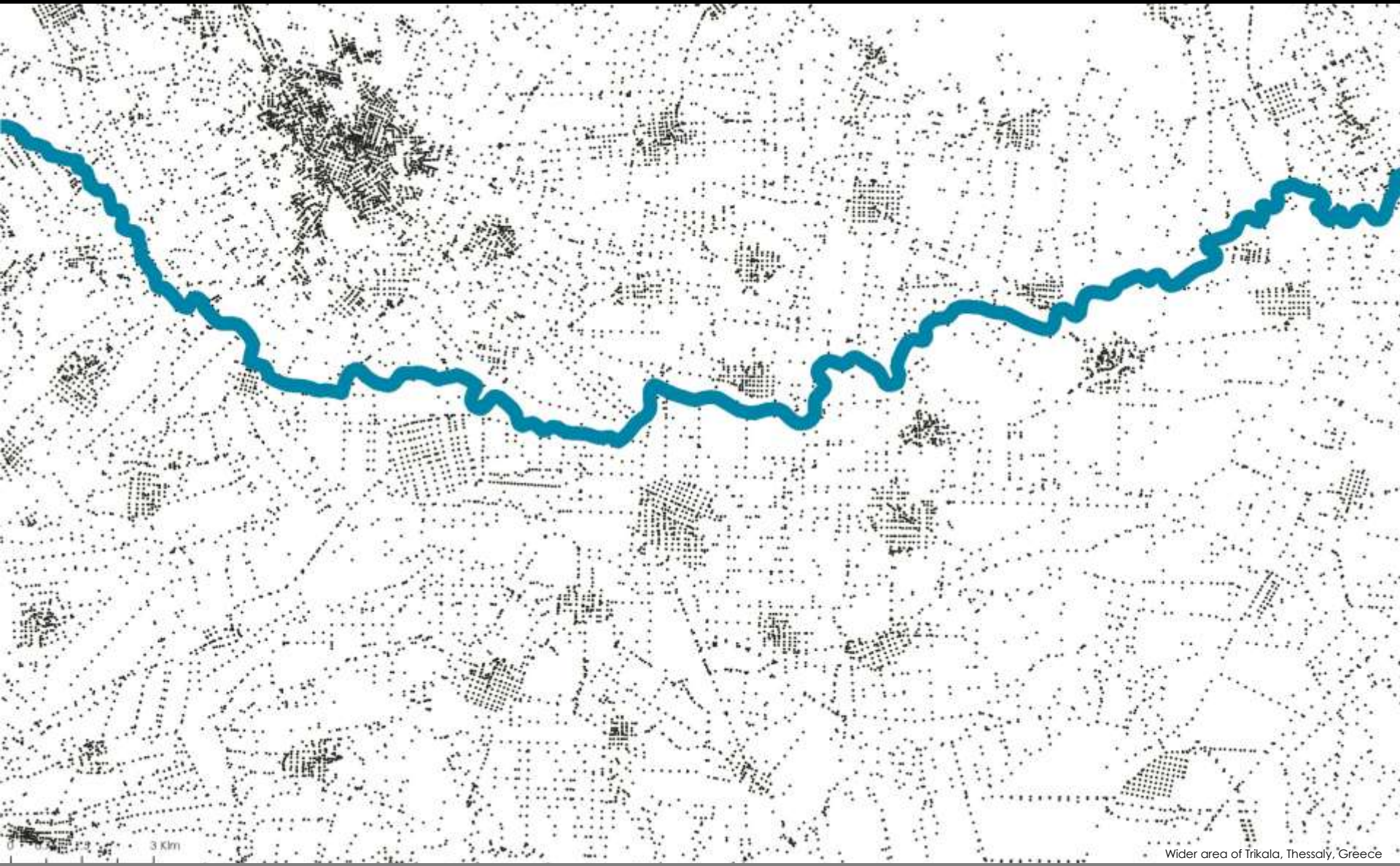
Diameter: the maximum length of all links, **Accessibility index:** the total length, **Dispersion index:** the total length for all possible routes

A network dataset for the “real” world



Wider area of Trikala, Thessaly, Greece

A network dataset for the “real” world



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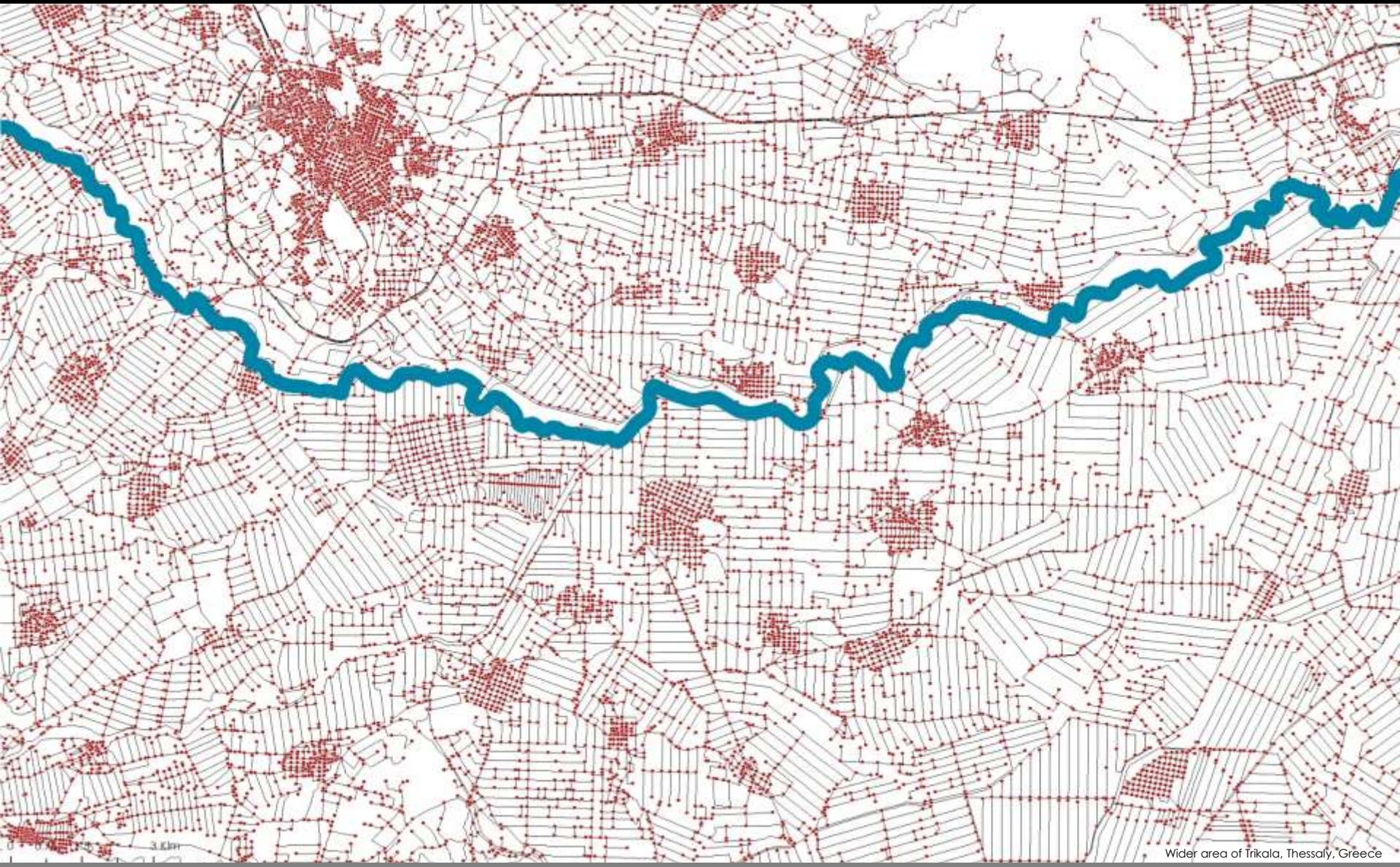

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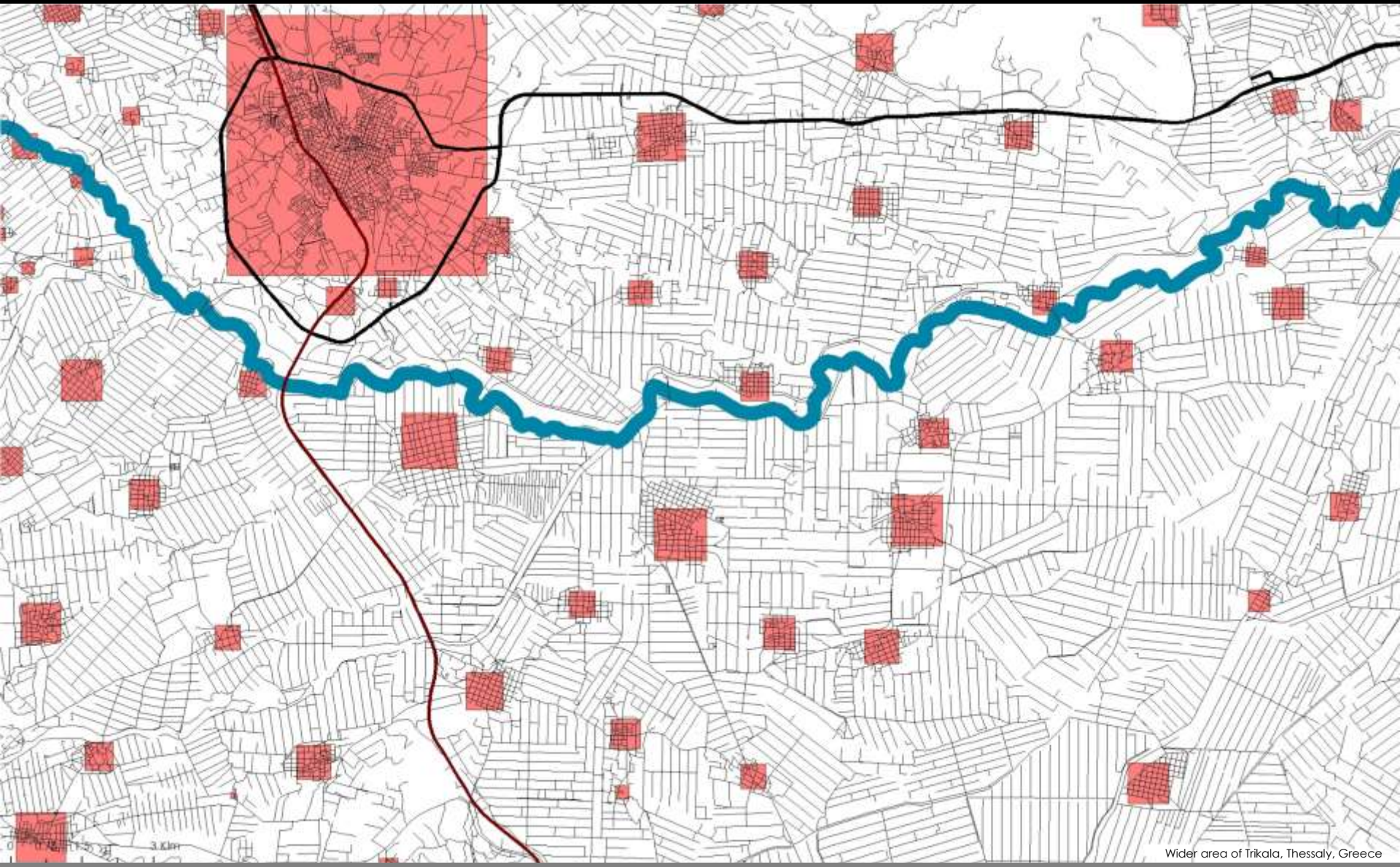
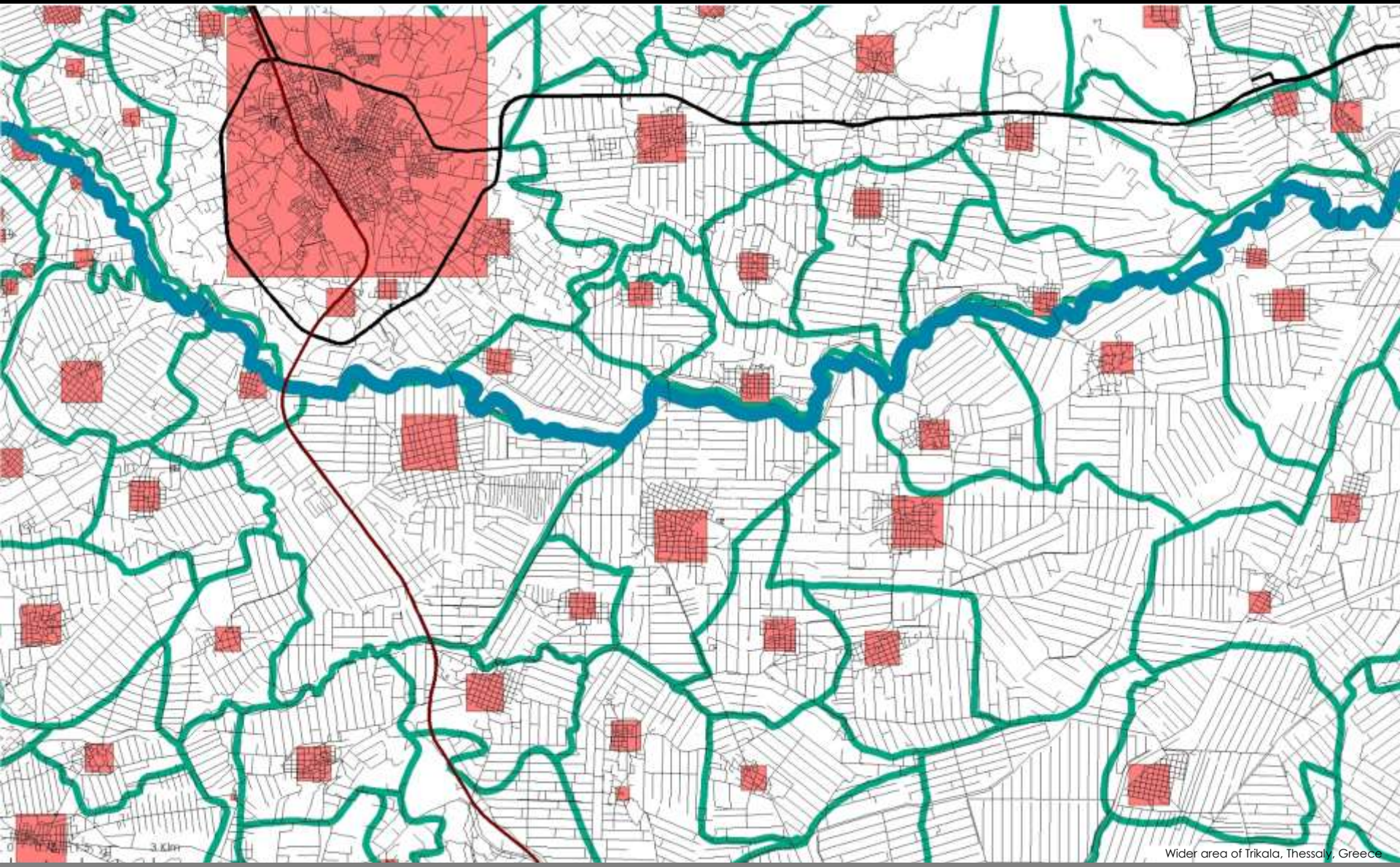


Wider area of Trikala, Thessaly, Greece

De facto population per settlement

1.000 inh.

