Chapter 64
Data Visualization and Web-Based Mapping for SGDs and Adaptation to Climate Change in the Urban Environment

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Abstract To address Sustainable Development Goals (SDGs) and face climate change effects, it is necessary to adopt multidisciplinary methodologies and strategies for risk prevention and mitigation of the impact in urban contexts. These phenomena represent a risk for cultural heritage conservation, with negative consequences for local economies. To move from the analysis of climate impacts to adaptation measures and governance tools, it is necessary to deal with the different characteristics of the urban context in its physical, historical, cultural, and socio-economic components. The paper focuses on the collaboration between UNIGE Architecture and Design Department (DAD), and Colouree S.r.l. that has developed an analytical platform that uses artificial intelligence, geo-referenced data, and automated analysis to define the characteristics of the urban context. The aim of the research is the identification of parameters and solutions to respond to the effects of climate change in the urban environment, considering risk levels and context settlement; alongside the climatic skills, also the architects' skills in environmental technologies, urban landscape, and cultural heritage have been given relevance. DAD aims to capitalize on the previous and ongoing experiences of Colouree, offering scientific and methodological support, to reach the definition of a detailed settlement analysis, providing indications on the risks associated with the main predictable effects (extreme weather events, heat island effect, water availability). The expected results will define a methodological structure to create a sensitivity mapping to meteorological phenomena, based on the data support from Colouree towards the carrying capacity of the urban fabric, making information more accessible thanks to the data

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visualization and web-based mapping, including, among the stakeholders, not only experts but also professionals and citizens.

Keywords Smart city · Resilience · Data-driven design · Key performance indicators · Climate change

64.1 Introduction

The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, provides a shared blueprint for peace and prosperity for people and the planet, for the present and next generations (United Nations 2015). The Agenda defines the 17 Sustainable Development Goals (SDGs), which are an urgent call for action by all countries—developed and developing—in a global partnership (https://sdgs.un.org/goals). These objectives aim to safeguard the health of people and the environment, to cope with climate change, to achieve an effective ecological transition towards renewable sources, and to make cities more resilient. The research presents in this paper will refer to Goal 11 "Make cities and Human settlements inclusive, safe, resilient, and sustainable" and Goal 13 "Take urgent action to combat climate change and its impacts".

Climate change is one of the most demanding challenges that the human being, and consequently the urban environment, must face nowadays. Global Warming caused a rise in temperatures of the planet by 0.98 °C and the trend observed since 2000 suggests that, in the absence of interventions, it could reach + 1.5 °C between 2030 and 2050 (Intergovernmental Panel on Climate Change 2022).

Plant and animal species move unpredictably from one ecosystem to another, creating incalculable damage to biodiversity around the world, even if ecosystems have demonstrated to be extremely resilient (Côté and Darling 2010). The framework of climatic weather phenomena that determine significant impacts in the cities is complex and concerns different natural matrices, due to the transformations that have taken place in urban areas, causing different behaviour from normal dynamics.

Therefore, in urban areas, the consequences of climate change are particularly dramatic, in relation to the strong impermeability of the soils, with consequent phenomena of flooding, or overheating conditions due to the Urban Heat Island effect (UHI) (Watson and Adams 2011).

The warming climate, combined with the UHI effect, will increase air pollution in cities (Akhtar and Palagiano 2018). It is very important to define trends and forecasts that address extreme events, both in terms of safety and risk, adaptation, and defence.

Cities should be prepared to anticipate these changes to fulfil a more sustainable future and be more resilient to climate-rated disasters, also reducing greenhouse gases (GHG) emissions (Rosenzweig et al. 2018).

The use of Key Performance Indicators (KPI) and the monitoring through them of the progress in achieving the SDGs are a way to develop strategies for cities management and to monitor their present conditions (Chan and Chan 2004). Thus,

the municipalities must equip themselves with tools capable of translating the information collected through the monitoring of the KPIs through digital tools, such as document reports and interactive dashboards.

