Konstantinos Athanasopoulos, Dr Transportation Engineer
National Technical University of Athens
kathanas@mail.ntua.gr

Thanos Vlastos, Professor of Urban Planning and Transportation
National Technical University of Athens
vlastos@survey.ntua.gr

Mapping the Geography of Cycling Infrastructure in Greece through an Open Participatory Procedure

Abstract

Cycling is a healthy, environmentally friendly and quick way to travel in urban areas. Cycling infrastructure network construction is a worldwide adopted way to raise cycling use. As cycling infrastructure is a rather new engineering orientation in Greece, no official data is available about spatial characteristics of those implementations. The paper describes a volunteered geographical information contribution towards the first "Cycling Infrastructure Map of Greece". The map was published and an open participatory procedure followed to raise precision of the information provided. The case of Greek Cycling Infrastructure Map shows that participatory mapping fosters communication among cyclists, raises public awareness, feelings of ownership of the information provided and raises precision of the information included. Analysis of spatial characteristics of the network, mainly cycling infrastructure density, proves that cycling infrastructure is underdeveloped in most cities. The areas covered by the network - with the exception of some small cities like Orestiada, Amaliada, Karditsa and Kos – are small and infrastructure implemented is unable to generate relevant change. The case of Athens metropolitan area reveals that administrative borders between municipalities create important spatial inconsistencies. Athens - a big metropolitan area, of approx. 4 million residents - divided into numerous local authorities has created a highly fragmented bicycle network, more extended in the wealthy parts of the city and absent in more marginalized areas of the metropolitan area.

Keywords: Cycling infrastructure, cycling network geography, crowdsourcing, participatory mapping.

Introduction

Cycling has been promoted as an environmentally friendly way to travel in urban areas and the raise of cycle use is a stated target of sustainable urban mobility policies. Cycling consumes far less energy for every km travelled than any other means of transport.

The construction of cycling infrastructure is an essential step towards improving cycling conditions. Countries which have achieved high levels of cycle use, like Netherlands, Denmark and Germany and have been constructing cycling infrastructures in their cities for many decades (Pucher & Buehler, 2008). Schoner & Levinson (2014) found a clear correlation between spatial characteristics of the bicycle infrastructure network, like density and directness and bicycle commuting in 74 cities of USA. The absence of cycling infrastructure in dangerous segments of cyclists' route, like roads with heavy traffic or traffic junctions, causes unacceptable level of stress, making connections by bicycle between origin and destinations in a city problematic (Mekuria et al. 2012). To compute the bikeability of a city it is crucial to have a georeferenced database of cycling infrastructure (Lowry et al. 2016).

These databases are taken for granted in countries with strong administrative culture, but this is not the case for all countries. Local authorities in Greece following the European directions towards promoting sustainable means of transport have built the last years many km of cycle lanes, tracks and paths. As this is a new transport policy field, no official data can be found about the type and the place of these new urban facilities.

Cycling infrastructure implementation is a rather new concept in engineering history of Greece. The first city which decided, in 2003, to implement a city-wide network of protected cycle tracks is Karditsa, a medium-sized city with tradition in cycling. In 2005, Kordelio, a municipality in the metropolitan area of Thessaloniki, followed, but this implementation was not successful because cycle lanes were not being respected by cars which used them for parking.

Crowdsourcing techniques are an obvious answer to data collection problems. Crowdsourcing emerged together with the raise of communication technologies, like internet and smartphone applications. "Crowdsourcing is a type of participative online activity in which an individual, an institution, a non-profit organization, or company proposes to a group of individuals of varying knowledge, heterogeneity, and number, via a flexible open call, the voluntary undertaking of a task" (Estelles-Arolas & Gonzalez-Ladron-de-Guevara, 2012, 197). The raise of on-line geographic tools like Wikimapia, OpenStreetMap, Google Earth and Google Maps has empowered citizens to take part and respond effectively to public calls asking for volunteered geographic information or any other kind of georeferenced contribution (Goodchild 2007).

Cyclists are a group familiar with using on-line tools to share geographic information. They seek to find aesthetic routes or avoid dangerous roads and so planners often use their input to evaluate cycling conditions. Pánek & Benediktsson (2017) used a participatory mapping technique named emotional mapping to evaluate road conditions for cyclists. A web-based public participation geographic platform was created where cyclists had the opportunity to give their feedback, their perceptions or experiences of Reykjavik's road network. Many other geographic crowdsource platforms give cyclists worldwide the opportunity to exchange information, about preferred routes, incidents of theft and dangerous spots.

