Spotted

Satellite Open Data for Smart City Services Development

Supporting Public Administrations in the field of green areas management

Version 1.0 / October 4, 2023

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SPOTTED Pilots: Leveraging Satellite Open Data for Sustainable Urban Development

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Executive Summary

The policy brief presents a comprehensive overview of the SPOTTED (Satellite oPen data fOr smarT ciTy sErvices) project, a ground-breaking initiative integrating satellite open data, AI, and cloud technologies for efficient green area management in cities. The project, funded by the European Commission under the Connecting Europe Facilities (CEF) program-Horizon 2020, addresses critical urban challenges in Milan, Helsinki, and Naples. By harnessing the power of satellite open data, SPOTTED exemplifies the potential of revolutionising smart city management.

The transformative pilots in Milan, Helsinki, and Naples demonstrate the tangible outcomes of this integrated approach. Each pilot is tailored to the specific needs of the city, focusing on critical areas such as soft mobility, tourism sustainability, and urban regeneration. These pilots serve as examples of how technology can drive innovation and sustainable urban development on a global scale.

1. Introduction

1.1 Background and significance of SPOTTED pilots

Historically, working with geospatial data has been difficult due to various reasons such as accessibility, usability and technical literacy. In recent years, however, the landscape has evolved dramatically, data is being openly shared across a plethora of platforms on an unprecedented scale, changing the playing field for both public and private sector players. This sharing of data coupled with advances in Artificial Intelligence (AI) has made geospatial data analysis more relevant and accessible than ever before. Many policymakers across the European Union have taken note of this trend, and have pushed for increased data standardisation and interoperability, to further increase the ease of use of these technologies through data and expertise sharing mechanisms.

Geospatial data and information management play a pivotal role across various sectors, initiatives, and programs within the European Union. In this context, the European Commission has adopted a multifaceted approach to handling geospatial and Earth Observation data, giving rise to several discernible activities. These encompass (1) **standardisation initiatives;** where the Commission engages with standardisation bodies like OGC, W3C, and ISO, (2) **legislative efforts;** the European Commission aligns its efforts with legislative frameworks such as the Public Sector Information (PSI) directive and open data policies, in consonance with the broader Digital Single Market initiative, (3) **research initiatives;** the Joint Research Centre is at the forefront of geospatial research and the European Commission through its various financing efforts funds different relevant research projects in this field. The two most prominent and long-lasting drivers in this landscape are **Copernicus** and the **INSPIRE Directive**. These initiatives wield substantial influence, encompassing legal, organisational, semantic, and technical dimensions, significantly impacting Member States. The contribution of these initiatives in promoting geospatial data and information management is widely recognised within the European Union.

Geospatial data is a crucial tool to monitor, assess and analyse territorial changes, natural or man-made. In urban contexts, such changes can have a strong negative impact on buildings and critical infrastructures in terms of territorial sustainability and resilience dynamics. Further, as our cities grow and more people move into already crowded spaces, there is an increasing demand for green spaces in our cities. Green spaces can indeed mitigate the negative effects of pollution and reduce the phenomenon known as urban heat island effect.[1] An increase in green spaces combined with an effective management of a city's green resources has also a positive impact on the well-being of citizens. Monitoring these resources has thus become a crucial task for urban planning and digital and accessible tools that support policymakers are now needed more than ever.

[1] The urban heat island effect appears in towns and cities as a result of human activity. The heat generated by people, transport, shops and industry is trapped in the narrow roads and concrete structures, unable to escape to the atmosphere. This can bring the temperature in urban areas up 3-4°C higher than the surrounding countryside, and with that comes a vicious cycle.

The **SPOTTED project** (Satellite oPen data fOr smarT ciTy sErvices) harnesses the power of open geospatial data and satellite technologies to drive innovation in smart city services, while answering to the increasing need of tools that help policymakers managing urban spaces.

The main idea of SPOTTED is to exploit the High Value Datasets[2], as defined by the European Commission, to support the decision takers in a better management of the green areas. Raw data coming from heterogeneous sources will be combined, analysed, and processed to be visualised through the Data Portals of the cities.

SPOTTED has a primary goal of offering an innovative solution that centres around the integration and tailored processing of extensive open data collections, including Earth Observation data. The final output will be the **SPOTTED Digital Service.** Starting from what a city wants to measure (e.g., one of the indicators from Milan is Natural Capital and Health), the **SPOTTED Platform** will provide a digital service that collects satellite and open data, analyses them and delivers the information to the city through the open data portal. The result of the SPOTTED Digital Service will be published in the European Data Portal as an open dataset. The project sources its data from various open data portals, including those managed by the public administrations collaborating within the consortium, the European Data Portal, and Copernicus. This data encompasses real-time information gathered by sensors, which will be managed using the CEF Context Broker Building Block. Ultimately, the overarching objective of the project is to demonstrate how this comprehensive framework can stimulate innovation and substantial value creation.[3]

To test and demonstrate the effectiveness of the solution, we are implementing three distinct pilots in the cities of Milan, Helsinki, and Naples. The three pilots have specific objectives, tailored to the different needs of the cities.

In **Milan**, the SPOTTED pilot focuses on **data-driven green and just transition.** The municipality of Milano aims at using the project platform, the impact of the presence (or not) of capital natural on urban areas and/or urban objects (e.g., hospitals, playgrounds, bike-pedestrian paths, etc.) through the perspective of three example-indicators: soft mobility, health, and social cohesion. These analyses will then provide policymakers with data-driven guidance about the development and management of natural capital in order to enhance a green, liveable, and resilient city.

[2] The Open Data Directive introduces the concept of 'high-value datasets' as datasets holding the potential to (i) generate significant socio-economic or environmental benefits and innovative services, (ii) benefit a high number of users, in particular SMEs, (iii) assist in generating revenues, and (iv) be combined with other datasets. Given this, the Directive requires that such datasets are available free of charge, are provided via Application Programming Interfaces (APIs) and as a bulk download, where relevant, and are machine-readable. The Directive does not include the specific list of high-value datasets—which is expected in the future—but only their thematic categories, one of which is 'Geospatial'. The 'high value dataset' concept is also considered in national data policy and programmes in different European countries, typically incorporating 'core' datasets, including geospatial data

[3] Antonio Filograna, Giovanni Giacco, Giuseppe di Caprio, "Leveraging cloud-based geospatial data to enhance public services. A case study of the SPOTTED project" 2023, Proc. of the International Conference on Electrical, Computer, Communications and Mechatronics Engineering (ICECCME 2023) 19-20 July 2023, Tenerife, Canary Islands, Spain

In **Naples**, the SPOTTED pilot focuses on **monitoring urban regeneration strategies.** It utilises satellite images to create thematic maps for analysing and continuously monitoring urban regeneration strategies, which include mobility and urban planning

In **Helsinki**, the SPOTTED pilot focuses on **monitoring sustainability of tourism and urban planning.** It identifies green areas using satellite imagery to create data products for planning nature tourism sustainability, monitoring status of green areas and supporting urban planning efforts.

