The onset of underground urban planning in Flanders

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Abstract. Urban underground space (UUS) can be an effective means to meet the needs of the cities and simultaneously deal with societal and urban challenges. However, in Flanders the use of UUS remains to be one of the most forgotten urban assets and is characterised by a haphazard, uncoordinated "last resort" practice detrimental to sustainable development. In a search for new possibilities for qualitative densification the Flemish Government instigated a policy exploration to investigate if efficient use of the UUS could be a possible solution for lowering the daily land take. This paper describes the process and content of the policy exploration and sets out policy recommendations. The paper concludes that although the merits of UUS have been thoroughly recognized and the significance of the subsurface in urban renewal is clear, the efficient use of UUS in Flanders and the fulfilment of Flemish policy objectives cannot be guaranteed without the development of UUS policy and the integration of UUS policy in the overall Flemish urban planning system. The research finds that a clear definition of planning factors for the use of UUS is necessary to support the transition from using the UUS to integration of the UUS into wider urban planning processes. It puts forward the need for a comprehensive list of planning factors, gathered in a holistic, integrated manner, necessary to transition from UUS projects to UUS planning.

1. Introduction
There is a broad acceptance and appreciation amongst academics and experts about the benefits and assets that urban underground space (UUS) provides. UUS has been acknowledged as a multifunctional natural resource which provides ‘psychical space, water, energy, materials, habitats for ecosystems and support for surface life, while also acting as a repository for cultural heritage and geological archives’ [1]. UUS is regarded as a valuable, irreplaceable resource [2–4].

UUS use can be an effective means to meet the needs of urban environments in terms of demographic growth, the consequent pressures on urban infrastructures, achieving high living standards, densification issues and counteracting further urban sprawl. UUS can contribute to global challenges such as climate change, energy crisis or water management [1,5,6]. Admiraal [7] states that UUS should be able to contribute to achieving six out of seventeen UN sustainable development goals (SDGs), such as building resilient infrastructure, promote inclusive and sustainable industrialization (SDG9) and making cities and human settlements inclusive, safe, resilient and sustainable (SDG 11). It is expected that the use of the urban underground shall increase in the next years due to technological innovations, resource supply and demand, socioeconomics and geopolitics [1].
Despite the wide acknowledgement of these potential benefits, UUS remains to be a much forgotten and underestimated urban asset and seems to be characterized by a haphazard, opportunistic, uncoordinated, first-come, first-served, 'last resort' practice [3, 8], which is most likely the result of a lack of foresight and planning [9]. This practice could lead to unintentional consequences, conflicts and competition for available resources which are detrimental for a sustainable development of the urban environment. In recent years an increasing number of municipalities in Europe are becoming aware of the benefits of UUS use [10]. Such as these municipalities, the Flemish government became aware of the possible role UUS could play in fulfilling urban planning policy objectives.

This paper presents a policy exploration into UUS in Flanders that was conducted from 2017-2019 by means of a literature review, expert workshops and bilateral expert interviews. It builds on the premise that UUS in Flanders is a valuable asset that should be taken into account in urban planning practice and hence needs to be included in the planning system and according policies. A brief depiction of the Flemish urban planning system is provided, followed by an overview of the process and content of the policy exploration. The paper concludes with policy recommendations on the use and planning of UUS in Flanders. The results clearly illustrate the need to develop a coherent policy on UUS use in Flanders and the need for a holistic and integrative planning of the urban underground space.

2. Urban planning policy and urban planning system in Flanders

2.1 Territorial organization

Belgium is a federal state that consists of Flanders, which is located in the north, Walloon (south) and the Brussels Capital (Figure 1). The federal level holds a restricted number of competencies in some key policy domains such as justice, defense, social security and health care. The regions are fully autonomous in territorial bound competencies such as spatial planning, environment, infrastructure, urban development and housing. Within the regions, federated entities called communities are responsible for personal bound competencies like education and well-being. In case of the Flemish region, the Flemish government is responsible for both territorial and personal bound competencies [11].