The aim of the paper is to present a voluntary geographic information provision effort, namely the production of the first cycling infrastructure map of Greece. The creation of the map was supported by the cycling community of Athens and other cities in Greece, who responded to an open call asking for their contribution. Finally the result of the effort, namely the geography of cycle infrastructure in Greece is analyzed.

Conducting the first initial map: Metropolitan Area of Athens (Region of Attica)

The procedure to collect public input to create the map was rather simple and no special on-line platforms were created, as the effort was to provide voluntary geographic information with the lowest cost. An initial map was developed, including all known bicycle infrastructure constructed in the metropolitan area of Athens. A google map platform was used. The majority of cycling infrastructure implementations in Athens were designed by Sustainable Mobility Unit at National Technical University of Athens and so Athens was an easy starting point to conduct the bicycle infrastructure map of Greece.

Metropolitan area of the capital city of Greece - Athens, officially termed as "Region of Attica" has a population of 3,828,384, according to 2011 population census (ELL.STAT., 2011). The area includes islands and remoted villages far distanced from Athens which do not have an urban or suburban character and some distanced towns which are not suburbs of Athens, like Lavrio. All these areas, not belonging to the metropolitan area of Athens, have approximately 120 000 residents. But the vast majority of settlements in Region of Attica are former villages or towns which are now included in the rapidly growing urban area of the two main core cities: Athens and Piraeus which are not separated any more. They form a metropolitan area with approximately 3,700,000 residents. The area is governed by 58 local authorities (municipalities), responsible to implement cycle infrastructures, and by regional authorities, responsible to approve or implement works on the main urban arteries.

An internet search followed with the term "cycling infrastructure" and the name of each municipality of the metropolitan area. This on-line search gave some new results. As the funds to implement cycling infrastructure projects derive from European sources, another search followed among projects approved for funding. The term "cycling infrastructure" was used to search databases listing funded projects. Municipalities which were found to have implemented a cycling infrastructure project were contacted to give more details about the implementation. Their statement was checked through on-site visits or Google Street view images.

Participatory mapping and social impact

The next step was to reach the public. On 10th of June 2013 the link to the produced map was published (Athanasopoulos, 2018a) in cycling forums to collect feedback. Following the administrative structure of Athens the network proved to be extremely fragmented. The total length of cycling infrastructure was rather small for a metropolitan area: 45 km. Cyclists who wanted to provide feedback were asked to write a comment in the cycling forum or through e-mails and they were not allowed to edit on-line the map. The effort was to keep a high level of quality of the information provided.

Three days after first publication in the cycling forum a cyclist reported a new cycling facility just implemented in a main road of a big Athens' suburb. The next day another cyclist commented on the cycling network of Elefsina, a former big town, now belonging to Athens agglomeration. The north part of the network had been left out. It was added to the map.

One month after first publication the network presented had reached 48 km.
Six months after first publication another user found another facility in the outskirts of Athens not included in the map. He made his own google map and provided his link in the forum. The facility was also included in the initial map. Another user posted a cycling facility in a rapidly developing coastal area, near Megara town. In the meanwhile some municipalities had begun to construct some new facilities. Six month after the first publication the network presented had reached 62 km.

The small but active cycling community of Athens had “adopted” the map and contributed to sustain the map up-to-date.

One year after the first publication of the map a cyclist who worked as a journalist posted the map on his blog. Soon many national-wide media (one political TV-show, a nation-wide newspaper and many internet sites) presented the effort because it sounded interesting to journalists: it was the first time residents of Athens could find information about where these new facilities are built and used this information to cycle safer in a hostile, traffic-congested metropolitan area. It was the first time the whole figure of cycling facilities in Athens was presented.

“I have moved to Athens recently, I am thinking to buy a bicycle. In the beginning I was afraid, but I see that there are enough cycle paths, so I will start” (Athens cycling infrastructure map forum, user nickname: Olympia, Date: 21/07/2017).

So far the on-line map has over 80,000 visits.