1.2 Aim and structure of the policy brief

The aim of this policy brief is to provide a comprehensive overview of the SPOTTED project and its transformative pilots in Milan, Helsinki, and Naples. Highlighting the significance of leveraging satellite open data for green area management. Furthermore, the brief wants to offer actionable policy recommendations focusing on how to effectively implement smart solutions based on public data. These objectives determine the structure of the brief, which comprises three main sections:

First, **Leveraging Satellite Open Data for Green Area Management,** discusses the importance of satellite open data in the context of green area management, highlighting its role in informed decision-making. This section also explores the advantages and challenges of using satellite data for monitoring and managing urban green areas. It is followed by **Transformative SPOTTED Pilots in Milan, Helsinki, and Naples** This section provides a brief overview of each pilot, outlining their scope and purpose. In doing so, it clearly defines the unique goals and objectives of each pilot, demonstrating their individual significance. Importantly, it describes how satellite data is applied within each pilot, showcasing its practical use. Lastly, it discusses the anticipated benefits and potential challenges that may arise during the implementation of the pilot projects. Lastly, we will propose a set of **Policy Recommendations for Green Areas Management.** This last concluding offers recommendations on how the insights and findings from the SPOTTED pilots can be applied to future green area management initiatives. Further, it provides actionable policy recommendations for promoting sustainable urban planning through the synergistic use of public open data and AI.

2. Leveraging Satellite Open Data for Green Area Management

2.1 Why Satellite Open Data Matters

Since the inception of space-based Earth observations with the TIROS-1 satellite in 1960, satellite observations enhance comprehensive global perspectives that hold a central position in enhancing our comprehension of various human and natural processes. Beyond their initial role in weather forecasting, satellite observations have emerged as indispensable sources of information across diverse societal, scientific, and economic domains.

These observations have significantly enhanced our comprehension of the Earth's complex systems and, owing to archives dating back to the 1970s, provide valuable objective references for trends. The scope and depth of these observations are encapsulated in the CEOS Database, which currently catalogues 192 distinct measurements organised into major domains, with over 3,600 instances of instruments capturing data to support these measurements[4].

Satellite imagery technology has actively enhanced the policy relevance of these observations by organising them around broad thematic areas. Examples include monitoring changes in the Earth's climate in alignment with the Paris Agreement, tracking alterations in ice sheets and extent, and supporting international initiatives such as the United Nations Sustainable Development Goals and the Sendai Framework for Disaster Risk Reduction 2015-2030[5].

Since the early 2000s, there has been a consistent enhancement in the spatial, spectral, and temporal revisit capabilities of open data flows. In 2014, the launch of the first Copernicus satellite, Sentinel-1A, marked a pivotal moment. It inaugurated a series of eight Sentinel satellites, each providing optical, C-band radar, ocean colour, temperature and altimetry, and atmospheric composition data on an open basis. Notably, Sentinel-1A and Sentinel-1B represented the advent of open radar imager data into the Earth Observation community. Some of these satellites are included in the case studies below, where their effectiveness is underscored.

The European Union has been a trailblazer in the use of satellite technologies, first making all of its satellite data freely available as early as 2013[6]. Satellite data within the European Union has been used for a plethora of different purposes, many of which are common across the world such as weather forecasting, and urban planning. The Union, however, has also implemented several **innovative uses of satellite technologies, such as measuring European Union cohesion funding through the use of satellite imagery.** This unique use of the technology has been adopted by several other technocratic and data driven organisations such as the World Bank, in measuring impact evaluation[7].

Another major use of satellite technology is **harnessing its power to help Europe achieve its Green Transition.** Through its flagship open data policy, the European Union allows the public and private sector alike to actively monitor the effectiveness of their policies, as well as provide a valuable instrument for government regulation. The continent is rife with evidence of the positive effect satellite technology, with projects from Madrid to Bucharest[8].

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[4] CEOS, “Open Data for Impact”, January 2022. Available Online: https://ceos.org/news/open-data-part1/#:~:text=Satellites%20and%20Open%20Data,-Since%20the%20first&text=By%20providing%20global%20synoptic%20views,helps%20to%20safeguard%20human%20life.

[5] GAVI, “Sustainable Development Goals, February 2020. Available Online: https://www.gavi.org/our-alliance/global-health-development/sustainable-development-goals?gclid=Cj0KCQjwgNanBhDUARIsAAeIcAv2r1OWtO8TgIHNCB6Pv1YGtEdyW6yRs3enlOU_L71aHh-78BYmtNUaAqHtEALw_wcB

[6] https://www.eea.europa.eu/highlights/eu-satellite-data-to-be

[7] https://medium.com/ecajournal/europe-seen-from-the-stars-evaluating-eu-cohesion-funding-using-satellite-data-4bae259595d1

[8] https://data.europa.eu/en/publications/datastories/open-data-achieve-eu-green-transition

2.2 Satellite Open Data and Green Area Management

The benefits of using satellite imaging technology to monitor and manage green spaces are numerous. One example is that **through precision land planning satellite data can help urban planners identify suitable areas for green space developmen**t, in any and all circumstances where large scale quantification is necessary- satellite imagery is a positive force. For example, through implementing sensors, scientists can gauge temperature, humidity levels, and air quality within the vicinity being recorded, this facilitates a deeper comprehension of the environmental prerequisites essential for the vitality of urban green spaces[9].

Further, there is the benefit of **ecosystem health monitoring.** Through utilising satellite imagery technology, scientists, and policymakers alike can assess vegetation health, biodiversity, and the impact of urbanisation on ecosystems. Subsequently, steps can be taken to better care for and monitor the local flora and fauna through a data driven approach focused on quantitative indicators[10]. This directly correlates with public engagement, as through open satellite data the public can better engage with the policy decisions taken by local governments and give their input as well as help raise awareness regarding urban ecology.

Finally, there is the benefit of **climate change mitigation and disaster preparedness.** Through satellite data, there can be facilitation for better understanding of the role of urban green spaces in mitigating climate change, as well as changes in carbon sequestration. In relation to disaster preparation, satellite imagery also plays a crucial role for a variety of tasks such as identifying flood prone areas, fire risks, and anomalies that may be indicators of disaster. Oftentimes in fact, satellite imagery is the only timely source of data for emergency response[11].

2.3 The SPOTTED Platform

As explained in the introduction of this policy brief, SPOTTED is driven by a core mission: to introduce an innovative solution centred on the integration and custom processing of extensive satellite open data resources, which include Earth Observation data, and other public open data coming from different heterogeneous data sources. The ultimate outcome of this endeavour is the SPOTTED Digital Service. Given a city's specific measurement needs, the SPOTTED Platform is designed to provide a digital service that systematically acquires satellite and open data, conducts meticulous analysis, and subsequently conveys this information to the city via the open data portal. So, in a nutshell, the SPOTTED solution is all about collecting, processing, storing, and sharing data to make our cities smarter and more informed in their decision-making.