![Figure 1. Location of Flanders, Belgium](image_url)

Flanders has a three-tier planning system defining the roles in spatial development for the regional level as well as its five provinces and 300 municipalities. The system is characterised by cooperation based on the principle of subsidiarity, which means that competences are exercised at the most appropriate level. Being responsible for spatial planning, the Flemish region has formulated a strategic vision and development principles which lower governments are expected to take into account [11].

2.2 Pressure on the current urban planning system
Today Flanders has a population of 6.5 million inhabitants and is expected to grow to 7.5 million by 2060. The main part of this growth will be realised within or nearby the bigger cities such as Antwerp and Ghent [12]. Flanders faces many challenges: 33% of the surface is considered settlement area and 14% of its surface is effective soil sealed area. This is amongst the highest in Europe [12, 13]. Every day an average of 6 ha land take is taking place. This leads to heat stress, flooding and puts pressure on the open space. Flanders is characterized by urban sprawl, which results in high car-dependency and congestion.

These developments lead to a change in spatial policy [12]. In 2017 a modification of the legislation on urban planning created a legal base for the new spatial policy plan. A spatial policy plan consists of a strategic vision and policy guidelines. In 2018 the strategic vision was approved by the Flemish Government [12]. The planning policy shifted from more traditional planning towards a place based planning, characterised by a more proactive approach and a better coordination in one area of initiators, plans and projects [14]. The strategic vision of the spatial policy plan Flanders focusses on safeguarding open spaces and intends to bring urban sprawl to a standstill by lowering the daily land take from six (2016) to zero hectares by 2040. The plan aims at lowering the daily land take by increasing the density on already developed land by applying densification development strategies such as intensification, re-use, temporary use and mixed use of space combined with stimulating nodal development [12]. The strategic vision of the spatial policy plan Flanders does mention the use of the subsurface as a means for increasing density, but does not elaborate. UUS in Flemish policy is approached narrowly if at all per policy sector (e.g. pipelines, excavating, archaeology), but is barely noticeable in Flemish urban planning policy.

The conclusion can be drawn that while the Government of Flanders was developing its planning policy frameworks, no integrated policy on UUS or regulatory framework was put in place for using and managing the urban underground space. Unfortunately the reasons as to why no framework or policy for UUS use was put in place is unclear and are grounds for additional research.

3. **Urban underground space policy exploration**

Parallel to the development of the Spatial Policy Plan Flanders (2018) the Flemish government instigated a policy exploration to increase densities within the settlement area. The purpose of a policy exploration is to stimulate and support innovation in (the development of) strategic urban planning policy, urban planning instruments and regulations. The main objective of this policy exploration was to examine if efficient use of urban underground space could be a possible additional solution for lowering the daily land take and fulfilling Flemish policy objectives on spatial efficiency.

![Figure 2. Process of the policy exploration.](image-url)
The policy exploration was conducted in four stages: information gathering, reflecting/discussing, concluding and implementing the outcome (Figure 2). The mentioned dates are indicative, some overlap between stages was inevitable. The information gathering stage consisted of a literature study, case study research, bilateral interviews with Flemish and international stakeholders and preliminary studies [15–19] on financial, legal, geological and ecosystem aspects of underground space use in Flanders. These activities also led to the creation of a network of stakeholders. The results of the first stage were the subject of reflection and discussion (stage 2) during a workshop with UUS stakeholders (such as engineers, architects, geologists and others), a workshop with 20 urban planning professionals (guided by the association of Flemish urban planners) and several discussions with local and regional policy officers. During this stage more general statements about UUS were re-interpreted to fit the Flemish situation and an analysis of the current state of UUS use in Flanders was conducted. The finding were condensed into specific policy recommendations (stage 3). In addition, political validation for the policy recommendations was sought. This process lead to new research questions to be asked as well as the definition of next steps to take towards producing an actual policy on UUS (stage 4). This last stage is currently still ongoing and aims to find ways to integrate UUS policy into the overall urban planning system. The results of the policy exploration to date will be presented in the following paragraphs.

