EO-based Smart City Decision Support Services for Integrated Urban Governance: the DECUMANUS Project

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1 ABSTRACT

Urbanization is a fundamental force of change and in Europe has underpinned the flourishing of civilization for millennia. However, the 21st-century is also witnessing the impact of other societal challenges, including climate change adaptation, and mitigation, as well as the need to secure the efficient utilisation of finite resources. These societal challenges are impacting not only the social fabric of urban life, and the economy of cities, but also the civil quality of urban environments throughout Europe.

It is clear that if properly governed cities can become a major part of the solutions to the growing threat of these urban challenges, and so can become economically vital, culturally vibrant, and healthy environments delivering first-class quality of life for hundreds of millions of city dwellers throughout Europe. Nonetheless, the challenge of urban governance is immense, and must address the complex and interconnected reality of urban systems to secure a proper balance between the socio-economic and environmental dynamics of urban areas.

The key to effective governance of cities is the generation of the necessary intelligence to inform decision-making by city administrations and politicians, to guide urban policy making and implementation, and to inform and engage all citizens in the delivery of sustainable urban development. DECUMANUS (DEvelopment and Consolidation of geo-spatial sUstainability services for adaptation and environmental and cliMAte chaNge Urban impactS) underpins this understanding that the delivery of more sustainable cities requires the application of enhanced intelligence in urban management, to produce an effective basis for assessment of urban complexity and decision-making. The enhanced services proposed by DECUMANUS offer the potential to provide urban planners with the tools and intelligence that allow city managers to deploy geo-spatial products in the development and implementation of their climate change strategies, and more generally in meeting the diverse challenges of sustainable urban development.

2 URBAN PLANNING PERSPECTIVES – INTEGRATED URBAN GOVERNANCE

Effective governance of the cities and city regions of Europe today is fundamentally undermined by urban complexity, whereby the high degree of interconnectedness and multiple interactions between socioeconomic and environmental factors in a territorial context create major barriers to the effective implementation of sustainable urban development. In response to this interconnectedness and complexity, the principles for integrated urban governance have become the pre-eminent framework for the development of appropriate policy responses to urban challenges.

Two fundamental poles of this integrated policy response concern first, the horizontal policy integration necessary between the sectoral agencies responsibilities for land-use management, transport and environmental planning, at the local and regional levels of governance. Horizontal integration demonstrates the need for integrated inter-sectoral, inter-departmental collaborations regarding the specification and implementation of policy and territorial decision making at city-region scale. Failure to secure an integrated policy response is attributed to variety of factors including notably organizational and procedural barriers to achieve active coordination, as well as problems of communication between organisations, frequently linked the lack of common intelligence and monitoring information on urban issues.

The second dimension of policy integration concerns vertical coordination between agencies responsible for policy delivery at local, regional, national and EU levels. Vertical integration supports the development of planning strategies that are specified and implemented simultaneously at different levels of governance, with impacts monitored at both city-region and EU levels. Similar factors to those identified in the horizontal perspective, are equally applicable in the vertical dimension, emphasising the need for a common understanding of urban challenges at all levels of governance.

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Common understanding of urban challenges requires effective monitoring of the pressures, state and impacts at the urban level, as well as the effectiveness of policy responses in controlling urban development. The key to effective governance of cities is the generation and application of enhanced intelligence to inform decision-making by politicians, to guide urban policy making and implementation, and to inform and engage all citizens in the delivery of sustainable urban development. Thereby, the governance of cities is a collective effort requiring joint initiative between planning and management agencies from EU to local level, clear coordination between a variety of agencies at the local level, as well as critical inputs from all stakeholder groups including citizens. Accordingly urban governance addresses the fundamental needs of all citizens for sustainable urban futures, as well as the key components of the political priorities of the European Union as defined by the framework policies of Europe 2020 and the Lisbon agenda, as well as those specifically targeting sustainable urban development.