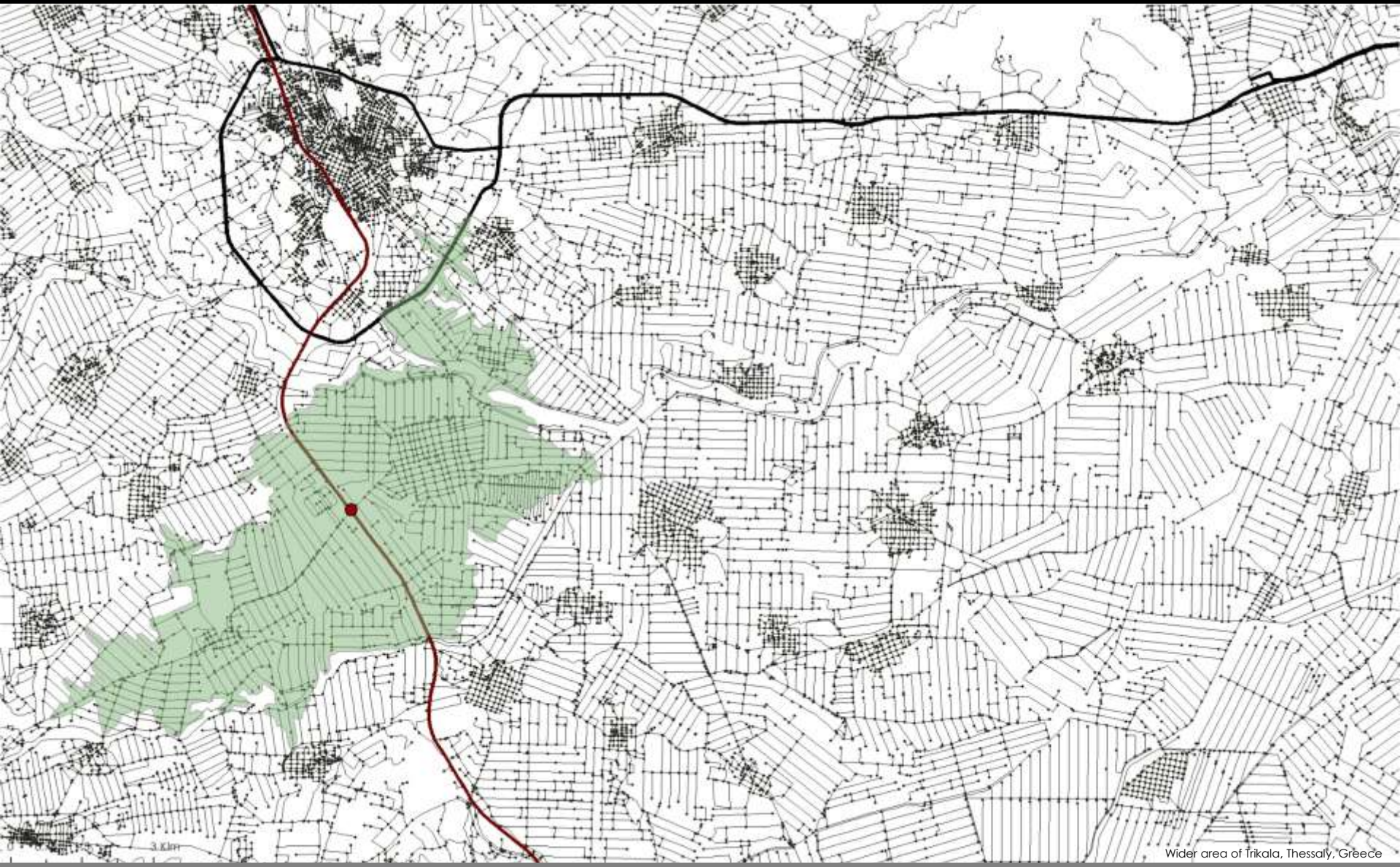
A network dataset for the “real” world



De facto population per settlement

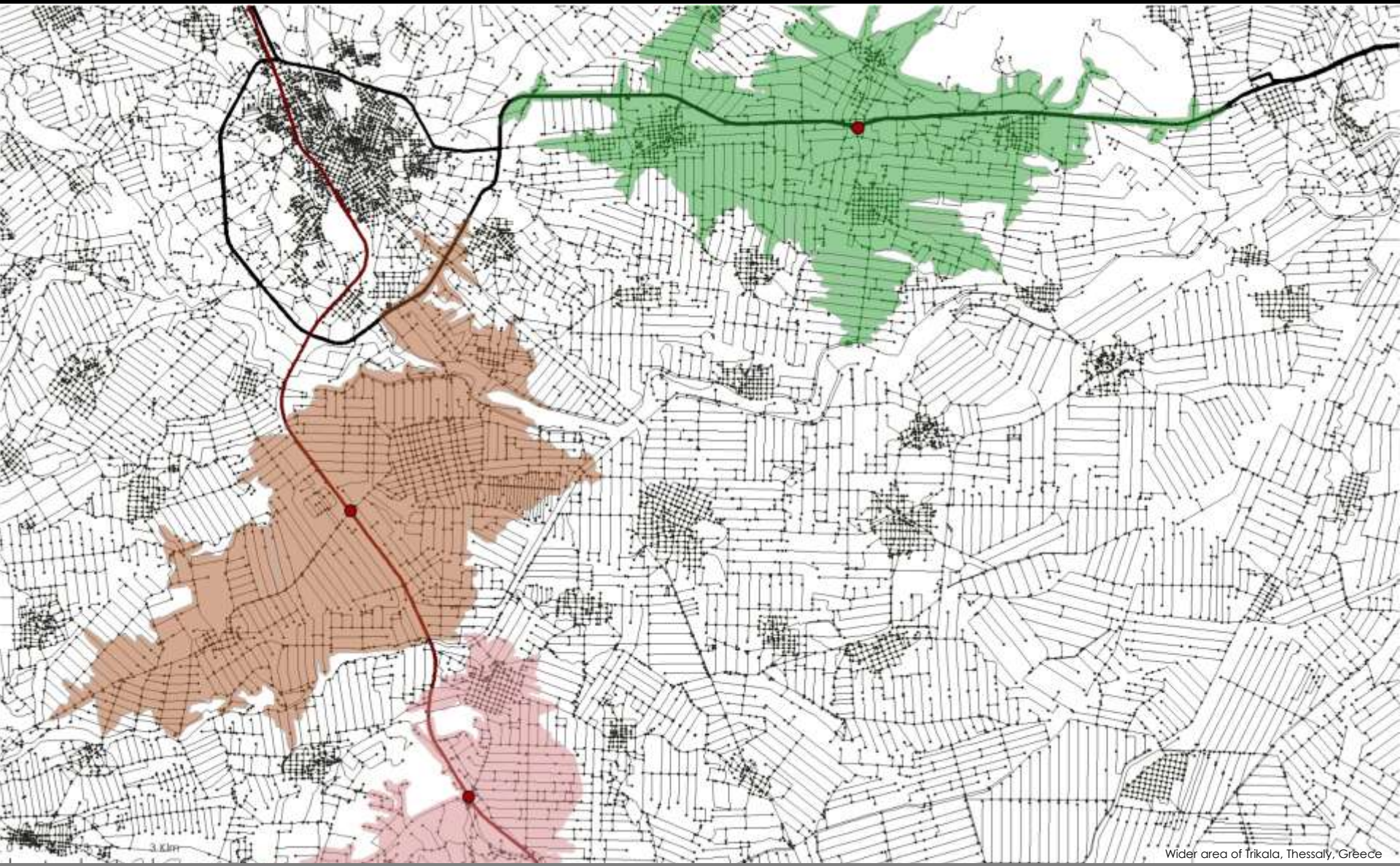
1.000 inh.

Creation of service area



Wider area of Trikala, Thessaly, Greece

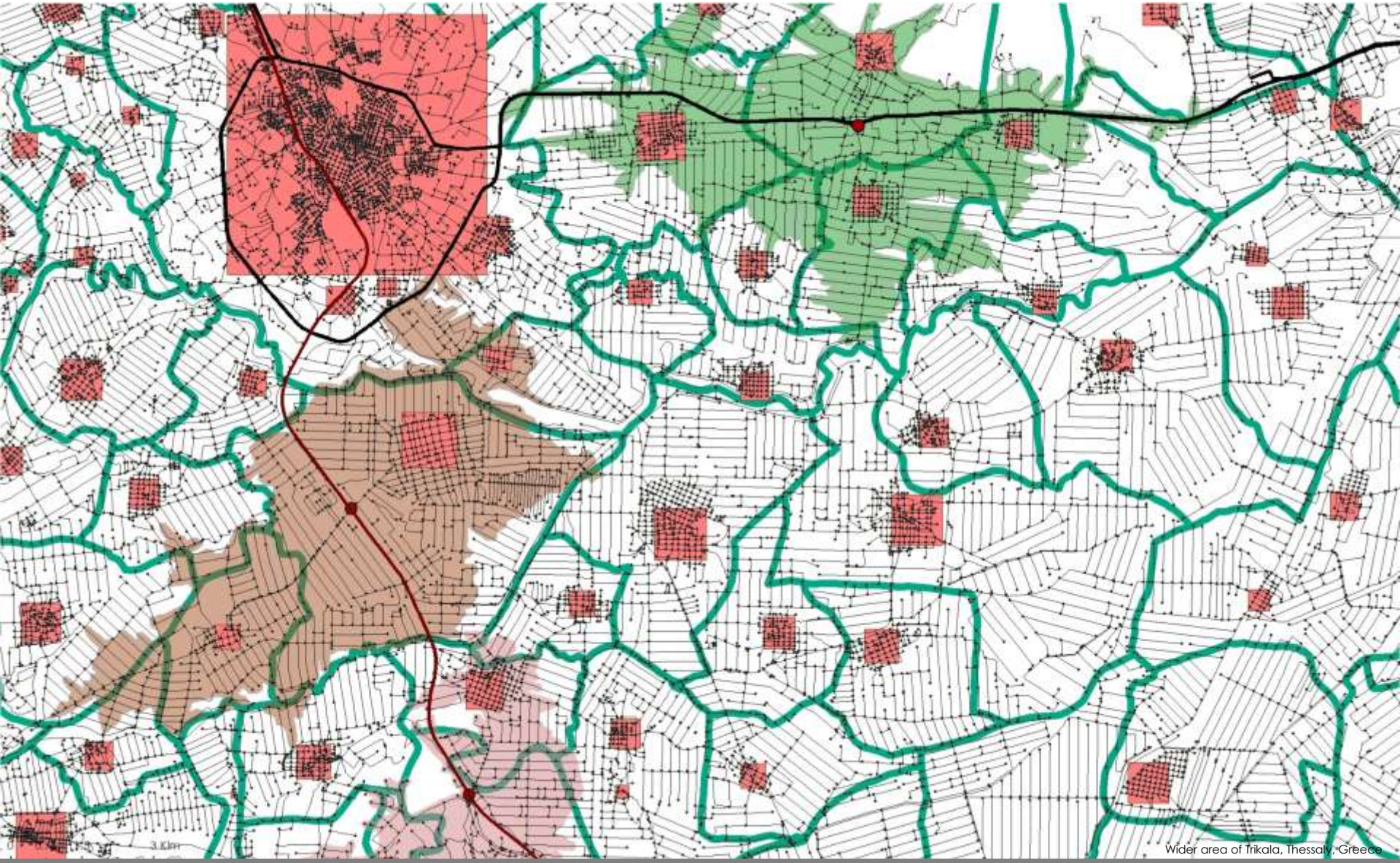
Creation of service areas (allocation of links and nodes)



Wider area of Trikala, Thessaly, Greece

The contribution of each cross (junction, link, etc.) is proportional to the population that will potentially use it (attracted population)

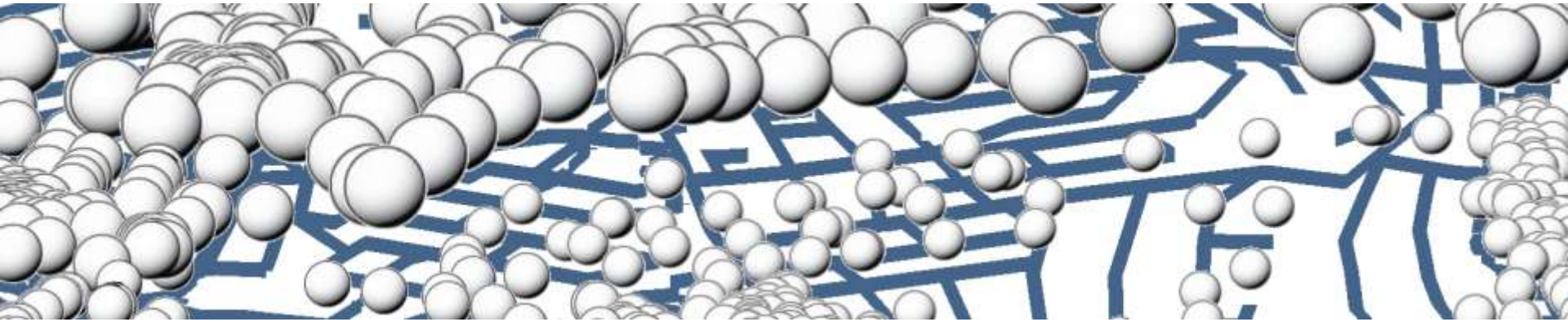
Allocation of population?