3.1 Current situation and relevance of international experience in Flanders

The main objective of the policy exploration was to review the current use, benefits and urban opportunities of urban underground projects as expressed in literature and discuss the relevance for Flanders. Through workshops and bilateral interviews with UUS stakeholders and urban planning professionals it was explored which topics apply to Flanders and how they play out in the specific Flemish context. In doing so an overview over the current state of UUS use in Flanders was gained. Figure 3 provides a summary of the conclusions of the workshops and interviews. The current use of UUS and practices of its development in Flanders can arguably be traced back to the lack of planning and policy for using the UUS.

![Figure 3. Relationship between urban planning system, practices and current state of UUS.](image)

In addition to the summary of the workshops and interview (Figure 3) the next paragraphs elaborate on significant issues detected during the bilateral interviews concerning UUS use and practices in Flanders, such as three-dimensionality, non-futureproof developments, solitary developments and the lack of cooperation between stakeholders.
The subsurface in Flanders contains a range of functions and users, such as sewers, utility pipes, parking, tunnels, storage areas and basements. Occasionally, the subsurface is innovatively used for other less obvious functions such as the extension of a museum or a sauna [15]. Today the Flemish subsurface holds 500,000 kilometres of cables and utility pipes, 40,000 kilometres of sewage lines, 18,000 private heat pumps, 35 kilometres of tunnel in the main road network and 11.2 kilometres of pre-tunnel systems (authors estimation based on internal governmental data). More and more functions and users take control of the subsurface.

Flemish UUS experts and stakeholders point out how a ‘last resort’ practice in underground development has led to the current condition of the subsurface. Only when all possibilities for expansion or extension have been exhausted at the surface the subsurface is suggested as a possible solution for accommodating the redundant program. Kaliampakos (2016) [20] refers to this as the spaghetti-subsurface: ad hoc placing of infrastructures in the shallow subsurface that hinders the subsurface’s future utilization. The ad hoc development of UUS use can lead to use-conflicts. The urban planning experts identified as origin of these conflicts one defining characteristic of underground space that is often ignored in urban planning processes: its three-dimensionality. The concept of three-dimensionality (or multi-dimensionality) of UUS and UUS planning has been examined by several experts [9, 21–23]. For example, Admiralal [7] described a conflict between transport and geothermal use of the subsurface.

Opportunities are missed by ill-considered non-future-proof developments [3] that may block future projects located in the same vertical, diagonal or horizontal plane. Interventions are carried out ad hoc without taking into account the future potential of the underground space and underground volumes are given to less interesting or suitable functions. Experts on Flemish urban planning state that the same appears to be true for Flanders and this ad hoc practice is supported by the Flemish approach to ownership. Flanders is characterised by a plethora of private property and private ownership, which creates a dispersed spatial development and hinders holistic approaches to large scaled underground developments [15]. In addition, ownership has strong (land) legal protection and the freedom to do what you want with your property is anchored both culturally and legally. Stakeholders, during bilateral interviews and the workshop, have declared that ownership rights can be interpreted ambiguously which hinders the development of UUS [15], while Stones & Heng [8] explicitly underline the importance to clarify the right to ownership in order to promote the enhanced use of UUS.

The review revealed that connecting existing underground developments into a network or adding to existing underground developments is encouraged in many countries and regions outside Flanders [22, 24]. Yet, during the workshops it became clear that in Flanders underground developments are often seen as solitary developments, little attuned to each other or to above-ground developments. This leads to a dispersed landscape of solitary underground developments, free from constructive relationships and not contributing to the creation of a dynamic urban fabric, which relies on relationships and networks between underground structures [19].

Although the literature review showed that an interdisciplinary approach to UUS use is recommended [24, 25], the workshop (holding several UUS stakeholders) exposed the lack of cooperation between UUS stakeholders. Coupled with a lack of knowledge about the location of underground structures, this may be the cause of frequently occurring incidents in the UUS.

The workshop and bilateral discussions with stakeholders also revealed that policy makers and developers tend to be reluctant towards using the UUS as an innovative way of densification due to a lack of knowledge and uncertainty. There is a lack of knowledge about the design requirements of underground developments, about the consequences of the underground space on the geological structure of the soil and subsoil, about the impact on ecosystem services, about the financial impact of construction projects. In addition, there seems to be uncertainty amongst the stakeholders about the interpretation of urban planning legislation and the adoption of surface legislation to the subsurface [15].

