Article

Beyond Smart: How ICT Is Enabling Sustainable Cities of the Future

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Abstract: Cities around the world face pressing sustainability challenges such as climate change, resource scarcity, and unsustainable growth. Smart cities have emerged as a response to these challenges, leveraging information and communication technologies (ICTs) to create more efficient and liveable urban environments. However, the concept of smart cities is often defined in vague and ideologically driven terms that lack clear guidelines for promoting sustainability. In this study, we use qualitative methods to examine how the use of ICTs can support the goals of sustainability in smart city development, resulting in what we call a 'smart sustainable city'. Drawing on a case study involving stakeholder analysis, semi-structured interviews, and document analysis, we investigate the key roles of local government, ICT firms, and citizens in shaping sustainable urban development through smart city initiatives. Our findings shed light on the potential of ICTs to promote sustainability in smart cities and provide insights for policymakers, practitioners, and scholars working towards creating more sustainable urban environments. The findings of this research showed that ICT's role in supporting sustainability in smart cities relies on understanding the interests and priorities of civic, ICT firms, and citizens, promoting effective collaboration and avoiding self-serving outcomes.

Keywords: smart cities; future cities; sustainable cities; sustainability; ICT; information systems

1. Introduction

The world is being faced with several core sustainability issues including climate change, resource scarcity, and a 'growth at any cost' approach to business [1]. In addition, cities are proliferating as the urbanization of the population is on an upward trajectory.

Between 2011 and 2050, the world population is expected to increase by 2.3 billion, passing from 7.0 billion to 9.3 billion. At the same time, the population living in urban areas is projected to increase by 2.6 billion, passing from 3.6 billion in 2011 to 6.3 billion in 2050. Thus, the urban areas of the world are expected to absorb all the population growth over the next four decades while at the same time drawing in some of the rural population [2,3]. This growing urbanization poses a challenge to the world by utilizing nearly all the world's natural resources and being responsible for the majority of carbon dioxide emissions [4]. From an environmental perspective, these include energy, transportation, water, food, emissions, and alternative energy. On the social justice front health, education housing and poverty are often cited. Major economic sustainability issues for cities are urban funding and finances. Cities have serious challenges in relation to the renewal and upgrade of infrastructure, transportation issues and infrastructure funding (e.g., Canada, 2010) [5].

The notion of 'smart cities' is offered as a response to the problems of urbanization and the sustainability challenges faced by cities. The term "smart city" is used globally in various contexts and with different interpretations. It can be modified by substituting the word "smart" with other adjectives like "digital", "intelligent", "urban", or "knowledge", resulting in multiple conceptual versions. Researchers have proposed several definitions for smart cities, which have been accepted and used in both practical and academic settings

that mainly consider information and communication technology (ICT) as an enabler for smart cities [6].

Viewing a city as a system of interconnected systems encourages thinking that spans different sectors within the city. This includes considering cross-sectoral business processes, which are part of the city system and contribute to the provision of city services. These processes should possess qualities such as flexibility, dynamism, agility, and connectivity to other relevant city systems [7,8]. Additionally, information should be easily accessible, shareable, and connected across various sectors within the city [9]. Citizens themselves should interact intelligently and smartly with each other, as well as with technologies, devices, and government offices. They should be an integral part of the city's economic, social, and cultural development, and be knowledgeable about utilizing and interacting with the smart infrastructure of their community [10]. Therefore, all the components necessary for delivering a service should be interconnected and these components are the key drivers of a digital transformation towards developing a smart sustainable city.

Currently, local government authorities (LGAs) have implemented technological solutions to automate and improve their business processes, aiming to provide agile, flexible, and more efficient city services. However, employing smart and innovative technologies alone does not fulfil the requirements of a smart city. A close and seamless integration between different sectors of the city enhances sustainability, quality of life, and efficiency in resource management and public service delivery [11,12]. Therefore, ref. [12] proposes four essential elements for smart city development (SCD), namely, systems integration, investment, collaboration among stakeholders, and technology. However, according to ref. [13,14], technology should be an integral part of an integrated system that spans various sectors, aiming to create a smart environment and facilitate more interconnected and citizen-centric services.

Hence, while there are clearly problems in defining smart cities and also problems in the discourse surrounding smart cities, there is recognition that ICT (information and communications technology) is important in relation to smart cities and that they are intrinsically linked [15]. Moreover, ICT has an important role to play in sustainability. However, the extent to which ICT serves sustainability rather than becoming an end in itself is unclear. Thus, this research is significant as there is a tendency for ICT to be promoted as the answer to sustainability issues without a proper understanding of how it can be used and without a clear link between sustainability and ICT in city development projects. The research question that is developed from this literature review is the following: How does the use of ICT in the context of smart cities support the goals of sustainability rather than being self-serving?

Hence, this research aims at exploring issues in ICT providing support for sustainability. The following sub-questions were considered:

(1) What are the issues in the alignment of ICT with sustainability in city projects?
(2) How do different stakeholders' interests in ICT and sustainability vary in the city context?
(3) What are the key roles in the alignment of ICT with sustainability in city projects?

The next section of this research presents a review of the literature on smart cities and relates this to the sustainability challenges faced by cities and explores the importance of ICT in this context, in order to support the research question. Section 3 discusses the research methodology and design of this study. Then, the coding and thematic analysis and the categorisation of the findings into the three main themes of civic, ICT firms and citizen-related theme are discussed. The findings of the research will be offered in Section 4. Then, all the findings will be discussed, and the research will be concluded in Section 5.

2. Research Background

2.1. Smart Cities

Smart cities have been offered as a response to the sustainability challenges of urbanization. Several definitions exist for a smart city, many of which are inconsistent, confusing,

complicated, and overlapping (e.g., the definitions provided in Table 1). Added to this is the fact that there is a number of conceptual variants that are very closely related to smart cities (e.g., digital city, intelligent city, knowledge city).

Table 1. Some examples of smart city definitions.

Author	Definition	Focus
[16]	A city where ICT strengthens the freedom of speech and the accessibility to public information and services.	ICT focus on freedom of speech, information and services
[17]	A city that gives inspiration, and shares culture, knowledge, and life, a city that motivates its inhabitants to create and flourish their own lives.	People-focused—improve lives through culture and knowledge
[18]	A smart city looks at all the exchanges of information that flow between its many different subsystems. It then analyses this flow of information, as well as of services, and acts upon it in order to make its wider ecosystem more resource-efficient and sustainable.	Information for services, resource efficiency, sustainability
[19]	Any adequate model for the smart city must focus on the smartness of its citizens and encourage the processes that make cities important: those that sustain very different—sometimes conflicting—activities. Cities are, by definition, engines of diversity; so, focusing solely on streamlining utilities, transport, construction and unseen government processes can be massively counter-productive, in much the same way that the 1960s idealistic fondness for social-housing tower-block economic efficiency was found, ultimately, to be socially and culturally unsustainable.	Citizen-focused, efficiency, diversity
[20]	Their smart cities framework consists of eight clusters of factors: management and organisation, technology, governance, policy, people and communities, the economy, built infrastructure and the natural environment.	Management/organisation, technology, governance, policy, people, economy, infrastructure and environment
[21]	The smart city is a territory with a high capacity for learning innovations, built on the creativity of its residents, their knowledge development, and their digital infrastructure for communications and knowledge management.	Citizen/community-focused, digital technologies and infrastructure
[22]	A system of systems in which cross-sectoral city system integration has been accomplished, enabling access to real-time information and knowledge by all the city sectors, providing integrated services, and enhancing liveability, workability, and sustainability for the citizens.	Systems integration, connectivity or the processes and data, future sustainable cities
[23]	A smart city is a sustainable city that solves urban problems and improves citizens' quality of life through the fourth industrial revolution, technology and governance between stakeholders	Smart sustainable cities, industry 4.0, governance and digital technology

