Research Paper

CHANGED PRECIPITATION PATTERNS AND THE NEED FOR A NOVEL APPROACH TO BUILDING PLOT PLANNING

The lessons learnt in the sub-alpine climate zone of Slovenia

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Abstract

The events related to climate change are recently challenging the Slovenian urban planning. One of them are the floods in urbanised areas that call for a radically new approaches to how the urban built structure is organised and managed. The continental (and largest) part of Slovenia has a subalpine climate which has been traditionally characterised by a moderate precipitation throughout the year. This is now being changed as the larger amounts of water fall on the ground in a shorter period. As the current urban structure is not shaped in accordance with these new circumstances, parts of the cities are getting flooded more often. Some mitigation measures have been implemented, however to address the issue comprehensively new urban planning approaches are needed too. The paper will present one of the tools that has been developed within the endeavours of the national Ministry of Spatial Planning to reform the urban planning system to better reflect the changes posed by the climate change. It is related to the urban design criteria for building plots planning. To allow the rainfall to penetrate the soil as soon as the precipitation reaches the ground, new measures in organisation of the building plots will be provided. The current system defines the percentage of the built-up area within the plot but does not consider the permitted percentage of the paved open spaces (which do not allow the water to penetrate into the grounds), therefore it will be supplemented by the new measures based on the ability of the plots to allow the penetration of the water. The paper firstly presents the current system of building plots regulation within the Slovenian planning system. It then reports the results of the extensive analyses that focused on the existing characteristics of building plots for different building typologies across the country (housing, production, trade, public services) with the aim to map the state of the art in terms of the potential of the existing building plots to allow the water to flow into the grounds. The third part explains the methodological framework for the new approach to the building plots regulation. The last part presents the newly proposed approach and relates it to other urban design tools that need to support the implementation in practice. The concluding section relates the lessons learnt in Slovenian case to the similar situations elsewhere and stress the responsibilities that the urban planning and design have in providing future urban environments that will ensure the environmentally just living conditions for all.

Keywords

urban environments, precipitation, building plot, urban design, urban planning regulation

1. Introduction

1.1. The changing climate conditions in Slovenia

Slovenia is a Central European country, measuring 20.271 km² and positioned between three distinctive geographical regions: the Alps, the Pannonian Plain and the Adriatic Sea. Most of the country is characterised by the hills and valleys with water streams (Melik, 1963). Even if the territory of the country is small, its geographical diversity results in a great variability of weather and climate conditions – the influences of the Mediterranean (coastal), Alpine (mountainous) and continental climate all meet and intervene in Slovenia.

As observed in many other parts of Europe, the climate conditions are quickly changing in Slovenia too. According to the national environment agency at the Ministry of the environment and spatial planning “climate change represents an increasing threat to environmental, social and economic development and requires rapid intervention” (internet source 1). The changes include the rising of the average temperatures in the last 20 years, the changed air currents, weather patterns and distribution of precipitation. The hazardous weather phenomena are rising too. An outstanding issue are the changes in the precipitation distribution which cause either floods or droughts. The changed precipitation distribution comes also due to the increased number of severe storms. This has very severe consequences for both rural and urban areas (Kajfež-Bogataj, 2008).

In the urbanised areas the excessive rainfall and short-term strong downpours are the climate change driven events that cause some of the major problems. Due to the relatively high percentage of the covering of the ground by an impermeable material in the urbanised areas the amount of the water that falls to the ground cannot directly leak through the soil. Additionally, the soil sealing is contributing to the increased heat-island effect, which in turn results in more thunderstorms and increased precipitation.

According to IPCC (2007) Slovenia can expect the average temperatures to increase for up to 3.5 °C by the end of the century. This means that the uprising issues need to be addressed systematically, also by challenging the existing and finding new future practices of planning and design of urban areas. This paper investigates the possibilities and opportunities offered by the introduction of the new spatial law in Slovenia which foresees the introduction of the so-called building plot as a basic tool for organisation of the built-up areas.