The participants concluded that in view of the increasing pressure on cities and therefore their subsurface, this practice of ‘last resort, first come, first serve’ is not a sustainable development model to extend into the future.
3.2 Societal and urban benefits of UUS use relevant for Flanders

To understand the societal and urban benefits of UUS use in Flanders case studies worldwide have been scanned and their relevance for the Flemish setting was assessed. It was revealed that the added value of UUS in Flanders goes beyond increasing urban densities or accommodating population growth. Benefits that were found particularly relevant for the case of Flanders are summarized in Table 1.

Table 1. Societal and urban benefits of UUS for Flanders.

| Societal and urban benefits                                      | Example                                      | Relevance for Flanders                                                                 |
|-----------------------------------------------------------------|------------------------------------------------|---------------------------------------------------------------------------------------|
| Increasing urban density and colocation [8]                    | Les Halles, Paris, France The Factory, Zaventem, Belgium | Flanders holds many restrictions on high rise buildings and had a cultural bias against high rise [19]. The spatial policy plan Flanders 2018 [12, 24] encourages colocation to increase urban density. |
| Contribute to the quality of life and safeguard open spaces [3] | M30, Madrid, Spain                             | UUS could help increase the amount of green spaces in urban centres. 21% of the Flemings does not have access to green open spaces within a radius of 400m (walking distance) from their home [26]. |
| Societal and environmental challenges (climate change, energy transition, transport infrastructure, waste management) [5, 20, 27] | Multifunctional carpark/waterbassin, Rotterdam, The Netherlands | 14.2% of Flanders is considered as soil sealing, which hinders the infiltration of water into the soil. Also 30% of Flanders is sensitive to flooding. There is an urgent need for additional space for water storage [26]. |
| Enhancing territorial identity [24]                           | Domingo Gascon-square, Teruel, Spain          | The shoreline in Flanders is characterized by remnants of worldwide II, such as ‘Atlantic Wall: underground bunkers are preserved and re-used. |
| Economic catalyst [28]                                         | Underground tunnel for public transport in city centre, Den Haag, The Netherlands | Underground shopping centres in cities can be connected to underground subway, which will increase passage and profit. |
| Decreasing import of minerals (quarring) [29]                  | Potential soil material can be excavated which may serve as an alternative to a primary surface minerals, this can amount up to 22% of the total need for mineral raw materials in Flanders [30]. |

3.3. Urban opportunities for underground space use

The case study research also laid bare urban opportunities for underground space use. The participants in the workshops identified four opportunities for UUS use within the redevelopment of Flemish cities:

- The redevelopment or densification of an urban area UUS creates an opportunity to increase densities while safeguarding landscape values. The underground space can be used to accommodate a program within an area of landscape value and simultaneously safeguard valuable landscapes by realizing the program underground. One example where this was a successful approach is the extension of the Africa Museum (Tervuren, Belgium).

- Abandoned underground spaces are opportunities for underground re-use of space. Doing so, dormant capital is revalued. Brussels (Belgium) still holds several unused underground constructions near underground public transport infrastructure.

- UUS use often uncovers archaeological finds that provide insight into our history and form a chronicle of the environment. A valuable find can be integrated into the urban fabric. Displaying archaeological heritage also strengthens the identity of a place. Fort Napoleon (Ostend) can be considered a good practice here.

- Smart use of underground space when extension or renovation of an existing building or monument is necessary. The Mauritshuis (Den Haag, The Netherlands) developed an underground passage to the plot next door to create more room for the museum.

4. Policy Recommendations

The information gathering and discussing/reflecting stage revealed that a lack of policy for and planning of the UUS lead to misguided UUS practices which resulted in an unsustainable use of UUS.
in Flanders. Yet simultaneously it was also established that using the UUS has several benefits and urban opportunities within the redevelopment of cities can be found, which can support the fulfilment of the policy objective of increasing densities in urban areas. The findings were condensed into policy recommendations to the Minister of Environment and Spatial Development to ensure a sustainable use of UUS and to contribute to the realization of the urban policy objectives of lowering the daily land take to zero by 2040 (stage 3). The main two recommendations concern the development of a holistic policy on UUS in Flanders and the integration into the overall current planning system (such as instruments, practices, processes, design) (Figure 4).