The contribution of each cross (junction, link, etc.) is proportional to the population that will potentially use it (attracted population)

1.000 inh.

- **The trip generation is based on distribution of buildings.**
- **Housing has strong relation with the population.**
- **Other buildings - points of attraction (industries, hospitals, etc.) have their own population.**
- **All buildings (houses and other points of attraction) have connection to the road network.**
- **The allocation of buildings is equable (uniform) across each link.**
- **The population is concentrated to the relevant nodes.**
- **The population is statistically significant for the number of road junctions (nodes).**



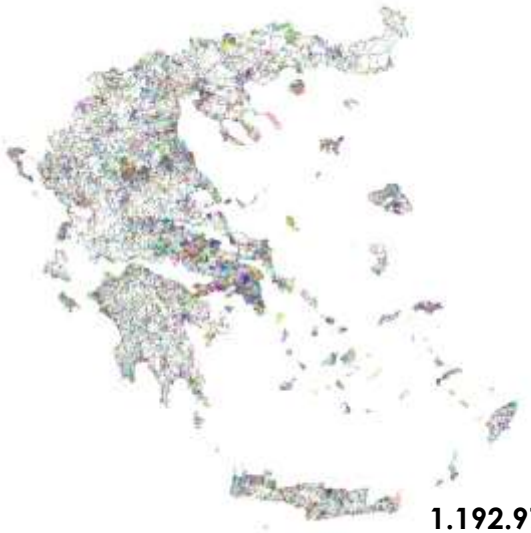
The Hellenic Road Network

1.190.458 edges

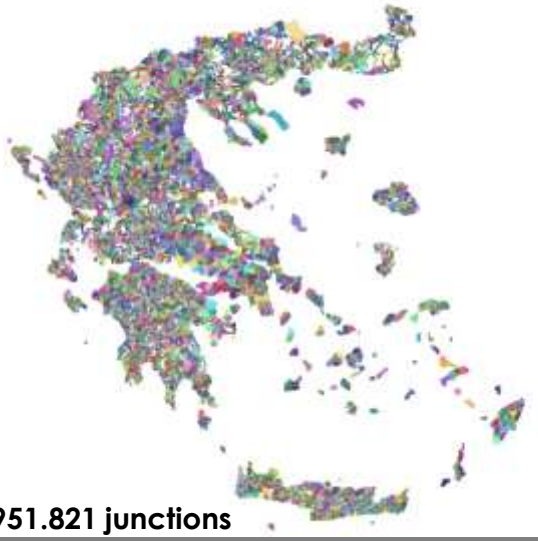
6.134 communities

951.821 junctions

Intersect



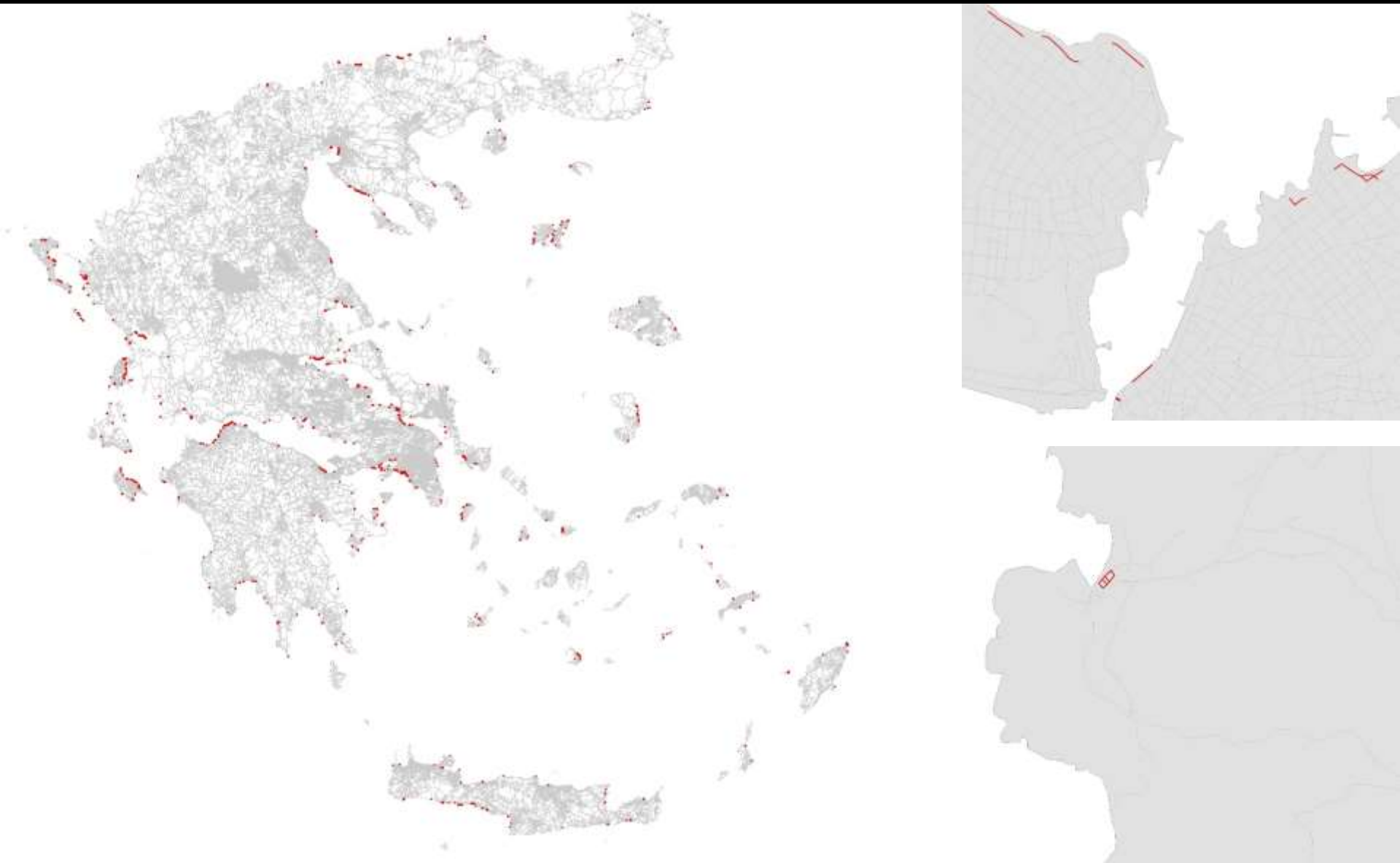
1.192.978 edges



951.821 junctions

OpenStreetMap, Geofabrik Downloads (https://download.geofabrik.de/) and building Network dataset

Interesting remarks on Intersect



Not assigned network edges: 1,33 ‰ of total length, 2,93 ‰ of total records

Serious problems with ArcGIS Spatial Join

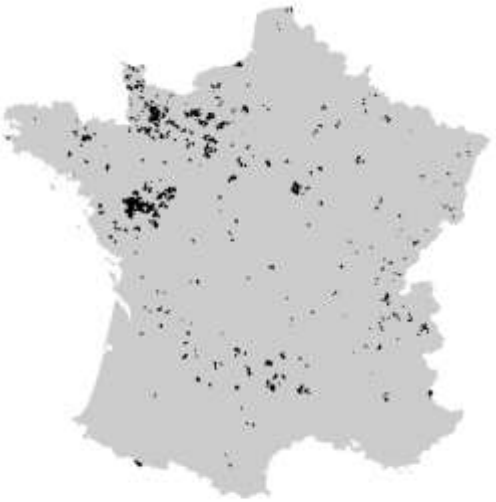
QGIS Intersect did not make it

The Communities database

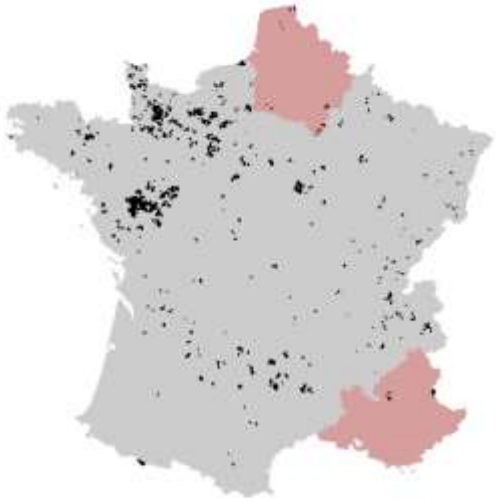
VARIABLE	DESCRIPTION
sid11	The official code for administrative level (l_7: Koinotites), 2011
Tname	The name of administrative area in Greek (as it was on 2011)
NoData	No data for road network from Gr_inter geodatabase
Area	The area as it is in the Gr_inter geodatabase (sqr. Meters)
DFpop11	De Facto Population, 2011 (source: ELSTAT, downloaded December 2015)
ResPop11	Residents, 2011 (source: ELSTAT, downloaded December 2015)
ktiria2011	Number of buildings, 2011 (source: ELSTAT, downloaded April 2018)
C_Nodes	Number of nodes in road network
S_Roads	Total length of roads (links between two nodes) in road network (in meters)
C_Total	Number of roads (links of nodes) in road network
C_Main	Number of Main roads
C_Primary	Number of Primary roads
C_Secondary	Number of Secondary roads
C_Tertiary	Number of Tertiary roads
C_Local	Number of Local roads
C_Cmotor	Number of Closed motorways
C_Urban	Number of Urban roads
C_Agro_Forest	Number of Agricultural and Forest roads
C_Other	Number of Other roads
S_Main	Length of Main roads (in meters)
S_Primary	Lengrh of Primary rpads (in meters)
S_Secondary	Length of Secondary roads (in meters)
S_Tertiary	Length of Tertiary roads (in meters)
S_Local	Length of Local roads (in meters)
S_Cmotor	Length of Closed motorways (in meters)
S_Urban	Length of Urban roads (in meters)
S_Agro_Forest	Length of Agricultural and Forest roads (in meters)
S_Other	Length of Other roads (in meters)

DGURBA (GISCO)

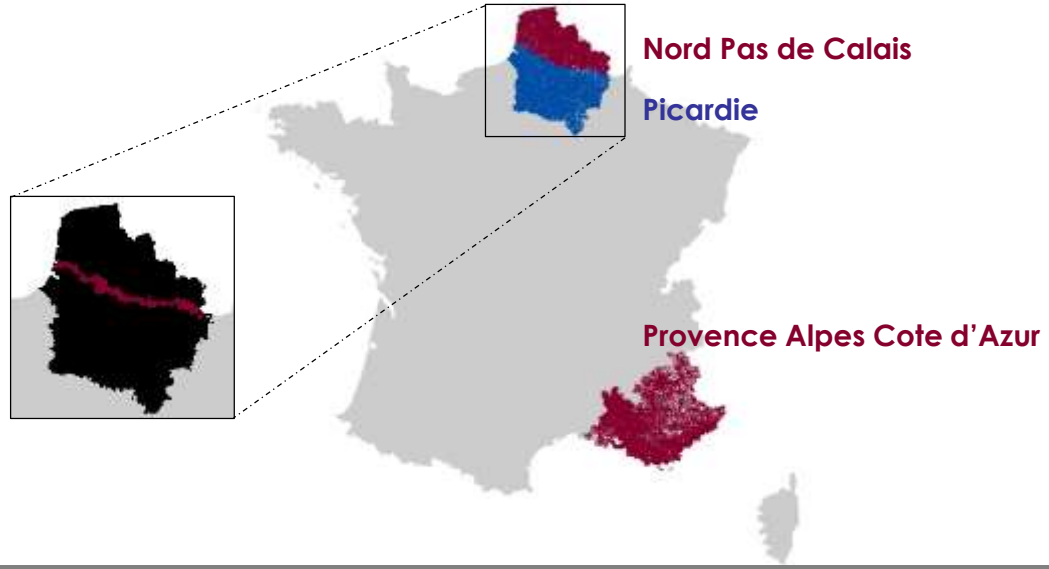
36.553 LAU2



804 records with no pop data (INSEE)



5.017 LAU2



Degree of urbanisation classification (DEGURBA) – harmonized spatial concepts based on population / LAU2
http://ec.europa.eu/eurostat/statistics-explained/index.php/Degree_of_urbanisation_classification_-_2011_revision

OpenStreetMap, Geofabrik Downloads (https://download.geofabrik.de/) and building Network dataset

The case of Metropolitan France

863.447 edges

1.237.024 junctions

36.553 LAU 2

Intersect

	EDGES	JUNCTIONS
Nord Pas de Calais	244,883	342,772
Picardie	182,061	255,473
Provence Alpes Cote d'Azur	436,503	638,779
Total	**863,447**	**1,237,024**

(after intersection)	EDGES	JUNCTIONS
Nord Pas de Calais	261,815	332,105
Picardie	207,907	254,312
Provence Alpes Cote d'Azur	452,807	631,309
Total	**922,529**	**1,217,726**

