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The use of bicycles in a mid-sized city –benefits and obstacles identified using a questionnaire and GIS

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ABSTRACT

The need for alternative means of transport is highlighted by many studies. This need can be satisfied by prioritizing the use of bicycles over the use of mechanical vehicles in daily mobility needs in a city. Here we show an investigation of the reasons that, at present, bicycle use is not prioritized over the use of other transportation means in Karditsa. For this purpose we use a questionnaire and a GIS regarding Town Planning Sectors (T.P.Ss). The following factors are investigated: a) width of the existing cycling routes, b) education/training on how to cycle in a city, c) extension of the existing cycling routes and d) use of bicycles. We found that the inhabitants believe that the width of the cycling routes must not be narrow, the inhabitants must be educated/ trained on how to cycle about in a city, the cycling routes must be extended in many parts of a city, and that they state that they use bicycles in their daily mobility needs. The results demonstrate the following: a) the width of cycling routes proper for two separate one-way cycling routes is preferable by the inhabitants, b) education/ training on how to cycle in a city is essential for the right way of cycling, c) cycling route extension to more parts of a city would reduce car driving for the daily mobility needs and increase bicycle use, and d) the data collected by a questionnaire from the inhabitants depended on their experiences as bicyclists, pedestrians, and car-drivers, and, therefore, they are close to the representation of the truth. These findings can improve the preference of using bicycles to using cars and, therefore, the prioritization of cycling.

Keywords: GIS, cycling routes, bicycle, city, Karditsa, T.P.S, questionnaire

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ABBREVIATIONS

CS	Coordinate System
D.U.P.I.K.	Department of Urban Planning Implementations of Karditsa
GIS	Geographical Information Systems
GG	Greek Grid
M.o.K.	Municipality of Karditsa
SUP-K	Study of General Urban Plan of the Extended Municipality of Karditsa A' Phase
T.P.S.	Town Planning Sector
T.P.Ss	Town Planning Sectors

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1. INTRODUCTION

Many studies reported in the literature (Ewing and Cervero, 2010; Stead and Marshall, 2001; van Wee, 2002) highlight the need for alternative means of transport. Such an alternative mean of transport is thought to be the bicycles. They do not generate gases harmful for the environment (Brussel and Zuidgeest, 2012). Their use can contribute also to significant reduction of noise pollution (Godefrooij & Schepel, 2010), to cleaner cities, to amplification of the green parts of cities, and to the reduction of car use, while they serve people for the coverage of their daily needs.

Especially, the need for the use of alternative means of transport seems to be obvious in urban areas that possess features of compact development with high densities. High density includes vertical development of numerous buildings concentrated in a small area. Krizek (2012) claims that in areas where heightened development density exists one could observe higher rates of cycling and lower rates of motor traffic.

Milakis et al. (2008) claim that the central areas of Greek cities have the characteristics of high densities and various urban land uses. It is highlighted that in Greek cities transport policies favour car use. Infrastructure policies for alternative means of transport are limited in Greece (OASA, 2007).

Heinen et al. (2010) suggest that inhabitants prefer to use bicycles for their daily transport needs when the distance to be covered is small or not so big as a consequence of a dense urban environment. Börjesson and Eliasson (2012) also support that the use of bicycle is reduced when travel distances are increased**.**

Further, the use of bicycle, as an alternative mean of transport, has become necessary in areas with various urban land uses (Ewing and Cervero, 2010; Stead and Marshall, 2001; van Wee, 2002) or with a great mix of urban land uses (Krizek, 2012), such as residence, commerce, public services, education etc.

Some of the urban land uses, specifically residential ones, could be attractive for bicyclists when these areas have well-designed cycling routes and cycling bridge(s),

as well as bicycle parking spots at stops of public interest (banks, market place, recreation areas, entertainment spots etc.) and stations (Parkin and Koorey, 2012).

Cycling promotion requires improvement of cycling infrastructure. Factors that should be taken into consideration for this purpose are, for example, satisfaction of the inhabitants' needs in terms of their daily transportation, well-designed cycling routes, cycling training, human behaviour, traffic violence, and cycling celebrations. Coherence, directness, attractiveness, safety, and comfort of cycling routes are also elements that amplify the prioritization of bicycle riding instead of car driving (Ploeger, 2003; Godefrooij & Schepel, 2010).

The present study reports the spatial division of the city of Karditsa and the thoughts of its inhabitants about cycling. Therefore, a GIS is an appropriate tool to integrate many different kinds (e.g., spatial data and social information) of data layers, because it has the capability to analyse spatial locations and to organize layers of information into maps (Steinberg and Steinberg, 2006).

In this study the objective is "to investigate the reasons that, at present, bicycle use is not prioritized over the use of other transportation means in Karditsa". Not only engineering matters, but also the views, the thoughts, and the experience of the inhabitants who use the cycling routes are also included (see Horton and Parkin, 2012).

Thus, the aims of the present study are two:

1) To investigate if the inhabitants' views towards bicycle riding could have a spatial dependence, i.e. access to cycling routes etc. and to use a GIS to visualise the extent of cycling routes and this spatial dependence, and

2) To use GIS to identify and visualise needed actions to encourage bicycle riding instead of car driving, based on a combination of the experiences and attitudes of the inhabitants, the current bicycle network, and relevant spatial analyses.

2. BACKGROUND

According to the National Census of 2011, the Municipality of Karditsa (M.o.K. from now on) had a total number of 38 554 inhabitants (Hellenic Statistical Authority, 2011).

Karditsa has been chosen for this study because it is one of the first Greek cities in which cycling routes were constructed (construction began in 2003). This means that the inhabitants' experience of, approximately, 14 years as bicyclists, pedestrians, and vehicle drivers was essential for the present study.

Urban cycling routes (routes that are within the city plan) have a length of 7.3 km (The Official Site of the Municipality of Karditsa, n. d.). Cycling routes occupying road parts are on the one side, have a width, approximately, 2.10 m. Some of the cycling routes are mounted in order to reach the height of pavements (see Figures 1a and 1b) and others are at the same level with the road (see Figure 2), segregated from car roads by low height cement and pillars.

Figures 1a and 1b: Cycling route mounted from the road. Photographs taken on 20/11/2017 by the author of this thesis

Figure 2: Cycling route at the same level with the road. Photograph taken on 20/11/2017 by the author of this thesis

Now, some words about layers, lines, polygons, and data points, since these concepts are used in the present study.