![Figure 4. Integration possibilities of UUS policy in urban planning system.](image)

(1) The Government of Flanders should develop policy on UUS that considers issues such as suitable location for UUS use, desirable functions, suitable depth, impact of geological, hydrological, archaeological characteristics of UUS and requirements for using UUS.

In Flanders urban planning policy regarding the location assessment for surface developments is based on the principles of the strategic vision of the spatial policy plan Flanders [12]. The level of existing amenities and nodal value are leading policy principles for urban development. Nodal value is the degree to which a place is integrated into the system of public transport. The nodal value and the level of amenities determine the development options of a place (place based policy), such as the expansion options, the target values for spatial efficiency or the type and mix of activities (living, working, facilities). According to this policy, places with high nodal values or with a high service level appear to be the most opportune places to stimulate UUS use. Existing UUSs (such as urban underground mobility networks) could also offer opportunities for connecting new underground developments. It seems likely that the location assessment for UUS projects will also be based on these principles, but complemented with other principles more specific for the territorial characteristics of the subsurface, such as geology and hydrology. In particular policy on UUS should aim at future-proofing UUS use in a manner that minimizes the probability of UUS projects hindering the development of future more advantageous or suitable UUS uses.

The policy exploration identified the need for clear and scientifically sound policy positions on matters such as what kind of functions are suitable in the subsurface, what specificities of the subsurface (such as geographical or hydrological) have an impact on UUS constructions, how do the characteristics of the subsurface influence decisions regarding using or preserving UUS, what are suitable locations for underground space use, what is the suitable depth for underground constructions or what should be the
maximum permissible impact on ecosystems and soil. Further research is necessary to substantiate policy on UUS.

(2) The policy on UUS needs to be integrated in the overall Flemish urban planning system. During the process of the policy exploration it became clear that in order to achieve sustainable use of UUS policy on UUS ought to be firmly integrated in the Flemish urban planning system. Possible fields of integration include planning instruments, planning practice, planning processes and urban design. Without a functional institutionalized framework, adapted to UUS use, none of the (to be developed) policy objectives on UUS will be able to be realized. To that end a benchmarking study was suggested in understanding the methods of integrating UUS policy into planning systems abroad. Further questions to be asked include: What are the assets and bottlenecks of the governance system in Flanders when integrating UUS into the planning system? How can ambiguity regarding the ownership legislation on UUS be avoided? Why isn’t there a current policy framework for UUS use in place?

In 2019 the policy recommendations were discussed with policy officers and government officials in an attempt to be placed on the political agenda of the newly elected government. Which resulted in an statement on UUS use in the policy document on Environment and Spatial Development 2019 – 2024 ‘Beleidsnota Omgeving’[31], submitted by Zuhal Demir, Flemish minister on Environment and Spatial Development. This policy document sets out strategic urban planning objectives and how to achieve them. Following the policy exploration a strategic objective regarding the use of urban underground was inserted: “Making sensible use of the subsurface”[31]. Further on it states: “We use this knowledge (of the subsurface) to gain a better insight into the interaction between the subsurface and the aboveground processes and to create policy regarding efficient use of urban underground spaces” [31]. The policy exploration presented here states that UUS use should become evident in Flanders, that the importance of the subsurface should be approached as much as the surface in its interest and potential [6, 29]. This implies an impact in all facets of the urban planning system: policy, design, planning process, permits, policy implementation. The policy exploration advices that a coherent, scientifically sound strategy for UUS use is needed, a strategy which also ensures an integration of UUS in wider urban planning processes. It demonstrates that UUS use offers added value, but that added value can only be captured by means of a well-thought-out coherent vision and planning for underground space use.

