NITEROI SMART CITY
FINAL REPORT

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12.16.2022

GSAPP | 2022 Fall | URBAN ANALYTICS AND HUMAN-CENTERED DECISION

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SECTION I: ABSTRACT

Niteroi's City Government came up with a Master plan from 2013 to 2030 to develop its Smart City long-term goals of:

- Productivity
- Innovation
- Facilitation
- Integration

The plan included a series of initiatives by improving:

- The organization and public security in urban development and mobility
- Health and sanitation,
- Education, innovation, and entrepreneurship
- Economic development and productivity
- Cultural and leisure activities
- Social inclusion and equality
- Efficient and committed governance and public management.

However, the key issue that the mayor and the City government faced was that they had a lack of understanding of the progress of these initiatives. Thus, our theory of change is that if we develop a dashboard that tracks the trend of data over time, then the city Government can understand their progress towards their long-term goals by determining the effectiveness of their initiatives (see Figure 1).

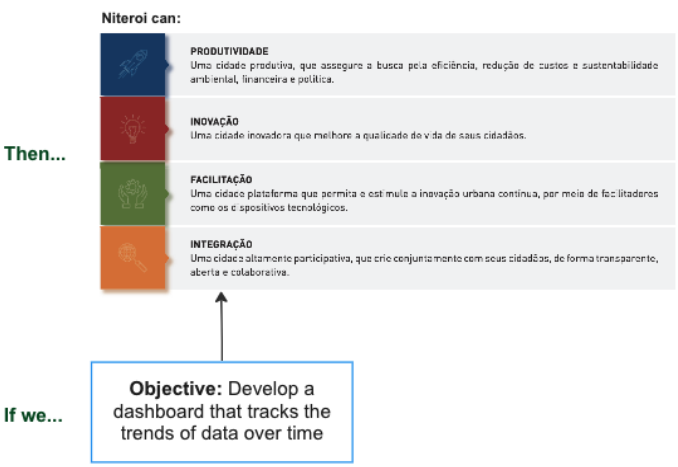

Fig 1. Theory of Change

To develop this solution, we utilized a series of tools to:

- Identify the issue and cause of the issue (problem tree),
- Considered variables such as stakeholder needs, other smart city plans (literature review / case studies), and existing methodology,
- Understood what data was available and what wasn't,
- To recommended metrics based on our study of variables and prioritized them
- To create an algorithm based on our recommendation of methodology improvements,
- To create a visualization of the data collected through a dashboard solution.

SECTION II: BACKGROUND

Throughout Brazil's history, Niteroi's urban planning and transportation systems have not been well coordinated with regulation and practice, resulting in constant controversy over urban space for pedestrians, cars, buses, and bicycles. Through some initial literature studies and case studies, we've found that Niteroi's urban planning and transportation systems have not been well coordinated with regulation and practice, resulting in constant controversy over urban space for pedestrians, cars, buses, and bicycles. Through our observation, we found there are certain road defects in some areas that are not in the city center, including very few bicycle lanes, little vegetation around the road, and relatively narrow roads.

According to the literature on Niteroi's mobility problem, the is now facing problems including increasing motorisation, vehicle-kilometers traveled and urban congestion due to the urban sprawl development since 1970s. To improve mobility and as part of the response to Brazil's Federal Government's requirement of Sustainable Urban Mobility Plans (SUMP), Niteroi started a project in 2012: the construction of the TransOceânica Road Corridor (CVT) in the Bus Rapid Transit (BRT) modality. The implementation of the road corridor required Environmental impact studies. The scenarios created when studying these studies are evaluated by the directly affected populations on how they occur, but the construction of road corridors has been an important strategy to address urban mobility problems, mainly due to excessive vehicle circulation.By informational investigation and literature research, we found that although the cross-sea tunnel built by Niteroi not long ago has alleviated the congestion of Niteroi to a certain extent, the residents are still dissatisfied with the current traffic situation. Most of the problems focus on severe pollution and road noise.[1] While conducting the research, we stayed in contact with our clients — representatives from the city of Niteroi. Through the weekly meetings we've decided the goal of building data-driven dashboards for Niteroi in the following dimensions: mobility, technology, environment, and economy.

LITERATURE REVIEW- DASHBOARDS

The utilization of data in the functioning of city governments has become a key standard in evaluating today's city governance. The development of data science and information technology also made data visualization more accessible, which bridged the gap

[1] Jose.G, Luciane. A, Andre. G, Carlos. S, Orlando. L, 2020，https://doi.org/10.3390/su12156052

between humans and information. One of the most useful and popular tools for data visualization today is dashboards. A dashboard was defined as a visual display of key information being integrated and organized together so that people can obtain the knowledge they need or further explore and analyze data from multiple sources.[2] With the world's trend of rapid digitalization, data visualization through dashboards has been applied in various fields besides data science, one of the most influential applications of dashboards is in urban governance.

City dashboards are useful visualization tools for the public sector to share complex information and data with stakeholders and citizens. In general, city dashboards display information about the performance, structure, pattern, and trends of cities through visual analytics with interactive graphics, maps, and 3D models.[3] They can integrate multiple visualization tools and provide more perceptions and insights. Decision-makers could utilize dashboards to release information to the public[4] and the public can also reversely scrutinize government actions. Sharing, use and interpretation of data through city dashboards can bridge the gap between the government and the public, influence government policy-making, impact interaction with the public and result in new applications.[5] In smart cities, dashboards should help to facilitate transparency, governance, trustworthiness and enable citizens to participate in decision-making.[6] In 2009, the US federal government utilized dashboards to increase the transparency and accountability of its economic recovery policy.[7] The Dutch government has created dashboards for the public to monitor large IT-projects since 2018.[8] In Brazil, Rio de Janeiro's Smart City dashboards were utilized to increase city's mobility through monitoring the city's traffic jam[9] and public transportation services.[10]

In all, the application of city dashboards is meaningful in creating transparency and accountability of city services. For smart cities, dashboards are key links that connect Smart Citizens with Smart Cities. However, studies have shown that the introduction of dashboards must accompanied with organizational changes. Through the platform,

[2] Cleveland, 2014.
[3] Kitchin, R., & Mcardle, G, 2017. doi:10.4324/9781315407388-9
[4] Matheus, R., & Janssen, M, 2013.
[5] Ganapati, 2011a.
[6] Allio, M. K, 2012.
[7] Ganapati, S, 2011b.
[8] https://rijksictdashboard.nl/
[9] https://www.waze.com/zh/live-map/
[10] https://moovitapp.com/nycnj-121/poi/

government needs return feedbacks timely and effectively. In addition, bad-designed dashboards may create misunderstanding of data and affect public's trust.[11]

STAKEHOLDER MAPPING

After understanding the literature provided by the Niteroi team and the data collected by research it was essential for us to map out the stakeholders to ground our project research and understand the categories that would be involved and impacted by the dashboard. For us, the stakeholders became the step where we understood the levels of integration required. Therefore we divided the categories into the level of influence and impact of stakeholders. This understanding helped us formulate our theory of change relevant to the people of Niteroi. The data provided by the clients to map out the stakeholders was limited; thus, we had to look for online sources to formulate information.

