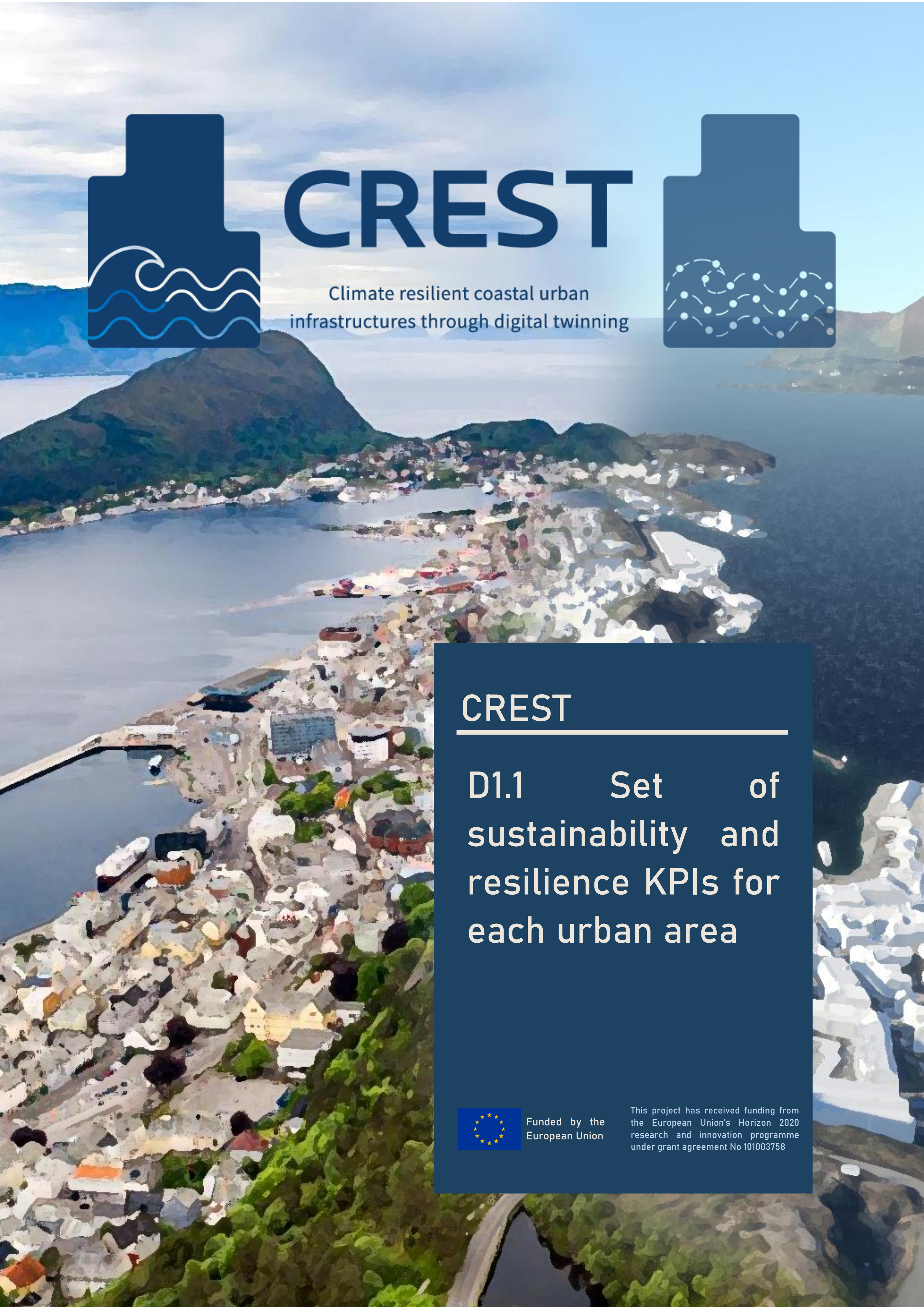

CREST

Climate resilient coastal urban infrastructures through digital twinning

CREST

D1.1 Set of sustainability and resilience KPIs for each urban area

Funded by the European Union

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D1.1 Set of sustainability and resilience KPIs for each urban area

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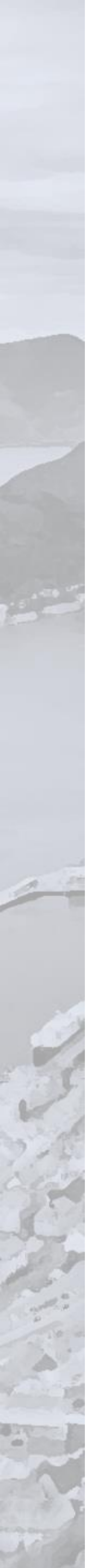

D1.1 Set of sustainability and resilience KPIs for each urban area

This deliverable is part of the first work package of the CREST project, an initiative co-funded by JPI Urban Europe and led by a consortium of eight partners, including Augmentcity AS, Møre og Romsdal Fylkeskommune, Gmina Kołobrzeg, INnCREASE Sp. z.o.o, ACCENT SUD, IRMiR, ETBX (INRAE) and GREThA (BSE). The CREST project goal is to support resilient urban infrastructure adaptation to climate change by means of a Digital Twin technology and co-creation approaches to support environmental decision-making and innovative policy practices.

WP1 is dedicated to the creation of a **sustainability and resilience monitoring framework of urban areas** and the following deliverable represents a synthetic document on the KPIs collection for the assessment of urban and coastal areas' sustainability and resilience and the implementation of the framework on the fields of experimentation; Bordeaux Métropole (France), Kołobrzeg (Poland), and Kristiansund (Norway).

Data collected for WP1 directly feeds the Digital Twin visualizations/simulations in WP3 used at the co-creation activities in WP2.

Elaborated by: Lina Essafi

Thanks to: Jeanne Dachary-Bernard, Guillaume Pouyanne, David Carayon, Olha Nahorna & Dora Fazekas

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Introduction

The rapid urbanization of today's cities raises a major challenge in terms of adapting to these societal transformations, coupled with the risks exacerbated by global warming. The world's population is projected to reach 8 billion by 2022, half of whom will live in urban areas. This trend is likely to expand, with 68% of the population living in cities by 2050 (UN-Habitat, 2022).
The pace of these urban movements imposes that cities need to strengthen their resilience and accelerate the adaptation of their housing, infrastructure and service sectors to these changes. Indeed, urban resilience is now an integral part of urban planning and development, in order to prepare territories for climate-related risks (Tong, 2021). In literature, there exist several definitions and frameworks for urban resilience. Among them, sustainability (WCED, 1987; Castells, 2000) appears as a common concept with a long history and a broad acceptance. In recent years and owing to the technological development of urban areas, the concept of smart city gained in popularity (Hollands, 2008; Mora, Bolici and Deakin, 2017), hinting to cities that use Information and Communications Technology (ICT) and other modern technologies to monitor infrastructures and services (e.g., energy, transport, waste etc.) (Batty, 2013; Albino, Berardi and Dangelico, 2015; Ahvenniemi *et al.*, 2017). Therefore, a necessity has emerged to reconcile the core principles of smart cities, which often prioritize technology-centric visions, with those of sustainable cities, whose definition has become outdated in light of the rapid and substantial digitalization of urban environments. As an answer to this challenge, the concept of "smart and sustainable city" emerged (Höjer and Wangel, 2015; Ahvenniemi *et al.*, 2017; Bibri and Krogstie, 2017; ITU, 2022a). Many studies established that both are constructed on similar basis and pathways and work towards similar objectives of development (De Jong et al., 2015). A "smart and sustainable city" designates a city that relies on the ubiquitous presence and massive use of advanced ICT, which in relation to various urban domains and systems and the way they are intimately linked, enable cities to become more sustainable and offer citizens a better quality of life (Bibri and Krogstie, 2017).

To adequately acknowledge the efforts made regarding resilience, cities need to ensure systematic performance evaluations in order to formulate appropriate urban policies and strategies, and ensure a successful transition to smart, sustainable cities. After a first review of existing impact and monitoring assessment frameworks described in the deliverable D1.2, the aim of this study is to select a set of sustainability and climate resilience Key Performance Indicators (KPIs) on the territories of the various study sites. In line with the project objectives and considering the studied sites, the selected evaluation framework comprises a set of generic indicators derived from the U4SSC framework and a selection of KPIs related to climate change adaptation and urban resilience, directly derived from the studied areas' context.

U4SSC is a United Nations initiative led by United Nations specialized agencies, which offers a standardized framework for cities to assess their urban resilience and sustainability performance through a set of KPIs and to guide policy formulation. These indicators provide a uniform approach to gather necessary data to measure progress and performance, in regard to the sustainability and smartness of the cities. In addition, it is a valuable tool to report on the achievement of the Sustainable Development Goals (SDGs). Assessing both the sustainability and smartness of cities serves as a safeguard to ensure that cities comply with current standards for resilient urban areas, addressing the challenges posed by global warming. Indeed, demonstrating the sustainability of a city becomes more efficient when cities are equipped with appropriate tools for reporting, transforming the use of ICT on a municipal scale into both a method and a benchmark for urban sustainability.

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Moreover, the KPIs evaluated for the areas under study were essential and highly valuable to accurately feed the geographical Digital Twins (DT) in WP3 in displaying the current and future impact of CC and in simulating mitigation measures. Additional visual and interactive metrics were developed to portray the KPIs and to give an overview of the progress of each related sector for the studied sites. Such representations are useful to showcase and compare their level of progress, as well as to highlight the specificities of each.

