Opportunities and Challenges for Management and Governance in Smart Cities in Brazil.

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Abstract. The inteli.gente platform is an adaptation and expansion of the Sustainable Smart City Maturity Model of the International Telecommunication Union – SSCMM-ITU and is the first step towards the formation of a Brazilian BIG DATA with customized information on the levels of maturity in digital transformation and sustainable development. The diagnoses and recommendations for the estimated maturity levels use AI and data science techniques for the analyses, predictions and estimates of the 5,570 municipalities, considering the diverse characteristics and specific needs of each Brazilian territory. The result presented on the Brazilian maturity level for digital transformation and development indicates a country between the planning level (3) and the alignment level (4) of its actions. For the sociocultural dimension, the diagnoses of the municipalities indicate the need for attention in their management and governance policies for digital inclusion and social inclusion in an equitable manner throughout their territory. For the economic dimension, the results indicate that Brazil already has a framework of management tools implemented that enable the development of digital transformation and a sustainable economy. The environmental dimension indicates that strong action is needed to improve basic infrastructure in sanitation, solid waste, among other topics for the resilience of future generations. The result of the Brazilian maturity level for the institutional capabilities dimension demonstrates that municipalities should be concerned with data governance, training leaders for digital transformation, planning and elaboration of goals and plans, among other topics. The availability and use of the inteli.gente platform by managers and public policy makers, using Artificial Intelligence (AI) tools, has made it possible to map and improve institutional public policies based on primary and secondary data from municipalities, promoting cooperation, exchange and the creation of innovative initiatives related to digital transformation and sustainable development in the public sector.

Keywords. Artificial intelligence, Smart cities, Governance systems, Public policies, inteli.gente, Management

1. Introduction

Planning and actions to become a smart city are increasingly present in sustainable development and digital transformation agendas around the world. The concepts of smart cities emerge from the development of information and communication technologies (ICT) and the need for their incorporation into the governance of public services, both in urban and rural environments.

According to Bibri, S. E., & Krogstie, J. (2017), smart city models were developed through standardization and

assessments to define their maturity level and for comparisons and incentives to competitiveness. In this sense, the Brazilian Ministry of Science, Technology and Innovation (MCTI) adapted and expanded the inteli.gente platform, a Sustainable Smart Cities Maturity Model (SSCMM- ITU-T Y 4906, 2016), developed by the International Telecommunication Union (ITU), to Brazil. Used mainly in countries of the Global North, also called U4SSC, it is a flexible model that can be applied in different contexts for decision-making regarding the use of technological infrastructure for digital transformation and sustainable development, with the differential of focusing on quality of life for the population.

The National Center for Research in Applied Artificial Intelligence – IARA-USP, supported by MCTI, since November 2021, has remodeled the inteli.gente platform, with AI tools transforming it into a data lake for sustainable development and digital transformation with estimated diagnoses of maturity levels for all Brazilian municipalities.

Using Artificial Intelligence (AI) tools, it is possible to map and improve institutional public policies based on data provided by municipalities, promoting cooperation, exchange and the creation of innovative initiatives related to digital transformation and sustainable development in the public sector.

Inteli.gente is made available free of charge to 5,570 municipalities for the management and governance of data and knowledge in real time, as well as to public policy makers, academia, the general population, students, council bodies, among others. Other initiatives for smart cities are applied in Brazil, as well as some indicators and metrics for international comparability: ITU ICT Development Index (IDI), Cybersecurity: ITU Global Cybersecurity Index (GCI), E-Commerce: UNCTAD B2C E-commerce Index, E-Gov: UN E-Government Development Index (EGDI).

As an ITU Member State, Brazil has approved the inteli.gente platform as a Brazilian use case in the implementation of the SSCMM-ITU (Y-78 ITU-T, 2023).

1.1 inteli.gente platform

The methodology used in the expansion and adaptation of the SSCMM-ITU followed the studies reported in Yigitcanlar (2019), which consider that public participation in decision-making and collaboration between all stakeholders ensure progress towards sustainability.