In developing the stakeholder hierarchy of importance and influence, we looked through the lens of who will be most affected by the emergence of the digital dashboard. The other factor in determining the hierarchy is the client's preferences. As the client wants to utilize the dashboard as a step towards a sustainable Niteroi, the environment becomes a vital stakeholder that should hold significant influence. This methodology may help in the decisions being made for the city but might hold less influence for the city hall or investors. Understanding the stakeholders helps us create a more nuanced risk assessment report in which we can determine which stakeholder might be adversely affected by any breach or shortcoming of the dashboard. It poses the questions of transparency and the risk of data being breached by external or internal threats. Other reservations might include the following: How would the elderly population of Niteroi adapt to the technological advances of the dashboard? Would it create a further divide between those who have access to the technology and those who might not get it?

[11] Matheus, Ricardo, Marijn Janssen, and Devender Maheshwari, 2020. https://doi.org/10.1016/j.giq.2018.01.006

Table 1. Stakeholder Mapping

Stakeholders	**Further Expanded**
Local Communities	➔ 19.5%1 of its population being elderly or chronically ill ➔ 15% Population lives in insecure areas ➔ 9,068 inhabitants live in extreme poverty ➔ Middle income communities ➔ Higher income communities ➔ Informal settlers
Health and Education	➔ Municipal Department of Health (SMS) ➔ Municipal Department of Education (SME) ➔ Public schools and universities ➔ Private educational institutions ➔ Hospitals, clinics, labs and pharmacies
The Environment	➔ Municipal Department of Environment, Water Resources and Sustainability (SMARHS)
The Local Government body	➔ Niteroi City Hall ➔ Municipal Department of Housing and Land Regularization ➔ Municipal Department of Civil Defence and Geotechnics Municipal Department of Cultures ➔ Municipal Department of Conservation and Public Services (SECONSER)
The Public Transport System	➔ Municipal Department of Urbanism and Mobility (SMU) ➔ Government owned public transport systems ➔ Privately owned public transport systems ➔ Pedestrians ➔ Bicyclists
Investors	➔ Accessibility Coordination (CODAC) ➔ Fund's Management Board ➔ Municipal Department of Planning, Budget and Modernization of Management (SEPLAG)
The South American government agencies?	➔ Economic Commission for Latin America and the Caribbean (CEPAL)
International community	➔ The United Nations ➔ International investors

Right after the mapping, we categorized the stakeholder in order of High Importance/ Influence to Low Importance/ Influence (see Figure 2).

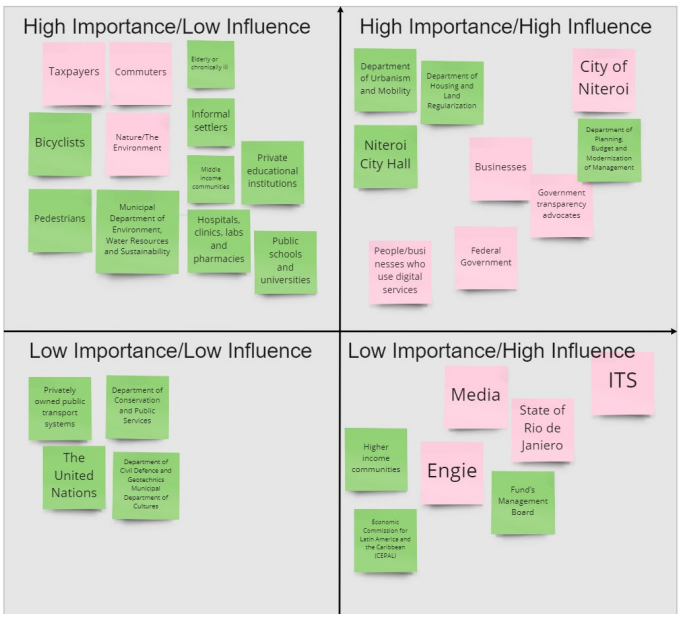

Fig 2. High to Low Importance/Influence Mapping

CASE STUDY

The case study initially looked for approaches to help Niteroi change the status quo. We found some relevant cases from the United Kingdom, Singapore, Spain, and other countries through investigation. During our meeting with the Niteoi's representatives, we realized that methods to improve urban mobility in these developed areas may not be suitable for Niteroi's case. Niteroi's side recommended us to focus on Medellin, an emerging smart city in the Latin America. We got a lot of inspiration and indicators from the case of Medellin, and we found that the case of Medellin can help Niteroi solve problems in various aspects.

Through the case of Medellin, we found that Medellin has installed many cameras and intelligent sensors, and these facilities can intelligently monitor the situation on the road. Medellin has also developed emerging cameras to catch traffic violations and read license plates. The popularity of such cameras has significantly reduced vehicle violations. Medellin has 80 visualization cameras with video analytics, operated by the Traffic Control Center (TCC), which allow visual monitoring of the road network (photo and video) to detect traffic-related incidents. Additionally, multiple cameras (depending on location) are used for automatic incident detection through intelligent software that can identify situations such as stranded vehicles, slow-moving vehicles in flowing traffic, and congestion. Traffic information such as intensity, occupancy, average speed, number of cars, and distance between vehicles can also be captured. For the long-term

monitoring of vehicle behavior, especially the number of routes on different roads, and to optimize the traffic light network, Medellin installed 120 evaluation units at 21 traffic light intersections powered by Vehicle Detection Sensor (VDS) cameras and video analysis software composition. [12]

At the same time, through our case study, we found that Medellin has also developed a system called SIMM, which can connect various cameras and sensors of Medellin. Not only that, but SIMM is a mobile system that can be applied to information technology, communication, transportation facilities, etc., to optimize road use and improve safety and mobility.

It is worth noting that Medellin's smart city project is not only about transportation, they also focus on the development of e-government, which connects the government and local citizens to a large extent, and citizens can directly Use the platform provided by Medellin - MiMedellin to report or handle business. Not only that, Medellin has also implemented an early warning system for natural disasters, and Medellin actively cooperates with private operators to increase the revenue of the secretariat.

