The Design of Citizen-Centric Green IS in Sustainable Smart Districts

Valerie Graf-Drasch, Robert Keller, Oliver Meindl, Felix Roehrich

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Appendix A: Final Design Principles

Design Principle 1	Involvement of Citizens
Aim	To foster a positive attitude to the Green IS among citizens, which should lead to a greater understanding and more extensive use
Context	Initiation, Development, Implementation
Mechanism	Ensure appropriate involvement of citizens via active and goal-oriented participation
Rationale	Involving citizens makes it possible to integrate their perspective at an early stage and facilitates their positive attitude towards using the Green IS (Venkatesh et al. 2012).
Exemplary Action	• Identify service demands of the citizens • Conduct an early test of the Green IS with the citizens • Create channels that reach different citizen types • Perform workshops with citizens • Integrate diverse perspectives from multiple district citizens • Provide information to train the citizen on the Green IS and how to use it

Design Principle 2	Realization of District Objectives
Aim	To align technology and its use with the objectives of the respective district under careful consideration of any potential conflict of interest
Context	Initiation, Development
Mechanism	Derive Green IS requirements and realize district objectives
Rationale	Contextual factors (environment, strategies, infrastructure) that are specific to a district have to be considered in order to create an appropriate Green IS (Alter 2013).
Exemplary Action	• Integrate diverse perspectives on objectives from various district stakeholders • Define values for the Green IS based on sustainability goals and district objectives • Make use of innovative digital technologies depending on the district's resources • Structure and prioritize requirements for the planned Green IS while considering the context of the district • Find a suitable trade-off for stakeholders' conflicts of interests regarding economic, ecological, and social sustainability

Design Principle 3	Response to the Feedback of Citizens
Aim	To consider the feedback of citizens through an iterative process in order to improve the Green IS in response to their needs.
Context	Operation
Mechanism	Respond to new or changing needs by continuously collecting feedback from a sufficient number of diverse citizens
Rationale	Focusing on the needs of citizens makes it possible to foster a wider application of the Green IS and allow sustainability growth among citizens (Graf-Drasch et al. 2022).
Exemplary Action	• Consider contextual factors regarding the socio-demographic structure (e.g., age distribution) of the district while collecting feedback • Ensure bi-directional communication between citizens and district Green IS service provider • Combine feedback and behavioral data from different sources (e.g., interviews, surveys, or focus groups) • Apply multiple analysis approaches to understand feedback data (e.g., encodings of interviews, surveys, workshop results) • Create new ways for interactions with citizens (e.g., embedded in the daily routine of the citizens) • Compare stated and observed behavior of citizens

Design Principle 4	Adoption of a Holistic District Perspective
Aim	To facilitate constructive interaction among essential district components
Context	Initiation, Development, Implementation, Operation
Mechanism	Understand the interdependencies of stakeholders, services, and technologies by adopting a holistic district perspective
Rationale	Broad perspectives prevent opinion silos and island solutions (Wang 2021).
Exemplary Action	• Introduce a digital platform to support the usability of a service ecosystem • Foster interaction with services from other districts • Facilitate the collaboration and knowledge exchange between public and private service providers • Develop journeys for relevant stakeholders (e.g., citizen journey) to identify the potential for new services and service improvements • Investigate the supply and demand of services from stakeholder groups within the district

Design Principle 5	Facilitation of a Flexible IT Architecture
Aim	To run a scalable Green IS that supports continuous provision of services
Context	Development, Operation
Mechanism	Retain a stable and flexible IT architecture capable of dealing with short-term shocks as well as long-term transformations
Rationale	A flexible and stable IT architecture supports innovation as well as systemic change (Jonkers et al. 2006).
Exemplary Action	• Provide interoperable interfaces that different technologies can use by multiple stakeholders • Realize opportunities from open data and open source • Integrate relevant district-external services without reinventing or reimplementing them • Ensure short-term scalability in citizen-relevant functionalities • Ensure long-term operation and support of the necessary hard- and software infrastructure

Design Principle 6	Exploitation of the Full Potential of District Data
Aim	To (re-)develop services with the help of data in order to tackle complex sustainability-related goals
Context	Initiation, Development, Implementation
Mechanism	Explore and exploit any potential arising from the collected data within the district and beyond
Rationale	Analyzing big data sheds light on complex urban interdependencies (Bibri 2018).
Exemplary Action	• Critically reflect on the overarching targets and underlying methods before collecting, managing, or analyzing data • Leverage the potential in combining historical and real-time data • Include suitable and available data sources from the individuals, the district, and the environment (e.g., nature or other comparable districts) • Analyze data, for example, by using artificial intelligence to identify new or non-anticipated patterns of service demands • Visualize and interpret data in a comprehensible way, especially when interacting with citizens

Design Principle 7	Preservation of Privacy and Security
Aim	To protect the digital and physical integrity of each citizen under consideration of legal and ethical issues
Context	Initiation, Development, Implementation, Operation
Mechanism	Comply with current laws, regulations, and ethical standards to preserve privacy and (IT) security
Rationale	Upholding the fundamental freedoms of individuals supports them in living a self-determined life (European Commission 2016).
Exemplary Action	• Establish contemporary (IT) security measures based on the maturity of the Green IS • Identify suitable privacy measures that prevent concerns of the citizens • Proactively communicate privacy and safety-related measures in a reasonable and comprehensible way to gain the trust regarding the Green IS • Consult external (IT) security and safety experts where necessary • Exploit trusted external resources of information regarding the current state of jurisprudence and ethical assessments

Appendix B: Meta Requirements for Operationalizing the Design Objective

When specifying the design objective of Green IS in an SSD, it is helpful to define meta-requirements (MRs). The insights thus gained enabled us to identify aspects currently amiss in IS, such as those widely used in the urban context, and, therefore, should be seen as a requirement for our design principles that ultimately instantiate new Green ISs and guide SSD projects. While other requirements may well be of interest to the design of Green ISs in an SSD, we consider the below three to be the most relevant at this specific intersection of Green ISs, citizens, and SSDs:

MR1: Improve the quality of life enjoyed by the citizens of an SSD.

MR2: Leverage smart technologies to create mutual benefits across SSD stakeholders.

MR3: Bridge the gap between SSD's goals and its citizens' priorities.

Appendix C: Full List of Extracted Statements for Design Principle Development

Quote	Topic Area	Design Principle	Reference	Page
Harnessing the knowledge of the crowd is a typical Citizen Science method. The active designing in the co-design approach is what we call Citizen Design. The combination of these two fields require techniques from a third research area, namely Design Science. Since the direct communication with the designers is replaced by anonymous submissions of design proposals, it is necessary to access the tacit knowledge of people in a different way. Design Science is therefore obligatory to identify design criteria which are essential for designers in the specific use case.	[TA1] Citizen Design Involvement	[DP1] Involvement of Citizens	Mueller, J., Lu, H., Chirkin, A., Klein, B., & Schmitt, G. (2018). Citizen Design Science: A strategy for crowd-creative urban design. Cities, 72, 181-188.	187
Furthermore, citizen engagement is critical to ensure transparency and provide assurance that their data is being used for what they approve, Section 2 provides examples of Living Labs, which aims to integrate the technical community with the city citizens to provide a citizen-centric smart city solution.	[TA1] Citizen Design Involvement	[DP1] Involvement of Citizens	Heaton, J., & Parlikad, A. K. (2019). A conceptual framework for the alignment of infrastructure assets to citizen requirements within a Smart Cities framework. Cities, 90, 32-41.	39
In doing so, we enabled the town to act as an overarching system of stakeholders and to achieve essential synergy effects attributed to the heterogeneous knowledge.	[TA1] Citizen Design Involvement	[DP1] Involvement of Citizens	Hosseini, S., Frank, L., Fridgen, G., & Heger, S. (2018). Do not forget about smart towns. Business & Information Systems Engineering, 60(3), 243-257.	252
"If you introduce a technical aid, [...] you have to talk to as many people as possible in the neighborhood [and work with them] so that they can independently realize that [it] has an added value for them"	[TA1] Citizen Design Involvement	[DP1] Involvement of Citizens	Renyi, M., Rombach, E., Teuteberg, F., & Kunze, C. (2019). Towards understanding the use of information systems in caring communities.	5
A participatory design process can hereby help to connect to existing structures and give everyone the chance to be part of the creation process.	[TA1] Citizen Design Involvement	[DP1] Involvement of Citizens	Renyi, M., Rombach, E., Teuteberg, F., & Kunze, C. (2019). Towards understanding the use of information systems in caring communities.	6
In both parts of the methodology, the Intelligenter method addresses multiple related subsystems and the participation of multiple stakeholders, thereby promoting mutual benefit and efficiency.	[TA1] Citizen Design Involvement	[DP1] Involvement of Citizens	Marsal-Llacuna, M. L., & Segal, M. E. (2016). The Intelligenter Method (I) for making “smarter” city projects and plans. Cities, 55, 127-138.	2
Potential user-types for city dashboards are broad; therefore, implement user-centered design methodologies for all system development workflows to build empathy with the different user types of dashboard systems.	[TA1] Citizen Design Involvement	[DP1] Involvement of Citizens	Young, G. W., & Kitchin, R. (2020). Creating design guidelines for building city dashboards from a user's perspectives. International Journal of Human-Computer Studies, 140, 102429.	16

The citizens must be engaged directly in planning and service design.	[TA1] Citizen Design Involvement	[DP1] Involvement of Citizens	Kumar, H., Singh, M. K., Gupta, M. P., & Madaan, J. (2020). Moving towards smart cities: Solutions that lead to the Smart City Transformation Framework. Technological forecasting and social change, 153, 119281.	10
In this sense, actors should not be treated as recipients of a designed artifact, but actively engaged in the design project, which requires human-centered methods.	[TA1] Citizen Design Involvement	[DP1] Involvement of Citizens	Grotherr, C., Vogel, P., & Semmann, M. (2020). Multilevel Design for Smart Communities–The Case of Building a Local Online Neighborhood Social Community.	2309
The need for an age-friendly design of the smart community is not mainly fulfilled by the design of an age-appropriate platform, but by specific interventions, such as training, or incorporation of trust-building institutions, such as churches (see Table 2, #2). These institutions should be mobilized and integrated, and reflect the (re-)configuration of the institutional setup of the actors and resources at the macro-level.	[TA1] Citizen Design Involvement	[DP1] Involvement of Citizens	Grotherr, C., Vogel, P., & Semmann, M. (2020). Multilevel Design for Smart Communities–The Case of Building a Local Online Neighborhood Social Community.	2309
The findings of this study stress the importance of involving citizens in discussions on smart city developments and of establishing a more collaborative approach to such developments.	[TA1] Citizen Design Involvement	[DP1] Involvement of Citizens	Marrone, M., & Hammerle, M. (2018). Smart cities: A review and analysis of stakeholders' literature. Business & Information Systems Engineering, 60(3), 197-213.	13
A main premise of inclusive management is that bringing people together from different backgrounds and of different perspectives in ways that encourage them to understand each other's perspectives helps enhance the design and implementation of policies.	[TA1] Citizen Design Involvement	[DP1] Involvement of Citizens	Marrone, M., & Hammerle, M. (2018). Smart cities: A review and analysis of stakeholders' literature. Business & Information Systems Engineering, 60(3), 197-213.	14
To design for social infrastructures, we need to put the human beings that enact the social infrastructure – service professionals and their colleagues – at the center.	[TA1] Citizen Design Involvement	[DP1] Involvement of Citizens	Van der Bijl-Brouwer, M. (2017). Designing for social infrastructures in complex service systems: a human-centered and social systems perspective on service design. She Ji: The Journal of Design, Economics, and Innovation, 3(3), 183-197.	195
Our position is that innovation requires creating a design space that helps to support design with – and for - citizens.	[TA1] Citizen Design Involvement	[DP1] Involvement of Citizens	Wolff, A., Barker, M., Hudson, L., & Seffah, A. (2020). Supporting smart citizens: Design templates for co-designing data-intensive technologies. Cities, 101, 102695.	2

This is a strong argument for finding new ways to involve citizens in co-design of smart cities and in providing better tools and support for citizens to gain the new skills that they need to innovate in this space, such as improving access to maker spaces and better training and tools for working with and interacting with data.	[TA1] Citizen Design Involvement	[DP1] Involvement of Citizens	Wolff, A., Barker, M., Hudson, L., & Seffah, A. (2020). Supporting smart citizens: Design templates for co-designing data-intensive technologies. Cities, 101, 102695.	10
The strategy should strongly rely on citizen engagement, including, as a first step, conducting communication campaigns for promoting the services, informing citizens about their availability and benefits.	[TA2] Training of Actors	[DP1] Involvement of Citizens	Cledou, G., Estevez, E., & Barbosa, L. S. (2018). A taxonomy for planning and designing smart mobility services. Government Information Quarterly, 35(1), 61-76.	72
To facilitate knowledge sharing, it would be helpful to maintain a knowledge base, accessible to the public, containing data and lessons learnt about conducted initiatives, whether they are active or not. This is important for other governments and researchers, but also for citizens, as accountability mechanism.	[TA2] Training of Actors	[DP1] Involvement of Citizens	Cledou, G., Estevez, E., & Barbosa, L. S. (2018). A taxonomy for planning and designing smart mobility services. Government Information Quarterly, 35(1), 61-76.	72
The municipality's commitment was important, and the information disseminated through press releases and flyers distributed to households exemplify its involvement and partnership in the project. In order to avoid inducing self-selection bias the flyers did not specify whether participating households would be able to save energy or not. Following this information phase, 172 households volunteered for the experiment and were enrolled in the TICELEC project.	[TA2] Training of Actors	[DP1] Involvement of Citizens	Kendel, A., Lazaric, N., & Maréchal, K. (2017). What do people ‘learn by looking’at direct feedback on their energy consumption? Results of a field study in Southern France. Energy Policy, 108, 593-605.	8
Nine people were of the opinion that there must necessarily be a neighborhood manager to support the technology implementation. Amongst others, this person (one or more) is an initiating driver who motivates the residents and maintains the platform with up-to-date information.	[TA2] Training of Actors	[DP1] Involvement of Citizens	Renyi, M., Rombach, E., Teuteberg, F., & Kunze, C. (2019). Towards understanding the use of information systems in caring communities.	4
Additionally, training courses should take place in the form of face-to-face training according to six interviewees.	[TA2] Training of Actors	[DP1] Involvement of Citizens	Renyi, M., Rombach, E., Teuteberg, F., & Kunze, C. (2019). Towards understanding the use of information systems in caring communities.	4
According to all interviewees, the announcement of the introduction of a new neighborhood platform works best through advertising material in paper form, e.g. flyers, brochures or postcards and the daily newspaper.	[TA2] Training of Actors	[DP1] Involvement of Citizens	Renyi, M., Rombach, E., Teuteberg, F., & Kunze, C. (2019). Towards understanding the use of information systems in caring communities.	5
Most believe "the focus should be on [the] bulletin boards, i.e. of the transmission of information and messages among each other". All other content the users "can get from somewhere else".	[TA2] Training of Actors	[DP1] Involvement of Citizens	Renyi, M., Rombach, E., Teuteberg, F., & Kunze, C. (2019). Towards understanding the use of information systems in caring communities.	5

