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DRAFT TECHNICAL PAPER //

Local and Regional Digital Indicators (LORDI)

A methodology framework for local indicator collection

Draft Technical paper version// February 2024

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Abbreviations

LORDI	Local and Regional Digital Indicators
LORDIMAS	Local and Regional Digital Maturity Assessment
EC	European Commission
CoR	The European Committee of the Regions
OECD	Organisation for Economic Co-operation and Development
EU	European Union
EFTA	European Free Trade Agreement
UN	The United Nations

Foreword by Martin Gauk

Digital transformation and scaling up digital innovation are the some of the key topics in the EU, its Member States, regions, cities, and communities. It is one of the central elements of the new Cohesion policy, the European Digital Decade, the Strategic Agenda of the new EU Commission and global commitments such as the Sustainable Development Goals.

Within the next programming period, different actors across Europe and beyond will invest billions of euros to benefit from and accelerate the revolution, to support the roll-out of the Digital Single Market and to help our cities and communities recover from the economic crisis, build resilience, and meet their climate targets and reduce their environmental footprint, while fostering citizen participation and bringing prosperity to all types of business, including SMEs and start-ups.

Even though the technological revolution holds great promise, the transformation can take many paths. It can make our continent more prosperous, competitive, just, and green, if to be driven by the voices of citizens and local communities and delivered under fair market terms. But it may also increase inequalities, inefficiencies, decrease opportunities and infringe upon many values we currently uphold if left to be shaped unchecked by the powerful global dynamics. The success of this transformation lies on local and regional communities and governments, and their capacity to manage this change. Largely, through multi-level governance mechanisms and cooperation with other actors from other cities, regions, countries, and the EU; within a common market, through joint agreements, investments, and projects. So far, the main beneficiaries of this digital revolution have been the most open and agile cities and communities with a strong vision, leadership, networks, and collaborative mindsets. While these pioneers and early adopters praise the positive impact of digitalisation, large scale holistic uptake and upscale remains slow and uneven across the continent.

LORDI – Local and Regional Digital Indicators - aims to support digital transformation efforts across Europe by providing the methodology and indicator framework to analyse what is happening on the subnational level, to help different cities and communities benchmark themselves with others to develop better policies and actions. Through a holistic monitoring framework, it can help to steer the relevant policies, commitments, and actions across Europe.

Martin Gauk,
Data and Knowledge Portal Manager, ESPON

1 LORDI

The Local and Regional Digital Indicators (LORDI) is a collaborative effort led by ESPON, the European Commission and the Committee of the Regions to develop a methodology and indicator framework to support policy makers, businesses, and citizens to better understand digital transformation at regional and local levels across Europe.

LORDI has a pan-European perspective, inspired by the common values reflected in the myriad of policies, actions, initiatives and best practices surrounding the topics around digital transformation. It aims to support the achievement of the objectives of the Digital Decade and the scaling up of digital transformation across Europe. In addition, it tries to match the overarching EU-wide goals with the operational needs and priorities of coming from the regional and local levels. The indicator framework offers close to 200 indicators that are divided into four main categories which are inspired by the targets of the Digital Decade:

- Digital Infrastructures
- Digital Skills
- Digital Economy
- Digital Government

While LORDI provides, in its inception, a viable framework for data collection across these key areas, we have only started to collect the data for the Digital Government dimension. For this, we have developed a self-assessment methodology and a tool called LORDIMAS – Local and Regional Digital Maturity Assessment that enables subnational governments to provide their inputs to see where they position in their digital transformation journey. The tool is accessible via: https://lordimas.espon.eu.

The LORDI performance measurement framework and LORDIMAS self-assessment tool are developed through desk research and expert consultations, and validated together with the cities and key stakeholders, mainly within the Monitoring and Measuring working group within the Living-in.eu[1] movement.

This is a living document, where we make a consistent effort to test the different approaches and indicators proposed and plan to expand/scrutinise the list.

1.1 The need for better metrics

1.1.1 Measuring digital transformation in regions, cities and communities' matters, but it is troublesome

Good metrics can direct better policies. To promote digital transformation and the scaling up of digital innovation in regions, cities and communities, we need to know what works, what doesn't and why. And that means turning to measurements and metrics.

A recent McKinsey study on digital transformation success[2] discovered that without extensive metrics, organisations might be able to achieve temporary improvements, but will find themselves unable to sustain them in the long-term. The study noted that to make success permanent, the first step is the adoption of digital tools that improve the accessibility of information across an organisation, which doubles the chance of a successful transformation. Pairing this with more frequent data-based decision making and a visible use of interactive tools can also improve the chances of a successful digital transformation initiative.

[1] https://living-in.eu/groups/commitments/monitoring-measuring

[2] Digital transformation survey results | McKinsey

The study found that organisations that were able to establish clear goals for key performance indicators, based on accurate data, were twice as likely to achieve transformation success over organisations that did not. Additionally, organisations that had clearly defined goals for its application of new technologies, improved their chances of success by 1.7 times. Additionally, these metrics must also be supported by real-time data, so organisations remain informed of how they are progressing.

But can we really measure the digital transformation and the uptake/upscale of digital innovation today? On a large scale and comparative manner? Are we doing it right? And are we able to do it right? Is the data there and are our metrics suitable?

Indicators have to account for many different forms of innovation, with widely differing motivations, processes of development and consequences. In the past it was possible to identify innovation within particular organizations, teams or individuals; nowadays innovation is more often networked among multiple contributors, which complicates its measurement.

Collecting data on to understand digital transformation is hampered by the desire to ensure indicators are simple, easily accessible, comparable across nations, and cheap to acquire and compute. And these requirements do not reflect the complex and often messy realities of the process, let alone capture whether the transformation has negative consequences, such as increasing inequalities and loss of jobs.

