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Enhancing Urban Development Control Through the Warsaw Natural System: A Case Study in Warsaw, Poland

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Abstract: This study delves into the Warsaw Natural System (WNS) in Warsaw, Poland, and its efficacy in regulating urban development within the city. The paper is divided into three main sections, each addressing a distinct aspect of urban development control. Firstly, the paper examines how WNS effectively manages outward urban expansion through the strategic use of wedge-shaped green spaces. Empirical evidence demonstrates the WNS's success in curbing urban sprawl and maintaining a balanced spatial layout. Secondly, the study investigates how the WNS controls inward urban over-development by employing small urban green spaces interconnected throughout the city. The analysis highlights the effectiveness of this approach in creating fragmented urban development, and preventing excessive density. Thirdly, the paper explores how the WNS contributes to the resilience of urban development by enhancing functional diversity within urban green spaces, and how this diversity enriches the lives of urban residents and sustains the WNS's spatial pattern, offering long-term control over urban space development. In addition to its strengths, the study also identifies existing shortcomings within the WNS and proposes recommendations for future improvement, aiming to enhance its effectiveness in controlling urban development. This research provides valuable insights into sustainable urban planning practices and underscores the importance of adaptable green infrastructure in shaping cities for the future.

Keywords: Warsaw Natural System, urban sprawl, green infrastructure, urban planning

1. Introduction

In recent years, the application of the green infrastructure (GI) concept in urban planning, aimed at preserving and enhancing green spaces in cities, has gained traction [1-4]. This approach not only enhances residents' quality of life but also provides ecosystem services that benefit humanity as a whole. It contributes to environmental and sustainability goals and, notably, helps mitigate excessive urban development [5].

The urban over-development discussed in this paper encompasses both outward expansion, known as urban sprawl, and inward expansion, characterized by overly dense urban development. Both forms of spatial over-development can adversely affect the well-being of urban dwellers and the sustainability of cities [5]. In 2013, the European Commission outlined the rationale and necessity for implementing this concept within urban areas [6]. Several EU member states, including Poland, responded to this call. Warsaw, as Poland's capital city, serves various functions, including

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administrative, transportation, and services. With a population exceeding 1.7 million inhabitants, Warsaw is Poland's largest city [7]. Approximately 55.9% of the city's land is occupied by built-up areas, while agricultural land, forests, and parks cover 44.1% of the city's area. This makes Warsaw one of Poland's most environmentally friendly cities [8]. Warsaw's Natural System (WNS) was integrated into the city's Spatial Policy [9], building upon the Environmental Study of Warsaw conducted in 2006 [10] and following the conceptual framework developed by Szulczewska and Kaftan in 1996 [11]. The WNS aims to maintain a balanced ratio between built-up and open areas, aligning closely with ecological principles and deeply ingrained in Warsaw's urban planning tradition.

To delve deeper into the study of WNS, this paper raises three key questions:

1. Does WNS effectively curtail the outward expansion of cities?
2. Does WNS effectively regulate excessive urban development within the city?
3. Can WNS effectively prevent the recurrence of urban over-development?

Consequently, this paper will explore these three research questions by conducting a literature review and utilizing various scales of maps of Warsaw to perform spatial analyses. Ultimately, this paper will identify the current limitations of the WNS in controlling urban over-development and propose recommendations to enhance its effectiveness in the future.

2. Controlling Urban Sprawl Through the Warsaw Natural System: A Case Study in Warsaw, Poland

2.1. The Warsaw Natural System Has the Capacity to Efficiently Manage Urban Sprawl

Urban sprawl, one facet of urban over-development, primarily arises from the rapid population growth within urban areas [12]. Dysfunctional urban sprawl exerts a significant influence on urban land utilization, contributes to climate change, and places increasing strain on urban infrastructure [5].