1.2. Building plots regulation

In 2017 Slovenia adopted a new spatial planning law, so called *Zurep-2* (Official Gazette of the Republic of Slovenia, 2017). The three main topics covered by the law are the spatial planning, land policy and monitoring and control. It sets the basic rules of spatial planning and management at the national level, while it also foresees the adoption of more detailed rules and regulations in the additional legally binding documents. One of these detailed regulations will be the National spatial order (in Slovenian: *Državni prostorski red*), which will replace the existing Spatial order of Slovenia (in Slovenian: *Prostorski red Slovenije*, abbreviated as PRS) (Internet source 2).

The still valid PRS defines the general planning rules at the national level. By the time of its adoption (2004) the climate change processes had not been accelerated to the extent as we know them today, therefore the adaptation and mitigation measures were not deliberately addressed. PRS covers the issues of changed precipitation patterns indirectly by defining the

approaches to channel the rainfall into the sewage system. E.g. it defines that the water from the roofs of the objects as a rule shall be drained within the object's building plot via the infrastructure such as drifting devices, sinking ditches or drainage pipes in accordance with the environmental protection regulations. At the same time, it stays rather flexible in terms of the regulation of the percentage of the surface of a building plot that can be sealed – this is regulated through the footprint index only which varies in accordance to the dedicated land use, however it does not regulate the character of the parts of the building plot that are not built-up. In practice this means that the open spaces within the building plots in theory can be either hundred percent sealed or hundred percent green surfaces. In practice this percentage greatly varies. Accordingly, the ability of the building plots to sink the rainfall directly into the ground varies too.

The aim of the study presented in this paper was to firstly analyse the state of the art in Slovenia in terms of the (un)sealed surfaces within the building plots for various types of developments, and secondly, to propose a new planning approach that would at the national level regulate the percentage of the sealed surface within the building plots. The study was undertaken under a leadership of the main national research institution in the field of urban planning, i.e. Urban Planning Institute of the Republic of Slovenia, in cooperation with LUZ Urban institute of Ljubljana and BD projektiranje Ltd in 2018 and 2019.

2. Analyses of existing building plots for different building typologies

2.1. The context

Reckien et al (2018) who made a comprehensive analysis of local climate planning to date and classified the alignment of climate change plans with spatial (local, national and international) plans in European Union report that cities of central and northern Europe in general have more elaborated approaches to adaptation and mitigation to climate change through planning documentation than cities in other parts of Europe. The endeavours of Slovenia in this field are largely related to some international documents and protocol, e.g. Kyoto Protocol and the related Operational Programme to Reduce GHG Emissions (internet source 1). This document lists many environment-oriented goals as a response to a climate change, such as savings of end-use energy, increasing the proportion of electricity generated from renewable energy sources, increasing the share of biofuels and increasing the renewable energy sources in energy end-use. However, these goals do not address the need to rethink the way how the planning of the cities most detailed land-use elements (i.e. building plots) shall be adapted to better meet the changed climatic circumstances. Some efforts have been made within other region-based international policies such as the Alpine Convention (AC) which sets the (sustainable) development goals for eight Alpine countries of Europe while protecting the nature (Morandini and Roblek, 2011) and was adopted by Slovenia in 1995 (Bogataj et al, 2011). One of the clear objectives of AC is to reduce the damage of the soil, among others via the restriction of soil sealing. AC as a guiding document does not define which tools each signatory country of the convention shall use to reach the objective in practice - this depends on the planning and other regulatory systems in each of the AC countries.

Slovenian Ministry of the environment and spatial planning has recognised an opportunity to develop such a tool within the preparation of the new National spatial order. However, the state of the art had to be revealed first in order to get an insight on the amount of the sealed soil within Slovenian cities and other settlements as described further below.

2.2. Analitical framework

The project brief clearly structured the research into two phases: the analytical phase (phase one) and the guidance-defining phase (phase two).

The analytical phase had the objective to identify relevant case studies across the country and reveal the following:

- the minimum, the maximum and the average size of building plots for each of the most common building typologies (housing, public services, trade and production);
- the percentage of the built-up surface of the plot;
- and the percentage of the sealed part of the open space within the building plot.

The task of the analytical phase was also to reveal the level to which each studied case is in compliance with the demands set in the local spatial development plans in terms of the above-mentioned criteria.

Due to the great variety of landscape conditions (and related climatic conditions) around the country the project brief demanded to choose the case studies in different parts of the country, i.e. in all statistical regions as well as in all architectural regions of Slovenia that have been defined previously in the study commissioned by the Ministry (Fister, 1993). It was also demanded that in each architectural region one urban settlement and one non-urban settlements are analysed. The third demand of the brief was that the chosen case studies shall represent a wide array of settlements by size (big, medium and small size settlements).