After Niteroi's improvement of methodology and the search for international benchmarks, the case of Medellín was a good match for Niteroi. Through Medellin's case study, the indicators we look for are as follows:

- 24% reduction in crash rate per 10,000 vehicles in areas covered by variable message boards (compared to 2011-14)
- In camera-covered areas, the crash rate per 10,000 vehicles 35% reduction in crash rate (compared to 2010-14).
- 14% reduction in Medellin's accident rate per 10,000 vehicles (compared to 2010-14)
- 7% reduction in response time to traffic crashes (compared to 2010-14).
- The percentage of negative events (responses to false alarms) decreased by 18 percent (compared to 2010-14).
- 74% fewer drivers were fined for speeding (compared to 2010-13).
- 2014 due to reduced response times compared to 2010, 193,840 hours of congestion time were saved in 2014
- 27% reduction in photo detections for speeding (compared to 2012-13)

[12] Darío Amar Flórez (2016), https://publications.iadb.org/publications/english/document/International-Case-Studies-of-Smart-Cities-Medellin-Colombia.pdf

- 24 out of every 1,000 vehicles need to undergo photo inspection; now only 4 per 1,000 vehicles (compared to 2011-14).
- Response time to incidents of 15 minutes or less increased by 8% (compared to 2010-14)
- 69% fewer drivers were fined for running red lights (compared to 2010-13).
- 59% of Medellín's population is an Internet user, thanks to the city's 510 connections to free Internet public sites.
- There are 48 community centers with access to ICTs. These centers allow citizens to access the Internet and training through the following means
- More than 93,000 people attended the city's Appropriate Technology Topics workshops and courses in the city's townships, towns, and neighborhoods.
- Four Smart City services have been deployed, 10 for accessing, engaging, transacting, and interacting with citizen applications, and 12 city portals are operating in a virtual space dedicated to inter-community collaboration and communication between communities.
- 340,000 citizens are connected to free Internet, available in 61 public spaces. 61 public places in the city.

We carefully disassembled the case of Medellin and created some dimensions according to the priorities (Mobility, Economy, Environment, Technology, and Society) we set at the beginning. We cooperated with Literature Review to fill in all our indicators Together. And we carefully classified these indicators according to our dimensions, from which we created our original case study metrics. We assign individual proportions to our dimensions through our unique method, and the distribution method is as follows:

In a client meeting, we fill out our priority matrix with our client. We visualize dimensions via a coordinate system. Together with our clients, we filled out this matrix through the status and importance of the data. The specific matrix is as follows (see Figure 3):

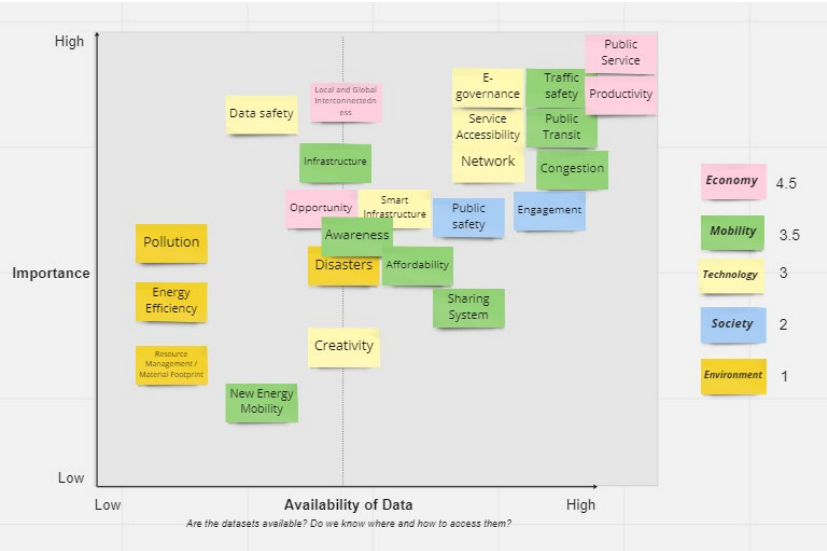

Fig 3. Indicator Priority Matrix *(Exercise with Client)*

After understanding our customers' views and needs on these dimensions, our case study team re-allocated the weights for the case study metrics. We introduce the analytic hierarchy process (AHP) to weight each indicator of Niteroi's digital transformation. AHP is a process that uses hierarchical decomposition to deal with complex information in multi-criterion decision-making, fitting well with the urban digital transformation of Niteroi. It contains three layers: 1) goal – digital transformation, 2) criterion – economy, mobility, technology, society, and environment, 3) alternative – 24 indicators. With suggestions from Niteroi City Hall, the relative importance within criterion layer and alternative layer can be identified. And finally, the alternative weights were calculated using the AHP algorithm (see Appendix III - Analytic Hierarchy Report of Smart Niteroi Metric). The final case study metric (see Appendix II - Niteroi Evaluation Metric based on Case Study) are available at: https://docs.google.com/spreadsheets/d/1YAi6WlygFITL_ouIQ3UgfPQqfMwotitbHlSJnmvbDBo/edit?usp=sharing.

SECTION III: IMPROVEMENT OF METHODOLOGY

Our clients gave us some tasks through the connection between the case study team, the data team, and the clients. Through the above case study metrics and the existing data provided to us by clients, we have concluded more solutions through more investigations. The data that the customer gave us is minimal. Some data is only the length of the bicycle lane, the number of people in the point-to-point bus service, and so on. These data are minimal for us. But the case study team summarized some of Niteroi's existing ideas for smart cities through these data (see Figure 4).

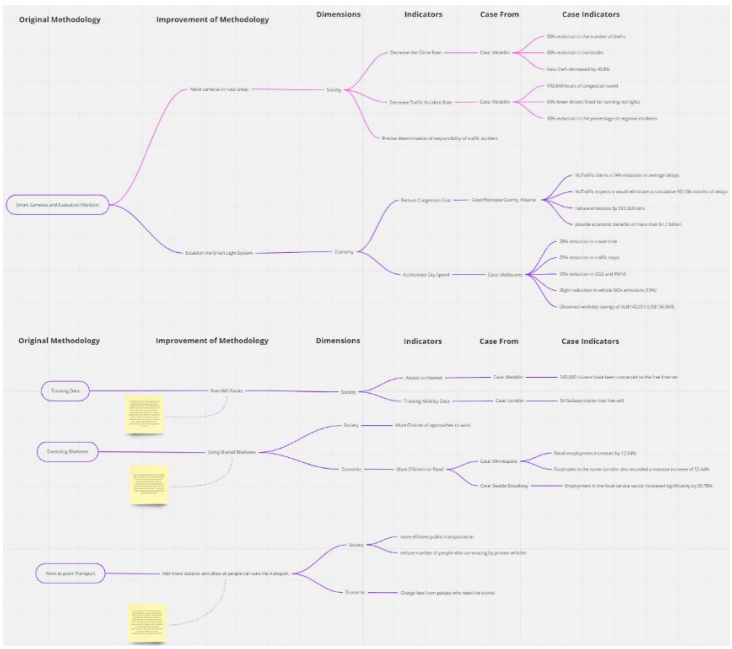

Fig 4. Improvement of Methodology

According to the priorities of dimensions that the customer introduced, we have concluded some ways to make Niteroi's transition to a smart city more accessible and efficient. It’s value noting that our group formed a problem tree at the beginning of our class, we took the problem trees as a reference, and we came up with some thoughts that we could come up some ideas that can deal with more than one problem by only improving one methodology.

Our idea is to build more cameras and sensors and build them in rural areas. With the Niteroi data, we used geocoding to maximize the density of Niteroi camera installations.