922.529 edges

1.217.726 junctions

Some figures

The selected Regions of France

Variable	Total	Average	Std	Max	Min
Area	68,141,203,786.0	13,582,061.7	20,953,311.1	757,679,475.4	157,182.3
Population	11,377,909.0	2,267.9	14,960.3	858,120.0	3.0
Roads Length (Km)	259,706.5	51.8	94.1	3,493.1	0.0
Nodes	1,217,726.0	242.7	842.2	40,897.0	0.0
Roads Km / Sq. Km		4.1	2.6	27.1	0.0
Nodes / Sq. Km		14.7	21.9	375.4	0.0
Population / Sq. Km		181.9	488.6	11,311.7	0.1
Nodes / Km		3.5	2.5	84.7	0.0
Roads (m) / Capita		2,207.2	12,252.7	565,624.2	0.0
Nodes / Capita		0.3	0.4	15.7	0.0

Hellas

Variable	Total	Average	Std	Max	Min
Area	132,086,741,496.1	21,540,564.5	24,193,067.4	576,914,533.5	225,872.5
Population	10,952,530.0	1,786.1	12,082.5	664,612.0	0.0
Roads Length (Km)	242,514.2	39.6	60.7	1,175.2	0.1
Nodes	951,821.0	155.5	406.1	14,441.0	1.0
Roads Km / Sq. Km		2.3	3.0	36.7	0.0
Nodes / Sq. Km		11.1	30.9	556.2	0.0
Population / Sq. Km		164.6	1,119.3	30,432.8	0.0
Nodes / Km		3.1	2.1	30.8	0.2
Roads (m) / Capita		133.0	424.6	14,643.6	1.1
Nodes / Capita		0.3	0.7	19.0	0.0
Houses	4,109,425.0	671.7	1,815.6	61,764.0	4.0
Houses / Sq. Km		52.0	163.5	3,039.1	0.0
Houses / Km		20.5	30.5	1,672.8	0.0

The French road network is more dense but more fragmented than the Hellenic one

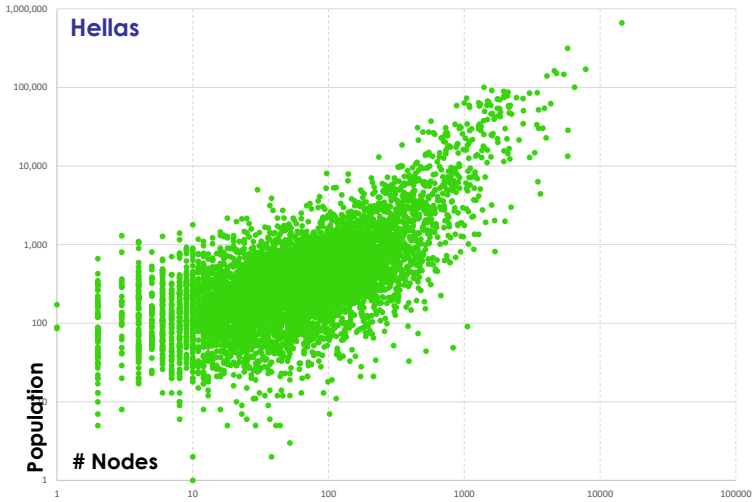
Relationships

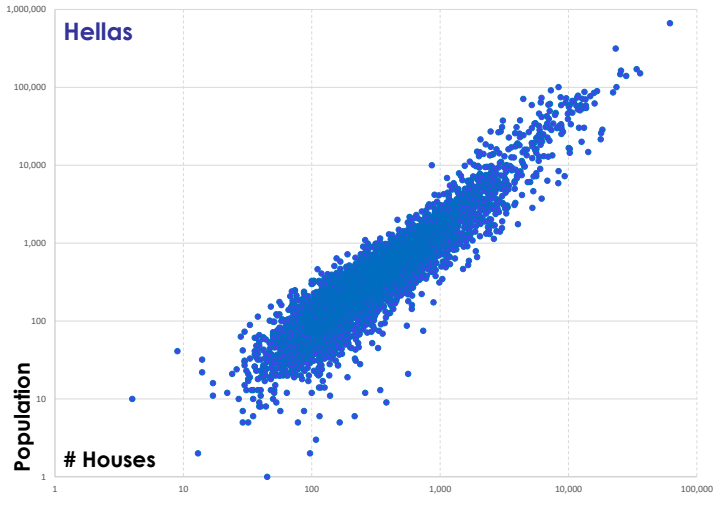
Hellas

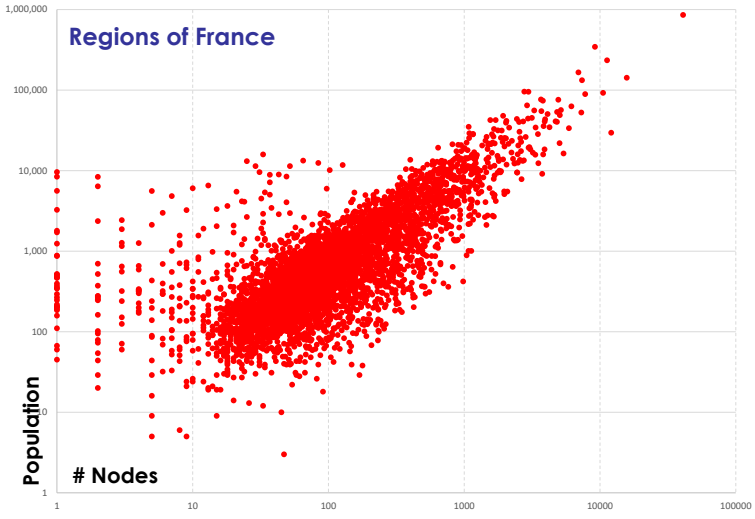
		Corr. Coefficient	Goodness of fit (R^2)
Population	# Houses	0.8577	0.7357
Population	[# Houses]^2	0.8965	0.8038
Population	# Nodes	0.7996	0.6394
Population	[# Nodes]^2	0.8543	0.7299
Population	Length of Roads	0.5300	0.2809
Population	[Length of Roads]^2	0.6020	0.3624

Regions of France

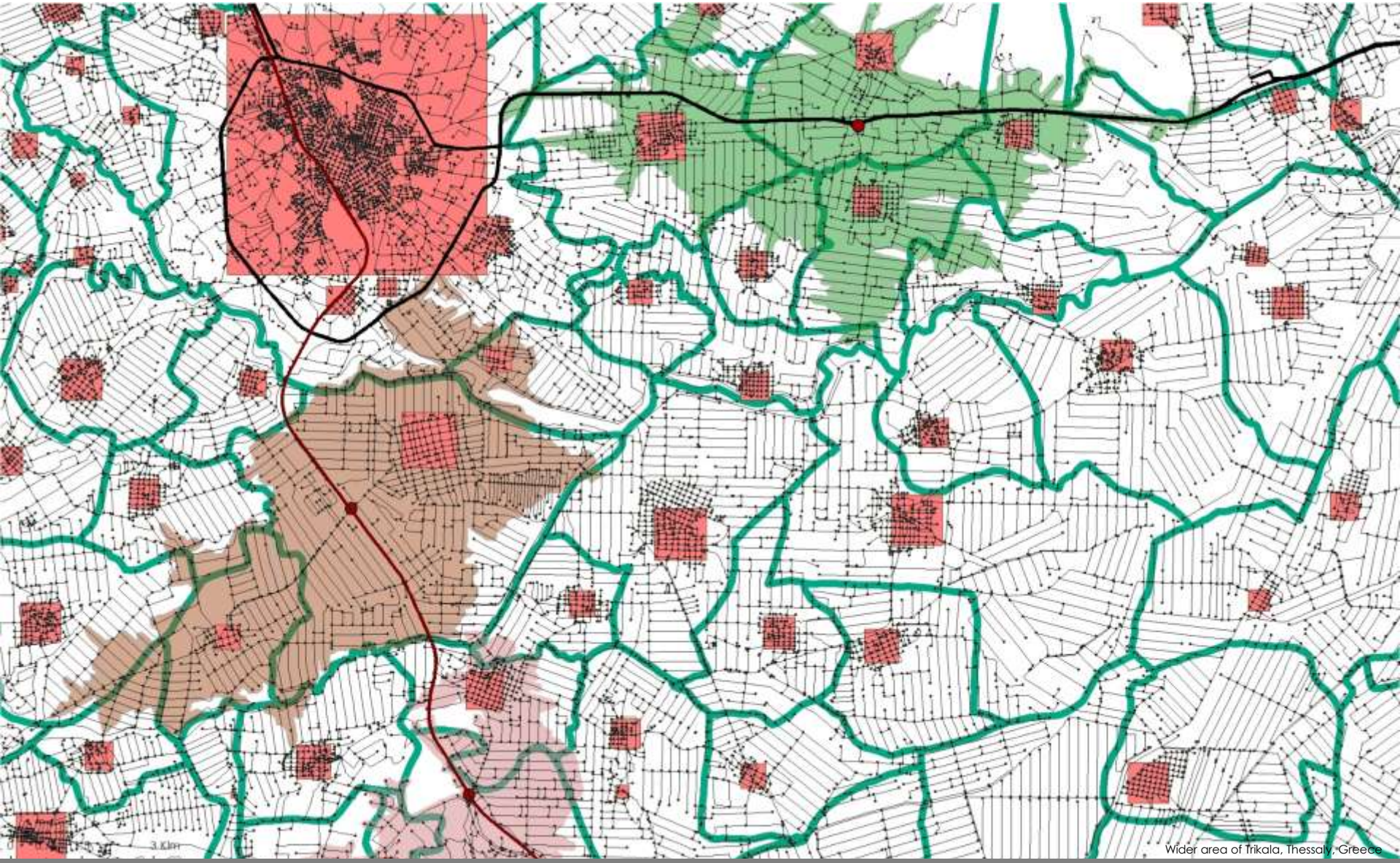
		Corr. Coefficient	Goodness of fit (R^2)
Population	# Nodes	0.8941	0.7995
Population	[# Nodes]^2	0.8759	0.7672
Length of Roads	# Nodes	0.9069	0.8224
Length of Roads	[# Nodes]^2	0.6253	0.3910







Population is statistical significant with road junctions



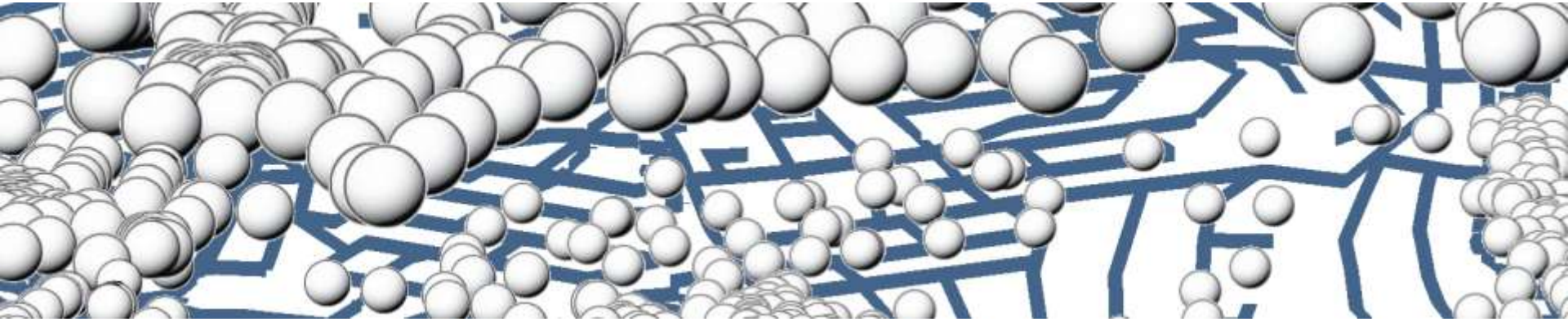
Pop = 1,14 + nodes ^{1,3} + 400, r = 0,9323, r^2 = 0,8692 (for the regions of France)

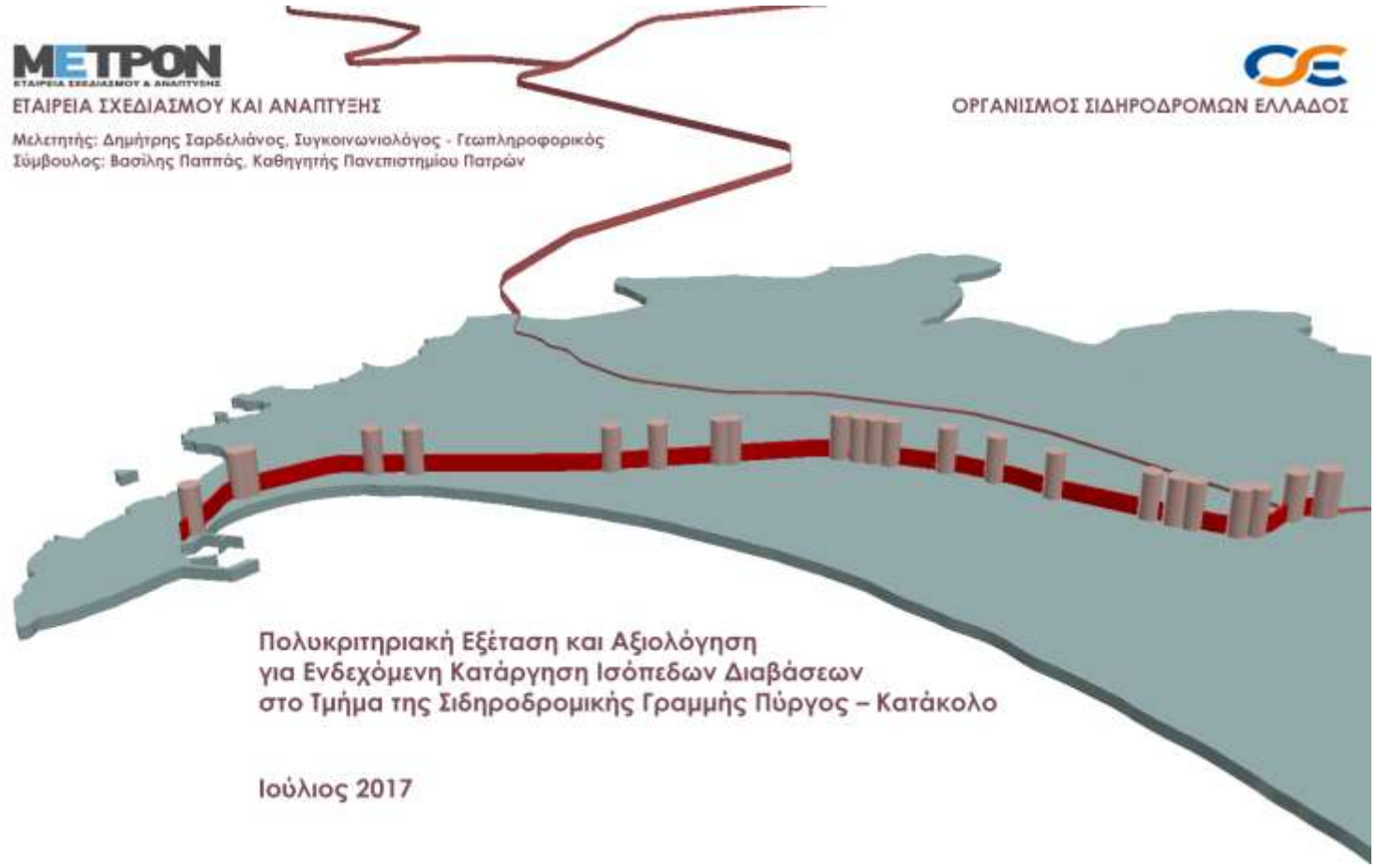
Pop = 0,0023 * nodes ^{2} + 10 * nodes - 300, r = 0,8845, r^2 = 0,7823 (for Hellas)

