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Article

A framework for digital transformation towards smart governance: Using big data tools to target SDGs in Ceará, Brazil

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Research Article

A framework for Digital Transformation towards Smart Governance: using big data tools to target SDGs in Ceará, Brazil



Lara Sucupira Furtado ^{a,*}, Ticiania Linhares Coelho da Silva ^b,
 Marianna Gonçalves Fontenele Ferreira ^c, José Antônio Fernandes de Macedo ^d,
 Jessika Kantnila de Melo Lima Cavalcanti Moreira ^e

^a Graduate School of Transportation Engineering - Smart Cities Sector, Federal University of Ceará, Fortaleza, Brazil

^b Instituto Universidade Virtual, Federal University of Ceará, Fortaleza, Brazil

^c Insight Data Science Lab, Federal University of Ceará, Fortaleza, Brazil

^d Department of Computer Science, Federal University of Ceará, Fortaleza, Brazil

^e IRIS Laboratory for Innovation and Data, State of Ceará, Fortaleza, Brazil

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ABSTRACT

Smart Governance is a key pillar of the Smart City movement and an important pathway to achieving Sustainable Development Goals through digital transformation and technologic tools. However, the digital transformation is highly contextual and solutions from the Global North may not be adequate to the reality of developing countries. We present how digital tools and policies, as part of the broader agenda for digital transformation, can touch upon several sustainability goals when focused on benefitting vulnerable citizens. Examples come from observing the process, stakeholders and products developed during the Digital Transformation of Ceará between 2019 and 2022. We build a framework that further links those examples with the SDGs and the Brazilian Letter for Smart Cities, a national set of guidelines towards equitable smart transitions. By setting the framework vis-a-vis a grounded experience, we seek to present seven components which can be adapted to other contexts as drivers of a Smart and Sustainable Governance. We argue that, by applying those elements to build digital tools that help governance, it is possible to create solutions that are inherently tied to SDGs.

1. Introduction

The Smart City movement emerged in recent decades with the digitalization of urban planning and engineering fields enabled by new data management networks, such as the Internet of Things (IoT), big data and cloud computing technologies (Gil-Garcia et al., 2016). In that context, new types of data sources have provided unprecedented clarity about complex urban dynamics, which can transform governance models and inform more effective urban policy and management (Kirimtat et al., 2020; Batty, 2016; Goldsmith & Crawford, 2014).

Since Smart Cities touch upon accessibility to urban opportunities, they can also further the agenda for Sustainable Urban Development (SUD) (De Guimarães et al., 2020). The New Urban Agenda set in 2017 by the United Nations emphasizes that Information and Communication Technology (ICT) solutions and Smart Cities can help achieve Sustainable Development Goals (SDGs) especially when it

* Corresponding author.

E-mail address: larasfur@gmail.com (L. Sucupira Furtado).

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comes to ensuring sustainable management of natural resources; giving all citizens equal access to basic services such as water and sanitation and promoting better management and reduction of solid waste. The SDGs represent milestones to prioritize progress while balancing social, economic and environmental sustainability.

Smart Governance is an important part of development towards sustainability, being the focus of this paper. Smart Governance “makes use of available technology to be aware of -and coordinate with the activities carried out by other municipalities, achieve synergies through collaborations with other stakeholders and reach citizens' needs in order to improve both public services and confidence in the public institutions (EIBI, 2017, p. 5).”

An important practice of Smart Government is referred to as E-government, or digital government, which seeks the digital delivery of public services and to enhance interface with citizens via digital channels (Castells, 2009; WBG- World Bank Group, 2015). As such, E-government is instrumental to the so-called digital transformation, through which governments use ICTs to create new automated public services that bring benefits to society's everyday life (Martin, 2008; Pereira et al., 2018).

Although such advancements can bring out sustainable solutions (Mergel et al., 2018), the process to become smart is complex and faces several setbacks. First, several cities are not seeking sustainability in a way that generates value for the society as whole (Batty, 2016; Hollands, 2020). Also, Digital Transformation can be an abstract concept, which requires researchers to effectively communicate findings and present concrete strategies that apply technology to build effective policy that benefits citizens (Gomez-Trujillo & Gonzales-Peres, 2021). Finally, there are contextual challenges to creating Smart Governance, especially when comparing Global North and South communities (Manda & Backhouse, 2019).

To address some of those challenges, this research seeks to answer two research questions: "How can digital tools be aligned with Sustainable Development Goals within an agenda of digital transformation?" and "What can a Smart Governance framework for sustainable development look like in the context of the Global South?". The paper nests itself in the experience of Ceará, a Brazilian state making efforts towards the digital transformation of several government processes. We present how the government of Ceará has touched upon several sustainability goals through E-government initiatives, as part of the broader agenda for digital transformation. We also tie this example to the Brazilian Letter for Smart Cities, a framework that bridges digital transformation and SUD (MDR, 2021). The Letter is directly connected to SDG 16 (Peace, justice and strong institutions) and SDG 17 (Partnership for the Goals), both centered around governance, since it sets guidelines for how municipal governments can proceed towards smart sustainable development.

This study contributes to the planning literature on Smart Governance and digital government. Two major takeaways emerged from the case of Ceará: first, a Smart Governance transition begins with data literacy, where adequate dialogue and collaboration are vital convey the importance of data transparency and analytically driven policy. Second, a commitment to social justice should be the guiding principle behind decisions to collect, organize and analyze data to strategically benefit vulnerable communities. By keeping those core principles in mind, digital government plays a key role towards Smart City transformation, while also following SDG's basic principles of "leaving no one behind".

2. Theoretical background

In the face of the challenges posed by increasing urbanization, governments are turning to Smart Cities to use technological tools to improve living conditions for their citizens (Gil-Garcia et al., 2016). The basis of the Smart City is "the combination of human capital, social capital and information, with the use of ICT, in order to generate economic development, improve well-being and people's quality of life (de Guimaraes et al., 2020, p. 3)."

A broadly used framework designed by the European Investment Bank Institute, organizes Smart City initiatives into six dimensions: Governance, Economy, Mobility, Environment, People and Living (EIBI, 2017). Accordingly, “they represent the specific aspects of a city upon which Smart Initiatives impact to achieve the expected goals of a Smart City strategy (sustainability, efficiency and high quality of life) (EIBI, 2017, p. 4).”

Though there are several other theoretical frameworks to conceptualize Smart Cities, it can be considered an umbrella term for the different types of innovations in the urban environment related to architecture, environment, planning and management, data and knowledge, energy, health, people and governance (Anthopoulos et al., 2016). Simply put, the Smart City comes from the conversion of digital and physical realms to improve quality of life and better distribute urban resources and services. It relies heavily on Information and Communication Technologies (ICTs), mobile devices with GPS systems, social network data shared by users, among many others, to have a fuller picture of citizens' needs and challenges (Barrionuevo et al., 2012).

2.1. Defining key concepts: Smart Governance and digital transformation

Among the multiple Smart City domains, Smart Governance emerges as the basis to open government, using ICTs and innovation to frame a new governance model, which is more aware of social groups, more efficient, citizen-centric, automated and that integrates multiple government departments (Pereira et al., 2018).