The brief also defined that in each of the settlements a number of typical morphological unit has to been chosen (so called distinctive morphological pattern) reflecting each of the main building typologies (housing, production, trade and public services).

Based on the demands of the project brief the following urban settlements have been included as case studies (the number of inhabitants is indicated in brackets): Ljubljana (> 100.000); Velenje, Novo mesto, Koper (10.000 – 20.000); Trbovlje, Ptuj (10.000 – 20.000); Idrija, Radovljica (5.000 – 10.000); Sevnica, Cerknica (3.000 – 5.000); Črna na Koroškem and Radenci (< 3.000). While among other (non-urban) settlements the following were chosen (the corresponding statistical region is indicated in brackets) Moravske toplice, Martjanci, Tešanovci (Pomurska); Lormanje, Šetarova, Zg. Voličina (Podravska); Podgorje, Šmartno pri Slovenj Gradcu (Koroška); Topolšica, Zavodnje, Bele vode (Savinjska); Čemšenik, Razbor pri Čemšeniku, Jesenovo (Zasavska); Kostanjevica na Krki, Orehovec (Posavska); Dolenjske toplice, Dolen. Sušice, Selišče (JV Slovenija); Dobrova, Polhov Gradec (Osrednja Slovenija); Begunje, Dobrova vas, Rodine, Smokuč (Gorenjska); Nova vas, Nemška vas na Blokah, Veliki vrh (Primorsko-Notranjska); Kozana, Dobrovo, Biljana (Goriška); Šared, Malija (Obalno-Kraška).

The more demanding step of the sampling was choosing the morphological units to be studied within each case study settlement. The research team decided to use a combination

of orto-photo analyses and on-site visits to choose the most relevant units. Once they had been selected a clear boundary was defined to enable a technical (GIS) part of the analyses.

The technical part of the analyses was done in the Arc-GIS environment on the following order (see Figure 1):

1. preparation of the dataset; the cadastre and other information from geodetic and other relevant state-datasets for each case study has been uploaded. This included the ortho-photo images, polygons of built structures, plot-division and road network for each case study;
2. digitalisation of the boundary of each morphological unit that has been studied;
3. based on the information from steps 1 and 2, the overlapping of relevant data gave precise numbers on the size of building plots, the percentage of the built-up surface of the plot and the percentage of the sealed part of the open space within the building plot.

Figure 1 An example from the Arc-GIS database showing the analysed morphological unit for the case of family-housing typology (red – boundary of studied morphological unit, blue – buildings, yellow and grey - private and public traffic surfaces, green – private gardens).

The analyses of the level that each studied case meets the requirements of these criteria as set in the local spatial development plans had were done by on-line or physical review of these plans.

2.3. Results of analytical step

As shown in the Table 1 below, the share of the type of surfaces greatly varies depending on the land use and the building typology. In the majority of non-housing typologies, the greatest share goes to sealed open spaces, with the exception of schools, kindergartens and family farming where the greatest share goes to unsealed open spaces. The unsealed open spaces are unsurprisingly also the most common type of surfaces within all building plots dedicated to housing typologies.

Table 1 The share between the built-up surfaces, sealed open spaces and unsealed open spaces for different land-use and building typologies

Type of surface:		Built-up surfaces (%)	Sealed open space (%)	Unsealed open space (%)
Land use / Building typology*:				
Trade	Shopping centres	35	50	15
	Local shops	26	54	20
Public services	Mixed use	29	56	15
	Fire-brigade	27	42	31
	School	23	15	62
	Kindergarten	25	18	57
	Healthcare centre	25	38	37
Production	Industry	40	43	17
	Small production and warehousing	36	47	17
	Large scale farming	28	39	33
	Family farms within settlements	22	16	62
	Remote family farms	18	24	58
Housing	Detached houses	21	14	65
	Semi-detached houses	29	9	62
	Row houses	31	14	55
	Smaller blocks of flats	20	28	52
	Large-scale housing	24	28	48

* For each land use and related building typology many concrete case-studies were analysed, the table shows the average values.