Results: The geography of Athens cycling infrastructure

Table 1 – The geography of Athens cycling infrastructure

a/a	Municipality in Athens Metropolitan Area	Regional Unit	Network Length (km)	Population	Area km^2	Network Length (km) per 10,000 residents	Infrastructure Density (/km)
1	Vrilissia	North Athens	4.8	30,741	3.9	1.56	1.23
2	Agia Paraskevi	North Athens	7.0	59,704	6.2*	1.17	1.13
3	Kallithea	South Athens	4.9	100,641	4.8	0.49	1.02
4	Papagou-Holargos	North Athens	4	44,539	4.5*	0.90	0.89
5	Philothei - Psychiko	North Athens	4.9	26,968	6.1	1.82	0.80
6	Moschato-Tavros	South Athens	3.1	40,413	4.5	0.77	0.69
7	Zografou	Central Athens	4.6	71,026	8.5	0.65	0.54
8	Kifisia	North Athens	13.2	71,259	25*	1.85	0.53
9	Chalandri	North Athens	5.3	74,192	10.8	0.71	0.50
10	Dafni - Ymittos	Central Athens	0.8	33,628	2.4	0.24	0.33
11	Marousi	North Athens	3.2	72,333	12.9	0.44	0.25
12	Ilion	West Athens	2.3	84,793	9.3	0.27	0.25
13	Agioi Anargyroi - Kamatero	West Athens	2.0	62,529	9.2	0.32	0.22
14	Petroupoli	West Athens	1.0	58,979	6.8	0.17	0.15
15	Korydallos	Pireaus	0.5	63,445	4.3	0.08	0.12

16	Elliniko-Argyroupoli	South Athens	1.9	51,356	15.4	0.37	0.12
17	Glyfada	South Athens	2.6	87,305	25.4	0.30	0.10
18	Aigaleo	West Athens	0.5	69,946	6.5	0.07	0.08
19	Athens	Central Athens	2.3	664,046	39.0	0.03	0.06
20	Vari-Voula-Vouliagmeni	East Attica	2.1	48,399	37.2	0.43	0.06
21	Elefsina	West Attica	2.3	29,902	36.6	0.77	0.06
22	Paiania	East Attica	1.7	26,668	53.2	0.64	0.03
23	Pallini	East Attica	1.4	54,415	29.4	0.26	0.05
24	Oropos	East Attica	5.5	33,769	338.2	1.63	0.02
25	Haidari	West Athens	0.4	46,897	22.7	0.09	0.02
26	Markopoulo Mesogaias	East Attica	0.5	20,040	81.8	0.25	0.01
27	Saronikos	East Attica	2.0	29,002	139.1	0.69	0.01
28	Galatsi	Central Athens	0.3	59,345	4.0	0.05	0.01
29	Megara	West Attica	1.4	36,924	332.9	0.38	0
	Total	**North Athens**	**42.4**	592,440	140.7	0.77	**0.30**
	Total	**South Athens**	**12.5**	529,826	69.4	0.24	**0.18**
	Total	**Central Athens**	**8.0**	1,029,520	87.4	0.08	**0.09**
	Total	**West Athens**	**6.2**	489,675	66.7	0.13	**0.09**
	Total	**Pireaus**	**0.5**	448,997	50.4	0.01	**0.01**
	Total	**East Attica**	**13.2**	502,348	1513	0.26	**0.01**
	Total	**West Attica**	**3.7**	160,927	1004	0.23	**0.00**
	Total	**All Regional Units**	**86.5**	3,744,012*	1042*	0.23	**0.08**

*=Only Urban Area (not including remoted towns, villages, forests and agricultural land)

Table 1 lists cycling infrastructure length and density in the municipalities of Region of Attica. Municipalities are shorted according to cycling infrastructure density which was found to correlate significantly with cycling commuting in Australia and the USA (Pistol & Goodman, 2014; Schoner & Levinson, 2014).

Region of Attica is divided into Regional Units. Regional Unit of Central Athens and Regional Unit of Piraeus are the most dense and populated areas. Municipality of Athens has a mean population density of 17,026 residents per km^2, but some areas in Central Athens reach population density of 35,000 people per km^2. Athens and Piraeus are the commercial and administrative centers of the whole metropolitan area, but have much less cycling facilities, compared to other Regional Units. In Piraeus cycling facilities are almost absent. In central area of Athens there is only 9 % probability to meet a cycling infrastructure when making a random, 1-km long trip, because the density of cycling infrastructure is 1 km every 11 km2. Regional Units of North Athens, South Athens and West Athens include residential suburbs and local commercial centers around the two central areas. These areas are still dense. Density ranges from 20 540 residents per km^2 (Kallithea) to 4420 residents per km^2 (Philothei – Psychiko). Table 1 and the cycling infrastructure map of Athens reveal that there is a clear lack of cycling facilities in the west.