3 DECUMANUS SERVICES

In response to these demands and to support effective integrated urban governance, the DECUMANUS project aims to provide enhanced integrated urban intelligence and so develop a more effective governance of the cities of Europe. These services are focused on providing information that allows urban decision-makers to understand the problems identified and deploy tools to mitigate the climate change and environmental impacts in cities, including land monitoring services targeting urban change and urban ecosystems; provision of information related to building energy efficiency, citizen awareness and health services related to air quality, heat wave and urban heat island, etc. The DECUMANUS services aim to make more effective use of existing vast data sources, including in situ measurement of environmental variables and the socio-economic characteristics of the city, by combining with innovative Earth observation (EO) derived data driven applications. Furthermore, development of integrated governance tools is critically dependent on end user requirements, and review of the added value potentials of new applications. Accordingly all DECUMANUS applications are developed in full collaboration with urban planning agencies in the partner cities of Helsinki, Antwerp, Madrid, Milan and the Royal Borrough of Kensington and Chelsea (RBKC) in London. The DECUMANUS business model is based on two services levels, according to considerations of scale and detail: Strategic Services (large scale, based on freely available data) and Local Service (local scale, on demand, based on local input data)

3.1 Land Monitoring Service

The DECUMANUS Land Monitoring Service provides novel Earth observation (EO) based products which reliably characterize built-up and paved surfaces, as well as urban green areas. In particular, they allow urban planners to better understand, assess and take action on climate change at both the regional and local levels. Currently, similar land monitoring products are generally extremely costly and time demanding for the municipalities as they are mostly produced by photointerpretation of very high resolution airborne imagery or in situ surveys by experts. Instead, the implemented services rely on completely automatic algorithms where the support of an operator is eventually required only at the end of the processing chain to visually check the outputs. This results in significantly lower costs and shorter production times, but also allows an easy and straightforward update once supplied with new suitable input data.

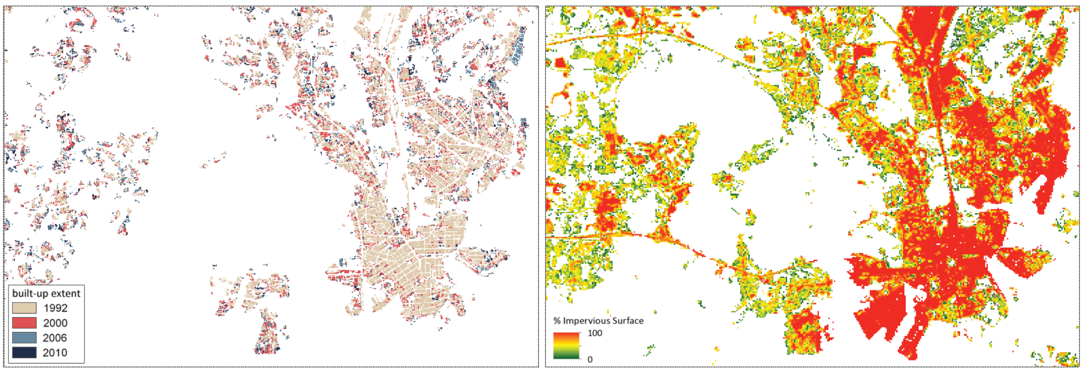

Fig. 1: Helsinki – extent of built-up growth (left) and 2014 percentage of impervious surface (right) for an area including the city center.

With the Strategic Services, urban planners are provided with key information about the temporal growth of built-up areas along with the extent of impervious surfaces (Figure 1 above).

Local Services supply maps of current and potential green roofs, along with the corresponding expected impact (estimated analyzing the local imperviousness) as well as tree locations and their canopy coverage (Figure 2 below). This suite of products is of great value in improving mitigation and adaptation planning strategies aimed at reducing stormwater runoff (which transports toxic chemicals, dirt and rubbish from roofs and roads into lakes, streams and rivers, and also leads to increased occurrence of urban flooding events), lowering air pollution (which is responsible for a variety of respiratory and cardiovascular conditions), mitigating the urban heat island effect (which causes high-energy consumption for cooling, and an increase of heat-related illness and fatalities), as well as enhancing the wellbeing and quality of life of urban residents. As an example, among the ~40.000 buildings in the RBKC, currently 600 (i.e., 1.5%) already mount a green roof, but about 19.000 (i.e., 47.5%) exhibit geometrical features suitable for their installation.