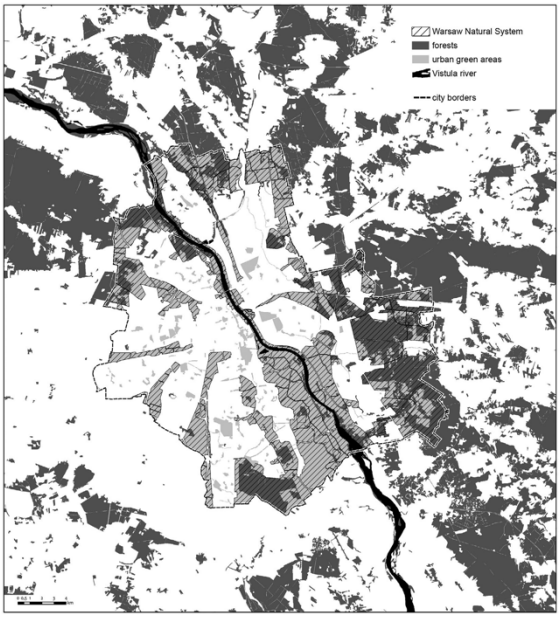

Figure 1: WNS at metropolitan scale [6].

In general, the Warsaw Natural System (WNS) effectively manages urban sprawl by constraining the connecting areas between the city and its surrounding regions. As depicted in Figure 1, WNS primarily achieves this control over urban sprawl through wedge-shaped green spaces positioned along the city's periphery. These wedge-shaped green areas gradually narrow from the city's interior

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toward its outer edge, preserving ample room for urban development within Warsaw while curbing the outward expansion of the city. Additionally, these wedge-shaped green spaces establish vital connections to the forests and farmlands beyond Warsaw, ensuring effective control of urban sprawl in the city's vicinity.

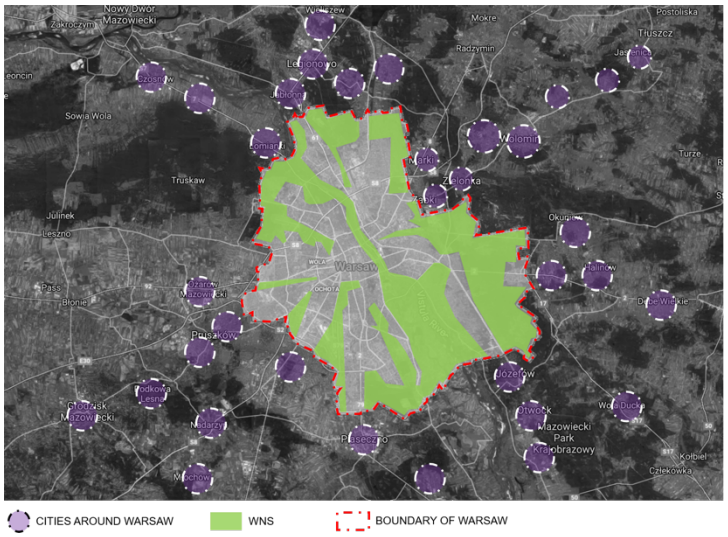

Figure 2: WNS used as a tool to control the urban sprawl.

Remarkably, the utilization of wedge-shaped green spaces within the Warsaw Natural System (WNS) to manage urban sprawl isn't intended to completely obstruct urban development and connections with neighbouring cities. Instead, its purpose is to exert some degree of control over the excessive expansion of the Warsaw metropolitan area, all while preserving room for the growth of other cities in the vicinity of Warsaw. What's even more intriguing is that by examining Figure 1 and Figure 2, it becomes evident that the spatial distribution of these smaller towns surrounding Warsaw is influenced by the common spatial limitations imposed by the WNS and the surrounding forests and farmlands. Notably, these small towns align themselves in the same direction as the gaps left by the wedge-shaped green spaces within the WNS. Consequently, the WNS has effectively prevented the outward expansion of Warsaw's boundaries.

2.2. The Warsaw Natural System Has the Potential to Curtail the City's Excessive Development to a Certain Degree

Over-dense development within urban areas represents another facet of urban over-development, stemming from the same factors as urban sprawl. Interestingly, over-dense urban development can be viewed as one of the primary catalysts for urban sprawl. This phenomenon occurs when urban infrastructure attempts to accommodate the maximum possible service population, exerting subsequent impacts on the health and well-being of urban residents [5].