[9] Frazkiewicz Marcin, “The Importance of Satellite Imaging for Mapping and Monitoring Urban Green Spaces”, tS2, March 2023. Available Online: https://ts2.space/en/the-importance-of-satellite-imaging-for-mapping-and-monitoring-urban-green-spaces/

[10] Mark Altaweel, “Mapping Ecosystem Health through Satellite Data”, GIS Lounge, December 2021. Available Online: https://www.gislounge.com/mapping-ecosystem-health-through-satellite-data/

[11] British Geological Survey, “Using Satellite Imagery for Emergency Disaster Response”, July 2021. Available Online: https://www.bgs.ac.uk/news/using-satellite-imagery-for-emergency-disaster-response/

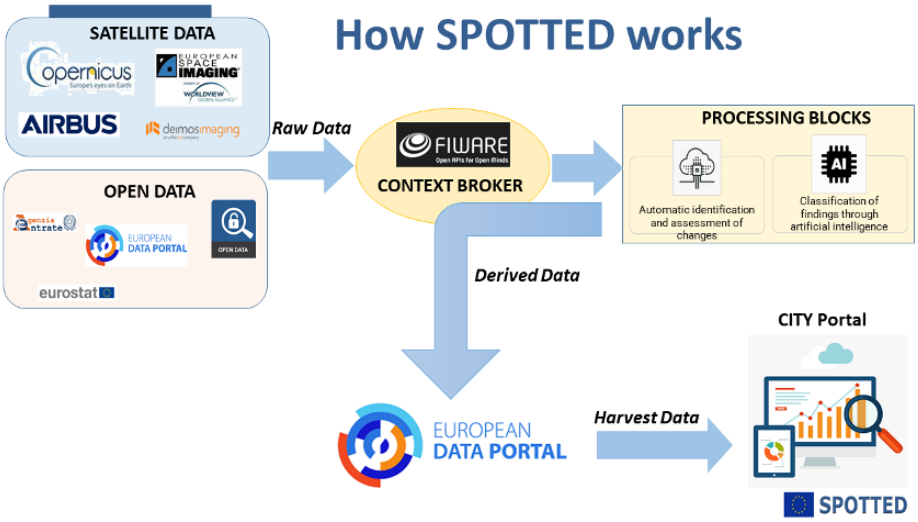

Figure 1: How SPOTTED works

The innovative technologies adopted in the SPOTTED Platform deal mainly with data management. The core of the SPOTTED Architecture is the CEF Context Broker, which allows managing all the data exploited during the process. SPOTTED provides a portal as a unique point of access to use the SPOTTED Digital Services.

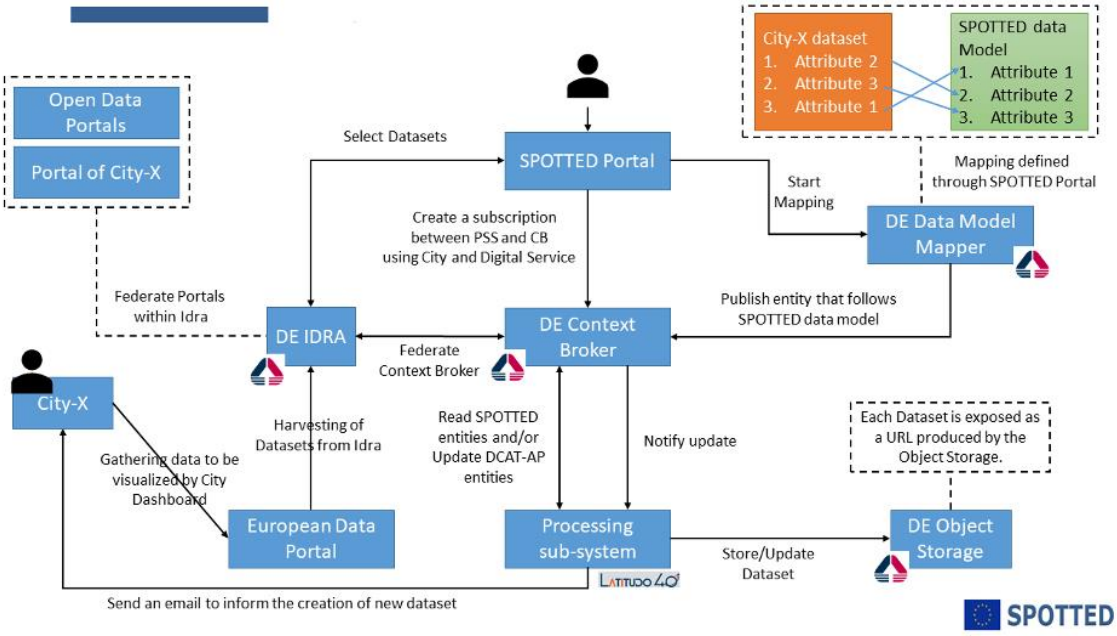

Figure 2: architecture of SPOTTED

The Architecture is based on three-layers: (1) **Data & Interoperability layer**; SPOTTED provides four components, i.e., CEF Context Broker, Idra, Digital Enabler Data Model Mapper and Digital Enabler Object Storage (2) **Processing layer**; SPOTTED provides one component, i.e., the Processing Subsystem (3) **Visualisation layer**; each City provides the environment to visualise the Dashboards.[12]

[12] D2.2 SPOTTED Technical Framework, 2022

The Platform is accessible online: http://portal.cef-spotted.eu/. Currently, the platform offers three digital services: (1) **Urban Heat Exposure,** (2) **Urban Green Index** and (3) **Urban Heat Vulnerability**.

The **Urban Heat Exposure** is used for calculating heat exposure of different urban objects and features, which can be points, lines and polygons.

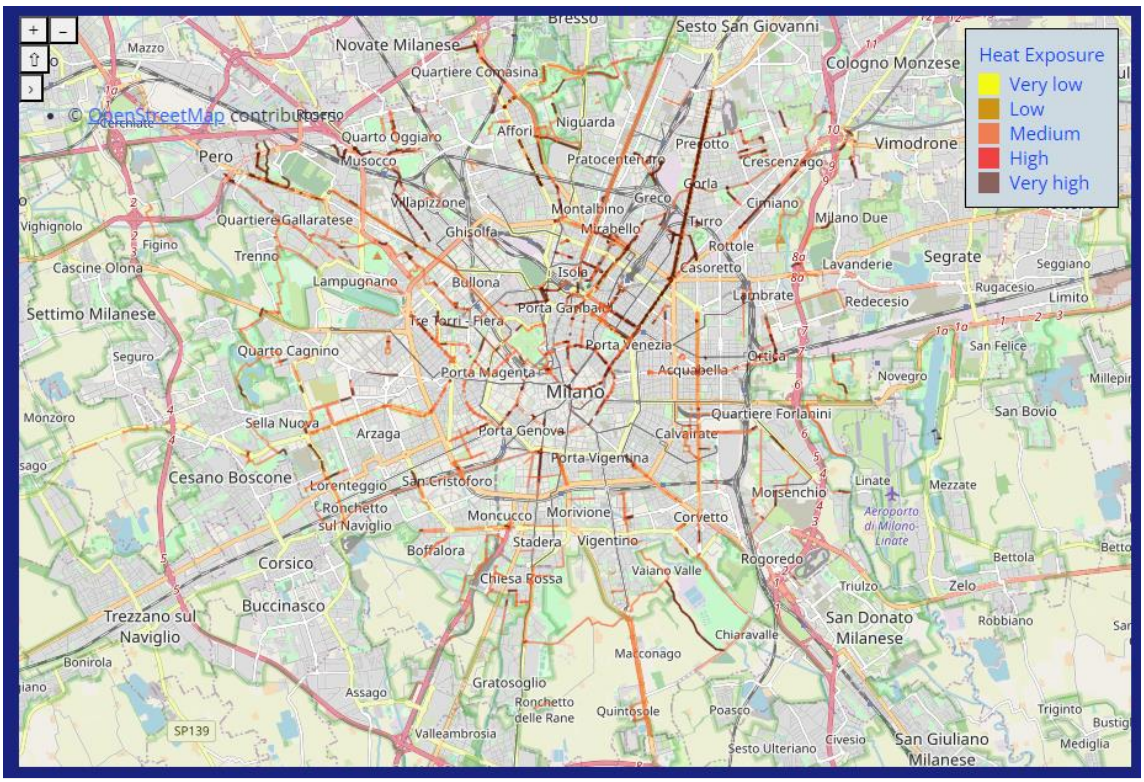

Figure 3: Urban Heat Exposure

The **Urban Green Index** is used for calculating the absolute and relative quantity of green areas/greenery in the city. Users can select a date/month/year to run the analysis on and to compare e.g., two different years for change detection.

