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Conference Paper · July 2013

DOI: 10.13140/2.1.1598.8484

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The green space factor as a tool for regulating the urban microclimate in vegetation-deprived Greek cities.

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Abstract
The Green Space Factor (GSF) is an innovative and flexible urban planning tool which aims at improving green infrastructure in private open spaces. After it became a popular measure in Berlin, more cities, such as Malmö, Seattle, Southampton and Stockholm have included it in their environmental planning toolkit. The GSF can be integrated in the Greek planning system, as the lack of public vegetated spaces can be counterbalanced to a degree by 'greening' private open spaces and building surfaces. The paper seeks to explore the possibility and effectiveness of employing the GSF in the context of Greek cities. It starts with a comparative analysis of existing applications of the GSF in different urban and legal contexts. Subsequently, the paper suggests an analogous planning tool for the Greek city. The suggested tool is further explored through its application at different plot configurations.
Keywords: Green Space Factor; urban climate; urban heat island effect; Greek urban planning.

1. INTRODUCTION

Nowadays several cities globally are pursuing an active environmental agenda in order to 'reconnect' man and nature, reduce consumption of energy and materials, create a thermally comfortable urban environment and forge a new 'green' identity. The Green Space Factor (GSF) is a relatively new planning tool, currently employed by metropolises and small cities alike to achieve these objectives. Position of this paper is that the Green Space Factor can be integrated into the Greek planning system to reintroduce vegetation in Greek cities and therefore aid towards the improvement of the their burdened urban climate.

The GSF constitutes a flexible and innovative planning tool that quantifies and assesses the quality of ecological and climatic functions of private green infrastructure. It aims at increasing the quality of urban landscaping by setting certain development standards. The GSF was initially applied to Berlin and other cities, such as Malmö, Seattle, Southampton and Stockholm soon followed. At a regional scale, the GSF was applied at North West England.

In contrast to an incentive-based approach to environmental interventions, the GSF is a regulatory measure, although this does not exclude the possibility of being used along with incentives. The GSF relies on the standardization of several environmental features and the quantification of their ecological benefits. A list of features which are factored according to their relative ecological significance is provided by the local authorities in the form of a worksheet for easy calculation. Individual factors usually range from 0 to 1.

The GSF is used to accomplish several goals, including urban climate regulation, reduction of energy and water consumption, flood control and restoration of the hydrological cycle, preservation and enhancement of wildlife habitats and improvement of urban aesthetics. However, priorities may differ from place to place.

As the formulae used by the cities to compute the GSF are almost identical, a generic GSF formula can be derived:

$$\mathrm{GSF} = \sum_i (area_i * factor_i)/total\ area \quad (1)$$

Where $area_i$ is the area of each GSF feature i, $factor_i$ the weight of each intervention i and *total area* the total area of the plot which may or may not include the area of the building's footprint, depending on each case.

2. APPLICATIONS OF THE GREEN SPACE FACTOR

2.1 Berlin's Biotope Area Factor.

The City of Berlin was the first that conceptualized and implemented the Biotope Area Factor (BAF) during the nineties, in order to counterbalance the deficits of open spaces in the densely-built inner city by upgrading ecologically areas of private property. The BAF initiative was a part of the Landscape programme, which was introduced in 1984 in West Berlin. The BAF is a legally binding force in areas with a Landscape Plan, which currently cover about 16% of Berlin. The Landscape Plan regulates development according to the strategy set out by Berlin's Landscape Programme. Outside these areas, the BAF is voluntarily used as a guideline for encouraging the use of environmental features. The BAF is implemented on the basis of planning permits for both extensions to existing development and new development [1].

The minimum BAF target is relative to the designated land uses and depends on whether the development is new or an extension. The BAF target ranges from 0.60 for new residential units, public facilities and nursery schools to 0.30 for commercial, city centre and technical infrastructure uses and for extensions to existing residential units and public facilities. The value of 0.30 represents a minimum standard which is achievable, even for very high density development [1].

The BAF rewards 'ecologically effective surfaces' in contrast to hard impermeable surfaces that prevail in the city. The 'connectedness' of uncovered topsoil with the subsoil is highly rewarded, as it allows space for development of the root system of flora, replenishment of underground aquifers with rainwater, as as well as penetration of air and nutrients. In the case of high density development on small land parcels green roofs and walls have to be employed in order to meet the minimum BAF target. The weakness of this approach is that it is indifferent towards different types or qualities of vegetation. For example, an area with sparse vegetation and a group of trees with extensive undergrowth of equal area would receive the same score as long as the topsoil surface is connected with the subsoil. Moreover, the BAF has received criticism for being too procedurally intense, requiring a lot of effort on the city's behalf, regarding initial research and continuous evaluation of the programme. However, its flexibility has made it a popular environmental initiative [1].