A useful definition of Smart Governance comes from Melhem where each S.M.A.R.T. letter accounts for Social, Mobile, Analytics, Radical openness and Trust, respectively. The social aspect means that governments must provide approachable services and platforms so citizens can co-create and interact with the government. The mobile aspect represents the use of mobile technologies, data storage, networks to deliver public services. The analytics involves the direct connection of data analytics into effective decision making. Radical openness is tied to transparency, accountability and citizen engagement. Finally, trust emphasizes the importance of cybersecurity to maintain privacy (Melhem, 2012). In short, Smart governance is a governance system which uses robust data sources to operate in complex social environments to draw effective public policies that achieve social goals (Sarker et al., 2018).

Key concepts tied to Smart Governance are: integration, innovation, information sharing, evidence-based, citizen-centricity, sustainability, creativity, effectiveness, efficiency, equality, entrepreneurialism, citizen engagement, openness, resiliency, and technology savviness (Pereira et al., 2018; Gil-Garcia et al., 2016).

The digital transformation has become a key ally to Smart Governance. Through it, public officers use digital outlets to learn about constituents, to better communicate with them and to co-create services that are more legitimate and dynamic (Mergel et al., 2018). Such a new type of digital government uses information and communication technologies, particularly the Internet, as a tool to achieve better governance (Melhem, 2012). Business analytics and big data become the drivers of digital transformation and sustainable societies, helping deliver public services (Gomez-Trujillo & Gonzales-Peres, 2021).

In short, the introduction of ICT in government organizations can improve the efficiency of public sector activities, adding value by increasing administrative efficiency and interoperability and improving service delivery through a citizen-centric approach (Pereira et al., 2018). By bringing public services on-line, citizens are viewed as consumers who should have quick, affordable, clear and non-bureaucratic access to a range of services (Kannabiran et al., 2004).

Countries like Canada and the UK have made pledges to take their services online and become fully interconnected with citizens as a strategy to increase citizen participation. India is implementing policies to spread IT awareness and data literacy, so citizens can enjoy the benefits of a networked government (Kannabiran et al., 2004).

As such, digitalization can also bring benefits to multiple SDGs towards sustainability. Leaving no one behind is a mandatory condition to fully exploit the expected value from digital governance and achieve societies' desired level of transformation and prosperity (Colglazier, 2015). In greater detail:

“Digital transformation holds a potential to support SDGs, where the captured information is analyzed by computational techniques to unveil trends and patterns and turned to be actionable dynamic information on human behaviors, environment and experiences. Such data hold a potential for policymakers to establish the proper development programs, monitor progress, and dynamic improvement. That creates new opportunities for the SDGs fulfillment with lower transaction costs (ElMassah & Mohieldin, 2020, p. 4).”

Evidently, data plays a key role in furthering Smart Governance. Big data can aid with information management in the sense that governments can apply big data to integrate operations, develop policies, allocate resources and evaluate performance (Bertot et al., 2014; Desouza & Jacob, 2017; Sarker et al., 2018). However, the lack of data about vulnerable populations remains a key challenge to designing policies that achieve social equity and sustainability (Furtado & Renski, 2019). A scenario of disinformation persists, especially in developing countries where citizens tend to reside in so-called informal settlements underrepresented in official surveys (Satterthwaite, 2020).

There are still many cases of social exclusion or digital divides affecting different socially vulnerable groups due to the implementation of digital governance (Hollands, 2020). As a result, the implementation of digital governance may not always generate equity (Batty, 2016; Manda & Backhouse, 2019). Connectivity can become a myopic solution to complex problems, especially in developing countries (Press et al., 2021).

Also, the knowledge produced by Smart Cities has yet to provide a strategic model for urban sustainability based on ICT (Mora et al., 2019). Smart Governance must address the data discrepancy and build on data driven policy to decrease social disparities and benefit people of extreme social vulnerability who are often digitally invisible (Furtado & Renski, 2019). Considering that need, we present how the principles set by the Brazilian Letter for Smart Cities intersect with SDGs to guide Smart Governance in Brazil.

2.2. Challenges and opportunities in Brazil with the Brazilian Letter for Smart Cities

Amidst the process of digital transformation, disseminating Smart Cities in Brazil means improving the lives of over 11 million vulnerable dwellers living in informal communities (in Brazil called favelas or subnormal conglomerates) (IBGE, 2010). Those communities are often not thoroughly mapped or surveyed in traditional planning processes, which hinders their claims for public services and policies (Rosenstrom et al., 2019).

In Brazil, most urban databases are mapped by governmental entities with the overall goal of calculating and collecting property taxes. In practice, the lower the land value, the lower the quality of the spatial data (Erba et al., 2005). Misinformation ends up impacting SDGs since governments struggle to obtain a clear picture on the magnitude of social and spatial issues and to monitor policy impacts and shortcomings.

Conceptually, the Smart City movement is essentially European and embedded in a neoliberal logic of production of space focused on attracting new development, which sets economic development as a primary condition to characterize a city as “smart” (Caragliu et al., 2013). Many cities buy into the idea that they need to increase connectivity to become globally competitive and that the internet and digitization will revitalize communities (Hollands, 2020).

A study by Barns combs through platforms or interfaces for urban data management that support services in the development of Smart City governance models (2018). The author brings examples from London, Boston, Sydney, Dublin, New York and Copenhagen to draw the most important types of technological tools being applied “to better clarify the range of data governance agendas embedded within these investments (p. 7).” Open data portals provide access to government data to promote transparency, city dashboards showcase government data into approachable formats to increase data visibility, city score cards integrate datasets to support performance monitoring and data marketplaces are stores created so third parties can access and even purchase data. Although the research takes strides in organizing a great number of initiatives, it only encompasses Global North examples and fails to connect typologies to SDGs (Barns, 2018). Additionally, relying on technology alone to promote economic development may not be effective in most Latin

American cities where about 33,7% of its population live below the poverty line (ECLAC, 2021).

Despite those challenges, the United Nations has made a connection between Smart Cities and SDGs the more governments make use of digital advancements to further a transformative agenda of urban development. A total of 17 SDGs encompass the four pillars of sustainability (social, economic, environmental and cultural) as a roadmap to eradicating poverty, protecting the planet and promoting prosperity by 2030. Since 2015, each country, state and city must adapt those global indicators to local issues and datasets available in each particular context.

To that end, digital governance or E-government emerges as a resource that can achieve SDGs by enabling research and solutions that streamline processes within government institutions and promote technological advancements (ElMassah & Mohieldin, 2020).

In a study about digital transformation in seven cities worldwide, ElMassah and Mohieldin found that Big Data and E-government can facilitate the localization of SDGs and that “digital transformation supports local governments’ efforts to build sustainable and resilient communities through inclusive data collection (ElMassah & Mohieldin, 2020, p. 4).” By localizing, the authors mean adopting strategies that fit SDGs into planning and development agendas. Thus, another contribution of Smart Cities is to serve as a platform for data sources and methods that can offer innovative solutions to structural issues related to sustainability and social equity.