These results show that some types of building plots have greater ability to sink the rainfall water directly into the ground than the others - in Slovenian case among the types shown in Table 1 the following have the highest ability: detached houses, semi-detached houses, schools and family farms within settlements. While the lowest ability has been detected mainly among the production-related typologies, such as industry, large scale farming, small scale production and warehousing.

The study also showed that in some studied cases the demands set in the local spatial development plans were not met. Out of all 246 studied cases, in 15 cases the footprint index was exceeded, in 21 cases the floorspace index was exceeded, in 13 cases the green-space index was exceeded and in 10 cases the open-living-area index was exceeded. The size of the building plot was exceeded in 16 cases, while the heights of the buildings were exceeded in 13 cases.

3. New approach to the building plots regulation in Slovenia

3.1. Methodological framework

Based on the results of the analytical phase and in accordance with the project brief, the second part of the project dealt with the development of the new regulation of the

organisation of the building plots in Slovenia. The main goal of such an endeavour was to improve the capacity of the urbanised areas to sink the water directly into the grounds by leaving appropriate amount of building plot's surface unsealed. At the same time, it was equally important to bear in mind the functional demands of each building type - to provide enough appropriate surfaces that allow the functioning of each building type, e.g. allowing enough open paved surfaces for the motorised traffic manipulation around warehousing etc.

One of not many Slovenian studies of the relation between the climatic conditions and the morphological patterns in the cities revealed that "the key parameters with the cooling effect are: green areas and their placement and the lack of traffic areas, particularly stationary traffic (i.e., parking)" (Fikfak, 2017, p. 18/20). The own analyses of the research team showed that while the built-up surfaces of the building plots stay within the very comparable limits (between 18% and 40% of the total surface of the building plot, as shown in Table 1) there are greater differences when it comes to the share of (un)sealed surfaces of the open spaces within the building plot: the sealed vary from as low as 14% up to 56%, while unsealed from 15% to 65%.

All these insights directed the project team into rethinking of the existing system that defines the organisation of the building plots. It is based on the distinction between the built-up and open space within the building plot, while there is a need to clearly define also the relation between the sealed and unsealed surface.

A new model was therefor based on the distinction between these two basic categories:

- the sealed area (in Slovenian: *neprekriti del*). The built-up area and all paved open spaces account into this category. The decisive criterion is that within sealed area the water cannot freely penetrate into the soils;
- the unsealed area (in Slovenian: *raščen teren*). The green spaces without underground construction account into this category. The decisive criterion is that within unsealed area the water can freely penetrate into the soils.

As shown in Figure 2 the category of sealed area is then subdivided further into the 1st sealed open space dedicated to motorised traffic, and 2nd sealed open space not dedicated to motorised traffic and 3rd the built-up area. While the category of unsealed area includes the green areas only in the part where there is no underground construction which would block the water enter the soils (e.g. cellars etc.). The open living area (marked with dashed grey line in Figure 2) extends across both new basic categories – it includes the unsealed surfaces in total while only a part of the sealed surface (the one that does not hold motorised traffic) – keeping this category as a part of the new system too was seen as important to continue the legacy of the existing system where the open-living-area index was introduced to assure enough surfaces for the non-motorised users of the open spaces surrounding the buildings.

Figure 2 The organisation of the building plot into two basic categories (sealed surface and unsealed surface) with sub-categories

In order to regulate the permitted percentage of the sealed surface within the building plot, a new urban planning index was introduced: sealed surface index (in Slovene: *faktor prekritih površin* – FPP), which defines the maximum percentage of the sealed surfaces and must not be exceeded.

3.2. Defining the building plot regulation by types

In order to achieve the appropriate extent of the unsealed surfaces in practice, each of the building plot types (reflecting the land use and its building typology as shown in Table 1) had to be defined by the percentage each of the categories defined in Figure 2 can cover. As shown in Figure 3 four aspects were defined for each of the land uses and related building typologies:

- A) the percentage of built-up area (maximum allowed),
- B) the percentage of sealed open space dedicated to motorised traffic (maximum allowed),
- C) the percentage of sealed open space not dedicated to motorised traffic (minimum required),
- D) and the percentage of unsealed surface (minimum required).