Although treated synthetically through U4SSC's KPIs, urban resilience and climate change adaptation can be addressed in depth with customized indicators that reflect the urban areas' contexts and their experience with climate-related events. The observations drawn from the co-creation workshops in WP2 were valuable for the development of resilience-related indicators specific to each of the three case studies. Indeed, the scenarios on climate events' impacts developed for the co-creation workshops accurately reflect the context of each urban area and bring participants together on a specific topic concerning the impact of climate change on their city.

In the first section, we will briefly review the list of existing evaluation frameworks for assessing sustainable and smart cities, and argument the choice of the U4SSC framework as a reference for our case studies. In the second section, we will present the indicators and develop on their application for the three case studies. The third section focuses on the description of the additional resilience-related indicators.

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1 Assessment frameworks for smart and sustainable cities

1.1 Overview of existing assessment frameworks

There exist several evaluation frameworks to assess the performance of cities in their engagement for greater resilience in tackling climate challenges. Through a comprehensive and complex approach, they integrate the assessment of the main attributes of urban resilience, namely the sustainability and intelligence of cities. In the following, we will briefly outline existing frameworks that illustrate this approach in evaluating urban sustainability and smartness.

In the scientific literature, few studies explore the characteristics of a sustainable smart city and develop methods for their evaluation (Monfaredzadeh and Berardi, 2015; Ahvenniemi *et al.*, 2017; Garau and Pavan, 2018; Huovila, Bosch and Airaksinen, 2019; Pira, 2021). The literature is more abundant when it comes to the individual evaluation of a smart city (Giffinger *et al.*, 2007; Lombardi *et al.*, 2012; Albino, Berardi and Dangelico, 2015; Anthopoulos, Janssen and Weerakkody, 2016) or a sustainable city (Sharifi and Murayama, 2013; Berardi, 2015; Estevez, Lopes and Janowski, 2016; Science for Environment Policy, 2018). On the other hand, numerous frameworks have been proposed in the grey literature for the joint assessment of the intelligence and sustainability of urban areas, most of them derived from international standardization bodies such as ISO, ITU and ETSI (ETSI, 2017; ISO, 2018a, 2018b; ITU, 2022a). Janik et al. (2019) provide a comparative analysis of the most comprehensive evaluation frameworks based on the representativeness of the intelligence and sustainability of cities. The frameworks reviewed in this analysis adopt the same evaluation method, namely the development of dimensions and indicators reflecting the performance of cities in terms of resilience to climate change. While the number of dimensions differs between the frameworks, it is important to highlight that multiplying the number of dimensions does not make a framework more exhaustive, as the evaluation approaches are rather distinguished by the number of indicators classified at the lowest level of aggregation of the elements composing the method (Janik, Ryszko and Szafraniec, 2019).

Nevertheless, there is a minimum of three dimensions covering the fundamental sectors of an urban area. The comparison of frameworks is based on the criteria of complexity and comprehensiveness of intelligence assessment and sustainability assessment, respectively.
The top-ranked frameworks include City Protocol, CITYkeys, U4SSC and ETSI TS 103 463. These frameworks are characterized by a level of complexity and comprehensiveness ranging from "high" to "very high" for both attributes. Considering the criterion of balance in assessing the intelligence and sustainability of cities, Huovila et al. (2019) support the latter conclusions, evaluating ETSI TS 103 463 and ITU 4903 (now U4SSC) as assessment frameworks that best ensure this balance.

Based on these assumptions, and after consultation with the various project stakeholders, U4SSC is selected as the benchmark for the evaluation of the three study sites, as discussed in the following paragraph.

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1.2 Adoption of U4SSC's framework as a reference

U4SSC stands for United for Smart Sustainable Cities, and is a United Nations initiative, coordinated by ITU, UNECE and UN-Habitat, and supported by 14 other agencies and programs, including CBD, ECLAC, FAO, UNDP, UNECA, UNESCO, UNEP, UNEP-FI, UNFCCC, UNIDO, UNOP, UNU-EGOV, UN-Women and WMO, with the aim of achieving SDG 11: "Make cities and human settlements inclusive, safe, resilient and sustainable". The U4SSC framework represents a standardized, cohesive approach applicable to various urban settings seeking to evaluate their sustainability and smartness. Its primary objective is to steer public policy towards prioritizing actions for the shift towards sustainable, smart cities. Furthermore, it promotes the utilization of information and communication technologies (ICT) to facilitate this transition.

The framework is composed of 92 KPIs, built according to the recommendations of ITU-T Y.4903 (ITU, 2022a). In fact, this United Nations agency has developed generic and fundamental performance indicators for smart and sustainable cities to assess the achievement of the SDGs. This underscores the validity of adopting the U4SSC framework as a reference, given its development by international experts, thus enjoying a consensus that distinguishes it from other assessment frameworks.
Since 2019, over 50 cities around the world have established their evaluation using this tool, including Dubai, Singapore, Manizales, Moscow, Valencia and Bizerte. The diversity of cities referring to this standard hints to its applicability across diverse urban sites. In this regard, it is essential to adopt a common framework, which facilitates the comparison between the three cities, while taking into account the characteristics of each. In addition, the calculation methodology is simple, ensuring accessibility and replicability for all evaluators.

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2 KPIs for evaluating smart and sustainable cities

2.1 Description of the KPIs

The 92 indicators composing U4SSC's framework are divided into three dimensions, each representing a pillar of sustainability: Economy, Environment and Society & Culture. The multiplicity of indicators offers a holistic and exhaustive overview of the progress achieved over time by cities in meeting their urban sustainability targets. By definition, indicators are particularly useful as they simplify complex phenomena - ranging from environmental and socio-economic phenomena to the climatic events - into easily understandable metrics (Hiremath et al., 2013; ISO, 2010).
The three dimensions are divided into sub-dimensions, themselves divided into categories (Figure 1). The sub-dimensions represent more specific areas (e.g. ICT, Productivity and Infrastructure for the Economy dimension), and the categories encompass the underlying KPIs. The distribution of categories and sub-dimensions among the initial dimensions is detailed in Table 2. According to the ITU, a first distinction is made between core indicators, i.e. those that cities are able to report on, providing a basic overview of a city's intelligence and sustainability, and advanced indicators, which provide a more in-depth view of progress made within the framework of more advanced initiatives (ITU, 2022a). The KPIs are further categorized into smart, structural and sustainable, allowing different ways of assessing and labeling these indicators (Appendix, Table 2, p. 23).

FIGURE 1 : KPIS' DISTRIBUTION

Dimension	Sub-dimension	Category
Economy	Energy	Air Quality
Environment	Education, Health and Culture	Buildings
Society and Culture	Environment	Culture
	Infrastructure	Drainage
	ICT	Energy
	Productivity	Education
	Safety, Housing and Social Inclusion	Employment
		Environmental Quality
		Electrical Supply
		Food Security
		Health
		Housing
		Innovation
		ICT Infrastructure
		Public Sector
		Public Spaces and Nature
		Safety
		Social Inclusion
		Transport
		Urban Planning
		Waste
		Water and Sanitation

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U4SSC's KPIs are designed to be observable and verifiable, quantitative or qualitative, relevant to local decision-making, specific, measurable, reproducible, actionable and dynamic (ITU, 2022b). Data availability and verification are essential criteria for selecting KPIs. Furthermore, the values attributed to the KPIs are point data for the metropolis or municipality, pertaining to one year. In our case, the reference year is 2023. In the absence of data for this date, the reference year is the most recent one for which a value exists for the KPI. In order to ensure compliance in data collection for the three sites, no additional indicators were added to the U4SSC's current KPIs selection.

Following the same pattern as U4SSC's framework, the KPIs represent values which reflect the progress status according to a target value. In general, these target values are fixed in compliance with pre-defined objectives set in parallel with the creation of the KPIs by the UN agencies, and occasionally extrapolated from national levels. Depending on the construction of the indicators, the related values can take several possible formats (e.g., in percentage, an index, per 100 000 inhabitants etc.). In percentage format, the target value is usually 100% when the target type is "the higher the better" (e.g. water supply for households). On the other hand, when the target type is "the lower the better" (e.g. poverty rate), the target value is 0%. For KPIs of type structural (e.g. unemployment rate), the target value is usually the national rate, as a 100% (or 0%) is unrealistic and most likely unreachable. The same applies for the KPIs of type per 100 000 inhabitants, as the national data is the only metric to rely on for this case. A sample of the KPIs is presented below, illustrating the case of Kristiansund (Figure 2).