In selecting the indicators, more than 1,000 indicators from various sources were analyzed, the most significant being (PCSI, 2018; ISO 37120, 2018; ISO 37122, 2019; ISO 37123, 2019; SEADE, 2023; ODS, 2023; CNM, 2023). From this evaluation, 113 indicators were selected. Due to its vast territorial extension, Brazil presents great regional and local differences. Although the laws stipulate that access to information and electronic services must be available on municipal websites, there are still varied realities between cities. In this diverse context, the inteli.gente platform is considered strategic, as it enables the understanding of these differences and realities, guiding the process of planning and building effective and efficient public policies for Brazilian cities.

The diagnoses and recommendations are divided into four dimensions: economic, environmental, sociocultural and institutional capacity, used for the management and governance of public policies. As in the SSCMM-ITU, the measurement of indicators in the inteli.gente platform adopts scoring levels based on the achievement of performance targets, defined based on the average Brazilian performance index, considering several thematic areas relevant to public policies for cities and the population.

The maturity levels provide a diagnosis for cities seeking their own development in the short, medium and long term. Each level has its objectives, indicators and expected practices organized by public policy themes, presenting an evolutionary diagnosis for sustainable smart cities.

The major change to the Brazilian model was the addition of two maturity levels at the bottom of the SSCMM-ITU. The other SSCMM-ITU maturity levels, known as planning, alignment, development, integration and optimization, were kept the same.

The two new Brazilian maturity levels were called "adherence" and "engagement" with the aim of covering Brazilian cities that are less advanced in terms of sustainable development and digital transformation. Thus, the creation of these two additional levels was necessary due to regional and local disparities between Brazilian cities, allowing all Brazilian cities to participate in the new model developed.

At the first level, called Adhesion, the city recognizes some of its main issues and understands the challenges for its digital transformation. This level is characterized by asymmetries in infrastructure, service provision and public facilities. The degree of digitalization related to services and processes is low. Cities at this level present the lowest results in terms of sustainable development and ICT indicators, indicating the need for improvements in economic, environmental and sociocultural aspects. The diagnoses provided by the inteli.gente platform at this level propose

the development of public policies that promote the benefits of public management in people's lives and improve sociocultural, economic and environmental indicators.

At the second level, called Engagement, we can see the beginning of transformation actions in the city. Sectoral goals for the incorporation of technology emerge. There are actions to identify the areas most prioritized for investments in basic infrastructure. Among the priorities are the reduction of asymmetries, the standardization of processes and the digitalization of public services, in addition to capturing ideas for the monitoring and evaluation of public policies. The diagnoses provided by the inteli.gente platform at this level propose to offer tools and paths for cities to improve their sustainable urban development strategy and digital transformation.

The structure of the inteli.gente platform is presented in Fig. 1, containing the topics (thematic areas) related to each dimension. These topics are used to guide the indicators according to their purposes.

The knowledge base and information for each topic are obtained through metrics, statistical analyses and adaptations based on (Odum, 1996; IISD, 1997). The data sources come from official regulatory bodies (secondary sources) and/or municipal managers (primary sources).

Thus, the diagnosis of the maturity level of the indicators in the inteli.gente platform offers opportunities and challenges to improve the provision of services to the population in terms of digital transformation, transparency and quality. These diagnoses and recommendations encompass aspects ranging from the infrastructure required for digital transformation and urban development to the training and digital literacy required for solutions and services that improve the quality of life of citizens and city management.