2.2 Malmö's Green Space Factor.

Following the example of Berlin, the City of Malmö introduced the Green Space Factor (GSF) for the redevelopment of the Western Harbour. The vision for the Western Harbour is to create an environmentally sustainable urban district. The neighbourhood of Bo01, the first completed stage of development, is acclaimed as a leading example of ecological urbanism.

The minimum GSF target was set to 0.5 for Bo01. The method of calculation is different from Berlin's BAF since some vegetation qualities, such as their type and size are factored in and it is also possible to layer different surface cover types to achieve a higher GSF. Hence, an area with significant vegetation can score more than 1.0 which is the maximum score for a specific surface type. Trees and bushes planted on connected soil, water features and green roofs score highly. A Green Points checklist is also used in conjunction with the GSF to describe landscape qualities that are not easily standardized or quantified. Developers have to include in the development proposal 10 out of 35 available features which include shelters for birds and bats, preferring meadows and semi-natural biotopes over mown lawns, greening all roofs or covering all walls with plants [2]. Most of these interventions have a strong ecological character.

During the development stage of Flagghussen, another neighbourhood of the Western Harbour district, a different approach of "creative dialogue" among the stakeholders was used. The "creative dialogue" between planners and developers aimed at achieving environmental goals at a realistic cost, to counterbalance the high prices of dwellings built in Bo01. The minimum GSF target became relative to the building coverage. The higher the building coverage, the lower the GSF minimum target. This was justified by the fact that high density areas have very few private open spaces to utilize for greening [2].

The evaluation and monitoring of the application of the GSF in Bo01 concluded that most development achieved the minimum GSF target. In contrast, a similar assessment of the efficiency of the "creative dialogue" approach in Flagghussen concluded that not a single developer had accomplished an acceptable result. This led to a strengthening of the GSF by raising the minimum required score to 0.6 and lowering the value of several individual factors [2].

2.3 The Seattle Green Factor.

The Seattle Green Factor (SGF) was modelled after Malmö's GSF and Berlin's BAF. It was adopted in 2006 for commercial zones and was revised in early 2009 to include residential multifamily units. The SGF minimum targets were set according to land use zoning. For various commercial land uses the minimum is 0.3, for mid-rise and high-rise multifamily residential 0.5 and for low-rise multifamily residential 0.6 [3].

Green roofs and walls and permeable pavements are given higher factors to encourage their use. Moreover, additional bonus points are given for use of harvested rainwater, planting native species, visibility of landscaping from the street and local food cultivation. Exceptional or preserved trees get more points than 'large' trees, while some points are given for structural soil systems, which help the soil retain its original properties in the urban environment.

2.4 The Green Infrastructure Score of North West England.

The Green Infrastructure Score (GI Score) was developed by the North West Development Agency (NWDA) as part of its "Sustainable Buildings Policy". However, the recent abolition of the NWDA in 2011 has downgraded the policy to the status of guidance. The GI score is used in conjunction with a GI Interventions worksheet in a way equivalent to Malmö's Green Points system. The available GI Interventions correspond to the eleven economic benefits set out by Natural Economy Northwest, which include climate change adaptation, flood alleviation, biodiversity and place quality. Planning applications that justify how multiple benefits are achieved through developing the site would be considered favourably [4].

A minimum GI Score of 0.6 is specified for development on vacant plots. However for development on plots with existing structures the GI Score of the proposed development should be higher than the pre-development GI Score by 0.2. Vegetation planted on topsoil connected to the subsoil, green roofs and water retention areas score highly [4].

2.5 Southampton's Green Space Factor.

The Southampton City Council following the aforementioned examples created its own GSF tool which is now required for the development of one or more dwellings or any development of more than $500m^2$ [5] The tool is used as part of the Sustainability Checklist to demonstrate sufficiency of green infrastructure in the proposed development, hence no minimum GSF target is set. The Sustainability Checklist is used by applicants who wish to obtain planning permission by demonstrating compliance to key principles of sustainable development as set out by the City of Southampton's Core Strategy Policy.