The definitions are not easily comparable; they involve differing concepts, some focusing on very broad principles of empowerment and inspiration while others mention quite specific physical structures, such as roads and airports. Furthermore, the definitions have very little to say about sustainability and are very focused on digital technologies. Figure 1 shows the underlying components and core factors for smart city initiatives derived from their analysis of a number of definitions of smart city and conceptual relatives aligned to three key dimensions: technology, people and institutions.
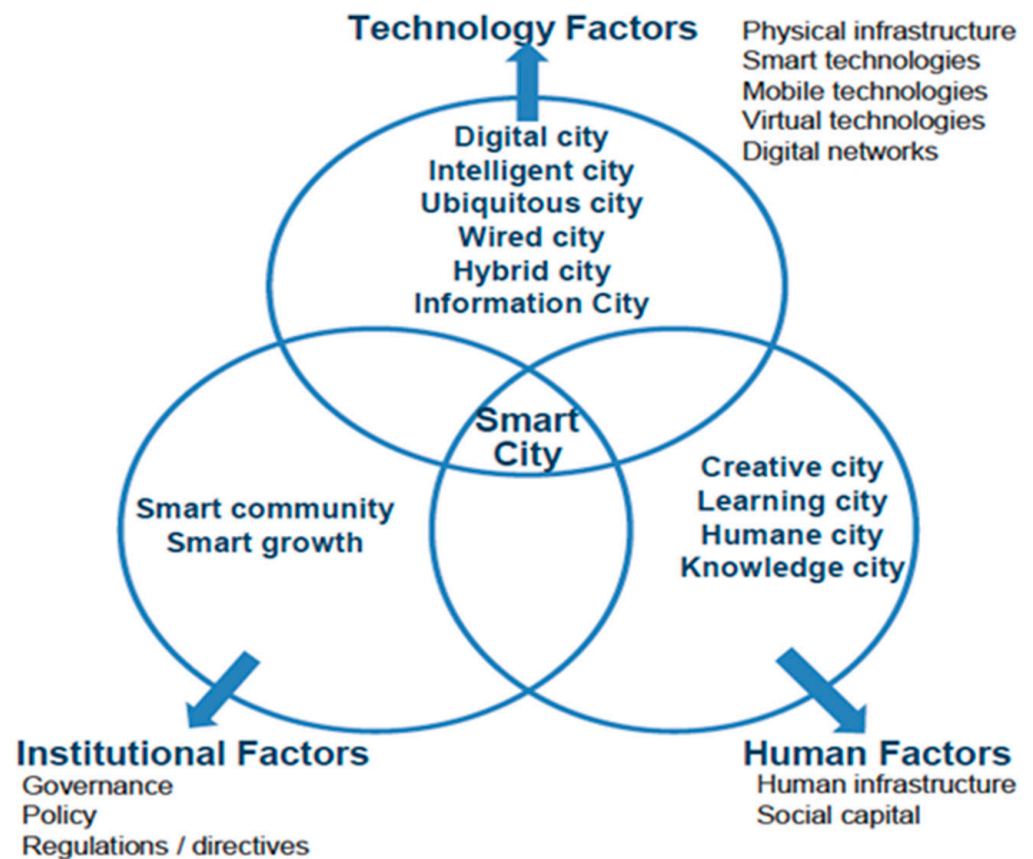
Figure 1. Fundamental components of smart city based on various definitions and conceptual variants (adopted from [18]).

The original use of 'smart' was very much related to sustainability and was used in the context of energy usage in the home through automated systems where computing enabled systems to be controlled without human intervention [24]. This original sustainability-focused use of smart appears to have replaced one that is ICT focused. Indeed, smart cities are seen as a response to the sustainability issues in cities, as discussed earlier. It is also apparent from the definitions that ICT seems to dominate and the link to sustainability appears to be lost or at least not very apparent and sometimes feels like the "technology will save us movement". It is clear that future cities are expected to be smart and sustainable through ICT, but this journey has significant challenges [25].

2.2. The Problems of the Smart Cities Discourse

As argued before, despite smart cities having been offered as a response to the problems of increasing urbanization, the link to sustainability has become unclear and the focus is very much on the technology aspects of 'smart' [26]. The smart cities agenda seems to be largely dominated by technologists and technology companies. In addition, the technology push is still dominant in the actual research agenda of smart cities [27].

As argued by [28], technology providers for smart cities are looking for a one-size-fits-all, top-down strategic approach to sustainability, citizen well-being and economic development. Their strategies focus on the city as a single entity, rather than the people/citizens that bring it to life. However, the term smart city is normative rather than just descriptive with the consequence that this implies that this needs to happen and policies must be created accordingly [29,30]. From an urban planning perspective, smart is also treated as not only normative but also ideological and hence characterised positively, suggesting a strategic direction. There is a further argument that this is a celebratory and self-congratulatory tendency that diverts attention from the important issues of definitional impreciseness,

underlying assumptions and hidden questions about sustainability [10,31]. Hence, it is crucial to recognise that the technology-centric perspective fails to fully consider the role of individuals and communities in shaping and revitalising cities. Moreover, the normative nature of a smart city can result in a singular perspective of what constitutes a smart city, potentially overshadowing other important considerations. This self-congratulatory tendency further masks the underlying issues of definitional imprecision and raises questions about the sustainability implications of such approaches. To address these issues, further examination and research are needed to shed light on the multifaceted nature of smart cities and to consider alternative approaches that incorporate a more inclusive and sustainable perspective. This requires exploring the dynamic interplay between technology, governance, citizen participation, and environmental considerations in order to develop holistic frameworks that prioritise the well-being and needs of citizens while promoting sustainable urban development.

2.3. ICT and Sustainability

In the context of smart cities, the link between ICT and sustainability is not always clear. One of the reasons for this is the varying levels of priority or interest in the two subjects by stakeholders. The key stakeholders in the city include city authorities (government), citizens, communities, businesses and service providers [32]. However, ICT has the potential to promote sustainable development by linking the economic, social and environmental dimensions. More specifically, ICT is a potential tool to address climate change and improve environmental performance [33,34]. In particular, the areas that contribute the majority of greenhouse gases, i.e., power generation and distribution, buildings and transportation are exactly the areas that could benefit from the application of ICT (e.g., [35]). ICT can help alter work, life and attitudes about energy. Availability of good information is key to enabling low carbon transformation and behavioural change can occur when adequate information is available for informed decision making. Ref. [36] identifies the positive and negative impacts of ICT on environmental sustainability on three levels: "first-order effects such as increasing electronic waste streams; second-order effects such as improved energy-efficiency of production; and third-order effects such as a product-to-service shift in consumption or rebound effects in transport".

ICT is seen as having the potential for achieving environmental policy goals, helping to alter environmental indicators such as CHG emissions, energy consumption and the proportion of renewable energy sources in electricity generation [37].

3. Materials and Methods

A qualitative approach based largely on semi-structured interviews within a case study, as an empirical enquiry that investigates a contemporary phenomenon within its real-life context, is used in this research. The design and the stages of conducting this research are summarised in Figure 2.

The case study was used to obtain a better understanding of a wider phenomenon. a city council was used as the organisation for the case study. It is a council that is committed to sustainability and is pursuing a number of projects to leverage ICT for improving its services as a local government. Participants for this research were selected from relevant key departments, such as Climate Change & Sustainability, whose remit covers sustainable energy and reducing CO_2 levels by 60% by 2027. The semi-structured approach was intended to aid discussion on areas relevant to the research question, to explore (Figure 3):

- Issues in supporting sustainability through ICT in the smart city context;
- Different levels of interest/priority in ICT and sustainability;
- Key roles in ICT for sustainability.

3.1. Selecting Participants

The participants were selected due to their work on ICT or sustainability projects. The idea was to explore their views on how ICT supports sustainability in city projects.