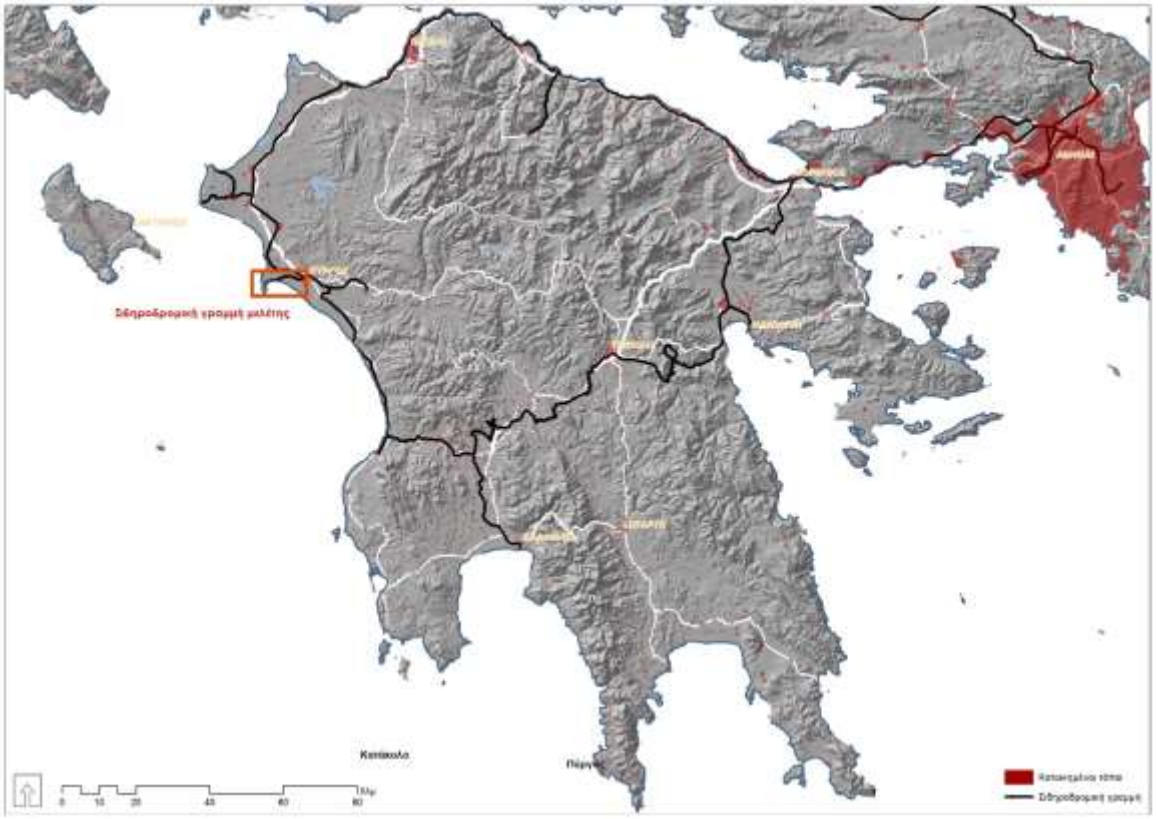
1.000 inh.

- **How reliable is OpenStreetMap?**
- **Has the same degree of reliability in all regions / countries?**
- **Is any significance between reliability and spatial allocation?**
- **Are other reliable sources?**
- **Is a node always a 'node'?**
- **What is the role of spatial resolution?**
- **What happens in the different type of roads?**

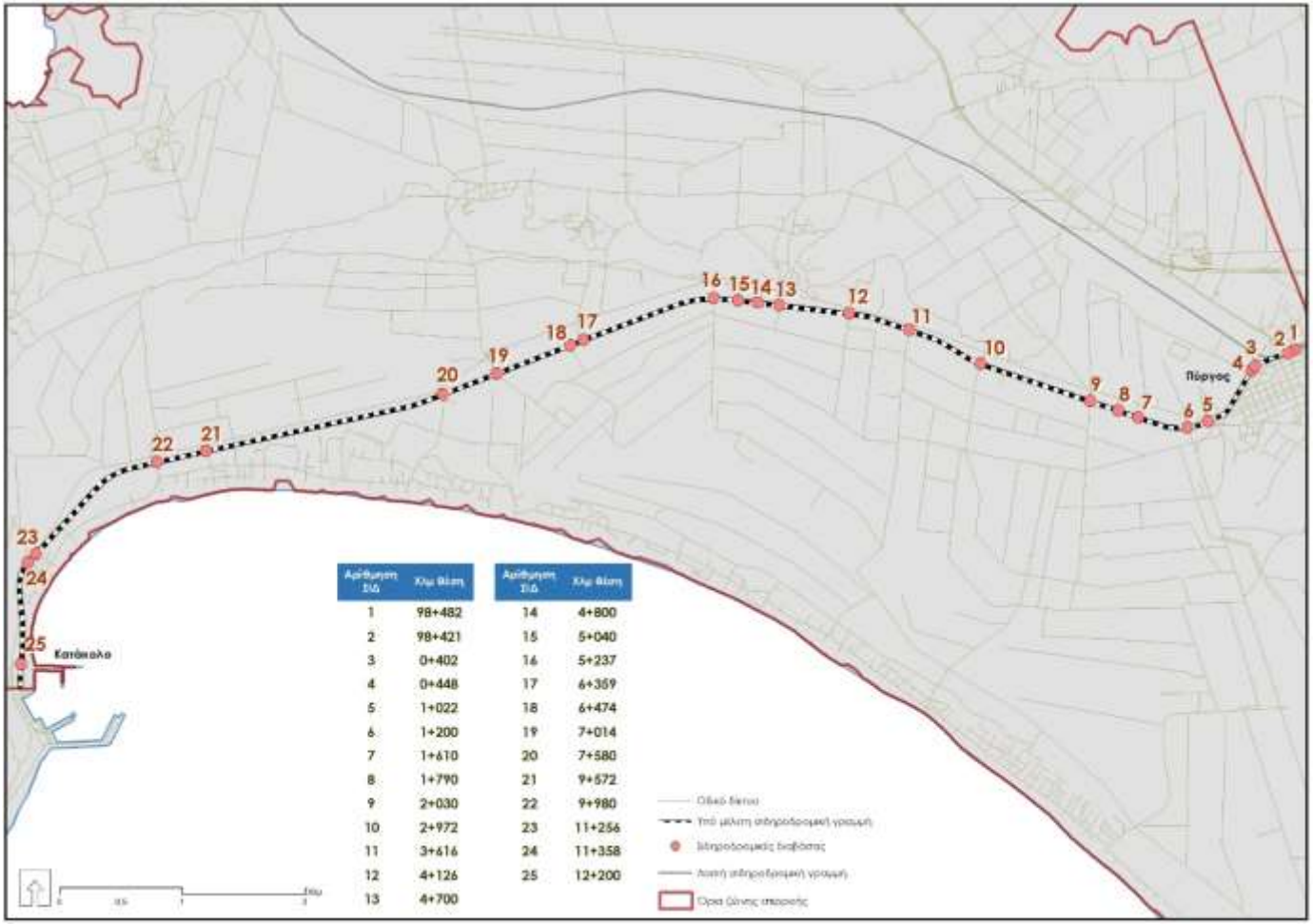
. . .




ΜΕΤΡΟΝ
ΕΤΑΙΡΕΙΑ ΣΧΕΔΙΑΣΜΟΥ & ΑΝΑΠΤΥΞΗΣ
ΕΤΑΙΡΕΙΑ ΣΧΕΔΙΑΣΜΟΥ ΚΑΙ ΑΝΑΠΤΥΞΗΣ
Μελετητής: Δημήτρης Σαρδελιάνος, Συγκοινωνιολόγος - Γεωπληροφορικός
Σύμβουλος: Βασίλης Παππάς, Καθηγητής Πανεπιστημίου Πατρών
ΟΡΓΑΝΙΣΜΟΣ ΣΙΔΗΡΟΔΡΟΜΩΝ ΕΛΛΑΔΟΣ
Πολυκριτηριακή Εξέταση και Αξιολόγηση
για Ενδεχόμενη Κατάργηση Ισόπεδων Διαβάσεων
στο Τμήμα της Σιδηροδρομικής Γραμμής Πύργος – Κατάκολο
Ιούλιος 2017



Photos sources: https://www.erapirgou.gr/, https://www.hotelmarily.gr, http://iqholidays.gr



Αριθμητική ΙΔ	Χλμ θέση	Αριθμητική ΙΔ	Χλμ θέση
1	98+482	14	4+800
2	98+421	15	5+040
3	0+402	16	5+237
4	0+448	17	6+359
5	1+022	18	6+474
6	1+200	19	7+014
7	1+610	20	7+580
8	1+790	21	9+572
9	2+030	22	9+980
10	2+972	23	11+256
11	3+616	24	11+358
12	4+126	25	12+200
13	4+700		

25 level crossings in a length of 12.500 meters!

- **Railway functionality**
  - **a) Risk of level crossing**
  - **b) Cost of action**

- **Spatial connectivity**
  - **The contribution of each cross (junction, link, etc.) is proportional to the population that will potentially use it (attracted population)**

Spatial connectivity

- **Influence zone (service area)**

  Based on geospatial analysis techniques and qualitative criteria

- **Calculation of the population**

  Proxy approach based on Hellenic Statistical Authority's data, the land uses, etc.

- **Attractiveness of crossings**

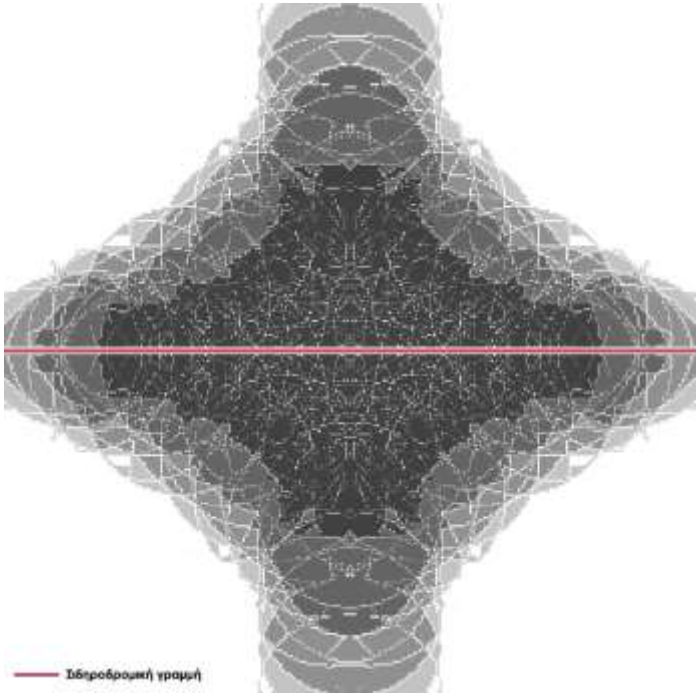
  Routes at less cost from one point to another. Calculation of potential users. Values 0 – 100.

- **Evaluation matrix (scale, weights, etc.)**

  Calculation of spatial connectivity index. Based on attractiveness, scale, etc.