FIGURE 2 : SCREENSHOT OF THE KPI COLLECTION SPREADSHEET

Dimension	Sub-dimension	Category	Indicator name	Value	unit of measure	Target	Max	Min
Economy	ICT	ICT Infrastructure	Household Internet Access	99	%	100	100	0
			Fixed Broadband Subscriptions	86,39	%	60	100	0
			Wireless Broadband Subscriptions	115706	Number / 100 000 inhabitants	100 000		0
			Wireless Broadband Coverage 3G		%		100	0
			Wireless Broadband Coverage 4G	100	%	100	100	0
			Availability of WIFI in Public Areas	67	number	100	100	0
		Water and Sanitation	Smart Water Meters	0	%	100	100	0
			Water Supply ICT Monitoring	29,21	%	100	100	0
		Drainage	Drainage / Storm Water System ICT Monitoring	0	%	100	100	0
		Electricity Supply	Smart Electricity Meters	99,75	%	80	100	0
			Electricity Supply ICT Monitoring	100	%	100	100	0
			Demand Response Penetration	0,05	%	80	100	0
		Transport	Dynamic Public Transport Information	100	%	100	100	0
			Traffic Monitoring	3,23	%	100	100	0
			Intersection Control	100	%	100	100	0
		Public Sector	Open data	78,31	number	100	100	0
			e-Government	148	number			0
			Public Sector e-procurement	13,89	%	100	100	0
	Productivity	Innovation	R&D Expenditure	1,23	%	3	100	0
			Patents	12,5	Number (of new patents granted) / 100 000 inhabitants (per year)	45		0
			Small and Medium-Sized Enterprises	99,89	%	98	100	0
		Employment	Unemployment Rate	3	%	4	100	0
			Youth Unemployment	3,8	%	6	100	0
			Rate Tourism Sector Employment	3,46	%	3	100	0
			ICT Sector Employment	1,49	%	8	100	0

An online dashboard[1] was developed to provide an overview of the KPIs and their status for each studied site. This website hosts various visual and interactive representations of the KPIs. For instance, Sunburst charts were created following the U4SSC methodology, particularly relevant in this case as they report on the ordering, classification and status of the KPIs. The aggregation rules are as follows.

[1] https://crest.pages.mia.inra.fr/dashboard/

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Aggregation rules

The Sunburst graph is designed to assign a level of progress for each different stage of categorization (dimension, sub-dimension and category). Based on the computation methodology described in Geneva's 2022 U4SSC report, the values obtained for each KPI are aggregated into four intervals :

- 0-33% of target – 1 point;
- 33-66% of target – 2 points;
- 66-95% of target – 3 points;
- 95% of target – 4 points.

The scores obtained for the KPIs are then summed up to establish a percentage score for each category, and so forth as we move to the higher category. The categories are highlighted in different colors based on their scores (Figure 3). Finally, the KPIs with no relative data or for which the benchmark criteria (=target) have not been defined yet were also highlighted but not taken into account in the computation.

FIGURE 3 : KPIS' LEVELS

2.2 Study sites and application of U4SSC's framework

The three urban areas selected for the project are Kristiansund (Norway), Bordeaux Métropole (France) and Kołobrzeg (Poland). These territories are particularly vulnerable to CC, due to their coastal or near coast location, and several similarities exist between them, primarily because of their geographical proximity. Yet, they encounter specific challenges, stemming from their respective national/local political, economic, societal, and scientific contexts. Including these urban areas as pilot locations in the project is an opportunity to apply consistent research methodologies in similar urban environments, resulting in diverse findings and solutions that can be more readily adapted to various other locations across Europe.

In this section, the KPIs for the three study sites were established based on U4SSC's assessment framework. Since the latter includes KPIs on Safety, the category that encompasses indicators directly related to resilience and climate change adaption, a brief characterization of these areas is presented below, highlighting the specific climate-related challenges each face. Next, we introduce a description of the KPIs and their assessment for the cities and an analysis of the results.

2.2.1 Case study 1 : Bordeaux Métropole

2.2.1.1 Presentation of the studied site :

Bordeaux Métropole is a French metropolis, located in the Gironde department of the Nouvelle-Aquitaine region. It comprises 28 municipalities and a population of 814 100 inhabitants. It is located in the Gironde estuary, 80 km upstream from its estuary on the Atlantic coast. Its environment is influenced by a fluvio-maritime regime, combining the effects of rivers and the ocean. A quarter of metropolitan France is particularly at risk from rising water levels, with over 40,000 residents living in flood-prone areas. The urbanization of its municipalities considerably increases the risk of flooding.

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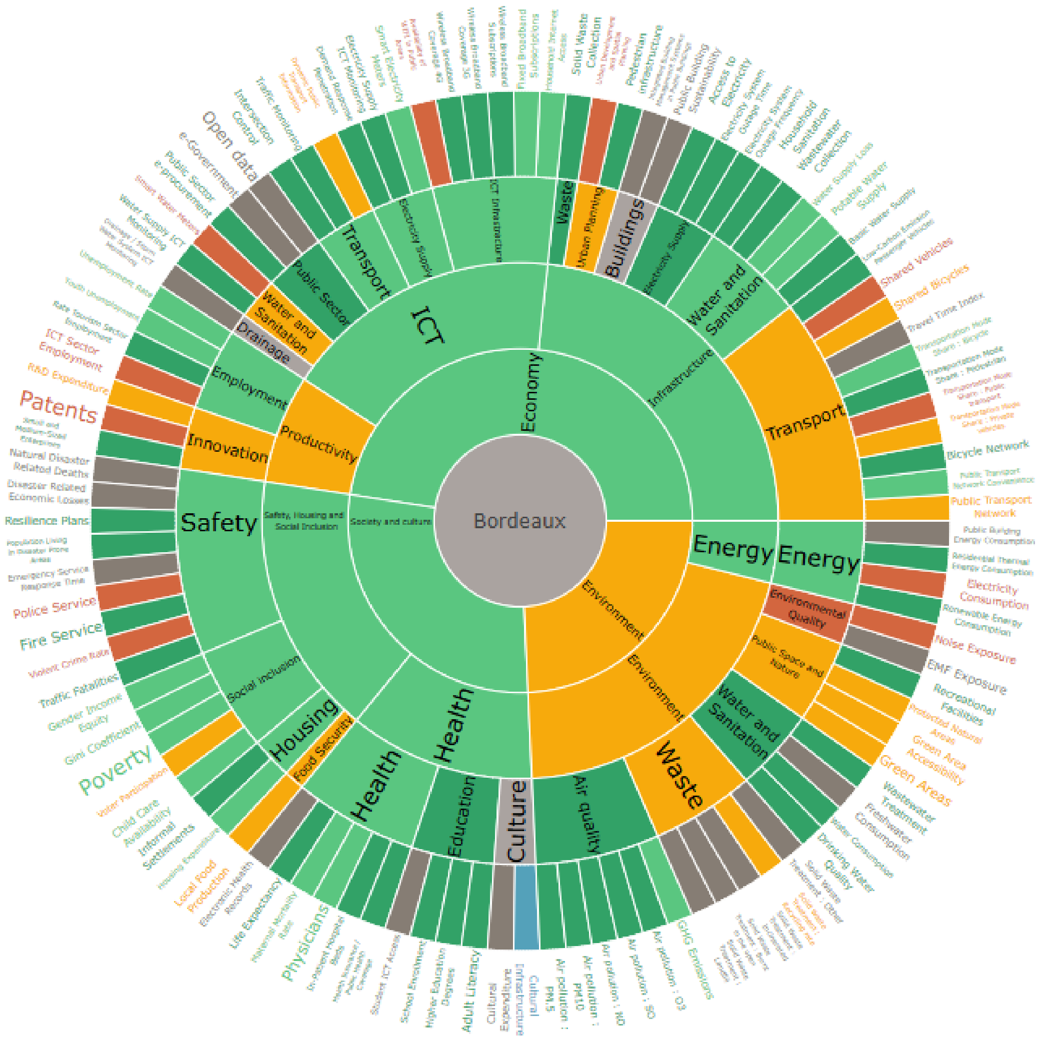
Faced with these challenges, Bordeaux Métropole is committed to improving its understanding of the impacts of climate change in the region, developing a long-term strategy for adapting to these risks, and preserving and enhancing the functions of flood expansion zones, low-lying areas and natural spaces. To meet these challenges, the metropolis has initiated and is coordinating a local flood risk management strategy (2016-2021) targeting the areas most at risk.

2.2.1.2 Assessment of KPIs :

The data used to fill the KPIs stem from various sources, namely the metropole's open data website and The French National Institute for Statistics and Economic Studies (INSEE), mostly related to socio-demographic and economic characteristics. More detailed data on the metropolitan services such as water, electricity, waste management etc., is available on the website of the concerned service department. Data is updated regularly in most cases, allowing for an accurate assessment of the city's current resilience status.

Around 81% of the data has been collected to assess Bordeaux Métropole's KPIs. The Sunburst diagram obtained with the latter is presented below.

FIGURE 4 : BORDEAUX MÉTROPOLE'S KPIS



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2.2.1.3 Analysis of the results :

The level of data collection for Bordeaux Métropole is relatively satisfactory. Yet, assessing the city's overall urban sustainability and resilience is more complex and cannot be encapsulated in a single word. A closer examination of its characteristics reveals a mixed performance. The Economy category shows strong results, with most dimensions performing well, except for Productivity. Conversely, data collection requires improvement in areas such as Waste, Culture and Buildings. Significant gaps are also observed for Safety, particularly crucial as it measures closely the city's level of preparedness to climate-related events. Moreover, the performance is tempered for Transport, as well as for that of Public, Space and Nature. Finally, the city's smartness is verified, with the majority of ICT indicators showing strong results, highlighting its potential in this area.

2.2.2 Case study 2 : Kołobrzeg

2.2.2.1 Presentation of the studied site :

Kołobrzeg is the administrative city in Kołobrzeg County in the Province of West Pomerania, with 44 737 inhabitants. It is located on Poland's northern coast along the Baltic Sea, lying at the mouth of the Parseta River. Kołobrzeg is an urban area facing a number of climatic risks. The 3-5 millimeter annual rise in the level of the Baltic Sea points to a scenario in which sea levels will rise to 45-65 centimeters by 2100. This increases the risk of intensified coastal erosion, flooding and the frequency and severity of storms. These impacts threaten not only essential coastal infrastructures such as dykes and quays, but also the safety of local residents and the economic viability of coastal areas. To our knowledge, no climate strategy has been adopted in Poland to tackle the risks associated with climate change.