These concepts should include training offers for self-study as well as training courses and a companion concept.	[TA2] Training of Actors	[DP1] Involvement of Citizens	Renyi, M., Rombach, E., Teuteberg, F., & Kunze, C. (2019). Towards understanding the use of information systems in caring communities.	6
Data security and privacy aspects need to be dealt with from different stakeholders' points of view to support end-to-end application security.	[TA2] Training of Actors	[DP1] Involvement of Citizens	Khan, Z., Pervez, Z., & Abbasi, A. G. (2017). Towards a secure service provisioning framework in a smart city environment. Future Generation Computer Systems, 77, 112-135.	6
Through social networking services (SNS), such as Facebook, government agencies can educate citizens and advocate the SC services, providing them with information regarding the improvements in the services, societal needs, and the perceived quality and satisfaction of the citizens, i.e., the service recipients.	[TA2] Training of Actors	[DP1] Involvement of Citizens	Yeh, H. (2017). The effects of successful ICT-based smart city services: From citizens' perspectives. Government Information Quarterly, 34(3), 556-565.	7
The promotion of mature services for smart cities and the launch of innovative smart-cities services require early adoption of work-related smart-cities services.	[TA2] Training of Actors	[DP1] Involvement of Citizens	Lytras, M. D., Visvizi, A., Chopdar, P. K., Sarirete, A., & Alhalabi, W. (2021). Information Management in Smart Cities: Turning end users' views into multi-item scale development, validation, and policy-making recommendations. International Journal of Information Management, 56, 102146.	6
I would like to see more services that would enable me to engage actively in community life in my city district.	[TA2] Training of Actors	[DP1] Involvement of Citizens	Lytras, M. D., Visvizi, A., Chopdar, P. K., Sarirete, A., & Alhalabi, W. (2021). Information Management in Smart Cities: Turning end users' views into multi-item scale development, validation, and policy-making recommendations. International Journal of Information Management, 56, 102146.	6
The overall look and feel should be representative of the city and should be applied consistently to help build familiarity and confidence as well as improving the overall user experience.	[TA2] Training of Actors	[DP1] Involvement of Citizens	Young, G. W., & Kitchin, R. (2020). Creating design guidelines for building city dashboards from a user's perspectives. International Journal of Human-Computer Studies, 140, 102429.	16
At the same time, several engagement-supporting interventions, such as promotions and training, affect actors' willingness to engage, and have to be applied to the engagement platform.	[TA2] Training of Actors	[DP1] Involvement of Citizens	Grotherr, C., Vogel, P., & Semmann, M. (2020). Multilevel Design for Smart Communities–The Case of Building a Local Online Neighborhood Social Community.	2309

Establish a transparent, cooperative and participatory structure to enable collaboration and competition between stakeholders.	[TA2] Training of Actors	[DP1] Involvement of Citizens	Keller, R., Röhrich, F., Schmidt, L., & Fridgen, G. (2019). Sustainability's coming home: preliminary design principles for the sustainable smart district. In 14. International Business Informatics Conference.	9
The importance of considering the perspectives and concerns of citizens is stressed by the view that it is necessary for citizens to feel involved and that their input is valuable if they are to be accepting of systems, such as smart cities	[TA2] Training of Actors	[DP1] Involvement of Citizens	Marrone, M., & Hammerle, M. (2018). Smart cities: A review and analysis of stakeholders' literature. Business & Information Systems Engineering, 60(3), 197-213.	13
Gaining a critical mass of end users, developers, and service providers and achieving self-sustaining growth and scalability is a key issue for the success of platforms.	[TA2] Training of Actors	[DP1] Involvement of Citizens	Ruutu, S., Casey, T., & Kotovirta, V. (2017). Development and competition of digital service platforms: A system dynamics approach. Technological Forecasting and Social Change, 117, 119-130.	120
These activities can include enhancing the positions of firms and economic agents within the urban hierarchy, deploying participatory technologies to engage citizens in local issues in a granular and accountable manner using platforms, such as interactive posters, media façades, projections, voting systems and urban screens.	[TA2] Training of Actors	[DP1] Involvement of Citizens	Abusaada, H., & Elshater, A. (2021). Competitiveness, distinctiveness and singularity in urban design: A systematic review and framework for smart cities. Sustainable Cities and Society, 68, 102782.	2
Despite their apparent ubiquity, smart city technologies have bypassed the lives of most of the world's population. Only 15% of the global population can afford access to broadband internet and 60% have no access to internet at all.	[TA3] Accessibility	[DP1] Involvement of Citizens	Sepasgozar, S. M., Hawken, S., Sargolzaei, S., & Foroozanfa, M. (2019). Implementing citizen centric technology in developing smart cities: A model for predicting the acceptance of urban technologies. Technological Forecasting and Social Change, 142, 105-116.	106
In addition, many have repeatedly pointed out that the "involvement of the entire neighborhood" is important and that a neighborhood platform should be designed across generations.	[TA3] Accessibility	[DP1] Involvement of Citizens	Renyi, M., Rombach, E., Teuteberg, F., & Kunze, C. (2019). Towards understanding the use of information systems in caring communities.	5
For this purpose, barrier-free use must be guaranteed as well as an adapted design and a suitable interaction concept.	[TA3] Accessibility	[DP1] Involvement of Citizens	Renyi, M., Rombach, E., Teuteberg, F., & Kunze, C. (2019). Towards understanding the use of information systems in caring communities.	6

added values of an own municipally organized neighborhood platform, as a tool for community work (with the aim to provide equality, motivate and solve community problems), must become comprehensible (local control, data economy and privacy, inclusion).	[TA3] Accessibility	[DP1] Involvement of Citizens	Renyi, M., Rombach, E., Teuteberg, F., & Kunze, C. (2019). Towards understanding the use of information systems in caring communities.	8
They also need to simplify interfaces and to provide the means whereby users feel no technology anxiety.	[TA3] Accessibility	[DP1] Involvement of Citizens	Lytras, M. D., Visvizi, A., Chopdar, P. K., Sarirete, A., & Alhalabi, W. (2021). Information Management in Smart Cities: Turning end users' views into multi-item scale development, validation, and policy-making recommendations. International Journal of Information Management, 56, 102146.	7
The portal must be a publicly available Web-based information system with the basic requirements of such an application, such as page retrieval.	[TA3] Accessibility	[DP1] Involvement of Citizens	Majchrzak, T. A., Sakurai, M., & Serrano, N. (2018). Conceptualizing and designing a resilience information portal.	49
Implement logical navigation patterns and menus so users can explore data with confidence and quickly trace their progress throughout the dashboard hierarchy.	[TA3] Accessibility	[DP1] Involvement of Citizens	Young, G. W., & Kitchin, R. (2020). Creating design guidelines for building city dashboards from a user's perspectives. International Journal of Human-Computer Studies, 140, 102429.	16
Usability heuristics should be applied at all stages by all project team members.	[TA3] Accessibility	[DP1] Involvement of Citizens	Young, G. W., & Kitchin, R. (2020). Creating design guidelines for building city dashboards from a user's perspectives. International Journal of Human-Computer Studies, 140, 102429.	16
Provide the age-friendly digital neighborhood platform with motivational mechanisms in order to encourage continued usage	[TA3] Accessibility	[DP1] Involvement of Citizens	Vogel, P., Jurcevic, N., & Meyer-Blankart, C. (2021). 10 Healthy, Active and Connected: Towards Designing an Age-Friendly Digital Neighborhood Platform. Designing Openness-Infusing Socio-Technical Artifacts, 109.	6
Design the services of the SSD in a simple and accessible way to integrate all users.	[TA3] Accessibility	[DP1] Involvement of Citizens	Keller, R., Röhrich, F., Schmidt, L., & Fridgen, G. (2019). Sustainability's coming home: preliminary design principles for the sustainable smart district. In 14. International Business Informatics Conference.	10

Therefore, the use of urban services could be promoted by behavior-oriented actions (e.g., smart card diffusion in urban facilities) that facilitate access to different urban services.	[TA3] Accessibility	[DP1] Involvement of Citizens	Belanche, D., Casaló, L. V., & Orús, C. (2016). City attachment and use of urban services: Benefits for smart cities. Cities, 50, 75-81.	80
The new wave of computing share the same core enabling technologies, namely sensing devices, computing infrastructures, data processing platforms, and wireless communication networks.	[TA3] Accessibility	[DP1] Involvement of Citizens	Bibri, S. E. (2018). A foundational framework for smart sustainable city development: Theoretical, disciplinary, and discursive dimensions and their synergies. Sustainable Cities and Society, 38, 758-794.	767
Human services (public services, social services, cultural facilities, etc.) involving delivery, accessibility, and optimization	[TA3] Accessibility	[DP1] Involvement of Citizens	Bibri, S. E. (2018). A foundational framework for smart sustainable city development: Theoretical, disciplinary, and discursive dimensions and their synergies. Sustainable Cities and Society, 38, 758-794.	781
Furthermore, it was noted that a citizen requirement is supported by multi city services. As an example, the citizen requirements for to learn is support by the service for education but also by the services of transportation to example teachers and students to travel to a school	[TA4] Citizen goals and Needs	[DP1] Involvement of Citizens	Heaton, J., & Parlikad, A. K. (2019). A conceptual framework for the alignment of infrastructure assets to citizen requirements within a Smart Cities framework. Cities, 90, 32-41.	40
n the recent years gamification has been proven to be a successful mechanism to trigger motivation in various areas such as education, work, health, and sustainable consumption.	[TA4] Citizen goals and Needs	[DP1] Involvement of Citizens	Brauer, B., & Kolbe, L. (2016). Towards IS-enabled Sustainable Communities–A Conceptual Framework and Research Agenda.	6
A prerequisite of big data use is identifying the right information for citizens; the requirements of employees are also crucial.	[TA4] Citizen goals and Needs	[DP1] Involvement of Citizens	Lim, C., Kim, K. J., & Maglio, P. P. (2018). Smart cities with big data: Reference models, challenges, and considerations. Cities, 82, 86-99.	94
The presented study, instead, has offered a structured model including key factors to predict the users' behavior towards using USTs. Kumar et al. (2018) emphasizes the critical importance of this citizen-centric approach to technology acceptance for smart city development.	[TA4] Citizen goals and Needs	[DP1] Involvement of Citizens	Sepasgozar, S. M., Hawken, S., Sargolzaei, S., & Foroozanfa, M. (2019). Implementing citizen centric technology in developing smart cities: A model for predicting the acceptance of urban technologies. Technological Forecasting and Social Change, 142, 105-116.	114

Compatibility (CT) refers to the degree to which a UST is consistent with the potential end-users' existing values and needs	[TA4] Citizen goals and Needs	[DP1] Involvement of Citizens	Sepasgozar, S. M., Hawken, S., Sargolzaei, S., & Foroozanfa, M. (2019). Implementing citizen centric technology in developing smart cities: A model for predicting the acceptance of urban technologies. Technological Forecasting and Social Change, 142, 105-116.	109
The platforms can be used for communication purposes between the neighborhood management and the neighborhood's citizens as well as among the citizens themselves.	[TA4] Citizen goals and Needs	[DP1] Involvement of Citizens	Renyi, M., Rombach, E., Teuteberg, F., & Kunze, C. (2019). Towards understanding the use of information systems in caring communities.	4
Users are likely to adopt services that offer support in emergencies and for social care.	[TA4] Citizen goals and Needs	[DP1] Involvement of Citizens	Lytras, M. D., Visvizi, A., Chopdar, P. K., Sarirete, A., & Alhalabi, W. (2021). Information Management in Smart Cities: Turning end users' views into multi-item scale development, validation, and policy-making recommendations. International Journal of Information Management, 56, 102146.	6
Our participants indicated that content-rich services improve satisfaction with smart-city applications and potentially improve people's quality of life.	[TA4] Citizen goals and Needs	[DP1] Involvement of Citizens	Lytras, M. D., Visvizi, A., Chopdar, P. K., Sarirete, A., & Alhalabi, W. (2021). Information Management in Smart Cities: Turning end users' views into multi-item scale development, validation, and policy-making recommendations. International Journal of Information Management, 56, 102146.	7
Determine tangible and intangible values to derive an incentive-structure and enable the development of value-adding services, to satisfy the stakeholders' needs.	[TA4] Citizen goals and Needs	[DP1] Involvement of Citizens	Keller, R., Röhrich, F., Schmidt, L., & Fridgen, G. (2019). Sustainability's coming home: preliminary design principles for the sustainable smart district. In 14. International Business Informatics Conference.	10
develop a specific city policy on new developments that accommodates the concerns of citizens, beyond the bare legal necessities	[TA4] Citizen goals and Needs	[DP1] Involvement of Citizens	Van Zoonen, L. (2016). Privacy concerns in smart cities. Government Information Quarterly, 33(3), 472-480.	479