With the experience of the IARA team and based on cities interested in digital transformation and sustainable development, projects and analyses are developed with large volumes of personalized urban data, expanding the range of diagnoses and recommendations for cities, using data science (prescriptive and predictive analyses) in their public policies.
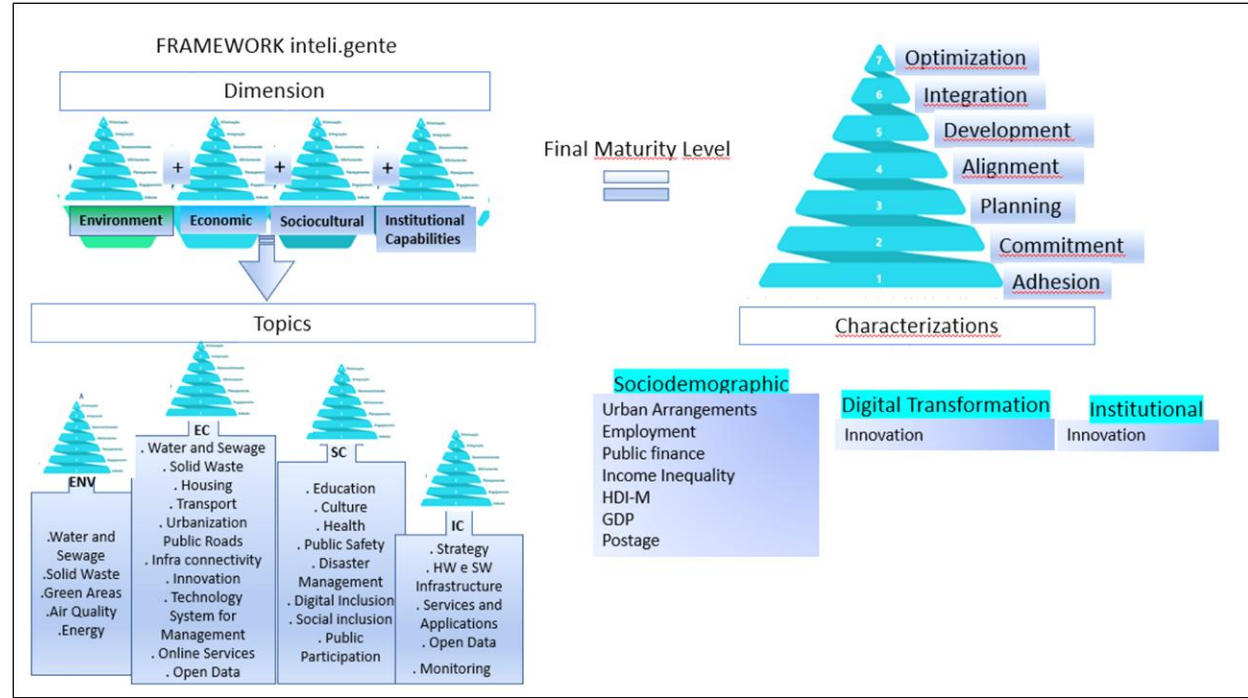

Figure 1 inteli.gente platform framework (Manual Reference, 2023)

2. Brazilian Results inteli.gente platform

The results presented in the inteli.gente analyses reflect the characteristics of a country in the global south, where municipal planning has not yet become a reality in local governance, although in some dimensional analyses the results indicate that the country has been implementing actions and programs for development.

The final maturity level in digital transformation and sustainable development estimated for Brazil, obtained by averaging the levels of Brazilian cities, was level 3 - Planning. This level obtained is equivalent to level 1 - Planning of the SSCMM-ITU.

The application of AI tools in the inteli.gente methodological model allowed cities to have their maturity level

estimated regardless of whether they provided their primary information in their own form.

The adaptations implemented in the inteli.gente platform for the Brazilian model were the use of four dimensions: Economic, Sociocultural, Environment and Institutional Capacity, which allowed the assignment of an estimated maturity level value to each dimension, indicator and public policy theme.

In this way, the final maturity level of the municipality is obtained by calculating the arithmetic mean of these four dimensions evaluated. The platform also used indicators to characterize the cities in terms of sociodemographics, digital transformation and institutional aspects.