2.2.2.2 Assessment of KPIs :

Data collection was conducted on the basis of two data sources in particular, namely the polskawliczbach.pl portal[2], which provides statistical data on Poland, its voivodeships[3], counties, municipalities, towns and villages. Most of the data comes from the Central Statistical Office, the Ministry of National Education, the National Police Headquarters and other national institutions and offices. On the other hand, specific data can be found on the website Strateg[4], which was created by the Central Statistical Office and contains indicators for monitoring the implementation of strategies in force in Poland.

The list of indicators for Kołobrzeg is 51% complete, primarily due to the lack of several data points. We obtain the following representation of the KPIs (Figure 5).

[2] https://www.polskawliczbach.pl/powiat_kolobrzeski
[3] The smallest administrative divisions of Poland.
[4] https://strateg.stat.gov.pl

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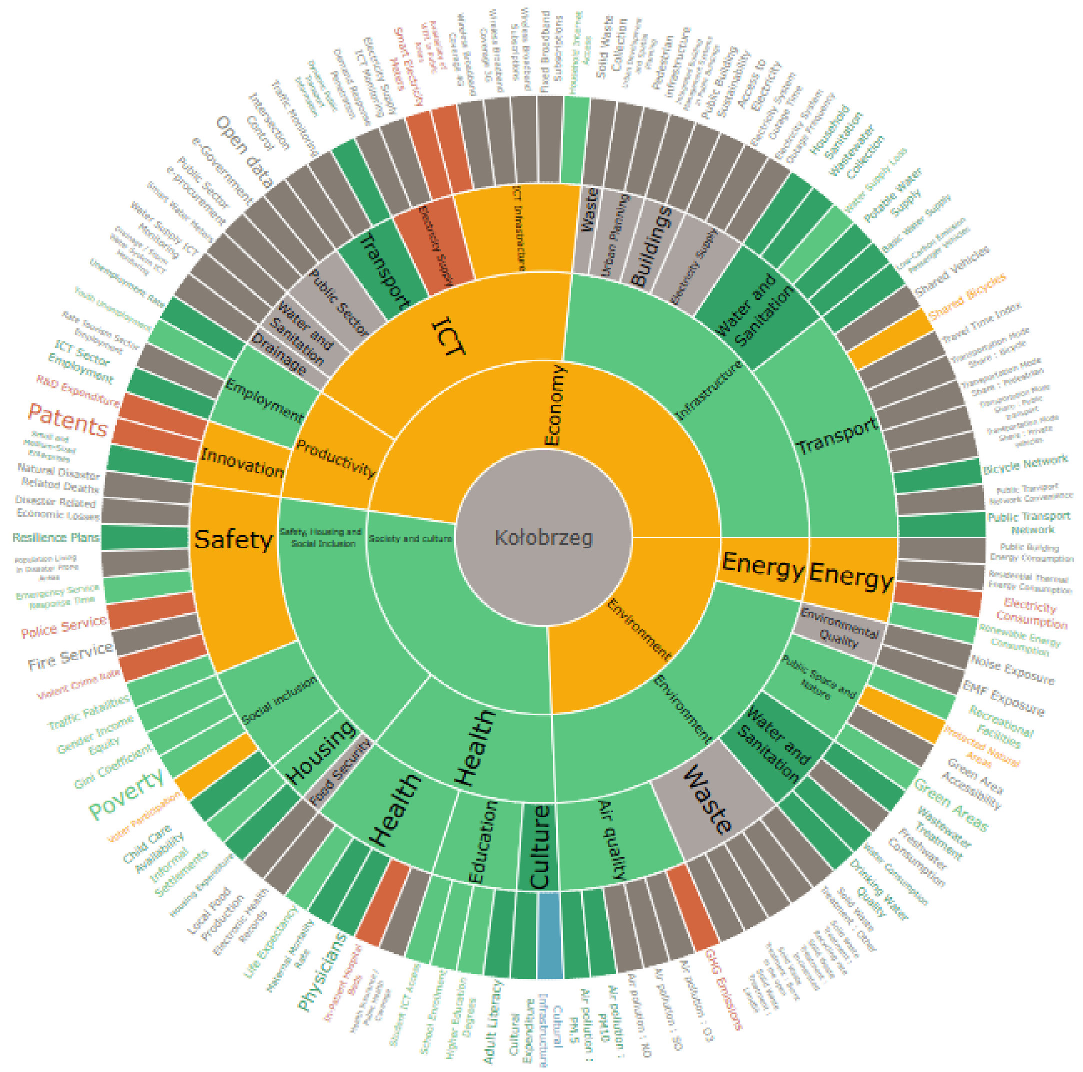
FIGURE 5 : KOŁOBRZEG'S KPIS



2.2.2.3 Analysis of the results :

The incomplete data collection for Kołobrzeg prevents a proper assessment of its urban resilience and sustainability. We notice that most of the lacking indicators are part of the Infrastructure categories, namely what involves Transport and Buildings. The same can be said for the dimension ICT, as well as the sub-dimension Waste. Regarding the second half of the indicators, these reflect a balanced status. As a matter of fact, a good performance is recorded concerning Water and Sanitation, Social Inclusion, Health and its categories including Education and Culture. On the other hand, the Safety sector requires a closer consideration as many indicators are not filled, and for some, the status is rather low (e.g., understaffed police service, moderately high violent crime rate, etc.).

2.2.3 Case study 3 : Kristiansund

2.2.3.1 Presentation of the studied site :

Kristiansund is a municipality on the west coast of Norway, in the Nordmøre district of Møre og Romsdal county, with 24 013 inhabitants. Kristiansund is surrounded by a network of islands and

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fjords in the Norwegian Sea. Its coastal position and proximity to the ocean make the municipality particularly vulnerable to the effects of climate change. Marine storms and rising sea levels threaten its coastal infrastructure and coastline. In addition, melting glaciers and changing precipitation patterns affect slope stability and increase the risk of landslides. At the same time, rising temperatures can disrupt marine ecosystems, affecting the fishing and aquaculture industries, which are economic cornerstones of the region.

2.2.3.2 Assessment of KPIs :

As such, Kristiansund is particularly prone to threatening climate events, which in turn undermines its resilience. Following the U4SSC's methodology, data collection has been achieved for Kristiansund, most of it derived from the annual report 2022 delivered by the municipality's office[5]. More detailed data on Kristiansund and other municipalities can be found in the national statistics website of Norway[6]. In case of missing data using these two sources, we resort to U4SSCs' Verification report (ITU, 2020) developed for Kristiansund. The verification report is the result of the participation of a city in a U4SSC evaluation, and contains the verification results of the data validity submitted by the city, carried out by an independent verifier.

Access to all this material enabled the collection of data for nearly all indicators, with 98 % being completed. The resulting Sunburst graph is shown below (Figure 6).

[5] https://www.kristiansund.kommune.no/_f/p1/i82d4ea1e-a0d8-495a-875f-a4eeaf4cccac/arsrapport-2022.pdf
[6] Statistics Norway : https://www.ssb.no/en

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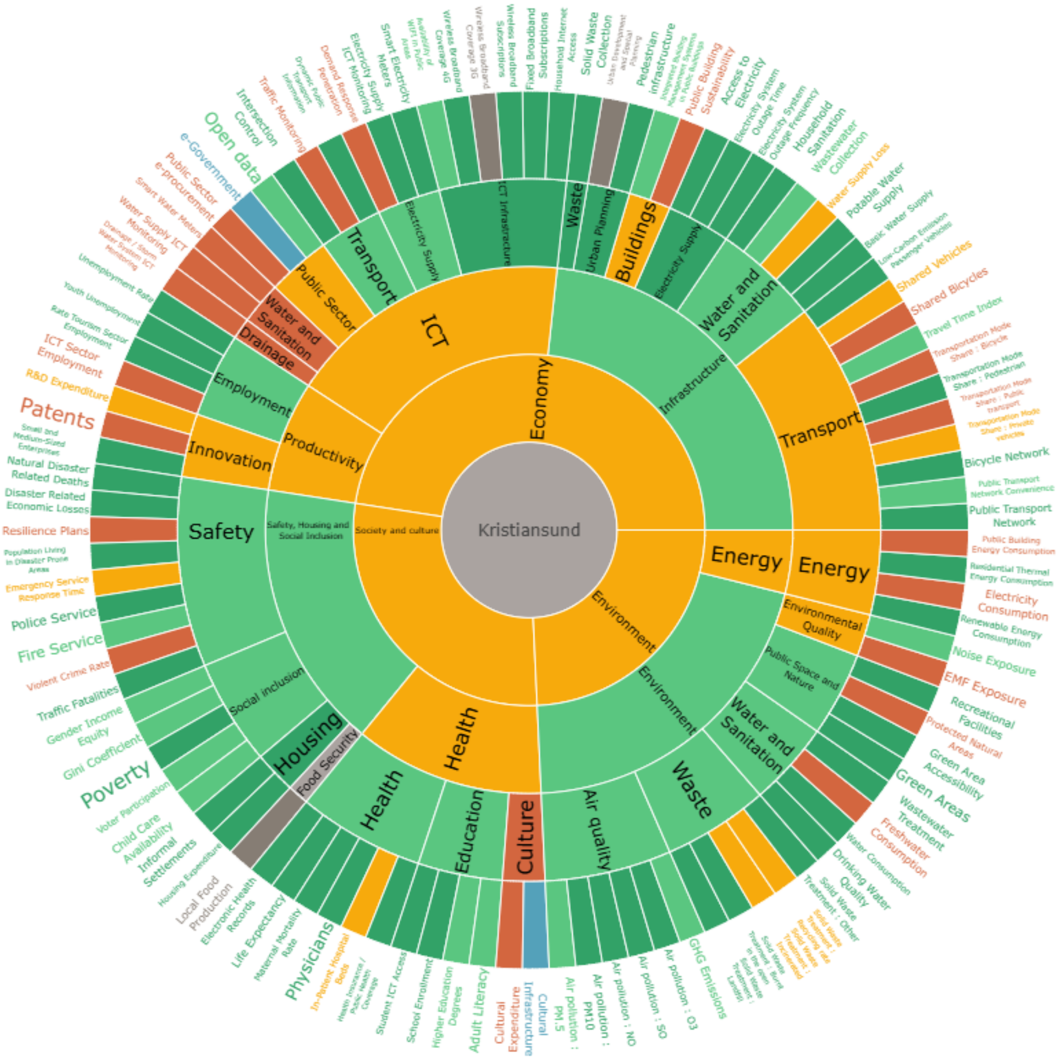
FIGURE 6 : KRISTIANSUND'S KPIS