Like Northwest England's GI score, the developer has to prove that there is a substantial increase of the GSF of the proposed development when compared to the pre-development GSF. A Geographic Information System (GIS) was also used to determine the existing pre-development GSF, which was found to be equal to 0.38 for the whole city and 0.16 for the city centre alone. It was also possible to predict that the inclusion of green roofs on all buildings would increase the city centre's GSF by 0.22 [5].

2.6 Stockholm's Green Space Factor.
Stockholm's Royal Urban Seaport, a 236 hectare industrial site is to be redeveloped into an environmentally sustainable neighbourhood. Development has started in 2010 and is expected to be completed in 2030. Malmö's GSF was adopted and further refined. The minimum GSF target is 0.6. Stockholm's GSF is differentiated from other examples by the addition of more detailed factors on biodiversity, social use of green space and climate adaptation. For example "butterfly restaurants", fruit-bearing flora, nesting boxes, lawns suitable for ball games and play, food cultivation on balconies, multi-layered green roofs, trees and pergolas shading playgrounds get additional scores [6] . Hence, some of the qualities described in the Malmö's Green Points System are integrated into a more detailed list of possible features, offering a larger degree of possible combinations. As the Royal Urban Seaport is still under development, no monitoring and assessment of the GSF has yet been made.

2.7 Summary of the GSF applications.
The concept of GSF remains more or less the same since its first application in Berlin. Some changes were made to adapt it to local planning conditions and modify ecological priorities. Since the GSF is relatively new, cities tend to pilot test it to certain neighborhoods or land uses before applying it at a wider scale. In most cases the absolute minimum GSF target is 0.3, which is believed to correspond to a minimum of green infrastructure that human settlements should achieve, regardless of density or land use. However, a minimum target of 0.5-0.6 is often set for new developments, where there is still room for achieving a higher environmental quality at the design stage. Table (1) illustrates the key differences between different applications of the GSF:

Table 1. Summary of the key differences of the GSF applications to the examined cases.

	Berlin	Malmö	Seattle	Stockholm	NW England	Southampton
Name	Biotope Area Factor	Green Space Factor	Seattle Green Factor	Green Space Factor	Green Infra-structure Score	Green Space Factor
Area of application	Compulsory in areas with Landscape Plans. Voluntary for rest of Berlin	Required for West Harbour Redevelopment	Compulsory for new commercial or multi-family development.	Compulsory for Royal Seaport Redevelopment	Voluntary. Since 2011 the policy has been downgraded to guidance.	Required for development of one or more dwellings or more than 500sq. meters.
Minimum target	Ranging from 0.6 for new residential units to 0.3 for commercial zones.	0.5 and later raised to 0.6.	Commercial and downtown 0.3, multi-family midrise and high-rise 0.5, multi-family low-rise 0.6	0.6	0.6 for vacant plot development, a +0.2 difference from pre-developed phase for extensions.	No minimum specified. Used to demonstrate sufficiency of green infrastructure.
Layering	no	yes	yes	yes	yes	yes
Green points	no	yes	no	no	yes	no

The ecological aims of the GSF are almost identical in all examined cases. The GSF is used to provide wildlife habitats, manage storm water, regulate the local climate, improve urban aesthetics and reduce air, soil and water pollution. In most cases, high factors are assigned to features such as green roofs and walls, water features and the preservation of large trees.

The size of trees is usually determined by their crown size which is also used to calculate their effective area. For example for Malmö shrubs are calculated at $2m^2$, small trees at $5m^2$, medium trees at $15\ m^2$ and large trees at $20m^2$ each. Similarly, in most cases, green walls are calculated according their 5-year projected coverage, which may have an upper limit, usually around 10m.

Table (2) compares factors given to different features. For an easier comparison, the individual features and their properties are provided in a simplified way and technical details are omitted.

Table 2. Comparison of the factors attributed to individual GSF features for each examined case.