A layer may be a slice or stratum of the reality or an interpretation of reality, rather subjective, of a particular area (Campbell and Shin, 2011). A point is "A map feature that has neither length nor area at a given scale…" while a line is "A map feature that has length but not area at a given scale…". A polygon is "a closed shape defined by a connected sequence of x, y coordinate pairs, where the first and last coordinate pair are the same and all the other pairs are unique" (Campbell and Shin, 2011).

3. METHODOLOGY

The methodology used in this study consisted of a questionnaire (see Appendix), data taken from the a) D.U.P.I.K. and b) information taken from the SUP-K (2013). These data, the information, and their origins were described further in this chapter.

3.1. Study area

Karditsa is located in Central Greece. It is, from a spatial view, a "flat" city, that is, a city situated on a level surface of land. The city has only one centre where most office firms and employment are concentrated. It is also formulated, at a great extent, in a normal orthogonal grid. The city covers an area of 7.261 km² (SUP-K, 2013).

3.2. The questionnaire

The distribution of 232 copies of the questionnaire lasted from 26th April 2016 to 19th June 2016. Their collection (answered or not) lasted from 26th April 2016 to 27th June 2016. The copies of the questionnaire were distributed to a variety of people, in order to achieve a more representative sample.

The reasons for selecting the method of questionnaire were that it is a quick, easy, and without much work way to gather information. It is also characterized by the absence of pressure to the respondents to respond to the questions "here and now". The Questionnaire was used for discovering people's thoughts, experience, attitudes, and orientations to future actions (see Bulmer, 2004).

The answers to the questions of the questionnaire were registered and edited in the Microsoft Excel software program in order to be transformed from crude to a structured and sorted form. Since the data mentioned above were not quantitative but categorical or qualitative, only frequencies could be calculated (Paraskevopoulos, 1990) which were transformed into percentages.

3.3. Identification of digitized data other than the questionnaire

All layers in this section were created and processed in the ArcMap software

programme on my own initiative, except the creation of the layer “Blocks”, and projected in the “GG” CS.

3.3.1. Blocks

Block is defined as a unified built-up area within a city’s, town’s, or settlement’s, in general, approved town plan or boundaries, which area is enclosed and described by communal areas, for example car roads and pedestrian parts (Greek Law 4067, 2012). A block may include various urban land uses such as residence, commerce, public/communal space, education etc.

Some of the data needed for this study and based on sources other than the questionnaire were required and extracted from the Public Service of D.U.P.I.K. These data were in a polygon shape file format, named “otdhmoykarditsas”, and depicted Karditsa’s blocks and the name of the road addresses.

The attribute table of this shape file provided information about the serial number of each polygon (Fid), the type of shape, the id, and the serial number of blocks. According to “otdhmoykarditsas” there are 1250 blocks in Karditsa. This shape file was renamed “Blocks” by me.

3.3.2. T.P.S.

A layer in polygon shape, that concerned the T.P.Ss, was created and named “T.P.Ss”. The layer of “Blocks” was used as a design subbase upon which T.P.Ss were designed according to their factual location. The attribute table of the layer “T.P.Ss” included the serial number of each polygon (Fid), the type of shape, and the id.

In order to ensure further the factual location of the city’s T.P.Ss, their design was based on the description of Karditsa’s T.P.Ss found in the SUP-K (2013), which showed the spatial division of the city in sectors. These sectors were defined by the name of roads’ addresses that enclose blocks. The processing of the polygon shape file T.P.S. was conducted by screening and comparing the name of road addresses and the serial number of blocks (SUP-K, 2013).

3.3.3. Cycling routes

A layer in a polyline shape which concerned the cycling routes was created and named "Cycling routes". The layer "Cycling routes" included the existing cycling routes of Karditsa. They are constructed alongside basic car roads of Karditsa and drive through the centre of the city. The layer "Blocks" was useful as a design subbase upon which the cycling routes of the city were designed in the ArcMap software program according to their factual location. This design was based on field studies performed by me (January 2016), (mapping the extent of cycling routes associated with roads mainly used by cars), and Galanis et al. (2015). The attribute table of "Cycling routes" included, among others, the names of the roads that the cycling routes of the city drive through them.

3.4. Spatial division of the city

The respondents were asked by a letter on the first page of the questionnaire to fill in the T.P.S. in which their place of residence was. For this reason, a map with the T.P.Ss was included in the second page of the questionnaire. T.P.Ss are sectors that are formed and sorted in order to cover the town planning and residential structure of Greek cities. That is, each T.P.S. to have a minimum level of equipment in terms of education, parks, squares, and athletic areas. For example, each T.P.S. must have a minimum level of 105 students representing the 4% of its population, 7-11 m^2/student etc. (SUP-K, 2013).

The spatial division of the city into T.P.Ss was used in order to investigate whether there were differences or similarities of the answers to each question of the questionnaire asked between the inhabitants of the T.P.Ss.

Each T.P.S. was combined with the answers to the Questions 7, 11, 16 and 22. These questions were dichotomous ("Yes"/"No" answers) (see Table 2). The questionnaires were examined in order to find those which the respondents filled in the T.P.S. they lived in and, then, to separate them in those who lived in each of the T.P.Ss.

The answers to each of the Questions 7, 11, 16 and 22 were counted for each of the T.P.Ss. Four polygon shape files were created based on source data from the layer "T.P.S.". Each of them corresponded to one, but not the same, of the Questions 7, 11,

16 and 22. The answers to the above questions of the inhabitants of each T.P.S. were inserted in the corresponding shape files in ArcMap (see Table 1) and converted into percentages. Their symbolization was determined by the (percentage) attribute.

3.5. Creation of maps

4 maps concerning Karditsa were created as follows:

Table 1: Type of maps and shape files used for their creation

Type of map	Names of shape files used to create the maps
1. Question 7: Are the Karditsa's cycling routes too narrow to be bidirectional?	"Answers to Question 7", "Cycling routes", "T.P.S.", and "Blocks"
2. Question 11: Is it essential to have an education/training on how to get around with a bicycle?	"Answers to Question 11", "Cycling routes", "T.P.S.", and "Blocks"
3. Question 16: Would you reduce your driving if there was more extended cycling infrastructure service in Karditsa?	"Answers to Question 16", "Cycling routes", "T.P.S.", and "Blocks"
4. Question 22: Do you use a bicycle for your daily mobility needs?	"Answers to Question 22", "Cycling routes", "T.P.S.", and "Blocks"

4. RESULTS

The official cycling routes connect the centre of the city with regional T.P.Ss and urban land uses such as education, public services. No cycling routes exist in T.P.Ss II3, III5, III15, IV7, V9, and V10.

