Analyzing and Mapping the Car Parking Sites Distribution in Technical University of Crete Campus - A DEMAND and OFFER Approach

Androniki Tsouchlaraki and Georgios Achilleos

Abstract**—** This paper discusses the distribution of parking sites on the Campus of Chania, in relation to the existing building facilities. The approach is based on the model of "OFFER and DEMAND" (or Supply and Demand) and the analysis which is carried out includes concepts such as "DEMAND COVERAGE" and "FAILURE" of Urban Planning Standards, according to which the required parking spaces on campuses are specified. The concepts of demand and demand coverage are defined via a theoretical and a practical/factual approach, and then the ensuing differences are examined. Next, the paper estimates the way in which the measured quantities are affected by the construction of a new building complex. The concept of "POTENTIAL" is utilized in order to transform the variables of demand and demand coverage into continuous spatial variables, while techniques of interpolation and three dimensional surface imaging are called forth, in order to then manage the emerging distributions. The results are mapped, the distributions are evaluated and the conclusions drawn are very interesting as to the overall perception of the phenomenon.

Keywords**— TUC campus, parking sites, demand - offer - coverage, spatial analysis, potential interpolation, GIS**

I. Introduction

CAMPUSES are essentially small cities and as such they are not impervious to the existence of environmental and urban planning problems. Such problems are the issue of the expansion of the structured environment as opposed to the natural environment, the large consumption of electricity and water, the increasing amount of waste being generated (solid and liquid), the regional pollutant generation (in land and air), traffic congestion and unauthorized parking, transportation safety for the community members, and so on [1], [2], [3], [4], [5], [6], [7]. These problems are often hard to solve and require a special approaches.

One of these problems concerns the car parking sites structure and organization, that occurs in a University Campus. This paper is dealt with the case of the Technical University of Crete (TUC) Campus in Akrotiri, Chania. Although the dimension of the problem does not appear alarming, it should still be monitored and a suitable policy should be followed so that it will remain under control. The cause for selecting the TUC Campus for the present research was the recurrent reports from the academic society to the Technical Division of the University, about the extended irregular parking phenomenon around some of the parking sites of the Campus. As these reports were strained, it was decided to research the theme. The field data which were collected through a graduated thesis were very useful to understand the problem and proceed to further research [8], [9].

There are 12 designated car parking sites throughout the TUC, positioned usually by the University Departments. Whilst conducting this research, it was observed the occurrence of unauthorized parking in several places on the Campus. The use of the term "unauthorized parking" here indicates vehicles which are parked outside the parking designated areas (such as on the road, on pavements, in pedestrian only areas and in empty spaces). Up to now there has not been a specific policy applied on the designated parking areas of the TUC. In other educational institutions in the country and abroad, numerous and intricate policies are applied, which can be effective in certain circumstances, but not so conducive in others [10], [11], [12], [13], [14]. These policies usually indicate the classification of parking areas into categories where only a specific group of the university community is allowed to park (e.g. professors, researchers, staff members, students, visitors, etc). However, any policy in order to have good results must have adequate supervision of the area and penalties enforcement for the offenders.

A question then arises, of whether – and to what extent – the existence of these 12 parking sites on the specific locations on the campus is satisfactory. The approach which takes place in this paper uses the concepts of OFFER and DEMAND. Through such an approach one can attempt to detect : what is, what needs to be, what is missing or is in surplus and how conditions are altered if new buildings or parking spaces are added.

The methodology used in this paper uses the model of OFFER (or Supply) – DEMAND, which is widely applied in Economic Sciences [15]. The present paper defines the quantities of this model, records their values, and reaches conclusions by analyzing these quantities. At the same time, there is the use of POTENTIAL - a fundamental quantity in Thematic Cartography- on the basis of which the results from the whole of the Campus are shown in three dimensional maps.

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The use of the concepts OFFER and DEMAND are widely used outside the confines of the Economic Sciences, mainly in cases of a network of objects (points, lines or surfaces) [16], [17], [18], [19], [20], [21] and this is one of the reasons why it was adopted in this paper. Other ways of approaching the issue of infrastructure evaluation is to conduct a collection of primary data directly from those involved. By means of a questionnaire, one can collect the data needed from people - who represent the DEMAND - thus being able to develop the analysis that is going to be conducted. Specialized research can also be conducted (pertaining transportation, traffic – in the case of parking) through which one can measure the satisfaction level of users' needs and estimate the satisfaction level of DEMAND.

According to the results of the paper the problem of parking sites sufficiency on the Campus is not particularly intense on the whole, with the exception of certain cases. The occurrence of unauthorized parking is mainly due to a poor mentality on the users' part wanting to park right next to the building where they work. This issue calls for further analysis, yet it is not the object of this paper, whose aim is to describe and illustrate this phenomenon.

II. TUC Campus Car Parking Infrastructure

A. Technical University of Crete (TUC)

The TUC was founded in 1977. The campus expands on an area of 300 hectares (Figure 1). Since then, the TUC has been steadily and rapidly growing. There are five Engineering Departments in the TUC all with pioneering specializations, and a Sciences Department. All departments offer postgraduate studies and are listed below, in the order of their foundation.

The entire Polytechnic Community numbers 4,361 members. Excluding the Department of Architectural Engineering which is located in the French School, far away from Akrotiri, the Polytechnic Campus amounts 3,884 people. According to a research conducted in 1994 by the Technical Division of the University [22], it is expected that the overall number of students at the anticipated 12-14 departments will be between 5,500 and 6,000. This is an optimum number of students for a small to medium-sized university which is in turn the ideal size for a city of 70,000 inhabitants such as Chania.

The built-up areas at the TUC are measured per section of building facilities, as shown in Figures 1, 2 and Table 1 below. According to the governmental legislation concerning universities, there should be one parking space per 100 – 150 square meters of built-up area.

B. Parking on the Polytechnic Campus

The TUC has 12 designated parking sites (Fig. 2, 3) which are located in several sections of the Campus.

These sites are recorded in Table 2, along with the surface area and the parking spaces per site.