2.3. The Brazilian Letter for Smart Cities

As a step in that direction, the National Secretary of Mobility and Urban and Regional Development from the Ministry of Regional Development developed the Brazilian Letter for Smart Cities in 2020 to stimulate convergence, consolidate and enhance existing Smart City initiatives across multiple government and civic sectors. One of its most important characteristics is its universality. The ambitious document sets a national public agenda and seeks to advise municipalities about smart principles within the Brazilian context and provides a framework, so governments can index their smart initiatives.

The Letter, launched in 2020, acknowledges the role of smart technologies to achieve SDGs within local planning agendas, being specifically interested in issues of governance (MDR, 2021). It also states that digital efforts must address the resource disparity within public agencies and protect vulnerable citizen groups from potentially excluding digital practices.

In the face of Smart City critiques, the Brazilian Letter for Smart Cities strives to be an important milestone in the debate about elitist Smart Cities and a valuable case study for other Global South countries. The Letter emphasizes the importance of smart advancements, and touches upon the broader SDGs of SDG 16 (Peace, justice and strong institutions) and SDG 17 (Partnership for the Goals), both centered around governance.

The letter is divided into eight strategic goals that decision makers, regulatory agencies, the private sector and technical experts should strive for:

- 1) Integration with SDGs: Digital transformation of public policy and programs integrated with sustainable development goals that respects diversity and Brazilian inequality
- 2) Access to the internet: universal access to the internet
- 3) Digital Governance: issues of transparency, privacy and safety
- 4) Urban Governance: innovative and inclusive means of governance that strengthen the role of the decision maker as manager and build trust in government
- 5) Local economy: support local businesses
- 6) Financing: create and stimulate financing instruments for initiatives that support SDGs
- 7) Education and communication: engage civic society in the process of digital transformation
- 8) Impact evaluation: set metrics and indicators to measure impact of smart initiatives

The guiding framework represents an ongoing institutional effort to highlight social equity and sustainability into future development and a paradigm shift towards the digital transformation of public sectors (deFátima et al., 2021). The Letter marks an important step towards operationalizing SDGs at a city level. An analysis of all 27 Brazilian state capitals reveals that 16 of them (60%) have developed sustainability plans or included sustainable goals in their strategic planning, but only 2 have developed methodologies to adapt global indicators to the local reality and to evaluate how policy impacts sustainability pillars (Lunardi, 2019). Such a gap begs for research that shares practical experiences about how to target SDGs in urban and planning policy, especially as more Smart Cities emerge.

3. Research methodology

In short, smart advancements do not always bring social benefits to those most disadvantaged (Batty, 2016; Hollands, 2020); and the digital transformation can be an abstract concept, begging for concrete examples of strategies in developing countries (Gomez-Trujillo & Gonzales-Peres, 2021; Manda & Backhouse, 2019), especially connecting how to target SDGs in urban and planning policy (Lunardi, 2019). On the other hand, Brazil has taken strides to connect those concepts and address challenges with a national framework set by the Brazilian Letter for Smart Cities.

Considering this context, this paper seeks to address the following research questions:

- RQ1: How can digital tools be aligned with Sustainable Development Goals within an agenda of digital transformation?
- RQ2: What can a smart Governance framework for sustainable development look like in the context of the Global South?

To address these goals, we employed a series of methods combining participant observation, review of policy reports, and analysis of existing program data and outcomes. This paper stems from over two years of engagement where us authors took on roles of participants as observers, being actively involved in the digital transformation. Three of us were university researchers spearheading the development of digital tools alongside government workers. Two of us were project managers part of the ÍRIS research lab in Ceará. The strategy was to follow the digital transformation from its inception to implementation, thus learning from government stakeholders about the intentions and demands behind the technologic products generated and the outcomes we observed. During that time, we were able to interact with hundreds of stakeholders to collectively develop digital tools to solve everyday governance problems. We also examined policy reports and grants approved under the umbrella of Smart Governance to understand the larger political agenda of Ceará in terms of what the administration wanted to achieve with digital transformation. Finally, we account for the digital tools created as an outcome of the digital transformation and organize them to propose and validate a theoretical framework that connects all concepts.

It is worth mentioning that there are contextual specificities and limitations to this research. The examples presented here are not one size fits all solutions that can be replicated *ipsis litteris* by other administrators. Also, saying that digital initiatives target SDGs does not mean that SDGs were in fact achieved. To address those issues, future research will include monitoring of how government stakeholders are using the tools to support decision-making and measuring impact of policies based on key performance indicators.

4. Research context: digital transformation in Ceará

Ceará is a poor state in northeastern Brazil with an average per capita income of USD 150 monthly. Out of its 7 million inhabitants, about 25% reside in poor rural areas, where the economic activity is mostly subsistence agriculture. The State of Ceará reported an estimated 243,000 families living in precarious housing, which are hard to geocode and include in official housing datasets (IBGE, 2019). Around 2007, the government began investing in technology and in improving connectivity by building the *Cinturão Digital do Ceará* (CDC) - a public private partnership to deliver broadband access throughout the State (Carvalho et al., 2015). Since then, digitalization remained in the public agenda to improve education levels and promote spatial and economic development.

In broad terms, the digital transformation includes investing in IT solutions and systems to modernize software and hardware in government departments, to host government services online, so public workers can better communicate with and serve citizens.

Considering that Smart Cities must use technological advancements to promote more equitable distribution of assets and services, the State of Ceará embarked on a process of digital transformation by fostering digital advancements in government processes. In Ceará, the digital transformation was a result of the Chief Scientist Program, which is a government policy that aims to integrate academia and government, through the creation of research and development projects that target problems of Ceará. In this context, the Chief Scientist of digital transformation prepared a project for the digital transformation of the Government of Ceará with a focus on accelerating the process of digitization of public services. Thus, sub-projects were created to solve problems related to large-scale data integration and rapid implementation of digital public services. We present two of its sub-projects as follows.

One sub-project was the creation of ÍRIS in 2019, a Laboratory for Innovation and Data, which runs research and development projects related to Big Data, Data Science, public sector innovation, Judicial Innovation and plain language. One relevant initiative developed by ÍRIS consists of training government workers from different Secretaries of the state of Ceará about plain language, so they can bridge the gap between government and citizens by developing content that is approachable and simple (Petelin, 2010). This is an important concern since more than 6% of the population is illiterate, in comparison with 4% nationwide, demanding uncomplicated forms of communication, especially if the purpose is to include lower-income citizens in the public sphere (IBGE, 2010). The main goal of ÍRIS was to improve citizens' quality of life by improving the delivery of public policies and services.

The other sub-project pertains to actually implementing the digital transformation vision, which resulted in the creation of data platforms, centralized communication channels, analytical solutions, among others. One key aspect of catalyzing the digital transformation of government services and entities in Ceará was to collect and integrate public databases. Government platforms with open datasets and a more direct channel of communication between citizens and government entities can lead to a better understanding of the needs of different citizen groups (ElMassah & Mohieldin, 2020; Janssen et al., 2012). Lastly, inclusivity was a priority, which reflected the type of data that was collected and manipulated. The project had a clear focus on understanding vulnerable populations so that the government could specifically target single women, rural dwellers and poor families living in precarious housing conditions.