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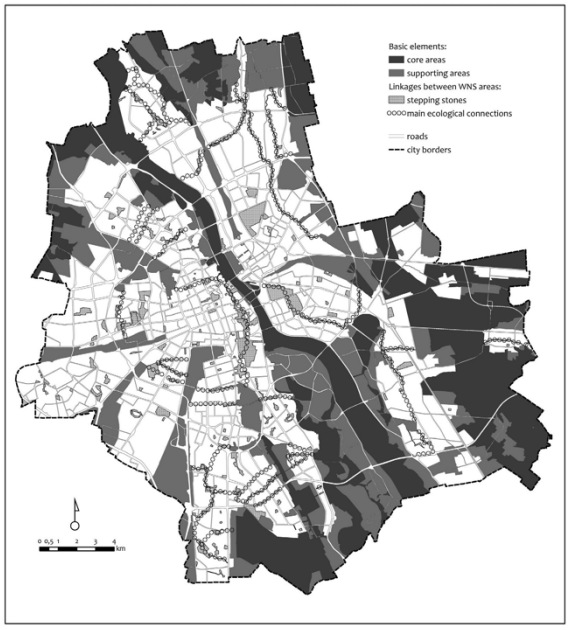

Figure 3: Linkages between green spaces of the WNS [6].

The Warsaw Natural System (WNS) primarily manages high-density urban development by incorporating small, block-shaped urban green spaces within the city. As illustrated in Figure 3, numerous of these smaller green spaces are interspersed amid the larger wedge-shaped green areas. These block-shaped green spaces are interconnected by linear green corridors, effectively segmenting the city into multiple blocks. This strategic approach turns the WNS into a series of barriers and enclosures, preventing the further expansion and connection of built-up areas. Consequently, this method ensures the strict control and containment of over-dense urban development within the city.

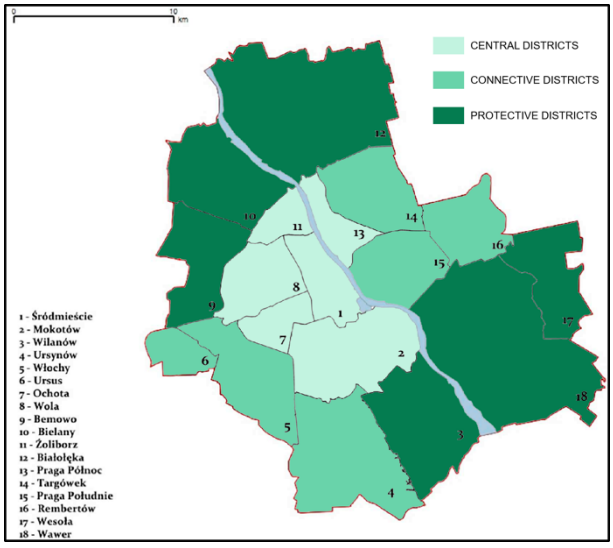

Figure 4: The classification of the 18 districts in Warsaw.

To conduct a more in-depth examination of the Warsaw Natural System's (WNS) effectiveness in controlling over-dense development within the city, as depicted in Figure 4, this paper categorized the 18 administrative districts in Warsaw into three distinct groups based on the spatial interaction between the built-up areas and urban green spaces. Subsequently, one district was chosen from each category for a more detailed analysis of the spatial dynamics between the urban built-up areas and

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the urban green spaces. This analysis aims to ascertain whether the implementation of green spaces within these districts has indeed resulted in the strict control of over-dense development.

Figure 5: The spatial pattern of the built up and green area in Wilanow district.

The Wilanow district, situated along the southern border of Warsaw, falls into the protective district category as per the classification in Figure 4. As evident from Figure 5, a significant portion of this district consists of green spaces, accounting for approximately 70% of its total area. Urban built-up areas are dispersed and enveloped by these urban green spaces, occupying only about 30% of the district's total area. This observation provides clear evidence that urban green spaces have effectively played a crucial role in controlling urban density within this particular area.