Building Facilities	Surface Area (sq.m.)	Required Parking Spaces
BC1	4450	30 - 45
BC2	8100	54 - 81
BC3	3885	26 - 39
BC4	17400	116 - 174
BC5	18800	126 - 188
TOTAL	52635	352 - 527

Table 1: Building Complexes in TUC

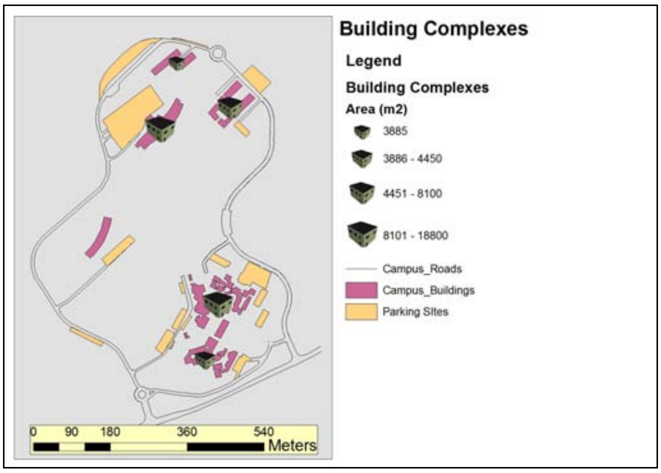

Fig. 1: Area of Building Complexes

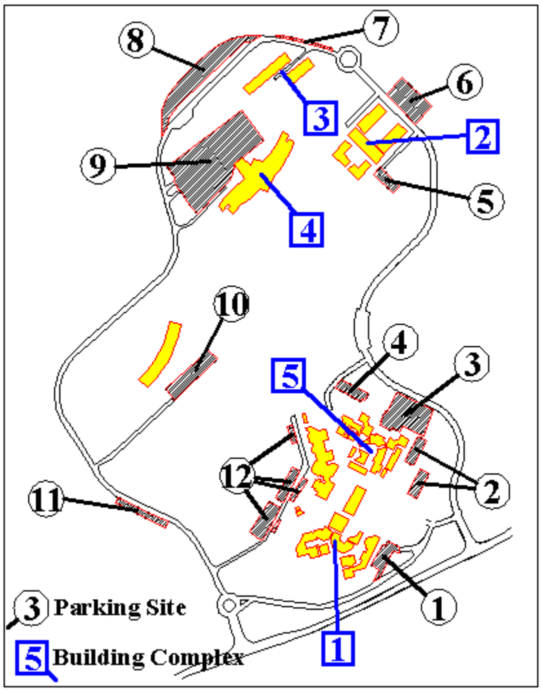

Fig. 2: Parking Sites and Building Complexes

As shown above, the existing parking spaces over exceed the ones required according to regulations. Consequently, the problem probably lies in the distribution of these spaces on the Campus.

Parking Sites	Surface Area (in sq.m.)	Parking Spaces
PS1	795	45
PS2	290	26
PS3	2870	89
PS4	745	35
PS5	480	29
PS6	1750	62
PS7	345	35
PS8	3865	135
PS9	9200	292
PS10	1715	57
PS11	420	34
PS12	2655	114
SUM	25130	953

Table 2: Parking Sites

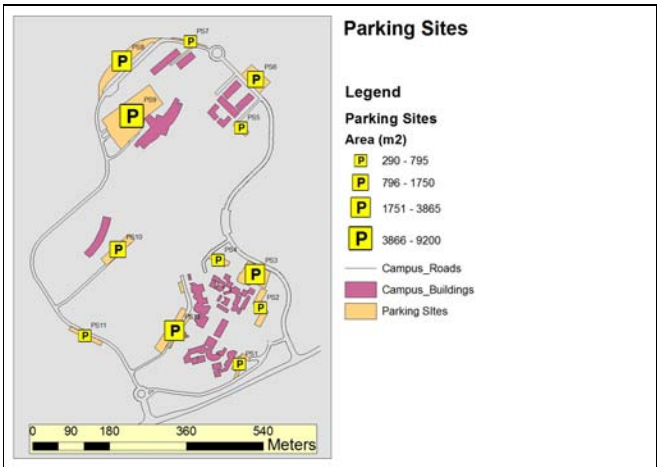

Fig. 3: Area of Parking Sites

III. Analyzing Method of the Parking Sites Distribution

During the stage of analysis of infrastructure data, the primary data in the database are processed and secondary data are produced in the form of variables in charts, geographic maps and thematic maps. This material constitutes the foundation of decision making, spatial design and development. It also enables one to detect any shortcomings of the infrastructure as well as which sections of the infrastructure need intervention.

The analysis product can be illustrated and be easily comprehensible only on the condition that a number of presentation tools are used, which should be supervisory, comprehensible and enable one to compare results. Such tools are maps of spatial distribution of phenomena, Comparison Variables, Thematic maps, etc. [23], [24].

A map, being the representation of an image, can illustrate a phenomenon better than a chart or a description in a text. A comparison cannot be carried out though, just by observing a map; certain variables are needed which will show any differentiation and allow for comparisons. These variables range from being simple to more complex ones.

The model of OFFER - DEMAND for approaching the issue enables one in this case to examine other variables as well, such as COVERAGE, FAILURE and POTENTIAL.

The DEMAND variable is defined as a need for the existence of sufficient parking sites on the Campus. The DEMAND is distinguished in two separate variables: a)Theoretical DEMAND and b)Real DEMAND.

The Theoretical DEMAND is defined as the number of parking spaces required according to the urban planning regulations concerning academic buildings and in relation to square meters of their surface [25].

The Real DEMAND is defined as the number of vehicles recorded through on site inspection, whether they occupy designated parking areas or they are parked outside of them.

The OFFER is defined as the number of parking spaces available in every parking area on the Campus.

The variable of COVERAGE is estimated by subtracting OFFER minus DEMAND. The existence of negative values for COVERAGE indicate a shortage of available parking spaces or the availability of parking spaces in remote places, where these values appear. Conversely, positive values indicate a surplus of parking spaces, or a sufficient number of them in nearby parking sites.

The variable of COVERAGE can be estimated in the specific case which is analyzed, as Theoretical COVERAGE and as Real COVERAGE. The Theoretical COVERAGE is defined as the difference of OFFER minus the Theoretical DEMAND, while the Real COVERAGE is defined as the difference of OFFER minus the Real DEMAND.

The variables of OFFER and DEMAND are then used as point counts (values), in order to estimate the phenomenon of OFFER Potential and DEMAND Potential. The concept of Potential refers to a surface distribution of a continuous value field; this distribution (as a spatial surface) is measured by using point counts and applying interpolation.

The potential is a continuous quantity in space which defines phenomena which are distributed as points and their value affects the surrounding area either positively or negatively (for example if there are three parking sites with an adequate number of available parking spaces in an area, then the area Potential is increased a multiplication way, given the fact that the available parking spaces increase against some other area where there is only one parking site.