Compared to Medellin, Niteroi has very few cameras and sensors, and there is no system to connect these cameras and sensors. Resulting in essentially no solution to traffic congestion. These cameras and sensors are mainly used to limit violations by local drivers and reduce crime rates. The camera density is shown in the Figure 5:

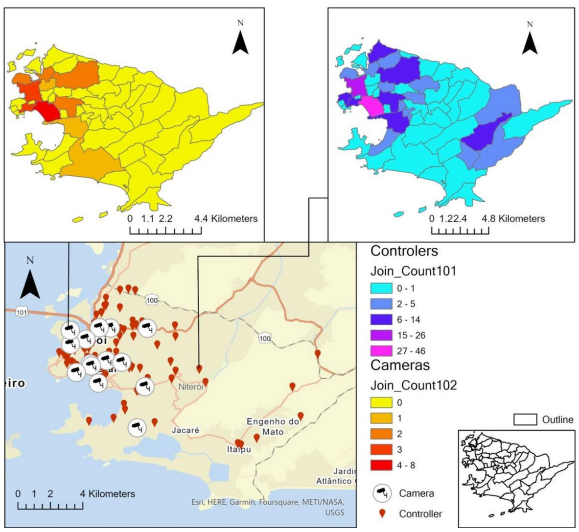

Fig 5. Niteroi Cameras and Controllers Density Distribution Map

Our group believes that Niteroi has started to regulate the traffic situation of Niteroi and reduce the crime rate through large-scale cameras and sensors.

Therefore, to improve Niteroi's existing methodology, our team believes that the number of cameras in rural areas can be increased to a certain extent, and a smart signal light system can be established. First of all, the increase of cameras in rural areas will reduce the crime rate to a certain extent, reduce car collisions or accidents on the road, and can accurately determine traffic accidents.

Our case study team found an example from Medellin for the crime rate. Here are the indicators from Medellin:

- 50% reduction in the number of thefts
- 60% reduction in homicides
- Auto theft decreased by 40.8%

Here are indicators that reduce car crashes or accidents on the road, from Medellin:

- 193,840 hours of congestion saved
- 69% fewer drivers fined for running red lights
- 18% reduction in the percentage of negative incidents

For the establishment of a smart signal light system, our team believes that this can significantly reduce the cost of congestion and speed up the pace of life in the city. That means less time is wasted on the road, and more GDP is produced. Our case study team found examples from Maricopa County, Arizona, and Melbourne, proving that improving the original methodology in this way has practical benefits.

Here are the indicators after Maricopa County adopted the smart traffic light system. The example of Maricopa County proves that the adoption of a smart traffic light system can reduce the cost of congestion:

- NoTraffic claims a 54% reduction in average delays
- NoTraffic expects it would eliminate a cumulative 93,106 months of delays
- Reduce emissions by 531,929 tons
- Provide economic benefits of more than $1.1 billion

The example of Melbourne proves that the use of intelligent traffic light systems can speed up the pace of life in the city to a certain extent. Here are the indicators from the case of Melbourne:[13]

- 28% reduction in travel time
- 25% reduction in traffic stops
- 15% reduction in CO2 and PM10
- Slight reduction in vehicle NOx emissions (13%)
- Observed workday savings of AU$ 142,051 (US$134,949).

Our group thought internet accessibility could also be improved. We believe we can develop a methodology that solves both problems of accessing the internet and tracking data. We think Niteroi could establish free WIFI points in a city like London. London's case shows that they have established many free Wi-Fi points for citizens, most of the Wifi points are located at the subway station, and 54 subway stations had free Wifi in 2019. Free Wifi Points are a handy way to track citizens' mobility stats. The United Kingdom has used this method to track citizens' data. Before citizens connect to WiFi, they will be prompted that the government will collect their mobility data and ask them whether they agree to connect. This can simultaneously track data and protect the privacy of citizens. And citizens can connect to the e-government anytime through these WiFi points.[14]

[13] Paul Stenquist,2020,https://www.nytimes.com/2020/12/10/business/smart-traffic-lights.html.

[14] James Malley,2019, https://www.wired.co.uk/article/london-underground-wifi-tracking

Medellin has also built lots of Wifi points for their citizens, so their citizens could access their e-government platform anytime and anywhere. 340000 citizens have been connected to the free internet.

According to the data by Niteroi, we think Niteroi is focusing on extending the bicycle lanes in the city. Making bicycle lanes simple and efficient is changing normal roads into Shared bike lanes. Shared Bike lanes are the ultimate budget saver, and they're super easy. For Niteroi, there are many roads where Shared Bikelanes can be implemented by lowering the speed limit and banning parking on the side of the road. It doesn't require widening the road, but simply a Shared Bikelane sign and no parking on the side of the road.

We found cases in Minneapolis and Seattle Broadway to show that shared bike lanes can create economic benefits for a city to a large extent. According to the cases of Minneapolis and Seattle Broadway, indicators in Minneapolis are Retail employment increased by 12.64%, and Food sales in the same corridor also recorded a massive increase of 52.44%. For the Seattle Broadway case, the Shared bike lane increased employment in the food service sector by 30.78%.[15]For Niteroi, the Shared bike lane is completely feasible, and simplifying the way to extend the bike lane can save more costs. In addition, the implementation speed of this method is more efficient.

Point-to-point transport is a public service provided by the Niteroi government. This transport provides the disabled person a way to travel in Niteroi. We think it’s a good approach that provides society and economic impact on local citizens. This is a good approach, but we think this transport system could provide more services and get more economic benefits. We think Niteroi could add more stations to this system, and they could open the service to all citizens in Niteroi. Niteroi might publish a certification that only disabled persons can carry, and a disabled person could use this certification using the transport system freely. If a normal person would like to use this service, they should pay some money. In this way, Niteroi could use an easy way to improve their public services and accelerate their economic impact.

- Solution Dashboard Tool
    - How it improves on Niteroi’s methods
    - Matrix of Indicators
    - Mechanics / Methodology
    - Visualization (using dummy variables)

[15] TREC,https://trec.pdx.edu/news/study-finds-bike-lanes-can-provide-positive-economic-impact-cities

SECTION IV: DATA

According to clients' demand, we summarized the smart Niteroi benchmark (see Appendix V – Smart Niteroi Benchmark) from four aspects, namely e-governance, mobile smart city, smart economy, and ethical and responsible governance. The complete benchmarks are available at: https://docs.google.com/spreadsheets/d/1YAi6WlygFITL_ouIQ3UgfPQqfMwotitbHlSJnmvbDBo/edit?usp=sharing

E-GOVERNMENT BENCHMARK

European Union's one of the top priorities is to boost the digital transformation of the government and aims to provide all key services online by 2030. Based on the European Commission's eGovernmnet Benchmark 2022, we identified four key dimensions and indicators that can be applied to Niteroi's digital transformation strategy. Niteroi's current economic impact spreadsheet overlooks the general overview of the key dimensions necessary to be highlighted. European Commission's eGovernmnet Benchmark 2022 focuses on four dimensions with 14 underlying indicators.