Based on the findings of this study, we recommend that future research into smart cities should ensure a consideration of the viewpoints of all stakeholders, including citizens.	[TA4] Citizen goals and Needs	[DP1] Involvement of Citizens	Marrone, M., & Hammerle, M. (2018). Smart cities: A review and analysis of stakeholders' literature. Business & Information Systems Engineering, 60(3), 197-213.	15
The fundamental dimensions of Culture, Metabolism and Governance, as prescribed, are ensured in this framework to ensure that the inclusion of Big Data and Artificial Intelligence is geared towards human liveability rather than the sole purpose of technological integration for economic pursuits by corporations alone. The following section discusses the implementation of the proposed model and its benefits.	[TA4] Citizen goals and Needs	[DP1] Involvement of Citizens	Allam, Z., & Dhunny, Z. A. (2019). On big data, artificial intelligence and smart cities. Cities, 89, 80-91.	86
It highlights a range of different possible touch-points and types of interaction throughout the processes of collecting, aggregating, analysing and deploying smart services to end users.	[TA4] Citizen goals and Needs	[DP1] Involvement of Citizens	Wolff, A., Barker, M., Hudson, L., & Seffah, A. (2020). Supporting smart citizens: Design templates for co-designing data-intensive technologies. Cities, 101, 102695.	9
Giving priority to the delivery of SC services in the hard domain that contribute to the realization of existence needs	[TA4] Citizen goals and Needs	[DP1] Involvement of Citizens	Ji, T., Chen, J. H., Wei, H. H., & Su, Y. C. (2021). Towards people-centric smart city development: Investigating the citizens' preferences and perceptions about smart-city services in Taiwan. Sustainable Cities and Society, 67, 102691.	8
Encouraging usage of SC services from the soft domain by stimulating citizens' desires to fulfill relatedness and growth needs.	[TA4] Citizen goals and Needs	[DP1] Involvement of Citizens	Ji, T., Chen, J. H., Wei, H. H., & Su, Y. C. (2021). Towards people-centric smart city development: Investigating the citizens' preferences and perceptions about smart-city services in Taiwan. Sustainable Cities and Society, 67, 102691.	8
Framing design research within the context of citizen-centered smart cities, our model unfolds into the following three distinct and yet interwoven component: (1) grounded vision, addressing the ideation of alternative futures that stem from specific needs or local opportunities; ...	[TA4] Citizen goals and Needs	[DP1] Involvement of Citizens	Andreani, S., Kalchschmidt, M., Pinto, R., & Sayegh, A. (2019). Reframing technologically enhanced urban scenarios: A design research model towards human centered smart cities. Technological Forecasting and Social Change, 142, 15-25.	8

Availability: Smart city systems require high availability in service provisioning, data management, communication, and sensing. Services need to be accessible and usable, especially if they support mission critical applications in the city.	[TA5] Overarching Design and Goal of Districts	[DP2] Realization of District Objectives	Bastidas, V., Helfert, M., & Bezbradica, M. (2018). A Requirements Framework for the Design of Smart City Reference Architectures. In T. Bui (Ed.), Hawaii International Conference on System Sciences. doi:10.24251/HICSS.2018.317.	2519
Reliability: Smart city systems require an appropriate level of reliability in technologies, devices, communication, service, and data management capabilities. The reliability is directly related to the consistent behaviour of the systems. The reliability of each component of the smart system finally helps in achieving system-level reliability.	[TA5] Overarching Design and Goal of Districts	[DP2] Realization of District Objectives	Bastidas, V., Helfert, M., & Bezbradica, M. (2018). A Requirements Framework for the Design of Smart City Reference Architectures. In T. Bui (Ed.), Hawaii International Conference on System Sciences. doi:10.24251/HICSS.2018.317.	2519
Context-aware: Devices, services, and systems require being able to monitor its own environment in which they operate and events within that environment. Context-awareness is a key requirement to allow systems to offer better results using contextual information to users. Some smart platforms use data from users, such as location, activity, and language. Other platforms use data from the city, such as traffic condition, climate, and air quality.	[TA5] Overarching Design and Goal of Districts	[DP2] Realization of District Objectives	Bastidas, V., Helfert, M., & Bezbradica, M. (2018). A Requirements Framework for the Design of Smart City Reference Architectures. In T. Bui (Ed.), Hawaii International Conference on System Sciences. doi:10.24251/HICSS.2018.317.	2519
Integrity: smart cities need to make heterogeneous physical objects accessible on a large scale and to integrate them with the digital world. Some approaches based on SOA, propose integrated architecture incorporating various layers for application interface, service management, device management, security, and platform abstraction and devices layer.	[TA5] Overarching Design and Goal of Districts	[DP2] Realization of District Objectives	Bastidas, V., Helfert, M., & Bezbradica, M. (2018). A Requirements Framework for the Design of Smart City Reference Architectures. In T. Bui (Ed.), Hawaii International Conference on System Sciences. doi:10.24251/HICSS.2018.317.	2520
City Oriented: Smart city systems should offer valuable services and applications that affect the city and every domain separately. The main purpose is to improve the everyday life of citizens and increase public safety.	[TA5] Overarching Design and Goal of Districts	[DP2] Realization of District Objectives	Bastidas, V., Helfert, M., & Bezbradica, M. (2018). A Requirements Framework for the Design of Smart City Reference Architectures. In T. Bui (Ed.), Hawaii International Conference on System Sciences. doi:10.24251/HICSS.2018.317.	2518
Cost minimization: Smart cities require optimizing the operational cost (i.e. development, installation, maintenance) and the resources by developing new energy-efficient solutions. Service providers and developers must consider this requirement in the implementation of devices and services.	[TA5] Overarching Design and Goal of Districts	[DP2] Realization of District Objectives	Bastidas, V., Helfert, M., & Bezbradica, M. (2018). A Requirements Framework for the Design of Smart City Reference Architectures. In T. Bui (Ed.), Hawaii International Conference on System Sciences. doi:10.24251/HICSS.2018.317.	2519

To support the alignment between the services and the citizen requirements it is proposed that within a Smart City framework the services have to be linked to the infrastructure assets (e.g., transport infrastructure) that support the operational requirements of that service.	[TA5] Overarching Design and Goal of Districts	[DP2] Realization of District Objectives	Heaton, J., & Parlikad, A. K. (2019). A conceptual framework for the alignment of infrastructure assets to citizen requirements within a Smart Cities framework. Cities, 90, 32-41.	36
When classifying infrastructure assets from the point-of-view of a Smart Cities framework, the highest functional output of the infrastructure assets should be identified such as transport, communication and waste disposal that align to support the city services.	[TA5] Overarching Design and Goal of Districts	[DP2] Realization of District Objectives	Heaton, J., & Parlikad, A. K. (2019). A conceptual framework for the alignment of infrastructure assets to citizen requirements within a Smart Cities framework. Cities, 90, 32-41.	36
A crucial challenge faced by smart cities is developing a trust framework which can ensure that services driving smart cities are without malicious intent.	[TA5] Overarching Design and Goal of Districts	[DP2] Realization of District Objectives	Khan, Z., Pervez, Z., & Abbasi, A. G. (2017). Towards a secure service provisioning framework in a smart city environment. Future Generation Computer Systems, 77, 112-135.	16
The cooperation between public and private actors results thus not only in the privatisation of pub- lic services but also in the transformation of public values.	[TA5] Overarching Design and Goal of Districts	[DP2] Realization of District Objectives	Ranchordás, S., & Goanta, C. (2020). The new city regulators: Platform and public values in smart and sharing cities. Computer Law & Security Review, 36, 105375.	5
In this context, we suggested a normative framework focusing on two points: departing from values shared by platforms and authorities, in order to shape a new kind of knowledge-service creation, namely local public-interest technology; and addressing the digital enforcement issue driven by the functional sovereignty role of platforms, by proposing a negotiated contractual system that seeks to balance platform values with public values.	[TA5] Overarching Design and Goal of Districts	[DP2] Realization of District Objectives	Ranchordás, S., & Goanta, C. (2020). The new city regulators: Platform and public values in smart and sharing cities. Computer Law & Security Review, 36, 105375.	15
But since they are measuring isolated features, these new non-siloed indicators (indices) are to be used to assess the performance of the collaborative subsystem and the references to initiate the design of future collaborative sub-systems in that given core subject.	[TA5] Overarching Design and Goal of Districts	[DP2] Realization of District Objectives	Marsal-Llacuna, M. L., & Segal, M. E. (2016). The Intelligenter Method (I) for making “smarter” city projects and plans. Cities, 55, 127-138.	10
Since the SC services are delivered and maintained by a diverse set of providers, governments should build a “smartness blueprint” or “smartness roadmap” of the city, which clearly identifies the scopes, goals, and stages of development, as well as the performance indicators.	[TA5] Overarching Design and Goal of Districts	[DP2] Realization of District Objectives	Yeh, H. (2017). The effects of successful ICT-based smart city services: From citizens' perspectives. Government Information Quarterly, 34(3), 556-565.	7

Provide the SSD with an adaptable and scalable digital infrastructure to integrate heterogeneous, connected IT systems and features, to facilitate the PBE	[TA5] Overarching Design and Goal of Districts	[DP2] Realization of District Objectives	Keller, R., Röhrich, F., Schmidt, L., & Fridgen, G. (2019). Sustainability's coming home: preliminary design principles for the sustainable smart district. In 14. International Business Informatics Conference.	9
Although greenness is a cornerstone of smart urban ecosystems, embedding environment-related issues into the strategic visioning of smart cities is not an easy endeavour.	[TA5] Overarching Design and Goal of Districts	[DP2] Realization of District Objectives	Palumbo, R., Manesh, M. F., Pellegrini, M. M., Caputo, A., & Flamini, G. (2021). Organizing a sustainable smart urban ecosystem: Perspectives and insights from a bibliometric analysis and literature review. Journal of Cleaner Production, 297, 126622.	9
It is posited that a greater understanding of the diverse perspectives that exist is essential in tackling the wicked nature of the issues smart cities seek to address.	[TA5] Overarching Design and Goal of Districts	[DP2] Realization of District Objectives	Marrone, M., & Hammerle, M. (2018). Smart cities: A review and analysis of stakeholders' literature. Business & Information Systems Engineering, 60(3), 197-213.	13
Combine top-down (government-led) and bottom-up (community-driven)	[TA5] Overarching Design and Goal of Districts	[DP2] Realization of District Objectives	Mora, L., Deakin, M., & Reid, A. (2019). Strategic principles for smart city development: A multiple case study analysis of European best practices. Technological Forecasting and Social Change, 142, 70-97.	82
Build a smart city strategic framework	[TA5] Overarching Design and Goal of Districts	[DP2] Realization of District Objectives	Mora, L., Deakin, M., & Reid, A. (2019). Strategic principles for smart city development: A multiple case study analysis of European best practices. Technological Forecasting and Social Change, 142, 70-97.	82
Built form (buildings, streets, residential and commercial areas, schools, parks, etc.) involving monitoring, design, evaluation, simulation, and forecast	[TA5] Overarching Design and Goal of Districts	[DP2] Realization of District Objectives	Bibri, S. E. (2018). A foundational framework for smart sustainable city development: Theoretical, disciplinary, and discursive dimensions and their synergies. Sustainable Cities and Society, 38, 758-794.	781

Administration (mechanisms for adherence to established regulatory frameworks, practice dissemination, policy recommendations, governance models, technical and assessment studies, etc.) involving design, analysis, implementation, evaluation, improvement, and integration.	[TA5] Overarching Design and Goal of Districts	[DP2] Realization of District Objectives	Bibri, S. E. (2018). A foundational framework for smart sustainable city development: Theoretical, disciplinary, and discursive dimensions and their synergies. Sustainable Cities and Society, 38, 758-794.	781
First, we recommend a matrix to compare service implementation scenarios and the resulting cost variances.	[TA5] Overarching Design and Goal of Districts	[DP2] Realization of District Objectives	Vandercruysse, L., Buts, C., & Dooms, M. (2020). A typology of smart city services: the case of data protection impact assessment. Cities, 104, 102731.	11
Similarly, highly specialized labor is required to oversee the complex processes of digitization	[TA5] Overarching Design and Goal of Districts	[DP2] Realization of District Objectives	Allam, Z., & Dhunny, Z. A. (2019). On big data, artificial intelligence and smart cities. Cities, 89, 80-91.	88
ICT of the new wave of computing has a number of potential risks and uncertainties in relation to environmental sustainability that need to be understood when placing high expectations on and marshalling resources for developing and deploying smart sustainable cities.	[TA5] Overarching Design and Goal of Districts	[DP2] Realization of District Objectives	Bibri, S. E., & Krogstie, J. (2017). On the social shaping dimensions of smart sustainable cities: A study in science, technology, and society. Sustainable Cities and Society, 29, 219-246.	31
Although the citizens were receptive of the new value that new services can create, some stated explicitly that a prerequisite of service implementation should be a guarantee of their privacy. Investigating the privacy issues and addressing these concerns are essential in data-based smart city development projects to create valid and sustainable value for citizens and visitors.	[TA6] Technology-driven Innovation	[DP2] Realization of District Objectives	Lim, C., Kim, K. J., & Maglio, P. P. (2018). Smart cities with big data: Reference models, challenges, and considerations. Cities, 82, 86-99.	94
On smart city context, open data initiatives seek to promote better city governance, enhance transparency, analysis, and planning, reinforce citizen engagement and participation, foster co-creation and collective intelligence, and support innovative products and services, while can be useful in providing solutions to many socio-economic and environmental problems.	[TA6] Technology-driven Innovation	[DP2] Realization of District Objectives	Neves, F. T., de Castro Neto, M., & Aparicio, M. (2020). The impacts of open data initiatives on smart cities: A framework for evaluation and monitoring. Cities, 106, 102860.	1
New age technologies like augmented reality, 3D printing and wearable technologies can help to create newer services based on evolving needs to the current age consumer (Mital et al., 2017).	[TA6] Technology-driven Innovation	[DP2] Realization of District Objectives	Kumar, H., Singh, M. K., Gupta, M. P., & Madaan, J. (2020). Moving towards smart cities: Solutions that lead to the Smart City Transformation Framework. Technological forecasting and social change, 153, 119281.	10