5. Results: digital tools and SDGs

As a result of the digital transformation agenda, several technological solutions were developed within the context of Smart Governance under the overarching SDGs 16 and 17. We present 7 initiatives developed in Ceará and how they fit the 8 strategic goals brought by the Brazilian Letter for Smart Cities, illustrating how data driven research and digital products can promote equity in a context of a Brazilian state making strides to adapt and take hold of the 4.0 industry.

5.1. Initiatives in ceará

5.1.1. Big Data Social

This web-based system aggregates, stores and processes multiple government databases with information about low-income families benefited by a welfare program called *Mais Infância* (Fig. 1). The system helps governance by integrating multiple datasets about families to build indicators and to show which existing social policies are benefiting them. These families are of extreme importance to State agencies since they live in extremely precarious conditions, mostly in rural areas and necessarily have at least one child under six-years of age.

In order to build the database, the government sponsored a statewide survey of over 150,000 families about issues of food insecurity, health, children's health, housing, income and education. Big Data Social stores that large volume of data and also presents a refined view of the data through analytics, data mining and visual dashboards to help policy makers explore the large volume of existing data about policies and services geared towards families of extreme social vulnerability (Fig. 2).

By mapping the location of families in relation to the social infrastructure provided by the department of social services, the system provides decision makers with data about how policies impact families' wellbeing (Fig. 3).

Having an adequate picture of families with children means looking ahead to develop policies that can stop the cycle of poverty for future generations. Big Data Social also translates data into action plans that localize SDG goals (Fig. 4).

5.1.2. Cerebrum

The main goal of Cerebrum is to integrate dozens of databases into a web-based platform where public officers from the Security Secretary can query, make decisions and monitor safety indicators, such as criminal incidences, citizen data, department of motor vehicles and prison records to run background checks, track inmates with ankle trackers and map the location of police cars in real time to maximize patrolling routes. (See work in: Chainey et al., 2021; do Rêgo et al., 2020; Dias et al., 2020; Cruz et al., 2021).

5.1.3. Citizen Relationship Management System

A Citizen Relationship Management System (CZRM) is a version of Customer Relationship Management, focused on improving communication between private companies and customers. The CZRM is geared at the public sector by organizing information about citizens' living conditions, especially those in extreme social vulnerability. The web-based system organizes, in a simple and user-friendly format, data collected for Big Data Social about housing, labor and income, education, health and social welfare policies. Government workers can search for a specific family member and understand their vulnerabilities. The most important and unique contribution of the CZRM is to automatically provide public workers with policy recommendations that target the specific vulnerabilities signaled by the system. For instance, the CZRM can show that a family has indicated hardships in accessing adequate meals, and help a public officer allocate a social worker to visit the family or allocate emergency relief funding to fight hunger (Fig. 5).

5.1.4. Ceará APP

App designed as a one-stop hub for citizens to access several government services digitally. The app is a digital service portal that offers a direct path for citizens to schedule appointments, contact government workers and make requests, and obtain information about government services (Fig. 6).

5.1.5. Chatbot

The chatbot was created in the context of the Covid-19 pandemic, around April 2020, as an automated tool to converse with patients via text and give them guidelines of how to proceed based on the emergency of their conditions. Specifically, the project *Plantão Coronavírus (PC)* was developed by ÍRIS Lab and the health Secretary of Ceará State to build a chatbot with artificial intelligence. PC



Fig. 1. Home Page of Big Data Social invites users to access a Data Thermometer which shows a diagnosis on families in the State based on their needs (through the button in yellow that reads Termômetro de Dados). The number on the right-hand side indicates how many families are currently receiving the welfare benefit. Source: taken by authors from system Big Data Social, 2023.

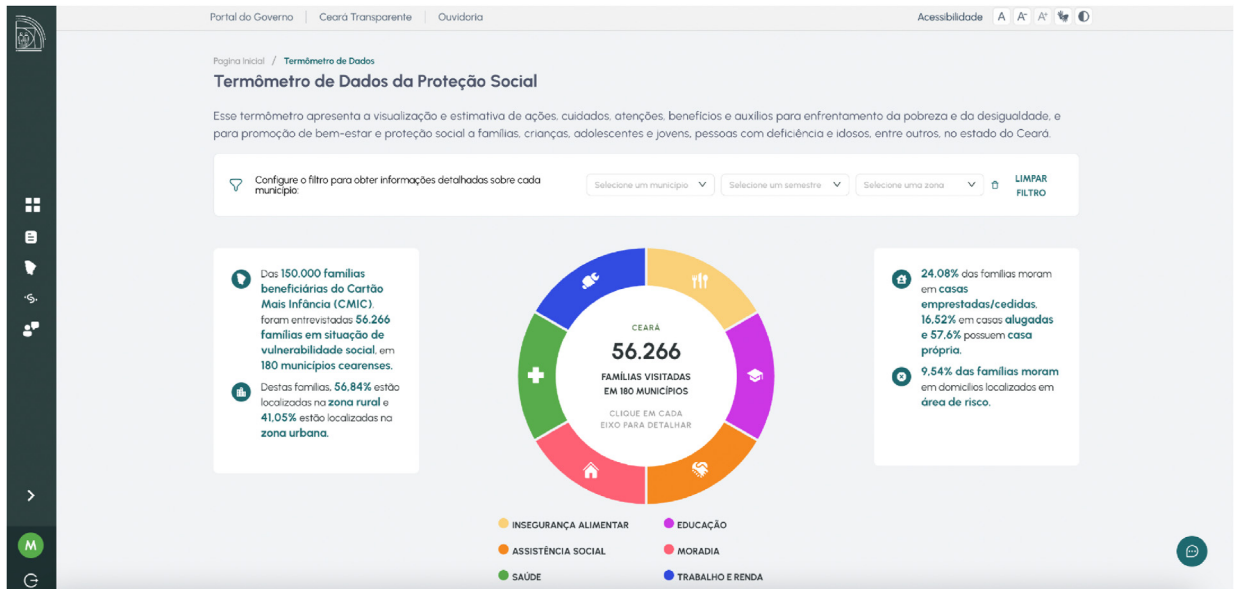


Fig. 2. Data Thermometer provides indicators about families in six major categories, which can be further explored by decision-makers (food security, social aid, health, housing, education and employment). Information can also be filtered by city. Source: taken by authors from system Big Data Social, 2023.