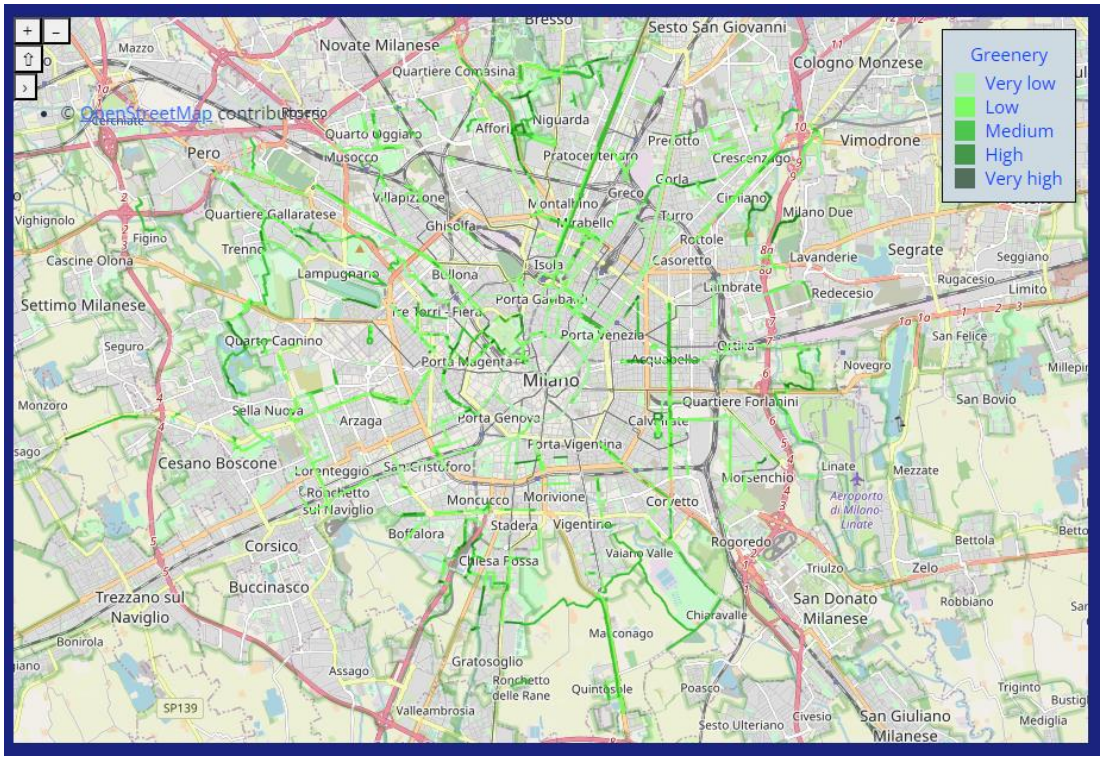

Figure 4: Urban Green Index

The Urban Heat Vulnerability is used for calculating heat exposure in relation to vulnerable populations (e.g., children < 10 and adults > 65). This service provides means for analysing heat vulnerability in urban areas and data could be used for quick assessment or prioritisation of heat mitigation actions.

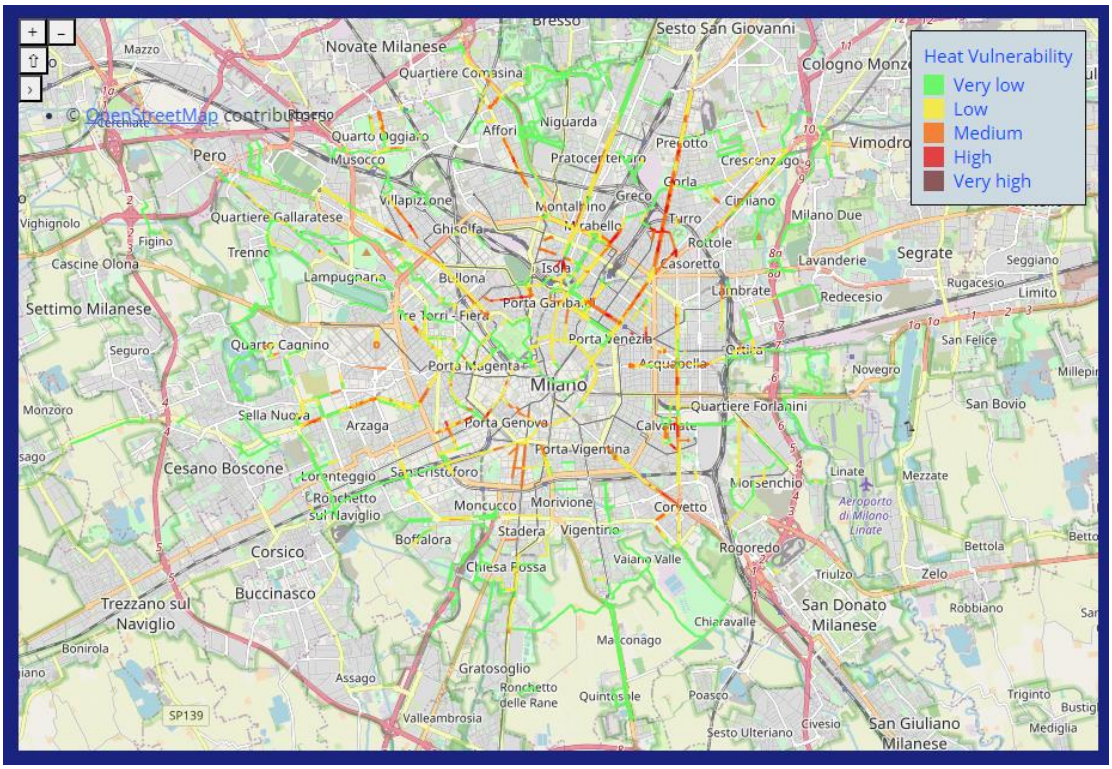

Figure 5: Urban Heat Vulnerability

The SPOTTED Platform has been carefully designed to offer an intuitive and user-friendly experience. To ensure its user-friendliness, the platform development closely involves feedback from the pilot cities, aligning it with their specific needs and preferences. It is worth noting that the primary users are intended to be public administrations, not individual citizens. While the platform is designed to be intuitive, some basic knowledge of data and digital services is helpful for effective use.

The users must login to the portal in order to run the service they need. Once logged in, the user can choose the city for which they need the service, which service they need and how often the requested service should be updated (Figure 6).