The move over the past 60 years from products to services to an increasingly experiential economy has changed the nature of research and development (R&D). Traditional measures of innovation and digital economy, such as R&D investment and patents, were fine when innovation mostly occurred in large manufacturing firms but are of limited value when much of the action lies in services, business models, and entrepreneurial start-ups, or when trying to understand how public policies, initiatives and investments at the EU or national level penetrate to the local levels or how best practices are adopted by peer organisations. Much innovation does not rely on traditional R&D investment and processes, and many innovations are not protected by formal intellectual property rights, but by the speed of changes and secrecy around them - and this makes them difficult to measure.

A great deal of expertise has been developed around innovation surveys that ask firms whether they innovate, and in what forms. The EU's Community Innovation Survey[3], for example, has coordinated national statistical agencies to collect extensive data on the innovativeness of EU regions and sectors. But self-reported innovations can be subjective and difficult to calibrate.

However, the complexity of measuring such innovations should not deter us from trying and here the LORDI framework intends to contribute to the discussions.

1.1.2 Problems with defining comparable units for analyses and matching these with data

What constitutes a region, city, or a community and how it is defined at national level is very different across Europe. Therefore, it is difficult to compare different regions, cities, towns, and rural communities with one another.

For example, in some of the EU and EFTA countries, regional administrative level doesn't exist, hence comparative statistical regions (eg NUTS[4]) do not have a matching governance structure associated. Also, comparing local administrations across countries is troublesome due to differences in how the territories are governed. This is especially visible when we try to distinguish cities[5] and towns[6]. In most countries, city/town status relies either on administrative designation in combination with population size thresholds (e.g. a municipality with over 50 000 inhabitants for cities) or only one of those parameters. If the administrative units are small in area, many places will drop below this size threshold - mostly small but densely built administrative units that otherwise display "typical city characteristics". If the units are very large in area, many will surpass the threshold, including rural areas around the cities that do not display "typical city characteristics", in

[3] https://ec.europa.eu/eurostat/web/microdata/community-innovation-survey

[4] https://ec.europa.eu/eurostat/web/nuts/history

[5] https://www.oecd.org/cfe/regionaldevelopment/THE%20EU-OECD%20DEFINITION%20OF%20A%20FUNCTIONAL%20URBAN%20AREA.pdf

[6] https://ec.europa.eu/regional_policy/information-sources/publications/working-papers/2023/towns-in-europe-a-technical-paper_en

terms of population/activity/service density and land use. This statistical distortion linked to the shape and scale of the spatial unit is a classic problem known as the modifiable areal unit problem (MAUP[7]).

To overcome this issue, a handful of sound approaches have been developed by EC, OECD and UN to define cities and towns and other types of functional and morphological settlement patterns independently from civil or administrative divisions, as referred in previous paragraph.

Whether we can agree with the definitions and territorial delineations or not, the problem with the availability, quality and comparability of the data remains. Public administrations are not necessarily collecting data on the same issues, using same methodologies, and ensuring comparability. Also, in many of the cases – this data – even when it exists, is hard to access without the "local" connections or knowledge. And there is very little statistics offered by international statistical organisations for local level. In addition, much of the comparisons must rely on self-reported or data that can be scraped from platforms, where the uncertainties or incompatibilities remain a considerable challenge.

1.1.3 Challenges with existing indicator frameworks

There are already a few indicator frameworks developed to measure digital transformation at local level but due to limitations of data, they are often too ambiguous. Given the reasoning above, comparable, and regularly updated information on the digital transformation on local level is hard to come by. Research and studies on digital transformation in cities are limited, particularly when it comes to studies that try to capture a pan-European picture. An index to annually measure different aspects of digitalisation of society and economy in European cities is missing so far.

Much of the current monitoring of digital transformation is carried out only at regional or national level only. For instance, the level and progress of Europe's digital performance is measured regularly, but only at the Member State level. EU member states' digital competitiveness is measured by the Digital Decade Indicators (formerly known as Digital Economy and Society Index - DESI[8]), a composite index summarising progress on connectivity, digital skills, use of internet by citizens, integration of digital technology by businesses and digital public services. In parallel, the annual eGovernment Benchmark[9] looks at the availability and usability of digital public services in EU Member States, indicates a need for improvement in transparency of public services delivery and use of supporting technologies like eIDs or eDocuments. Information digital economy and society can also be accessed at regional level. For example, through the Eurostat's ICT community surveys, OECD Regpat[10], ORBIS[11] and ORBIT[12] databases. Other indexes, some of these at sub-national level, such as the Global Entrepreneurship Index (GEDI); the Regional Entrepreneurship and Development (REDI); the Digital Entrepreneurship Monitor (DEM); the Atlas of ICT Poles of Excellence (EIPE); the IESE Cities in Motion Index; the Global Innovation Index (GII); the Compass / Startup Genome Global Startup Ecosystem Ranking; the Kauffman Index; the World Economic Forum Networked Readiness Index (NRI); the European Regional Economic Growth Index (E-REGI); Regional Innovation Scoreboard also contain useful information on digital transformation and innovation.