The effect of the values positions of a phenomenon on the rest of the positions in the surrounding area is directly proportional to the value of the phenomena and inversely proportional to the distance of the positions of these phenomena. This expression of Potential is derived from the natural law of gravitational pull and is called Gravitational Method.

In order to chart Potential, surface illustration techniques in space are put forward.

The Potential is given by :

$$V_i = x_i + \sum_{j=1, j \neq i}^{n} \frac{1}{dr_{ij}} \cdot x_j$$
$$dr_{ij} = \max(d_{i1}, d_{i2}, ... d_{in}) \quad (1)$$

where :

Vi: the value of phenomenon potential on measurement position i
xi: the value of phenomenon on measurement position i
dij: the distance between two measurement positions of the phenomenon (i, j)
drij: the scaled distance between measurement points i,j

The phenomenon of Potential represents a continuous distribution of values in space. By doing point counts of the phenomenon in space, one can have a perception of its configuration in space, but not a comprehensive one. In order to have an overall perception, one needs to use three-dimensional surface illustration techniques.

This paper uses the Inverse Distance Weighted [26], [27] interpolation method. This method is widely used and tried, it is based on the natural law of gravitational pull just like in the case of Potential, which makes it the most appropriate method to use in the interpolation.

Another quantity that would be interesting to define is the concept of FAILURE of Urban Planning Regulations concerning parking spaces per academic facility.

The Regulations FAILURE can be defined as the difference of Theoretical DEMAND minus Real DEMAND. If this difference has positive values it means that urban planning regulations specify more parking spaces than actually required. In the case of negative values, the required parking spaces are more than the ones specified by urban planning regulations, which indicates failure.

A. Results

Table 3 shows the required positions for the building complexes on the Campus, according to the Urban Planning Regulations. The total of the required parking spaces for the campus is 527 (Table 3).

BC	Needed Parking Places from BCs before New Building	Needed Parking Places from BCs after New Building	Vi Before	Vi After
1	45	45	1160	1203
2	81	81	978	1133
3	39	82	1105	1148
4	174	174	881	1074
5	188	188	739	787

Table 3: Theoretical Demand Potential of Building Complexes Before and After the New Building

The available parking spaces in the parking sites of the Campus are 953 (Table 4). Conclusively, this research starts on the basis that the existing parking spaces are on the whole over sufficient according to the regulations. Are they, though, suitably distributed within the campus so as to meet the needs of the polytechnic community? This is the point at issue in this research.

A surveying of parking sites took place between March 14, 2011 and March 28, 2011, every two hours from 08:00 to 20:00. During this specific time period the majority of the academic community is present at the Institution (it is not an exam or holiday period).

The surveying included the number of parked vehicles at every parking site as well as the ones in unauthorized parking areas around it.

PS	Offered Parking Places by the Parking Sites (OFFER)	Maximum Counted Cars inside and outside the Parking Site (REAL DEMAND)	Vi OFFER	Vi REAL DEMAND
1	45	72	1712	1178
2	26	19	2504	1747
3	89	29	2048	1714
4	35	41	1633	1167
5	29	38	1937	1560
6	62	68	2026	1586
7	35	51	2635	1680
8	135	28	2352	1896
9	292	207	1664	1030
10	57	18	1507	1071
11	34	22	2086	1419
12	114	85	1386	979

Table 4: OFFER Potential of Parking Sites and Real Demand Potential of Building Complexes

The recorded values of the OFFER and DEMAND phenomenon are shown on Maps in Figures 4, 5, 6 in the form of point symbols.

Some basic data for the Potential evaluation (for OFFER and DEMAND) are the phenomenon value at point positions for which there are phenomenon recordings, as well as the distance between these point positions. These distances are shown in Table 5 for the building complexes and on Table 6 for the parking sites.

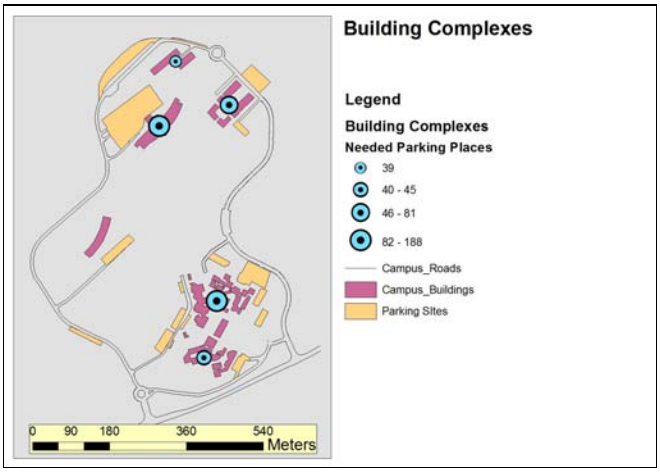

Fig. 4: Values of Theoretical DEMAND (No of Needed Parking Places)

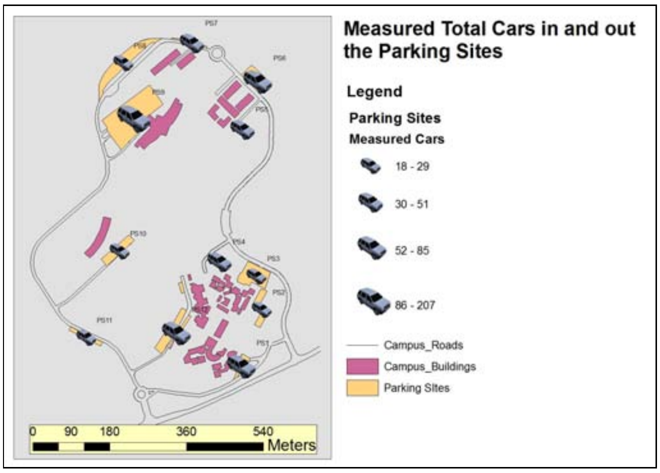

Fig. 5: Values of Real DEMAND (Measured Total Cars in and Out the Parking Site)

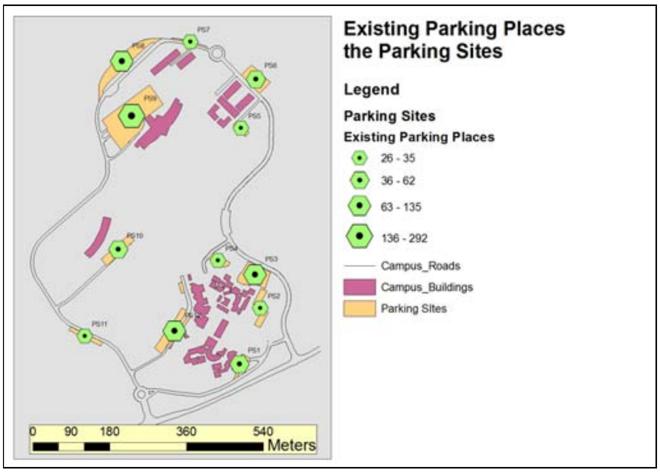

Fig. 6: Values of OFFER

The values of the Real DEMAND variable for every parking site on the Campus are recorded in Table 4.