Semi-structured interviews (typically an hour) with 10 project participants were conducted. This is considered to be a sufficient number of participants because the saturation point, where the collected data no longer add new information or insights to the original research topic, was met after 8–10 interviews. Table 2 lists the participants and a brief description of their roles. The interviews took place face-to-face at the interviewees' organizations. Each interview took an average of 45 min. Ethical approval was obtained prior to the project start date and every interviewee was informed about the process, their rights to withdraw at any time, as well as the data management matters. A consent form was also obtained from every interviewee before conducting the interviews.
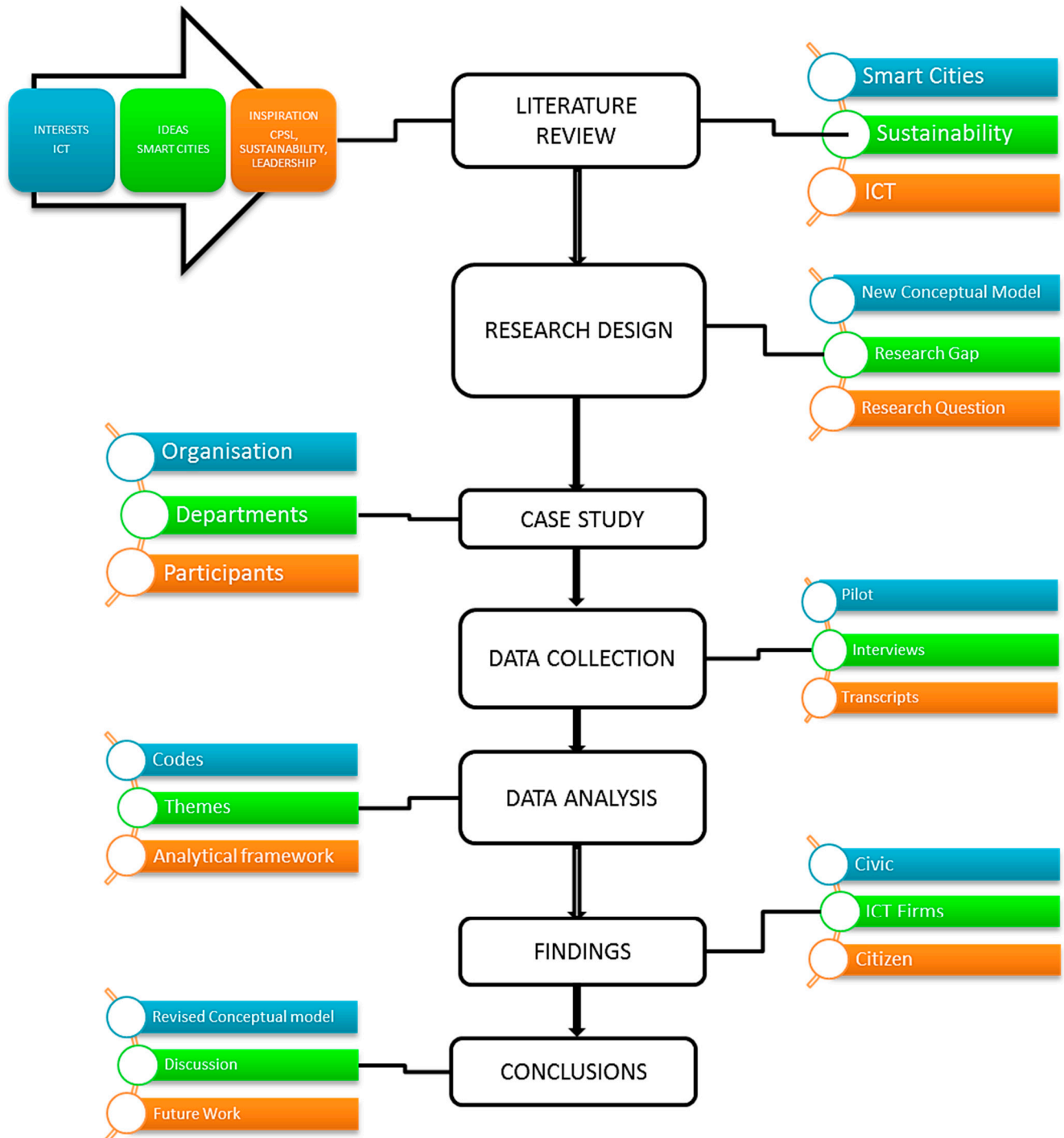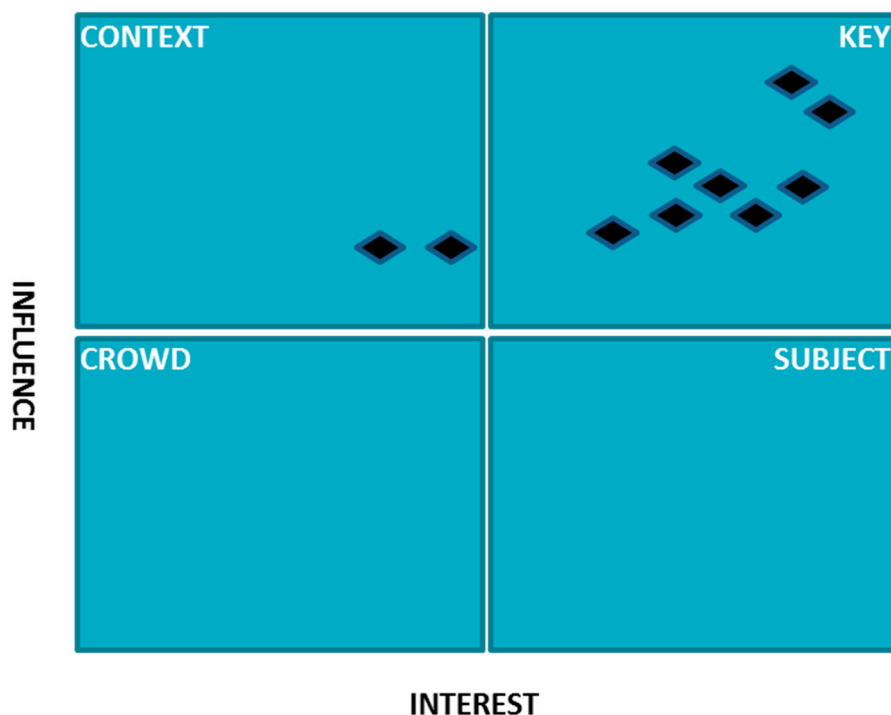

Figure 2. Research design.

Figure 3. Stakeholder analysis.

Table 2. Participants and their roles.

Participant	Participant Type
Participant 1	Strategic Development
Participant 2	ICT Innovation
Participant 3	ICT Solutions
Participant 4	Information Strategy
Participant 5	Environmental Sustainability Strategy
Participant 6	ICT Strategy
Participant 7	ICT Strategy
Participant 8	ICT Strategy
Participant 9	Pilot (Sustainability and Technology Expert)
Participant 10	Pilot (ICT Expert/Advisor to Local Governments)

As shown in the research design, the interviews and the analysis were developed after an initial version was piloted with two participants. The pilots were conducted with people who had a very strong professional interest in the area and worked with the council but were not as directly involved as the main participants. The pilot allowed the instrument to be refined. The interviews were also recorded and later transcribed. Transcriptions were intelligent verbatim, i.e., they included interviewer and participant, but background noises were left out and no repetitions, descriptors or tripping over words were included.

3.2. Analysing the Interview Data

Interview responses were thematically analysed, and themes were identified, over a number of coding, categorisation, and iterations of reviewing texts, codes, categories, sub-themes, and themes. The themes were used to draw inferences and conclusions. The analysis process involved moving from the descriptive to the analytical resulting in

categories with the researcher looking for new ideas, theories and explanations in the interview data. After analysis, the findings were also discussed with the research team. Analysis of the data in light of the research question, 'How does the use of ICT in relation to smart cities support the goals of sustainability rather than being self-serving?' revealed some interesting findings that covered a number of themes. Rather than reporting the findings as a list of the themes, the research team spent some time reviewing the findings and searching for a framing mechanism that would provide insights and enlighten the reader. An interpretive framework based on the concept of "knowing" was chosen as an ordering mechanism for the findings because it provides a simplified (but not simplistic) way of framing that attempts to remain true to the interview data but enables the outcomes of this research to move the discussion forward.