<table>
<tr><th></th><th>Berlin</th><th>Malmö</th><th>Seattle</th><th>NW England</th><th>Southampton</th><th>Stockholm</th></tr>
<tr><td>vegetation on shallow unconnected soil</td><td>0.5</td><td>0.7</td><td>0.1</td><td>0.4</td><td>0.4</td><td>0.3</td></tr>
<tr><td>vegetation on deep unconnected soil</td><td>0.7</td><td>0.9</td><td rowspan="2">0.6</td><td>0.6</td><td>0.6</td><td>1.2</td></tr>
<tr><td>vegetation on connected soil</td><td>1.0</td><td>1.0</td><td>1.0</td><td>1.0</td><td>0.2</td></tr>
<tr><td>water surfaces</td><td>N/A</td><td>1.0</td><td>0.7</td><td rowspan="2">0.7</td><td rowspan="2">1.0</td><td rowspan="6">N/A</td></tr>
<tr><td>collection/retention of storm water</td><td>0.2</td><td>0.2</td><td>1.0</td></tr>
<tr><td>permeable pavement and partially-sealed areas (no vegetation)</td><td rowspan="2">0.3</td><td>0.2</td><td rowspan="3">0.2/0.5 (1)</td><td>0.2</td><td>0.2</td></tr>
<tr><td>areas covered with gravel or sand</td><td>0.4</td><td rowspan="2">0.4</td><td>0.4</td></tr>
<tr><td>Green pavers</td><td>0.5</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Structural soil systems</td><td>N/A</td><td>N/A</td><td>0.2</td><td>N/A</td><td>N/A</td></tr>
<tr><td>shrub</td><td rowspan="5">N/A</td><td>0.2</td><td>0.3</td><td>0.3</td><td>0.3</td><td>0.2</td></tr>
<tr><td>tree - small</td><td>1.0</td><td>0.3</td><td rowspan="4">0.4</td><td rowspan="4">0.4 per m2 of canopy cover</td><td>1.0</td></tr>
<tr><td>tree - medium</td><td>1.5</td><td>0.4</td><td>1.5</td></tr>
<tr><td>tree - large</td><td>2.0</td><td>0.4</td><td>2.4</td></tr>
<tr><td>tree - protected/exceptional</td><td>N/A</td><td>0.8</td><td>3.0</td></tr>
<tr><td>green roofs</td><td>0.7</td><td>0.6</td><td>0.4/0.7 (2)</td><td>0.7</td><td>0.7</td><td>0.1/0.4 (2)</td></tr>
<tr><td>vegetation on vertical surfaces</td><td>0.5</td><td>0.7</td><td>0.7</td><td>0.6</td><td>0.6</td><td>0.4</td></tr>
<tr><td>bonuses for specific vegetation qualities</td><td>no</td><td>no</td><td>yes</td><td>no</td><td>no</td><td>yes</td></tr>
</table>

(1) for shallow and deep substrate of gravel accordingly

(2) for low and high vegetation height accordingly

The main strengths of the GSF are the following:

- It is flexible; it sets a minimum design standard and it is up to the developer to decide how to achieve it. Therefore, interference with architectural freedom is kept to a minimum.
- It follows the same logic as planning ratios and can be linked to lot coverage and density. Planners and Developers can quickly get accustomed to it and the method is transferrable from place to place.
- Its regulatory role ensures that minimum standards will be met in contrast to providing incentives or engaging in a dialogue with developers, as the case of Flagghussen shows.

On the other hand, the required commitment, in terms of effort and financial sources, of the local authorities to its development, dissemination and on-going evaluation has been mentioned [2] as a weakness of the GSF.

3. PRIVATE OPEN SPACES AS A KEY CLIMATIC REGULATOR OF GREEK CITIES.

It is well known [7] that the climate of cities is differentiated from the rural climate of the same region. The climate of Athens is burdened as the Urban Heat Island (UHI) intensity, i.e. the air temperature difference between the city and its surroundings, can reach 6^oC in the suburbs and exceed 10^oC in certain parts of the city centre [8]. Similarly, the UHI intensity in Thessaloniki ranges from 2^oC to 4^oC [9]. Medium-sized Greek cities, such as Patra, Volos and Herakleion also demonstrate a surface temperature difference with their surroundings of about 2-3°C [10]. The key factors that alter the climate of Athens are the high-density urban continuum lacking adequate vegetation, the domination of materials with high heat capacity like concrete and asphalt, the production of anthropogenic heat and air pollution. A similar development model has been followed in most Greek cities, resulting in similarly dense urban fabrics lacking adequate green space. It can be assumed that such features combined with heavy traffic result in similar climatic conditions.