2.2.3.3 Analysis of the results :

With only three indicators for which there is no data, the assessment of Kristiansund's sustainability and smartness is quite straightforward. Indeed, many sectors seem to be on the path towards urban sustainability according to the standards of the SGDs, among them the dimensions Environment, Safety, Housing and Social Inclusion, and many of the Infrastructure categories. The dimension ICT is rather well-performing except for Public Sector, Water and Sanitation and Drainage ICT related indicators. Similarly, Culture appears to lag significantly behind its target. In general terms, the objective toward a sustainable and smart seems to be well underway for Kristiansund.

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3 Designing indicators on urban resilience

3.1 Description of the design approach

U4SSC's framework thoroughly encompasses the dimensions of urban sustainability and smartness through the selection of indicators mentioned above. While the category Safety resonates with resilience in this framework, we deemed necessary to generate additional KPIs that directly addresses urban resilience, in line with the context of each case study.

As such, the design process of these KPIs evolved following the organisation of the co-creation workshops, as part of WP2. More precisely, these workshops were organised as a deliberative and participatory process, to apprehend how the DT affects the perception of different stakeholders (experts, professionals, lay citizens) on the impacts of climate-related events. Many insightful observations were pointed out by the participants during these workshops, arguing in favor of more customized indicators to grasp the urban resilience and sustainability of these cities. The topics related to climate events and their impacts are chosen according to the specific features of each site. For instance, the co-creation workshops held in Bordeaux Métropole raised the issue of mobility in the face of flooding and submersion risks in the metropole.

As for Kołobrzeg, the city faces flooding risks from multiple sources, including flooding caused by atmospheric precipitation and threats from the sea, as well as flooding resulting from a breach of the embankment. Both scenarios pose significant risks to the surrounding property areas, particularly the allotments.

Finally, strong wind and gale are perceived as major threats in Kristiansund, events that are particularly prevalent in the area because of its coastal position. When rather intense, they can lead to bridge closures and the suspension of ferry traffic. Hence, this matter constituted the subject of the co-creation workshops in Kristiansund, addressing mobility issues during these events.

3.2 Illustration of resilience-related indicators

Table 1 summarizes the list of created indicators stemming from the selected observations during the co-creation workshops. In some cases, these indicators may be common across the studied sites, due to the similarities in the scenarios.

The indicators are constructed in a similar form to the one used in the U4SSC's framework. As illustrated below, they are notably more precise and specific than the latter. However, the data required for their calculation is hard to find and does not feature in most of the resources used for the initial data collection, which was confirmed by the project partners. The same applies for the target values, which have no specific reference and are rather arbitrary.

Ideally and to ensure a comprehensive assessment of the case studies' urban resilience and sustainability, data collection for the following indicators should be conducted in collaboration with the concerned institutional bodies and organisations. Further still, the indicators should be annually updated, so as to constitute a solid database, addressed for monitoring and policy making.

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TABLE 1 : LIST OF RESILIENCE RELATED INDICATORS

Category	Indicator	Method of computation	Target	Bordeaux Métropole	Kołobrzeg	Kristiansund
Mobility	Percentage of additional distance more congested than on a normal day	Total number of congested meters / Total number of congested meters in a normal day	10- 15 %	✓		✓
	Percentage of streets closed in case of flooding	Number of streets closed / Total number of streets	10 %	✓	✓	
	Percentage of streets closed in case of strong wind and gale	Number of streets closed / Total number of streets	10 %			✓
	Percentage of bridges closed in case of strong wind and gale	Number of bridges closed / Total number of bridges	1/3			✓
	Average time duration bridges are closed	End time of closure - start time of closure/ Total number of closure	< 2 hours			✓
Transport	Transportation mode share : Ferries	Number of travelers using ferries / Total number travelers	20 - 30%			✓
	Percentage of ferries in emergency period	Number of ferries in emergency periods/ Total number of ferries	2/3			✓
Infrastructure	Proportion of city land area dedicated to blue and green infrastructure	Total area dedicated to blue and green infrastructure (Ha) / Total area of the city (Ha)	10- 20 %	✓	✓	
	Percentage of impenetrable surfaces	Total area of impenetrable surfaces (Ha)/ Total area of the city (Ha)	<50 %		✓	
	Storm sewer capacity per capita in flood-prone areas	Total storm sewer capacity (liters/hour)/ number of inhabitants (in flood-prone areas)	50 %		✓	
	Percentage of streets in natural depressions	Number of streets in natural depressions/ Total number of streets	10 %		✓	
Building viability	Percentage of buildings on stilts in flood-prone areas	Number of buildings on stilts / Total number of buildings (in flood-prone areas)	High-risk areas : 50 – 75 % Moderate -risk areas : 20 – 50 %	✓		
	Percentage of ground-floor apartments in flood-prone areas	Number of ground-floor apartments / Total number of apartments (in flood-prone areas)	10- 20 %	✓	✓	
	Percentage of buildings with cellars and underground parkings in flood-prone areas	Number of buildings with cellars and underground parkings/ Total number of apartments (in flood-prone areas)	20 %		✓	

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	Percentage of buildings fully submerged under water in case of leeve failure in flood-prone areas	Percentage of buildings fully submerged under water in case of leeve failure/ Total number of buildings (in flood-prone areas)	5 %		✔	
	Percentage of multi-family buildings with no residential units on the ground floor	Number of multi-family buildings with no residential units on the ground floor / Total number of multi-family buildings (in flood-prone areas)	10- 20 %	✔		
	Percentage of multi-family buildings featuring crisis facilities	Number of multi-family buildings featuring crisis facilities / Total number of multi-family buildings (in flood-prone areas)	10- 20 %	✔		
Emergency preparedness	Average time of receiving notification from the public transport sector	Total notification time/ Total number of notifications	20 - 30%			✔
	Percentage of public safety perception	Number of positive response/ Total number of responses	above 50%			✔
	Smart Infrastructure Readiness Index	Total score of digital connectivity + energy infrastructures + resilience + citizen engagement platforms	above 65%			✔
Social resilience	Percentage of buildings insured in case of flood in flood-prone areas	Percentage of buildings insured in case of flood/ Total number of buildings (in flood-prone areas)	High-risk areas: 90% Moderate-risk areas: 50%		✔	

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Conclusion

The present document highlights a section of the work undertaken within WP1, namely the presentation of the selected KPIs portraying urban areas' sustainability and resilience and their application for the case of the three partner cities; Bordeaux Métropole, Kołobrzeg and Kristiansund. Indeed, both the application of the U4SSC framework and the design of specific indicators to resilience and climate change adaptation provided a comprehensive multidimensional perspective, integrating economic, environmental, and socio-cultural dimensions into the evaluation process.

Each of the three cities studied reflects unique challenges and opportunities shaped by their geographical, political, and socio-economic contexts. As such, Bordeaux Métropole has demonstrated significant progress in data collection (81%) and urban sustainability, particularly in the economy and ICT dimensions. However, the city faces challenges in areas such as waste management, public spaces, and safety indicators, which are crucial for enhancing climate resilience in flood-prone zones. Kołobrzeg, with only 51% of its data collected, illustrates the difficulties in acquiring reliable and complete datasets for many KPIs, particularly in the infrastructure and ICT dimensions. Despite these limitations, the city demonstrates potential in sectors like water and sanitation, and social inclusion. Finally, Kristiansund stands out with a nearly complete dataset (98%) and high performance in most dimensions, including environment, safety, and housing. While minor gaps remain in ICT infrastructure and cultural indicators, the city provides a robust model for other urban areas aspiring to align with SDGs. Such an application of U4SSC's framework underscored the critical need for both comprehensive and centralized data collection to ensure consistency, accuracy, and accessibility of information across all relevant sectors. Comprehensive data collection ensures that all key performance indicators (KPIs) are addressed, providing a holistic understanding of urban sustainability and resilience. It further supports informed decision-making and the effective monitoring of progress toward strategic goals.