Look beyond technology	[TA6] Technology-driven Innovation	[DP2] Realization of District Objectives	Mora, L., Deakin, M., & Reid, A. (2019). Strategic principles for smart city development: A multiple case study analysis of European best practices. Technological Forecasting and Social Change, 142, 70-97.	82
Boost the digital transformation by establishing a smart city accelerator	[TA6] Technology-driven Innovation	[DP2] Realization of District Objectives	Mora, L., Deakin, M., & Reid, A. (2019). Strategic principles for smart city development: A multiple case study analysis of European best practices. Technological Forecasting and Social Change, 142, 70-97.	28
Previous research suggests that combining hard and soft infrastructures and creating a platformto integrate urban services can build closer information- and transactionoriented relationships with citizens in a real-life context	[TA6] Technology-driven Innovation	[DP2] Realization of District Objectives	Bibri, S. E. (2018). A foundational framework for smart sustainable city development: Theoretical, disciplinary, and discursive dimensions and their synergies. Sustainable Cities and Society, 38, 758-794.	79
city administrators are encouraged as part of future SC development to invest in advanced and emerging smart technologies	[TA6] Technology-driven Innovation	[DP2] Realization of District Objectives	Ji, T., Chen, J. H., Wei, H. H., & Su, Y. C. (2021). Towards people-centric smart city development: Investigating the citizens' preferences and perceptions about smart-city services in Taiwan. Sustainable Cities and Society, 67, 102691.	8
(2) embraced technology, elaborating on the role played by urban technologies in augmenting the inner intelligence of places;	[TA6] Technology-driven Innovation	[DP2] Realization of District Objectives	Andreani, S., Kalchschmidt, M., Pinto, R., & Sayegh, A. (2019). Reframing technologically enhanced urban scenarios: A design research model towards human centered smart cities. Technological Forecasting and Social Change, 142, 15-25.	8
Camero and Alba (2019), Parlikad and Heaton (2019) and Ranchod (2020) examined community-driven initiatives to improve the quality of life, focusing on digital, intelligent, ubiquitous, wired, hybrid and informative technology – community-driven solutions enhancing the potentialities for creativity and learning in a knowledge city.	[TA6] Technology-driven Innovation	[DP2] Realization of District Objectives	Abusaada, H., & Elshater, A. (2021). Competitiveness, distinctiveness and singularity in urban design: A systematic review and framework for smart cities. Sustainable Cities and Society, 68, 102782.	2

Other steps should include initiatives for listening to citizens' feedback, facilitating user experimentation as part of innovation labs, documenting the level of user satisfaction, modifying services based on appropriate feedback, maintaining users informed about how their feedback is being used, ensuring the correct maintainability of the software, and collecting data about the actual usage of the services.	[TA7] Feedback and Monitoring	[DP3] Response to the Feedback of Citizens	Cledou, G., Estevez, E., & Barbosa, L. S. (2018). A taxonomy for planning and designing smart mobility services. Government Information Quarterly, 35(1), 61-76.	72
Previous work has emphasized that 'carefully designed feedback could enable users to readily understand the habits and routines that generate their household patterns and thus make more concrete the viable energy saving actions available to them.	[TA7] Feedback and Monitoring	[DP3] Response to the Feedback of Citizens	Kendel, A., Lazaric, N., & Maréchal, K. (2017). What do people ‘learn by looking’at direct feedback on their energy consumption? Results of a field study in Southern France. Energy Policy, 108, 593-605.	19
The results of our experiment show that all participants reduced their consumption and learnt either directly from feedback or indirectly through self-monitoring.	[TA7] Feedback and Monitoring	[DP3] Response to the Feedback of Citizens	Kendel, A., Lazaric, N., & Maréchal, K. (2017). What do people ‘learn by looking’at direct feedback on their energy consumption? Results of a field study in Southern France. Energy Policy, 108, 593-605.	24
Housing characteristics: Some characteristics influence energy practices and might explain electricity consumption. Following Gram-Hanssen (2014), house size is included as an explanatory variable rather than electricity consumption per square meter.	[TA7] Feedback and Monitoring	[DP3] Response to the Feedback of Citizens	Kendel, A., Lazaric, N., & Maréchal, K. (2017). What do people ‘learn by looking’at direct feedback on their energy consumption? Results of a field study in Southern France. Energy Policy, 108, 593-605.	13
In plans and projects, intelligence ismore tangible than in policies and regulations because it establishes physical collaborations based on mutual ground-based learning and spatial complexity cooperation between subsystems.	[TA7] Feedback and Monitoring	[DP3] Response to the Feedback of Citizens	Marsal-Llacuna, M. L., & Segal, M. E. (2016). The Intelligenter Method (I) for making “smarter” city projects and plans. Cities, 55, 127-138.	2
Load shifting measures, control of heating systems or combined micro heat and power plants can also considerably benefit from information beyond pure metering data if, for example, up-to-date knowledge on thepresence of the inhabitants is available.	[TA7] Feedback and Monitoring	[DP3] Response to the Feedback of Citizens	Sodenkamp, M., Kozlovskiy, I., Hopf, K., & Staake, T. (2017). Smart meter data analytics for enhanced energy efficiency in the residential sector.	1236
The role-concept must allow do design bi-directional communication flows. This for example is required to provide citizens with the possibility to give feedback.	[TA7] Feedback and Monitoring	[DP3] Response to the Feedback of Citizens	Majchrzak, T. A., Sakurai, M., & Serrano, N. (2018). Conceptualizing and designing a resilience information portal.	49

The real time data and dashboard monitoring can support city administration to manage smart services and control for better governance (Novotný et al., 2014). Implementation of smart meters technologies in households (Lee et al., 2014) can provide consumption patterns to optimize the usage and supply.	[TA7] Feedback and Monitoring	[DP3] Response to the Feedback of Citizens	Kumar, H., Singh, M. K., Gupta, M. P., & Madaan, J. (2020). Moving towards smart cities: Solutions that lead to the Smart City Transformation Framework. Technological forecasting and social change, 153, 119281.	8
Continuously monitor the SSD and evaluate feedback to achieve or iteratively adapt visionary objectives and goals.	[TA7] Feedback and Monitoring	[DP3] Response to the Feedback of Citizens	Keller, R., Röhrich, F., Schmidt, L., & Fridgen, G. (2019). Sustainability's coming home: preliminary design principles for the sustainable smart district. In 14. International Business Informatics Conference.	10
This involves how they can be monitored, analyzed, probed, assessed, and planned to improve their contribution to the goals of sustainable development by relying on big data analytics and context–aware computing	[TA7] Feedback and Monitoring	[DP3] Response to the Feedback of Citizens	Bibri, S. E. (2018). A foundational framework for smart sustainable city development: Theoretical, disciplinary, and discursive dimensions and their synergies. Sustainable Cities and Society, 38, 758-794.	778
Ecosystem services (energy, raw material, water, air, food, etc.) involving provision, distribution, and efficiency	[TA7] Feedback and Monitoring	[DP3] Response to the Feedback of Citizens	Bibri, S. E. (2018). A foundational framework for smart sustainable city development: Theoretical, disciplinary, and discursive dimensions and their synergies. Sustainable Cities and Society, 38, 758-794.	781
Many researchers have discussed improving the performance of cities and promoting their competitiveness compared to other cities	[TA7] Feedback and Monitoring	[DP3] Response to the Feedback of Citizens	Abusaada, H., & Elshater, A. (2021). Competitiveness, distinctiveness and singularity in urban design: A systematic review and framework for smart cities. Sustainable Cities and Society, 68, 102782.	4
In Commuter Village, whilst digital communications were also important to residents, they tended to reinforce separation between residents, so that locality-based communications were far more limited. Therefore, although ICT can help to promote social cohesion, this needs to be seen in terms of the structure and development of the community as such.	[TA8] Social Integration	[DP3] Response to the Feedback of Citizens	Wallace, C., Vincent, K., Luguzan, C., Townsend, L., & Beel, D. (2017). Information technology and social cohesion: A tale of two villages. Journal of Rural Studies, 54, 426-434.	433

The portal must allow for the integration of social media.	[TA8] Social Integration	[DP3] Response to the Feedback of Citizens	Majchrzak, T. A., Sakurai, M., & Serrano, N. (2018). Conceptualizing and designing a resilience information portal.	49
Smart cities should be understood as platforms, which aim at the achievement of self-organized urban smartness through citizens' entrustment and empowerment. Platforms should be pervasive and they should act as: 1) repository of shared information; 2) a collaboration mechanism; 3) a social learning space; and 4) a catalyst of commitment and involvement	[TA8] Social Integration	[DP3] Response to the Feedback of Citizens	Palumbo, R., Manesh, M. F., Pellegrini, M. M., Caputo, A., & Flamini, G. (2021). Organizing a sustainable smart urban ecosystem: Perspectives and insights from a bibliometric analysis and literature review. Journal of Cleaner Production, 297, 126622.	9
However, these emotional bonds positively influence the affective-evaluative perceptions of city-related entities, which positively affect actual behaviors such as uses of urban services.	[TA8] Social Integration	[DP3] Response to the Feedback of Citizens	Belanche, D., Casaló, L. V., & Orús, C. (2016). City attachment and use of urban services: Benefits for smart cities. Cities, 50, 75-81.	80
We stress the importance of citizen trust to safeguard social cohesion and economic growth.	[TA8] Social Integration	[DP3] Response to the Feedback of Citizens	Vandercruysse, L., Buts, C., & Dooms, M. (2020). A typology of smart city services: the case of data protection impact assessment. Cities, 104, 102731.	12
Service Organizations are Complex Social Service Systems	[TA8] Social Integration	[DP3] Response to the Feedback of Citizens	Van der Bijl-Brouwer, M. (2017). Designing for social infrastructures in complex service systems: a human-centered and social systems perspective on service design. She Ji: The Journal of Design, Economics, and Innovation, 3(3), 183-197.	186
Event management: Smart city systems need to control events in progress (i.e. events generated in IoT applications) and to produce timely responses to that stream of events. Event management should provide a real-time analysis of data so applications can use accurate and real-time information.	[TA10] Platforms	[DP4] Adoption of a Holistic District Perspective	Bastidas, V., Helfert, M., & Bezbradica, M. (2018). A Requirements Framework for the Design of Smart City Reference Architectures. In T. Bui (Ed.), Hawaii International Conference on System Sciences. doi:10.24251/HICSS.2018.317.	2518
Under SDL, SDP openness means that it could be open towards service providers and consumers between all actors on the platform whereas some restrictions existing. So we re-divide the openness of the SDP into three dimensions including accessibility, transparency and participation.	[TA10] Platforms	[DP4] Adoption of a Holistic District Perspective	Yu, J., Wen, Y., Jin, J., & Zhang, Y. (2019). Towards a service-dominant platform for public value co-creation in a smart city: Evidence from two metropolitan cities in China. Technological Forecasting and Social Change, 142, 168-182.	4