- **Creations of scenarios**

Detailed - on situs - survey for each crossing



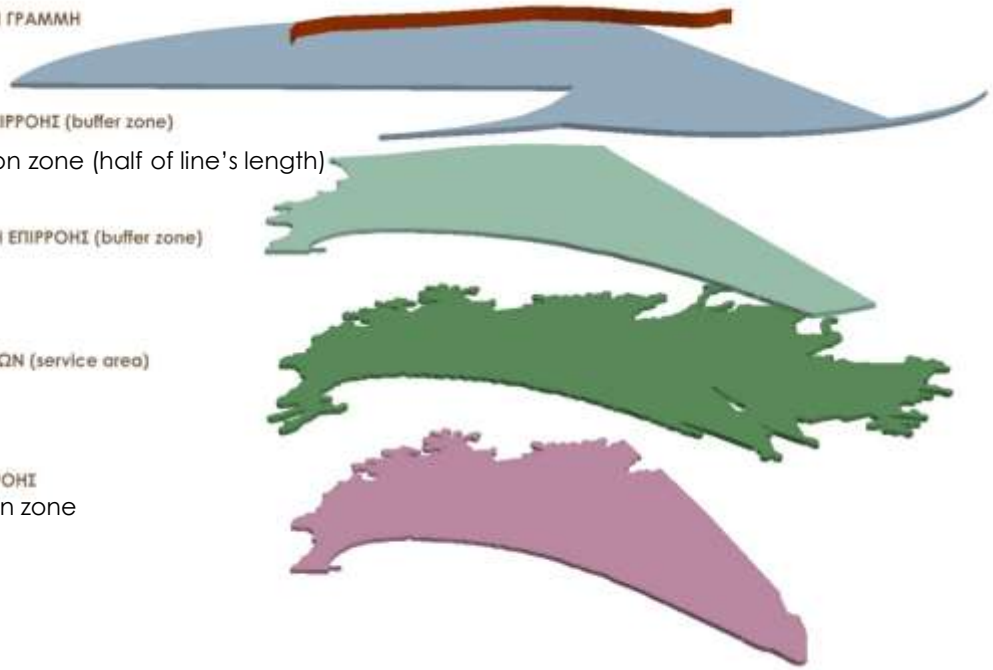
Η ΣΙΔΗΡΟΔΡΟΜΙΚΗ ΓΡΑΜΜΗ
Railway

Η ΑΡΧΙΚΗ ΖΩΝΗ ΕΠΙΡΡΟΗΣ (buffer zone)
Initial Attraction zone (half of line's length)

ΒΕΛΤΙΩΜΕΝΗ ΖΩΝΗ ΕΠΙΡΡΟΗΣ (buffer zone)
Buffer zone

ΖΩΝΗ ΜΕΤΑΚΙΝΗΣΕΩΝ (service area)
Service area

ΤΕΛΙΚΗ ΖΩΝΗ ΕΠΙΡΡΟΗΣ
Final attraction zone

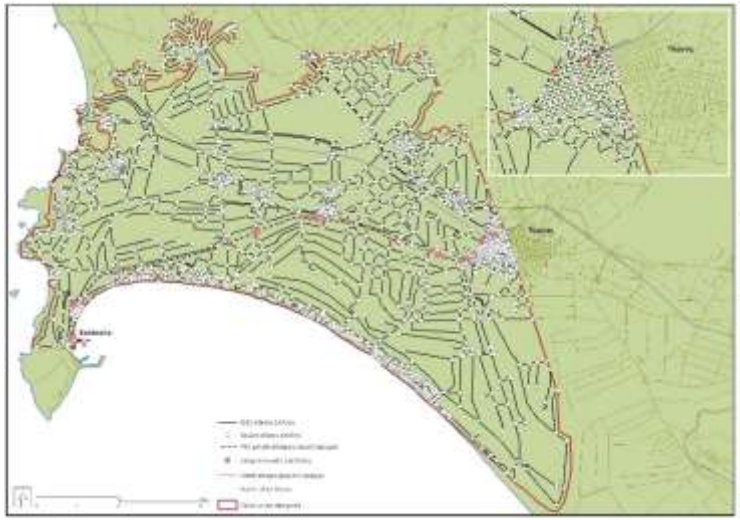


The geodatabase:

- **The railway track**
- **The crossings as nodes with special attributes**
- **The road network**
- **The settlements as nodes**
- **The administrative division of the wider area**
- **Satellite images and orthophoto maps**
- **Data (attributes) from the Hellenic Statistical Authority**

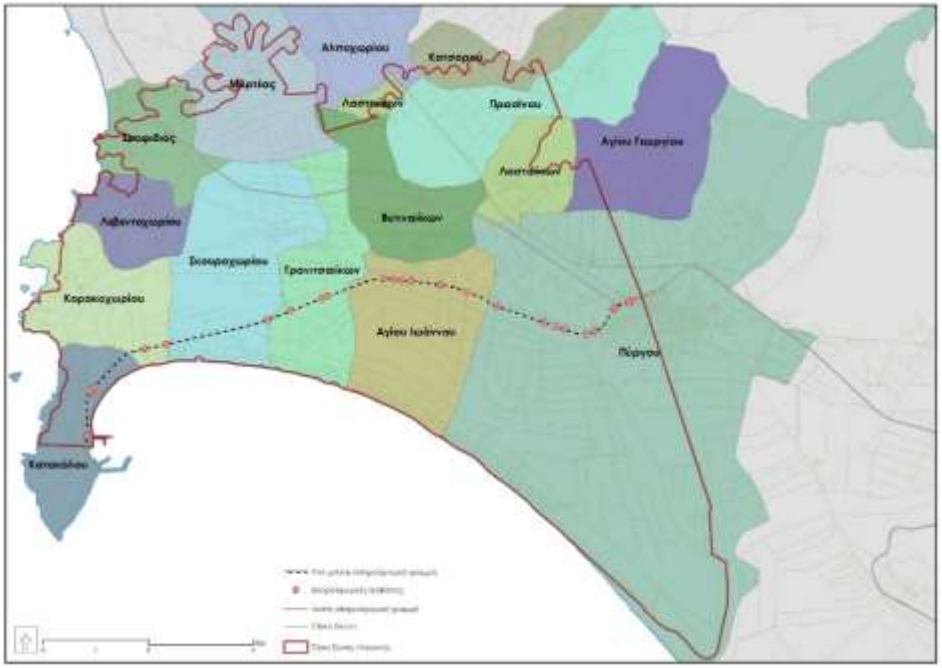
Are required:

- **Detailed mapping of railway and crossings**
- **Detailed mapping of road network and settlements, etc.**
- **Detailed population data**
- **Detailed data of railway operation (stops, schedule, etc.)**
- **Detailed costs of maintenance, construction, etc. of crossings**
- **Detailed traffic**

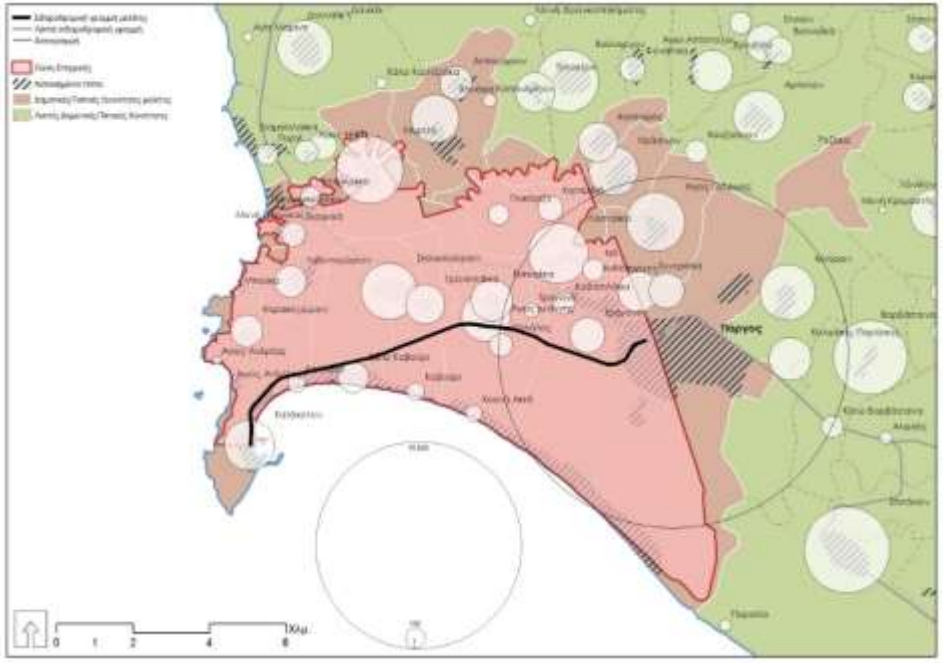


0 = aver. Speed 105 km/h
1 = aver. Speed 80 km/h
2 = aver. speed 50 km/h
3 = aver. Speed 40 km/h
4 = aver. speed 30 km/h
5 = aver. Speed 20 km/h

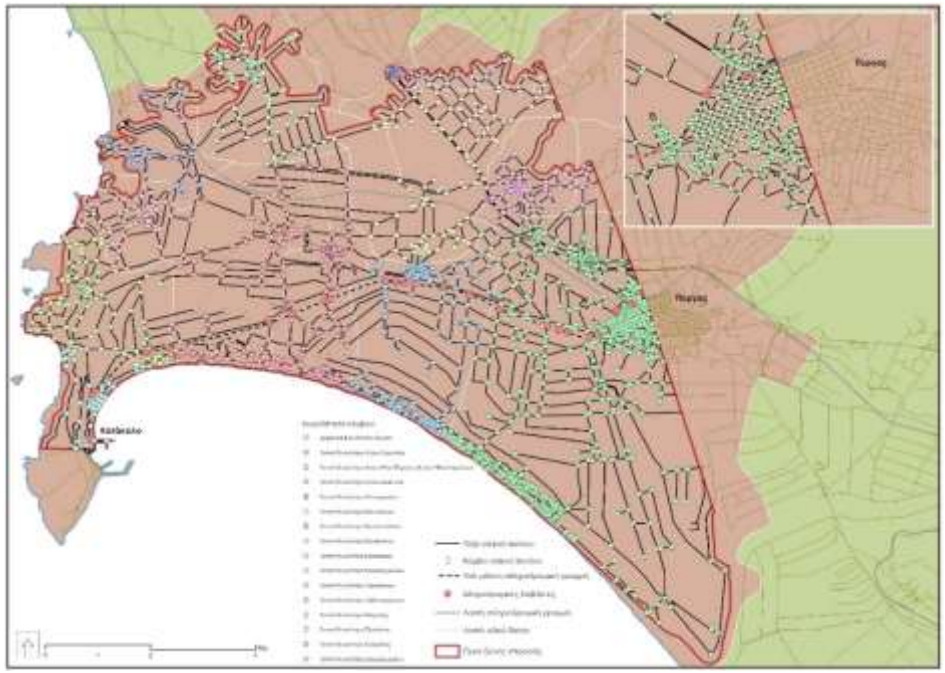
The road network in the attraction zone of railway



Administrative division in the attraction zone of railway



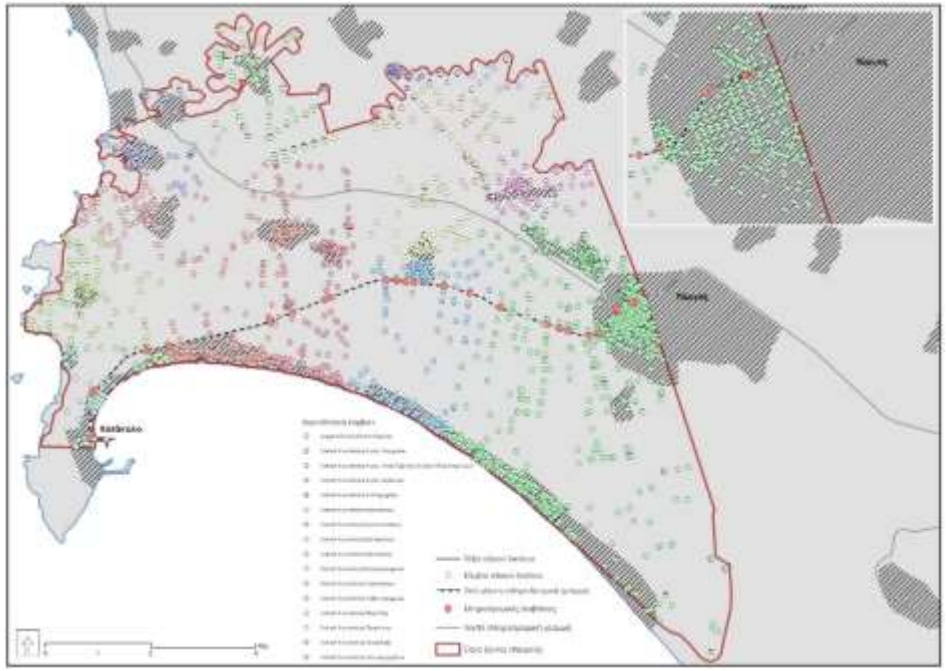
Settlements and populated places



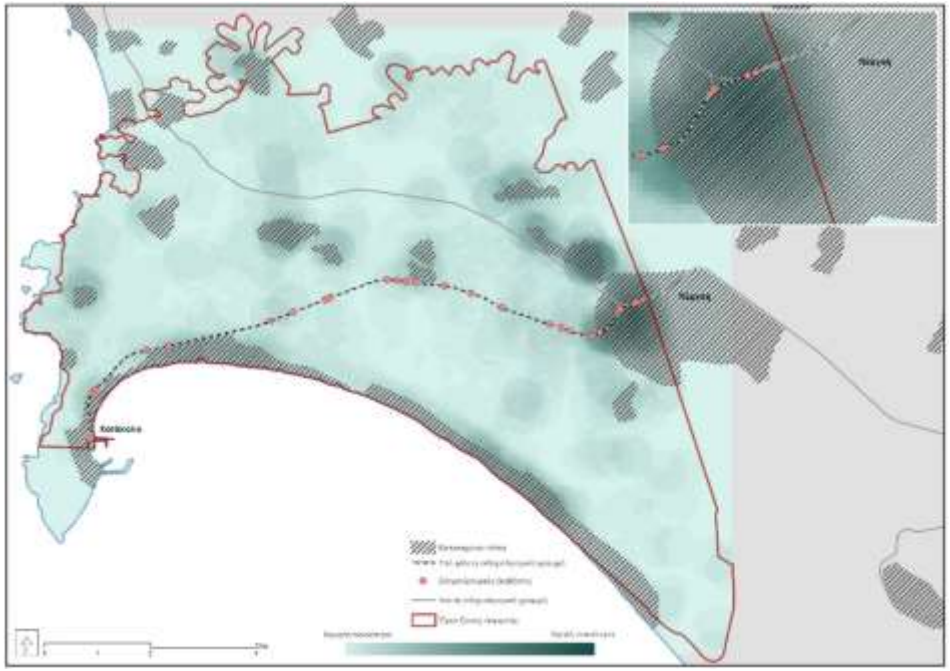
Allocation of road junctions (nodes) in Municipal / Local Units