Next, the values of the Theoretical DEMAND, Real DEMAND, OFFER, Theoretical COVERAGE, Real COVERAGE and Regulation FAILURE variables are interpolated. The interpolation results are shown in Figures 7, 8, 9 which follow.

	BC1	BC2	BC3	BC4	BC5
BC1	0	600	740	565	150
BC2		0	205	210	530
BC3			0	165	655
BC4				0	510
BC5					0

Table 5: Distances Between Building Complexes

PS	1	2	3	4	5	6	7	8	9	10	11	12
1	0	200	275	485	880	835	1025	1200	1125	740	475	485
2		0	90	300	685	625	840	1010	1005	910	600	650
3			0	220	605	545	760	930	925	830	520	570
4				0	565	530	705	885	1170	1280	980	995
5					0	150	365	535	820	1360	1300	1360
6						0	210	400	645	1235	1160	1330
7							0	185	475	1025	940	1235
8								0	285	870	760	1055
9									0	765	650	940
10										0	270	555
11											0	300
12												0

Table 6: Distances Between Parking Places

The Potential values for the DEMAND (Theoretical and Real) as well as for OFFER are shown in Tables 3 and 4 above.

The values for the Theoretical and Real Coverage Potential for the 12 parking sites are shown in Table 7 that follows. The values for Regulation FAILURE Potential are also shown in the same Chart.

PS	Vi THEOretical COVERAGE	Vi REAL COVERAGE	Vi REGulation FAILURE
1	643	534	-108
2	1629	750	-888
3	1211	334	-877
4	808	466	-341
5	961	377	-583
6	1039	440	-599
7	1559	954	-604
8	1333	456	-877
9	746	633	-112
10	577	436	-141
11	1113	667	-447
12	388	407	18

Table 7: Theoretical Coverage Potential, Real Coverage Potential and Regulation Failure Potential of Parking Sites

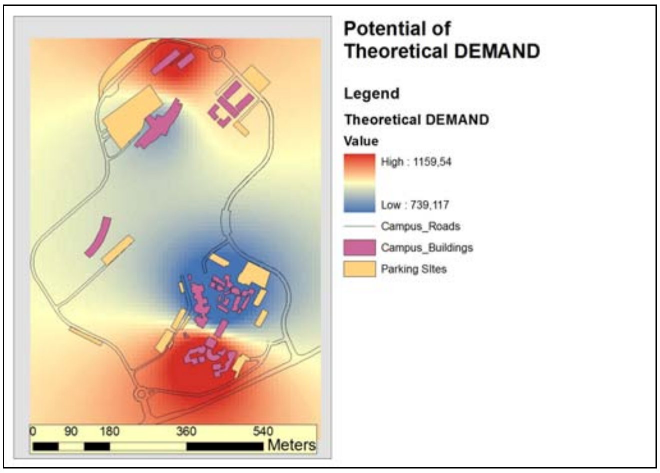

Fig. 7: Potential of Theoretical DEMAND

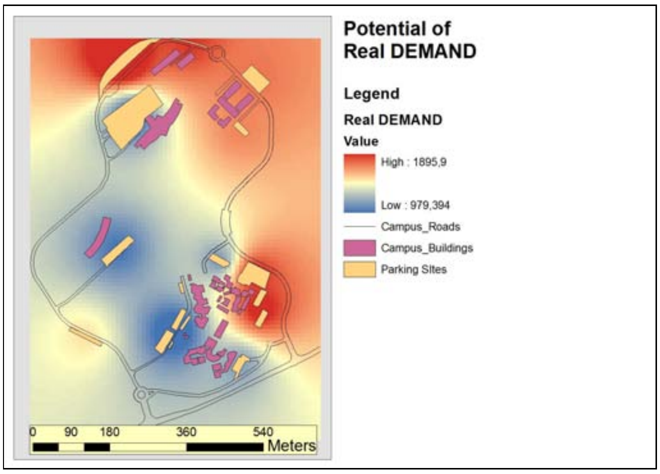

Fig. 8: Potential of Real DEMAND

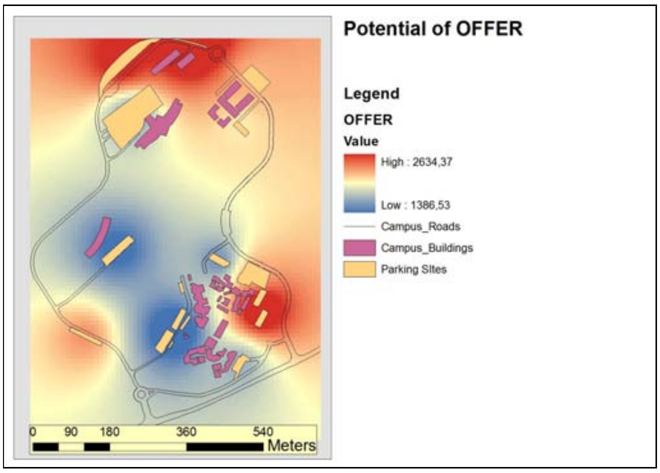

Fig. 9: Potential of OFFER

B. Discussion on Results - Present Conditions

By observing the figures of the cartographic depiction for the Theoretical and Real DEMAND, one detects two differentiations in two points in space. These are next to Building Complex 1 and next to Building Complex 5.

The first case (Building Complex 1), concerns a medium size building with a proportionately medium size parking site (Parking Site 1), which appears to cover the needs of the building complex personnel sufficiently. Its Theoretical DEMAND is quite high which could be accounted for by the presence of the very large building complex 5. Its Real DEMAND though does not match the Theoretical, as it is actually fairly low.

The second case concerns Building Complex 5, which is the largest building complex on the Campus, and yet its Theoretical DEMAND is low. It is surrounded by several parking sites which are located in that area. Its Real DEMAND though is quite high and this could be due to the fact that the building in question houses many classrooms, the restaurant, the library and the Data Processing Centre.

There is also a small differentiation in building complex 3, between its Theoretical and Real DEMAND, the latter being higher than the former. The building complex in question includes classrooms being used for the educational purposes of building 3. This could account for the increased levels of Real DEMAND.