Service innovation on the SDP is defined as the process of integrating (re-bundle) various resources and innovate (recreate) new resources by actors on the platform in which is the venue of service innovation. And we analyzed this process from two dimensions including service portal integration and service process innovation.	[TA10] Platforms	[DP4] Adoption of a Holistic District Perspective	Yu, J., Wen, Y., Jin, J., & Zhang, Y. (2019). Towards a service-dominant platform for public value co-creation in a smart city: Evidence from two metropolitan cities in China. Technological Forecasting and Social Change, 142, 168-182.	4
When it mentions that governance of the SDP, we should answer two questions that who make decisions for the platform (leadership) and how the leader of the platform control or make it flexible to the actors on the platform	[TA10] Platforms	[DP4] Adoption of a Holistic District Perspective	Yu, J., Wen, Y., Jin, J., & Zhang, Y. (2019). Towards a service-dominant platform for public value co-creation in a smart city: Evidence from two metropolitan cities in China. Technological Forecasting and Social Change, 142, 168-182.	4
For this reason, neighborhood activities and association structures vary and must be analyzed for each platform individually.	[TA10] Platforms	[DP4] Adoption of a Holistic District Perspective	Renyi, M., Rombach, E., Teuteberg, F., & Kunze, C. (2019). Towards understanding the use of information systems in caring communities.	5
The portal must provide not only static pages but be ready for arbitrary dynamic content. This includes features such as newsfeeds, Weblogs, Wiki pages, and forums.	[TA10] Platforms	[DP4] Adoption of a Holistic District Perspective	Majchrzak, T. A., Sakurai, M., & Serrano, N. (2018). Conceptualizing and designing a resilience information portal.	49
The portal must allow existing dynamic content to be integrated. This should be possible by inlining existing Web sites and by integration XML-based data sources.	[TA10] Platforms	[DP4] Adoption of a Holistic District Perspective	Majchrzak, T. A., Sakurai, M., & Serrano, N. (2018). Conceptualizing and designing a resilience information portal.	49
Users with adequate rights must be able to edit pages.	[TA10] Platforms	[DP4] Adoption of a Holistic District Perspective	Majchrzak, T. A., Sakurai, M., & Serrano, N. (2018). Conceptualizing and designing a resilience information portal.	49
The portal must provide a so called “emergency mode”. This pre-defined home page should contain but the most relevant (live) data for a specific threat or emergency.	[TA10] Platforms	[DP4] Adoption of a Holistic District Perspective	Majchrzak, T. A., Sakurai, M., & Serrano, N. (2018). Conceptualizing and designing a resilience information portal.	49
A sufficient search functionality must be provided.	[TA10] Platforms	[DP4] Adoption of a Holistic District Perspective	Majchrzak, T. A., Sakurai, M., & Serrano, N. (2018). Conceptualizing and designing a resilience information portal.	49
The portal must be user friendly and ergonomic to use.	[TA10] Platforms	[DP4] Adoption of a Holistic District Perspective	Majchrzak, T. A., Sakurai, M., & Serrano, N. (2018). Conceptualizing and designing a resilience information portal.	50

Previous research suggests that combining hard and soft infrastructures and creating a platform to integrate urban services can build closer information- and transactionoriented relationships with citizens in a real-life context	[TA10] Platforms	[DP4] Adoption of a Holistic District Perspective	Belanche, D., Casaló, L. V., & Orús, C. (2016). City attachment and use of urban services: Benefits for smart cities. Cities, 50, 75-81.	79
Definition of business models: The changes in the city and in technology imply changes in business models. The IoT drives the development of new business models to achieve competitive advantage through better information and more effective decision making.	[TA9] Ecosystems and Services	[DP4] Adoption of a Holistic District Perspective	Bastidas, V., Helfert, M., & Bezbradica, M. (2018). A Requirements Framework for the Design of Smart City Reference Architectures. In T. Bui (Ed.), Hawaii International Conference on System Sciences. doi:10.24251/HICSS.2018.317.	2518
Resources on the SDP indicate that operant resources which act on other resources and produce an effect on value cocreation.	[TA9] Ecosystems and Services	[DP4] Adoption of a Holistic District Perspective	Yu, J., Wen, Y., Jin, J., & Zhang, Y. (2019). Towards a service-dominant platform for public value co-creation in a smart city: Evidence from two metropolitan cities in China. Technological Forecasting and Social Change, 142, 168-182.	4
In the following, we elaborate on the main problems and challenges that need to be considered when implementing smart solutions in towns, among them mainly the importance of considering local context factors, ensuring local stakeholders' involvement as well as gathering solution information and identifying and aligning suitable ICT solutions.	[TA9] Ecosystems and Services	[DP4] Adoption of a Holistic District Perspective	Hosseini, S., Frank, L., Fridgen, G., & Heger, S. (2018). Do not forget about smart towns. Business & Information Systems Engineering, 60(3), 243-257.	247
On the other hand, cities deploy user oriented information systems to offer easier accessible or additional services to their citizens to make governance tasks more comfortable and to increase the quality of life as well as to optimize internal processes.	[TA9] Ecosystems and Services	[DP4] Adoption of a Holistic District Perspective	Brauer, B., & Kolbe, L. (2016). Towards IS-enabled Sustainable Communities–A Conceptual Framework and Research Agenda.	2
Services running within the environment are sets of functions, information, and infrastructure required to offer a sustainable intervention. They are attributed to a specific application area (see Figure 1) like the mobility sector and use different mechanisms to drive user engagement – the supportive capabilities of appropriate mechanisms are discussed in the next section.	[TA9] Ecosystems and Services	[DP4] Adoption of a Holistic District Perspective	Brauer, B., & Kolbe, L. (2016). Towards IS-enabled Sustainable Communities–A Conceptual Framework and Research Agenda.	5
Hence, our goal is to include these actors and environmental characteristics into the framework. We argue that a holistic solution in a centralized municipal context can have higher potential than a diffusion of loose individual applications with different characteristics in various domains.	[TA9] Ecosystems and Services	[DP4] Adoption of a Holistic District Perspective	Brauer, B., & Kolbe, L. (2016). Towards IS-enabled Sustainable Communities–A Conceptual Framework and Research Agenda.	7

The fourth consideration is to create synergies and minimize conflicts between data-related stakeholders. The notion of stakeholders involved in service has been emphasized in the literature to design sustainable and workable services that create value for multiple stakeholders.	[TA9] Ecosystems and Services	[DP4] Adoption of a Holistic District Perspective	Lim, C., Kim, K. J., & Maglio, P. P. (2018). Smart cities with big data: Reference models, challenges, and considerations. Cities, 82, 86-99.	96
Fourth, the cooperation between public and private service providers needs to be deepened.	[TA9] Ecosystems and Services	[DP4] Adoption of a Holistic District Perspective	Schreieck, M., Wiesche, M., & Krcmar, H. (2016). Modularization of digital services for urban transportation.	8
Chan et al. (2019b) reported the initiative of the Hong Kong government to introduce subsidies and credit facilities to private developers and clients to facilitate adopting BIM and sustainability practices in the Hong Kong built environment too much success.	[TA9] Ecosystems and Services	[DP4] Adoption of a Holistic District Perspective	Olawumi, T. O., & Chan, D. W. (2020). Concomitant impediments to the implementation of smart sustainable practices in the built environment. Sustainable Production and Consumption, 21, 239-251.	10
Identify stakeholders taking part in the PBE of the SSD to assign roles.	[TA9] Ecosystems and Services	[DP4] Adoption of a Holistic District Perspective	Keller, R., Röhrich, F., Schmidt, L., & Fridgen, G. (2019). Sustainability's coming home: preliminary design principles for the sustainable smart district. In 14. International Business Informatics Conference.	8
Citizens' participation in policy making and decision making processes are key features of smart urban ecosystems.	[TA9] Ecosystems and Services	[DP4] Adoption of a Holistic District Perspective	Palumbo, R., Manesh, M. F., Pellegrini, M. M., Caputo, A., & Flamini, G. (2021). Organizing a sustainable smart urban ecosystem: Perspectives and insights from a bibliometric analysis and literature review. Journal of Cleaner Production, 297, 126622.	9
Smart urban ecosystems involve the transition towards cohesive and cogenerating urban communities.	[TA9] Ecosystems and Services	[DP4] Adoption of a Holistic District Perspective	Palumbo, R., Manesh, M. F., Pellegrini, M. M., Caputo, A., & Flamini, G. (2021). Organizing a sustainable smart urban ecosystem: Perspectives and insights from a bibliometric analysis and literature review. Journal of Cleaner Production, 297, 126622.	9

Smart urban ecosystems can be metaphorically conceived of as living organisms with a strong knowledge orientation. From this standpoint, a combination of network management and knowledge management practices is needed for ensuring the viability of smart urban ecosystems.	[TA9] Ecosystems and Services	[DP4] Adoption of a Holistic District Perspective	Palumbo, R., Manesh, M. F., Pellegrini, M. M., Caputo, A., & Flamini, G. (2021). Organizing a sustainable smart urban ecosystem: Perspectives and insights from a bibliometric analysis and literature review. Journal of Cleaner Production, 297, 126622.	9
Social sustainability is quintessential to the smartization of urban ecosystems.	[TA9] Ecosystems and Services	[DP4] Adoption of a Holistic District Perspective	Palumbo, R., Manesh, M. F., Pellegrini, M. M., Caputo, A., & Flamini, G. (2021). Organizing a sustainable smart urban ecosystem: Perspectives and insights from a bibliometric analysis and literature review. Journal of Cleaner Production, 297, 126622.	9
Smart urban ecosystems are place-specific organizational fields, whose structuring involves a high-level stage (i.e., the outlining of the ecosystem's boundary) and a bottom-level stage (i.e., the definition of individual roles and tasks).	[TA9] Ecosystems and Services	[DP4] Adoption of a Holistic District Perspective	Palumbo, R., Manesh, M. F., Pellegrini, M. M., Caputo, A., & Flamini, G. (2021). Organizing a sustainable smart urban ecosystem: Perspectives and insights from a bibliometric analysis and literature review. Journal of Cleaner Production, 297, 126622.	9
The urban ecosystems' ability to sharpen smartness depends on the combination of top-down and bottom-up initiatives, exploiting their positive, synergisticeffect on the urban innovation capacity.	[TA9] Ecosystems and Services	[DP4] Adoption of a Holistic District Perspective	Palumbo, R., Manesh, M. F., Pellegrini, M. M., Caputo, A., & Flamini, G. (2021). Organizing a sustainable smart urban ecosystem: Perspectives and insights from a bibliometric analysis and literature review. Journal of Cleaner Production, 297, 126622.	9
Move towards a quadruple-helix collaborative model	[TA9] Ecosystems and Services	[DP4] Adoption of a Holistic District Perspective	Mora, L., Deakin, M., & Reid, A. (2019). Strategic principles for smart city development: A multiple case study analysis of European best practices. Technological Forecasting and Social Change, 142, 70-97.	82

Therefore, it is important to adopt an integrated intervention logic that: (1) cuts across the multitude of application domains that smart city development represents; and (2) extends the benefits that ICT solutions can offer to any policy sectors of the city.	[TA9] Ecosystems and Services	[DP4] Adoption of a Holistic District Perspective	Mora, L., Deakin, M., & Reid, A. (2019). Strategic principles for smart city development: A multiple case study analysis of European best practices. Technological Forecasting and Social Change, 142, 70-97.	81
Urban infrastructure (transportation, water supply, communication systems, distribution networks, etc.) involving control, management, optimization, and automation	[TA9] Ecosystems and Services	[DP4] Adoption of a Holistic District Perspective	Bibri, S. E. (2018). A foundational framework for smart sustainable city development: Theoretical, disciplinary, and discursive dimensions and their synergies. Sustainable Cities and Society, 38, 758-794.	781
The role of urban intelligence functions in monitoring and planning smart sustainable cities	[TA9] Ecosystems and Services	[DP4] Adoption of a Holistic District Perspective	Bibri, S. E. (2018). A foundational framework for smart sustainable city development: Theoretical, disciplinary, and discursive dimensions and their synergies. Sustainable Cities and Society, 38, 758-794.	791
From a macro level perspective, the use of Big Data, collectively, from personal, government, businesses and media coupled with AI technologies can help to address numerous of urban services and further encourage the safety of urban residents just as much as expensive urban infrastructures that are vital at safeguarding the liveability of cities	[TA9] Ecosystems and Services	[DP4] Adoption of a Holistic District Perspective	Allam, Z., & Dhunny, Z. A. (2019). On big data, artificial intelligence and smart cities. Cities, 89, 80-91.	88
and (3) urban co-evolution, fostering a mutually-constructive interaction between the urban players (citizens, researchers and designers, and stakeholders) for collaborative innovation.	[TA9] Ecosystems and Services	[DP4] Adoption of a Holistic District Perspective	Andreani, S., Kalchschmidt, M., Pinto, R., & Sayegh, A. (2019). Reframing technologically enhanced urban scenarios: A design research model towards human centered smart cities. Technological Forecasting and Social Change, 142, 15-25.	8
Many researchers have discussed how cities might improve their performance and promote their competitiveness compared to other cities. Hollands (2008), Kresl (2013), S´aez and Peri´a˜nezb (2015) and Glasmeier and Christopherson (2015) identified the principles of competitive cities based on the urban economy, such as enhancing high-skilled jobs, promoting the desirability of environmental goods and services and engaging in activities to shape the future rather than passively accepting fate.	[TA9] Ecosystems and Services	[DP4] Adoption of a Holistic District Perspective	Abusaada, H., & Elshater, A. (2021). Competitiveness, distinctiveness and singularity in urban design: A systematic review and framework for smart cities. Sustainable Cities and Society, 68, 102782.	4