The analysis of the indicators and themes of the economic dimension (Fig. 2) for Brazilian municipalities indicates that of the 5,570 municipalities, 152 still require greater efforts to reach the level of maturity in digital transformation Planning. These are municipalities that still need to be concerned with basic infrastructure in sanitation, solid waste, housing, innovation and governance strategies, development of master plans, among other topics. The 2,357 cities at maturity level 4 (alignment) and 2,438 at maturity level 3 (planning) indicate that Brazil already has a framework of management tools implemented that enable the development of digital transformation and a sustainable economy.
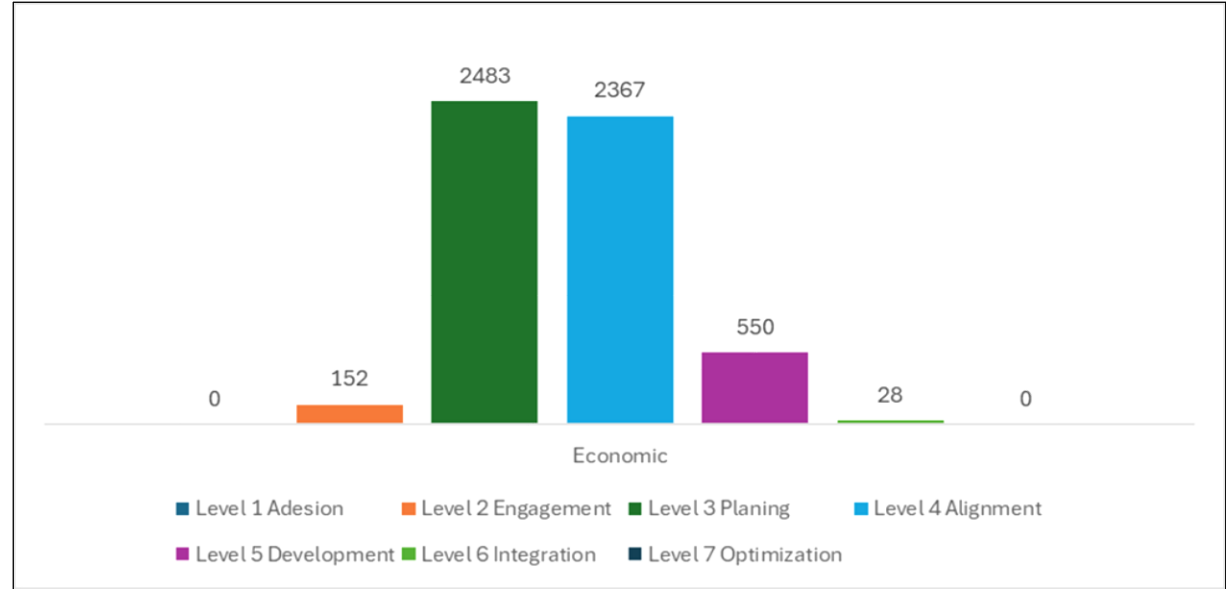

Figure 2 Maturity Level Economic Dimension All Brazilian cities

The analysis of indicators and themes of the environmental dimension (Fig. 3) for Brazilian municipalities indicates that of the 5,570 municipalities, 2,609 still need greater efforts to reach the level of maturity in digital transformation Planning. These are municipalities that still need to be concerned with basic infrastructure in sanitation, solid waste and governance strategies, development of master plans, among other topics. The main demands on solid waste are the lack of selective collection in cities and of selection and recycling, as well as waste of treated water, between the treatment plant/capitation and domestic taps. The 957 cities at maturity level 4 (alignment) and 1,990 at maturity level 3 (planning) indicate that Brazil already has a framework of management tools implemented that enable the development of digital transformation and the preservation and sustainable use of its green areas.
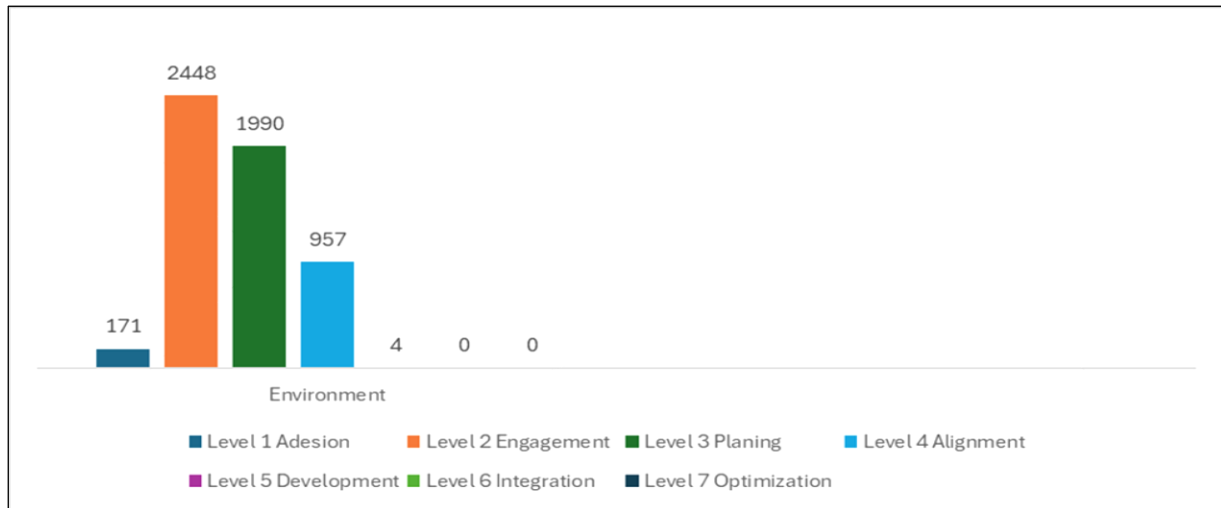
Figure 3 Maturity Level Environment Dimension All Brazilian cities