The geography of cycling infrastructure in the urban core of Athens follows the social geography of the same area (ELL. STAT., 2011) (Table 2).

Table 2 – The social geography of Athens cycling infrastructure

Regional Unit	Cycling Infrastructure Density (per km)	Unemployment Rate (%)
North Athens	0.30	13.2
South Athens	0.18	16.4
Central Athens	0.09	19.3
West Athens	0.09	19.7
Pireaus	0.01	20.8

Regions of East and West Attica are low population density areas around industrial areas, former villages, towns and cities. These distanced areas rarely use bicycle to commute to the inner city and so facilities constructed there are less capable to boost change.

Expanding the map to include every city in Greece

The successful implementation of the first cycling infrastructure map of Athens led to the widening of the area included in the map. We used the same methodology: a) internet search, b) databases of funded projects search and c) contact with local authorities an initial map of cycling infrastructures of Greece. It took 2 months (Spring 2015) to conduct the initial country-wide map. The map was published and all local cycling communities were contacted to comment on the map. They participated to correct the map and to add some new segments in their cities.

The results of cycle network implementation in Greek cities is listed on table 3 (Athanasopoulos, 2018). The results were provided to European Commission Directorate for Mobility and Transport (DG MOVE) as the only available data in Greece on cycling infrastructure statistics at the urban and national level.

Table 3 – The geography of cycling infrastructure in Greek cities

a/a	City	Popula-tion	Network Length (NL) (km)	NL per 10,000 res.	Urban Area (km2)	Network Density (km per km2)	Network Diameter (ND) (km)	"Π" index (NL/ND)
1	Orestiada	18,426	5.9	3.20	5	1.18	3.2	1.84
2	**Amaliada**	16,763	5.8	3.46	6	0.97	2.5	**2.32**
3	***Karditsa***	42,785	***12***	2.80	19	0.63	5.1	**2.35**
4	*Kos*	23,847	*12.3*	5.16	22	0.56	7.9	1.56
5	Nafpaktos	15,049	3.6	2.39	8	0.45	2	1.80
6	Florina	17,676	2.6	1.47	6	0.43	2.6	1.00
7	Rethymno	48,500	8	1.65	22	0.36	9.7	0.82
8	Ptolemaida	32,142	7	2.18	20	0.35	6	1.17
9	Mesologi	12,785	1.7	1.33	5	0.34	1	1.70
10	***Volos***	124,575	***11.7***	0.94	35	0.33	4.4	**2.66**
11	**Corfu**	48,775	7.9	1.62	25	0.32	2.7	**2.93**
12	***Larisa***	166,986	***15.5***	0.93	60	0.26	4.6	**3.37**

13	Lamia	62,728	8	1.28	31	0.26	4.6	1.74
14	*Patra*	213,984	*16.8*	0.79	68	0.25	16.7	1.01
15	Korinth	34,108	3.6	1.06	15	0.24	2.2	1.64
16	**Preveza**	21,937	5.2	2.37	26	0.20	2.2	**2.36**
17	Pirgos	25,180	2	0.79	10	0.20	2	1.00
18	Ierapetra	15,309	1	0.65	5	0.20	0.7	1.43
19	Kalamata	62,427	3.8	0.61	21	0.18	2.5	1.52
20	Kastoria	20,103	0.9	0.45	5	0.18	0.8	1.13
21	Alexandroupoli	60,044	4.5	0.75	27	0.17	2.3	1.96
22	Kozani	46,778	3.3	0.71	20	0.17	3.1	1.06
23	Alexandria	15,474	0.9	0.58	6	0.15	0.9	1.00
24	**Komotini**	58,071	3.8	0.65	28	0.14	1.6	**2.38**
25	Trikala	65,069	4.3	0.66	40	0.11	3.9	1.10
26	Levadeia	21,379	0.6	0.28	6	0.10	0.6	1.00
27	Heraklion	180,595	5.3	0.29	57	0.09	7.3	0.73
28	Drama	51,510	2.5	0.49	27	0.09	1.3	1.92
29	Katerini	69,008	4.7	0.68	52	0.09	8.1	0.58
30	Ioannina	110,247	6.8	0.62	78	0.09	6.3	1.08
31	Serres	62,101	2.4	0.39	28	0.09	1.9	1.26
32	Xanthi	63,083	2.7	0.43	32	0.08	3.8	0.71
33	Argos	23,086	0.5	0.22	6	0.08	0.4	1.25
34	*Attica Region*	3,744,012	*86.5*	0.23	1042	0.08	52.7	1.64
35	Naousa	19,268	0.6	0.31	12	0.05	0.6	1.00
36	Nafplio	18,513	0.3	0.16	6	0.05	0.3	1.00
37	*Thessaloniki*	830,934	*20.4*	0.25	441	0.05	21	0.97
38	Chalkida	81,994	0.6	0.07	28	0.02	0.5	1.20