Both offer priorities to meet socio-morphological characteristics as a fundamental aspect because they depend on the integration between people and place from smartness viewpoints.	[TA9] Ecosystems and Services	[DP4] Adoption of a Holistic District Perspective	Abusaada, H., & Elshater, A. (2021). Competitiveness, distinctiveness and singularity in urban design: A systematic review and framework for smart cities. Sustainable Cities and Society, 68, 102782.	10
Scalability: A smart city system needs to be scalable to respond effectively when the system increases in the volume of sensor data flowing, in the volume of data being stored in databases, in the number of devices handled by the management system, in the number of data processed by services and applications, and users should be considered.	[TA11] Adaptability and Extensibility	[DP5] Facilitation of a Flexible IT Architecture	Bastidas, V., Helfert, M., & Bezbradica, M. (2018). A Requirements Framework for the Design of Smart City Reference Architectures. In T. Bui (Ed.), Hawaii International Conference on System Sciences. doi:10.24251/HICSS.2018.317.	2519
Flexibility: The smart city systems require providing different functionalities, depending on user needs and context. Service providers and developers need to consider certain flexibility from their software, products, and sensors for smart city applications.	[TA11] Adaptability and Extensibility	[DP5] Facilitation of a Flexible IT Architecture	Bastidas, V., Helfert, M., & Bezbradica, M. (2018). A Requirements Framework for the Design of Smart City Reference Architectures. In T. Bui (Ed.), Hawaii International Conference on System Sciences. doi:10.24251/HICSS.2018.317.	2519
Adaptability: Smart city systems require providing high availability in service provisioning, data management, communication, and sensing. Dynamic adaptation ensures availability and quality of applications at execution time. Adaptability is related to context awareness. Many platforms adapt their behaviour based on the context to achieve fault-tolerance, select a closer server to improve efficiency, decide for batch or real-time processing, and adapt data from multiple data sources.	[TA11] Adaptability and Extensibility	[DP5] Facilitation of a Flexible IT Architecture	Bastidas, V., Helfert, M., & Bezbradica, M. (2018). A Requirements Framework for the Design of Smart City Reference Architectures. In T. Bui (Ed.), Hawaii International Conference on System Sciences. doi:10.24251/HICSS.2018.317.	2520
Extensibility: Smart city systems need to add new functionalities, components, services, and applications to the platform anytime. This helps to ensure that these systems meet evolving city requirements and user needs.	[TA11] Adaptability and Extensibility	[DP5] Facilitation of a Flexible IT Architecture	Bastidas, V., Helfert, M., & Bezbradica, M. (2018). A Requirements Framework for the Design of Smart City Reference Architectures. In T. Bui (Ed.), Hawaii International Conference on System Sciences. doi:10.24251/HICSS.2018.317.	2520
Service-based: Smart city systems require offering services and adding new functionalities easily in a flexible environment for application development. For example, a service-based middleware provides abstractions for the complex underlying hardware through a set of services (e.g., data management, reliability, security) needed by applications.	[TA11] Adaptability and Extensibility	[DP5] Facilitation of a Flexible IT Architecture	Bastidas, V., Helfert, M., & Bezbradica, M. (2018). A Requirements Framework for the Design of Smart City Reference Architectures. In T. Bui (Ed.), Hawaii International Conference on System Sciences. doi:10.24251/HICSS.2018.317.	2520

Code management: The smart city environment requires providing code allocating and code migration services. Code allocation selects the set of devices to be used to complete a user or application level task. Code migration transfers the code from one device to another one in the network.	[TA11] Adaptability and Extensibility	[DP5] Facilitation of a Flexible IT Architecture	Bastidas, V., Helfert, M., & Bezbradica, M. (2018). A Requirements Framework for the Design of Smart City Reference Architectures. In T. Bui (Ed.), Hawaii International Conference on System Sciences. doi:10.24251/HICSS.2018.317.	2518
Application run-time: Smart city platforms require managing the execution of their applications. The aim is to facilitate the deployment and integration of smart city applications. Some platforms provide a complete environment for developers to deploy their applications. Other platforms offer an execution run-time service for applications with tools that the platforms provide.	[TA11] Adaptability and Extensibility	[DP5] Facilitation of a Flexible IT Architecture	Bastidas, V., Helfert, M., & Bezbradica, M. (2018). A Requirements Framework for the Design of Smart City Reference Architectures. In T. Bui (Ed.), Hawaii International Conference on System Sciences. doi:10.24251/HICSS.2018.317.	2518
Software engineering tools: Smart city platforms require providing a set of tools for the development and maintenance of services and applications. Some platforms provide workflow design and analytics tools to facilitate the development of data visualization and the dynamic creation of reports.	[TA11] Adaptability and Extensibility	[DP5] Facilitation of a Flexible IT Architecture	Bastidas, V., Helfert, M., & Bezbradica, M. (2018). A Requirements Framework for the Design of Smart City Reference Architectures. In T. Bui (Ed.), Hawaii International Conference on System Sciences. doi:10.24251/HICSS.2018.317.	2518
In case the portal must serve a high-number of requests in cases of crises, good scalability must be given. The extensibility of the portal must be very good, both regarding content and functionality.	[TA11] Adaptability and Extensibility	[DP5] Facilitation of a Flexible IT Architecture	Majchrzak, T. A., Sakurai, M., & Serrano, N. (2018). Conceptualizing and designing a resilience information portal.	50
The designed services should be scalable to extend in nearby places also to make neighborhood smart (Kumar et al., 2017).	[TA11] Adaptability and Extensibility	[DP5] Facilitation of a Flexible IT Architecture	Kumar, H., Singh, M. K., Gupta, M. P., & Madaan, J. (2020). Moving towards smart cities: Solutions that lead to the Smart City Transformation Framework. Technological forecasting and social change, 153, 119281.	10
Since smart urban ecosystems show a need for flexibility and adaptability, conventional bureaucratic approaches to arrange smart policies and regulations should be avoided in order to minimize compartmentalism, poor convergence, and disintegration.	[TA11] Adaptability and Extensibility	[DP5] Facilitation of a Flexible IT Architecture	Palumbo, R., Manesh, M. F., Pellegrini, M. M., Caputo, A., & Flamini, G. (2021). Organizing a sustainable smart urban ecosystem: Perspectives and insights from a bibliometric analysis and literature review. Journal of Cleaner Production, 297, 126622.	9

In addition to scalability, the main design requirements for the platform include: flexibility and extensibility, achieved via modular, decoupled, distributed services that enable independent evolution of components and facilitate the addition of new features; interoperability, achieved with the adoption of open, wellaccepted standards and protocols; code writing productivity and reliability, achieved with the reuse of robust, highly-tested opensource tools, libraries, and frameworks.	[TA11] Adaptability and Extensibility	[DP5] Facilitation of a Flexible IT Architecture	Del Esposte, A. D. M., Santana, E. F., Kanashiro, L., Costa, F. M., Braghetto, K. R., Lago, N., & Kon, F. (2019). Design and evaluation of a scalable smart city software platform with large-scale simulations. Future Generation Computer Systems, 93, 427-441.	431
In dynamic smart city contexts, with varying demands throughout the day and random citizen behavior, InterSCity must be able to individually scale out the stressed services to properly support workload fluctuations, rather than scaling the entire system as a whole.	[TA11] Adaptability and Extensibility	[DP5] Facilitation of a Flexible IT Architecture	Del Esposte, A. D. M., Santana, E. F., Kanashiro, L., Costa, F. M., Braghetto, K. R., Lago, N., & Kon, F. (2019). Design and evaluation of a scalable smart city software platform with large-scale simulations. Future Generation Computer Systems, 93, 427-441.	434
Interoperability: Smart cities need to operate between heterogeneous components and systems. Systems function among sensors from multiple vendors, systems implemented in different languages, platforms that share data and users, and legacy systems that must communicate with the new platforms. Software platforms for smart cities adopt techniques to handle this requirement, such as adopting generic and standard interfaces or applying Semantic Web to integrate all platform components.	[TA12] Modularity	[DP5] Facilitation of a Flexible IT Architecture	Bastidas, V., Helfert, M., & Bezbradica, M. (2018). A Requirements Framework for the Design of Smart City Reference Architectures. In T. Bui (Ed.), Hawaii International Conference on System Sciences. doi:10.24251/HICSS.2018.317.	2519
Configurability: Smart city systems need to allow (re)configuration of their components. A smart city platform has many configuration options and parameters that define its behaviour at execution time. Configuration is useful for these environments where there are many and varied components that can change over time. This configuration should allow automatic configuration of devices and networks.	[TA12] Modularity	[DP5] Facilitation of a Flexible IT Architecture	Bastidas, V., Helfert, M., & Bezbradica, M. (2018). A Requirements Framework for the Design of Smart City Reference Architectures. In T. Bui (Ed.), Hawaii International Conference on System Sciences. doi:10.24251/HICSS.2018.317.	2520
Resource discovery: Users, services, and devices require finding dynamically resources on the network at any time. The resources include heterogeneous hardware devices, devices' power and memory, analogue to digital converter devices, the communications module available on those devices and the services provided by these devices. This resource discovery should be automated because of human intervention for resource discovery is no viable.	[TA12] Modularity	[DP5] Facilitation of a Flexible IT Architecture	Bastidas, V., Helfert, M., & Bezbradica, M. (2018). A Requirements Framework for the Design of Smart City Reference Architectures. In T. Bui (Ed.), Hawaii International Conference on System Sciences. doi:10.24251/HICSS.2018.317.	2518

Resource management: Applications require providing services that manage the resources. Resource usage should be monitored, resources allocated in a right manner, and resource conflicts solved. In IoT architectures, especially in service oriented or virtual machine (VM)-based architectures, middleware needs to facilitate resource (service) composition, to satisfy users and applications needs.	[TA12] Modularity	[DP5] Facilitation of a Flexible IT Architecture	Bastidas, V., Helfert, M., & Bezbradica, M. (2018). A Requirements Framework for the Design of Smart City Reference Architectures. In T. Bui (Ed.), Hawaii International Conference on System Sciences. doi:10.24251/HICSS.2018.317.	2518
External data access: Smart city platforms require providing an interface to data access from external applications. The most common approach is an application program interface (API) to access the data collected from the city. Some smart city platforms use the concept of data as a service to make the data available to users and applications.	[TA12] Modularity	[DP5] Facilitation of a Flexible IT Architecture	Bastidas, V., Helfert, M., & Bezbradica, M. (2018). A Requirements Framework for the Design of Smart City Reference Architectures. In T. Bui (Ed.), Hawaii International Conference on System Sciences. doi:10.24251/HICSS.2018.317.	2518
First, every mobility services needs to be designed in a modular and interoperable way as part of the service system.	[TA12] Modularity	[DP5] Facilitation of a Flexible IT Architecture	Schreieck, M., Wiesche, M., & Krcmar, H. (2016). Modularization of digital services for urban transportation.	8
Use effective language and appropriate visualizations to communicate meaning across multiple platforms, media, and via multiple modalities if possible.	[TA12] Modularity	[DP5] Facilitation of a Flexible IT Architecture	Young, G. W., & Kitchin, R. (2020). Creating design guidelines for building city dashboards from a user's perspectives. International Journal of Human-Computer Studies, 140, 102429.	16
As our simulation results reveal, the use of open interfaces and data transferability have benefits for platform firms as well, particularly in the early growth phase.	[TA12] Modularity	[DP5] Facilitation of a Flexible IT Architecture	Ruutu, S., Casey, T., & Kotovirta, V. (2017). Development and competition of digital service platforms: A system dynamics approach. Technological Forecasting and Social Change, 117, 119-130.	128
For the public sector it is important to strive toward policies that encourage actors to use open interfaces and standardized ways to transfer user data.	[TA12] Modularity	[DP5] Facilitation of a Flexible IT Architecture	Ruutu, S., Casey, T., & Kotovirta, V. (2017). Development and competition of digital service platforms: A system dynamics approach. Technological Forecasting and Social Change, 117, 119-130.	128

Real-time: Smart city systems can require real-time sensing and monitoring, intelligent processing and big data online analytics. For instance, process control systems, healthcare, and transportation need on-time delivery of their data and services. Real-time monitoring helps users to predict and to forecast various situations that can affect the city's prosperity.	[TA13] Big Data Analytics and Sources	[DP6] Exploitation of the Full Potential of District Data	Bastidas, V., Helfert, M., & Bezbradica, M. (2018). A Requirements Framework for the Design of Smart City Reference Architectures. In T. Bui (Ed.), Hawaii International Conference on System Sciences. doi:10.24251/HICSS.2018.317.	2519
As shown in Fig. 5, various types of data are collected from different sources in modern cities. The key is to connect different types of data to produce a high level of knowledge and high-quality information for citizens and city officials.	[TA13] Big Data Analytics and Sources	[DP6] Exploitation of the Full Potential of District Data	Lim, C., Kim, K. J., & Maglio, P. P. (2018). Smart cities with big data: Reference models, challenges, and considerations. Cities, 82, 86-99.	94
Data from different modalities, along with publically available information, are processed to provide desired services.	[TA13] Big Data Analytics and Sources	[DP6] Exploitation of the Full Potential of District Data	Khan, Z., Pervez, Z., & Abbasi, A. G. (2017). Towards a secure service provisioning framework in a smart city environment. Future Generation Computer Systems, 77, 112-135.	10
The data mining and pattern recognition in time-series data, feature extraction, machine learning, light-weight signal processing, event processing, automated reasoning, embedded web server (Farahani et al., 2018) incorporate the smartness in service design and deliveries.	[TA13] Big Data Analytics and Sources	[DP6] Exploitation of the Full Potential of District Data	Kumar, H., Singh, M. K., Gupta, M. P., & Madaan, J. (2020). Moving towards smart cities: Solutions that lead to the Smart City Transformation Framework. Technological forecasting and social change, 153, 119281.	10
The government should release non-confidential government data freely open for reuse and application development by third parties and citizens to promote citizens' driven innovative initiatives for resource optimization and sustainable urban growth.	[TA13] Big Data Analytics and Sources	[DP6] Exploitation of the Full Potential of District Data	Kumar, H., Singh, M. K., Gupta, M. P., & Madaan, J. (2020). Moving towards smart cities: Solutions that lead to the Smart City Transformation Framework. Technological forecasting and social change, 153, 119281.	10
If a planner, strategist, or expert proposes to improve a particular energy, traffic, environment, or healthcare application by extracting knowledge from urban data, it is crucial for the data scientist (or urban analyst) to be able to assess the proposal systematically and decide whether and why it is sound or flawed.	[TA13] Big Data Analytics and Sources	[DP6] Exploitation of the Full Potential of District Data	Bibri, S. E. (2018). A foundational framework for smart sustainable city development: Theoretical, disciplinary, and discursive dimensions and their synergies. Sustainable Cities and Society, 38, 758-794.	770