Furthermore, documents that were in the public domain were also reviewed for triangulation of the interview data. These were reports related to the city council but also some key documents produced by other UK city councils in their bid for government funds under the initiative of "Future Cities" by the Technology Strategy Board (now called, Innovate UK) which is a business-led executive non-departmental public body, established by the government.

4. Results

As Figure 4 shows, ICT supporting sustainability rather than being self-serving is based on the key concept of knowing in relation to three elements: the civic (local government), the ICT firms and the citizen. In terms of the civic element, knowing is linked to six key themes: knowing what smart and sustainable means; knowing who is leading; knowing how things fit together; knowing what needs to change; knowing who needs to be involved; and knowing through data and information. The ICT firm element is linked to two main concepts: knowing the impact of the contracts on ICT and sustainability alignment and knowing the requirements. The citizen element is linked to two main concepts: knowing for self-sufficiency and knowing for participation. Accordingly, the themes of this research's findings have also been categorised.
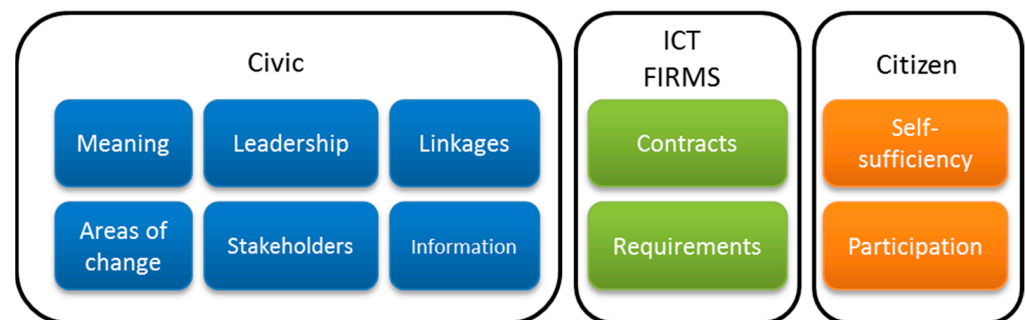

Figure 4. Themes.

4.1. The Civic Elements of Knowing

The following data themes were identified during the interviews.

(1)   Knowing what is meant by smart and sustainable

To effectively use ICT for sustainability goals within a smart city context requires knowing what is meant by smart and sustainable. These meanings are not always known because the time is never actually taken to work through the detail of early ideas that were not initially well formed (Participant 3).

For some, this broadness of coverage is problematic since 'sustainability is too wide a word, it is too amorphous and what does it really mean' (Participant 3). Clarity of meaning is a feature of understanding and acceptance of the ideas by others. So, while the broad ideas were sufficient in their original context, they require another level of detail to eventually be developed. The lack of detail in terms of meaning leads to difficulties with

using the term since it is vague and is potentially a marketing term rather than something specific (Participant 4).

A smart city is an intelligent city that uses technology to capture and provide access to data in support of timely decision making (Participant 7). However, this is only happening in a limited way, as the body of data that could be useful for decision making is currently 'constrained and held within databases, it's not shared with a person that might sit in the next booth across that's working in a different area' (Participant 8).

Smart cities enable transformational change in service provision. They carry this out by an underlying IT infrastructure, networks and sensors supporting integration and collaboration for effective outcomes in the delivery of services and the achievement of sustainability goals (Participant 7).

A smart city concerns itself with knowing what it should be changing. Key areas of potential change are transport, housing, health, education, energy, and economic growth. Change is also about a more integrated approach that cuts across various areas. While a smart city as an approach that implies a whole-city approach... the city as a system of systems; most of the smart city work so far is relatively siloed (Participant 1).

It is clear that ICT can support energy security and aid another civic goal—reducing the amount of energy imported into the city. This requires ICT-supporting improvements in energy, energy distribution and transportation flows by 'understanding the city's energy systems better and... working with the existing energy grid providers... and also what kind of tools do we need... to make it a bit more transparent about energy flows within the city...' (Participant 5).

A smart city is focused on knowing 'how' to generate and manage the distribution of its own energy in order to reduce its energy costs. A reduction in energy costs would be returned to the local economy. Future potential sources of energy on a large scale are biomass, solar, and waste. These alternative energy sources require ICT support for the intelligent grid, heating and buildings system. If the city can understand how to use ICT to achieve these "big ticket" (Participant 5) ideas, then other smaller-scale activity can be achieved along the way.

(2)   Knowing who is leading

Strong leadership, appropriate organisational structures and clear linkages are important for ICT to support sustainability goals. Smart city initiatives need to be strategically driven by central or local government (Participant 5). However, ICT infrastructure needs to run the risk of being overlooked by the ICT suppliers' focus on investment and returns. They and other commercial organisations will benefit from this investment but none of them individually wants to put the (huge) investment in. They are all looking to the council to make these investments, but it is difficult for this council to justify doing this when 'the benefits will then be reaped by every commercial organisation' (Participant 7).

The city needs to know that it is a 'green and smart city', and the civic authorities need to communicate this in a bolder more visionary way since currently it is just seen as something that is nice to have. In addition, green and smart are running parallel to each other with limited links when what is needed is a clear roadmap for each that also shows an understanding of the links between them. This would make it easier for the city to understand what it needs to procure rather than being bombarded with many different and varying solutions that it cannot make sense of (Participant 5).

Sustainability needs to be much clearer and a more obvious priority on ICT projects would help reduce fragmentation and raise awareness within the organisation. Sustainability is low-key and does not have the profile that it should, and this is seen as limiting innovation by partner organisations. ICT partner firms can benefit from an understanding of the priorities and incorporate them into projects appropriately. This lack of prioritisation is exacerbated, as there are no specific processes or stage gates for considering sustainability on ICT projects (Participant 3).

(3)   Knowing how things fit together

It is seen as important that the city council knows how things fit together to assist with a way of visualising the bigger picture to help manage the complexity via tools that could 'at least in very general terms, map out the general relationships between different things' (Participant 4). This lack of tools to see the bigger picture and inter-connections limits support for new initiatives and pilots as the knowledge required exists but is held by very experienced city officers and therefore is not easily available to others.

Knowing how to access funding to run pilots and enable experimentation is not straightforward. What works locally is becoming increasingly important. For example, as commented by participant 7:

'European funds are difficult to access, and the enforced cross European aspect makes that local emphasis difficult when actually you want to make it work in your city, your neighbourhood and your district'.

Moreover, as commented by participant 5, there is a need to understand successes and collect evidence for those successes and develop an understanding of how those small successes will scale up:

'. . .we are talking about 60,000 homes to be retrofitted over 8 years. But when the city has got over 450,000 homes there is still an awful lot to be done. . . So the challenge with the carbon road map is both to celebrate that we've started a substantial journey but also at what point do we build up and accelerate the programme?'

(4)   Knowing what needs to change

It is important to know that change is driven by significant external factors. The global financial crisis and the budgetary cuts faced by the city council are having a big impact on decision-making and investment priorities. The cost savings that need to be made are significant and drastic, with hundreds of millions over the next three years. The scale of the cuts is dominating everything. This challenge is seen as an opportunity for new models of local government and other innovations. The cuts are leading to the restructuring of the organisation and outsourcing of services and the consideration of new business models. This in itself is seen as a driver for sustainability as "we are trying to reinvent ourselves. . . the existing models that we have in place in terms of providing services are no longer sustainable" (Participant 1).