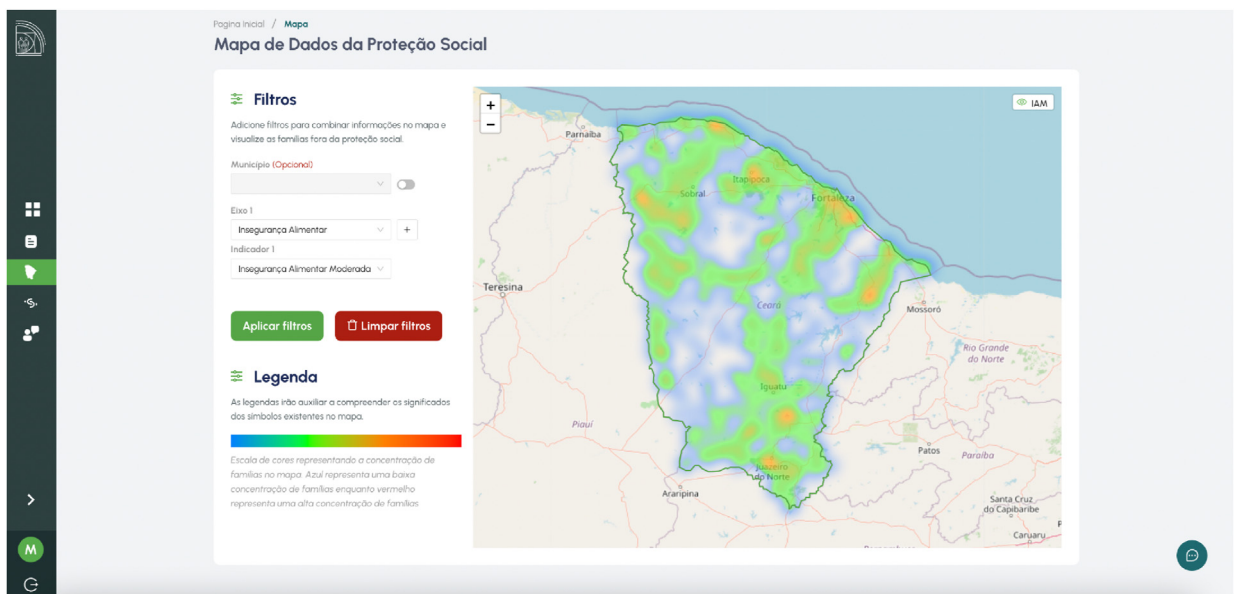


Fig. 3. Social Deserts Map page shows the heat map of the concentration of families receiving the Mais Infância benefit. A filter on the left-hand side allows users to select a category of vulnerability to target families that have specific needs and understand their distribution. Source: taken by authors from system Big Data Social, 2023.

performs a screening of the symptoms reported by the user in the dialogue box within the chat and classifies their health state into light, mild or grave. The chatbot then recommends different services to the user, which can be a medical appointment or suggest a COVID test, among others. The chatbot can also be customized to other contexts based on the needs of other government departments to assist them in expediting processes at a low-cost (see models in Magalhães et al., 2022; Júnior et al., 2021).

5.1.6. Citizen unique ID “Acesso cidadão”

Unique login that can be used for the multiple systems geared towards citizens and public workers to control access to sensitive information. It uses a JSON Web Token (JWT), a compact and independent way to safely transmit information. The integration of the

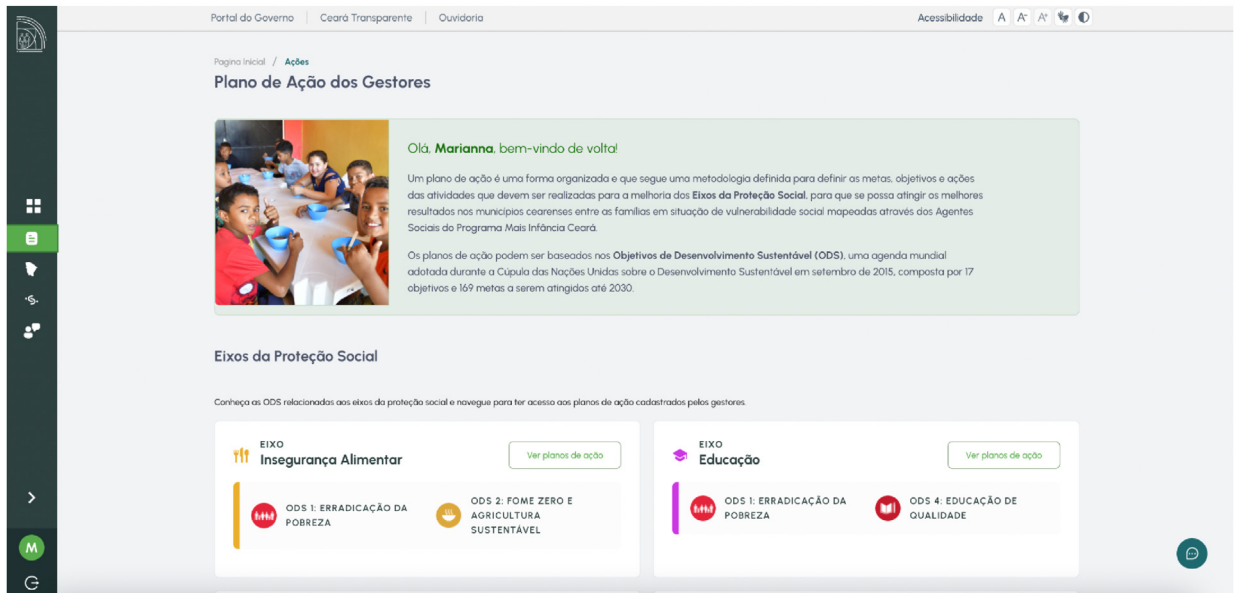


Fig. 4. Action Plans Page shows the action plans (green button ‘ver planos de ação’) that have been developed by the municipality to achieve specific SDGs (showcased by the colored icons ODS). Source: taken by authors from system Big Data Social, 2023.