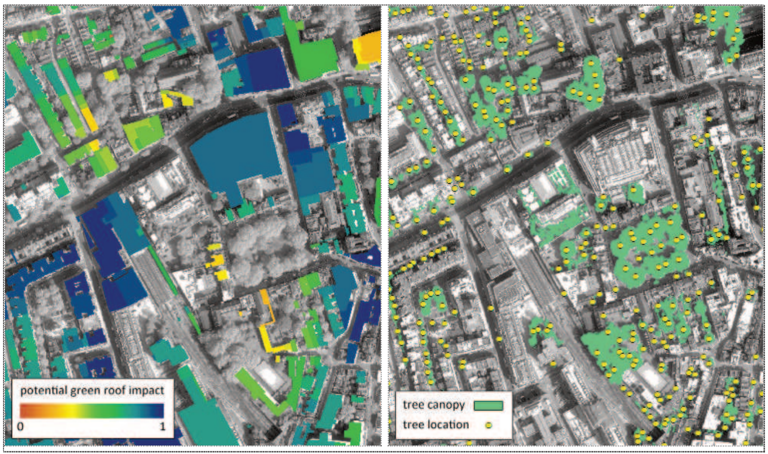

Fig. 2: London – estimated impact of identified potential green roofs (left), tree canopy coverage and tree locations (right) derived for part of the RBKC.

3.2 City Energy Efficiency Service

The DECUMANUS City Energy Efficiency Service enables detection of heat loss from building roofs (~30% of all energy losses for a standard house) and excessive lighting (night-time emissions). The Service can be used by city planners as policy support for large-scale retrofitting campaigns, and also to alert citizens to the benefits of saving energy.

The Strategic Service is derived from satellite data, while the Local Service requires the acquisition of specific data, such as aerial data. The broader resolution of the strategic products makes them useful for analysis at a neighborhood scale (several building blocks) and for inter-city comparisons (Figure 3). On the other hand, the high-resolution local products provide enough details to detect, and moreover to identify energy losses at a building and a street light scale. These characteristics of strategic and local products make their uses complementary.

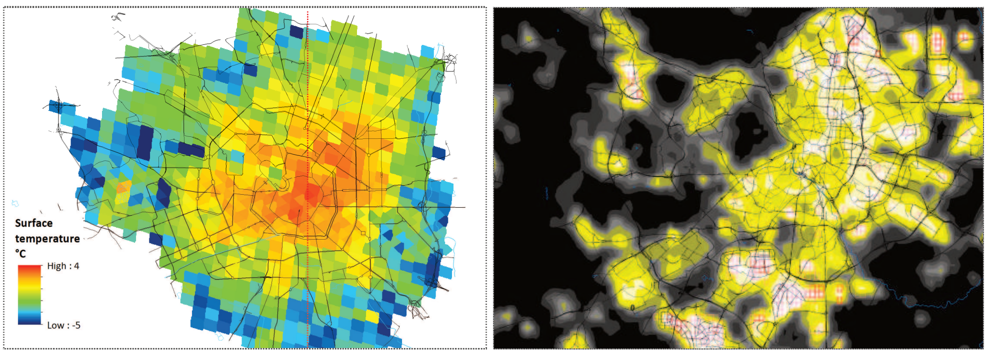

Fig. 3: Milan – heat loss map (750 m resolution) based on night-time satellite acquisition (Landsat-8 and Suomi-NPP data) (left) and light emission (375 m resolution) detecting light spots at neighbourhood scale (several building blocks) (right)

Furthermore, a Local Service evaluates the photovoltaic potential of each building (Figure 4). This service uses high resolution terrain data and a solar model to identify areas suitable for the installation of solar panels and to evaluate potential electricity yield (Figure 4).