Smart city development projects require changes to development processes that create capabilities early so that 'un-sustainability' does not become built-in. There is a need to move away from a 'silos' approach and consider the infrastructure, information and services that will be required in a given development in order to avoid the disruption and cost of the retrofit. Knowing how to combine ICT infrastructure planning with built environment planning reduces the future need for rework and retrofit. This more integrated approach requires a change to planning processes and legislation. It also requires the city council to engage effectively with developers in order for them to understand the future commercial opportunities that would arise for them through this more forward-looking approach (Participant 6).

Knowing the future role of mechanical and electrical engineers is seen as key to ICT supporting sustainability in smart cities. It was felt that they do not, currently, see ICT beyond its role as a tool for creating their drawings. Yet, those tools could be the basis of more detailed information for controlling and monitoring those buildings in use. In fact, building management systems are essentially ICT systems that could make more of an impact on sustainability if better interconnections were made (Participant 3).

In addition, ICT and sustainability alignment also requires a shift in mindsets, to ensure that there is not just automation of current processes and practices but a move towards understanding how ICT can be used to do things differently and future-proofing so that flexibility is built in. It is not answers or technical solutions that are always required

but enablers and foundations for future answers and solutions such as standards, skills, and education. The city council has an important role to play in creating the environment to facilitate that (Participant 6).

(5)   Knowing who needs to be involved

Collaboration is very important for effectively leveraging ICT for sustainability goals. Knowing who needs to be involved from within and beyond the organisation is key and aids in awareness and integration while avoiding duplication. Internally, cross-department linkages matter, given that energy, sustainability and ICT are in different departments; so, there is a challenge in maintaining those connections on initiatives (Participant 8).

There is a complex array of partnerships and bodies across the region; however, they represent an opportunity for collaboration for better outcomes for everyone involved:

> '. . .you have, for instance, the Science Park, . . . you'll have the city council and the local enterprise partnership. . . and you'll have another board which is Creative City Partnerships. Each of those are looking to do different things around skills and enterprise, but there are a lot of potential crossovers. How do you actually get the benefit of that synergy? ' (Participant 8)

The challenge to collaboration is understanding who the interested parties and stakeholders might be and how and when to involve them. How different groups are engaged also needs to be reconsidered. For example, commercial suppliers may be interested to work with the city on riskier, more innovative activities, if they can see how this type of collaboration will result in the creation of new markets via combined cutting-edge technical expertise to create effective commercial business cases (Participant 7).

There are existing relationships, for example, with the regional universities, which are drawn upon as required but there is recognition that more could be performed to utilise these relationships. The city council is officially acknowledged as a 'Living Lab'. Living labs require partnership and collaboration between universities and product/service companies and citizen-engaged public sector organisations. They enable an iterative approach to developing ideas, which eventually are fed back to IT developers in the community who are typically SMEs (Participant 7).

Communication surfaced as an important aspect of collaboration and partnership. This was just as relevant to internal collaboration as it was externally. The use of interest or group-specific terminology (jargon) and acronyms is particularly problematic. There is a need for a much clearer expression of the requirements in a language that is more broadly accessible (Participant 7).

(6)   Knowing through data and information

Data from disparate sources may have the potential to be combined in powerful ways. Knowing what data can be connected and how it can be connected and made available is key. This could be the basis of improvements in different areas of the city's business as well as being foundational for other innovations in relation to sustainability. It was suggested that the use of ICT, such as GPS, 3G and Wi-Fi for automatic data capture for real-time information to improve travel, energy use, etc., is important to sustainability outcomes (Participant 3).

Furthermore, aggregating the data to be presented in meaningful ways is complicated and challenging. Technology is increasingly sophisticated, but the challenge is to use ICT to provide access to the right data for the required purpose as 'the difficulties we have traditionally inside the organisation are of unlocking data to begin to do some of these things' (Participant 4).

Data and information are really important in analysis for the provision of new services and the council can play a significant role in how data and information are made accessible even from third parties and not just their own. They are seen to have the necessary clout and empowerment:

'So this discussion is going on saying we need to have a view on what happens when all these people are providing council services, but are not part of the council, because they're using data and information. And that data and information, one, it may be our legal responsibility anyway so that is an issue, and secondly, even where it isn't, that's a value to us because there's several uses for that, one is the analytical and the understanding about that when you're trying to push services together'. (Participant 4)

There is a civic role of working with suppliers who provide services and ensuring that the changed information is brought back into the city council. Council data are given to private companies as a consequence of contracted services, so they obtain data about, for example, the physical environment. During their activities, they make changes to the data, but the council has no way of accessing these changed data. There is recognition that this needs to be addressed and that the council must receive the data back as they need to know of the changes that have taken place—particularly when the changes are a consequence of the change to the physical environment.

(7) Summary

ICT for sustainability rather than becoming self-serving requires a civic perspective that sets a context for smart city activities and develops thinking as a precursor to ICT. That context is about clear and shared meanings of what smart and sustainable means, strong leadership being evident, and mechanisms for holistic understanding being in place. In addition, it is necessary to have clear means by which pilots and experimental work can be learnt rather than moving from initiative to initiative without making the connections. Most importantly, there needs to be clarity about how data and information will be leveraged in the smart city.

4.2. The ICT Firm-Related Themes

(1) Knowing the impact of contracts

Contracts for outsourced services such as ICT drive a lot of what happens as well as determining attitudes and beliefs. There is a tendency to focus on only doing what is required by the agreed contracts. The emphasis tends to be on cost reduction and references to sustainability are usually references to financial sustainability. Environmental and social sustainability are seen to be the remit of the city itself rather than the contracted suppliers and there is vagueness about what it might mean to them:

'. . .we are funded to support their IT systems and we respond to change that is required within the city. We also have a responsibility to help drive innovation in the city, so identifying where there are opportunities; and those opportunities may be cost saving, improvement to service, sustainability'. (Participant 2)

Contracted suppliers are focused on only delivering what is required by the core part of their contract with the city. They essentially do what they are paid to do. The contracts are particularly problematic in the later years when it is harder for the ICT firms to recover their investment costs—so there is little incentive to develop and innovate solutions from which the city could benefit.

However, contracted ICT suppliers to the city council are willing to explore innovation opportunities if there are other external prompts. They are also able to bring to the city opportunities that may have a sustainability angle to them because of being approached by third parties. For the ICT suppliers, this is a potential business development opportunity, and they are happy to be the intermediary that evaluates the implications for themselves and the council.

In addition, the ICT suppliers have quite overt mechanisms to enable business development that may be (but not necessarily) sustainability-related. They look within their own organisations to develop new business with the council by looking to see 'what are we doing elsewhere with other local authorities and the accounts that we're winning, and

how can we transfer some of that learning'. In addition, the ICT firms can help bring in others—giving the city council access to the ICT firms' relationships and partners. The ICT firms' own cost focus can leave little room for speculation; however, the ICT firms look beyond their own organisations to bring opportunities to the council where they may be involved but in a smaller way as "more of a systems integrator and a partner that will try and draw the resources in to help the city achieve what they want to achieve" (Participant 2).

The ICT firms as would be expected are very business-focused, needing to ensure cost recovery and return on investment, and tend not to have a research and development (R&D) budget. ICT firms' strategic drivers can drive R&D and innovation, but this only happens if it is something the firm is already doing elsewhere, or if there are specific outcomes that the firms want to achieve. Where this is not the case, the ICT firms are looking to the council to make the required investment. The business case is key for investment to happen and if the city 'doesn't want to progress it then essentially it falls apart' (Participant 2).

However, once the city has paid for it, the firm will use its resources to develop the opportunity, try to learn from best practice elsewhere and will leverage its other partnerships. Working together, the city and ICT firms encourage innovation, and organize competitions and events around specific sustainability challenges but there was some evidence of fatigue with more general smart city events.

The timing in relation to bringing in the ICT firms has the potential to impact sustainability outcomes. There is little scope for the ICT firm to contribute to a broader agenda vis-a-vis sustainability as they are typically brought into the project when the IT implementation is required—this leaves little room for innovation or for sustainability issues to be considered sufficiently early.