Public green infrastructure of Greek cities is inadequate in general terms. For instance, it is estimated that Athens and Thessaloniki provide roughly about 2.5m^2 and 2.7m^2 of green space per capita respectively [11], in contrast to the minimum of 8m^2 suggested by the Greek Planning Standards [12]. Moreover, the few public open spaces are often fragmented, unevenly distributed in the urban tissue and poorly designed in environmental terms while vegetation is often mismanaged or absent. The prevalence of impermeable surfaces in open spaces disrupts the hydrologic cycle, leading to a generally drier urban environment, susceptible to flooding during heavy storms. Private spaces in-between buildings are also sealed off with impermeable materials are often used as parking spaces and are rarely vegetated. Often, they are inaccessible and completely unmanaged.

One of the key interventions that are capable of regulating the climate of Greek cities is the extensive coverage of available surfaces with vegetation. The climatic benefits of vegetation include the local decrease of air temperature through the process of evapotranspiration and the provision of solar and wind protection. Additionally, it balances the natural cycles of oxygen, water and carbon, prevent soil erosion, can act as noise barrier, filter certain air pollutants, provide shelter to urban wildlife and contribute to local food supply.

Inside parks with dense tree coverage a considerable decrease of air temperature by 4 to 7°C has been observed during hot days in Athens [13]. However, the range of the temperature reduction effect of urban parks is usually small, as it rarely exceeds one or two urban blocks, usually to the leeward side of the park [13,14,15]. The presence of trees near buildings is also associated with a reduction of surface temperatures of buildings and energy savings [13,16]. Additionally, the combination of green walls and roofs can lead to a reduction of local air temperature of up to 6.5°C for the centre of Athens [17]. Therefore, there is a need not only to increase the amount of urban greenery but also to distribute vegetation more evenly in the urban tissue and as close as possible to buildings. This requires an urban design strategy that pursues the extensive vegetation of both public and private building plots as well as the ‘greening’ of building facades and roofs to maximize the climatic and ecological benefits of greenery in densely-built environments.

Another important strategy for mitigating the UHI effect is to minimise the sealing of the ground with impermeable materials such as concrete or asphalt. This strategy is also useful for restoring the hydrologic cycle in cities. The use of green pavers, porous pavements or “cool materials” [18] can be promoted as a viable alternative.

Such landscaping strategies can be realized by adopting new regulatory tools such as the Green Space Factor in the Greek planning process.

4. EXISTING LANDSCAPING REGULATIONS IN GREECE.

Landscaping of private property in Greek cities is regulated by the “New Building Code” (NBC), which was introduced in 2012, replacing the General Building Code (GBC) which was valid, with one intermediate revision in 2000, since 1985. The NBC has a nation-wide application, unless local plans provide stricter specific regulations. According to the GBC (article 23), two thirds of the open space of plots in areas with an approved urban development plan need to be left unpaved for planting. Development on plots larger than 200m^2 need to retain existing or plant new trees to achieve a coverage of one tree per 200m^2. Specifically, front yards must be planted at a density of one tree per 25m^2 [19]. The NBC does not make any significant changes to GBC's landscaping regulations. However, it specifies green roof standards for the first time and sets a limit to the area of permissible underground structures, which cannot extend to more than half of the unbuilt area of the plot, to preserve the "connectedness" of the soil [20]. Another new aspect of the NBC is the new "Environmental Bonuses" which offer an increase of the maximum permissible plot ratio in exchange for lower plot coverage, thus encouraging taller buildings and higher densities. The NBC does not include a mechanism for securing the quality of the saved-up spaces, other than the aforementioned landscaping regulations.

The landscaping regulations of the NBC could be characterized as inflexible. The requirement of vegetating two thirds of private open space is often incompatible with the high plot coverage and plot ratios, the subsequent car parking demand and the small urban plots that are the norm in Greek cities. The obligation to plant a tree per 200 m^2 of open space could be regarded as inadequate. Moreover, no specifications are given regarding the quality and suitability of vegetation and no distinction is made for mature trees, which should be preserved as much as possible. Additionally, the new "Environmental Bonuses" do not take into account the fact that higher densities increase the demand for car parking, which could have a negative impact on the quality of the urban landscape.

5. THE GREEN SPACE FACTOR AS A FLEXIBLE TOOL FOR THE ENVIRONMENTAL SUSTAINABILITY OF THE GREEK CITY.

The GSF can be integrated into the Greek planning system as a tool for improving the environmental performance of private open spaces, thus contributing to the regulation of the climate of Greek cities. A future amendment of the Building Code could include the GSF as a replacement of current relevant regulations. Alternatively the GSF could be adopted within the framework of a local development plan. In any case, the tool should not be simply imported but needs to be optimized for the specific conditions of Greek cities and climate and tested extensively. This paper proposes a general framework that can become the basis for further research.