The cities are ranked according to cycle network density as in the case of Attica Region (Athens Metropolitan Area). "Π" index is derived from graph theory (Rodriguez, 2009). Pi index under 1 shows a linear and fragmented network, under 1.5 a rather linear continuous network or a developed, but fragmented network. Pi index over 2 shows a rather developed network. Only 7 cities in Greece have a developed network (bold cities in Table 3). Komotini has a high Pi index, but low infrastructure density, which means that the city has a developed, dense network but with low diameter, covering a small part of the city. Rethymno (in Crete) on the other hand has cycling infrastructure density higher than other cities, but low Pi index. This can be explained because Rethymno is a linear city between the seaside and the mountains. Hence A linear cycling infrastructure network covers most areas of the city. From the above examples it is clear that the most important characteristic is infrastructure density and "pi index" gives additional information about the cycling infrastructure network shape.

Comparisons with US cities are rather frustrating for Greek cities. Only the city with the highest cycling network density (1, 18 km/km^2) has reached the average cycling network density of 72 US cities (Schoner & Levinson, 2014). Only 7 Greek cities have cycling network length over 10 km. Athens metropolitan urban area has only 86.5 km long cycle infrastructure. The average cycle network of US cities is 311.16 km in length.

The urban area appearing in density calculations of table 3 is not the official administrative area. It was derived from Google Maps Satellite Images and includes the urban core, urban expansion areas around the city and satellite settlements, which are everyday trip generators, contributing to downtown traffic. Small cities like Orestiada, Amaliada, Karditsa, Kos, Nafpaktos and Florina have high infrastructure density because the area contributing to downtown traffic is rather low as most residents live near the city center. All these cities are rather small and the cycling network they have implemented seems capable of serving most cyclists' needs. Medium-sized cities and metropolitan areas must implement an extended network to serve cyclist's trips.

Conclusions

The scope of this paper was to present the whole participatory procedure towards bicycle infrastructure mapping and analyze the geography of bicycle infrastructure in Greek cities.

Participatory mapping seems to foster publicity of a map, raise public awareness, feelings of ownership of the information provided and raise precision of the information included.

Two basic indicators were used to measure spatial characteristics of bicycle infrastructure network in Greek cities (with more than 10 000 residents): density of the network and "pi index". Only the first indicator is correlated with intense cycle use. The second indicator was used to describe the form of the network. Generally, spatial characteristics are poor in most cities. The average value is density of 0.25 km bicycle infrastructure length every square km of urban area. In other words (in those cities who have constructed a cycling infrastructure) the average cycling trip to meet a cycling infrastructure is 4.0 km long. Most trips do not meet a cycling infrastructure, even less are served by them. The average cycling infrastructure density in US urban areas is 10 times higher and the average cycling infrastructure length is 40 times higher (US cities have more extended urban areas than Greek cities).

Analysis of the Athens case reveals that administrative borders create important spatial inconsistencies. Athens - a big metropolitan area, of approx. 4 million residents - divided into numerous local authorities has created a highly fragmented bicycle network, not offering connections between important trip origins and destinations. Instead, few medium-sized cities, under the authority of one local government, were able to shape coherent and uninterrupted networks, able to foster cycling. Moreover the construction of a cycle network by local authorities instead of regional authorities has resulted in more wealthy areas to enjoy more cycling facilities than marginalized areas. The density of cycling infrastructure in every Regional Unit of Athens metropolitan area follows employment rate in the Regional Units. Marginalized areas have less money, more weak administrative structures and less interest to fund cycling infrastructure implementation.

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