There are two peaks in the values of the distribution of the DEMAND variable. The first peak occurs in the area of Parking Sites 2,3 and 4. These three parking sites are near each other. Furthermore, Parking Site 3 is quite large. The second peak occurs in the area of parking sites 7 and 8. Although parking site 7 is small, it is located in an area where there is a plethora of parking sites (5,6,8,9) with a large number of parking spaces. Under these circumstances, the OFFER potential has got high recordings.

By combining OFFER and DEMAND (Theoretical and Real), the spatial phenomenon of the needs COVERAGE can be measured for the existence of parking spaces and sites in the research area.

The following figures (Fig. 10, 11) show the distribution of Theoretical COVERAGE and Real COVERAGE.

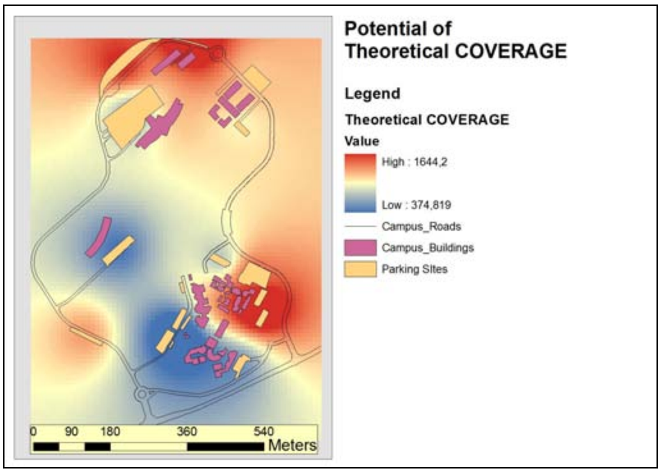

Fig. 10: Potential of Theoretical COVERAGE

From these figures one can observe that the Theoretical COVERAGE displays high values in the areas of building complexes 3 and 5 and a rather high value in the area of building complex 3. This is contradicted by the distribution of Real COVERAGE, where half the area of building complex 5 and the entire area of building complex 3 displays a quite low value of Real COVERAGE. It is essential to mention at this point that the values of both Theoretical and Real COVERAGE are positive. The maximum values of Theoretical COVERAGE are higher than the ones of Real COVERAGE, which indicates a tendency for the regulations not to estimate the actual needs for parking sites precisely, thus specifying less parking sites than the required ones.

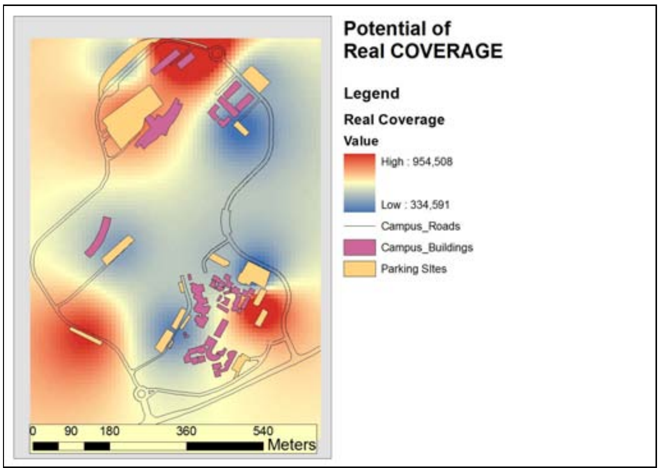

Fig. 11: Potential of Real COVERAGE

This fact is also verified by the distribution of the FAILURE variable. The distribution of this variable is shown in Figure 12.

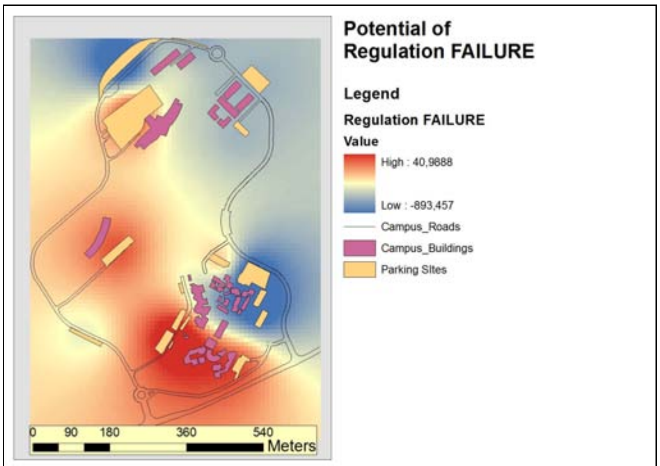

Fig. 12: Potential of Regulation FAILURE

The FAILURE variable displays negative values for the areas of building complexes 2,3 and 5. In fact, in the area of building complex 5 the negative values of the variable are quite high, which is recorded as a high FAILURE of the regulation.

The Real DEMAND, which the regulation FAILURE depends on, is a function of factors that cannot be assessed or predicted. They have to do mainly with the academic community's attitude concerning the issue of parking their vehicles and their willingness to comply or not with the regulations which apply to the Campus. Previous research conducted on the issue [8], [9], concluded that there is not sufficient compliance with the existing regulations.

Further research on the phenomenon of parking within academic areas of OFFER – DEMAND approach, is likely to indicate the need to revise the regulations governing parking spaces per academic building.

To sum up, the parking spaces seem to be rather well distributed in space and with sufficient available parking spaces, according to the analysis results. This conclusion can be reached from the fact that the DEMAND for parking spaces appears to be covered spatially by the OFFER of parking spaces in the specific parking sites. There were no negative values in the results of both the Theoretical and the Real COVERAGE.

What remains to be established is whether these parking sites in the way they are distributed and their given capacity, are sufficient in order to cover the new DEMAND which arises after the completion of the new building complex, which will bring about new demands for parking spaces.

IV. Analyzing Conditions after a New Building Complex Construction

In addition to what has already been examined, the case of a new building appendage to the existing building complex 3 is now being examined. This appendage is now under construction at a rapid pace and its completion is expected in 2013, according to relevant study. This construction will approximately double the surface area of the existing complex (resulting in the doubling of Theoretical DEMAND) and will evidently alter the distribution of the phenomenon of the Theoretical DEMAND variable, as well as the variables of Theoretical COVERAGE and regulation FAILURE. New parking spaces will not be constructed.

The new building section which is added to building complex 3 will measure a surface area of 4300 square meters. With the 3885 square meters of the already existing building, the overall surface area of the building complex will amount to 8185 square meters.