The analysis of the indicators and themes of the sociocultural dimension (Fig. 4) for Brazilian municipalities indicates that of the 5,570 municipalities, 171 still need greater efforts to be able to reach the level of maturity in digital transformation Planning. These are municipalities that still need to be concerned with basic infrastructure in sanitation, solid waste, health, education, public safety, among other topics. The low number of cities that still require an effort in governance shows that social programs and inclusion efforts are on a positive path. The 29 cities at maturity level 4 (alignment) and 4,356 at maturity level 3 (planning) indicate that Brazil, despite the effort in social inclusion, still needs attention in its management policies to enable the development of digital transformation and social inclusion in an equitable manner throughout its territory.
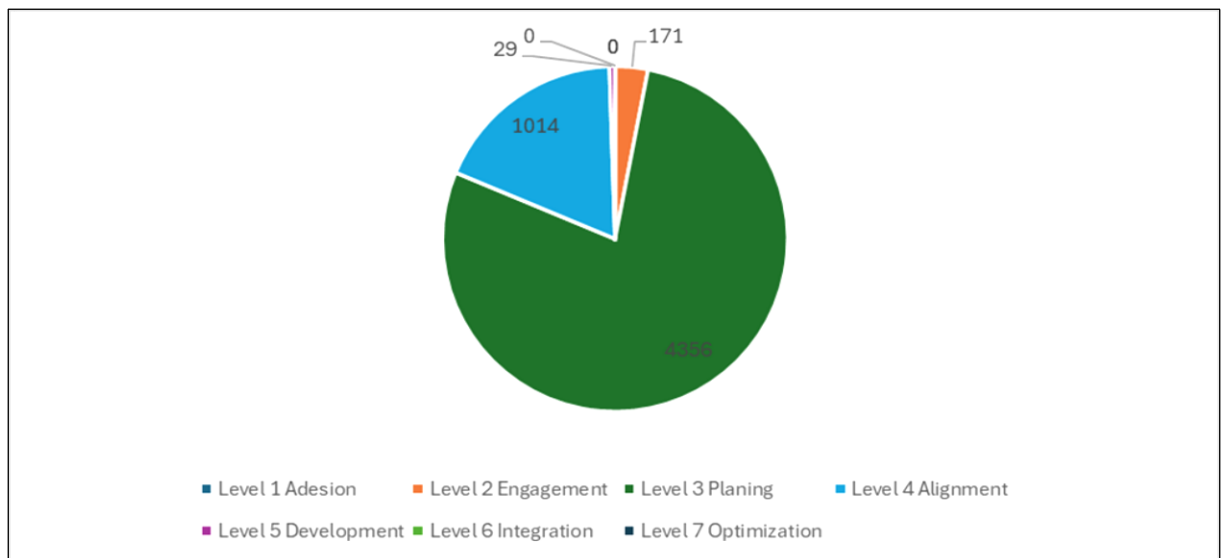