- **User Centricity** – To what extent are services provided online? How mobile friendly are they? And what online support and feedback mechanisms are in place? Currently about 81% of the government services are available online and 92% government websites are mobile friendly in Europe.

- **Transparency** – Are public administrations providing clear, openly communicated information about how their services are delivered? Are they transparent about policy making and digital service design processes, as well as about the way people's personal data is being processed? 58% of the government portals in Europe show whether personal data has been consulted (verifying a citizen's eligibility of public services). 43% of the services indicate the time length for the completion of the online procedure.

- **Key Enablers** – What technological enablers are in place for the delivery of eGovernment services? 67% of the services accept official electronic identification solution (eID). Moreover, the data system helps 67% of the online application to be prefilled with the previously known dataset. More than 75% of the governments

have digital mailbox solution implemented that helps users to receive and upload the online document.

- **Cross-Border Services** – How easily are citizens from abroad able to access and use the online services? And what online support and feedback mechanisms are in place for cross-border users? 46% of the services can be completed online by non-nationals (linguistic issues and only quarter of the services are accepting the eID from other European countries are the main obstacles).

These four dimensions are the benchmark European countries are currently following to achieve the digital transformation. Based on these four dimensions and 14 underlying indicators, European countries get scores ranging from 0% to 100% (Malta has 96%, Estonia has 90%, Portugal has 78%, and average score of EU27+ is 68%). The 14 underlying indicators are following:

- **User Centricity**
    - **Online availability**: the extent to which informational and transactional services and information concerning these services is provided online, and can be reached via a portal website.
    - **User support**: the extent to which online support, help features, and feedback mechanisms are available.
    - **Mobile friendliness**: the extent to which services are provided through a mobile-friendly interface, an interface that is responsive to the mobile device.
- **Transparency**
    - **Transparency of service delivery**: the extent to which the service process and expectations are clarified.
    - **Transparency of service design**: the extent to which user are informed on and involved in policy and service design processes.
    - **Transparency of personal data**: the extent to which user can manage their personal data held by government organisations.
- **Key Enabler**
    - **eID**: the extent to which electronic Identification (eID), any means accepted by eGovernment services (e.g., smartcards, username and password) for online identification, can be used during service processes.

    - **eDocuments**: the extent to which electronic documents (eDocuments), any document in digital form that the user needs to submit/upload in order to complete an eGovernment service, or that the user obtains as a proof or a result of the service (e.g., certificate, diploma, proof of registration) can be used during service processes.
    - **Authentic sources**: the extent to which Authentic Sources, base registries used by governments to automatically validate or fetch data relating to citizens or businesses, can be used during the service process.
    - **Digital post**: the extent to which public authorities allow citizens to receive communications digitally only and opt-out for paper mailings. Digital Post refers to the possibility that governments communicate electronically-only with citizens or entrepreneurs through e.g. personal mailboxes or other digital postal solutions.
    - **Security**: the extent to which government websites implemented basic security measures and internet standards.

- **Cross-border Services**
    - **Cross-border online availability**: the extent to which informational and transactional services and information concerning these services is provided online for users from other European countries.
    - **Cross-border user support**: the extent to which online support, help features, and feedback mechanisms are available for users from other European countries.
    - **eID**: the extent to which electronic Identification (eID) can be used during service processes by users from other European countries, a government-issued document for online identification, and authentication.
    - **eDocuments**: the extent to which electronic documents (eDocuments) can be used during service processes by users from other European countries, documents that have been authenticated by its issuer using any means recognised under applicable national law, specifically through the use of electronic signatures, e.g., not a regular PDF or Word file.

MOBILE SMART CITY BENCHMARK

Connected devices, distributed sensors, and Internet technologies enable cities to capture valuable data, deploy new services, and enhance existing ones, ushering in the

era of smart cities. These services can improve the efficiency of city management, create new growth opportunities for local businesses, and improve the quality of life of citizens.

- **Building Productive Partnerships**
    - Successful smart city services are often underpinned by strong partnerships between local governments, including one or more telecom operators and in many cases, a systems integrator or technology supplier.

- **Smart and interoperable ICT**
    - Most smart city projects need to leverage data from multiple sources, which may change and evolve over time. To meet this requirement, the underlying information and communication technology (ICT) architecture must be flexible and interoperable with existing urban ICT systems and a wide range of sensors.

- **Capture and distribute actionable information**
    - To be truly effective, smart city services must enable citizens and organizations to make well-informed decisions on time. As the value of information can rapidly diminish, smart city services need to capture relevant information in real-time and distribute it in a format that citizens and organizations can take immediate action on.

- **Potential business models**
    - For smart city services to continue to grow, they need to have a revenue stream that covers their costs and reflects the value they provide. In many cases, business models may view smart city ICT as a platform that becomes more valuable over time. Once the smart city infrastructure required to collect, process, store and share large amounts of data is in place, it can serve as a platform for new business opportunities using cloud services.

- **Engaging citizens and developers**
    - To have a significant impact, smart city projects need to engage citizens and application developers in a systematic and ongoing manner. Potential engagement channels include apps enabling citizens to flag everyday problems, such as potholes or vandalism, and asking citizens and app developers to help identify new service concepts and create new projects.

- **Focus on solving specific problems**
    - Today’s sophisticated ICT networks can address a wide range of challenges facing city administrations. But rather than trying to tackle many different aspects of city life simultaneously, most successful smart city programs have initially homed in on a specific problem before going on to address related issues and challenges: Start with a simple use case and expand from there.

- **The roles of mobile operators**
    - Smart city services depend on secure, reliable, and responsive connections, often delivered over the telecommunications company's wireless network. This connection can both capture valuable data from sensors and provide real-time information to citizens' mobile phones.

SMART ECONOMY BENCHMARK

With the reference to European Smart Cities Indicators (2007), New KPIs for a Smart City (2016), The CITYKeys Indicators (2017), Mckinsey Institue Report (2018), and ESG framework (e.g., GRI, SASB, CDP), the smart economy aims to promote economic development and livelihood through digital transformation. Key elements are as follows:

- **Economic Performance**
    - Successful smart cities need sufficient economic performance, which can be strongly reflected through groos revenue, net revenue, and growth rate.

- **Entrepreneurship**
    - Enterprises are the main undertakers of commodity production and circulation, and the main participants in market economic activities. To help promote the smart economy, good entrepreneurship can be measured through 5 indicators: employment, equity, ability to transform, productivity, and attractiveness, competitiveness.

- **Cost**

- Control and manage costs are quite important, no matter what kind of economic evaluation. We focus on the indicators of cost performance and cost of living, to ensure competitive in local markets and sufficient to support a sustainable standard of development.

- **Green Economy**
    - For continuous smart city operations, it is recommended to focus on green economy to maintain long-term development and show environmental, social and governance (ESG) responsibilities. We summarized 4 indicators to measure, namely consumption, clean energy use, loss by natural disasters, and investment in pollution.

- **Innovation**
    - Innovation constitutes the primary productive force. High R&D investments can predict the opportunities and crises of cities to help cities improve their competitiveness.