Code	Name	Houses	DF Pop	NC Pop	Pop Differ	Nodes	Length	NodePop
Κωδικός ΕΛΣΤΑΤ	Ονομασία	Κατοικούμενες Κατοικίες	Πραγματικός πληθυσμός	Νέος υπολογιζόμενος πληθυσμός	Διαφορά πληθυσμού	Αριθμός Κόμβων	Μήκος Δικτύου (μέτρα)	Πληθυσμός κόμβου
(α)	(β)	(γ)	(δ)	(ε) = (γ) * 3,699	(στ) = (ε) - (δ)	(ζ)	(η)	(θ)
24239010101	Δ.Κ. Πύργου	6.776	25.062	25.071	9	1.572	160.574,6	16
24239010102	Τ.Κ. Αγίου Γεωργίου	306	703	1.132	429	80	1.883,5	14
24239010104	Τ.Κ. Αγίου Ιωάννου	397	688	1.469	781	159	51.470,8	9
24239010303	Τ.Κ. Αλποχωρίου	311	718	1.151	433	238	6.619,5	5
24239010107	Τ.Κ. Βυτιναίικων	156	339	577	238	65	20.313,6	9
24239010108	Τ.Κ. Γρανιτσαίικων	346	382	1.280	898	160	36.216,9	8
24239010110	Τ.Κ. Κατακόλου	397	508	1.469	961	112	14.773,9	13
24239010305	Τ.Κ. Κατσαρού	158	316	585	269	74	6.821,9	8
24239010112	Τ.Κ. Κορακοχωρίου	382	293	1.413	1.120	122	29.997,7	12
24239010113	Τ.Κ. Λασταίικων	332	804	1.228	424	102	15.292,9	12
24239010114	Τ.Κ. Λεβεντοχωρίου	117	204	433	229	103	19.434,1	4
24239010115	Τ.Κ. Μυρτέας	366	913	1.354	441	169	27.071,4	8
24239010308	Τ.Κ. Πρασίνου	274	697	1.014	317	136	20.311,1	7
24239010118	Τ.Κ. Σκαφιδιάς	190	211	703	492	115	16.104,8	6
24239010119	Τ.Κ. Σκουροχωρίου	897	1.107	3.319	2.212	191	34.084,8	17

(η) = εντός της ζώνης επιρροής)



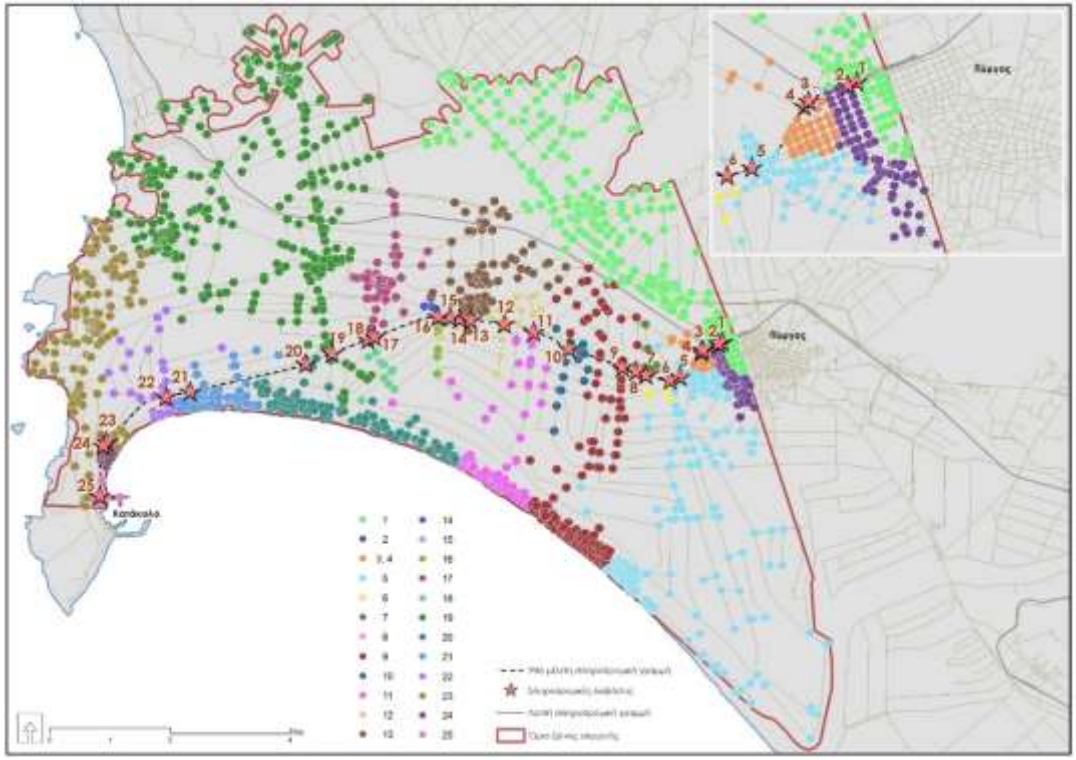
Allocation of road junctions (nodes) and populated places



Allocation of population densities (based on nodes) and populated places

Allocation of population / trip generation

Multi-criteria analysis and evaluation for the potential removing of level crossings in the railway Pyrgos – Katakolo, Greece



Allocation of road junctions (nodes) to railway crossings (service areas)

Code	Dist.	Pop	Nodes	% Pop	%Nodes	AI
ΚΩΔΙΚΟΣ ΣΙΔ	Επίσημη Χιλιομέτρηση	Εξυπηρετούμενος Πληθυσμός	Εξυπηρετούμενοι κόμβοι	% Πληθυσμού	% Κόμβων	Δείκτης Ελκτικότητας
1	98+482	6,650	544	24.2%	24.2%	**100.0**
2	98+421	1,264	79	4.6%	3.3%	**18.7**
3	0+402	640	40	2.3%	2.0%	**9.3**
4	0+448	640	40	2.3%	2.0%	**9.3**
5	1+022	1,360	85	4.9%	3.8%	**20.1**
6	1+200	2,784	174	10.1%	7.7%	**41.6**
7	1+610	192	12	0.7%	0.5%	**2.5**
8	1+790	32	2	0.1%	0.1%	**0.1**
9	2+030	2,601	163	9.5%	7.2%	**38.9**
10	2+972	281	18	1.0%	0.8%	**3.8**
11	3+616	709	68	2.6%	3.0%	**10.3**
12	4+126	180	20	0.7%	0.9%	**2.3**
13	4+700	892	97	3.2%	4.3%	**13.1**
14	4+880	63	7	0.2%	0.3%	**0.5**
15	5+040	27	3	0.1%	0.1%	**0.0**
16	5+237	63	7	0.2%	0.3%	**0.5**
17	6+359	634	79	2.3%	3.5%	**9.2**
18	6+474	88	11	0.3%	0.5%	**0.9**
19	7+014	3,899	425	14.2%	18.9%	**58.5**
20	7+580	1,263	109	4.6%	4.8%	**18.7**
21	9+572	951	58	3.5%	2.6%	**14.0**
22	9+980	381	31	1.4%	1.4%	**5.3**
23	11+256	1,575	148	5.7%	0.5%	**23.4**
24	11+358	221	17	0.8%	6.8%	**2.9**
25	12+200	117	9	0.4%	0.4%	**1.4**

Attractiveness index: $E_i = 100 * (P_i - P_{min})/(P_{max} - P_{min})$

Code	Distance	Type of Road	Class	Weight	AI	Weight	SCI
ΚΩΔΙΚΟΣ ΣΙΔ	**Επίσημη Χιλιομέτρηση**	**Κατηγορία Οδού**	**Ιεράρχηση ΣΙΔ**	**Συντελεστής Βαρύτητας Ιεράρχησης**	**Δείκτης Ελκτικότητας**	**Συντελεστής Βαρύτητας Ελκτικότητας**	**Δείκτης Χωρικής Συνδεσιμότητας**
1	98+482	1	100	5	100.0	1	**600**
2	98+421	3	50	3	18.7	1	**169**
3	0+402	2	75	4	9.3	1	**309**
4	0+448	3	50	3	9.3	1	**159**
5	1+022	2	75	4	20.1	1	**320**
6	1+200	4	25	2	41.6	1	**92**
7	1+610	5	1	1	2.5	1	**3**
8	1+790	5	1	1	0.1	1	**1**
9	2+030	4	25	2	38.9	1	**89**
10	2+972	4	25	2	3.8	1	**54**
11	3+616	3	50	3	10.3	1	**160**
12	4+126	4	25	2	2.3	1	**52**
13	4+700	2	75	4	13.1	1	**313**
14	4+880	5	1	1	0.5	1	**2**
15	5+040	5	1	1	0.0	1	**1**
16	5+237	4	25	2	0.5	1	**51**
17	6+359	4	25	2	9.2	1	**59**
18	6+474	4	25	2	0.9	1	**51**
19	7+014	4	25	2	58.5	1	**108**
20	7+580	3	50	3	18.7	1	**169**
21	9+572	4	25	2	14.0	1	**64**
22	9+980	4	25	2	5.3	1	**55**
23	11+256	3	50	3	23.4	1	**173**
24	11+358	4	25	2	2.9	1	**53**
25	12+200	4	25	2	1.4	1	**51**

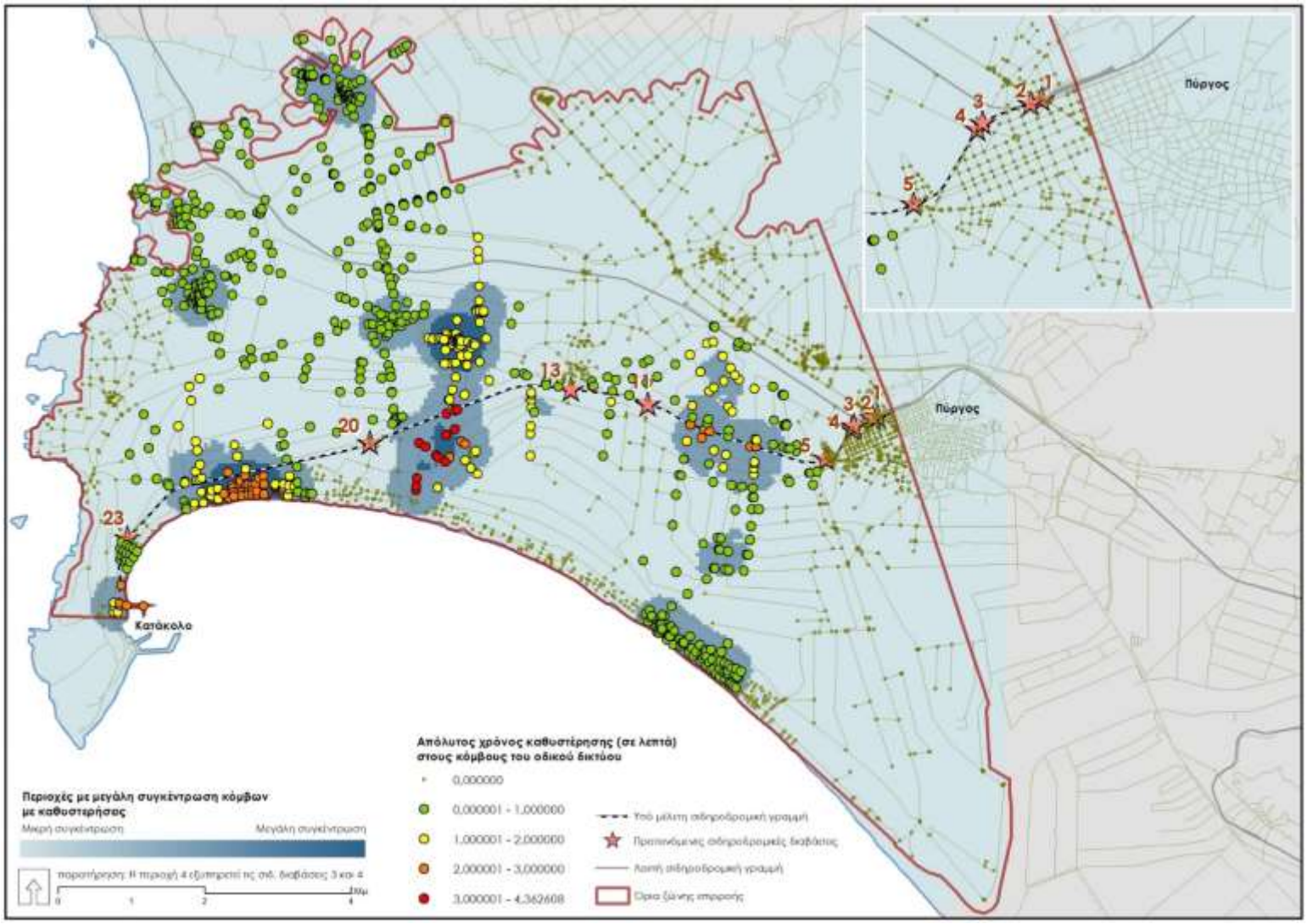
Spatial Connectivity Index: based on attractiveness index and the hierarchy of the crossing