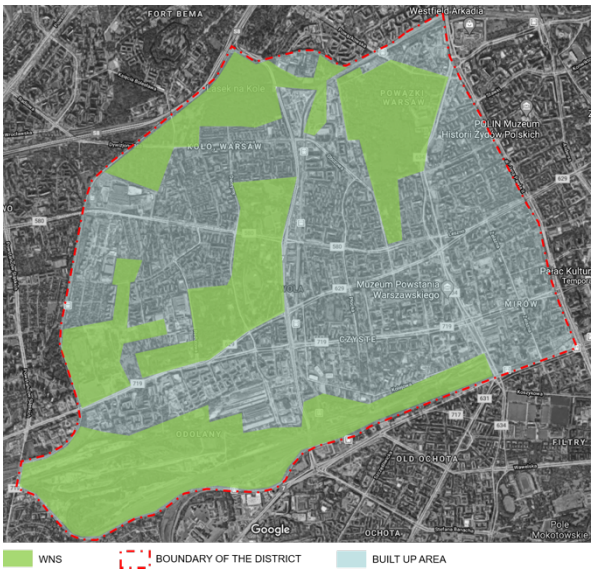

Figure 6: The spatial pattern of the built up and green area in Wola district.

The Wola district, classified as a central district according to Figure 4, exhibits distinct characteristics, as shown in Figure 6. In this district, urban green spaces encompass nearly 40% of

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the total area, and they are evenly dispersed throughout the region. Moreover, these urban green spaces are substantial in size. Despite the presence of numerous high-density city blocks, consisting of office buildings and high-rise apartments, the ample distribution and size of these green areas ensure that the high-density urban built-up areas do not experience further intensification.

Figure 7: The spatial pattern of the built up and green area in Targowek district.

The Targowek district, positioned on the eastern border of Warsaw and categorized as a connective district in Figure 4, exhibits distinct characteristics, as evident in Figure 7. In this district, urban green spaces encompass a significant 50% of the total area. Notably, the spatial arrangement of these extensive urban green spaces is such that they are interconnected by linear green corridors. This configuration effectively divides the urban built-up areas within the district into several distinct blocks, serving as an efficient means to control over-dense urban development in this area.

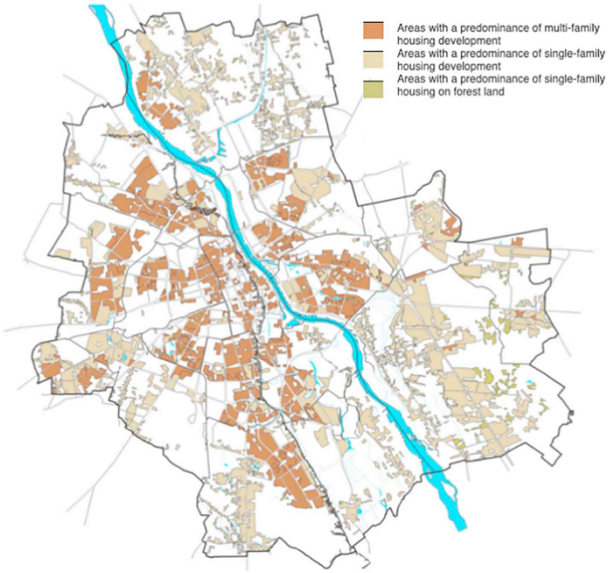

Figure 8: The spatial distribution of the built up blocks in Warsaw [5].

Based on the analysis of the three districts and the information provided in Figure 8, it becomes apparent that the Warsaw Natural System (WNS) has successfully achieved spatial integration with the urban areas. The presence of green spaces within these cities has led to a fragmented development

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pattern, preventing the formation of high-density urban blocks. This fragmentation serves as an effective mechanism to control over-dense development within the city. In essence, the WNS has played a vital role in shaping the urban landscape in a way that curbs excessive urban density and promotes a more balanced and sustainable urban environment.