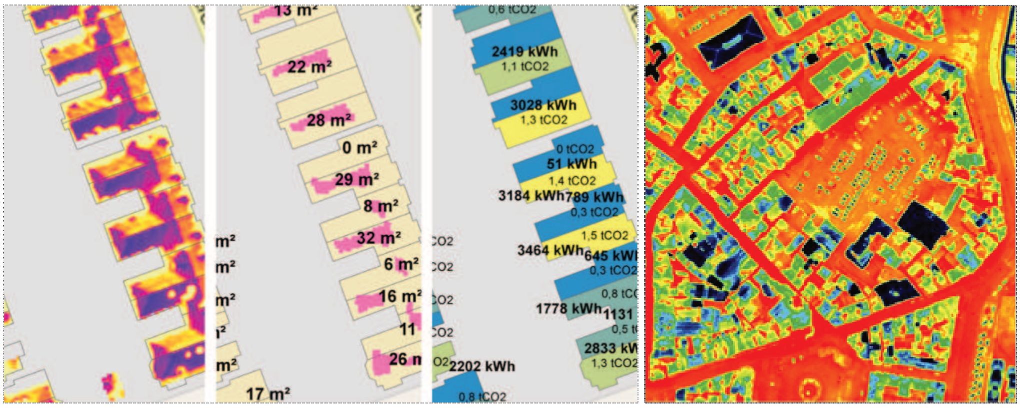

Fig. 4: London – photovoltaic potential maps derived for part of the Royal Borough of Kensington and Chelsea (left) and high resolution (50 cm) heat loss map based on aerial thermography in Helsinki (blue = very good to red = very bad) (right)

With the Strategic Service, city planners are able to locate neighbourhoods with anomalously high energy losses from building roofs. It enables also to detect city light spots at a neighbourhood scale, and to monitor street lights over time. By doing so, the service can be used as evidence-based policy support for large-scale retrofitting campaigns across the city (i.e. conversion to LED lights).

With the Local Service, city planners can launch campaigns among their citizens to encourage the improvement of their roof insulation (using aerial thermography) and the installation of solar panels. Each citizen is able to verify the quality of their roof insulation on a map, as well as the suitable areas for the installation of solar panels and the corresponding potential electricity yield. This allows for estimations regarding potential areas for energy savings. By using their full photovoltaic potential, rooftop solar panels could, for example, cover between 14% (Helsinki) to 30% (Madrid) of yearly electricity consumption.

		Buildings			**Suitable area**		**Potential electricity yield**		**CO2 Savings per City (kCO2/year)**	**Current Electricity consumption per City**	
	Area (km²)	Number	Area total (km²)	Number suitable	Total (km²)	Average by roof (m²)	Total (GWh/year)	Mean by roof (kWh/year)		GWh/year	**Solar potential in % of current consumption**
ANTWERP	204,3	157.843	27	107.396	10	66	1.163	7368	227.615	6000	19%
HELSINKI	765,6	261.409	40	114.454	17	66	1.870	7154	356.763	13200	14%
MADRID	604,4	498.534	50	333.062	26	51	4.465	8956	1.299.250	15125	30%

Moreover, the service can be used by the city planners to make an overall evaluation of the street lighting network (using aerial data). The luminance values are compared to European standards to detect over-exposed areas and thus potential areas for energy savings.

3.3 Population Impact Assessment

The DECUMANUS Population Impact Assessment Service analyses the impact of climate change scenarios for both the night (residential) and the day-time populations. The products are based on freely available EO-based land cover and land use data (Strategic Service) and locally-provided data from the cities (Local Service) to refine available census information and so the spatial distribution of the population (Figure 5 below). Knowing, for example, the type of urban fabric (residential or non-residential) or the number of commuters and work places can permit very detailed population estimates both during the night as well as the day.

From the DECUMANUS services, city planners can get a better understanding of where people are located in the night and day, the real scale of commuting, and the locations of the main concentrations of population. Accordingly, city planners can derive new information on the extent of population exposed to climatic impacts such as poor air quality, floods, storm waters, heatwaves and sea level rise. This information can then be used to support effective climate change adaptation and mitigation. In the case of Helsinki, especially sea level rise will have a tremendous impact on the population in the Metropolitan Area. With the developed service not only the most affected areas and the number of affected building can be detected, but also the number of potentially affected population. Such information is of major importance for urban planners, especially to support climate change adaption and mitigation strategies.