Nevertheless, the land use and related building typology could not be the only decisive factor. In some cases, it was important to consider the location of the building plot within the urbanised area. Many Slovenian cities follow the policy of densification of the urban areas nowadays in order to avoid the greenfield developments (Cotič et al, 2017). Therefore for those housing typologies that can appear in both densely built up as well as in the more suburban (lower densities) zones this distinction has been made. Similarly, the distinction between the farmhouses within the settlements and the farm houses standing alone in the

landscapes was made in the new system too. In some cases (see Shopping centres in Table 2) it was also defined how much of the unsealed area must be defined in one larger piece (and not scattered around in many smaller pieces).

Table 2 The share between the built-up, sealed and unsealed surfaces within the building plot for different land use and building typologies, as proposed for the new Slovenian National spatial order

	Built-up area	Sealed surfaces		Unsealed surfaces
		For motorised traffic	Not for motorised traffic	
	Max (%)	Max (%)	Min (%)	Min (%)
Housing				
Detached houses	central: 40 non-central: 30	central: 20 non-central: 30		40
Villas	20	20		60
Semi-detached houses	central: 40 non-central: 35	central: 30 non-central: 35		30
Row houses	50	20	10	20
Smaller blocks of flats	central: 40 non-central: 35	25	15	central: 20 non-central: 25
Large housing estates	35	20	15	30
Public services				
Kindergartens	30	20	15	35
Schools	30	20	15	35
Healthcare centres	50	25	5	20
Trade				
Smaller local shops	50	15	5	30
Larger local shops	40	30	10	20
Shopping centres	40	20	10	30 (out of which at least 50% in one unit)
Agriculture				
Farms	within settlement: 50 out of settlement: 60	within settlement: 30 out of settlement: 20		within settlement: 20 out of settlement: 20
Production				
Industry and warehousing	60	25		15

4. Soil sealing as one of the considerations in building plots organisation

Soil sealing is however only one aspect of the organisation of the building plots and may not stay the only one if the high-quality urban environments are to be achieved. Therefore the proposed new regulation addressed some other aspects of the plot organisation too.

4.1. Integration of soil sealing measures and urban design measures

To make a clear guidance for the future decision makers at the local levels of spatial planning in Slovenia (local authorities, local planning offices, urban planning bureaus etc.) the guidance has been prepared in a form of the Manual (Nikšič et al, 2019). The introductory pages give some general approaches to the organisation of the building plots, such as explain main terminology and definitions, list the general objectives of building plot organisation (functioning of the building, environmental footprint, relation to the existing context, sanitary and technical requirements and above all the assurance of quality living standards), and then explains the division of the building plot into two main categories (sealed and unsealed surface) and their sub-categories. As shown in Figure 3, the requirements for the organisation of the building plot for each of the building typologies is presented in a textual and graphical manner.

Figure 3 An example of the textual and graphical guidance for the organisation of a building plot in the manual for building-plot organisation (the case of Detached housing)

4.2. Implementation issues

The preparation of the Manual is only the first step in the process of changes aiming to introduce a new practice of building plots planning in Slovenia. The important further steps must be done. Firstly, the new approach has to be translated into a legally binding form within the new National spatial order. If this will not be done and the new guidance will stay only at the level of the recommendation it is less likely that the long-term goals (i.e. the ability of plots within urbanised areas to directly sink the rainfall into the soil) will be reached. And secondly, a new approach (and Manual) has to be promoted to the decision

makers and any other potential user, preferably via short face-to-face teaching or video lectures that would explain a rational behind the new approach as well as detail the information how to use and implement the new regulation for each of the addressed typologies.

5. Concluding thoughts

The climate change with the changed precipitation patterns is forcing the city authorities, planners and other stakeholders in urban development to rethink the long-established practices of city making. One of the basic elements and tools of the regulation of the urban areas is the regulation of the building plots. As this study showed on the case of Slovenian planning system, the current approach to building-plot organisation must be reformed to address the fact that it is important to regulate the amount of the surfaces that stay unsealed – not only by regulating the footprint and open-living-area index, but also the sealed surface index. It is of a great importance to raise the awareness that the capacity of the city to sink the rainfall greatly depends on the amount of the open space that is (not) sealed. In order to rise this awareness, the combination of soft (manual, educational activities) and hard measures (translation of recommendation into a legally binding rules) must be followed.

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