There have been some attempts to capture the digitalisation at city level. For example, OECD has measured innovation capacity in municipalities, NESTA composed a European Digital City Index (EDCI)[13] in 2015 and 2016 and European Digital Social Innovation Index (EDSCII)[14] in 2019 and the TUWIEN team has been sporadically measuring the performance of smart cities[15]. In addition, some groundwork has been laid out for the measurement of digitalisation at local level

[7] https://www.geographyrealm.com/modifiable-areal-unit-problem-gis/

[8] https://digital-decade-desi.digital-strategy.ec.europa.eu/

[9] https://digital-strategy.ec.europa.eu/en/library/egovernment-benchmark-2023

[10] https://www.oecd.org/sti/inno/intellectual-property-statistics-and-analysis.htm

[11] https://www.moodys.com/web/en/us/capabilities/company-reference-data/orbis.html

[12] https://www.questel.com/product-release/intelligence/

[13] https://www.nesta.org.uk/blog/edci-2016-updating-the-european-digital-city-index/

[14] https://www.nesta.org.uk/feature/european-digital-social-innovation-index/

[15] https://www.smart-cities.eu/

by recently concluded CITYKeys[16] project. CITYkeys developed and validated, with the aid of cities, key performance indicators and data collection procedures for the common and transparent monitoring as well as the comparability of smart city solutions across 5 European cities. Additional frameworks can also be found under different initiatives, such as the Digital Cities Challenge[17].

One of the major shortcomings of these local indexes have been the limited geographic coverage of these indexes – approximately 50-70 cities, which is not very representative on European scale. This is largely also due to the poor availability of the data at local level. Even though EDCI and EDSCII already rely on big data to a great extent, local level indexes are still relying mostly on regional and national data.

There is also an open question on the extent to which digitalisation should be analysed as a "standalone" process, or whether there should rather be a deeper integration into existing measurement frameworks, whether on innovation or other socio-economic developments. Some of these indexes tend to focus on specific dimensions only, for example connectivity or e-government, which makes it harder to envision truly impactful policies. Others have taken a broader "smart city" approach, where it is hard to differentiate in the end "digital" progress from the more generic socioeconomic/governance related progress.

1.1.4 New opportunities from combining different data and methods

Availability of big data and data science provide new opportunities for developing useful metrics for digital transformation. It is also welcoming to see, that international and national statistics offices and agencies such as Eurostat are exploring the ways in which new sources of data can complement and supplement their work. For example, by establishing agreements with big platforms such as Booking.com, TripAdvisor, Airbnb, and Expedia to provide more detailed insights on (digital) collaborative economy.

While there are concerns about the self-selecting and potentially unrepresentative nature of the information collected, data-scraping and analytical tools can be used to provide useful new and real-time insights into digital transition and innovation.

Furthermore, there is some valuable and highly relevant information that can only be collected via self-assessment surveys. They are often considered problematic and pose also a lot of challenges for the data collection process. However, it is still a necessary approach. Hence, we developed the LORDIMAS framework to capture the "Digital Government" dimension of the LORDI framework. ESPON piloted this approach though the DIGISER project, which was able to capture 250 cities in 2021[18]. This served as a valuable test case and input for the development of LORDI Digital Government indicators and the LORDIMAS tool.

As government policies have to be based upon, and directed towards improving the performance and practices of the new digital era, they need to be able to tap into real time data and new data sources. The way digital innovation occurs is changing - and so the indicators that measure it must respond to this new reality.

[16] https://cordis.europa.eu/project/id/646440

[17] https://www.intelligentcitieschallenge.eu/sites/default/files/2019-03/DCC%20Guide%20for%20Self%20Assessment%20Tool.pdf

[18] https://www.espon.eu/DIGISER

2 Methodology

In order to deliver comparable, policy relevant information to different types of actors at different geographical levels, LORDI local indicator framework aims to be robust, yet flexible, simple but meaningful. There are many challenges related to the data availability as well as with matching the different types of data with different analysis units, while ensuring sustainability, modularity as well as pan-European coverage.

2.1 Indicator development

2.1.1 Developing KPIs

In order to create meaningful KPIs for measuring digital transformation progress, LORDI will utilise its geographic reference framework to make use of as many different official datasets already available as well as tap into the big data potential. The focus in selecting the indicators relies on (universal) policy relevance, availability, reliability geographic coverage and accessibility.

Relevance to policy making is of key importance for the process. Therefore, the methodology is developed and validated together with stakeholders from cities across the EU to international organisations. Cooperation between the EU institutions (EC, CoR, EIB), international organisations (ESPON, OECD, OASC, EUROCITIES) and research institutions (NESTA, Polytechnic University of Milan, Connected Places Catapult etc), is especially relevant: many of them have committed themselves to better understand the digital transformation processes and are actively engaging in indicator collecting and methodology development. A joint approach would enable to save resources, pool the necessary expertise, and build upon the different competences, experiences and results the different organisations have access to.

In addition, cooperation with the data providers, both public and commercial, is also crucial. This ensures that we understand better the potential and the limitations of the different datasets and enables us to work on common frameworks when it comes to storing and giving access to data.

As the data availability through official data providers is very limited, LORDI will turn combine official statistics with other reliable sources, utilising both data mining techniques, APIs and also self-reported data by public administrations. Nevertheless, data needs to be scrutinised and temporal/geographical/participant bias addressed whenever necessary.

2.1.2 Developing context indicators

Even though many of the official public sources for comparable data for cities have limitations for measuring digital transformation, they are often still relevant for context, and background for meaningful comparisons. For cities, it would be useful to benchmark themselves not necessarily against the best performers, but against the cities that face similar territorial make up or challenges. For example: How is my city faring in terms of digital skills in comparison with other rapidly growing cities? How come ageing and shrinking is a big obstacle for developing digital public services due to limited resources in city X, but not in city Y, where they are facing the exact same challenges?

It will also allow cities to identify their peers while benchmarking and establishing cooperation projects to tackle similar challenges or learn from each other.

2.2 Geographic reference framework

LORDI indicators are potentially available and can be collected at different geographic scales. Incorporating, developing and harmonising a myriad of standard and non-standard spatial definitions for a “region”, “city”, “town”.