The role of big data analytics in disentangling the intractable problems pertaining to urban sustainability	[TA13] Big Data Analytics and Sources	[DP6] Exploitation of the Full Potential of District Data	Bibri, S. E. (2018). A foundational framework for smart sustainable city development: Theoretical, disciplinary, and discursive dimensions and their synergies. Sustainable Cities and Society, 38, 758-794.	791
Heterogeneity: Smart city systems require managing the variety of devices, services, data formats, applications and communication technologies. This heterogeneity creates numerous challenges for the resulting smart city systems.	[TA14] Data Management	[DP6] Exploitation of the Full Potential of District Data	Bastidas, V., Helfert, M., & Bezbradica, M. (2018). A Requirements Framework for the Design of Smart City Reference Architectures. In T. Bui (Ed.), Hawaii International Conference on System Sciences. doi:10.24251/HICSS.2018.317.	2519
Data management: Users and applications require managing large volumes of data generated by devices and transmitted through the network infrastructure. A smart city system needs to provide data management services to applications including data collection, data streaming and processing, and data storage.	[TA14] Data Management	[DP6] Exploitation of the Full Potential of District Data	Bastidas, V., Helfert, M., & Bezbradica, M. (2018). A Requirements Framework for the Design of Smart City Reference Architectures. In T. Bui (Ed.), Hawaii International Conference on System Sciences. doi:10.24251/HICSS.2018.317.	2518
Policymakers should implement a healthy and feasible government-held data infrastructure which provides the guidelines and systematic solutions to the city-related data access for service designers.	[TA14] Data Management	[DP6] Exploitation of the Full Potential of District Data	Yeh, H. (2017). The effects of successful ICT-based smart city services: From citizens' perspectives. Government Information Quarterly, 34(3), 556-565.	7
For the development of our methodology and the training of our machinelearning based green IT artifact, we used smart meter data collected at 15-minute granularity from a Swiss utility company and conducted a customer survey in 2015.	[TA14] Data Management	[DP6] Exploitation of the Full Potential of District Data	Sodenkamp, M., Kozlovskiy, I., Hopf, K., & Staake, T. (2017). Smart meter data analytics for enhanced energy efficiency in the residential sector.	1246
Second, standardized data formats need to be used, in order to facilitate co-creation of value.	[TA14] Data Management	[DP6] Exploitation of the Full Potential of District Data	Schreieck, M., Wiesche, M., & Krcmar, H. (2016). Modularization of digital services for urban transportation.	8
The portal must provide templates for often used data structures and their representation, such as a contact list.	[TA14] Data Management	[DP6] Exploitation of the Full Potential of District Data	Majchrzak, T. A., Sakurai, M., & Serrano, N. (2018). Conceptualizing and designing a resilience information portal.	49
It must be possible to represent complex information. This particularly addresses incident data.	[TA14] Data Management	[DP6] Exploitation of the Full Potential of District Data	Majchrzak, T. A., Sakurai, M., & Serrano, N. (2018). Conceptualizing and designing a resilience information portal.	49

The intended meaning of the data being presented must be explicit and haveactionable applications for diverse user types with different data literacies.	[TA14] Data Management	[DP6] Exploitation of the Full Potential of District Data	Young, G. W., & Kitchin, R. (2020). Creating design guidelines for building city dashboards from a user's perspectives. International Journal of Human-Computer Studies, 140, 102429.	16
Data visualizations must be of a suitable type and have further contextual information or metadata attached for clarity of meaning.	[TA14] Data Management	[DP6] Exploitation of the Full Potential of District Data	Young, G. W., & Kitchin, R. (2020). Creating design guidelines for building city dashboards from a user's perspectives. International Journal of Human-Computer Studies, 140, 102429.	16
The accuracy, precision, lineage, source, and age of data must accompany all data.	[TA14] Data Management	[DP6] Exploitation of the Full Potential of District Data	Young, G. W., & Kitchin, R. (2020). Creating design guidelines for building city dashboards from a user's perspectives. International Journal of Human-Computer Studies, 140, 102429.	16
Use both real-time and historic data; arrange them logically and group them thematically.	[TA14] Data Management	[DP6] Exploitation of the Full Potential of District Data	Young, G. W., & Kitchin, R. (2020). Creating design guidelines for building city dashboards from a user's perspectives. International Journal of Human-Computer Studies, 140, 102429.	16
Context awareness has been defined in multiple ways depending on the application domain in terms of the number and nature of the subsets of the context of a given entity [...] that can be integrated in the design and development of a given computational artifact.	[TA14] Data Management	[DP6] Exploitation of the Full Potential of District Data	Bibri, S. E. (2018). A foundational framework for smart sustainable city development: Theoretical, disciplinary, and discursive dimensions and their synergies. Sustainable Cities and Society, 38, 758-794.	767
Users of cloud computing, including individuals, organizations, and government agencies employ it to, as a variety of enabled services, store and share information; manage, sift, and analyze databases; and deploy Web services, including processing huge datasets for complicated problems of scientific kinds	[TA14] Data Management	[DP6] Exploitation of the Full Potential of District Data	Bibri, S. E. (2018). A foundational framework for smart sustainable city development: Theoretical, disciplinary, and discursive dimensions and their synergies. Sustainable Cities and Society, 38, 758-794.	767
The cluster percentages table (Table 2) shows that the citizen ideation samples produced a diverse spread of ideas, displaying a range of different methods for generating intelligence with data.	[TA14] Data Management	[DP6] Exploitation of the Full Potential of District Data	Wolff, A., Barker, M., Hudson, L., & Seffah, A. (2020). Supporting smart citizens: Design templates for co-designing data-intensive technologies. Cities, 101, 102695.	3

Security: Smart city systems need to include security as a critical in the operation. Security needs to be considered during capturing, storing, transferring, aggregating and processing the data of things, as well as to the provision of services in the city. The security requirements include data confidentiality and authentication, access control within the IoT network and the enforcement of security policies.	[TA15] IT-Security	[DP7] Preservation of Privacy and Security	Bastidas, V., Helfert, M., & Bezbradica, M. (2018). A Requirements Framework for the Design of Smart City Reference Architectures. In T. Bui (Ed.), Hawaii International Conference on System Sciences. doi:10.24251/HICSS.2018.317.	2519
Information systems (IS) can hereby help to collect, store, organize, and distribute data throughout the neighborhood.	[TA15] IT-Security	[DP7] Preservation of Privacy and Security	Renyi, M., Rombach, E., Teuteberg, F., & Kunze, C. (2019). Towards understanding the use of information systems in caring communities.	1
From a technological perspective, the whole concept of smart cities evolves with the technological advancement in transmitting and sharing data methodologies from diverse modalities with the consideration of real-time, reliable and robust communication between data sources and data consumption points.	[TA15] IT-Security	[DP7] Preservation of Privacy and Security	Khan, Z., Pervez, Z., & Abbasi, A. G. (2017). Towards a secure service provisioning framework in a smart city environment. Future Generation Computer Systems, 77, 112-135.	9
The portal must provide users accounts, adequate authentication and authorization mechanisms, as well as a (adaptive) role management.	[TA15] IT-Security	[DP7] Preservation of Privacy and Security	Majchrzak, T. A., Sakurai, M., & Serrano, N. (2018). Conceptualizing and designing a resilience information portal.	49
The portal most offer a sufficient level of security, keeping in mind the kind of data that is processed.	[TA15] IT-Security	[DP7] Preservation of Privacy and Security	Majchrzak, T. A., Sakurai, M., & Serrano, N. (2018). Conceptualizing and designing a resilience information portal.	49
Multi-layered security solution (Chang, 2018a), network authentication and network firewall (Farahani et al., 2018) ensure a strong cybersecurity (Liao et al., 2017) solutions for smart city applications.	[TA15] IT-Security	[DP7] Preservation of Privacy and Security	Kumar, H., Singh, M. K., Gupta, M. P., & Madaan, J. (2020). Moving towards smart cities: Solutions that lead to the Smart City Transformation Framework. Technological forecasting and social change, 153, 119281.	10
Integrate public and IT security concepts to provide safety for people, public, and private property.	[TA15] IT-Security	[DP7] Preservation of Privacy and Security	Keller, R., Röhrich, F., Schmidt, L., & Fridgen, G. (2019). Sustainability's coming home: preliminary design principles for the sustainable smart district. In 14. International Business Informatics Conference.	11

Trust: Stakeholders and users require having confidence that the smart city systems/devices process and handle the data according their needs and rights. Trust management in smart cities helps people overcome perceptions of uncertainty and risk and engages in user acceptance and consumption on services and applications. Smart city systems should identify untrusted devices and implement policies to address problems of untrusted devices on the system.	[TA16] Privacy Concerns	[DP7] Preservation of Privacy and Security	Bastidas, V., Helfert, M., & Bezbradica, M. (2018). A Requirements Framework for the Design of Smart City Reference Architectures. In T. Bui (Ed.), Hawaii International Conference on System Sciences. doi:10.24251/HICSS.2018.317.	2519
Privacy: Owners and users require the protection of their personal information related to their habits and interactions with other people and services. Privacy protection should be considered during capturing, transferring, storing, validating and processing data of devices.	[TA16] Privacy Concerns	[DP7] Preservation of Privacy and Security	Bastidas, V., Helfert, M., & Bezbradica, M. (2018). A Requirements Framework for the Design of Smart City Reference Architectures. In T. Bui (Ed.), Hawaii International Conference on System Sciences. doi:10.24251/HICSS.2018.317.	2519
All personal data should be protected under a data privacy framework, the European Union (EU) development of the General Data Protection Regulation (GDPR) (European Union, 2016) is an example of a data privacy framework that organisations which store personal data within the EU must follow.	[TA16] Privacy Concerns	[DP7] Preservation of Privacy and Security	Heaton, J., & Parlikad, A. K. (2019). A conceptual framework for the alignment of infrastructure assets to citizen requirements within a Smart Cities framework. Cities, 90, 32-41.	39
Investigating the privacy issues and addressing these concerns are essential in data-based smart city development projects to create valid and sustainable value for citizens and visitors.	[TA16] Privacy Concerns	[DP7] Preservation of Privacy and Security	Lim, C., Kim, K. J., & Maglio, P. P. (2018). Smart cities with big data: Reference models, challenges, and considerations. Cities, 82, 86-99.	94
Thus, governmentdeployed sensors and monitors with seamless privacy protection must be installed to collect and coordinate an unprecedented amount of data on citizen's daily life.	[TA16] Privacy Concerns	[DP7] Preservation of Privacy and Security	Yeh, H. (2017). The effects of successful ICT-based smart city services: From citizens' perspectives. Government Information Quarterly, 34(3), 556-565.	7
In addition, the laws and policies for the protection of personal information should be adapted to the contemporary environment of information processing.	[TA16] Privacy Concerns	[DP7] Preservation of Privacy and Security	Yeh, H. (2017). The effects of successful ICT-based smart city services: From citizens' perspectives. Government Information Quarterly, 34(3), 556-565.	7
Comply with current law and regulations to aim for legal certainty.	[TA16] Privacy Concerns	[DP7] Preservation of Privacy and Security	Keller, R., Röhrich, F., Schmidt, L., & Fridgen, G. (2019). Sustainability's coming home: preliminary design principles for the sustainable smart district. In 14. International Business Informatics Conference.	11

identify which privacy concerns for their citizens may be at stake with specific technologies and data practices	[TA16] Privacy Concerns	[DP7] Preservation of Privacy and Security	Van Zoonen, L. (2016). Privacy concerns in smart cities. Government Information Quarterly, 33(3), 472-480.	479
identify if and how these (specific technologies and data practices) are subject to the EU data protection regulation	[TA16] Privacy Concerns	[DP7] Preservation of Privacy and Security	Van Zoonen, L. (2016). Privacy concerns in smart cities. Government Information Quarterly, 33(3), 472-480.	479
The aimof the regulation is that a person could transfer their personal data fromone platformto another in a structured and commonly used electronic format.	[TA16] Privacy Concerns	[DP7] Preservation of Privacy and Security	Ruutu, S., Casey, T., & Kotovirta, V. (2017). Development and competition of digital service platforms: A system dynamics approach. Technological Forecasting and Social Change, 117, 119-130.	128
For public and private stakeholders, the results of this study are useful to classify existing Smart City services according to DPIA costs or data protection requirements.	[TA16] Privacy Concerns	[DP7] Preservation of Privacy and Security	Vandercruysse, L., Buts, C., & Dooms, M. (2020). A typology of smart city services: the case of data protection impact assessment. Cities, 104, 102731.	12
More broadly, as smartness is related to data, data protection can ensure that smartness is durable and sustainable over the long term.	[TA16] Privacy Concerns	[DP7] Preservation of Privacy and Security	Vandercruysse, L., Buts, C., & Dooms, M. (2020). A typology of smart city services: the case of data protection impact assessment. Cities, 104, 102731.	11

Appendix D: Development of the Initial Design Principles

Our systematic literature review resulted in 44 relevant papers, out of which we extracted 210 prescriptive statements (see Appendix C). These statements served as our theoretical foundation for extracting seven initial DPs through two coding stages: i) topic area generation, ii) initial DP creation.

In *stage i) topic area generation*, we iteratively performed open and axial coding steps to generate descriptive topic areas potentially relevant to being transformed into prescriptive DPs. All these steps were performed in presence so that interactive collaboration and accompanying discussions could ensure a high level of mutual exclusiveness of the resulting clusters. For the first open coding, we relied on a self-developed natural processing clustering tool that had previously been valuable in other research projects. Using the 210 statements' semantic embeddings received from the Universal Sentence Encoder and Ward's hierarchical clustering analysis, the tool generated 25 initial clusters. We labeled initial clusters according to the most frequent occurrences of a specific topic. Outliers that did not match a cluster's label were marked, removed, and redistributed to other clusters. We eliminated suggested clusters and created new clusters within manual open coding steps where necessary. For instance, two clusters suggested by the tool included statements about the term 'service.' We deemed this to be unspecific for being a concise cluster and redistributed all the statements to other clusters. We further strived in axial coding steps to adjust the clusters so that they would all be at roughly the same level of abstraction. To do this, we discussed within our research group identifying main clusters that contain several smaller clusters. Herby, the manual open and axial coding steps were interwoven, so they did not follow a linear sequence. This iterative approach was conducted until the research team reached a consensus on 16 clusters we now refer to as topic areas.