It is important that the ICT firms and the city council have a clear understanding of each other's goals and their common goals. Otherwise, there is a risk that the search for ICT opportunities for sustainability by ICT firms are bottom-up and self-serving, i.e., a 'solution looking for a problem'. This risk of the council and its ICT suppliers not sharing their strategic vision can impact projects or service delivery and the sharing of information on projects. One area in which ICT and sustainability goals have clearer alignment is at the hardware level. For example, in terms of power usage and efficiency, the ICT firms have reviewed the back-end data centre ICT systems and management of desktops and networks. This is seen as the more traditional side of sustainability from an ICT viewpoint.

While collaboration is recognised as being important for ICT firms, innovation is restricted by a focus on delivering contractual aspects. Unfortunately, collaboration requires investment and even if it is people's time rather than direct funds, that is still seen as problematic. ICT firms value an easy-to-be-involved-in, low-cost collaboration model. The city can drive the ICT firms to innovate only by investing. There was a view that much more is possible but that there is no indication of this as a priority and no drivers from the client for including sustainability as a consideration when producing ICT solutions.

(2)   Knowing the sustainability requirements

The ICT firms' need for clear requirements for any sustainability aspect in relation to ICT projects emerged as an important theme. Capturing sustainability requirements in new systems, projects or programmes does not appear to be a problem if there is a clear driver from the city for it. It was noted that only clearly articulated sustainability requirements will feature in ICT solutions, with the city making the sustainability requirement clear and identifying its need. The city can "engage" the ICT firms' requirements team if required—but engagement means payment. In addition, the specification of ICT requirements is very focused on addressing a specific problem. This means that sustainability will not be relevant in ICT projects unless the council directly asks for it via their requirements (Participant 2).

There is an assumption by the ICT firms that requirements can be clearly articulated and mapped to a solution. Broad initiatives were seen as problematic due to business cases that were too difficult to describe and the lack of steps necessary to execute them.

It was seen as the city council's responsibility to capture all requirements in the contract or pay for them if needed and not in the contract. When sustainability is not being translated by the city council into requirements, financial or non-financial, then the supplier has no reason to consider sustainability issues in the provided ICT solution. Where alignment happens, it is largely enabled through actual drivers; otherwise, it is not likely to happen. Sustainability is not considered that important unless it is a direct driver that is built into the requirements (Participant 3).

(3)   Summary

ICT supporting sustainability rather than becoming self-serving requires an understanding of ICT firms' perspective. Much of the current use of ICT for supporting sustainability goals is achieved through changes and developments in the city's IT systems. Sustainability-related changes will only occur because they are in the requirements that the city has developed in relation to the change. The contracted ICT firms are responsible for implementing the changes, but any sustainability-related innovation has to be largely driven by the city itself. It is essential that future ICT contracts build in longer-term needs and sustainability by understanding how these should be built into future requirement specifications.

4.3. The Citizen

(1)   Knowing for self-sufficiency

Knowing that the citizen perspective is often missed from initiatives and that this has an impact on social sustainability, the city council must address this. With the contraction of the public sector due to budget cuts, the local government may have a new and different role. As a consequence, there is a need to know how to support the local communities in being more sustainable and self–sufficient by helping them generate their own solutions.

It is recognised that a challenge to ICT and sustainability alignment is the digital divide. This is important from a social sustainability perspective and can have a significant impact on communities since 'overcoming the digital divide and giving access in the community to information technology is very empowering' (Participant 1). Moreover, inclusion brings with it environmental, social and economic benefits; hence, ICT needs to be embedded in people's lives and people need to be able to use technology (Participant 8). However, a challenge to self-sufficiency is the skill level since skills are important in enabling people to access council services. Self-service by communities requires access to information. Providing access to information requires understanding how the information will be used. The change to a self-service model represents an opportunity for communities to start to shape services, deliver services, and manage services themselves. In relation to this challenge, Participant 8 said the following:

> 'You've got the city Energy Savers that are going out and doing their retrofits and going into social housing, especially when they're touching where there's fuel poverty, how do you link that into social care services? How are you collecting/aggregating that information that sits out there from people that go into people's homes?'

Access to data is difficult as data are locked away in various organisational silos. ICT is an enabler, offering the potential opportunity of unlocking the data silos. Combining disparate sources of data to produce information will allow for the sharing and more effective targeting of resources to improve the delivery of services for citizens (Participant 4).

The council needs to know how to make connections, using one link or opportunity to connect users to other services that will support their lives in terms of their job, their business, or their personal life. The council has to know what is relevant to that person at that time and provide personalized support that will 'engage them in other areas of city life, which could be around the refuse collection, education, all sorts of things' (Participant 8).

Civic dashboards have been an attempt to aid visualisation, for example, to 'show the pattern of service geographically; this is put onto a map' (Participant 4). It is only

through providing information that is relevant (by understanding their needs) that this can be achieved:

> 'But I think it's trying to focus the conversation on something that's relevant to them... Because it's their understanding, and I think a lot of is around education, you have to understand where they're coming from and then start to understand what the issues are for them, then you can start to then talk to them about how data, information or technology could make a difference'. (Participant 8)

The joining together of private sector and public sector services via data access is important. This implies that the data are available and that there is a driver to create the linkages across, for example, local authority data, NHS data, economic data, and transport data (Participant 4).

(2)   Knowing for participation

It is accepted that early community engagement is important but challenging and that education plays an important part in community engagement. Knowing that this needs to be performed at the outset of initiatives by 'educating people, understanding people, taking people on a journey with us, getting people engaged, and it's the point at which you get them engaged, I think it's doing that really from the outset' (Participant 8). There is a need to 'encourage communities to work more closely together to solve their own problems' (Participant 1). Strong, organic, bottom-up, community-driven growth with involvement from communities and grass-roots levels is needed.

The 'smarter citizen' concept is as important as the smart city concept. Involving citizen groups or their proxies is important to this. The proxies are often involved via the council's links to voluntary organisations, and they can represent the needs and priorities of the citizens. The council needs to understand why they might become involved and how to involve them:

> 'I'd say you need a proxy set of translators. In a social sustainable project rather than an environmental sustainable project we work with proxies. So, we will find somebody in say the city Carer Centre—people have nothing to do with IT, . . .—we use those people to engage with the actual carer to ask them to work with them'. (Participant 7)

Involvement needs to happen, but it should be through partnership and the 'continual involvement of community people through the whole process, through the journey as you evolve.' This collaboration is essential for innovation and the council should know 'how you create those innovation groups, that they will bring together different groups of people that wouldn't normally have sat round a table to look at how they then solve problems' (Participant 8).

(3)   Summary

ICT supporting sustainability rather than becoming self-serving requires a citizen perspective that recognises the changing relationship between the city and its citizens. There is a need to focus on how citizens can be supported through ICT to become self-sufficient and to be able to participate in the processes, which shape those services and the city going forward. This again is not about the technology per se but more about how a smart city ensures that its investments in ICT are the right ones for its citizens and how it ensures that they are able to participate in that self-sufficient future.