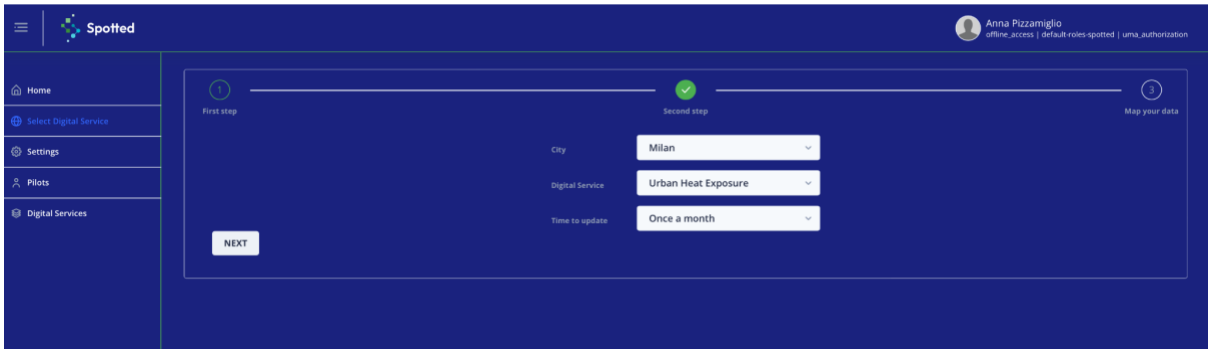

Figure 6: step one

In the next step (Figure 7), users are prompted to upload their initial dataset or provide a link to it. The dataset should be in geojson or csv format. Ensuring data compatibility is crucial. The provided dataset must be mapped to the specific data model adopted for the chosen service (step three, Figure 08). This step ensures that the data provided by the city aligns with the predefined SPOTTED Data Model, which is tailored for the selected Smart Digital Service. This mapping acts as a bridge between the data in the dataset and the SPOTTED Data Model for the chosen service. Standardising the data format makes it easy to understand and process data from various sources.

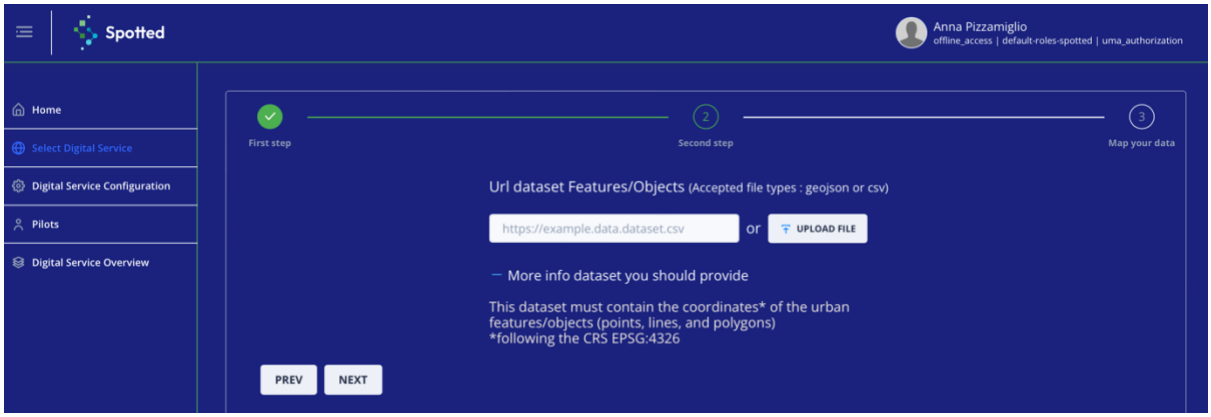

Figure 7: step two

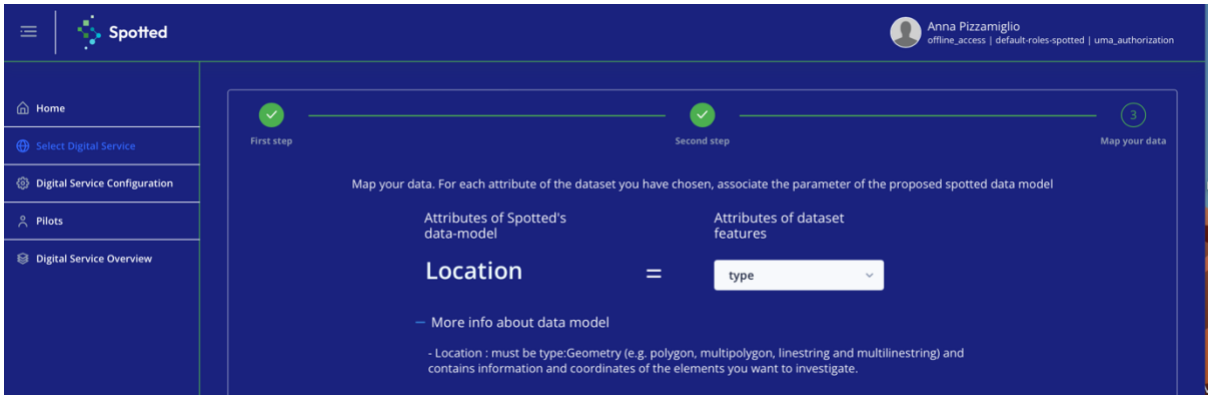

Figure 8: step three

After the data is mapped and compatibility is ensured, the dataset is uploaded for the analysis to the Processing Sub-System (PSS, Figure 9 and 10), where the real magic happens. This system is responsible for analysing the data to derive meaningful insights and information. The user will be notified by email when the analysis is ready.

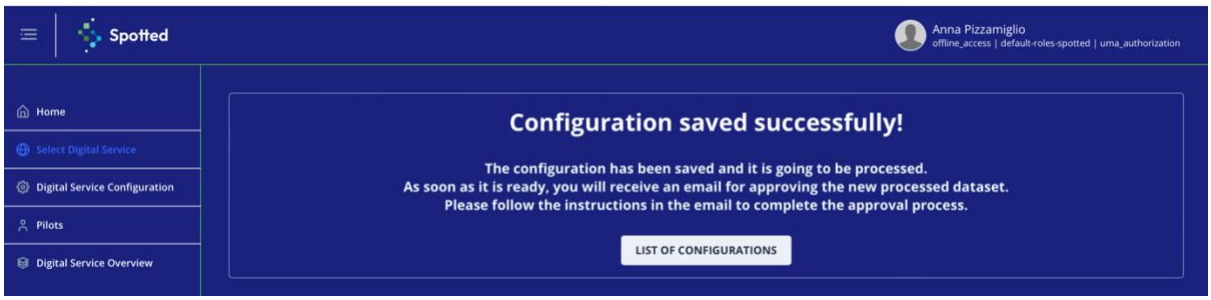

Figure 9: step four

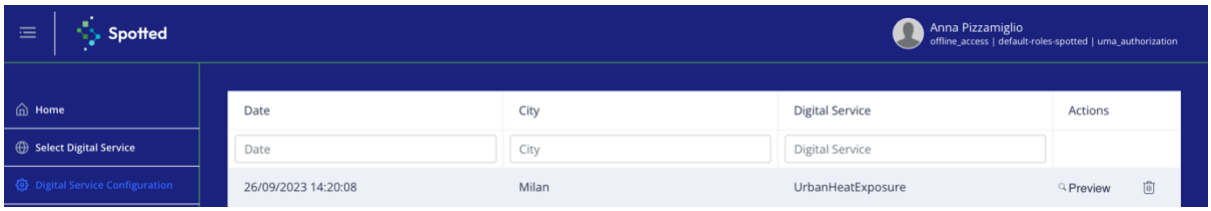

Figure 10: final step

After analysis, the PSS does not just keep the data to itself. It stores the new datasets in a secure location known as the Object Storage. This storage system creates a URL, i.e., a web address that allows anyone with access to the internet to find and use the dataset. But datasets are more than just numbers and figures; they come with explanations. The PSS also updates a document with information about what the dataset contains, describing its metadata. This document includes a link to where you can download or access the dataset.