4.1. Spatial division of the city

The majority of the respondents, 134 (59.03%) out of 227 respondents, filled in the T.P.S. where their place of residence was. The most represented T.P.S. was the V8 (Centre) as 33 (24.63%) of those who filled in the T.P.S. lived within its boundaries whereas the T.P.Ss III5 and VII13 were not represented because no one of the respondents chanced to live in them. Thus, the T.P.Ss III5 and VII13 were not included in the analysis of the data.

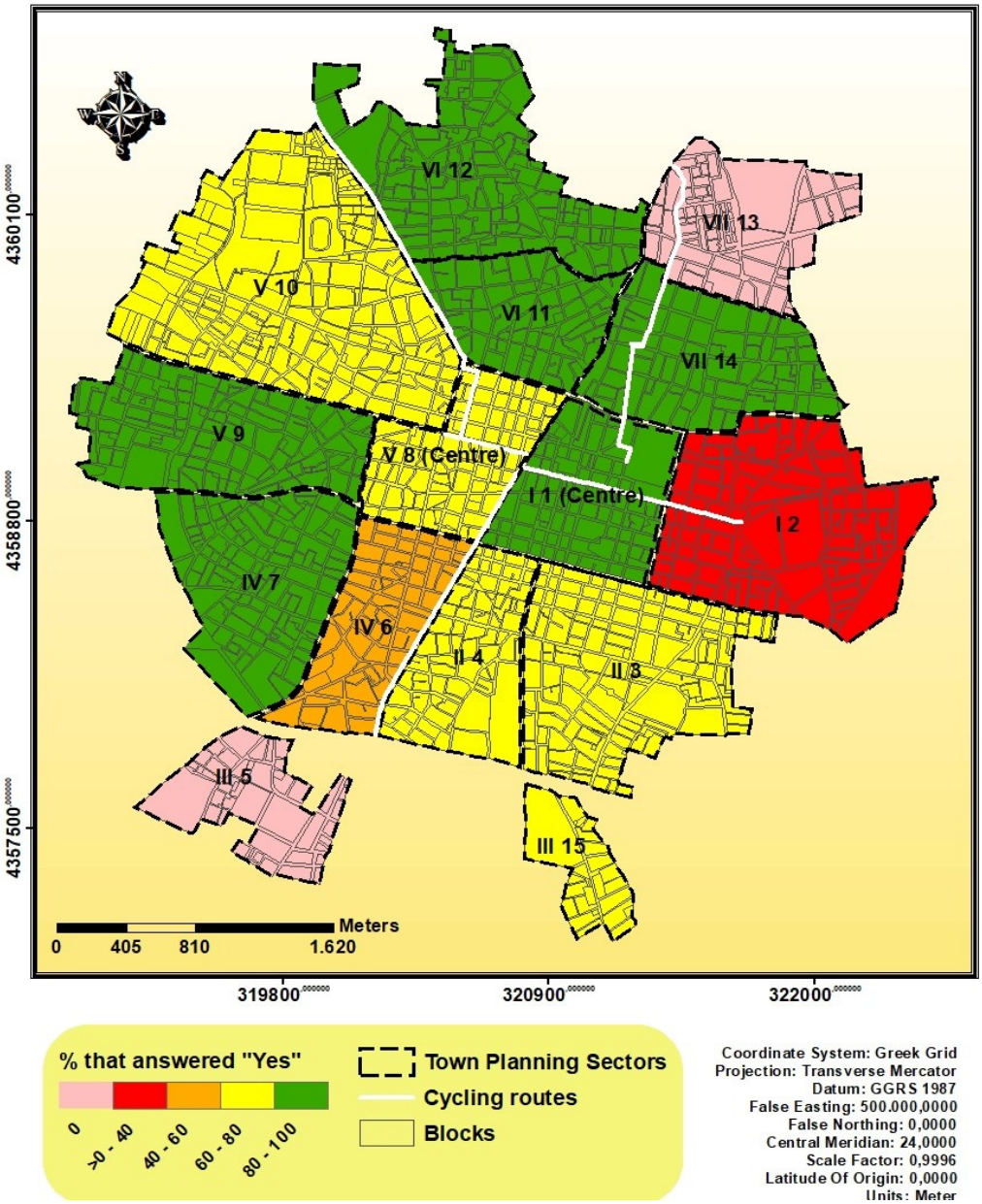
4.2. Spatial analyses involving a combination of the results from the questionnaire and digital data

Table 2: Spatial comparison of the answers to the Questions 7, 11, 16, and 22

Answers of the inhabitants who filled in their T.P.Ss								
T.P.Ss	**Questions**							
	7		**11**		**16**		**22**	
	Answers %							
	Yes	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
I1 (Centre)	83	17	100	0	100	0	67	33
I2	40	60	100	0	100	0	80	20
II3	77	23	91	9	68	32	82	18
II4	76	24	90	10	71	29	95	5
III5	0	0	0	0	0	0	0	0
IV6	55	45	73	27	55	45	100	0
IV7	100	0	83	17	83	17	100	0
V8 (Centre)	73	27	91	9	70	30	82	18
V9	100	0	100	0	100	0	100	0
V10	75	25	100	0	75	25	100	0
VI11	89	11	78	22	33	67	89	11
VI12	100	0	100	0	100	0	100	0
VII13	0	0	0	0	0	0	0	0
VII14	100	0	80	20	80	20	100	0
III15	80	20	80	20	60	40	80	20

The analysis of the data regarding the inhabitants' views on cycling depending on in which T.P.S. they live showed differences and similarities between the inhabitants of the T.P.Ss (Figures 3-6). These views referred to a) whether the existing cycling routes were narrow to function as bidirectional (Question 7), b) whether it is necessary to be educated/trained how to get about by a bicycle (Question 11), c) whether the respondents to the questionnaire would reduce their driving a mechanical vehicle if the existing cycling routes were extended (Question 16), and d) whether the respondents use bicycle for their daily mobility needs (Question 22).

Question 7: Are the cycling routes too narrow to be bidirectional?



<u>Figure 3:</u> Map of answers to Question 7

As to whether the existing cycling routes were narrow to function as bidirectional, the results showed that most of the inhabitants from most of the T.P.Ss and all the inhabitants of the T.P.Ss IV7, V9, VI12, and VII14 believe that the existing cycling routes were narrow to function as bidirectional. On the contrary, most of the inhabitants of the I2 believed that the existing cycling routes were not narrow.