5. Ongoing and further work
As a result of the policy exploration, the government of Flanders has currently embarked on several follow up projects to support the development of UUS policy and the integration of UUS into urban planning system:

- The development of a viability-tool for estimating the feasibility of UUS projects, when taken the impact of geological and geotechnical characteristics on the budget into account. This requires a long lasting discourse between geologists, geo-engineers and urban planners.
- The development of a map indicating potential locations for UUS in Flanders based on territorial characteristics of the subsurface and surface. For example characteristics concerning geology, ground water, brownfields and existing underground structures.
- Study on design principles for urban underground space projects in dense areas.
- Benchmark on urban underground space policy and methods of integrating UUS policy in foreign urban planning systems.

These projects will be carried out in the administration of the Flemish Ministry of Environment and Spatial Development in collaboration with experts on UUS and urban planning and are expected to deliver valuable support in creating policy on UUS and integrating this policy into the Flemish urban planning system. Since UUS policy requires an interdisciplinary approach [24, 25], the newly formed network of Flemish UUS stakeholders will play a vital role.
6. Discussion: From ad hoc UUS projects to UUS planning by means of planning factors

In recent years underground as a dimension and multi-dimensional approaches to planning have gained increasing interest in research and practise [23]. However, in Flanders, UUS has, as a dimension, a unit of space, remained invisible in planning practice, design and policy. The subsurface as a dimension is not limited to space for utility lines, linear infrastructure or uses that hinder the surface, but could be considered a fully-fledged dimension full of added value for society. In addition, taking the subsurface as a fully-fledged dimension [22] also means an evolution in the view of urban planning experts, an evolution from surface thinking to volume thinking [32]. We are no longer attached to static surfaces, but should be able to use all the opportunities offered by the volumes, depth, cohesion and relationships in the subsurface and in relation to the surface.

The importance of UUS is slowly being discovered worldwide, leading to a global search for ways to integrate the underground dimension into wider urban planning processes and urban policy. Several cities and countries have taken the step towards a more holistic and integrated manner of planning the use of the UUS [3, 8, 29, 33–36]. The subsurface should be integrated as a dimension within the urban planning system, planning process, planning instruments and design. However the enrichment of wider urban planning processes cannot happen overnight. There is currently no generic methodology in play for transitioning from UUS projects to UUS planning and integrating the subsurface into the planning system [9, 22]. Each country is supposed to work out its own methodology, based on local conditions.

However one could wonder if there are general planning factors in play that are comparable in each country and support the transition to UUS planning? Planning factors are key elements that should be taken into account when planning the subsurface and aiming at sustainable use of the UUS. Although considerable research has been devoted to detecting key factors for the use of UUS [3, 8, 29, 34, 37–42], less attention has been paid to gathering these key factors in a coherent and integrated manner. With each new article on the subject of UUS use and UUS planning new planning factors implicitly arise from different sectoral approaches. Planning factors for UUS use can be detected in fields such as urban planning, ownership, architecture, heritage, project development, behaviour analysis, marketing and other related fields. Generic planning factors for the use of UUS may appear very valuable when shifting towards an urban planning policy and practice that includes UUS as a worthy urban planning dimension.

The policy exploration presented here states that UUS use should become evident in Flanders, that the importance of the subsurface should be approached as much as the surface in its interest and potential [6, 29]. The policy exploration advices that a coherent, scientifically sound strategy and policy for UUS use should be developed, a strategy which also ensures an integration of UUS in the overall urban planning system. The aim ought to be to devise a clear framework for using UUS. This framework could be based upon generic planning factors, that are defined as generic as possible so they can be attuned to regional uniqueness of planning systems. These generic integrated planning factors should enable regional and local governments to ensure a better use of UUS and serve as a baseline for planning underground space use. Further research is necessary to define these planning factors and to evaluate their relation to successful integration of UUS into urban planning.

7. Conclusion

Although the merits of UUS have been widely recognized and the significance of the subsurface in urban development is well established, the efficient sustainable use of UUS in Flanders cannot be guaranteed as an integrated planning approach to UUS is missing. The policy exploration concludes that if the urban planning policy objectives are to be met and a sustainable use of UUS in Flanders is desired UUS policy and an integration of UUS policy in the overall Flemish urban planning system is necessary. This integration of UUS could be achieved by a framework of generic planning factors, gathered in a holistic, integrated manner. However further research is necessary to define these planning factors.

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