Beyond data collection, the co-creation workshops conducted in each city provided localized insights, enabling the development of site-specific indicators to address unique challenges, such as mobility issues in flood-prone areas for Bordeaux Métropole or during gale events in Kristiansund, and allotments at risk of flooding in Kołobrzeg. These tailored indicators complement the U4SSC framework, fostering a more actionable and community-centric approach to resilience planning.

As a complement to the Digital Twin (DT) which will display the KPIs, a dashboard was created, illustrating the indicators in various graphical forms (e.g., Sunburst charts). Such representations provide a generic overview of the KPIs' status, enhance transparency and enable real-time visualization of progress, if data is updated annually. Having access to both of these tools provides a comprehensive representation of the cities' progress toward urban sustainability and resilience, making them indispensable for policymakers and stakeholders.

In conclusion, this study underscores the importance of harmonized evaluation frameworks like U4SSC for enabling global comparability while advocating for localized, context-specific approaches to urban planning. Moving forward, strengthening data availability, fostering stakeholder engagement, and leveraging digital technologies will be pivotal in accelerating the transition of cities into smart, sustainable, and resilient urban systems.

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Appendix

TABLE 2 : LIST OF KPIS FOLLOWING ITU'S RECOMMENDATIONS

Dimension	Sub-dimension	Category	Indicator name	Definition/Description	Elements composing this indicator	Type 1	Type 2	Data Sources / Relevant Databases
Economy	**ICT**	ICT Infrastructure	Household Internet Access	Percentage of households with Internet access	Number of households with internet access Total number of households	Core	SMART	The data may be collected from the local statistics department or may need to be extrapolated from national data. The data may also be collected from local Internet service providers and telecommunications companies. Data may be collected from local mobile service providers.
			Fixed Broadband Subscriptions	Percentage of households with fixed (wired) broadband	Number of fixed broadband subscriptions Total number of households	Core	SMART	
			Wireless Broadband Subscriptions	Wireless broadband subscriptions per 100,000 inhabitants	Number of wireless broadband subscriptions One 100,000th of the city's population	Core	SMART	
			Wireless Broadband Coverage	Percentage of the city served by wireless broadband (3G and 4G)	Area of city covered by mobile services (km2) Total area of the city (km2)	Core	SMART	
			Availability of WIFI in Public Areas	Number of public WIFI hotspots in the city	Total number of WIFI hotspots provided by the city administration (excluding commercial entities)	Advanced	SMART	
		Water and Sanitation	Smart Water Meters	Percentage implementation of smart water meters	Number of smart water meters installed Total number of water meters installed	Core	SMART	Data can be collected from local water utilities.
			Water Supply ICT Monitoring	Percentage of the water distribution system monitored by ICT	Length of system monitored by ICT (km). Total length of total system (km).	Advanced	SMART	
		Drainage			Length of system monitored by ICT (km)	Advanced	SMART	

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			Drainage / Storm Water System ICT Monitoring	Percentage of drainage / storm water system monitored by ICT	Total length of total system (km)			Data can be collected from local authorities responsible for drainage.
		Electricity Supply	Smart Electricity Meters	Percentage implementation of smart electricity meters	Number of smart electricity meters installed	Core	SMART	Data can be collected through the local electrical utility.
					Total number of electricity meters installed			
			Electricity Supply ICT Monitoring	Percentage of electricity supply system monitored by ICT	Length of system monitored by ICT (km).	Advanced	SMART	
					Total length of total system (km).			
			Demand Response Penetration	Percentage of electricity customers with demand response capabilities	Number of demand response enabled electricity customers.	Advanced	SMART	
					Total number of electricity customers.			
		Transport	Dynamic Public Transport Information	Percentage of urban public transport stops for which traveler information is dynamically available to the public in real time	Number of stops and stations with dynamic information available.	Core	SMART	Data can be collected from transportation agencies serving the city.
					Total number of stops and stations.			
			Traffic Monitoring	Percentage of major streets monitored by ICT	Length of major streets monitored by ICT (km).	Core	SMART	Data can be collected from municipal, regional or national transportation and roads departments.
					Total length of major streets (km).			
			Intersection Control	Percentage of road intersections using adaptive traffic control or prioritization measures	Number of intersections with adaptive traffic control.	Advanced	SMART	Data can be obtained from local or national transportation / traffic authorities.
					Total number of signal controlled intersections.			
		Public Sector	Open data	Percentage and number of inventoried open datasets that are published	Total number of open data sets published.	Advanced	SMART	Data can be collected through municipal ICT departments.
					Total number of data sets.			
			e-Government	Number of public services delivered through electronic means	Number of public services available through online service.	Advanced	SMART	Data can be collected through surveys of municipal departments/websites.

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			Public Sector e-procurement	Percentage of public sector procurement activities that are conducted electronically	Number of public sector procurement activities conducted online. Total number of public sector procurement activities.	Advanced	SMART	Data can be obtained through city departments with procurement functions and IT departments.
	Productivity	Innovation	R&D Expenditure	Research and Development expenditure as a percentage of city GDP	R&D expenditure (USD) City GDP (USD)	Core	Structural	Data can be sourced through municipal economics departments, business associations or through interpretation of national economic statistics.
			Patents	Number of new patents granted per 100,000 inhabitants per year.	Total number of new patents issued to residents and organizations of the city. One 100,000th of the city's population.	Core	Structural	Data can be found through organizations such as WIPO (World Intellectual Property Organization), national or regional patent offices, or through national research institutions.
			Small and Medium-Sized Enterprises	Percentage of small and medium-sized enterprises (SMEs)	Number of SMEs Total number of enterprises	Advanced	Structural	Data can be collected through local, regional, or national business registration data.
		Employment	Unemployment Rate	Percentage of the total city labour force that is unemployed	Total number of the city labour force that is unemployed. Total number of the city labour force.	Core	Structural	The preferred official national data source for this indicator is a household-based labour force survey. The population census and/or other household surveys with an appropriate employment module may also be used to obtain the required data. Unemployment registers can serve as instruments to collect data on unemployment levels.

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			Youth Unemployment	Percentage of the city youth labour force that is unemployed	Total number of the city youth labour force that is unemployed.	Core	Structural	Data can be collected from local or national bodies, including municipal sites or government statistical agencies.
					Total number of the city youth labour force.			
			Rate Tourism Sector Employment	Percentage of the city labour force working in the tourism sector	Number of employees in the tourism sector	Advanced	Structural	Data can be collected through labour surveys and government departments with responsibility for tourism.
					Total number of the city labour force			
			ICT Sector Employment	Percentage of the city labour force working in the ICT sector	Number of employees in the ICT Sector	Advanced	Structural	This indicator is typically calculated using data from the national account tables.
					Total number of the city labour force			
	Infrastructure	Water and Sanitation	Basic Water Supply	Percentage of households with access to a basic water supply	Number of city households with access to basic water sources.	Core	Sustainable	Data can be collected through the local water utility.
					Total number of city households.			
			Potable Water Supply	Percentage of households with a safely managed drinking water service	Number of city households with a safely managed drinking water service.	Core	Sustainable	
					Total number of city households.			
			Water Supply Loss	Percentage of water loss in the water distribution system	Volume of water supplied minus the volume of utilized water (l/year).	Core	Sustainable	
					Total volume of water supplied (l/year).			
			Wastewater Collection	Percentage of households served by wastewater collection	Number of city households served by wastewater collection.	Core	Sustainable	Data should be collected from local utilities that operate wastewater facilities.

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					Total number of city households.			
			Household Sanitation	Percentage of households with access to basic sanitation facilities	Total number of city households with access to basic sanitation and facilities. Total number of city households.	Core	Sustainable	WHO-UNICEF Joint Monitoring Program for Water Supply and Sanitation
		Waste	Solid Waste Collection	Percentage of households with regular solid waste collection	Number of city households that are served by solid waste collection Total number of city households.	Core	Sustainable	This information could be provided by municipal bodies, public services and major private contractors dealing with solid waste collection and disposal.
		Electricity Supply	Electricity System Outage Frequency	Average number of electrical interruptions per customer per year	Sum of customers interrupted (customers) Total number of customers served (customers)	Core	Structural	Data can be provided by the local electrical utility. IEEE Standard 1366-1998
			Electricity System Outage Time	Average length of electrical interruptions	Sum of all customer interruption durations (mins). Total number of customer interruptions.	Core	Structural	
			Access to Electricity	Percentage of households with authorized access to electricity	Number of city households with an authorized connection to the electrical system. Total number of city households.	Core	Structural	Data can be obtained from local electricity utility providers.
		Transport	Public Transport Network	Length of public transport network per 100,000 inhabitants	Length of public transport lines within city boundaries (km) (one-way length). One 100,000th of the city's population.	Core	Sustainable	Data can be collected from local transportation, road departments and local transit authorities.
			Public Transport Network Convenience	Percentage of the city population that has convenient access (within 0.5 km) to public transport	Total number of city inhabitants living within 0.5km of a public transport stop	Advanced	Sustainable	Data can be obtained through overlays of GIS data from the city and local public transport operator information.