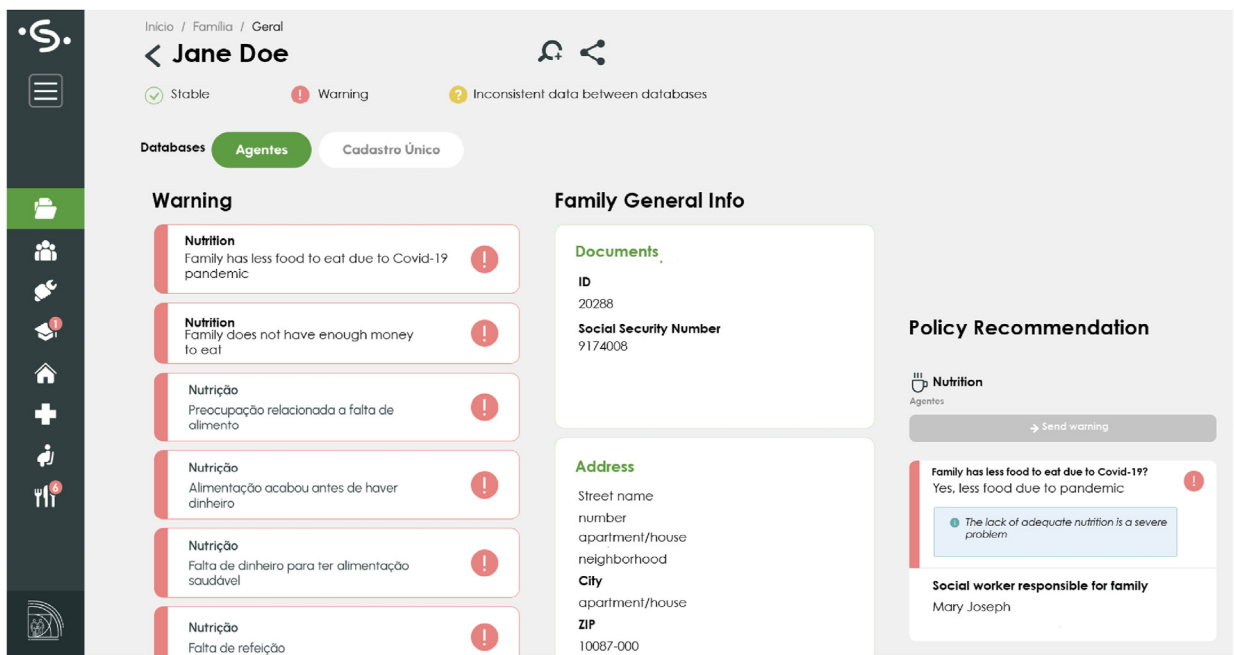


Fig. 5. Family information page from the Citizen Relationship Management System, shows the basic information obtained for a given family whose head of household being Jane Doe. The system creates several warnings based on how families have answered questions on the State Census. This image shows warnings about food insecurity and gives a policy recommendation and person responsible for reaching out to that family. Some information has been translated for clarity, but the system is in Portuguese. Source: taken by authors from the Citizen Relationship Management System, 2023.

unique ID with various government web platforms for public service delivery services allows citizens to access, authorize and authenticate multiple services with one single registration, saving time and improving accessibility (Fig. 7).

5.1.7. Scheduling API

This product consists of an API where users can virtually schedule in-person appointments at several government entities (such as the DMV and health facilities), saving them time and of the need to commute.



Fig. 6. Home Page on the left shows the different categories of services available. Menu bar on the right shows the different public resources related to health ('saúde' at the top). The buttons allow the citizen to schedule an appointment, donate blood, access resources on diversity, print an ID, access a vaccination pass, enter a virtual appointment Ceará App. Source: taken by authors from system Ceará App, 2023.

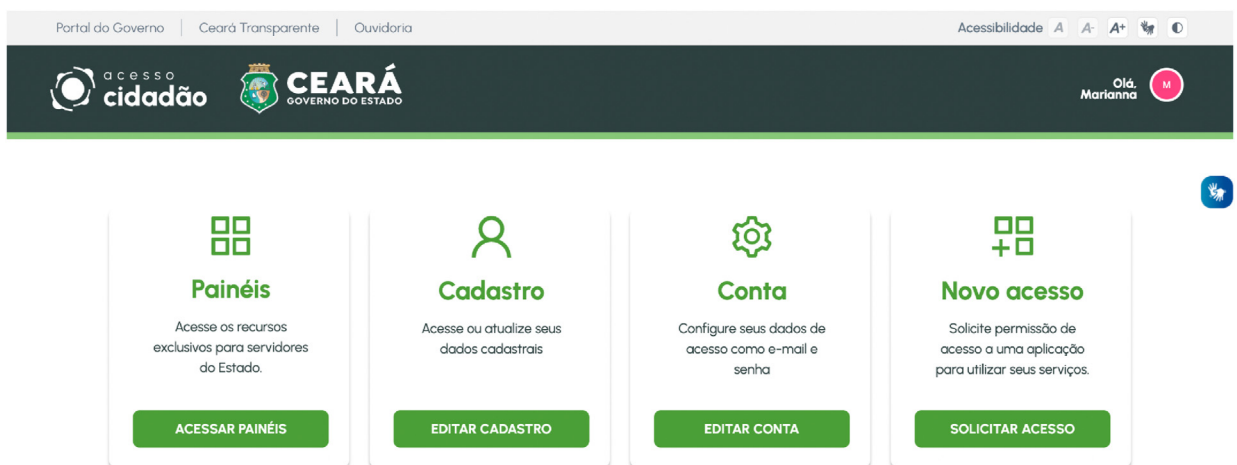


Fig. 7. Home Page of Citizen unique ID allows users to access sensitive resources that are available uniquely for government stakeholders, and for all citizens to register their unique ID, to see the account settings and to request access to any of the systems developed under the umbrella of digital transformation. Source: taken by authors from system Citizen unique ID, 2023.

5.1.8. Knowledge transfer and plain language

All of those tools were created based on plain language - a movement that advocates against institutionalized, bureaucratic, and evasive modes of communication in all types of governmental communications. ÍRIS Lab took the lead on spearheading the plain language movement in Ceará by reviewing documents that were being developed by government institutions, and conducting workshops to teach plain language principles to public workers so they could build agency and adopt plain language as a common practice. ÍRIS defended that a simple mode of communication can democratize public information by guaranteeing the civil right to understanding. The lab has conducted over 100 workshops to 4000 government workers from multiple municipalities in Brazil. Additionally, knowledge transfer was imperative. The tools were handed to secretaries with enough documentation and with workshops so that workers could use functionalities, provide feedback and so that local IT teams could claim ownership of the systems to maintain them.

5.2. Relating the initiatives with SDGs

Within that larger agenda of digital transformation, a series of initiatives touched upon other principles and had direct repercussions to other SDGs, which can be found on the right column (detailed in Fig. 8). As shown, initiatives such as Big Data Social and CZRM focused on gathering and analyzing data about families of extreme vulnerability and Cerebrum provided simple interpretations of complex data that spawned over dozens of databases. All are examples of how technological strategies can create actionable knowledge to improve access to government basic services. Cerebrum and Big Data Social address Impact Evaluation, meaning they set metrics and indicators to measure the impact of smart initiatives, in this case, linked to Smart Governance.