However, the “Yes” answers of the inhabitants of the T.P.Ss I1, IV7, V9, VI11, VI12, and VII14 were more than those of the inhabitants of the T.P.Ss II3, II4, V8, and V10. The “Yes” answers of the second above group of T.P.Ss were more of those of the T.P.S. IV6.

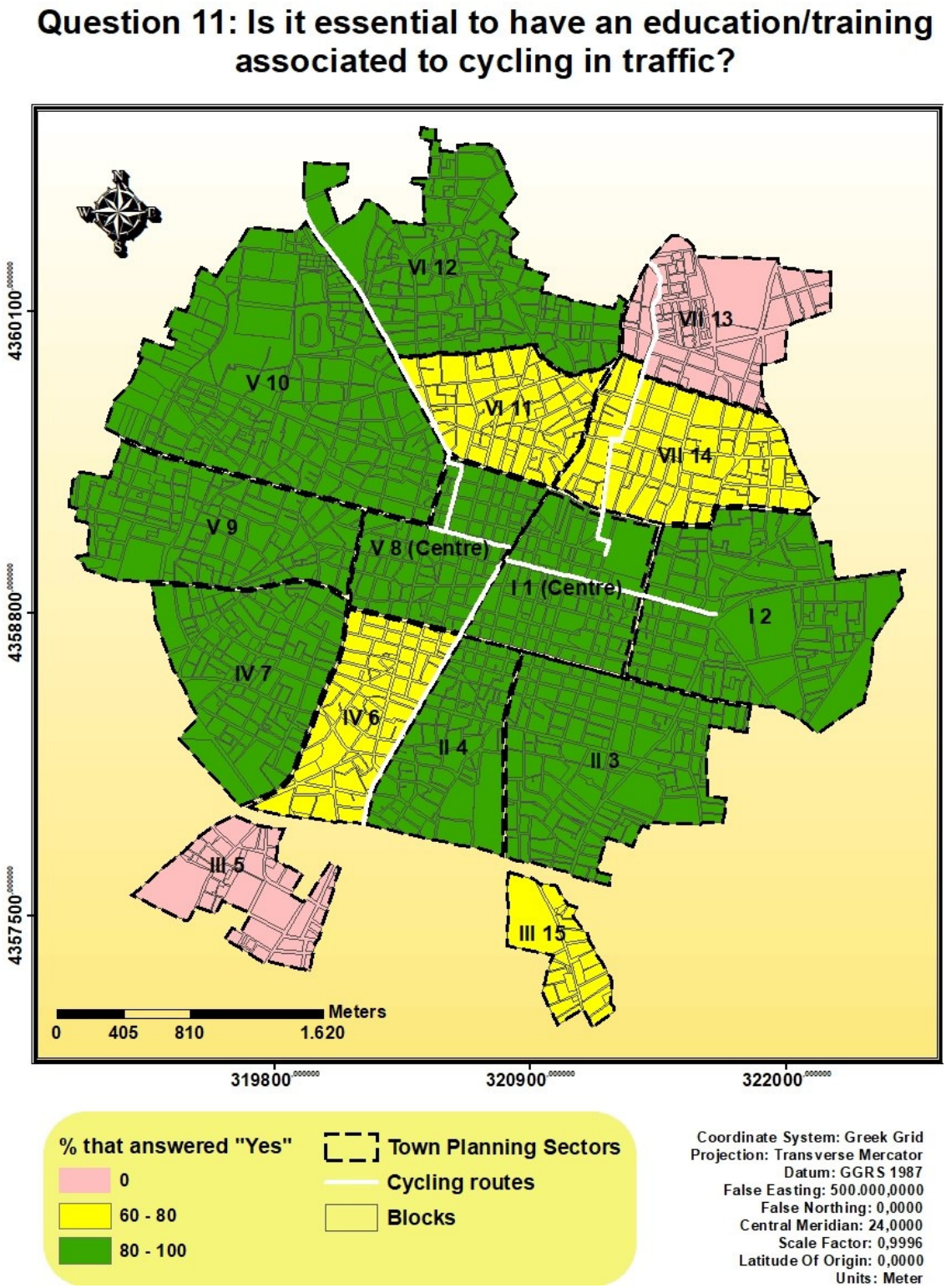


Figure 4: **Map of answers to Question 11**

As to whether it is necessary to be educated/trained how to get about by a bicycle, the results showed that most of the inhabitants from most of the T.P.Ss and all the

inhabitants of the T.P.Ss I1, I2, V9, V10, and VI12 believe that it is necessary to be educated/trained how to go around by a bicycle.

However, the inhabitants of the T.P.Ss I1, II2, II3, II4, IV7, V8, V9, V10, and VI12 who believe that they must be educated/trained how to go around by a bicycle were more than those of the T.P.Ss IV6, VI11, VII14, and III15.