ETHICAL AND RESPONSIBLE GOVERNANCE BENCHMARK

The ethical and responsible governance act as a significant role towards achieving digital transformation. In collaboration with Deloitte, World Economy Forum published the white paper on governing smart cities in July 2021, from which we identified five key dimensions with 14 underlying indicators. The key elements are as follows:

- **ICT Accessibility**
    - To promote equity, inclusivity and social impact, we recommend to build ICT accessibility standards into procurement to ensure digital -related services are accessible to all stakeholders, especially to those with disabilities. Public services and verification of conformance are main indicators.

- **Privacy Impact Assessment**
    - To ensure privacy and transparency, we suggest defining processes to assess privacy implications of urban technology deployments, with indicators of organizational values for privacy, privacy training and awareness, and senir officer (PIAs).

- **Cyber Accoutability**
    - For security and resilience, we recommend defining key accountability measures to be taken in order to protect the assets of cities and citizens, with indicators of accountability to senior leaders, regular review framework, and updated ICT inventory.

- **Digital Infrastructure**
    - For operational and financial sustainability, it would be better to set out planning policies that improve coordination among city stakeholders and reduce the cost and complexity of digital infrastructure roll-out, with indicators of policy in written form, list of notifiable activities, political structure, and advanced GIS.

- **Open Data**
    - To promote openness and interoperability, we strongly suggest developing a model policy for open data strategy, with the consideration of value and cost of open platform and level of trust.

METRICS SYSTEM & DASHBOARD DESIGN

- **Demand of Design**
    - According to the suggestions and recommendations from Niteroi smart city team, the metrics system and the dashboard should mainly focus on the economic status of Niteroi city, should take the comparable city (such as Rio de Janeiro or Medellin) as a mocking model, and should take future expansion into consideration. Also, the client has also requested the dashboard meeting the international standard.

- **Solution Part A:** Sustainable Development Goal Framework and Indicators
    - Sustainable development Goals are the core of the 2030 Agenda for Sustainable development and have been used by all member states to guide their sustainable development and transmission. The 17 SDGs marks that ending poverty and other deprivations need international cooperation. Improving economic growth, reducing inequality and

injustice, promoting health care and education system are all included in SDGs.

- Sustainable Development Goals indicators are a set of indicators used by UN in order to track the progress of member states' application of the 2030 Agenda. The SDG Indicators should be disaggregated, where relevant, by income, sex, age, race, ethnicity, migratory status, disability and geographic location, or other characteristics, in accordance with the Fundamental Principles of Official Statistics[16].

- Based on the needs and requirements of clients, we merged SDG indicators in the Metrics System, as the part represents international cooperation and Nitetoi's vision toward sustainable development. Based on clients' focus, the economic indicators (SDG 1 related) would be put into the metrics system in stage 1.

- **Solution Part B:** Custom Metrics System
  - Based on the clients' needs, SDG framework, and evaluation metric from case study team, the Niteroi Urban Dashboard Metrics System (see Appendix IV - Niteroi Urban Dashboard Metrics System) is available at: https://docs.google.com/spreadsheets/d/1YAi6WlygFITL_ouIQ3UgfPQqfMwotitbHlSJnmvbDBo/edit?usp=sharing.

[16]SDG Indicators, https://unstats.un.org/sdgs/indicators/indicators-list/

SECTION V: SOLUTION

DISCUSSION OF IMPLICATION

- AI / Ethics
- Transparency

As robust and sensitive data is becoming more in-demand to make informed urban planning decisions it's imperative to have a note on the Artificial Intelligence (AI) Ethics and digital transparency relevant to the scope of this project. A major concern is data privacy and ensuring that individual peoples' sensitive information is kept private and/or anonymous. The data provided by Niteroi's City Government and the data for the city's digital transformation is entirely open data with no private entity involvement in its collection. Moreover, this data is compliant with Brazil's General Data Protection Law, Lei Geral de Proteção de Dados (LGPD) (Usercentrics 2022). The law came into effect in August 2020 and is enforced by the Autoridade Nacional de Proteção de Dados (ANPD), the National Data Protection Authority. LGPD outlines enforceable privacy requirements for personal data collection in Brazil. Generally, the data collected by the city does not have personal information, however traffic-camera data that possesses license plate information is also subject to the LGPD to ensure privacy. A second important concern for AI Ethics is ensuring transparency of data. The data was reportedly collected by the municipality and should cover the whole population of Niteroi. Since the data is open data, it is available for use by the public, private entities, university researchers, and even by other countries.

VALUE PROPOSITION AND CONCLUSION

The value proposition map presented highlights not only the goal of Niteroi's Smart City Master Plan, but also the stakeholder needs in order to drive those goals. Our value proposition states that our dashboard solution addresses these needs as well as improves upon the Master Plan already developed, by improving the methodology to track its Goals. It also makes progress towards two of the Smart City goals by incorporating citizen participation through technology. The dashboard allows citizens to access and easily understand the progress of the city, which could be incorporated into the Niteroi's city government website / app of city services. Our analysis also provides

recommendations for considering additional metrics that may better track the progress of initiatives based on case studies and literature review conducted (see Figure 6).

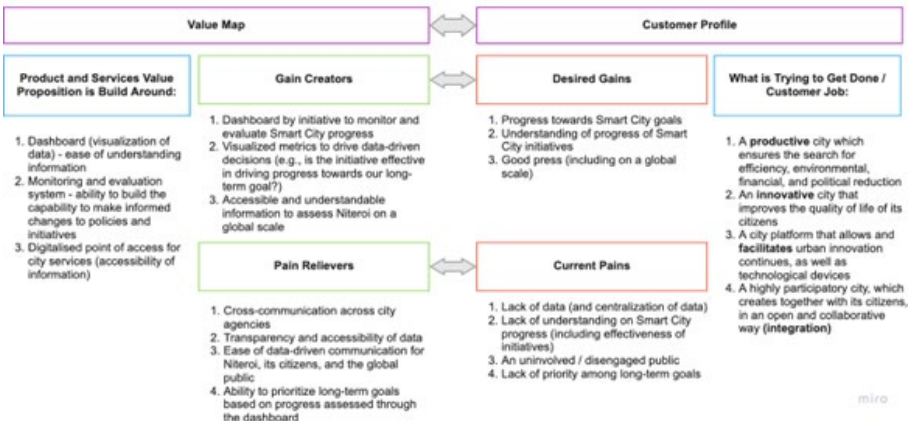

Fig 6. Value Proposition Map

RECOMMENDATIONS FOR NEXT STEPS

In terms of next steps towards driving change, we propose the following recommendations. First, we recommend that the appropriate data collected for the Smart City initiatives (below) be used to replace the dummy data in our prototype dashboard.

- **Smart City Initiatives**
    - We also recommend considerations to incorporate some of our recommended metrics and collecting additional data from those metrics as additions to the data that already exists. Doing so will provide a more conclusive and accurate representation of progress made towards each of the initiatives you have outlined. You should also consider the ethics of the monitoring and accessibility of data in your selection. However, a result of an increased data system can improve the collaboration between city agencies and integration of future policies and solutions.