Taking into account the myriad of problems related to the multitude of city definitions and the diversity of how different datasets are defining, collecting or giving access to the underlying spatial reference data, and to address the modifiable areal unit problem, the LORDI methodology framework takes an innovative approach. It builds a relational GIS reference framework that links the different spatial definitions related to cites, to make it easier for the experts/developers to select the right spatial scale for collecting and integrating the data and building the index, as well as for the end users to understand and translate it. However, many of the usual conflicts between administrative, morphological and functional definitions will remain as it is inevitable in these types of exercises.

The issue of comparability of metropolitan areas is directly tied to the choice of the unit of analysis, that is to say whether these are defined on the basis of administrative boundaries, continuity of the built-up area or functional measures such as commuting rates or other parameters, and to the size of components to be aggregated. Moreover, the accurateness of the definition has to be pondered with a) the availability of socio-economic indicators in a certain metropolitan area and b) the degree of international comparability in the choice of the different parameters.

2.2.1 Example: adopting the LORDI framework for cities

As the cities are in constant change, also in terms of their administrative boundaries, we have chosen some definitions for cities that are more stable and are associated with the majority of the indicators (both KPI and content) as “anchor points”. The basis for this will be the OECD/EC/UN/FAO/WB Global Human Settlement harmonised definition of the city and its underlying database GHS-UCDB R2019A. This will establish the sample size and starting point for the overall framework – **706 cities/greater cities**.

- **UC - Urban Centre (version 2015)**
- **CR - Urban Centre Centroid and Radius**
- **MR - Metropolitan region/NUTS3** (versions 2013, 2016, 2021)
- **C- Ambiguous “City”** (or sum of cities – see urban centre database)
- Z - Postal codes
- FUAs
- LAU2
- NUTS2/NUTS1 (versions 2013, 2016, 2021)

C - Ambiguous “City” (or sum of cities) – in many of datasets, it is impossible to understand what - [insert any city name here] - means geographically. Furthermore, In some cases, the spatial definition is also not relevant, or can be relative, change quickly in time and difficult to trace. E.g. a cities commitment/decommitment on open data/privacy are not directly related to the extent of administrative boundaries or the changes in the latter.
Reference: N/A; ESPON; for selection and sums GHS-UCDB R2019A.
Relevance for data collection: Any dataset where locations are defined by city name; where specifying location beyond city name would be not relevant or counterproductive.
CR - Urban Centre Centroid and Radius – These spatial units will be produced by ESPON. They will be built up based on the centroids of Urban Centres Database and the radius will be calculated using the Minimum Bounding Geometry functionalities in ArcGIS/PostGIS/OpenJump.
Reference: ESPON
Relevance for data collection: The units will be used to access data from APIs such as the APIs of Facebook and Twitter that require centroid and radius.
L - LAU2 – local administrative boundaries. Not all countries classify their locally governed areas in the same way and LAUs may refer to a range of different administrative units, including municipalities, communes, parishes or wards.
Reference: Eurostat
Relevance to data collection: very limited.
UC - Urban Centre – The Urban Centres are defined by specific cut-off values on resident population and built-up surface share in a 1x1 km global uniform grid. The input data it is generated by the GHSL, and the operating parameters are set in the frame of the “degree of urbanization” (DEGURBA) methodology. The DEGURBA is a methodology for delineation of urban and rural areas made for international statistical comparison purposes that is developed by the European Commission, the Organization for Economic Co-operation and Development (OECD), the Food and Agriculture Organization of the United Nations (FAO), UN-Habitat and the World Bank. The reference GHSL input data used to delineate the Urban Centres are included in the Community pre-Release of GHS Data Package (GHS CR2018) in support to the GEO Human Planet Initiative. The parameter set used to delineate the Urban Centres from the input data are included in the GHSL settlement classification model SMODv9s10E 2018. The reference epoch for the spatial delineation of the Urban Centres is 2015.
These spatial units will be used when collecting data that is relevant for densely populated areas (e.g. 5G coverage, number of public wifi hotspots, e-bike sharing stations, etc) that could be distorted when measuring within administrative boundaries (compare Finnish city municipalities to Irish ones for example - Finnish municipalities extend far into their rural hinterlands and functional areas, Irish cities have tens small municipalities within morphological city boundaries).
Reference: GHS-UCDB R2019A.

Relevance for data collection: most APIs for spatial queries.

Z - Postal codes – The city-postal codes matching tables needs to be developed. They will contain a lookup-list of European postal codes and their corresponding Urban Centres. Similar tables already exist for codes for the NUTS versions 2010, 2013, and 2016, developed by GISCO. For NUTS 2016, there are matching tables for most of the EU28, and EFTA Countries. Eurostat has applied a number of quality assurance measures to ensure the best possible quality of the data including formatting checks, checks for completeness of postal codes and checks for spatial accuracy of the geocoding. Nevertheless, due to the very diverse and complex situation in Europe for postal codes data they cannot guarantee that all postal codes have been correctly matched.
Reference: Eurostat/TERCET/GISO; https://www.zip-codes.com/; http://www.geonames.org/
Relevance for data collection: Any database providing detailed address data.
F - FUAs – Functional Urban Areas are defined as a city and its commuting zone, based on a harmonized methodology developed by the EC. In cases where cities are connected by commuting, the functional urban area may consist of multiple cities and their single commuting zone. There are a few cases where cities do not have a commuting zone: for these, the city is equal to the functional urban area. The data collection exercise (formerly known as Urban Audit) is undertaken jointly by the National Statistical Institutes, the DG Regio and Eurostat. The datasets encompass statistical information on individual cities and on their commuting zones (the so-called Functional Urban Areas). The topics covered include demography. Recently, ESPON and JRC have developed tools for data estimations, which will develop additional indicators for FUAs with great spatial coverage. Thus, these spatial units will be included in the reference.
These spatial units may be used depending on the quality and coverage of the data/potential estimates.
Reference: Urban Audit; OECD; ESPON FUORE
Relevance for data collection: Eurostat, JRC, OECD, ESPON