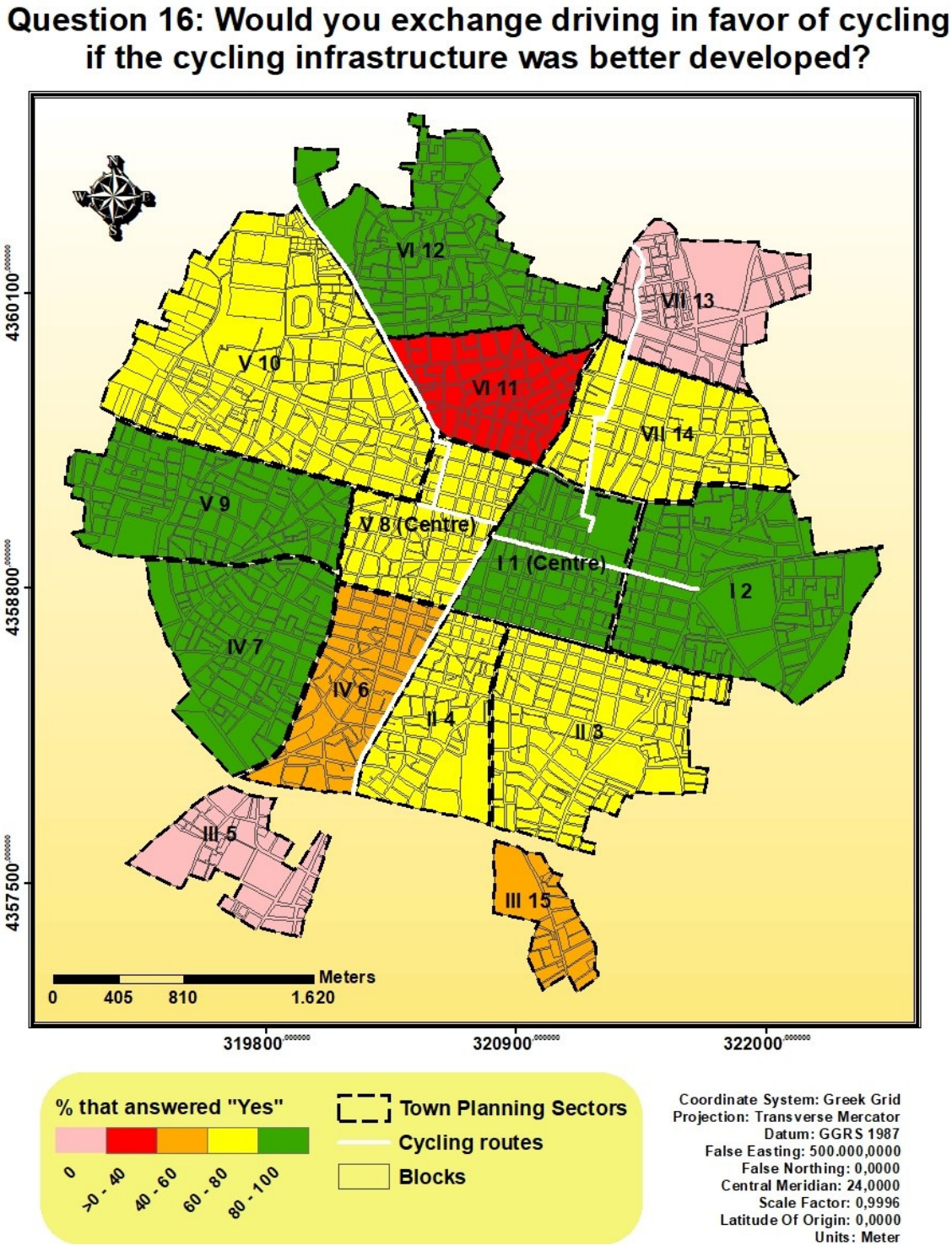


Figure 5: **Map of answers to Question 16**

As to whether the inhabitants would reduce their driving a mechanical vehicle if the existing cycling routes were extended, the results showed that most of the inhabitants from most of the T.P.Ss and all the inhabitants of the T.P.Ss I1, I2, V9, and VI12 would reduce their driving a mechanical vehicle if the existing cycling routes were extended. On the contrary, most of the inhabitants of the T.P.S. VI11 replied negatively.

However, the inhabitants of the T.P.Ss I1, II2, IV7, V9, and VI12 who would reduce their driving a mechanical vehicle if the existing cycling routes were extended were more than those of the T.P.Ss II3, II4, V8, V10, and VII14. The inhabitants of the last T.P.Ss were more than the inhabitants of the T.P.Ss IV6 and III15.

Question 22: Do you use a bicycle for your daily mobility needs?

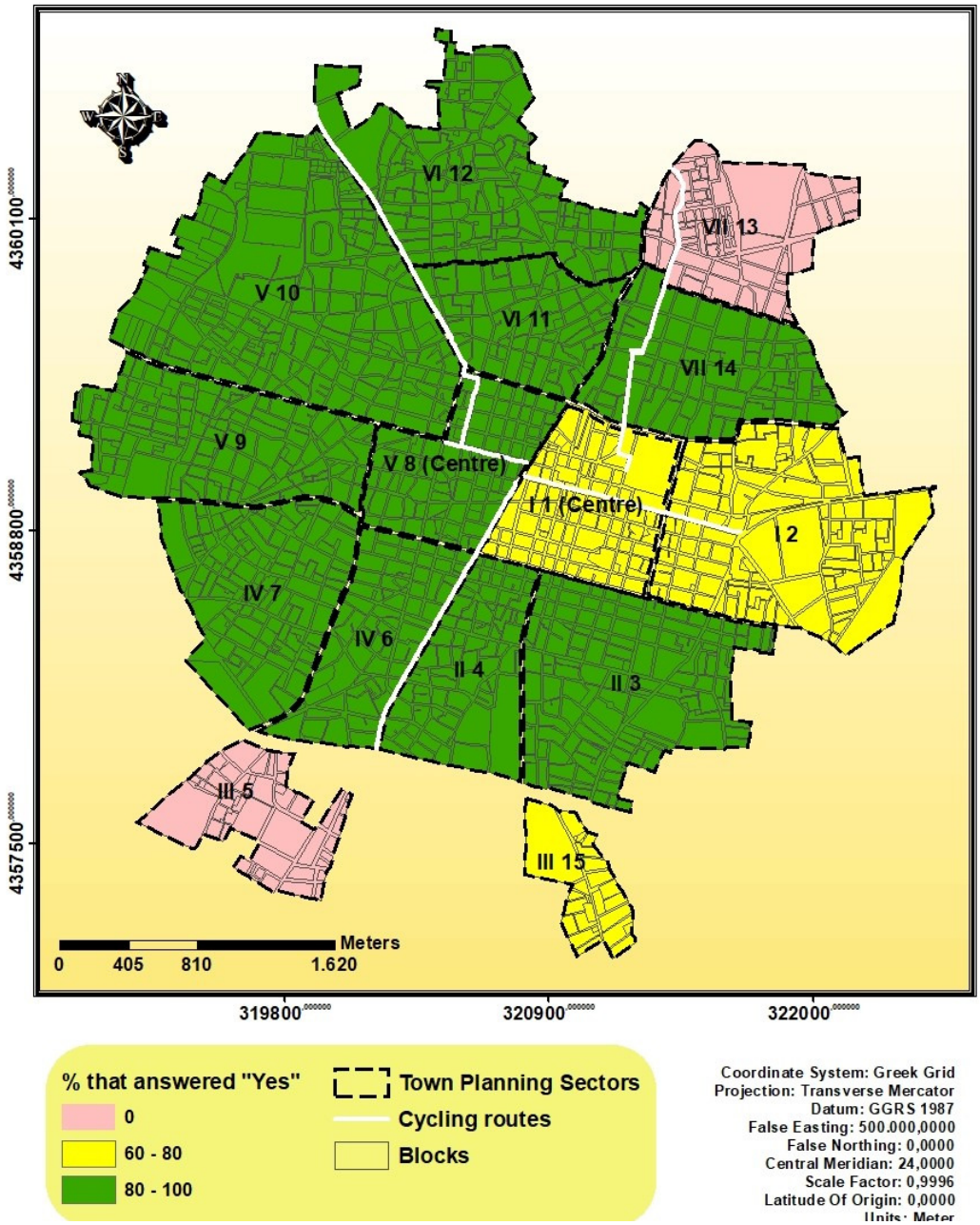


Figure 6: **Map of answers to Question 22**

As to whether the inhabitants use a bicycle for their daily mobility needs, the results showed that most of the inhabitants of most of the T.P.Ss and all the inhabitants of the T.P.Ss IV6, IV7, V9, V10, VI12, and VII14 used a bicycle for their daily mobility needs.