5. Discussion and Conclusions

The study found that ICT supporting sustainability rather than being self-serving is based on the key concept of knowing in relation to three elements: the civic (local government), the ICT firms and the citizen. In the context of smart cities, ICT has a key role in supporting sustainability but the effort needs to be put into 'knowing' that then enables 'doing', ensuring that what is undertaken is effective, in that it is what is

required, and that view is shared and agreed upon. Figure 5 illustrates that different elements in smart cities will have different interests and priorities in relation to ICT and sustainability. ICT firms' interest obviously prioritizes ICT. Civic interest is clearly high in terms of sustainability but also in terms of leveraging ICT infrastructure. Citizens and citizen groups will have very diverse and wide-ranging priorities; hence, they are shown as being potentially positioned in any of the four quadrants. The purpose of knowing is not to move a particular element's priority or interest from one part of the matrix to another. Instead, it is to recognise these differences and identify how to connect those different interests and priorities. This is to help ensure that ICT supports sustainability and reduces the likelihood of it being self-serving.
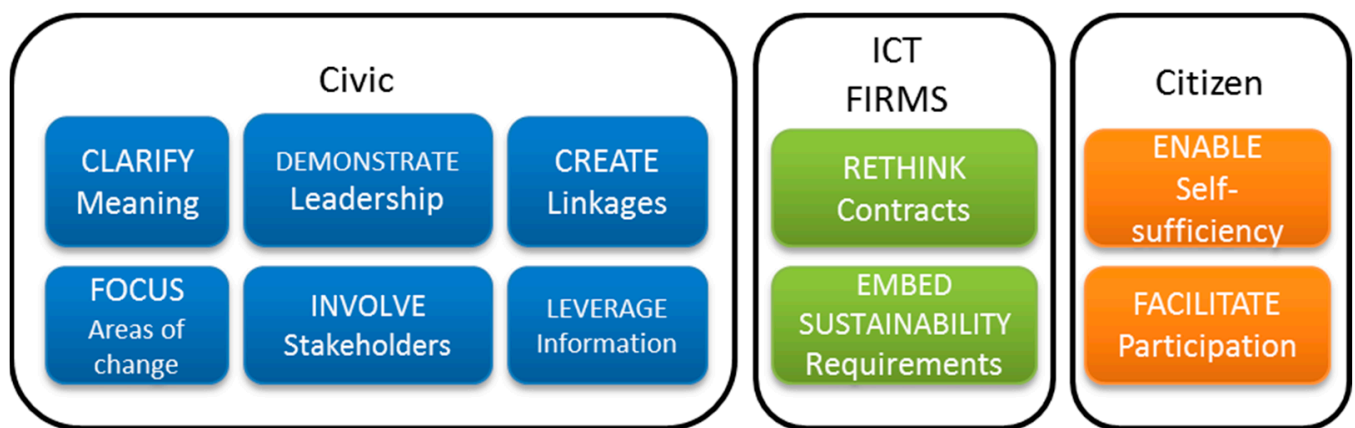

Figure 5. Themes revisited.

5.1. Clarify Meaning

In order for ICT to support sustainability goals in the context of a smart city, cities need to be absolutely clear about what smart means and how sustainability relates to that. The findings of this research showed how lack of clarity of meaning and ideas that are too broad limits understanding and acceptance. The provision of data and information via integrated platforms is a key concept for a smart city [26]. According to the findings of this research, this has implications for the role of ICT in the automatic capture of data via sensors and data availability, integration and the accessibility of data. This is consistent with a number of the definitions explored in Section 2. Integrated systems linking the physical to the information, e.g., energy flows, were also suggested. As we identified in Section 4, there is tension in terms of who pays for the significant underlying infrastructure that is required to make much of this possible. This is comparable to the nature of investments in 'resilience' in cities where the savings are not clear-cut, longer term and the benefits are not directly returned to individual economic agents. Moreover, sustainability is often 'hijacked' as a term to focus on low carbon; however, an "emphasis on entrepreneurialism and market forces to reduce carbon emissions can exclude other environmental factors which need to be addressed to make cities sustainable" [38]. Figure 6 illustrates that different elements in smart cities will have differing interests and priorities in relation to ICT and sustainability. ICT firms' interest obviously prioritizes ICT. Civic interest is clearly high in terms of sustainability but also in terms of leveraging ICT infrastructure. Citizens and citizen groups will have very diverse and wide-ranging priorities and hence they are shown as being potentially positioned in any of the four quadrants (represented by the black arrow). The purpose of knowing is not to move a particular element's priority or interest from one part of the matrix to another. Instead, it is to recognise these differences and identify how to connect those different interests and priorities. This is to help ensure that ICT supports sustainability and reduces the likelihood of it (the ICT) being self-serving.
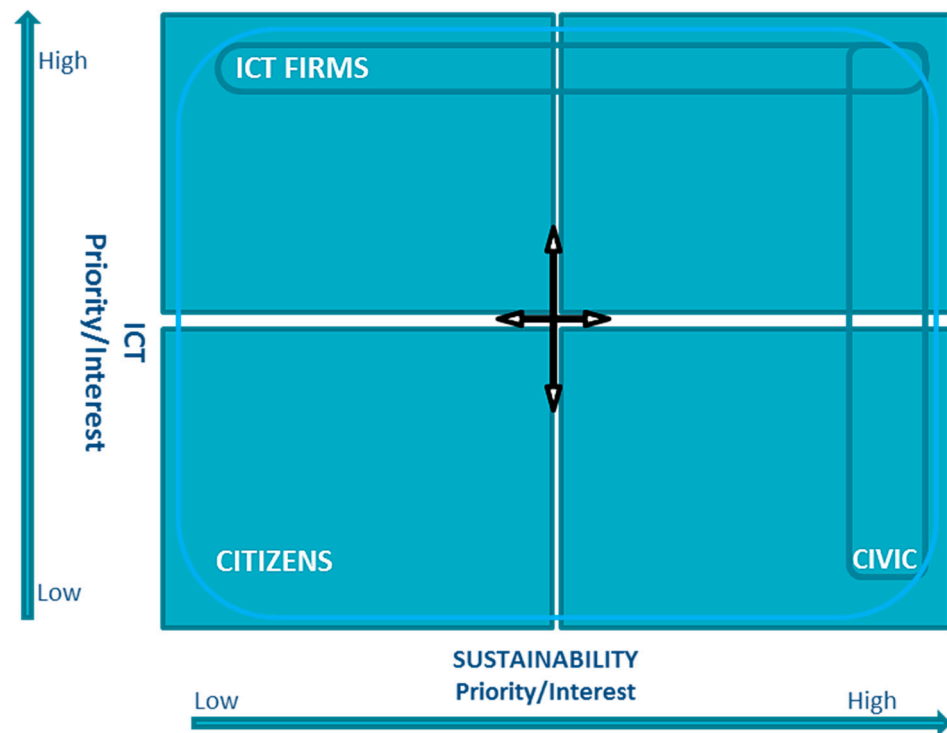
Figure 6. ICT and sustainability priorities and interests for different elements.

5.2. Demonstrate Strong Leadership

Strong leadership, effective organisational structures, and linkages must be in place for achieving ICT and sustainability alignment within a smart-city context. Based on the findings of this study, the impact of the recession and local government budget cuts are a driver for cost-cutting, leading to change. We also found that change needs to be more than the automation of existing processes and a move to new mindsets and new ways of doing things. This is consistent with the view expressed in [39,40] that top-management support and commitment to organizational change are crucial for successful innovation. The comments on Glasgow City Council's winning bid for government funding as a future city demonstrator identified strong visionary leadership as a key factor in the city's selection.

Smart cities must make bold, visionary statements about their green and sustainability ambitions. As we saw in Section 4, clear communication of those messages is important. This is consistent with [41], which suggests that corporate vision and organisational structures are drivers for a set of mechanisms that will legitimate the integration of sustainability, including a mechanism for communication and monitoring. The role of senior leaders in establishing 'unambiguous reasoning for change' and developing clear goals is also significant [39]. For example, under the visionary leadership of its mayor, the city of Rio has embarked on an ambitious program to use ICT for better management of disasters and emergencies (following the recent experience of landslides and flooding) and to improve transport management [42].

The issue of sustainability is too low-key and therefore limited innovation was raised in the previous section. The current recession risks a focus on the economy, but cities must attempt 'to balance economic growth with sustainability' [30,43]. Similarly, the importance of a city knowing its sustainability priorities and making those priorities clear was apparent.

5.3. Create Linkages

As per the findings of this research, there is a significant need to understand what works by being able to see the bigger picture and collecting an ongoing evidence base.