MR - Metropolitan Region – Metropolitan regions are NUTS 3 regions or a combination of NUTS 3 regions which represent all agglomerations of at least 250 000 inhabitants. These agglomerations were identified using the Urban Audit's Functional Urban Area (FUA). Each agglomeration is represented by at least one NUTS 3 region. If in an adjacent NUTS 3 region more than 50% of the population also lives within this agglomeration, it is included in the metro.
These spatial units will be used for indicators where functional geographies are relevant (e.g. investments, economic performance, labour market, skills). As the metro-regions are based on agglomerations, which include the commuter belt around a city, this approach corrects the distortions created by commuting and many of the typical “regional socioeconomic indicators” such as GDP per inhabitant become meaningful, whereas comparison of GDP per inhabitant of NUTS 3 regions (let alone LAU2) are far more difficult to interpret, since the difference may be partly artificial. Some of the smaller cities coming from the sample will not overlay with a Metropolitan Region definition. These cities and underlying NUTS3 regions will be identified and NUTS3 regions added to the database (some data issues will arise from that and are important to keep in mind). Many Urban Centres will belong to one Metropolitan Region. Blanket approach and normalisation will be used to address this. The reference epoch for the spatial delineation of the Metropolitan is 2015.
Reference: Eurostat
Relevance for data collection: Any large database that disseminates regional statistics and NUTS3/Metropolitan Region level.

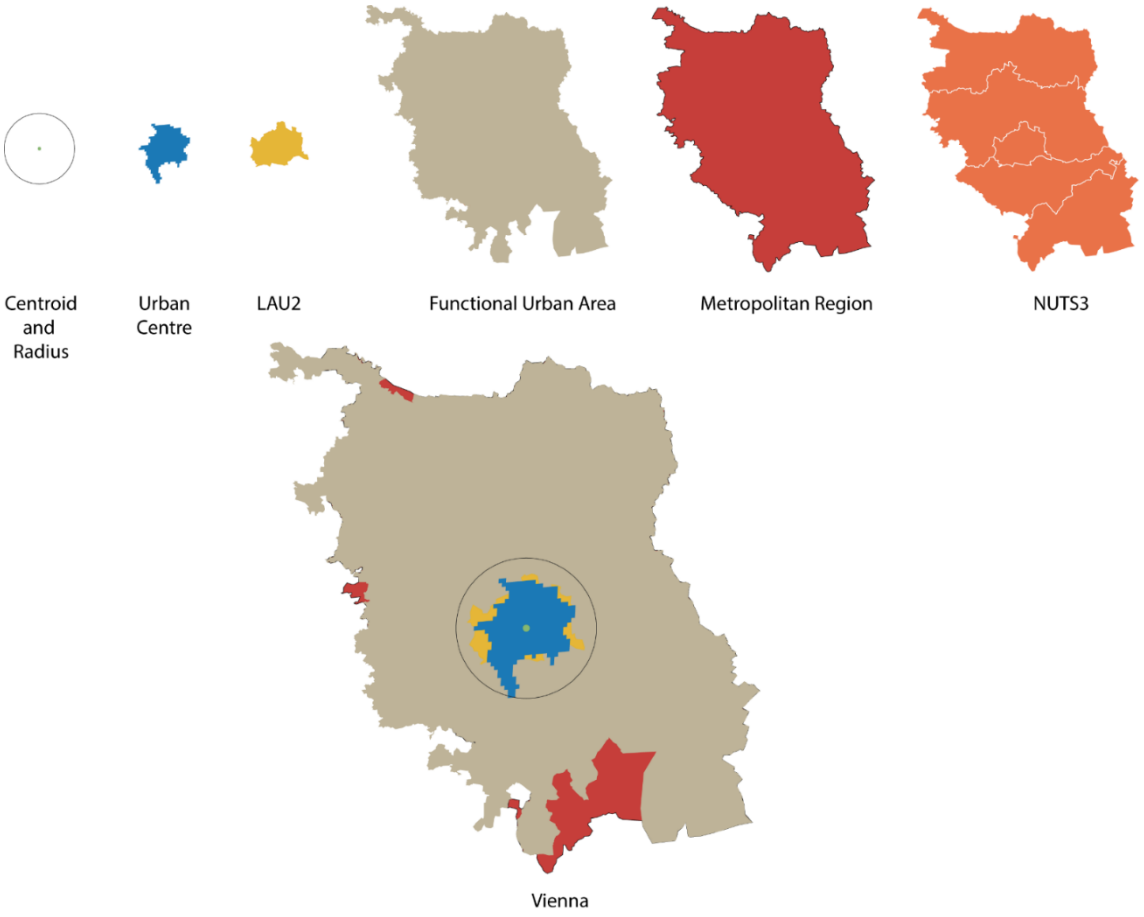

Figure 1. Example of utilising multiple spatial extents for Vienna

2.3 Indicators

The Key Performance indicators are currently divided up to four main topics:

1. Digital Infrastructures
2. Digital Skills
3. Digital Economy
4. Digital Government

In addition, it proposes a selection of context indicators for analysis

2.3.1.1 Digital Infrastructures

Digital transformation is enabled by a good and accessible infrastructure. The “Digital infrastructure” theme looks at the internet (such as the fixed and mobile broadband), IoT and other physical infrastructure.