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					Total number of city inhabitants			
			Bicycle Network	Length of bicycle paths and lanes per 100,000 population	Km of bicycle paths/lanes. One 100,000th of the city's population.	Core	Sustainable	Data can be collected from municipal transportation and road authorities.
			Transportation Mode Share	The percentage of people using various forms of transportation to travel to work	Number of travelers using a specific transportation mode. Total number of travelers.	Advanced	Sustainable	Data would be gathered from local road and transport authorities and local transit authorities. Data may be available from transportation surveys.
			Travel Time Index	Ratio of travel time during the peak periods to travel time at free flow periods	Travel time during peak periods (min) Travel time during free-flow periods (min).	Advanced	Sustainable	Data can be obtained from local or national transportation authorities.
			Shared Bicycles	Number of shared bicycles per 100,000 inhabitants	Number of shared bicycles available. One 100,000th of the city's population.	Advanced	Sustainable	Data can be collected from municipal transportation agencies and/or bicycle sharing service operators.
			Shared Vehicles	Number of shared vehicles per 100,000 inhabitants	Number of shared vehicles. One 100,000th of the city's population.	Advanced	Sustainable	Data can be collected from providers of car sharing services.
			Low-Carbon Emission Passenger Vehicles	Percentage of low-carbon emission passenger vehicles	Number of low emission vehicles registered (PHEV & EV). Number of total vehicles.	Advanced	Sustainable	Data can be collected from government agencies that register passenger motor vehicles.
		Buildings	Public Building Sustainability	Percentage area of public buildings with recognized sustainability certifications for ongoing operations	Floor area of public buildings with certification to a recognized standard for ongoing building operations (m2).	Advanced	Sustainable	Data can be obtained through the facilities group within the city and through the websites of various certification agencies.

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					Total floor area of public buildings (m2).			
			Integrated Building Management Systems in Public Buildings	Percentage area of public buildings using integrated ICT systems to automate building management	Floor Area of public buildings using ICT-based systems for integrated management in the city (m2)	Advanced	SMART	Data can be obtained from the department of urban planning or city buildings councils or associations.
					Total floor number of public buildings (m2)			
		Urban Planning	Pedestrian infrastructure	Percentage of the city designated as a pedestrian/car free zone	Total area of pedestrian/car free zones	Advanced	Sustainable	Data may be collected from city Geographical Information Systems (GIS) data or planning department.
					Total city area			
			Urban Development and Spatial Planning	Existence of urban development and spatial planning strategies or documents at the city level	To collect the data for the measurement: Step 1: Identify city (in scope); Step 2: Deduce whether there is an urban plan for the city; and Step 3: Examine if urban plans contain all 5 sustainability principles/elements (if the plans are digitalized and on the web then consider using automated web queries with semantics to examine these elements). If an urban plan has a smart methodology (as defined above) and meets all 5 sustainable urban plan principles, then it qualifies as a smart sustainable city's urban plan. If these principles are only partially met, mark as "partial" for further development.	Advanced		Urban planning websites and data repositories of local, municipal and/or national governments.

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Environment	Environment	Air quality	Air pollution	Air quality index (AQI) based on reported value for: Particulate matter (PM10, and PM2.5); NO2 (nitrogen dioxide); SO2 (sulphur dioxide); and O3 (ozone).	Mass of pollutant collected (µg)	Core	Sustainable	Air quality data can be found on the WHO website, and greenhouse gas inventory data on the UNFCCC website.
					Volume of air sampled (m3)			
			GHG Emissions	Greenhouse gas (GHG) emissions per capita	Total GHG emissions (tons eCO2)	Core	Sustainable	
					Total number of city inhabitants.			
		Water and Sanitation	Drinking Water Quality	Percentage of households covered by an audited Water Safety Plan	Total amount of freshwater consumption	Core	Sustainable	Information on the volume of water coming from freshwater sources or intakes can be received from city water utilities and water distribution and treatment companies. Hydrological data can also be requested from the Ministry of the Environment and the National Water Authority.
					Total amount of water consumption			
			Water Consumption	Water consumption per capita	Total amount of water consumption in cities (l /day).	Core	Sustainable	
					Total number of city inhabitants.			
			Freshwater Consumption	Freshwater consumption	Total amount of freshwater consumption	Core	Sustainable	
					Total amount of water consumption			
			Wastewater Treatment	Percentage of wastewater receiving treatment (Primary, Secondary, Tertiary)	Total amount of wastewater that has undergone (primary /secondary / tertiary) treatment (l).	Core	Sustainable	
					Total amount of wastewater collected (l).			
		Waste	Solid Waste Treatment	The percentage of solid waste dealt with in the following ways should be reported on: a) disposed to sanitary landfills; b) burnt in an open area; c) incinerated;	Total amount of solid waste that is (disposed to landfills/incinerated/burnt in an open area/disposed in an open dump/other/recycled) (tons).	Core	Sustainable	Data can be collected from municipalities, municipal contractors or private contractors responsible for solid waste collection and disposal.

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				d) disposed to an open dump; e) recycled; and f) other (with regard to total amount of solid waste produced).	Total amount of solid waste produced (tons).			
		Environmental Quality	EMF Exposure	Percentage of mobile network antenna sites in compliance with EMF exposure guidelines	Number of sites complying with WHO guidelines.	Core	Sustainable	Data can be collected by municipal/national environmental departments, and EMF exposure data is obtained via the ITU EMF Guide and WHO Standards and Guidelines.
					Total number of sites.			
			Noise Exposure	Percentage of inhabitants exposed to excessive noise levels.	Number of city inhabitants exposed to noise levels [LDEN (day-evening- night)] over 55 dB(A).	Advanced	Sustainable	
					Total number of city inhabitants.			
		Public Space and Nature	Green Areas	Green area per 100,000 inhabitants	Total area of green space in the city (hectares) (public and private).	Core	Sustainable	Data may be obtained through municipal parks and recreation departments, planning departments, aerial surveys or GIS data.
					One 100,000th of the city's population.			
			Green Area Accessibility	Percentage of inhabitants with accessibility to green areas.	Number of inhabitants living with 300m of a publicly accessible green space of at least 0.5ha.	Advanced	Sustainable	Data may be obtained from municipal parks and recreation departments, planning departments, aerial surveys or GIS data overlaid with population data or maps.
					Total number of city inhabitants.			
			Protected Natural Areas	Percentage of city area protected as natural sites	Area of protected natural areas preserved by law or other effective means (hectares).	Advanced	Sustainable	Data may be obtained through municipal parks and recreation departments, planning departments, aerial surveys or GIS data.
					Total city area (hectares).			
			Recreational Facilities	Area of total public recreational facilities per 100,000 inhabitants	Total area of indoor and outdoor facilities (m2).	Advanced	Sustainable	Data can be obtained through municipal recreations, planning and sports departments and GIS data.
					One 100,000th of the city's population.			

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	Energy	Energy	Renewable Energy Consumption	Percentage of renewable energy consumed in the city	Total consumption of electricity from renewable sources (kWh/yr). Total city electricity consumption (kWh/yr).	Core	Sustainable	Data can be obtained through local utility providers.
			Electricity Consumption	Electricity consumption per capita.	Total consumption of electricity (kWh / year). Total number of city inhabitants.	Core	Sustainable	Data can be collected from local electricity utilities.
			Residential Thermal Energy Consumption	Residential thermal energy consumption per capita	Total consumption of thermal energy (Gj/year). Total number of city inhabitants.	Core	Sustainable	Data can be collected from local utilities supplying thermal sources of energy.
			Public Building Energy Consumption	Energy consumption of public buildings	Total energy consumption by public buildings (ekWh/yr). Total floor space of public buildings (m2).	Core	Sustainable	Data can be collected from municipal facilities departments and local utilities.
Society and Culture	**Education, Health and Culture**	Education	Student ICT Access	Percentage of students with classroom access to ICT facilities	Students with classroom access to ICT facilities. Total number of students enrolled in schools.	Core	SMART	Data can be collected from local school boards / authorities or regional / national education departments or through education surveys.
			School Enrollment	Percentage of school-aged population enrolled in schools	Number of students in primary and secondary levels in public and private schools. Total number of the school aged population.	Core	Structural	
			Higher Education Degrees	Higher level education degrees per 100,000 inhabitants	Number of city inhabitants holding at least one higher-level education degree. One 100,000th of the city's population.	Core	Structural	Data can be collected from local or regional departments of education or through national census data.
			Adult Literacy	Adult literacy rate	Number of adult city inhabitants who are deemed literate Total number of adult city inhabitants.	Core	Structural	The data may be collected from local education or labour force departments or may need to be interpreted from national data.

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		Health	Electronic Health Records	Percentage of city inhabitants with electronic health records	Number of city inhabitants with electronic health records. Total number of city inhabitants	Core	SMART	The data may be collected from local health departments or may need to be interpreted from regional or national data.
			Life Expectancy	Average life expectancy	Average number of years that a newborn is expected to live if current mortality rates continue to apply.	Core	Structural	The data may be collected from local health departments or may need to be interpreted from regional or national data.
			Maternal Mortality Rate	Maternal deaths per 100,000 live births	Number of maternal deaths in a year. Number of live births in a year.	Core	Structural	Data may be collected from local health authorities, local/public hospitals and/ or labour force surveys.
			Physicians	Number of physicians per 100,000 inhabitants.	Number of general or specialized physicians working in the city (FTE) One 100,000th of the city's population.	Core	Structural	
			In-Patient Hospital Beds	Number of in-patient public hospital beds per 100,000 inhabitants.	Total number of in-patient hospital beds (public and private). One 100,000th of the city's population.	Advanced	Structural	Data can be collected from local health departments or from hospital facility records or hospital surveys.
			Health Insurance / Public Health Coverage	Percentage of inhabitants covered by basic health insurance or a public health system	Number of inhabitants covered by health insurance or a public health system. Total number of city inhabitants.	Advanced	Structural	The data may be collected from local health departments or may need to be interpreted from national data.
		Culture	Cultural Expenditure	Percentage expenditure on cultural heritage.	Municipal expenditure on preservation, protection and conservation of all cultural and natural heritage (USD). Total city operating budget (USD).	Core	Structural	Data can be collected through municipal financial reports.
			Cultural Infrastructure	Number of the cultural institutions per 100,000 inhabitants.	Number of cultural institutions. One 100,000th of the city's population.	Advanced	Structural	Data can be collected from municipal, regional or national cultural and arts departments.