Figures 13 and 14 show in the form of maps the new surface areas of the building complexes and the new Theoretical DEMAND (in the form of potential recordings) that ensues for every building complex after the completion of the new section under construction.

This modification will evidently affect both the Theoretical DEMAND, as well as the Theoretical COVERAGE. It will also call for a new estimation on the regulation FAILURE which defines the required parking spaces in the case of academic buildings.

The following Tables 8 and 9 show the distribution values of the aforementioned variables.

By observing these carts and by comparing them to Tables 4 and 7, one witnesses the fluctuations of variable values. It is noticed that the Theoretical DEMAND seems to be increased in the areas of building complexes 2 and 4, which are adjacent to building complex 3 being altered. In the same areas the Theoretical COVERAGE is reduced and the estimated Regulation FAILURE is increased. These observations become better perceived next, with the charting of these alterations.

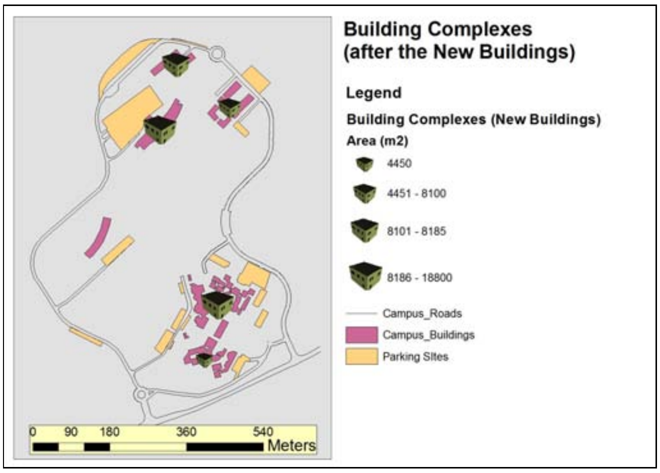

Fig. 13: Building Complex Area (after new Building Complex)

PS	Vi THEOretical DEMAND after New Building Compex	Vi REAL DEMAND (no difference as it is not based on Regulation)	Vi REGulation FAILURE after New Building Complex
1	1117	1178	61
2	910	1747	837
3	901	1714	813
4	892	1167	275
5	1124	1560	436
6	1124	1586	462
7	1138	1680	542
8	1117	1896	779
9	1084	1030	-54
10	1023	1071	48
11	1043	1419	376
12	1048	979	-69

Table 8: Theoretical Demand Potential after the New Building Complex, Real Demand Potential (no difference) and Regulation Failure Potential after the New Building Complex

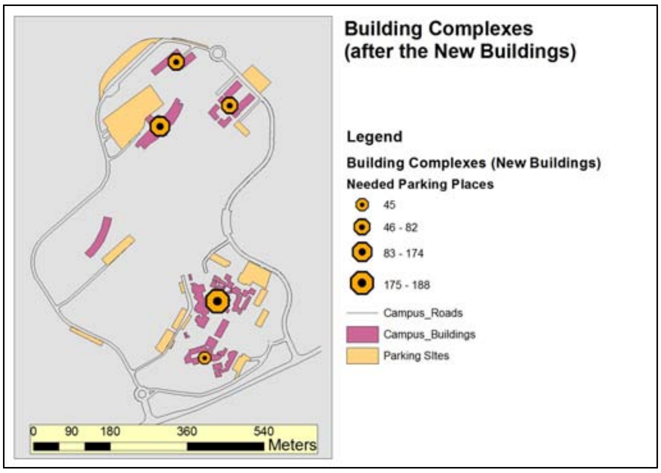

Fig. 14: Values of Theoretical DEMAND Potential (after new Building Complex)

PS	Vi OFFER	Vi THEOretical DEMAND after New Building Compex	Vi THEOretical COVERAGE after New Building Compex
1	1712	1117	595
2	2504	910	1594
3	2048	901	1147
4	1633	892	741
5	1937	1124	813
6	2026	1124	902
7	2635	1138	1497
8	2352	1117	1235
9	1664	1084	580
10	1507	1023	484
11	2086	1043	1043
12	1386	1048	338

Table 9: Offer Potential, Theoretical Demand Potential after new Building Complex and Theoretical Coverage Potential after the New Building Complex

Tables 10, 11, 12 that follow record the differences in number values of the variables under examination, between the existing conditions and the ones that will ensue after the completion of the section which is added to the existing building complex 3. In these charts and figures, one is able to observe the findings of the previous unit, which is the differentiations of the variables in the area of building complexes 2 and 4.

PS	Vi THEOretical DEMAND after New Building Compex	Vi THEOretical DEMAND	Difference of THEOretical DEMAND
1	1117	1069	48
2	910	856	54
3	901	836	65
4	892	829	63
5	1124	976	148
6	1124	986	138
7	1138	1074	64
8	1117	1017	100
9	1084	924	160
10	1023	929	94
11	1043	971	72
12	1048	997	51

Table 10: Theoretical Demand Potential after new Building Complex, Theoretical Demand Potential, Difference of Theoretical Demand Potential

PS	Vi THEOretical COVERAGE after New Building Compex	Vi THEOretical COVERAGE	Difference of THEOretical COVERAGE
1	595	643	-48
2	1594	1629	-35
3	1147	1211	-64
4	741	808	-67
5	813	961	-148
6	902	1039	-137
7	1497	1559	-62
8	1235	1333	-98
9	580	746	-166
10	484	577	-93
11	1043	1113	-70
12	338	388	-50

Table 11: Theoretical Coverage Potential after new Building Complex, Theoretical Coverage Potential, Difference of Theoretical Coverage Potential

The cartographic depiction of the variables examined in the form of dynamic surfaces, is attainable through the use of three dimensional surface illustration techniques. The following Figures 15, 16, 17, 18, 19 and 20, show the distribution of variables after the completion of the new section of the building complex 3. These variables are the new Theoretical DEMAND, the difference between the new Theoretical DEMAND and the existing one, the new Theoretical COVERAGE and its difference with the existing Theoretical COVERAGE, as well as the new FAILURE of Urban Regulation and its difference with the existing one.