Variable	No.	Indicator	Geo	Source(s)	Access	Relevance	Concerns
Internet infrastructure							
Fixed broadband infrastructure						Access to affordable and fast fixed internet is paramount for digital economy and society, to potential service providers, developers as well as users. It is also a measure for digital inclusion.	Not possible to distinguish between businesses and priv.
Coverage	1.1.1	Households covered by fast broadband	UC	[1]; [2];	€/API		
	1.1.2	Households covered by ultrafast broadband	UC	[1]; [2];	€/API		It is possible that the ookla.com platform is more popular in some parts of Europe than others which may cause bias in the number of people in the sample.
Speed	1.2.1	Average broadband download speed	C/UC	[1]; [2]; [3]; [4]	€/API		
	1.2.2	Average broadband upload speed	C/UC	[1]; [2]; [3]; [4]	€/API		
	1.2.3	Average broadband latency	C/UC	[1]; [2]; [3]; [4]	€/API		
Take-up	1.3.1	Unique WIFI networks per households	C/Z	[1]	API		
Security	1.4.1	% of WIFI networks with default SSID	C/Z	[1]	API		
	1.4.2	% of wireless encryption technologies	C/Z	[1]	API		
Affordability	1.5.1	Monthly fee as % of disposable income	Countr		M		
Mobile broadband infrastructure							
Coverage	1.6.1	Number of cell towers per capita	C/Z	[1]	API		
	1.6.2	% of population covered by 4G network	UC	[1]; [2]; [3]	€/API		
	1.6.3	% of population covered by 5G network	UC	[1]; [2]	€/API		
Speed	1.7.1	Average mobile download speed	UC/C	[1]; [2];	€/API		
	1.7.2	Average mobile upload speed	UC/C	[1]; [2];	€/API		
	1.7.3	Average mobile latency	UC/C	[1]; [2];	€/API		
Take up	1.8.1	Number of BT devices per capita	C/Z	[1]	API		
Public wireless infrastructure							
Coverage	1.9.1	Number of free hotspots per capita	C/Z	[1]; [2]; [3]	API		
IoT infrastructure							
Network	1.10.1	Availability of LTE-M network (Y/N)	C	[1]	M	The IoT will transform all industries, governments, and lifestyles in the coming decades, and infrastructure will just be one piece of that. IoT allows citizens to frequently connect their public infrastructure in order to more efficiently run their cities and improve the quality of life for residents. Also poses a lot of cyber security and privacy concerns.	Network data might be too vague at this stage. Not sure if we are able to currently measure a lot of the different IoT infrastructure centrally.
	1.10.2	Availability of NB-IoT network (Y/N)	C	[1]	M		
	1.10.3	Availability of LTE-M & NB IoT networks (Y/N)	C	[1]	M		
Solutions	1.11.1	EV charging stations per capita/vehicles	UC	[1]	API		
	1.11.2	Smart lampposts per capita	UC	[1]	API		
	1.11.3	CCTVs per capita	UC	[1]	API		
	1.11.3	Speed traps per capita	UC	[1]	API		
Other physical infrastructure							
Co-working infrastructure						Digital economy and new ways of working relies more and more on shared and flexible office space as a place to work, hold meetings and network, and use very specific equipment. Alongside this, flexible workspaces facilitate the exchange of ideas and collaboration between people with different skills and from different sectors.	It is possible that the coworker.com platform is more popular in some parts of Europe than others which may cause bias in the number of coworking spaces reported for each city.
Coverage	1.12.1	Co-working spaces per capita (15-65)	C/CR	[1]	API		
	1.12.2	Meeting spaces per capita (15-65)	C/CR	[1]	API		
	1.12.3	Fabrication and manufacturing facilities per capita (15-65)	C/CR	[1]; [2]; [3]; [4]	API		
Affordability	1.13.1	Monthly fee as % of disposable income	C/CR	[1]	API		
Equipment	1.14.1	Shared 3D printing equipment per capita (15-65)	C/CR	[1]	API		
	1.14.2	Shared VR equipment per capita (15-65)	C/CR	[1]	API		
	1.14.3	Shared AR equipment per capita (15-65)	C/CR	[1]	API		
	1.14.4	Shared supercomputers per capita (15-65)	UC	[1]	API		

2.3.1.2 Digital Skills

A diverse mix of skills is needed to boost quality employment and active participation and inclusion in an increasingly digitalised economy and society. Developing the necessary skills, both personal as well as organisational, require a certain capacity. This entails education and reskilling, tackling inequalities and the digital divide, promoting participation and collaboration in funding, development, and establishing new institutions.