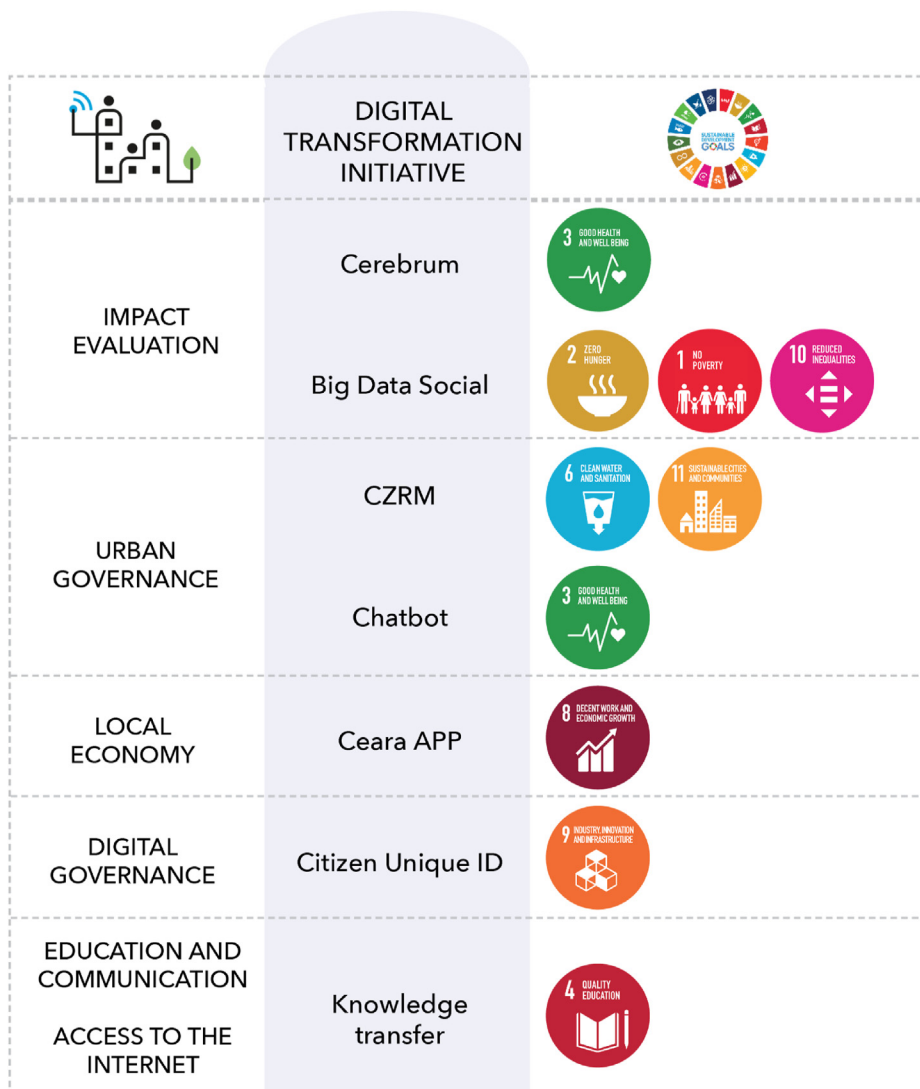


Fig. 8. Framework illustrates how digital transformation initiatives tackle both principles set by the Brazilian Letter and by the SDGs. Created by authors, 2023.

CZRM strengthens the role of the decision maker as manager by subsidizing decision makers with an adequate picture of social issues and the chatbot builds trust in government by creating a swift and user friendly channel of communication with citizens, which is fundamentally interested in their wellbeing, addressing the principle of Urban Governance.

Ceara APP provides an overview of government services and how citizens can apply for permits, make requests, schedule appointments, to name a few, which strengthen the local economy by offering information that can help small businesses. The Citizen Unique ID is a simple solution to the complex issue of transparency, privacy and safety (albeit not all encompassing). It allows the government to control access to sensitive information while also opening up new resources via a Digital Governance mechanism that is unbureaucratic and secure.

The Knowledge Transfer programs promoted by ÍRIS are key to ensure that government stakeholders feel like a part of the digital transformation and have mastery of the new digital tools produced. The more simple choice of words awarded by Plain Language, combined with appropriate visual elements, led to user-friendly systems, changing the culture in government institutions to bring government closer to citizens. Access to the Internet installed statewide is fundamental to engage civic society and run an inclusive process of digitization.

We note that the Brazilian Letter for Smart Cities is directly tied with governance SDGs, specifically SDG 16 (Peace, justice and strong institutions) and SDG 17 (Partnership for the Goals) (Fig. 9).

As defined by the United Nations, SDG 16 seeks to promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels. The Ceara APP, chatbot, scheduling API and the Unique ID are all examples of technological solutions that can improve communications between government and citizens, showcase existing government services, and increase celerity of government processes, contributing to effective governance. These products were enabled by strategic collaboration among stakeholders, which is touched upon by SDG 17.

6. Discussion

As stated in previous literature, "There is a need for the advancement of empirical research that provides answers and an academic understanding between technology and governance (De Guimaraes et al., 2020, p. 5)." Also, it is important we understand how particular technologies and interfaces associated with the digital transformation emerge in the context of developing countries, specifically to act within the governance structure to achieve social goals (Barns, 2018; Luque-Ayala & Marvin, 2015). Conceptually, the Smart City movement is essentially European and theoretical frameworks are based on building up ICT infrastructure that may not generate public value (Hollands, 2020; Mora et al., 2019). Previous attempts at organizing typologies for digital interfaces and to conceptualize Smart Governance have been focused on Global North examples or failed to connect initiatives to SDGs (Barns, 2018; Manda & Backhouse, 2019).

This paper contributes to those gaps by presenting concrete examples of what the digital transformation can look like in the context of a Brazilian city through initiatives developed by the State of Ceará. Based on observations during the process to develop the aforementioned tools, we notice three key strategies adopted by Ceará to answer **RQ1: How can digital tools be aligned with Sustainable Development Goals within an agenda of digital transformation?**

Early on during the conceptualization of the digital transformation, government stakeholders expressed their needs for tools that helped them draw social policies towards equity. From that moment on, all initiatives were centered around data creation and data organization specifically about communities in need. Considering that data-driven development strategies are instrumental to bridge the gap between public services and vulnerable populations, digital interfaces became inherently tied to SDGs, whether directly or indirectly. There are close connections between Smart Governance and decision making supported by knowledge management structures which integrate data and process information (Hassani et al., 2021; Lytras, 2006). Drawing user profiles about low-income families was instrumental to help government stakeholders directly involved with social policies to gain knowledge about citizens' environment and identify urgent areas of action.

Additionally, funding was used to strategically unite Academic and Public sectors to build tools with practical applications to Smart Governance. Ceará invested a sum of USD 5 million, over a three year period, on the account that digital solutions had to solve real problems faced by government entities. By partnering with University researchers, the government of Ceará was able to sponsor several technological solutions to public challenges, which fit the Smart Governance agenda of using ICTs to improve government processes. Thus, it is a case of a financing instrument that supports SDGs and that brings the digital transformation of public policy.

Last, another aspect of the digital transformation movement was to implement ÍRIS, a Lab for Data and Innovation. The projects promoted by ÍRIS were all centered around the SDGs and in making sure that Ceará was aligned with the global pact towards sustainability. The lab offered training and educational materials to introduce SDGs to local government institutions, touching directly upon SDG17 to strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development. The Lab supported data collection and data literacy to educate government stakeholders about the importance of data-driven policy. The commitment to changing government culture shows a concern with how smartness can be embedded in institutional processes and lead to lasting changes. As well stated by ElMassah & Mohieldin, "countries-especially the developing countries-should be prepared with updated infrastructures, institutions as well as skills and most importantly with streamlined mentalities (2020, p. 2)." Data literacy was imperative to make sure that government stakeholders and civic society were amenable to the benefits of digital transformation and are familiar with data, so they can process and synthesize vast quantities of information (Koltay, 2016).

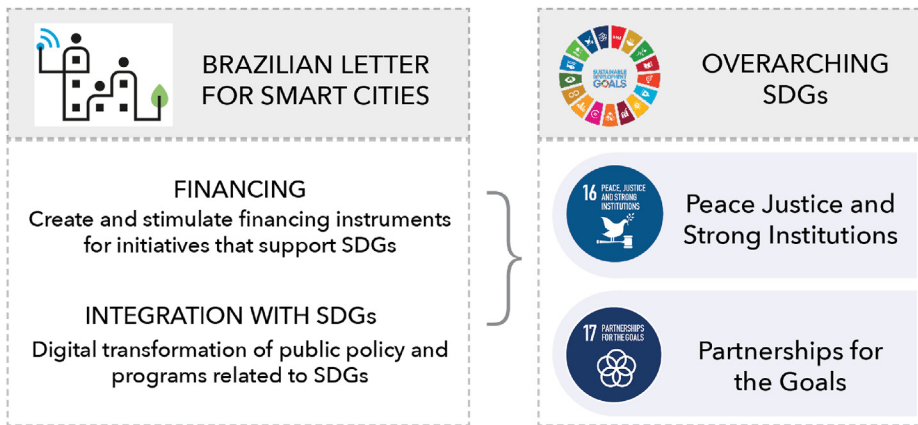


Fig. 9. General framework for digital transformation in Ceará two overarching principles from the Brazilian Letter for Smart Cities to two SDGs tied to governance. Created by authors, 2023.