The collaboration between Ecosystemics Research Group, which operates within the University of Genoa (UNIGE), Architecture and Design Department (DAD), and Colouree S.r.l., a company that has developed an analytical platform that uses artificial intelligence, geo-referenced data, and automated analysis to define the characteristics of urban context, focuses on the development of a shared methodology for organize KPIs to define trends to help municipality to fulfil targeted SDGs and improve resilience measures. This partnership is supported by the research carried out on the Operative National Programme (PON) Research and Innovation 2014–2020 (currently in progress), which provides for a collaboration between researchers and companies.

64.2 Key Performance Indicators for SDGs and Climate Change

64.2.1 Key Performance Indicators: Role and Selection

To better understand and monitor the progress in achieving the SDGs considering the conditions of each individual country, region, or metropolitan city, it is necessary to identify comparable and universally shared evaluation parameters. KPIs can define in a realistic and measurable way essential factors related to a specific object, such as climate change reduction, or communities' resilience achievement. KPIs are an important instrument also for set environmental policies, especially for public bodies, that can define realistic goals for the fulfilment of SDGs and to understand in which sectors they are most lacking (Schokker et al. 2022).

Accountability and monitoring for city governments is a central concern in local and multilevel governance strategies (Hughes et al. 2020). Compared to monitoring on a national scale, those on a local scale can be extremely significant in mapping the actual differences found on a regional and metropolitan scale. However, it is necessary to select sets of indicators with adequate units of measurement and refer to databases that offer values on a small scale, updated and updatable in future (Arup 2014). To identify a shared statistical information framework as a tool for monitoring and evaluating progress towards the objectives of the Agenda, the United Nations Statistical Commission has set up the Inter Agency Expert Group on SDG which has defined a set of over 200 indicators. The Italian National Institute of Statistic (ISTAT) is involved in the production of statistical measures for monitoring progress towards the Sustainable Development Goals (Rapporto Sdgs 2021).

The measures consider the indicators defined by the Expert Group together with some specific national context data, also deriving from the Equitable and Sustainable Well-being framework (Bes) (Il Benessere Equo e Sostenibile in Italia 2021). The

Bes project was born in 2010 to measure fair and sustainable well-being, with the aim of evaluating the progress of society not only from an economic point of view, but also from a social and environmental point of view (https://www.istat.it).

64.2.2 SDGs Monitoring Experience

The collaborations between DAD and Colouree, started on March 2022, focusing on the DataLab project (Guidelines for Integrated Agenda Monitoring Sustainable Underground) promoted by Metropolitan City of Genoa and Metropolitan City of Milano. DataLab stems from the experience gained within the project Decimetre, an online consultation platform, which allows dialogue between public administration bodies and provides an environment for the analysis of territorial data decision support. Starting from the objectives and targets defined by the Sustainable Metropolitan Agenda, DataLab was imagined as a dashboard for data analysis and monitoring, multitenant, open, and interoperable, which can be shared with other Metropolitan cities, and with European metropolitan areas (access online on https://sdgcittametropolitana.mi.it/).

Colouree offers Artificial Intelligence (AI), Data and Location Intelligence solutions in the Smart City and Real Estate, oriented to monitoring, decision support, and based user engagement on the ability to analyse the interactions between people, activities, and the built space. The DataLab activities consist in the diagnosis and setting of Data Architecture starting from the defined objectives and targets in the Sustainable Metropolitan Agenda and Italian Alliance for Sustainable Development (ASVIS) and ISTAT indicators; data-driven storytelling definitions based on needs and strategic scenarios of the administration; design of the technological platform for indicators monitoring and viewing; implementation of indicators and dashboard (Fig. 64.1).

64.2.3 Data-Driven Storytelling as a Strategy for Sustainable Development

Data-driven storytelling gives the possibility to turn raw data into more easy-to-read and understandable concepts that help users to have a wider view. This approach is very relevant considering KPIs: they could give a very detailed kind of information, especially in relation to SDGs fulfilment and to each goal. Therefore, SDGs are correlated to KPIs that could describe different scenarios and being associated to define a trend. Data-driven storytelling allows to communicate sustainability into its complexity, trough data visualization, infographic elements thank also to dashboard architectures (Ren 2019).