Variable	No.	Indicator	Geo	Source(s)	Acc.	Relevance	Concerns
Education							
Access to higher education & academic expertise in relevant subjects							
Presence and rating of universities	2.1.1	Computer Sciences and Information Systems	MR	[1]	M / WS	Presence of top universities who can educate the population, generate spill-over effects for knowledge, collaborate with businesses and gov and attract expertise and investments is highly important for transformation of the urban regions.	How to best calculate based on total number and rankings?
	2.1.2	Engineering: mech., manuf. & aeronautics	MR	[1]	M / WS		
	2.1.3	Statistics	MR	[1]	M / WS		
Digital end-user skills							
Digital end-user skills							
Social media users	2.2.1	Facebook users per capita	C&R	[1]; [2]	M / API	An active community of people involved in social media is a good indicator for digital end-user skills.	
	2.2.2	Twitter users	C&R	[1]; [2]; tbd	API		To be explored further
Crowdsourcing contributions	2.3.1	% of TripAdvisor/Yelp/Foursquare contributors		[1]; [2]; [3];	API	Indication of citizen involvement around common interest or expertise through co-creation. These contributions show digital maturity of the society and can accelerate digital innovation and generate public value.	
	2.3.2	% of Wikipedia contributors	tbd	tbd			To be explored further
	2.3.3	% of Open Street Map contributors	UC	[1]; [2]	API		
Professional skills							
General professional skills							
	2.4.1	Employment in ICT sector	MR	[1]; [2]	API / M	As digital is embedded everywhere, thrive of all sectors, but especially ICT, as well as digital transformation of any organisation requires access to people with wide range of digital skills. As data is at the core of digital economy, products and services, having access to people with skills in collecting, manipulating, analysing, visualizing and interpreting data is crucial. In order to any product or service to come to life and function, programming and software development skills are central. Also, in order to create and diffuse innovation, collaboration skills are essential. Successful user-centric approaches require service design skills.	
Advanced professional skills							
Collaboration skills	2.5.1	% of GitHub users (15-65)	C	[1]	API		
	2.5.2	% of GitLab users (15-65)	C	[1]	tbd		
Data skills	2.6.1	% employees with data skills (15-65)	C	[1]	API		
	2.6.2	% advanced data experts (15-65)	C	[1]	API		
Programming skills	2.7.1	% employees with programming skills (15-65)	C	[1]	API		
	2.7.2	% advanced programming experts (15-65)	C	[1]	API		
Service design sk	2.8.1	% employers with service design skills (15-65)	C	[1]	API		Incomplete data?
Hubs / labs / accelerators / incubators etc							
Living labs	2.9.1	Living labs per capita / Presence of a living lab	MR/C	tbd		Digital innovation hubs, living labs, accelerators and incubators offer the necessary support for private and public organisations to undergo digital transformation. They offer the necessary expertise, funding, collaboration opportunities, networks, testing for ideas, products and services.	Will be explored further with ENoLL and EC.
	2.9.2	Projects funded per capita	MR/C	tbd			
	2.9.3	End-users involved per capita	MR/C	tbd			
	2.9.4	National partners per living lab	MR/C	tbd			
	2.9.5	International partners per living lab	MR/C	tbd			
Innovation Hubs	2.10.1	IH per capita / Presence of IH	MR/C	tbd			
	2.10.2	Business and public sector entities supported	MR/C	tbd			
	2.10.3	Digital maturity of entities supported	MR/C	tbd			
IoT Labs	2.11.1	Mobile IoT labs per capita	MR/C	tbd			
Private funding							
Business support	2.12.1	Organisations in impact investment	C	[1]; [2]; [3]	API	Investors can, in return of products, equity of debt, provide the seed money or investment needed for businesses to develop and grow via digital platforms.	
Crowdfunding	2.12.2	ICT related businesses supported by crowdfunding	C	[1]; [2]; [3]; [4]	API		
Diversity of skills, capacity and participation							
Sex & age	2.13.1	% female founders in tech	C	[1]	API	Diversity within and inclusion of wide range of interests, backgrounds and ideas fuels digital innovation. Digital inclusion and skills among all groups within the population are important for holistic transformation of the society. Without inclusion, digital technologies can exacerbate inequality and discrimination.	
	2.13.2	Facebook users (M, F, 13-15), per age/sex group	CR	[1]; [2]	M / API		
	2.13.3	Facebook users (M, F, 15-65), per age/sex group	CR	[1]; [2]	M / API		
	2.13.4	Facebook users (M, F, 65+), per age/sex group	CR	[1]; [2]	M / API		
Education	2.14.1	% of founders in tech who do not hold a degree	CR	[1]	API		

2.3.1.3 Digital Economy

Digital transformation is enabled by a good and accessible infrastructure. The “Local digital infrastructure” theme looks at the internet (such as the fixed and mobile broadband), IoT and other physical infrastructure.

Variable	No.	Indicator	Geo	Source(s)	Acc.	Relevance	Concerns
Economy							
General macroeconomic accounts							
GDP and GVA	3.1.1	GVA in ICT per capita in PPS	MR	[1]; [2]	API / M	This data allows to understand the size and profitability of the ICT sector in the economic activities in a city.	Biased towards ICT sector.
4.0 inventions	3.2.1	Intensity of 4.0 patents per capita	MR	[1]; [2]; [3]	M		
	3.2.2	Intensity of 4.0 patents by sectors per capita	MR	[1]; [2]; [3]	M		
Firms & employment	3.3.1	Firms by 4.0 inventing sector and industry per cap	MR	[1]; [2]	M / API		
	3.3.2	Revenue of firms by 4.0 inventing sector per cap	MR	[1]; [2]	M / API		
	3.3.3	Employment in 4.0 inventing sector and industry	MR	[1]; [2]	M / API		
Business demography	3.4.1	Birth rate of the enterprises in ICT per capita	MR	[1]; [2]	API / M		Biased towards ICT sector.
	3.4.2	Survival rate of the enterprises in the ICT/KET per cap	MR	[1]; [2], [3]	API / M		
	3.4.3	Share of high growth enterprises in ICT/KET	MR	[1]; [2], [3]	API / M		
Global embeddedness	3.5.1	Total deal value in FDI projects by ICT/KET sector	MR	[1]; [2]	M		
	3.5.2	FDI projects in ICT/KET sector per capita	MR	[1]; [2]	M		
Services							
Collaborative economy							
Short-term accommodation services	3.6.1	% of nights booked from individuals	?	[1]; [2]	API / M	This data allows to better understand the development of collaborative digital economy. This very detailed and reliable data will inform ongoing discussions about this new type of economy at the very local level and address the new reality in a balanced manner.	Indicators and access will be further detailed through ongoing collaboration between ESPON and EC.
	3.6.2	% of nights booked from hotels	?	[1]; [2]	API / M		
	3.6.3	% of individuals booking from individuals	?	[1]; [2]	API / M		
	3.6.4	% of individuals booking from hotels	?	[1]; [2]	API / M		
Shared transport services	3.7.1	Availability of bike sharing system (Y/UD/N)	C	[1]	?		Data in some cases not available for all cities. Methodological challenges on temporality need to be solved.
	3.7.2	Bikeshare operators per capita	C	[1]	?		
	3.7.3	Docking stations per capita	C	[1]	API		
	3.7.4	Bikes per capita	C	[1]	API		
	3.7.5	Bikes in use per capita (needs further definition)	C	[1]	API		
	3.7.6	Number of cars in car sharing per capita	?	Eurostat	?		Data not available yet, but Eurostat is working on it.
	3.7.7	Number of daily trips per capita	?	Eurostat	?		