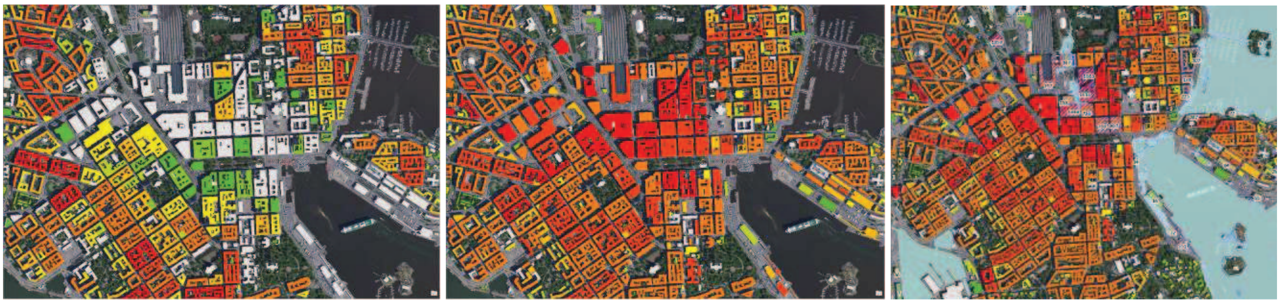

Fig. 5: Helsinki – The maps show three different Local Service outcomes. The first and the second image show the night- and day-time differences of the population in the area of the Helsinki central station. The third image shows the potential impact of a 250 year sea flood event for the population per building.

HELSINKI		Potentially affected buildings			Potentially affected people (night)			Potentially affected people (day)		
		20 year flood event	100 year flood event	250 year flood event	20 year flood event	100 year flood event	250 year flood event	20 year flood event	100 year flood event	250 year flood event
	River flood	497	697	745	427	1.475	2.111	1.100	1.984	2.345
	Sea flood	1.722	2.528	3.058	4.939	8.806	12.343	14.754	25.677	33.698

Beyond the scope of the project, the service can furthermore be used for traffic or public transport planning, geo-marketing, the creation of emergency/evacuation plans or the calculation of health effects on the population e.g. at street level. Additionally, depending on data availability, demographic data can be used to further refine these datasets in respect of , for example, a focus on elderly or children.

4 CONCLUSION

DECUMANUS tools and methodologies reviewed above are supporting the development of a new integrated, hugely more powerful and effective urban governance, creating the expectation that the most intractable urban planning issues, including the management of the vast complexity of urban interactions, evident as city living specified in socio-economic activity, can be managed within both environmental limits and the territorial frame. Ongoing validation activities in cooperation with the project partner cities to assess the accuracy of the corresponding EO-based products, confirms their great potential for supporting sustainable urban development strategies both at district and local level.

Full realisation of the vision of an integrated and necessarily transformational governance is critically dependent on end-user engagement in system redesign and intelligence requirement specification, as the system of urban governance cannot be transformed effectively and appropriately on the basis of systems re-engineering alone. DECUMANUS city partners support these objectives, providing end user specifications aligned with technological capacity to ensure effective solutions and effective urban management.

Realisation of transformational governance also requires greater stakeholder engagement in the urban planning process, as municipal experts providing a top-down view of the urban vision, and its local level specification, are no longer able to manage the inherent complexity of the sustainable city alone. Greater bottom-up stakeholder engagement thereby secures the quality of integrated assessment necessary to effectively plan the modern city, providing inputs in respect of the political diversity of views on the best way forward, all essential to secure the democratic legitimacy of the urban plan.

DECUMANUS tool and methdologies are simultaneously sources of intelligence, and means of communication, and so perform vital roles in supporting bottom-up engagement in the planning process as an essential complement of the top-down municipal system of guidance.

DECUMANUS therefore has the potential to drive new experiments in the co-design and co-production of plans, in which technological opportunity including social media allied to other ICT dynamics, such as mobile technologies supporting citizen science, has significantly enlivened the dynamic of governance development supporting more effective integrated urban governance.

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