6.1. Proposed theoretical framework

Another goal of the research was to answer **RQ2: What can a smart Governance framework for sustainable development look like in the context of the Global South?** To that end, it was useful to lean on the Brazilian Letter for Smart Cities to build a model that ties Smart Governance with Sustainable Development Goals in the context of digital transformation (Fig. 10). Although we developed a framework out of our observations in this study, we draw a series of components that can be used in other settings.

Oftentimes, it is difficult for federal agencies to create regulatory frameworks and solutions for the wide array of local issues. To address that need, it is important for a *Federal Regulatory Framework* to set macro strategic goals so each municipality can define their agenda based on local priorities. The federal framework should be inclusive of local specificities and provide legitimacy to cities' efforts towards Smart Governance. The Brazilian Letter offers an example which can be further studied and adopted by other countries.

Within that overarching structure, Strategic Funding can tie projects together around core principles. Grant bylines should specify that Digital Transformation projects must target SDGs, and address governance challenges.

Partnerships between the public and academic sectors open a pathway for innovation and strategically use human capital from higher education institutions to solve real governance challenges. Considering the global demand for IT workers and the growth of the industry, involving students and researchers in the public sector can be an optimized alternative

Evidently, minimal IT infrastructure standards are an important foundation, specifically having broadband access to the internet. Any sort of move towards *smart* begs for a *Basic Digital Infrastructure*, as shown by the project Cinturão Digital in Ceará, envisioned long before the Digital Transformation in 2019.

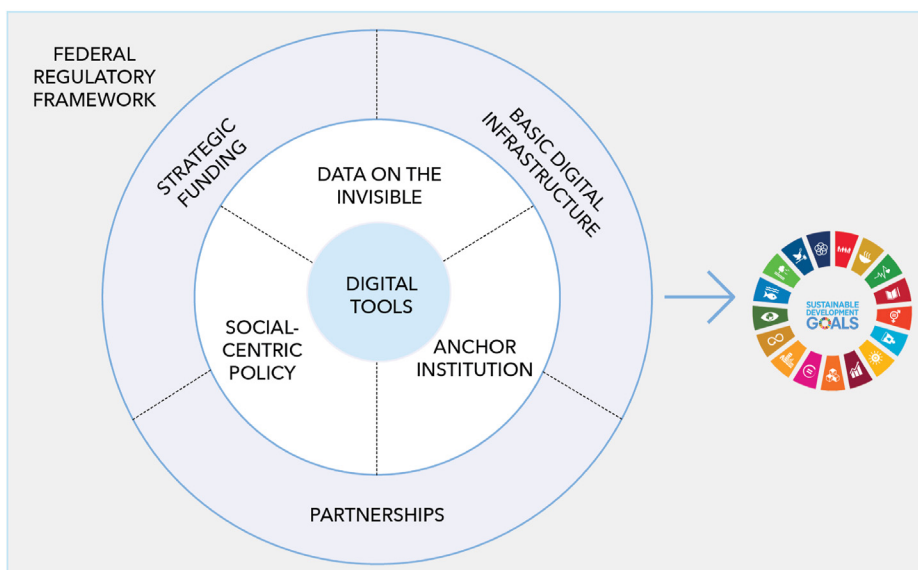


Fig. 10. Smart Governance Framework for Sustainable Development shows 7 components instrumental to develop digital tools that impact SDGs. Created by authors, 2023.

Most cities lack the technical expertise to kickstart a digital transformation, nor see its potential. An *Anchor Institution* should promote engagement among public agencies and members of Academia to achieve integrated results. This laboratory for innovation should spearhead communication strategies to raise awareness about Smart structure principles so government stakeholders can reflect on how it could fit their local agenda. Engagement with local government is essential to get workers to embrace the agenda of digitization, especially in a continental country where several agencies still operate with a level of resource disparity and invisibility. Courses and knowledge transfer are indispensable to that end.

Also, promoting data literacy means emphasizing the importance of data-driven decision making, which is connected to collecting and disseminating *Data on the Invisible*. Producing data and knowledge about vulnerable populations is imperative to the agenda of sustainable governance. It should come in alignment with Social-centric Policy, meaning that data can provide a diagnosis of social needs and directly inform policies that promote equity. Actions developed in Ceará place Big Data at the center to show how collecting and analyzing adequate information about vulnerable citizens can be a starting point towards a sustainable Smart City.

All of these components make up a framework that sets a pathway for how to conceptualize and program computational products that stem from a goal of social justice, and thus, are inherently tied to SDGs. These *Digital Tools* can support Smart Governance in areas that have impacts to several SDGs and be further used to measure policy impact.

7. Conclusions

This research sought to answer two research questions: "How can digital tools be aligned with Sustainable Development Goals within an agenda of digital transformation?" and "What can a Smart Governance framework for sustainable development look like in the context of the Global South?". To answer the first one, we observed the process of conceptualizing the digital transformation in Ceará, Brazil, enabled by a State grant that lasted nearly three years. We organized the digital tools developed to support decision-making, showing how they benefit citizens, especially those disenfranchised. The initiatives included APPs, a Unique ID and a chatbot to inform citizens and expedite their access to public services, an API to schedule appointments online, web-based platforms to integrate data about vulnerable citizens and suggest policy and educational programming to government workers about the benefits of digital transformation and how to use the tools.

To answer the second question, we built a framework that further links those examples with the SDGs and the Brazilian Letter for Smart Cities, a national set of guidelines towards equitable smart transitions. By setting the framework vis-a-vis a grounded experience, we sought to present key elements and drivers of a digital transformation that could be tied to sustainable urban development.

We highlight seven components to the framework, which can be adapted to guide developing countries to make the transition towards Smart Governance: Federal Regulatory Framework, Strategic funding, Partnerships, Basic Digital Infrastructure, Data on the invisible, Anchor Institution, Social-centric policy. We argue that, by applying those elements to build digital tools that help governance, it is possible to create solutions that are inherently tied to SDGs. This is mostly due to the core guiding principle of creating technological tools that place vulnerable communities at the center of digital transformation and data science.

There are some limitations to this study. While the framework is transferable, the digital examples presented here are contextual to the demands expressed by stakeholders in Ceará and they can not be replicated in other contexts. Also, saying that digital initiatives target SDGs does not mean that SDGs were in fact achieved. To address those issues, future research will include monitoring of how government stakeholders are using the tools to support decision-making and measuring impact of policies based on key performance indicators. This example illustrates that investing in instruments and initiatives that contribute to equity and governance can have broader impacts to other SDGs.

Declaration of competing interest

We authors disclose that we have no conflict of interest regarding this publication.

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