2.3.1.4 Digital Government

These indicators are collected via self-assessment survey directly from public administrations. The tool and the data can be accessed here: https://lordimas.espon.eu. The self-assessment questionnaire can be accessed under “Participate” within the tool.

Variable	No.	Indicator	Geo	Source(s)	Acc.	Relevance	Concerns
Governance							
Twin transition	4.1.1	Degree of digital and green transition linked	Local/regional	[1];	LORDIMAS		
Strategy	4.1.2	Degree of digitalisation strategy	Local/regional	[1];	LORDIMAS		
Institutions	4.1.3	Degree of having relevant structures that coordinate	Local/regional	[1];	LORDIMAS		
Capacity	4.1.4	Degree of working on upskilling staff	Local/regional	[1];	LORDIMAS		
KPIs	4.1.5	Degree of objectives and monitoring	Local/regional	[1];	LORDIMAS		
Privacy and security	4.1.6	Degree of measures on privacy and security	Local/regional	[1];	LORDIMAS		
Service design							
Digital-by default	4.2.1	Degree of adhering to the principle	Local/regional	[1];	LORDIMAS		
Agile and iterative design	4.2.2	Degree of adhering to the principle	Local/regional	[1];	LORDIMAS		
User engagement	4.2.3	Degree of user engagement	Local/regional	[1];	LORDIMAS		
Monitoring	4.2.4	Degree of monitoring services by metrics	Local/regional	[1];	LORDIMAS		
Innovation ecosystems	4.2.5.	Degree of utilizing ecosystem approach in service design	Local/regional	[1];	LORDIMAS		
Data management							
Data strategy	4.3.1	Degree of data strategy adoption	Local/regional	[1];	LORDIMAS		
Data catalogue	4.3.2	Degree of availability of information	Local/regional	[1];	LORDIMAS		
Data platform	4.3.3	Degree of integration of data to the platform	Local/regional	[1];	LORDIMAS		
B2G/G2B data sharing	4.3.4	Degree of data sharing	Local/regional	[1];	LORDIMAS		
AI registry	4.3.5	Degree of algorithms recorded	Local/regional	[1];	LORDIMAS		
Sensor registry	4.3.6	Degree of different types of sensors recorded	Local/regional	[1];	LORDIMAS		
Personal data	4.3.7	Degree to which citizens have control over their data	Local/regional	[1];	LORDIMAS		
Digital twin	4.3.8	Degree of the virtual representation via a digital twin	Local/regional	[1];	LORDIMAS		

Variable	No.	Indicator	Geo	Source(s)	Acc.	Relevance	Concerns
Interoperability							
Technical specifications	4.4.1	Degree of adoption of technical specifications	Local/regional	[1];	LORDIMAS	.	
Open source	4.4.2	Degree of using open source	Local/regional	[1];	LORDIMAS		
Open standards	4.4.3	Degree of adopting open standards	Local/regional	[1];	LORDIMAS		
Open APIs	4.4.4	Degree of providing open APIs	Local/regional	[1];	LORDIMAS		
Building blocks	4.4.5	Degree of using building blocks and microservices	Local/regional	[1];	LORDIMAS		
Service delivery							
Digital services	4.5.1	Degree of adoption of providing key services digitally	Local/regional	[1];	LORDIMAS		
Once-only principle	4.5.2	Degree of applying once-only principle	Local/regional	[1];	LORDIMAS		
One-stop-shop	4.5.3	Degree of providing one access point to all services	Local/regional	[1];	LORDIMAS		
Digital inclusion	4.5.4	Degree of providing necessary support and alternative access	Local/regional	[1];	LORDIMAS		
Proactive services	4.5.5.	Degree of providing proactive services	Local/regional	[1];	LORDIMAS		
Technology							
Big data	4.6.1	Degree of Big Data use	Local/regional	[1];	LORDIMAS		
Immersive technologies	4.6.2	Degree of immersive tech use	Local/regional	[1];	LORDIMAS		
AI	4.6.3	Degree of AI adoption	Local/regional	[1];	LORDIMAS		
IoT	4.6.4	Degree of sensors in use	Local/regional	[1];	LORDIMAS		
Robotics	4.6.5	Degree of robotics in use	Local/regional	[1];	LORDIMAS		
Blockchain	4.6.6	Degree of blockchain adoption	Local/regional	[1];	LORDIMAS		
5G	4.6.7	Degree of 5G adoption	Local/regional	[1];	LORDIMAS		
Networking							
Cross-sector	4.7.1	Degree of cross-sector collaboration	Local/regional	[1];	LORDIMAS		
Multi-level	4.7.2	Degree of collaboration with different tiers of governments	Local/regional	[1];	LORDIMAS		
Peer-to-peer	4.7.3	Degree of collaboration with peers domestically	Local/regional	[1];	LORDIMAS		
International	4.7.4	Degree of collaboration with peers internationally	Local/regional	[1];	LORDIMAS		

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