Fig. 64.1 SDGs dashboard for metropolitan city of Milan—copyrights: Colouree S.r.l

DAD, according to Colouree, provides data-driven storytelling methodology, starting from the selection of strategic indicators for the metropolitan city, considering the development lines, the leading sectors (based for example on SWOT analyses provides by municipalities) it is possible to define trends that group proven indicators with different macro-objectives. The municipalities have identified the most relevant indicators for the specific territories among the ISTAT and Bes SDGs indicators. The reference data have been identified for each indicator. Starting from these selected indicators, some reference scenarios have been identified, defining specific trends. The defined trends, according with Municipalities, are "Resilient Communities", "Inclusiveness and Empowerment", and "Smart Connections". "Resilient Communities" trend, for example, helps in understanding, through the selected indicators, how the Metropolitan City of Milan and the communities that inhabit it can respond in time to perturbative events, learning to be more flexible and active in dealing with difficulties, making cities and human settlements more inclusive, safe, sustainable, and self-sufficient. The table below summarizes the objectives and indicators (Table 64.1).

The same approach is applied for "Inclusiveness and empowerment" trend, that allows to understand through the selected indicators how the Metropolitan City of Milan contributes to promoting the coexistence and enhancement of differences, the quality of life and connections, guaranteeing equal opportunities to its citizens, and for "Smart Connections", that shows how the communities and the inhabitant are able to use connections (tangible and intangible networks) to improve synergies, communications, mobility, exchange and access to information (Figs. 64.2 and 64.3).

Table 64.1 "Resilient communities" trend

SDGs goal	Objectives	KPIs
2. Zero hunger	2.3 Double the productivity and income of small-scale food producers	Added value per hectare of agricultural area used
	2.4 Ensure sustainable food production and resilient agricultural practices	Agricultural area utilized (UAA) invested in organic crops
6. Clean water and sanitation	6.6 Protect and restore water-related ecosystems	Efficiency of drinking water distribution networks
7. Affordable and clean energy	7.3 Double the overall rate of improvement in energy efficiency	Total electricity consumption (GWh) required from the distribution networks per 10,000 inhabitants
11. Sustainable cities and communities	11.7 Provide access to safe and inclusive green and public spaces	Availability of urban green public spaces
12. Responsible production and consumption	12.4 Handle chemicals and waste responsibly	Selected collection of urban waste
13. Climate action	13.1 Strengthen resilience and adaptability to climate-related disasters	Population exposed to flood risk
	13.2 Integrate climate change measures into policies and planning	Emissions of tons of CO_2 eq per capita
		Population exposed to landslide risk