However, the inhabitants of the T.P.Ss II3, II4, IV6, IV7, V8, V9, V10, VI11, VI12, and VII14 who used a bicycle for their daily mobility movements were more than those of the T.P.Ss I1, I2, and III15.

5. DISCUSSION

The purpose of this study is to investigate the reasons, that at present, bicycle use is not prioritized over the use of other transportation means in Karditsa. In order to achieve this purpose, a questionnaire was used to find out the views and attitudes of the inhabitants towards cycling as well as spatial information relevant to the city of Karditsa and its existing cycling routes.

This methodology is used because it is supported that failure in promoting cycling is attributed to lack of information in connection with people's needs, lack of cycling facilities, and lack of much information about the way people can be convinced to cycle instead of to use cars (see Hydén et al., 1999).

5.1. The inhabitants' views towards bicycle riding and their spatial dependence

Four questions were used in order to see if for each of them there were any differences in the views about cycling between the inhabitants of the T.P.Ss of the city of Karditsa. The four questions chosen, 7, 11, 16, and 22, have to do with: a) promoting the existing cycling routes of Karditsa (see Questions 7 and 16), namely width and extension respectively, b) educating/training how to cycle in the city (see Question 11), c) whether the extension of the existing cycling routes would affect the inhabitants' intension to reduce their driving of vehicle (see Question 16), and d) using a bicycle for daily mobility (see Question 22). The analysis of these data showed differences and similarities between the inhabitants of the T.P.Ss (see Figures 3-6).

According to the results of this study, most of the inhabitants from most of the T.P.Ss and all the inhabitants of the T.P.Ss IV7 and VII14 believe that the existing cycling routes are narrow to function as bidirectional (see Figure 3). On the contrary, most of the inhabitants of the I2 believed that the existing cycling routes were not narrow.

This means that most of the inhabitants of the city of Karditsa, independently of the T.P.S. they live in, with exception only of the inhabitants of the T.P.S. I2, think that the existing cycling routes of the city are inappropriate to be used as two-way cycling

routes. This idea may emanate from the thought that a narrow cycling route can cause risks, for example, cycling accidents and, consequently, accidental injuries. Why this thought?

Bicycles are unstable and that means that enough room must be available for cycling. Bicycles are not automobile. They are powered by people, which means, that bicyclists lose energy and they may become somehow unstable when cycling (C.R.O.W., 1993).

Therefore, cycling safety may be one of the main factors that may play a key role in order to decide to use cycling and, furthermore, to contribute to the prioritization of the use of bicycles over the use of cars in a city.

However, most of the inhabitants of the T.P.S. I2 have a different idea of that of the inhabitants of the rest of the T.P.Ss. Why do they have this idea? Is it due to that the I2 T.P.S. is a regional T.P.S. and abuts on a central T.P.S. Is it due to that a short cycling route covers a small part of this T.P.S.? These factors can not explain the difference mentioned above. The opinion of the inhabitants of the rest of the regional T.P.Ss, independently of whether there is a long or short cycling route in them, is different of that of the inhabitants of the T.P.S. I2. The data of this study are not enough to give an explanation to the difference in question.

Thus, spatial analysis, as far as cycling transportation is concerned, shows that it is needed the city's routes to be broadened or to be reconstructed into two separate one-way cycling routes.

Another factor that could help to promoting cycling and make it prioritized over the use of cars in a city for its inhabitants' daily mobility needs is educating/training the inhabitants how to cycle around a city. Do the inhabitants think that cycling education/training is essential?

Indeed, the results show that most of the inhabitants from most of the T.P.Ss and all the inhabitants of the T.P.Ss I1, I2, and V10 believe that it is necessary to be educated/ trained how to go around a city by a bicycle (see Figure 4). Since the inhabitants have this belief, a cycling culture could be cultivated by educating/training them according to

the needs of cycling in the city and its advantages against the other transportation means. Such a culture could help in making the inhabitants prioritize the use of bicycles over the use of other transportation means part of their daily traffic behaviour.

It is supported that cycling promotion requires an interweaving of infrastructure provision and development of cycling culture. More specifically, it is suggested that four elements are necessary to gain the benefits of cycling: "engineering, education, enforcement, and encouragement" (see Parkin and Koorey, 2012).

Now, looking at the question that refers to whether the inhabitants would reduce their driving a mechanical vehicle if the existing cycling routes were extended (see Figure 5), the results show that most of the inhabitants from most of the T.P.Ss and all the inhabitants of the T.P.Ss I1 and I2 would reduce their driving a mechanical vehicle if the existing cycling routes were extended. On the contrary, most of the inhabitants of the T.P.S. VI11 replied negatively.

These results imply that most of the inhabitants of all the T.P.Ss, except only those of the T.P.S. VI11, reason that the existing cycling routes do not satisfy them. This dissatisfaction may be due to the fact that the four cycling routes radiated from the centre to the skirts of the city cannot cover the needs of the overwhelming majority of the inhabitants of the regional areas. There are also cycling routes that are not connected (see Figure 3). It is suggested (Hydén et al., 1999) that the lack of a continuous and proper cycling network constitutes a main mobility problem that bicyclists can oppose. The creation of continuous cycling routes could enhance cycling safety (Segadilha and Sanches, 2014).

In a city where transport networks exist, such as Karditsa, it is not easy to develop a network suitable for cycling traffic. For example, there are links and junctions which may or may not be in coincidence with cycling routes and motor traffic routes. Then, it could be suggested that proper networks for cycling have to be retrofitted into the existing cycling networks. Four actions: spatial planning, demand modelling, traffic and speed management, construction of links, and integration with public transport can help in succeeding in retrofitting.

Therefore, a good cycling infrastructure in the city would influence the inhabitants to reduce the use of cars. That is, promotion of the existing cycling routes could contribute to the prioritization of the use of bicycles against the use of cars.

As to whether the inhabitants use a bicycle for their daily mobility needs, the results show that the overwhelming majority of the inhabitants of most of the T.P.Ss and all the inhabitants of the T.P.Ss IV6, IV7, V9, V10, VI12, and VII14 use a bicycle for their daily mobility needs (see Figure 6).