For an initial pilot study the GSF can be applied to residential and mixed residential uses (low and medium degree of land use mixing respectively), setting a minimum GSF target of 0.5 for development on vacant plots and 0.3 for already developed plots. Individual features and their factors are provided in Table (3) below. The proposed features are found in all applications of the GSF in the examined cases. Emphasis is given to elements that can actively regulate the urban microclimate, such as medium and large trees, green roofs and walls or pergolas and water surfaces. Moreover, a bonus is given to trees located in the front yard.

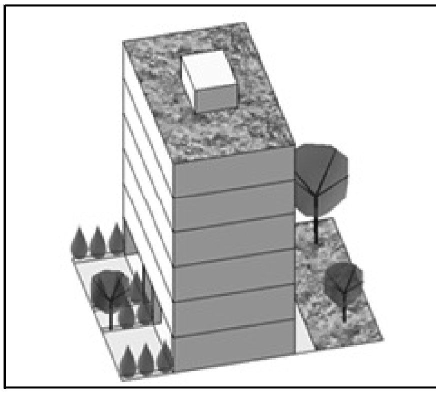
Table 3. List of proposed features and their individual factors.

Feature	Factor	Feature	Factor
vegetation on connected soil	0.4	tree-small (at 10m^2 per tree)	0.7
vegetation on unconnected soil	0.2	tree-medium (at 20m^2 per tree)	0.8
permeable pavements	0.3	tree-mature (at 30m^2 per tree)	1.0
green pavers or gravel	0.5	green roofs	0.7
water surfaces	1.0	vegetation on vertical surfaces	0.6
shrubs	0.4	trees in frontyard extra bonus	0.2

For a preliminary analysis, the proposed GSF is applied to three real-world examples of multifamily residential buildings, located in Thessaloniki, Greece. Sources of the collected data were the online

GIS services of Thessaloniki [21] and Kalamaria [22] Municipalities and the Hellenic Cadastre's online orthophoto service [23]. The basic morphological characteristics were derived using oblique aerial photos provided by Microsoft's Bing Maps [24] and were verified by a site visit. The GSF is calculated twice for both cases of extension to or retrofitting of existing development and new development. Its calculation is just an example of how the developer might choose a combination of GSF features. The 3D models that accompany the calculations demonstrate the use of the selected GSF features for the case of new development, through the use of symbols for trees and bushes and textures for green and paved areas.

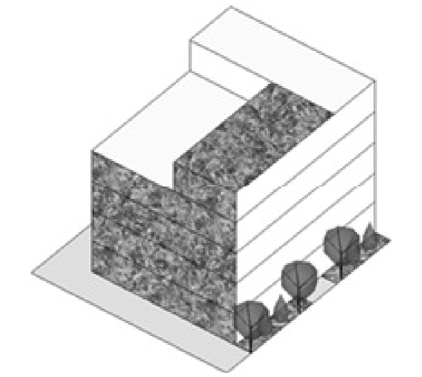
The first example (Figure 1) is a five storey building with a footprint of $120m^2$ situated on a plot of about $250m^2$. It was built in the 90's under the GBC of 1985 at a plot ratio of 2.1 and a maximum coverage of 70%. As it follows the old continuous system of development it demonstrates a clear separation between the front and back yard. Although the presence of a front yard allows for extensive planting, the ground floor is used for car parking, thus limiting the space available for vegetation. This constitutes a common case in Greek cities, where *pilotis* make up for the lack of adequate on-street parking spaces. The calculated GSF scores above the minimum target of 0.3 for the case of existing development. For new development, the developer would have to choose additional features such as a green roof. The picture on the left demonstrates how:



	Factor	Existing area (m^2)	New area (m^2)
vegetation on connected soil	0.4	74	74
vegetation on unconnected soil	0.2		
permeable pavements	0.3	56	56
green pavers or gravel	0.5		
water surfaces	1.0		
shrub (at 2 sq m per shrub)	0.4	22	22
tree-small (at 10 sq m per tree)	0.7	20	20
tree-medium (at 20 sq m per tree)	0.8	20	20
tree-mature (at 30 sq m per tree)	1.0		
green roofs	0.7		80
vegetation on vertical surfaces	0.5		
trees on frontyard extra bonus	0.2	10	10
Total Area = 250 sq. meters	GAF =	0.35	0.57

Figure 1. First example of GSF application.