Code	Distance	Next Cross	Urban	Near Station	Category	SCI
ΚΩΔΙΚΟΣ ΣΙΔ	**Επίσημη Χιλιομέτρηση**	**Απόσταση κοντινότερης ΣΙΔ**	**Εντός Πολεοδομικού Συγκροτήματος**	**Κοντά σε Στάση - Σταθμό**	**Κατηγορία ΣΙΔ**	**Δείκτης Χωρικής Συνδεσιμότητας**
1	98+482	66	ΝΑΙ	ΝΑΙ	A3	**600**
5	1+022	178	ΝΑΙ	ΝΑΙ	A1	**320**
13	4+700	180		ΝΑΙ	A1	**313**
3	0+402	46	ΝΑΙ		A1	**309**
23	11+256	102		ΝΑΙ	A1	**173**
2	98+421	66	ΝΑΙ		A3	**169**
20	7+580	566		ΝΑΙ	A1	**169**
11	3+616	510			A1	**160**
4	0+448	46	ΝΑΙ		A1	**159**
19	7+014	540			A1	108
6	1+200	178	ΝΑΙ		A1	92
9	2+030	240			A1	89
21	9+572	408			A1	64
17	6+359	115			A1	59
22	9+980	408			A1	55
10	2+972	644			A1	54
24	11+358	102			A1	53
12	4+126	510			A1	52
25	12+200	140		ΝΑΙ	A1	51
18	6+474	115			A1	51
16	5+237	197			A1	51
7	1+610	180			A1	3
14	4+880	160			A1	2
8	1+790	180			A1	1
15	5+040	160			A1	1

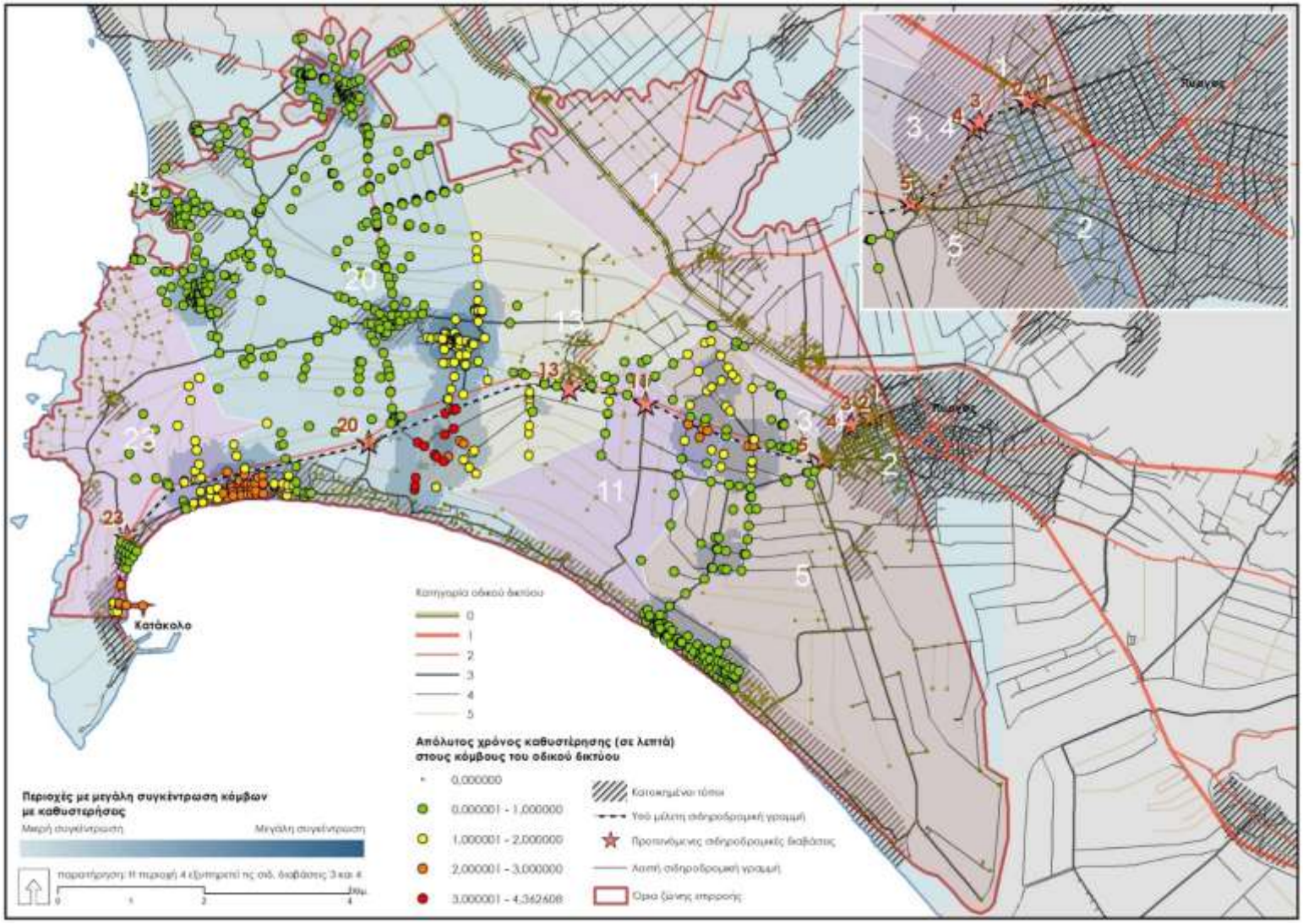
Time change	Nodes	% nodes	Pot. Pop.	% Pop.
Χρονική μεταβολή (min)	**Αριθμός Κόμβων**	**% Κόμβοι**	**Δυνητικός Πληθυσμός**	**% Πληθυσμός**
0	1380	62.6%	17611	65.5%
έως και 0,5	491	22.3%	4882	18.2%
> 0,5 - 1	252	11.4%	3250	12.1%
> 1 - 2	61	2.8%	900	3.3%
> 2 - 3	11	0.5%	136	0.5%
> 3	11	0.5%	88	0.3%

Scenario 1: Only the first nine are remain in operation

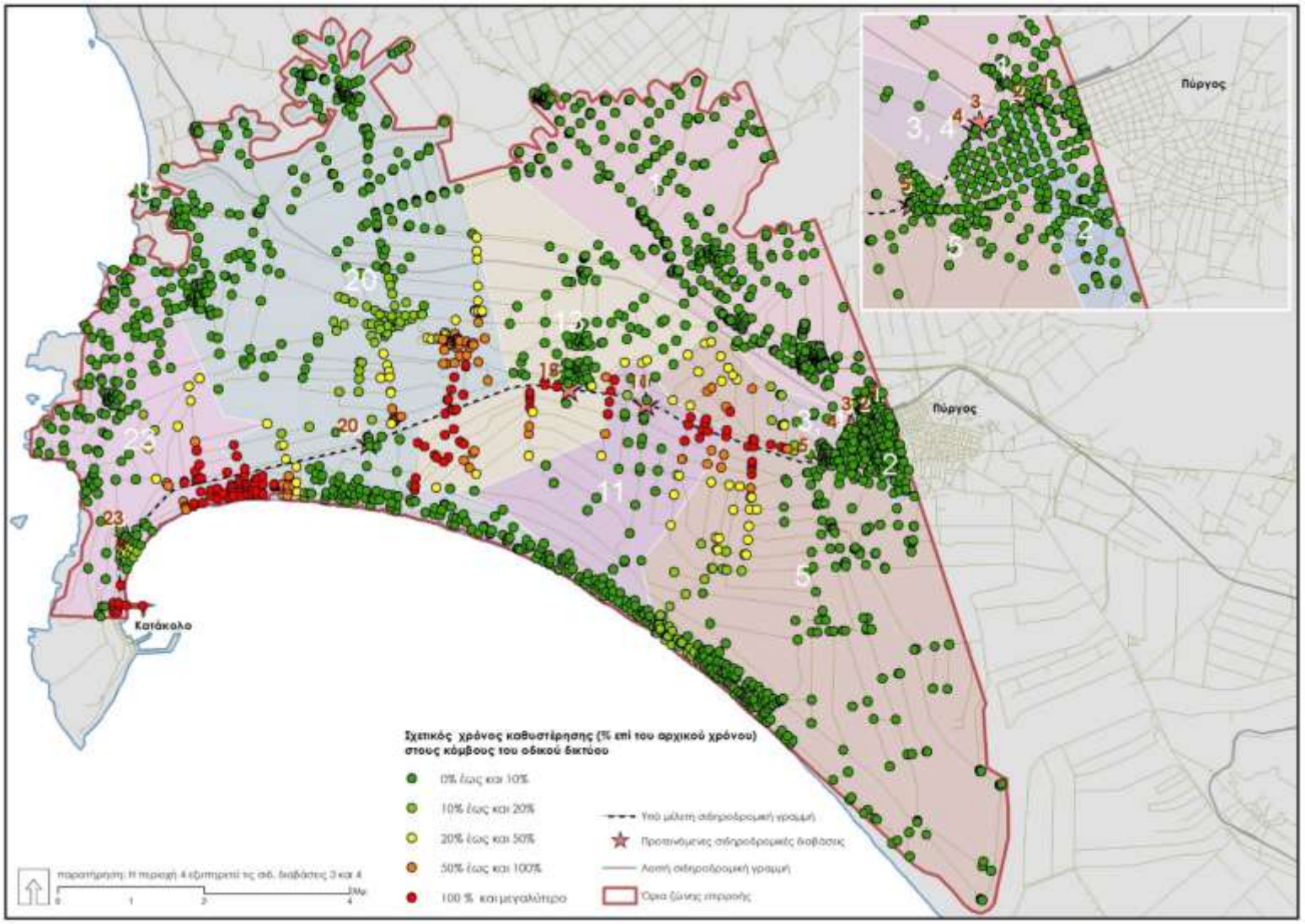
Distance change	Nodes	% nodes	Pot. Pop.	% Pop.
Μεταβολή απόστασης (m)	**Αριθμός Κόμβων**	**% Κόμβοι**	**Δυνητικός Πληθυσμός**	**% Πληθυσμός**
0	1356	61.5%	17270	64.3%
έως και 250	47	2.1%	617	2.3%
> 250 - 500	453	20.5%	4390	16.3%
> 500 - 1000	182	8.3%	2753	10.2%
> 1000 > 1500	121	5.5%	1218	4.5%
> 1500	47	2.1%	619	2.3%



Scenario 1: Absolute travel delay time (in minutes) at nodes



Scenario 1: Areas with large concentration of nodes with travel delays



Scenario 1: Relevant travel delay time (as % of initial travel time) at nodes

An alternative model for the distribution of population

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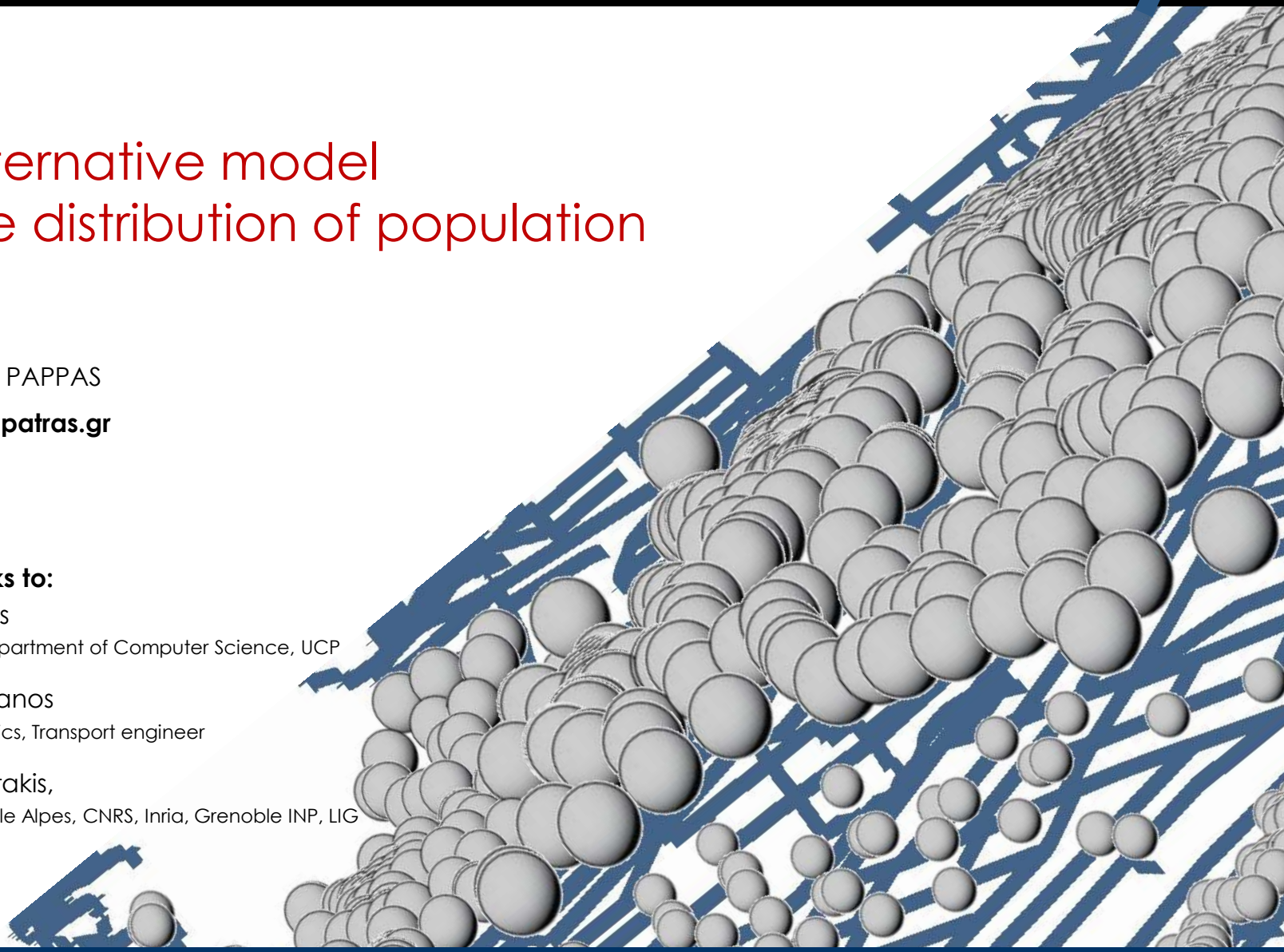

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