Now, the data is ready to be shared with the wider world. To do this, the city connects to a massive data hub known as the European Data Portal (EDP). This connection allows the EDP to collect data regularly. However, before sharing data on the EDP, there is an important quality control step. The city receives an email from the PSS about the new dataset. They need to thoroughly check if the data is accurate, reliable, and up to their standards. Only after the city gives its approval, the dataset is made public on the EDP.

Once the dataset is on the EDP, it is available for anyone interested. The city then takes this approved data from the EDP and displays it on its own City Portal Dashboard. This dashboard is like a visual platform where people can explore the data, turning numbers and figures into useful information that can guide decisions and actions.

2.3.1 Positive Impact of the SPOTTED solution

By acting as a **centralised hub for geospatial data,** SPOTTED contributes to the **harmonisation of historical geospatial data related to green infrastructure.** As the pilot cities provide detailed historical geospatial datasets on green infrastructure, they will obtain through the SPOTTED solution a detailed land use change analysis over the past twenty years. This is a crucial feature to identify trends and fragile spots. This knowledge can be used to **design climate change mitigation and adaptation strategies** and to program monitoring activities at appropriate steps. In this sense, **SPOTTED presents itself as a key enabler of Urban Regeneration activities.**

Further, **SPOTTED has the potential to heavily contribute to the digital transformation of Public Administration** and to the gradual employment of digital tools in support of decision- and policy making across Europe. These tools are not mere innovations; they are catalysts for change, empowering policymakers with real-time data, predictive analytics, and sophisticated modelling capabilities.

The uptake of digital technologies by the public administration enables policymakers to envision multiple scenarios and their potential impacts, facilitating the **development of more informed and effective policies.** From urban planning to environmental conservation, these tools act as virtual laboratories, allowing policymakers to experiment with different strategies and anticipate outcomes. Moreover, they usher in a **new era of transparency and public engagement.** Citizens, too, can access and interact with data, fostering a more collaborative approach to policy formulation. This transparency not only strengthens trust in government but also ensures that policies are rooted in the needs and aspirations of the community.

At its core, the overarching aspiration of this initiative is to showcase how this comprehensive framework can serve as a catalyst for innovation and substantial value generation. The digital tools employed in support of policy and decision-making represent a pivotal transformation in the way cities envision their future. Municipalities and their Public administrations are the digital architects of a more sustainable, accessible, and prosperous city, where policies are not just written but dynamically crafted, informed by real-time insights and guided by the collective wisdom of its residents. This digital journey is more than an evolution; itis a revolution in governance that promises to reshape the very fabric of the pilot cities' urban landscape.

3. Transformative Pilots in Milan, Naples and Helsinki

3.1 Milan: a data-driven green and just transition

3.1.1 Overview

Milan Municipality has largely invested for the past ten years into the green transition and the city's development. This entails a long-term plan detailed into the "Milano 2030 – A Green, Liveable, Resilient City". Its main objectives are:

- To minimise land consumption
- To enhance green and blue infrastructures
- To reduce greenhouse gas and carbon emissions
- To mitigate extreme events (e.g., heat islands, torrential rains) by promoting microclimate cooling and water drainage
- To cut building energy consumption
- To activate circular materials recovery processes
- To initiate processes of re-naturalization of surfaces, both horizontal and vertical

Milano 2030 is the overarching framework within which the SPOTTED project works in terms of strategy and objectives. A significant liaison project of SPOTTED is the Piano Aria e Clima whose multi-dimensional, ambitious work programme includes objectives such as:

- To not exceed the limit values for particulate matter and nitrogen oxides;
- To reduce CO2 emissions by 45% by 2030 and to become a Carbon Neutral City by 2050;
- To maintain the increase of temperatures below 2°C by 2050. [13]

3.1.2 Specific objectives and expected results

In particular, the Milano pilot aims at analysing the socio-economic impact associated with the presence (or not) of natural capital through the use of the SPOTTED technological platform. The platform will serve as a policy-making support tool. It will specifically provide policymakers with data-driven guidance to assess, plan, and develop natural capital, and the associated socio-economic impact, thanks to the combination of open satellite with statistical data and artificial intelligence algorithms.

Throughout the project's development, Milan gathered requirements for the city's analytical needs and established a set of example-indicators according to which run the analyses enabled by the three digital services provided by the platform.

The City of Milan proposes three indicators: Natural Capital and Soft Mobility, Natural Capital and Health, Natural Capital and Social Cohesion.

[13] https://www.comune.milano.it/aree-tematiche/ambiente/aria-e-clima/piano-aria-clima

Natural Capital and Soft Mobility
This indicator looks at how green areas make an impact on enhancing or inhibiting the effective usability of soft mobility and slow travelling networks by guaranteeing (or not) adequate thermo-hygrometric comfort. Data that can be particularly insightful in this context are green data and data related to mobility (i.e. pedestrian-bike routes and stations). The combination of satellite data and data provided by the municipality on urban areas can be used to create heat maps and guarantees a fundamental element for a healthy use of the urban area, especially in consideration of the growing need to mitigate the effects of climate change.

Natural Capital and Health
The second indicator analyses how green areas make an impact on mitigating risk health, for example, by contributing to reducing body overheating and heat-related illness, focusing on the most fragile cohorts of the society (young and/or old people) especially. The preferred type of data to perform this analysis consists in green data and demographic data. The aim is to identify the most critical urban areas from this point of view, considering the heat islands, the age of the population that resides there and the amount of existing greenery.

Natural Capital and Social Cohesion
The third indicator aims at understanding how natural capital can make an impact on enhancing or inhibiting people's sociality, in terms of socio-cultural events and/or activities organization, such as shared urban gardens. This analysis will be performed through the combination of satellite open data to detect effective usability of green areas and statistical demographic data.

3.2 Naples: Strategies to Monitor Urban Regeneration and Planification

3.2.1 Overview

Urban regeneration is a crucial aspect of modern city planning, and the city of Naples is no exception. The Napoli pilot within the SPOTTED project aims to use satellite images to create thematic maps for analysing and continuously monitoring urban regeneration strategies.

The Municipality of Naples is an example of digital transformation on a city-wide scale. The Napoli pilot project seeks to detect, analyse, and monitor the city's green capital while evaluating the urban, social, and economic implications associated with green transformation initiatives—those already implemented or in planning phases. To this end, a technological platform and tools that serve as a decision support mechanism for policymakers are being developed. SPOTTED envisions data and analyses to be utilised in urban planning, aligning with the strategy for urban regeneration through environmental revitalisation interventions, as outlined in the Urban City Plan (PUC). It also includes specific tools for the management of urban green assets (green capital), including the measurement of impacts on soil, air, human health, and environmental risk.

The objectives of the Napoli pilot project are in alignment with the municipality's higher-level planning processes, particularly the **"Napoli 2019-2030 preliminary urban masterplan,"** which encompasses five key drivers: attractiveness, accessibility, inclusivity, sustainability, and productivity.