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	Safety, Housing and Social Inclusion	Housing	Informal Settlements	Percentage of inhabitants living in slums, informal settlements or inadequate housing.	Number of people living in slums, informal settlements or inadequate housing Total number of city inhabitants.	Core	Structural	Data can be collected from municipal planning and housing departments.
			Housing Expenditure	Percentage expenditure of income for housing	Expenditure on Housing (USD) Total household income (USD)	Advanced	Structural	Data can be obtained through national statistics offices.
		Social inclusion	Gender Income Equity	Ratio of average hourly earnings of female to male workers.	Average hourly earnings of female employees (USD) Average hourly earnings of male employees (USD).	Core	Structural	Data can be collected through labour market surveys. Data may need to be interpreted from national statistics.
			Gini Coefficient	Income distribution in accordance with Gini coefficient	Area between 45 degree line and Lorenz curve. Entire area below 45 degree line	Core	Structural	World Bank, OECD: Income distribution database.
			Poverty	Percentage of inhabitants living in poverty.	Number of city inhabitants living below the poverty line. Total number of city inhabitants.	Core	Structural	National poverty thresholds can be used to determine the poverty level of a city.
			Voter Participation	Percentage of the eligible population that voted during the last municipal election	Total number of people who voted in the previous administrative city elections. Total number of eligible voters	Core	Structural	Data about voter participation can be extracted from the international database organised by the Institute for Democratic and Electoral Assistance (IDEA).
			Child Care Availability	Percentage of pre-school age children (0-3) covered by (public and private) day-care centers.	Number of day-care spots available for pre-school children Total number of pre-school age children.	Advanced	Structural	EUROSTAT, OECD Family Database.
		Safety	Natural Disaster Related Deaths	Number of natural disaster related deaths per 100,000 inhabitants.	Number of annual natural disaster related deaths. One 100,000th of the city's population.	Core	Sustainable	Data can be collected from municipal emergency services and hospitals.
			Disaster Related Economic Losses	Natural disaster related economic losses as a percentage of the city's GDP.	Total economic losses (last annual reporting period) related to disasters.	Core	Sustainable	Data can be obtained through governmental economics statistics and insurance statistics.

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					GDP of the city.			
			Resilience Plans	Implementation of risk and vulnerability assessments for disaster mitigation.	The indicator would involve a summation of qualitative data from various sources on the presence of risk and vulnerability assessments, financial (capital and operating) plans and technical systems for disaster mitigation addressing natural and human induced disasters and risks in the cities. Possible categorization may be: plans present and adequate; plans present and inadequate; or plans do not exist. The second option could even be expanded further to provide level of inadequacy.	Advanced	Sustainable	Data on risk and vulnerability assessments and actions can be derived from global datasets on risks and vulnerabilities, the United Nations Framework Convention on Climate Change, the United Nations Office for Disaster Risk Reduction, The World Bank, Global Environment Facility, OECD, Asian Development Bank, African Development Bank, Development Bank of Latin America, the World Risk Index, etc.
			Population Living in Disaster Prone Areas	Percentage of inhabitants living in a zone subject to natural hazards	Total number of city inhabitants living in areas subject to significant risk of death or damage caused by prominent hazards	Advanced	Sustainable	EM-DAT Database
					Total number of city inhabitants			
			Emergency Service Response Time	Average response time for Emergency Services.	Sum of all the minutes from an initial call to the on-site arrival of the emergency service in the year.	Advanced	Structural	Data can be collected from local emergency services.
					Number of emergency responses in the same year.			
			Police Service	Number of police officers per 100,000 inhabitants.	Number of full time police officers (expressed as FTE).	Core	Structural	Data can be collected from police service personnel records.
					One 100,000th of the city's population.			

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			Fire Service	Number of firefighters per 100,000 inhabitants.	Number of full time firefighters (expressed as FTE). One 100,000th of the city's population.	Core	Structural	Data can be collected from municipal fire service personnel records.
			Violent Crime Rate	Violent crime rate per 100,000 inhabitants	Number of violent crimes committed. One 100,000th of the city's population.	Core	Structural	Data can be collected from local police departments and departments of justice. UNODC, WHO.
			Traffic Fatalities	Traffic fatalities per 100,000 inhabitants.	Number of traffic fatalities. One 100,000th of the city's population.	Core	Structural	Data can be collected from local transportation and emergency departments and local hospitals. The World Health Organization can also provide adequate data on traffic fatalities.
		Food Security	Local Food Production	Percentage of local food supplied from within 100 km of the urban area.	Amount of local food supplied to the city (within 100 km) (tons). Amount of total food supplied to the city (tons).	Advanced	Sustainable	Data can be collected from local, regional and national departments related to agriculture and trade.

CONSORTIUM

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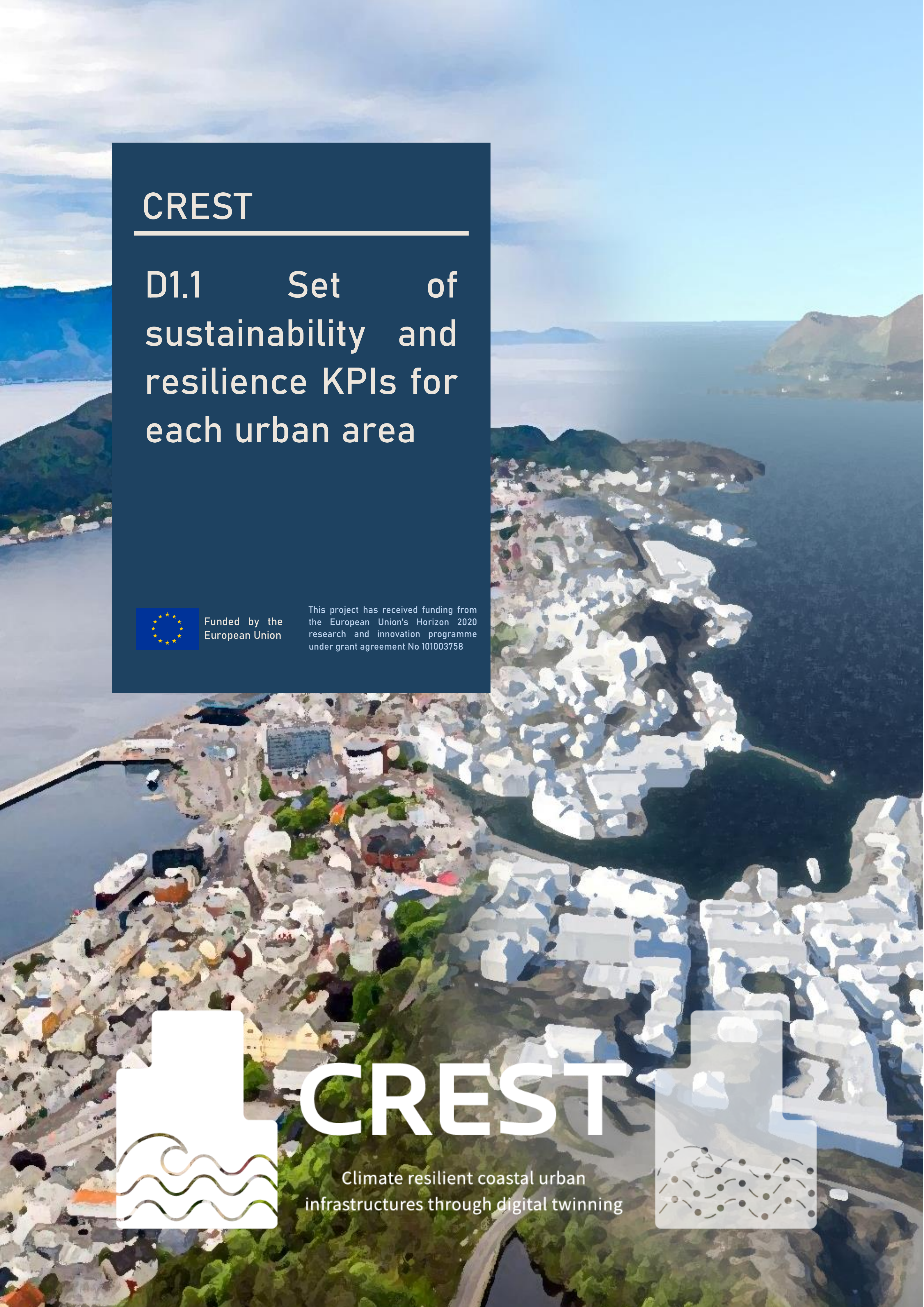

CREST

D1.1 Set of sustainability and resilience KPIs for each urban area

Funded by the European Union

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CREST

Climate resilient coastal urban infrastructures through digital twinning