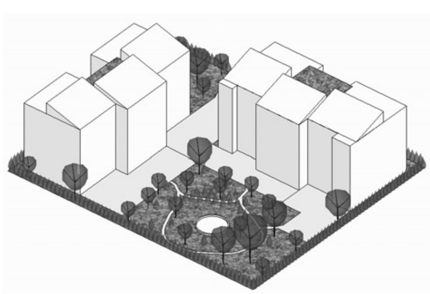
The second example (Figure 2) is a mixed-use residential building with a footprint of $230m^2$ situated on a plot of $380m^2$. It was built in early 1980's, under the GBC of 1973, at a plot ratio of 2.1 and at 50% coverage. It can be observed that the developer chose to use up all the available coverage. A narrow set back of 1.50m imposed on a square plot produces a fragmented private open space. Since most of the open space is used for car parking, the developer would have to cover the blind wall with vegetation, in order to comply with the GSF minimum for extensions and retrofitting. For new development, he would have to combine it to a green roof to meet the minimum GSF standard. It can be observed that in this case, the choices are limited. The higher factors assigned to green walls and roofs tend to promote them as viable choices in high-density urban areas.



	Factor	Existing	New
		area (m^2)	
vegetation on connected soil	0.4	20	20
vegetation on unconnected soil	0.2		
permeable pavements	0.3	116	
green pavers or gravel	0.5		116
water surfaces	1.0		
shrub (at 2 sq m per shrub)	0.4	8	8
tree-small (at 10 sq m per tree)	0.7	30	30
tree-medium (at 20 sq m per tree)	0.8		
tree-mature (at 30 sq m per tree)	1.0		
green roofs	0.7		70
vegetation on vertical surfaces	0.5	140	140
trees on frontyard extra bonus	0.2	30	30
Total Area = 380 sq. meters	GAF =	0.38	0.57

Figure 2. Second example of GSF application.

The third example (Figure 3) is a group of residential apartments of a total area of $820m^2$ situated on a plot of 3000 m^2. They were built in 2003 under the GBC of 2000 with a maximum plot ratio of 0.8, the maximum allowed according to current Greek planning legislation and at a coverage of 70%. A lower plot ratio combined with larger plots and urban blocks, commonly found in the outskirts of the cities, tend to generate an urban landscape where building volumes are placed more freely in the urban tissue. The developer has a high degree of choice and can combine multiple features to reach the minimum GSF target.



	Factor	Existing	New
		area (m^2)	
vegetation on connected soil	0.4	1752	1752
vegetation on unconnected soil	0.2		
permeable pavements	0.3		200
green pavers or gravel	0.5		230
water surfaces	1.0		30
shrub (at 2 sq m per shrub)	0.4	150	230
tree-small (at 10 sq m per tree)	0.7	100	200
tree-medium (at 20 sq m per tree)	0.8	180	180
tree-mature (at 30 sq m per tree)	1.0	30	30
green roofs	0.7		160
vegetation on vertical surfaces	0.5		100
trees on frontyard extra bonus	0.2	100	100
Total Area = 3000 sq. meters	GAF =	0.34	0.50

Figure 3. Third example of GSF application.

6. CONCLUSIONS

Since its first application in Berlin, the GSF has become a valuable tool for translating landscape design standards to planning regulations. Its ease of use, responsiveness, flexibility and transferability potential are reasons behind its popularity. The results from the preliminary investigation of GSF's applicability in the Greek planning framework demonstrate that the GSF can successfully regulate private green infrastructure of both new and existing development in urban areas. Therefore, it can contribute positively towards improving the environment of densely-built and vegetation-deprived Greek cities, an objective that seems unachievable under existing regulations. Unlike current landscaping regulations, the GSF retains its regulatory role while allowing the developer to choose how to meet the minimum standards. This can be particularly useful in the context of Greek planning, where the existing voluminous legislation, by imposing stiff measures and generic geometric constraints, is often unresponsive to the context of each specific development case. Moreover, the GSF could cooperate with the new "Environmental Bonuses" of the NBC, thus ensuring the delivery of high quality private open spaces as the legislator originally envisioned it. The inclusion of the GSF in the Greek planning system is not a cure-all by any means. However it constitutes a component of a much-needed overhaul of planning legislation oriented towards a new model of environmentally responsive urban development.

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