3.2.2 Specific Objectives and Expected Results

The Naples pilot project, leveraging on projects already underway such as **Urban City Plan (PUC)** and **Sustainable Mobility Urban Plan (PUMS)** as well as the **Sustainable Energy and Climate plan (PAESC)** with specific actions on urban regeneration, focuses on the use of satellite images to create **multi-temporal and multi-parameter thematic maps** for a thorough analysis of the starting point of the actions and for a **constant and continuous monitoring** of the achievement of the identified objectives. In addition to these overarching plans, the Napoli pilot organises data and analysis to feed into specific sector plans and regulations related to green management, namely:

- **Green Plan (Piano del Verde):** An urban strategy for safeguarding and enhancing green capital, addressing climate change-related risks, and offering solutions for green capital management.
- **Regulation on Green Capital (Regolamento del Verde Urbano):** Governing procedures for private green authorisations, public park management, and general maintenance of green capital in the city.
- **Updated Management Plans in Landscape Parks:** Informing urban planning rules for public open spaces and assisting project engineers in choosing sustainable solutions with positive impacts.

We can already see some of the benefits the city is reaping from the integration of SPOTTED in these key planning activities. The participation of Naples in the project prompted the involvement in research activities to determine what are key indicators to consider. The development of a set of climate indicators related to heat island effect and extreme precipitation combined with the identification of risks, have supported the implementation of the PAESC, and the environmental report of the preliminary PUC. The static framework and risk-assessment crystallized in the acts of the administration must develop into a monitoring system and decision support system through the use of updated imagery coupled with the analysis derived from the digital services of SPOTTED, to inform and evaluate public decisions.

3.3 Helsinki: sustainability of tourism and urban planning

3.3.1 Overview

In the city of Helsinki, the SPOTTED pilot is primarily concerned with monitoring the status of urban green areas and sustainability of tourism. The Helsinki pilot embodies a vision where technology and nature converge for the betterment of urban life. The pilot holds the potential to generate a range of valuable data products for enhancing urban planning and green area maintenance. The Green Index, for instance, offers insights into vegetation changes, while the

project's ability to detect urban forests and meadows potentially streamlines maintenance efforts. The project aspires to foster proactive environmental stewardship by demonstrating how seemingly conflicting goals, such as tourism and ecological preservation, can coexist harmoniously with the right policies and strategies. The goal is to ensure that the growing number of tourists visiting the city every year, do not harm the long-term ecological viability of Helsinki region.

The project also contributes to the city's urban climate adaptation goals by monitoring the Urban Heat Island effect and land surface temperatures. Data products produced in the project, aim to assist in the assessment of changes following maintenance efforts, turning satellite data into valuable tool for environmental management.

In various departments of the city's organisation the specialists have needs and interests to get more accurate time series information and analyses e.g., about the change of the green areas and vegetation in the urban areas. The needs and focus vary from a tree level to overall understanding of the green index in the city. One of the City of Helsinki's goals is to preserve as many trees and greenery as possible in any urban development and transportation projects.

The Helsinki pilot cooperates with numerous national research organisations (e.g. Luke - Natural Resources Institute Finland and Syke – Finnish Environmental Institute) which are specialised to observe environmental and ecological sustainability using satellite data.https://www.luke.fi/en However, so far, they are more experienced on monitor non-urban areas. They have deep and specialised expertise to use and analyse the satellite data and combine various data sources to undertake more complex and advanced analyses. This kind of specialised expertise is rare inside the city and the lack of resources and data analysis capabilities are limiting the capacity to utilise raw satellite data as such.

3.3.1 Specific Objectives and expected results

At its core, the Helsinki pilot is driven by a set of visionary goals. First and foremost, it seeks to monitor the sustainability of nature tourism and maintain the **Urban Green Index** through advanced satellite imagery analysis. The Urban Green Index quantifies the ratio of green space in relation to the total public area, offering insights into spatial and temporal changes in vegetation patterns.

The Green Index is well aligned with Helsinki's climate objectives and nature conservation mentioned in the City Strategy 2021 – 2025. Helsinki is aiming to became carbon neutral by 2030, reduce risk of flooding, and mitigate the urban heat which all can be fostered by planting more trees and increase green areas (part of the Climate change adaptation plan). In addition, Helsinki has set an objective to ensure that every resident lives in close proximity to nature.

From the tourism perspective, Helsinki will continue the development its maritime environment with improvements to connections, waterfronts, piers and base camps as well as preserving the Baltic Sea and its shoreline. Developing tourism sustainably, the city requires data products that can help in planning but foremost in monitoring and managing sensitive nature areas.

The Helsinki pilot focuses on these objectives:

- **Data-driven urban planning**: By providing urban planners with data-driven insights, the project enables informed decision-making regarding planning and management of urban green areas.
- **Climate resilience:** The project aims to mitigate climate change-related impacts, including flood risk reduction, urban heat stress alleviation, and climate adaptation. By monitoring fluctuations in disaster indicators and negative effects of climate change, the project enhances awareness and preparedness.
- **Preservation of green spaces:** As global temperatures change; this will come even more important for both mitigation and adaption purposes. The establishment of new protected areas and ability to monitor the status and potential changes in both urban vegetation and natural areas are vital for building greener cities. Through satellite data collection, policymakers gain insights into the potential effects of their policies on nature.

The Helsinki SPOTTED pilot project is a testament to Helsinki's commitment to sustainable urban development. While growing city and climate change pose critical challenges for management and maintenance of urban green areas, the potential benefits of utilising satellite data for environmental preservation, informed planning, and climate resilience are substantial. SPOTTED project is a prime example of the city of Helsinki’s ambitious commitments for building greener and more resilient cities.

3.4 Satellite Data Applications in the Pilot

As highlighted throughout this brief, satellite imagery is increasingly used to study and develop targeted policies on the interactions between human activities and the environment, boosting green economic development and improving social life.

In particular, the innovation of SPOTTED is mainly focused on the integration of big data coming from different data sources and geo-visual data with the related analysis to build added-value services, enabling the reuse of public data, to improve the management of green areas. In this scenario, the involvement of local administrations and the availability of their open datasets pave the way to new policy-making decisions.

For a comprehensive description of the type of satellite data usage, their collection and the policy implications the authors recommend reading the paper *“Leveraging cloud based geospatial data to enhance public services”* by Antonio Filograna, Giovanni Giacco and Giuseppe Di Caprio.

4. Policy Recommendations for Future Green Area Management

The SPOTTED project embodies a forward-looking approach to urban management, where technology and data converge to create smarter, greener, and more resilient cities. The transformative pilots in Naples, Helsinki, and Milan exemplify the potential of satellite

technology, AI-driven data analysis, and innovative approaches to green area management. As we move forward into an era marked by both rapid urbanisation and growing environmental concerns, the lessons learned from these pilots serve as an example for future green area management policies. The pilots underpin the importance of a sustainable urban planning that prioritises the preservation and enhancement of our green areas, ensuring a healthier and more vibrant future for urban dwellers across the European Union and beyond.

The sustainable development of urban areas has become an increasingly complex challenge in today's world. Urban green spaces, vital for enhancing the quality of life in cities, face various demands and pressures. These spaces are not only essential for ecological balance but also contribute significantly to the well-being of urban communities. To navigate the complexities surrounding urban greenery and to make informed decisions, cities need comprehensive insights. While satellite data holds tremendous promise for providing these insights, it is often underutilised in urban planning compared to other Earth observation methods.

4.1 Leveraging insights from SPOTTED pilots

This section of the policy brief presents a strategic framework for cities to maximise the potential of satellite data in managing urban greenery and promoting sustainable urban development. It highlights the importance of **co-creation with local stakeholders**, **showcases satellite data's unique advantages**, advocates for **integration with other Earth observation methods**, and **addresses challenges in accessibility and usability**. By embracing these strategies, cities can harness the power of satellite data to create greener, more resilient, and sustainable urban environments.