Figure 4 Maturity Level Socialculture Dimension All Brazilian cities

The analysis of the indicators and themes of the institutional capabilities dimension (Fig. 5) for Brazilian municipalities indicates that of the 5,570 municipalities, 5,026 still need greater efforts to be able to reach the level of maturity in digital transformation Planning. These are municipalities that still need to be concerned with data governance, training leaders for digital transformation, planning and developing goals and plans, among other topics. The 21 cities at maturity level 4 (alignment) and 514 at maturity level 3 (planning) indicate that Brazil, despite its efforts, still needs attention in its data management, transparency and public participation policies to enable the development of digital transformation and digital social inclusion in an equitable manner throughout its territory.
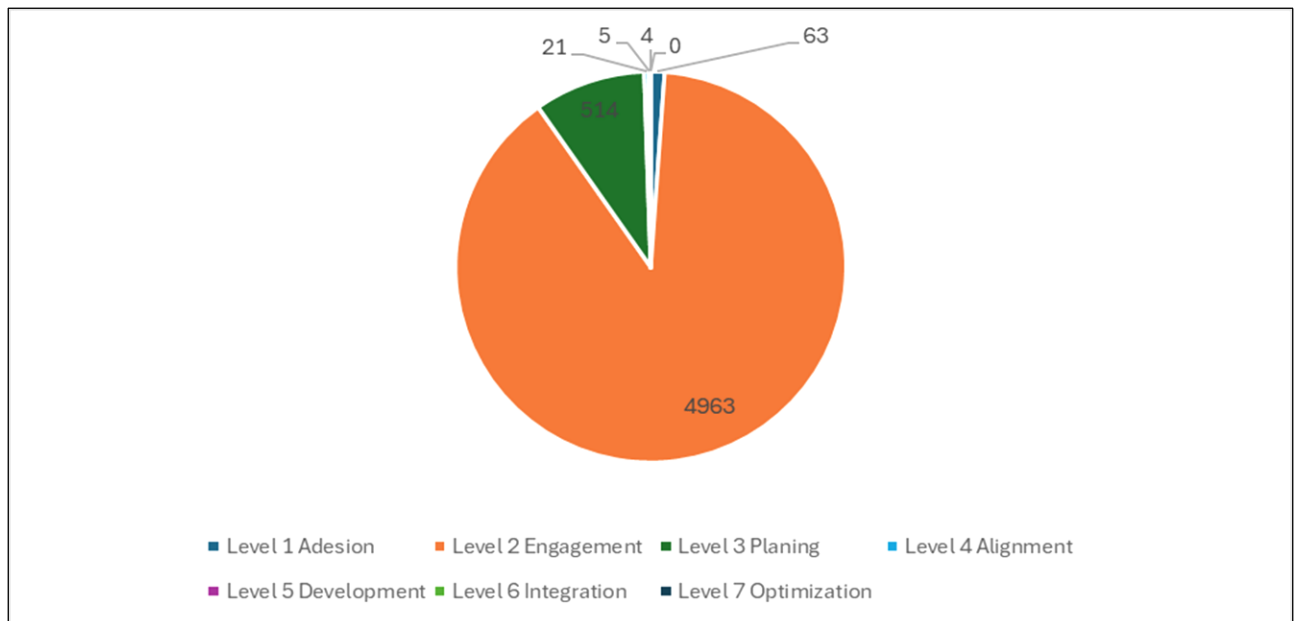
Figure 5 Maturity Level Institutional Capability Dimension All Brazilian cities

3. Conclusions

Diversity in Brazil has led to the need to contextualize recommendations regarding new maturity levels, with the main objective of covering the reality of Brazilian cities and their trajectories, as well as expanding the scope of analysis and diagnostics from the local to the global level of maturity of cities (Paseto, 2021:2020).

The new maturity levels implemented in inteli.gente have demonstrated asymmetries in infrastructure, service provision, public participation and public equipment made available to the population. The degree of digitalization related to services and processes in cities is still low, indicating the need to propose and develop public policies that promote the benefits of public management in people's lives and improve sociocultural, economic and environmental indicators.

The inteli.gente platform allows public policy makers to introduce and develop public policies with knowledge and in synergy with the needs of the population and also demonstrates that the level of maturity of digital transformation and sustainable development of a city does not depend on the size of the population, or even the influence of the municipal network, but rather on data management and governance where knowledge will be a feeding tool for decision-making.

Acknowledgement

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