PS	Vi REGulation FAILURE after New Building Complex	Vi REGulation FAILURE	Difference of REGulation FAILURE
1	-61	-108	47
2	-837	-888	51
3	-813	-877	64
4	-275	-341	66
5	-436	-583	147
6	-462	-599	137
7	-542	-604	62
8	-779	-877	98
9	54	-112	166
10	-48	-141	93
11	-376	-447	71
12	69	18	51

Table 12: Regulation Failure Potential after new Building Complex, Regulation Failure Potential, Difference of Theoretical Coverage Potential

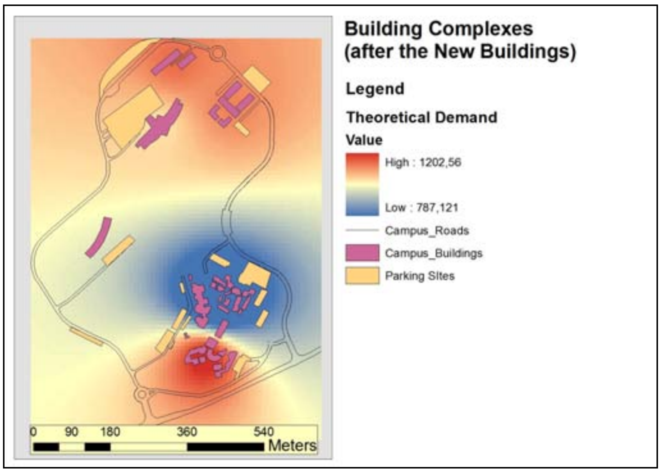

Fig. 15: Potential of Theoretical DEMAND (after new Building Complex)

By observing the new Theoretical DEMAND (Fig. 15) and by comparing it with the existing Theoretical DEMAND (Fig. 7), one confirms what was previously mentioned, that is the fact that the direct impact of the new conditions is the distribution of the Theoretical DEMAND, which is expanding spatially towards the areas of building complexes 2 and 4. In fact, this impact is more intense in building complex 4. This is also evident by the distribution of the difference in the Theoretical DEMAND Potential (new and existing) which is shown on the Map in Figure 16.

As regards the variable of the new Theoretical COVERAGE, it is substantially affected in the area of building complex 2. The construction of the new section in building complex 3 affects the variable values, which are reduced in the area of building complex 2. The differences of the variable of Theoretical COVERAGE before and after the construction of the new section in building complex 3 (Fig. 17) are shown in Figure 18 that follows.

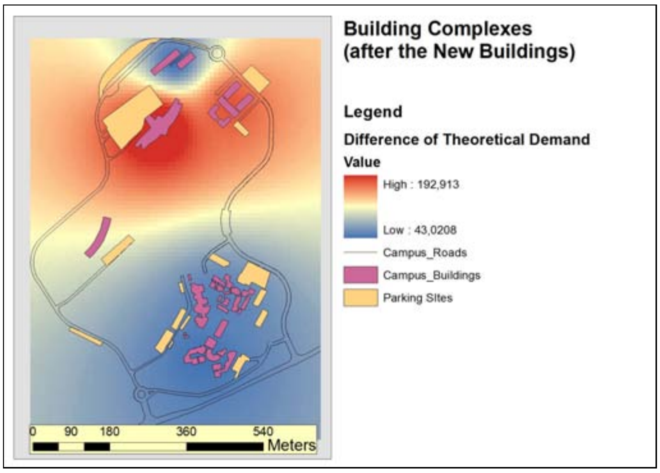

Fig. 16: Difference of Potential of Theoretical DEMAND (before and after new Building Complex)

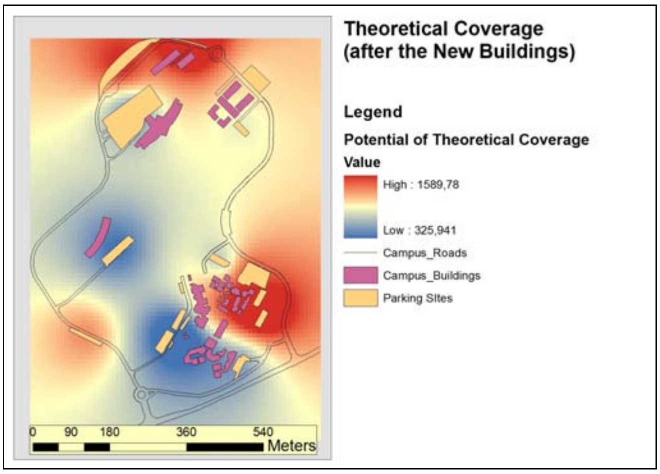

Fig. 17: Potential of Theoretical COVERAGE (after new Building Complex)

As regards the Urban Regulation FAILURE variable, one observes that the FAILURE increases with the completion of the new section in building complex 3, and this change is located in the area of building complexes 2 and 4, which are adjacent to the construction (Figures 19, 20).

The same observation becomes evident in Figure X, which shows the difference of the Regulation FAILURE variable, before and after the construction of the new section of the building complex. Table 12 shows that the big fluctuations in the variable are recorded in Parking Sites 5, 6 and 9. Especially increased values are found in the area of building complex 4.

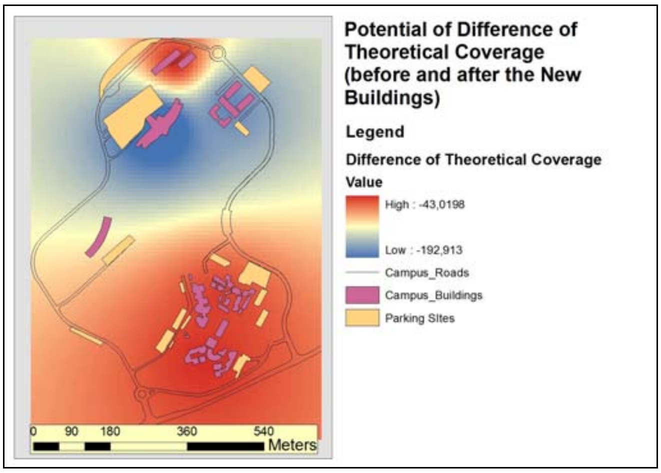

Fig. 18: Difference of Potential of Theoretical COVERAGE (before and after new Building Complex)

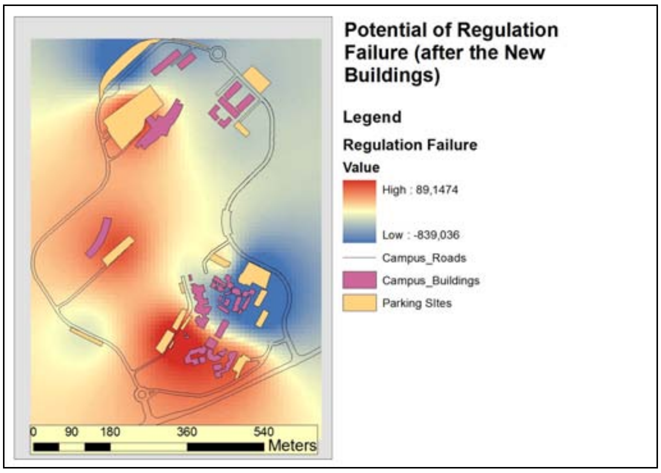

Fig. 19: Potential of Regulation FAILURE (after new Building Complex)