    - Next, we recommend refining your monitoring and evaluation (M&E) system to assess your dashboard over time. The dashboard may reveal issues in progress from specific initiatives. By recognizing that an issue exists, you can take the following steps to improve your system. First, conducting an M&E exercise will help you determine whether the

indicators you are using to measure progress in your initiatives are appropriate. See below for an example.

Table 2. M&E Framework Table

	Definitions	Indicators	Means of Verification	Assumptions
Impacts	Saved time for households / citizens	# of citizens that utilize services through digital website	Annual digitalized service audit	X
Outcomes	Streamlined services to citizens	# of citizens that have access to the Internet	Verification that workers and citizens are able to access the dashboard	Digitalization system work with no flaw, data structure has no problem, citizens have access to internet, citizens understand how to access digitalized services
Outputs	Digitalized system of data	# of the documents have been digitalized	Government branches are equipped with digital systems	Digitalization system work with no flaw, data structure has no problem
Inputs	Transforming paper documents to the digitalized documents	Build the digital transformation system, digitize all documents	Verification of resources and capabilities available	Government resources to convert paper documents to digital documents; there is a database available to hold these resources

Additionally, perhaps the metrics you are using to assess your initiative is appropriate but the initiative itself is not appropriate from driving the results and progress towards your long-term city goals. If the latter is true, we hope our recommended methodology, metrics, and case study examples can help inspire changes to your monitoring system (i.e., data you are using to measure progress). Additionally, engaging stakeholders, particularly the public, can help inform better metrics and initiatives to incorporate into the Master Plan. If the issue is not the metric nor the initiative, stagnated progress can be a result of bad policy or an outstanding blockade against the initiative. In either scenario, the next step is to conduct research, get policy advising, and engage stakeholders to come up with a solution to remove or mitigate the obstacle causing the issue.

All in all, the process to ensure progress towards change is a cycle of trial and error, in which prototyping interventions through data-driven decisions will help you determine whether the city government is implementing the right policies and solutions to help enact change.

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TREC, Study Finds Bike Lanes Can Provide Positive Economic Impact in Cities, https://trec.pdx.edu/news/study-finds-bike-lanes-can-provide-positive-economic-impact-cities

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Appendix

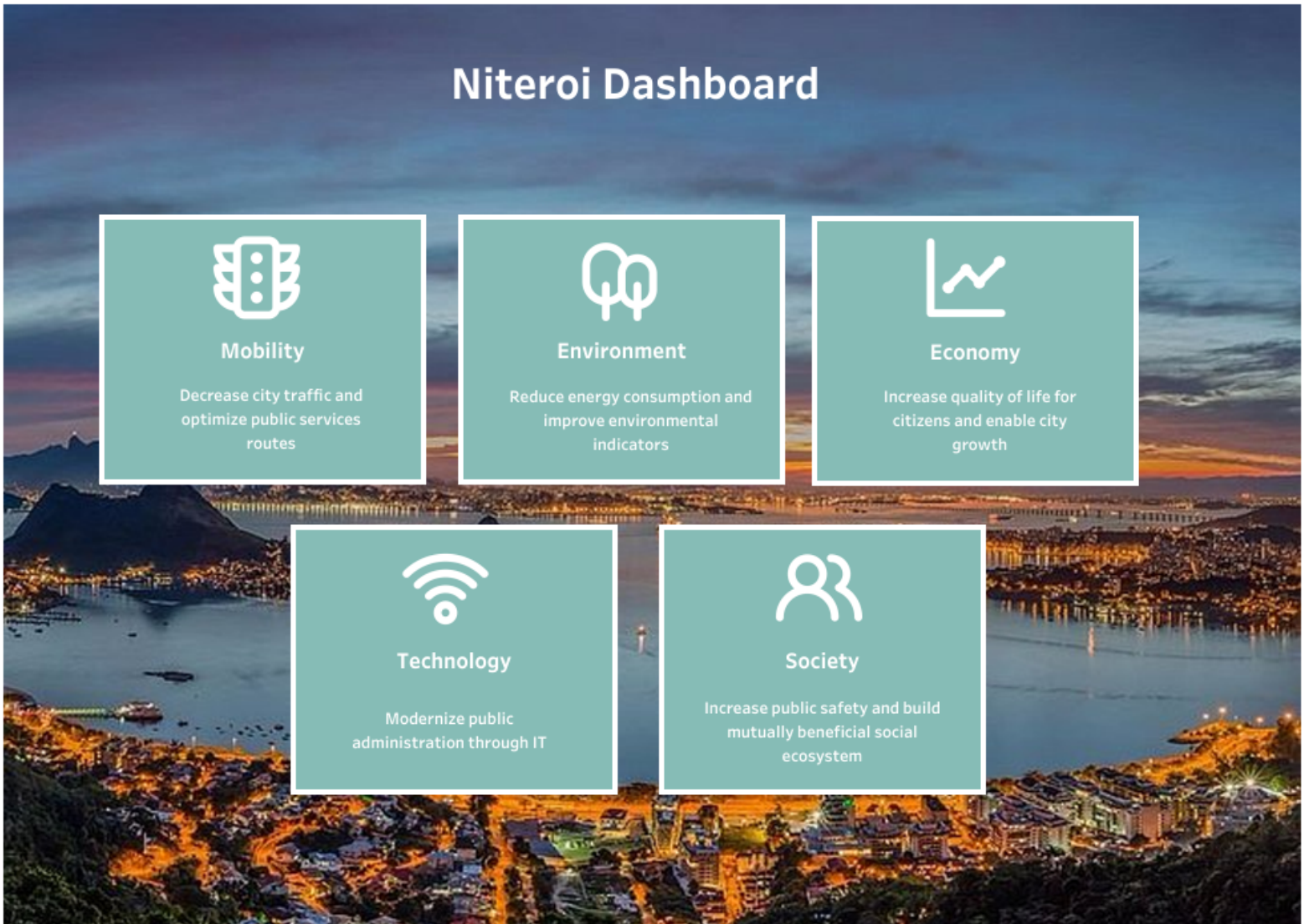
Appendix I - Niteroi Dashboard (6 pages)

Appendix II - Niteroi Evaluation Metric based on Case Study (3 pages)

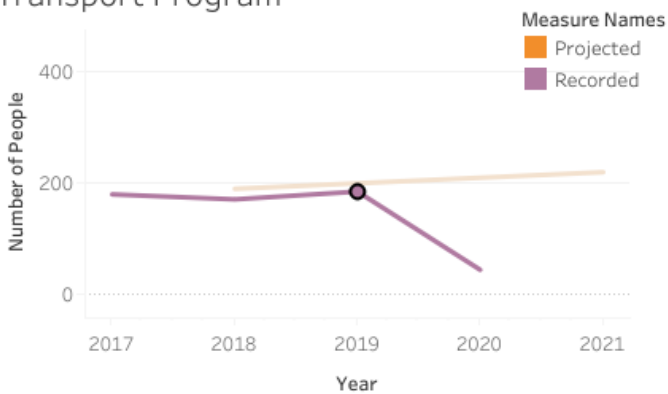
Appendix III - Analytic Hierarchy Report of Smart Niteroi Metric (5 pages)