2.3. The Warsaw Natural System Can Exert Partial Control Over the Resilience of Urban Area Over-Development in the Future

The above analysis indicates that the current Warsaw Natural System (WNS) effectively manages both the outward and inward over-development of cities at a spatial level. Moreover, this control is not only sufficient for present needs but also capable of being sustained into the future, specifically to address the resilience of urban sprawl. Urban sprawl's resilience, stemming from ecological concepts, pertains to its potential recurrence. Given that urban sprawl involves intricate interactions among various resilient systems, encompassing social, psychological, physical, structural, engineering, natural, environmental, and others, it becomes complex and challenging to regulate [5]. Therefore, it is imperative to deliberate on how to utilize the WNS to address this issue.

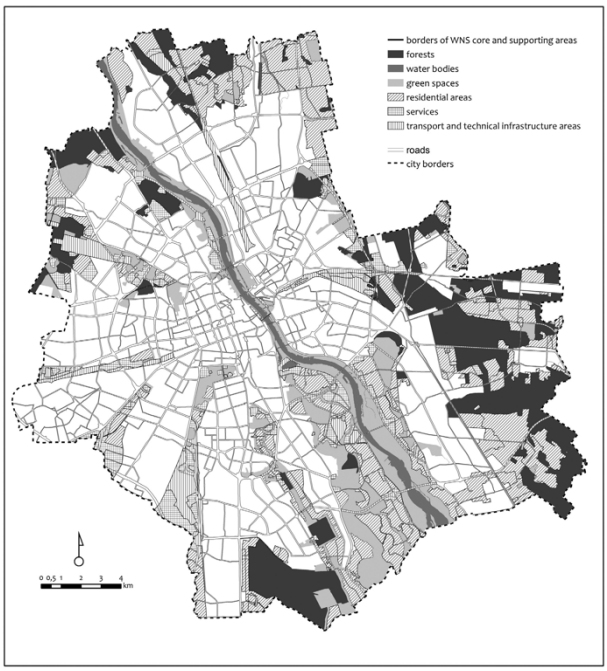

Figure 9: The multifunctional use of the green space of WNS [6].

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Figure 10: The multifunctional green area in Mokotow district.

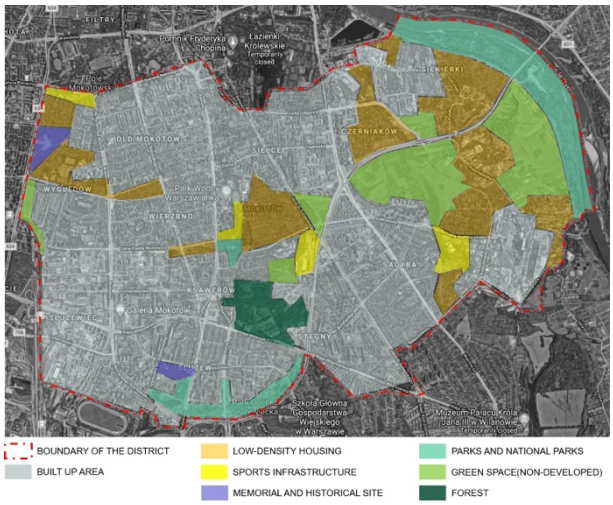

Figure 11: The multifunctional green area in Mokotow district.

WNS effectively manages the resilience of urban expansion primarily due to the diverse functions of urban green spaces [5]. As depicted in Figure 9, these urban green areas offer a wide range of spaces that enhance the urban residents' quality of life. For instance, let's consider the Mokotow district, as illustrated in Figure 10, where urban green spaces occupy nearly half of the district's total area, and these green spaces can be further categorized into six distinct types. This functional diversity significantly enriches the lives of residents and holds substantial environmental and social value (see Figure 11). Consequently, these multifunctional urban green spaces are less likely to be converted into office buildings or housing, which would increase the city's density. Their ability to persist in their current form for an extended period ensures their capacity to manage the resilience of urban expansion in the future.

2.4. How Can the Warsaw Natural System Enhance Its Capabilities for Future Urban Development Control?

While the WNS appears to be capable of managing urban over-development, it currently exhibits some shortcomings that require future improvements.