Connecting sectoral, political and scientific actors in a strategic process of developing attractive images of the future shapes a common view for all participants to jointly build

the future in the present: collaborating within a shared mental image of a joint vision of Smart Cities [44,45]. Ref. [45] suggests a foresight framework that ensures 'newly gained perspectives and action plans are not "standing alone", but are a part of a "bigger picture" allowing for mutually reinforcing and concerted actions from very different applied fields and points of view'.

5.4. Focus on Key Areas of Change

To enable transformation, the way that the city council conducts its business and works with ICT firms needs to change. We saw from the findings that this change needs to be to key processes such as procurement, allowing for review, investment in new technologies, etc. There needs to be a change to local government planning processes and legislation that encourage infrastructure to be inbuilt rather than rely on future retrofit and change.

5.5. Involve Stakeholders

Collaboration and citizen participation have been identified as important but also complex tasks. Identifying who the stakeholders are and why they would want to be involved is significant. Moreover, internal collaborations are as necessary as external collaborations. Early community engagement and also realistic time frames enable effective collaboration leading to organic, bottom-up growth and valuable citizen influence on services.

There is a notion of the city as a laboratory for modelling and understanding ICT innovation for cities [46]. Ref. [47]'s views are that 'the prospect of building models of cities functioning in real-time from routinely sensed data is now a clear prospect and smart cities should evolve intelligence functions in the form of laboratories—that enable their monitoring and design'.

5.6. Leverage Information

According to the findings presented in the previous section, information is crucial to providing services, and monitoring and controlling processes and activities. In a smarter city, intelligence in individual sub-systems must be sufficient; it requires a more organic, holistic view of the city as a network of linked systems (system of systems) [13,48,49]. This view is often constrained by the absence of data or fragmentation of data including operational data to ensure real-time delivery of a service, user data to make available to those accessing the service, or performance data to understand that delivery is providing added value. As we saw in Section 3, this requires a technology infrastructure that integrates data across a number of agencies within and beyond the local government.

5.7. Rethink Contracts

ICT firms, when contracted as suppliers of services, are focused on their costs since this impacts their profits. As would be expected, they need a clear business case for any activities that they will engage in. Furthermore, they require very clear specifications of the requirements for the IT solution they are to provide. Cities need to think about how these arrangements work for them in the long term and how sustainability requirements are built into future contracts. The ICT firms can also leverage partnerships with other departments in their own organisations and with other major suppliers (competitors and non-competitors)—and local government can benefit from these relationships. ICT firms are keen to collaborate with the civic authorities, but they recognise that collaboration is a cost and want easy low-cost mechanisms for their involvement. There is a risk that ICT firms' strategic drivers and business development approach can lead to self-serving ICT. However, their approach to costs is leading to the alignment of ICT to sustainability goals at a hardware level. The opportunity for more systemic (third-order) effects may be missed.

The ICT firms' employees can contribute to the ICT/sustainability alignment of the city in their own right and this needs to be facilitated more easily. They have ICT skills that may be useful in working with citizens, and community groups in a voluntary capacity.

5.8. Embed Sustainability in ICT Requirements

As found in this study, any sustainability requirements related to ICT projects must be made explicit; otherwise, they are likely to be overlooked. In a smart city context, sustainability needs to be institutionalised in ICT projects. Given that the ICT firms require clear requirements for the solutions they are tasked to produce, it is important that a city's broader sustainability requirements are incorporated into the specific system requirements.

It needs to become embedded in the culture and processes of developing IT systems in the same way that usability is now a given. In the UK Ministry of Defence ICT strategy, there is a commitment that 'ICT procurement will take sustainability into consideration'. Sustainability is included as one of its ten ICT main guiding principles 'Defence shall ensure that Sustainability is recognised and embedded across all Defence ICT programmes in order to deliver or exceed government targets'.

5.9. Enable Self-Sufficiency

The budgetary cuts and recession have given the city a new perspective on its role with respect to citizens, recognising the need to support them and their communities to become self-sufficient. The research findings offered the idea of the self-sufficient citizen, supported through integrated service provision enabled through technology-based platforms produced by businesses innovating in partnership with the city council and its citizens. The importance of end users in communities and their participation as stakeholders in city initiatives were raised in Chapter 3.

The findings of this study suggested that self-sufficiency requires access to digital technologies, but the digital divide is a potential problem. While the term can be ambiguous and difficult to define, it does reflect genuine concerns that the rapid development of ICT (e.g., the Internet) risks further widening the gap between rich and poor. This was more recognised during the COVID-19 pandemic [50].

5.10. Enable Participation

It is a collaboration-based business model that enables participation in policymaking projects and decision-making. In addition, a number of changes have emerged in terms of smart cities and their innovation ecosystems (e.g., Living Labs), including increasing participation, empowerment of citizens in societal issues, using social media and open data on a wider scale, and the shift from government agency control to citizen empowerment in the use of information and design technologies for solving local problems. Hence, technology alone is insufficient, and supportive policies and governance platforms need to be in place to promote the development of applications that use open data [27,51,52].

5.11. Research Limitations and Recommendations for Further Research

Despite the contributions and insights gained from this research, it is important to acknowledge its limitations. The study's sample size, consisting of 10 participants, might be perceived as relatively small. However, it is important to note that qualitative research often aims for data saturation, where additional interviews no longer yield new insights or themes. By reaching this saturation point, it was ensured that the findings are based on a comprehensive exploration of the research topic. Nevertheless, future studies could consider expanding the sample size to include a broader range of participants, potentially capturing a wider spectrum of perspectives and experiences.

In addition to the findings presented in this study, there are several opportunities for further research that can contribute to the advancement of knowledge in the field of ICT and smart sustainable cities. First, future work could focus on establishing a stronger link between the identified themes and the conceptual model. This would involve conducting more in-depth analyses and exploring the underlying mechanisms and relationships between these themes, thereby providing a deeper understanding of the dynamics at play.

Furthermore, investigating how the changes suggested by the identified themes can be practically implemented and the specific actions required to achieve them would be a valu-

able next step. This could involve engaging with stakeholders, such as local governments, ICT firms, and citizens to develop strategies and roadmaps for effectively integrating ICT solutions into the context of smart sustainable cities. Such research would help bridge the gap between theory and practice and provide actionable insights for policymakers and city planners.

Additionally, there is potential for both qualitative and quantitative research to further explore the sub-themes identified in this study. Qualitative research could delve into the experiences, perspectives, and motivations of different stakeholders, providing rich insights into their roles, interactions, and expectations in the context of ICT and sustainability. On the other hand, quantitative research could employ surveys and statistical analyses to quantify the impact and effectiveness of specific ICT interventions and initiatives on sustainability outcomes. By combining these approaches, a more comprehensive understanding of the complex dynamics between ICT, stakeholders, and sustainability in smart cities can be achieved.

5.12. Policy Implications of This Research

The findings of this study have important implications for policymakers involved in the development and implementation of smart city initiatives. Firstly, it is crucial for policymakers to recognise the need for a balanced approach that goes beyond purely technological advancements. They should focus on integrating sustainability goals and citizen-centric perspectives into smart city strategies to ensure long-term benefits for communities. Secondly, policymakers should prioritise collaboration and engagement among various stakeholders, including local governments, ICT firms, and citizens. This can be achieved through the establishment of inclusive governance structures and participatory decision-making processes. By involving diverse perspectives and incorporating feedback from citizens, policymakers can enhance the effectiveness and acceptance of smart city interventions. Additionally, policymakers need to be aware of the potential risks and challenges associated with the dominance of technology-driven approaches in smart-city initiatives. They should consider measures to address issues such as data privacy, digital divide, and equity concerns to ensure that the benefits of smart cities are accessible to all segments of society. Furthermore, the findings highlight the importance of evidence-based policy formulation and implementation. Policymakers should consider the empirical insights generated from studies like this one to inform their decision-making processes. This research underscores the need for policies that not only support technological advancements but also align with sustainability objectives and prioritize the well-being of citizens.

Conflicts of Interest: The author declares no conflict of interest.

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