These results confirm the fact that the answers given by the respondents about the width of the existing cycling routes and the need for their extension as well as for the inhabitants to be educated/ trained are based on their experience. This lends weight and validity to the answers of the respondents and the results of the present study may be, more or less, representative of the reality.

However, the inhabitants of the T.P.Ss II3, II4, IV6, IV7, V8, V9, V10, VI11, VI12, and VII14 who used a bicycle for their daily mobility movements were more than those of the T.P.Ss I1, I2, and III15.

One reason why the inhabitants of the T.P.S III3 are less may be the combination of the fact that there is not any cycling route even near their T.P.S. and the fact that this T.P.S. is cut off from the rest of the T.P.Ss.

As to the inhabitants of the central I1 T.P.S. who use a bicycle for their daily mobility needs, they are less than those of the other central T.P.S. V8 maybe due to the fact that, although cycling routes exist in them, the first T.P.S. covers a larger area than the second. Therefore, the inhabitants who live away from cycling routes may be more in the T.P.S. I1 than those of the T.P.S. V8. Since shops, public services, and so on are at hand for them and the cycling routes are somehow away from their home, they do not care much to use a bicycle. They rather prefer to go on foot.

For the reason why the inhabitants of the T.P.S. I2 who use bicycles are less, it is difficult to find out why this difference happens, since the inhabitants of the rest of the regional T.P.Ss have the similar characteristics with it.

Generally, it could be suggested that the differences mentioned above have to be further studied.

5.2. Proposals for actions to encourage bicycle riding instead of car driving based on a combination of the experiences and attitudes of the citizens, the current bicycle network, and relevant spatial analyses.

By visualizing, editing, and analysing all data needed for this study, which originate from different sources, one could say that the use of GIS for these purposes leads up to practical and tangible results.

According to the results of this study, the following proposals could be made in order the authorities to take actions relevant to promotion and prioritization of the use of bicycles:

a) The study highlights that the existing cycling routes are not adequate to function as bidirectional, because their width is narrow. When width is adequate to cycle on freely, the bicyclists' feelings of comfort and safety can be strengthened. Lack of those feelings may work against prioritization of cycling. Therefore, one of the actions that could contribute towards prioritization of using bicycles instead of cars for the daily mobility needs is the city's existing cycling routes to be broadened or to be reconstructed into two separate one-way cycling routes.

b) A second action that the authorities should put into practice is to recommend and implement programs that aim at the education/training not only pupils but also people of all ages how to cycle about the city. This would cultivate a cycling culture, promote cycling, and cultivate a preference for prioritization of the use of bicycles to the use of car-driving.

c) Another important proposal that could be made and based on the results of the present study is to extend the existing cycling routes or to create new ones. This aims at reduction of driving cars and further to preference of using bicycles for the daily

mobility needs to the use of cars, since the overwhelming of the inhabitants of all the T.P.Ss, except one, would reduce driving cars.

6. CONCLUSIONS

As far as the inhabitants' views towards bicycle riding and their spatial dependence are concerned, the present study shows prioritization of the use of bicycles over the use of cars could be promoted by the following actions:

- Broadening the existing cycling routes for them to function as bidirectional or constructing them into two separate one-way cycling routes
- Educating/training people how to cycle about in a city and, as a sequence, creating a cycling culture
- Extending the existing cycling routes and creating new ones wherever they are needed

As far as the proposals for actions to encourage bicycle riding instead of car driving, based on a combination of the experiences and attitudes of the citizens, the current bicycle network, and relevant spatial analyses, this thesis shows the following:

- The cycling transportation in the city of Karditsa entails risks for bicyclists
- The authorities need to take responsibility to facilitate, encourage, and to some degree demand the inhabitants to be educated/ trained how to cycle about the city
- The existing cycling routes need to be extended
- New cycling routes must be designed and constructed in the T.P.Ss where cycling routes do not exist

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APPENDIX

Questionnaire

If it is possible, locate and put in circle the Town Planning Sector, in which your residence is. This is important in order to analyse and organise the selected data.