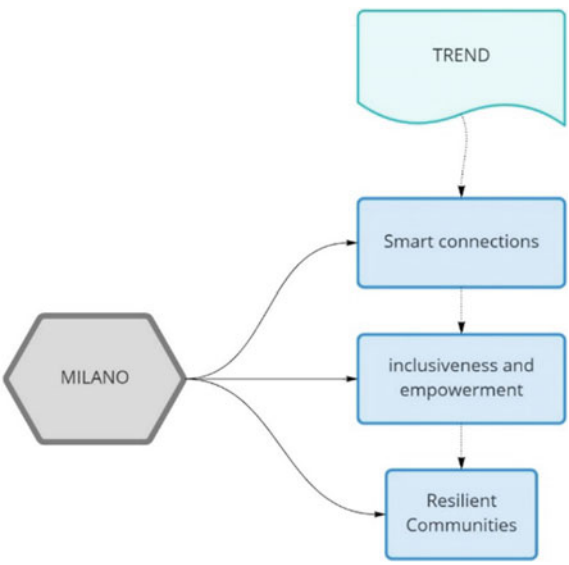

Fig. 64.2 SDGs trends for metropolitan city of Milan—copyrights: authors

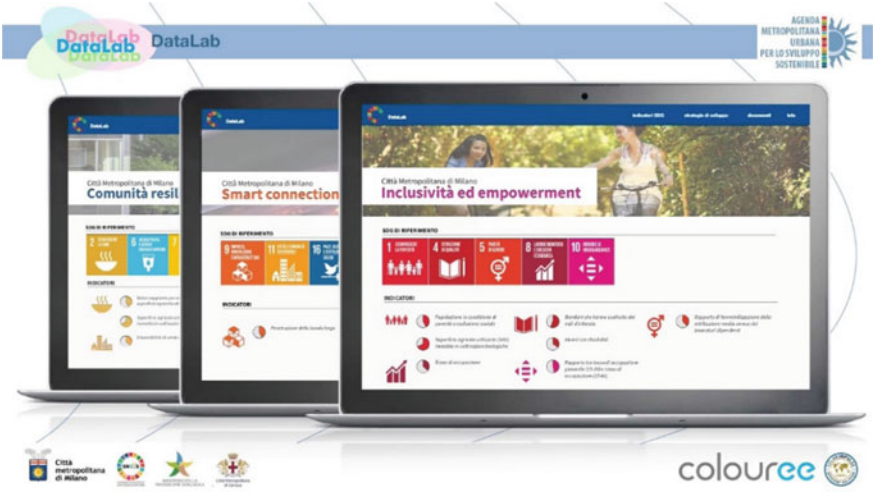

Fig. 64.3 Trends dashboard visualization for metropolitan city of Milan—copyrights: Colouree S.r.l

64.3 Parameters and Solutions to Respond to the Effects of Climate Change

64.3.1 Monitoring Extreme Events in Urban Areas

The project developed during the research and the collaboration with Colouree on KPIs (as requested by RTDa PON agreement) aims also to develop an integrated model for the analysis of urban space, adaptable to different contexts, and the identification of adaptation strategies and solutions to climate change, with the objectives of reducing risk and mitigating residual impacts. To move from the analysis of climate drivers and related impacts to adaptation measures and related governance tools capable of making them operational, it is necessary to deal with the different characteristics of the local context in its physical, spatial, historical, cultural, and socio-economic components (Quijano et al. 2022). Events can lead to a loss of both architectural and landscape values—as in the case of events in a coastal environment—and affect the most fragile social groups (e.g., the elderly)—as happens, for example, in relation to the effects of the UHI, as well as with the loss of private and public assets (as in the case of flooding). This step implies the use of parameters for evaluating the sensitivity of the urban space, at different scales (KPI) (Amoah 2021).

DAD and Colouree will collaborate on the Project "Urban resilience: nowcasting of flood risk with IoT sensors and open data—RUN", promoted by University of Genoa, Colouree and Iride Enia (IREN), an Italian joint stock company, operating as a multiservice. The project involves the development and demonstration of a nowcasting service of the risk of flooding in the presence of intense rains and making

use of Internet of Things (IoT) technologies and Big Data Analysis Tools designed for Smart City and urban drainage network operators, allowing faster actions to protect people and properties.

64.3.2 Outlook and Expected Results

The methodology developed to face urban climate change adaptation, capitalizing the experience of the RUN Project, could be applied to different risk drivers, referring to several areas in relation to the context characteristics, defining the urban and building parameters necessary for the analysis and forecast simulations. One of the in-depth analyses intended to be carry out regards the possibility of using data management and visualization systems, and their combinations as representative of specific phenomena, referring to the prediction of the effects of climate change in urban space. Predictive software, for example, starting from climatic data, allow us to anticipate changes in different environmental parameters (atmospheric temperature, relative humidity, speed of air flows, radiant temperatures, thermal comfort parameters) without the need for direct detection, starting from data collected in adjacent areas. It is therefore possible to create scenarios relating to microclimatic (local) variations according to the different characteristics of the urban fabric: height of buildings, settlement density, presence of vegetation, distribution, and shape of buildings, etc. Similarly, it is possible to make forecasts relating to the effects of rainy events on the ability of urban areas to manage water volumes in the disposal process (in relation to soil permeability, capacity of canalizations, etc.). Climate events can have serious consequences on people's safety and cause loss of assets if their effects are not correctly foreseen, therefore mitigating and adaptation solutions are put in place.