4.1.1 Co-creation in Urban Greenery Projects

One of the fundamental challenges in utilising satellite data effectively for urban greenery management lies in the varied perspectives and priorities of different stakeholders. Urban greenery encompasses a diverse array of elements, from parks and forests to green roofs and community gardens, and its value can be perceived differently by various interest groups, such as city officials, environmentalists, residents, and businesses. For urban planners and environmentalists, it may signify biodiversity preservation and climate resilience. For developers, it might represent potential construction sites. Residents might see it as spaces for leisure and recreation. These diverse perspectives can create challenges in decision-making, as consensus becomes critical.

To address this issue, a crucial step is fostering co-creation among stakeholders. Co-creation involves actively involving all relevant parties in the decision-making process, encouraging them to collaboratively define the goals, strategies, and indicators for urban greenery management. This participatory approach allows for the creation of a shared vision that accommodates the diverse perspectives and priorities of different stakeholders.

The SPOTTED project recognises the need for co-creation and clear definitions, especially in collaboration with local stakeholders, to harmonise these differing viewpoints. Through a collaborative approach, cities can build a shared understanding of urban greenery, fostering consensus on its management and utilisation.

4.1.2. Unlocking the Potential of Satellite Data in Urban Decision-Making

Despite its potential, satellite data is often underused in operational decision-making compared to methods like drones and aerial imagery. Incorporating satellite data effectively into urban decision-making processes can be a transformative endeavour. It's essential to highlight the unique advantages that satellite data offers compared to other remote sensing and Earth observation methods, such as drones and aerial imagery. Satellite data provides distinct advantages when it comes to large-scale urban monitoring and decision-making.

For instance, satellites can capture data over vast urban areas, offering a comprehensive view that drones or aerial imagery might struggle to achieve cost-effectively. This broad coverage is particularly valuable for assessing urban greenery on a city-wide or regional scale. Moreover, satellites offer the capability for regular and consistent monitoring, providing time-series data that allow urban planners to track changes and trends over time. This is crucial for decision-making related to long-term urban development and environmental sustainability. Lastly, while drones and aerial surveys have their merits, they can be expensive and logistically challenging to deploy frequently over large urban areas. Satellite data, on the other hand, is generally more accessible and cost-efficient, making it a practical choice for ongoing monitoring.

Importantly, satellite data can offer valuable insights into a range of urban decisions, including but not limited to:

Urban Heat Island Analysis: satellite data is particularly useful for assessing urban heat islands, which are areas with higher temperatures than their surrounding regions. This information can inform strategies for mitigating heat stress and optimising urban greenery to cool down these areas.

Large-Scale Urban Greenery Analysis: assessing the extent and health of urban green spaces on a city-wide scale is a complex task. Satellite data, with its broad coverage, can provide comprehensive insights into the distribution and condition of urban greenery.

Green Roof Potential: satellite data can assist in identifying suitable locations for green roofs, which can enhance urban greenery and provide multiple benefits, including energy efficiency and stormwater management.

Land Cover/Use Changes: monitoring changes in land cover and land use is critical for sustainable urban planning. Satellite data can help detect shifts in urban development patterns and guide decision-making regarding land use policies.

Solar Potential: assessing the solar potential of urban areas is essential for renewable energy planning. Satellite data can identify rooftops and open spaces with the greatest solar exposure, aiding in the development of solar energy projects.

SPOTTED pushes cities to explore specific scenarios where satellite data excels. For instance, satellite data offers unparalleled advantages in analysing urban heat islands, assessing urban green infrastructure quality and quantity, and evaluating the feasibility of

green roofs. By leveraging these applications, cities can unlock satellite data's potential to provide valuable insights for informed urban decisions.

4.1.3 Integration of Satellite Data with Other Earth Observation Methods

The utilisation of satellite data in isolation is valuable, but its potential is exponentially increased when integrated with other Earth observation methods and high-value datasets. Satellite data offers a unique perspective due to its wide spatial coverage, frequent revisits, and consistent data collection over time. However, to extract the most valuable insights, it should be considered a component within a broader Earth observation ecosystem.

One pivotal aspect of this integration is linking satellite data with other high-value datasets. These high-value datasets encompass various types of information, from urban infrastructure records to socio-economic data. When integrated with satellite data, they provide a more comprehensive understanding of urban greenery and its impact on cities.

For instance, combining satellite data with urban infrastructure records can enable cities to assess the correlation between green spaces and factors like temperature regulation, flood risk mitigation, and air quality improvement. This integration empowers cities to make data-informed decisions about where and how to invest in urban greenery to maximise its benefits. Moreover, merging socio-economic data with satellite observations offers a holistic view of the societal impact of green spaces. It allows cities to evaluate how urban greenery contributes to residents' well-being, economic opportunities, and overall quality of life. This multidimensional perspective can help prioritise green initiatives that align with a city's social and economic goals.

In practice, linking satellite data with high-value datasets necessitates robust data infrastructure and interoperable systems. Cities should invest in platforms, such as SPOTTED, that facilitate data integration, harmonisation, and analysis. By establishing these linkages and promoting data-sharing mechanisms, cities can uncover valuable insights that drive evidence-based urban greenery management and sustainable urban planning.

4.1.4 Leveraging Satellite Data for Time Series and Wider Spatial Coverage

Satellite data excels in providing time series information, allowing for the continuous monitoring of environmental conditions over time. This capability is especially valuable for assessing the health and changes in forests and green areas. It enables urban planners to identify trends and respond to environmental challenges more effectively. Additionally, satellite data offers unparalleled spatial coverage, which is challenging to achieve through other means like drones or ground-based sensors. This wider spatial coverage is particularly advantageous for large and complex urban areas, where collecting data manually would be resource-intensive and time-consuming.

Satellite data offers a consistent and standardized means of observation. This uniformity ensures that changes observed in the time series are due to actual events or phenomena rather than inconsistencies in data collection methods.

4.1.5 Overcoming Challenges: Accessibility and Utilisation of Satellite Data

While the potential of satellite data is immense, its widespread utilization encounters several challenges. One significant hurdle is ensuring accessibility, particularly for cities with limited resources or technical expertise. Many municipalities face difficulties in procuring and interpreting satellite imagery due to cost constraints and the need for specialized skills. This issue is compounded by the fact that satellite data is often part of a broader ecosystem of geospatial information, which necessitates integration with existing datasets. Bridging this gap demands concerted efforts to provide cities with pre-analysed, readily accessible satellite data that aligns with their specific urban planning needs.

The challenges extend beyond the public sector; the private sector also grapples with similar issues. Small and medium-sized enterprises (SMEs), in particular, may find it financially burdensome to access high-quality satellite data for their ventures. Additionally, for businesses to effectively utilize this data, they require expertise in geospatial analysis and the necessary infrastructure for processing and interpretation. Overcoming these obstacles necessitates collaborative efforts between governments, private sector stakeholders, and research institutions. This could involve the establishment of data-sharing partnerships, capacity-building programs, and the development of user-friendly tools and platforms. By the same token, making available repositories of best practices for the re-use of satellite data by SMEs and other organizations will increase the awareness by economic operators and citizens in general. By addressing these challenges collectively, cities and private enterprises can unlock the full potential of satellite data for sustainable urban development.

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Co-financed by the Connecting Europe Facility of the European Union.

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