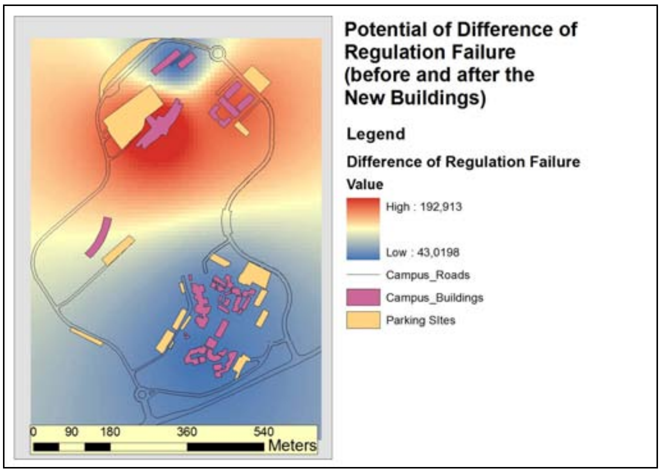

Fig. 20: Difference of Potential of Regulation FAILURE (before and after new Building Complex)

By summing up the observations and the conclusions resulting from the analysis of the new Campus conditions, one realizes that the alterations in the examined quantities are noticeable but for the time being do not bring about any major changes. There is a noticeable reduction in the COVERAGE of the need for parking spaces after the completion of the new construction. This reduction is located in the area nearest to the construction and is therefore an indication that should the need increases (that is DEMAND), then it is highly likely to be a problem (negative values in the distribution of COVERAGE might occur).

This indication should be taken into consideration by the decision makers of the institution (administration, technical services), in order to make the necessary provisions for interventions so as to prevent a shortage of parking spaces. A simple provisional measure would be to expand the existing parking sites around the construction area, for example parking sites 5, 6 and 7. A new site could also be designed, suitably located.

V. CONCLUSIONS

The present research attempted to establish whether the existing parking facilities on the Campus are sufficient or not. In case it is not sufficient, provisional measures should be taken in order to tackle the issue.

The analysis that was conducted produced some significant results which are illustrated on the maps included in the paper.

The distribution of Theoretical DEMAND, as a quantity, showed that its high values are distributed in the north and south of the Campus (areas of building complexes 1 and 3 mainly). Conversely, the Real DEMAND is distributed mainly with high values in the Northeast and up to the Southeast (areas of building complexes 2,3 and 5). This differentiation produces the Regulation FAILURE variable, which as a spatial distribution is located in the same area with the Real DEMAND and mostly in the area of building complex 5 (parking spaces 2,3 and 4).

The Urban Regulation FAILURE is accountable for by the fact that it is restricted – by definition – in the parameter of built square meters of the academic facilities. As such, it does not take into consideration the fact that on a Campus there are also cafeterias and restaurants of a relatively small square surface which attract students, who use vehicles and therefore need parking spaces. Furthermore, the insufficient presence of classrooms or laboratories makes students move from one building to another to fulfil these educational needs. This results in a redistribution of the parked vehicles and the Theoretical DEMAND deviate from the Real DEMAND.

The OFFER variable is spatially distributed in the same way as the Real DEMAND, which contributes to the variable of DEMAND COVERAGE. This COVERAGE is distinguished in Theoretical COVERAGE and Real COVERAGE. It is obvious that the two types of COVERAGE will differ, since they depend on the two types of DEMAND which also differ between them. The Real COVERAGE exhibits high values in the areas of building complexes 3 and 4 and in the area between complexes 1 and 5, while building complex 2 seems to lag behind. It is important to note the differentiation between the high prices of the Theoretical and the Real COVERAGE. The Theoretical COVERAGE appears overestimated thus giving higher values in relation to the Real COVERAGE, whose values are estimated to be lower.

The most significant conclusion in this research is that the Parking Sites facilities sufficiently cover the needs of the Campus. This sufficiency appears to be low in the area of building complex 2.

It is also important to note that a building intervention alters most of the variables concerning this research. The Theoretical DEMAND differentiates and directly influences the wider intervention area. In specific, it alters the Theoretical DEMAND potential in the area of building complexes 2 and 4. The difference is more intense in area 4. This has an impact on the Theoretical COVERAGE variable, which is decreased in the area of building complex 4 and less in area 2. The Theoretical COVERAGE decreases throughout the Campus (the values of difference in the Theoretical COVERAGE before and after the new building are negative throughout). It is also important to record the number of vehicles in every Parking Site, after the completion of the new building section so as to have the New Real DEMAND.

Another –expected- important observation is the increase of the Regulation FAILURE after the completion of the new building complex. The difference in FAILURE potential before and after the new building section exhibits only positive values, which ascertains the increase.

The overall picture resulting from the data analysis is that for the moment there is not any substantial problem regarding the sufficiency of parking sites on the Campus. There is also the tendency of the COVERAGE potential to be altered between building complexes 2 and 4 with the addition of the new building section in 3, which does not allow the people in charge to get complacent when it comes to the campus facilities issues. One should monitor the development of parking facilities sufficiency and forward intervention at the right time (addition of new parking space, organising the already existing ones, etc).

It is also worth observing that the variables in the area of parking site 8 are not compatible. This happens mainly when the Real DEMAND variable is involved. This is due to the fact that it is a new parking site and surprisingly, it is not used by the campus community. In the area in question there are increased unauthorized parking incidences, outside the parking site (mostly on the road).

If anyone attempts to evaluate the success of the methodology followed – and at the same time being aware of the situation on the campus – they would conclude that the phenomenon was satisfactorily described. It is evident on a daily basis to anyone who has a personal experience of this phenomenon that certain parts of the campus are more stretched for the existence of parking spaces. These parts are near parking sites 1 and 2 and in the area of parking sites 5 and 6. The picture one has through personal experience is directly reflected up to an extent on the results of the analysis. This constitutes a satisfactory documentation of the success of the methodology.

Finally, it would also be important to record the human resources of every building complex, as well as the number of vehicles. In this way, one could have a more objective approach on the concept of Real DEMAND, define the variable of COVERAGE of needs more objectively, and assess the quantity of Urban Regulation FAILURE on the urban specifications of parking sites in academic facilities.

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