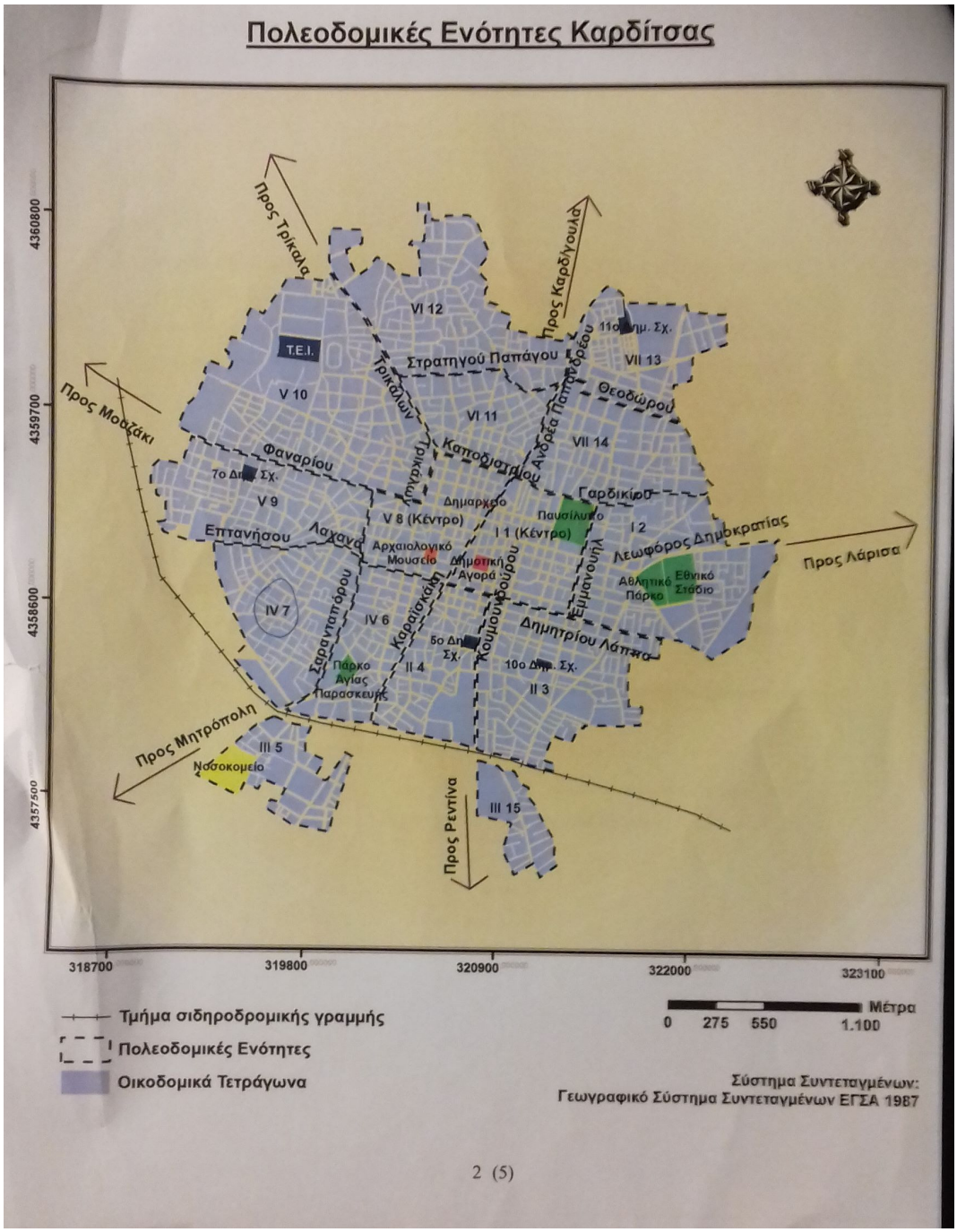

Figure 7: Map included in the questionnaire (in Greek)

(Put x where appropriate)

General information

1. Sex

   Male Female

2. Age

   9-18, 19-30, 31-45, 46-67, >67

3. Educational level

   Primary, lower secondary, higher secondary, tertiary (university/higher technological education), Master Degree, PhD

4. Job

   Employer, employee, self-employed, retired, student, unemployed, housekeeping, other

5. Do you live near cycling routes?

   (i) Within 50 m from cycling routes

   (ii) Within 80 m from cycling routes

   (iii) Within 100 m from cycling routes

   (iv) No

6. Do you possess a vehicle? (Select more than one if needed)

   Car, motorcycle, bicycle, nothing

Cycling routes adequacy

7. Are the Karditsa's cycling routes too narrow to be bidirectional?

   Yes No

Cycling transportation safety

8. When do Karditsa's cycling routes entail any risk for a bicyclist? (Select more than one if needed)

   (i) When cycling routes are alongside a heavy traffic road

   (ii) When a bicyclist has to cross roads

   (iii) When the cycling routes are narrow and bidirectional at the same time

   (iv) When car drivers do not respect bicyclists

   (v) It does not entail risk

9. Do pedestrians respect the function of Karditsa's cycling routes?

   Much I am not sure A little Not at all

10. Do cars obstruct free bicycle mobility?

    Much I am not sure A little Not at all

11. Is it essential to have an education/training associated to cycling in traffic?

    Yes No

12. Do you believe that lights (front and rear) and helmet are mandatory for bodily protection when cycling?

    Lights: Yes No Helmet: Yes No

13. How frequent do you use lights (front and rear) and/or helmet when cycling?

    Lights: (i) always (ii) many times (iii) sometimes (iv) almost never (v) never

    Helmet: (i) always, (ii) many times (iii) sometimes, (iv) almost never (v) never

14. Have you ever been involved in an accident with your bicycle? If the answer is "Yes" then write the name(s) of the road(s) in the closest, to the accident, junction.

    Yes No

Cycling routes extension

15. Do you believe that the cycling routes should be extended further in the town of Karditsa, according to your daily mobility needs?

    (i) very much (ii) fairly (iii) I am not sure (iv) no

16. Would you exchange driving in favor of cycling if the cycling infrastructure was better developed?

    Yes No

Cycling routes adequacy

17. Are there many parking spots for bicycles in Karditsa?

    Yes No

18. Do you believe that the cycling routes are adequate for people with kinetic problems?

    Yes No

Motives for using alternative means of transport

19. Is using alternative means of transport (bicycle, walking, and bus) stress-free?

    Much I am not sure A little Not at all

20. Does using alternative means of transport (bicycle, walking, and bus) save some money?

    Much I am not sure A little Not at all

21. Do you believe that car use for mobility needs in the city of Karditsa is time saving?

    Much I am not sure A little Not at all

Cycling prioritization

22. Do you use a bicycle for your daily mobility needs?

    Yes No

23. Do you prefer using a bicycle to another transportation mean for your daily mobility needs?

    Yes No

24. If yes, why you prefer to use it? (Select more than one if needed)

    (i) time-saving, (ii) costless, (iii) stress-free, (iv) quickness, (v) other

25. If no, which one of the following do you prefer?

    (i) my own car, (ii) motorcycle, (iii) bus, (iv) other

26. For what purpose do you use it (bicycle, car etc.)? (Select more than one if needed)

    (i) daily movements, (ii) job, (iii) there is no cycling route/network, (iv) entertainment/recreation, (v) sport, (vi) personal administration/bureaucracy obligations, (vii) school (viii) other

27. Do you believe that bicyclists must be prioritized against vehicles?

    Yes No

28. Are bicyclists prioritized against vehicles in Karditsa?

    Yes No

Table 3: Data borrowed/retrieved for the needs of this study

Number	Object	Format of object	Borrowed/ retrieved from	Date of borrowing /retrieval	Author	Date of creation
1	Layer "Blocks"	Digital-polygon shape file	D.U.P.I.K.	11/2015	D.U.P.I.K.	Unknown
2	SUP-K	Digital-pdf	Web	01/2016	Cooperation of private offices	04/2013

Table 4: Data created and modified for the needs of this study

Number	Layer (digital)		Creation				Modification			Columns
	Name	Format	Object	By	Date	Based on	Type	By	Date	
1	Blocks	Polygon shape file	-	-	-	-	Renaming and projection to GG	Me	12/2015	Fid, shape, id, & serial number of blocks
2	Cycling routes	Polyline shape file	Digitalization of urban cycling routes & projection to GG	Me	01/2016	Blocks	-	-	-	Fid, shape, id, & name of road
3	T.P.Ss	Polygon shape file Polygon shape file	Digitalization of T.P.Ss	Me	02/2016	Blocks, map/drawing & SUP-K	-	-	-	Fid, shape, & id
4	Q7		Addition of answers (%) to Question 7	Me	11/2016	T.P.S.	-	-	-	Fid, shape, id, "Yes_per", "No_per"
5	Q11		Addition of answers (%) to Question 11				-	-	-	
6	Q16		Addition of answers (%) to Question 16				-	-	-	
7	Q22		Addition of answers (%) to Question 22				-	-	-	

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