In *stage ii) initial DP creation*, we performed a series of further axial coding steps in workshops with the aim of abstracting the prescriptivity out of the 210 statements, ultimately condensing the 16 topic areas into a concise set of meaningful DPs. Therefore, we first discussed the topic areas on a high level, considering the insights from the literature and the real-world experience we made during the project [blinded for review]. This helped to enrich our collective understanding of the topic areas, which we elucidated in Appendix E. Using the conceptual perspective on a Green IS in an SSD (see Figure 1) and

our deduced MR1-3, we secondly started to merge topic areas being close to each other in terms of the topic areas description or the prescriptive statements within. For instance, we combined the topic areas ‘Overarching design and goal of districts’ (TA5) and ‘Technology-driven innovation’ (TA6) into the ‘Realization of district objectives’ (DP2) based on our understanding of the beneficial utilization of innovative or smart technology creating mutual benefits across SSD stakeholders. (MR2). We see that smart technology emerging from innovation can enable SSDs to realize their goals better but needs to be adequately aligned on them within a design suitable for the SSD. Those reasoned merges allowed us to reduce the number of topic areas successively, rematch the prescriptive statements, and enable a high level of detail for initially written DP drafts. These written drafts were then discussed with the research team to avoid the risk of disregarding important prescriptive statements. We continued rematching the statements and overhauling our DP drafts until theoretical saturation was reached and a consensus within the research team was established. Thirdly, an additional refinement workshop set out to improve the understandability of the DPs and to identify evaluation criteria for the evaluation steps further downstream.

Appendix E: Final Definitions of the Topic Areas

Topic Area	Name	Definition
TA1	Citizen Design Involvement	Refers to actively engaging citizens in designing and planning SSD development through participatory or collaborative design processes.
TA2	Training of Actors	Refers to the training and support provided to SSD stakeholders to increase their knowledge and engagement with SSD services.
TA3	Accessibility	Refers to providing SSD technologies and services that allow universal use and remove barriers.
TA4	Citizen Goals and Needs	Refers to identifying and satisfying citizens' specific values, requirements, and demands in developing SSD services.
TA5	Overarching Design and Goal of Districts	Refers to the SSD's overall objective, direction, and alignment using a Green IS to create value for various stakeholders.
TA6	Technology-Driven Innovation	Refers to using advanced and innovative technologies to improve SSD services while addressing sustainability-related problems.
TA7	Feedback and Monitoring	Refers to collecting and analyzing user feedback, usage data, and performance metrics to improve SSD services and achieve sustainability-related goals within the SSD.
TA8	Social Integration	Refers to the process of fostering a sense of community and connectedness among residents in an SSD.
TA9	Ecosystems and Services	Refers to holistically integrating stakeholders, processes, technologies, and information to create innovative SSD ecosystems that improve the quality of life with sustainable services.
TA10	Platforms	Refers to economic, technical, or organizational structures that promote and facilitate transactions and interactions between SSD stakeholders.
TA11	Adaptability and Extensibility	Refers to the ability of Green IS to adjust to changing conditions dynamically and to integrate new services based on citizens' needs quickly.
TA12	Modularity	Refers to designing and organizing complex systems as a collection of smaller, independent, and interchangeable modules allowing flexibility and scalability.
TA13	Big Data Analytics and Sources	Refers to collecting, processing, and analyzing diverse data from various sources to enable sustainable and smart service designs.
TA14	Data Management	Refers to managing large volumes of generated master and transaction data to allow an effortless co-creation of valuable services for the citizens.
TA15	IT-Security	Refers to the measures taken to physically and virtually protect data and systems within an SSD by providing multi-layered security solutions.
TA16	Privacy Concerns	Refers to protecting (sensitive) information of citizens and other stakeholders complying with data privacy regulations.

Appendix F: Initial Design Principles

Design Principle 1	Involvement of citizens
Aim	Positive attitude of citizens towards the manifestation of the information system.
Context	Initiation, Development, Implementation
Mechanism	Ensure involvement of citizens via active participation during the creation of the information system.
Rationale	Involving citizens enables early integration of their perspective and facilitates their positive attitude towards using the information system (Venkatesh et al. 2012).
Exemplary Action	• Identify service demands of the citizens • Conduct early test of the information with the citizens • Create channels that reach different citizen types • Perform workshops with citizens • Integrate diverse perspectives from multiple district citizens • Provide Information to train the citizen on the information system and how to use it

Design Principle 2	Realization of district goals
Aim	Align innovative technology with the overarching sustainability goals of the respective district.
Context	Initiation, Development
Mechanism	Include information systems requirements derived from district goals with help of innovative technologies.
Rationale	Contextual factors (Environment, Strategies, Infrastructure) within the districts have to be considered in order to create an appropriate information system (Alter 2013).
Exemplary Action	• Define values for the information system based on SDGs or SSD goals • Make use of disrupting digital technologies depending on the SSDs resources • Balance between bottom-up and top-down initiatives • Consider costs while exploring potentials with innovative technology • Integrate diverse goal-related perspectives from multiple district stakeholders

Design Principle 3	Response to citizen feedback
Aim	Consider citizens' feedback to continuously improve the information system in respect to their needs
Context	Operation
Mechanism	Respond to new or changing needs of the citizen by collecting their feedback.
Rationale	Focusing on the citizen needs to foster application of the information system and allow a sustainable growth of the citizens (Graf-Drasch et al. 2022).
Exemplary Action	• Consider contextual factors regarding housing while collecting feedback • Ensure bi-directional communication between citizens and SSD IS service provider • Combine feedback and behavioral data from different sources • Apply multiple analyzation approaches to understand feedback data • Create new ways for interaction with citizens • Leverage feedback to existing services (bundles) offered to citizen

Design Principle 4	Integration of an ecosystem perspective
Aim	Facilitate constructive interaction between stakeholders, services, technologies, and information systems.
Context	Initiation, Development, Implementation, Operation
Mechanism	Integrate technical and human perspectives from multiple stakeholders into sustainable services.
Rationale	A holistic perspective avoids siloed ways of thinking and island solutions (Wang 2021).
Exemplary Action	• Develop a citizen journey to identify potential for services and service-improvements • Investigate the supply and demand of services from all stakeholders in the SSD • Facilitate the collaboration and knowledge-exchange between public and private service provider • Introduce a digital platform to support the emergence of an ecosystem • Foster interaction with ecosystems from other districts

Design Principle 5	Facilitation of a flexible IT architecture
Aim	Run a scalable information system capable of dealing with short-term shocks and long-term transformations.
Context	Development, Operation
Mechanism	Retain a stable as well as flexible IT architecture that is robust regarding the status-quo and open to changes.
Rationale	A flexible and stable IT architecture supports innovativeness and change of the system (Jonkers et al. 2006).
Exemplary Action	• Provide interfaces for multiple service providers • Evaluate potentials from open data and open source • Avoid redundant functionalities within the information system and considering SSD-external services available • Define generic interfaces that can be used from different technologies • Ensure scalability in citizen-relevant functionalities

Design Principle 6	Usage of collected district data
Aim	(Re-)Develop services with help of data to tackle complex sustainability-related goals.
Context	Initiation, Development, Implementation
Mechanism	Collect, manage, and analyze data from within the district using state-of-the-art technology.
Rationale	Analyzing big data shed light on complex urban interdependences (Bibri 2018).
Exemplary Action	• Analyze data to identify new or non-anticipated patterns of IS usage • Provide guidelines regarding the management of data • Leverage the potentials in combining historic and real-time data • Include all available data sources from the individuals, the district, and the environment • Visualize data in a comprehensible way when interacting with citizens

Design Principle 7	Preservation of information privacy and security
Aim	Protect sensible Information and property within the district.
Context	Initiation, Development, Implementation, Operation
Mechanism	Integrate multi-layered security concepts to preserve privacy and (IT-) Security.
Rationale	Upholding the fundamental freedoms of individuals, supports living a self-determined life (European Commission 2016).
Exemplary Action	• Align contemporary IT-security measures within the information system • Comply with applicable laws and regulations • Identify suitable privacy measures that prevent concerns from the citizens • Proactively address and communicate privacy and safety related issues • Consult external security and safety experts where necessary

Appendix G: Implemented Feedback to the Initial Design Principles from the Evaluation Episode 2

DP	Final DP Name	Evaluation Criteria				
		Ease of Use	**Elegance**	**Simplicity**	**Understandability**	**Completeness**
DP1	Involvement of citizens		[ID4] Inconsistent use of key terms must be unified [ID11] Suggestions regarding typos and words to be replaced	[ID3] 'Manifestation of the information system' in the aim is not concise	[ID1] The understanding of the citizens should be included in the aim [ID9] Concrete description of the added value of a positive attitude needs to be emphasized more [ID12] The aim is formulated as too complex	[ID3] The involvement of citizens should also be described as appropriate in relation to the target group [ID5] The participation of citizens should also consider the goals of the different stages of life
DP2	Realization of district objectives	[ID2] Uncertainty whether there are district goals in practice [ID5] Feasibility of the third exemplary action at the given level of detail is doubtful [ID8] Not every district must necessarily have a goal	[ID4] Inconsistent use of key terms must be unified [ID8] Due to a high priority, the last exemplary action should be placed on top [ID9] The aim is not fluently to read	[ID8] Technology does not ultimately need to be innovative to realize district objectives [ID10] The mechanism is not intuitive to read	[ID4] Distinction between district goals and sustainability goals needs to be improved [ID5] The third exemplary action is unclear [ID8] The third exemplary action is hard to understand [ID10] The sole focus on costs in the fourth exemplary action comes out of the blue [ID11] 'Disrupting digital technologies' can be misunderstood [ID12] 'disrupting' should be replaced	[ID7] The potential opportunities created by a Green IS must take into account the context [ID8] 'information systems requirements' can be relocated to the exemplary actions [ID10] There is a lack of consideration of the potential conflicts of interest of competing stakeholders and district objectives

DP3	Response to the feedback of citizens	[ID3] More concrete examples of implementation would help to use the design principle	[ID1] ‘Continuously’ is misleading in the aim [ID4] Inconsistent use of key terms must be unified; suggestion to improve the title of the design principle; [ID9] ‘Continuously’ should be included in the mechanism		[ID1] Multiple solicitations of feedback from citizens are important [ID2] Concretization of how exactly the feedback can be collected operationally is necessary [ID4] The last exemplary action is confusing; the first exemplary action should focus more on the social structure of the citizens [ID5] The necessity of the last exemplary action is unclear [ID11] The handling of the responses to the citizens’ feedback is not yet clear enough [ID12] The response to the ideas of the citizens to the citizens can be further strengthened	[ID2] The consideration of the knowledge-behavior-gap among citizens is missing [ID10] Examples needed for the first exemplary action [ID11] Examples needed for the fifth exemplary action [ID12] Examples needed for the fifth exemplary action
DP4	Adoption of a holistic district perspective	[ID1] Mechanism is hard to implement since stakeholders are not clearly stated [ID4] Suggestion to modify the title, including ‘district perspective’ [ID5] Is not actionable enough, as the design principle is at a high level	[ID4] Inconsistent use of key terms must be unified [ID8] Suggestion regarding spelling mistakes	[ID1] Level of abstraction is too high for the design principle	[ID2] ‘technical and human perspectives’ in the mechanism are not clear enough [ID3] A stronger focus on the services within the district is needed [ID14] Restructuring the exemplary actions’ order is necessary for the understanding	[ID10] Journeys named in the first exemplary action should also be developed for other stakeholders

DP5	Facilitation of a flexible IT architecture		[ID3] A better separation of the descriptions in mechanism and aim is necessary [ID4] Inconsistent use of key terms must be unified [ID8] Suggestion to change the perspective in the third exemplary action from ‘avoid’ to ‘integrate’	[ID6] The first and fourth exemplary actions could be merged	[ID5] ‘Evaluate’ in the second exemplary action is misleading since the potentials should be leveraged	[ID7] Lack of consideration of the fast-moving nature of technologies and the need to ensure long-term operation [ID10] Interfaces should also be available for stakeholders
DP6	Exploitation of the full potential of district data	[ID5] The exemplary actions could be supported even more with examples to be more concrete	[ID4] Inconsistent use of key terms must be unified [ID3] ‘state-of-the-art technology’ is ultimately not necessary to perform the mechanism [ID10] The name of the design principle should be reevaluated		[ID5] The level of abstraction for all the exemplary actions could be homogenized	[ID7] The interpretation of data is missing in the last exemplary action [ID9] The scope of the last exemplary action should be broadened [ID10] Lack of consideration of a reflection in the use of data
DP7	Preservation of privacy and security		[ID3] Suggestion regarding typos [ID4] Inconsistent use of key terms must be unified [ID8] Suggestion regarding typos and small reformulations		[ID8] Comprehensibility could be improved by explicitly referring to relevant points apart from laws [ID9] The whole design principle could be improved by explicitly referring to relevant points apart from laws	[ID3] Beyond data protection, other legal and moral factors need to be considered [ID8] A critical reflection between legal and legitimate is missing [ID14] The third exemplary action is missing the topic of trust