Regarding its effectiveness in controlling urban sprawl, the spatial distribution of the WNS along the city's periphery remains uneven, with a more pronounced contrast between the east and west sides

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of the city. As indicated by Figures 1 and 2, it's evident that the green spaces on the east side of the city are notably more successful in curbing urban sprawl. This can be attributed to the higher density of green spaces on the east side, coupled with the expansive forested areas outside the eastern city limits. In contrast, the west side primarily features farmland, which is less effective at mitigating future urban sprawl. Therefore, in the future, it would be advisable for the WNS to prioritize the construction of urban edge green spaces on the west side of the city to address this imbalance.

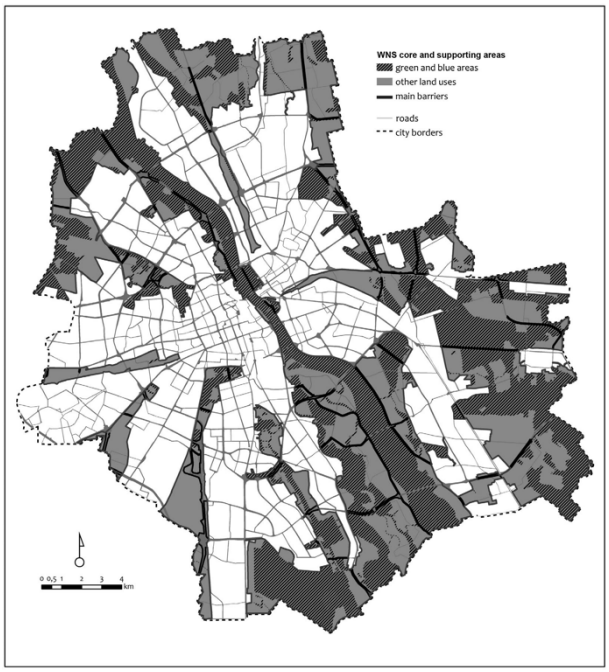

Figure 12: The barriers of the WNS [6].

Figure 13: Utilization of the river system as connections of urban green spaces in Beijing.

WNS continues to exhibit drawbacks in its control of city over-dense development, primarily manifesting in two aspects. Firstly, as illustrated in Figure 12, there are still obstacles hindering the connection of various small urban green spaces within the city. Therefore, breaking down these

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barriers will be a key direction for the future development of WNS. Secondly, each urban green space within the WNS lacks proper integration with the city's water system, such as the Vistula River, as demonstrated in Figure 13. In contrast, the Beijing Urban Park System effectively connects water systems with urban parks to enhance the control of over-dense development in the city. Therefore, this could serve as a valuable example for the WNS to draw inspiration from in the future.

To address the resilience of future urban spatial over-development, the Warsaw Natural System (WNS) still faces limitations in terms of functional diversity. As depicted in Figure 11 above, a significant portion of the WNS's urban green spaces consists of forests and undeveloped green areas. However, when compared to other types of urban green spaces within the WNS, these forests and undeveloped green spaces serve relatively singular functions and provide only a certain level of ecological benefit. Consequently, it is essential to enhance the functionality of these green spaces in the future. One approach could involve the conservation and development of forests and undeveloped green areas, transforming them into forest parks to offer recreational amenities for nearby residents. This transformation can increase the value of these forested regions, providing the government with more compelling reasons to preserve them for long-term control over urban space over development.

3. Conclusion

This paper investigates the Warsaw Natural System (WNS) in Poland and explores its capacity to regulate excessive urban development in spatial terms. It comprises three main sections. Firstly, the WNS manages outward urban over-development primarily by utilizing wedge-shaped green spaces. Secondly, the WNS addresses inward urban over-development by employing small urban green spaces and establishing interconnections between them, resulting in fragmented urban development. Thirdly, the WNS governs the resilience of urban over-development through the functional diversity of urban green spaces. The study illustrate how this functional diversity enhances the lives of urban residents, allowing the WNS's spatial pattern to persist over time and effectively control the resilience of urban space over-development. The paper also highlights existing shortcomings in the WNS and offers recommendations for enhancement, aiming to improve the WNS's effectiveness in controlling urban over-development in the future.

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