64.4 Conclusions

Data visualization and web-based mapping are always more relevant to address SDGs and face climate change effects, offering to municipality the opportunity to use dynamics tools to support governance decision process. Also, it could be possible to monitor the parameters on a reduced scale, operating a downscaling compared to the data already available, allowing to take more effective measures, linked to the specific territories. The limits of these tools can be conditioned by the scarce availability of data, or by the lack of continuity over the years. To achieve more consistent results, it's important to adopt multidisciplinary methodologies and strategies for risk prevention and mitigation of the effects in urban contexts, implementing dashboards with real-time data and specific KPIs for sustainability objectives that are intended to reach.

Although the collaboration between DAD and Colouree is in the initial phase, the first data relating to data-driven storytelling have been published in the first draft of the dashboards, constantly updated.

Considering the ongoing "RUN" Project, the forecasting simulation processes, however, require processing time, as well as expert personnel capable of managing the data and interpreting the results. This specific PON research, among the various objectives, aims to verify the possibility of interactions between meteorological conditions and the urban fabric characteristics, categorizing them in cases, to understand, almost in real time, as the climatic conditions change, the level of risk for people and goods. Although the simulations can be carried out at different dimensional scales, the effects of climate change, in fact, retain a certain uncertainty that should be managed with immediate interventions. Subsequently, it would be possible to identify a set of intervention strategies, which can modify the characteristics of the elements constituting the urban fabric (soil permeability, use of the land, constraints on activities at risk, adoption of Nature Based Solutions, etc.). In certain cases, behavioural strategies can instead be implemented such as those that are currently triggered according to the level of alert that local administrations set and which, due to the complexity of the territory, are often excessively precautionary if applied throughout the territory, with the risk of being underestimated by the population.

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References

Akhtar R, Palagiano C (2018) Climate change and air pollution the impact on human health in developed and developing countries. Springer International Publishing, Cham

Amoah J et al (2021) In: Dima A (ed) Resilience and economic intelligence through digitalization and big data analytics. Sciendo, Warsaw

Arup (2014) City resilience index: research report, vol 2. Fieldwork data analysis. Ove Arup & Partners International Limited. https://www.arup.com/-/media/arup/files/pdf-downloads/cri_research_report_vol2_comp.pdf

Chan AP, Chan AP (2004) Key performance indicators for measuring construction success. Benchmarking Int J. http://doi.org/10.1108/14635770410532624

Côté I, Darling E (2010) Rethinking ecosystem resilience in the face of climate change. PLoS Biol 8(7):e1000438. https://doi.org/10.1371/journal.pbio.1000438

Hughes S, Sarah G, Tozer L (2020) Accountability and data-driven urban climate governance. Nat Clim Chang 10(12):1085–1090. https://doi.org/10.1038/s41558-020-00953-z

Il Benessere Equo e Sostenibile in Italia, Bes 2021 (2021) Technical report. ISTAT. https://www.istat.it/it/archivio/269316

Intergovernmental Panel on Climate Change (2022) Climate change 2022 impacts, adaptation and vulnerability. IPCC, Switzerland

Quijano A et al (2022) Towards sustainable and smart cities: replicable and KPI-driven evaluation framework. Buildings (Basel) 12(2):23. http://doi.org/10.3390/buildings12020233

Rapporto Sdgs (2021) Informazioni Statistiche per l'agenda 2030 in Italia. Technical report. https://www.istat.it/it/files

Ren D (2019) Visualization authoring for data-driven storytelling. eScholarship, University of California. https://escholarship.org/uc/item/1ks25661

Rosenzweig C et al (eds) (2018) Climate changes and cities. Cambridge University Press, New York

Schokker J, Kamilaris A, Karatsiolis S (2022) A review on key performance indicators for climate change, progress in IS. In: Wohlgemuth V, Naumann S, Behrens G, Arndt H-K (eds) Advances and new trends in environmental informatics. Springer, Berlin, pp 273–292

United Nations (2015) Transforming our world: the 2030 agenda for sustainable development. A/RES/70/1

Watson D, Adams M (2011) Design for flooding architecture, landscape, and urban design for resilience to flooding and climate change. Wiley, Hoboken, N.J.