Appendix IV - Niteroi Urban Dashboard Metrics System (2 pages)

Appendix V - Smart Niteroi Benchmark (2 pages)


Niteroi Dashboard
Mobility
Decrease city traffic and optimize public services routes
Environment
Reduce energy consumption and improve environmental indicators
Economy
Increase quality of life for citizens and enable city growth
Technology
Modernize public administration through IT
Society
Increase public safety and build mutually beneficial social ecosystem

People Assisted By Ponto A Ponto Transport Program



193,840 hours of congestion saved

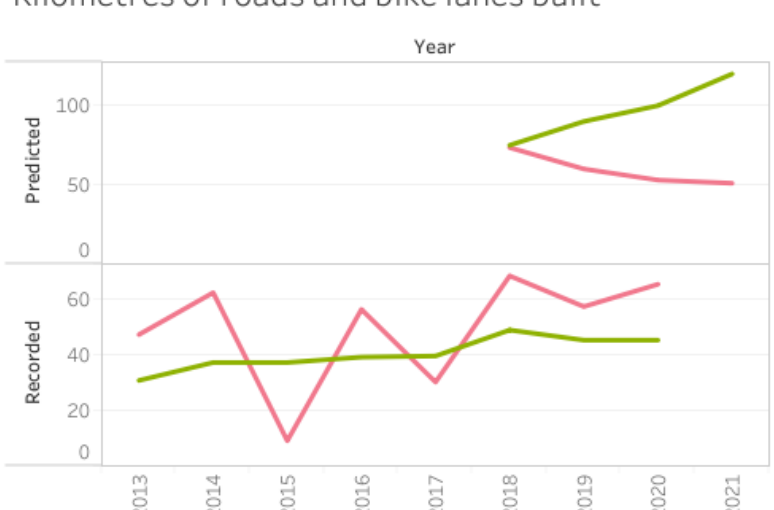
28% reduction in travel time

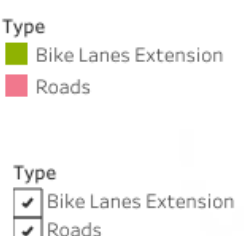
25% reduction in traffic stops

600+ smart traffic lights installed

69% fewer drivers were fined for running red lights

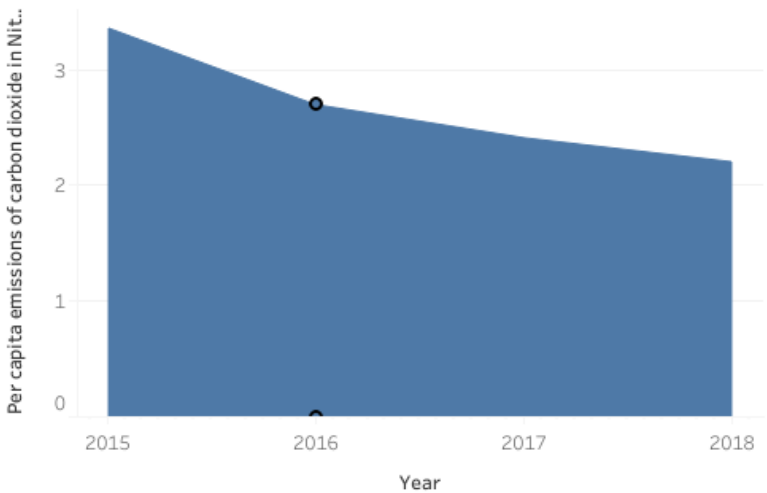
Kilometres of roads and bike lanes built





Note: Data values in text are based on case study data

Per capita emissions of carbon dioxide In Niterói

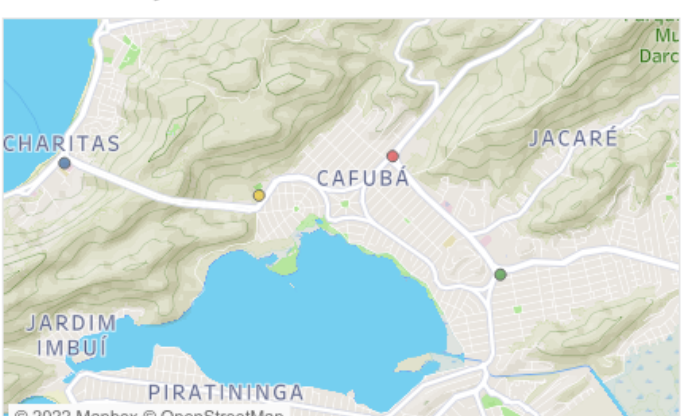


15% reduction in CO2 and PM10

Reduced emissions by **531,929 tons**

Slight reduction in vehicle NOx emissions (**13%**)

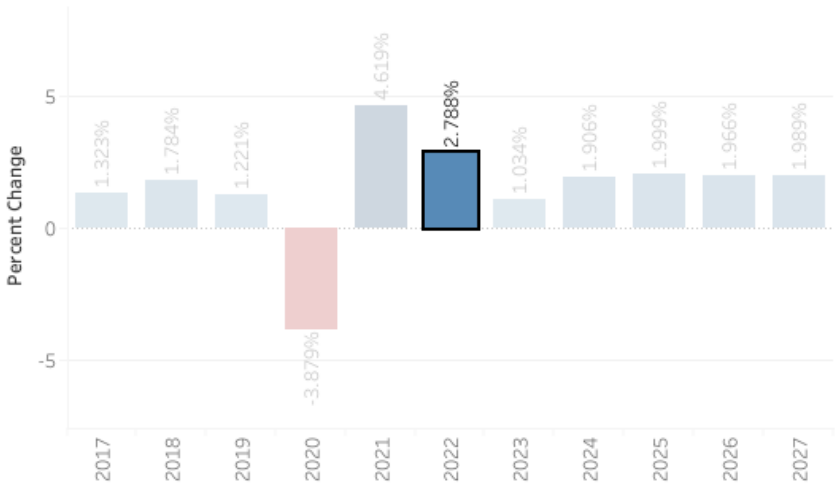
Air Quality Stations in Niteroi



Address
- Avenida Quintino Bocaiúva, s/n - São Francisco
- Estrada Francisco da Cruz Nunes, 1810 - Itaipu
- Estrada Francisco da Cruz Nunes, s/n - rotatória
- Estrada Francisco da Cruz Nunes, s/n, Itaipu
- R. Manoel Pacheco de Carvalho, 14 - Piratininga
- Rua Raul de Oliveira Rodrigues, 2600

Note: Data values in text are based on case study data

GDP Growth Rate



12.64% increase in retail emploment

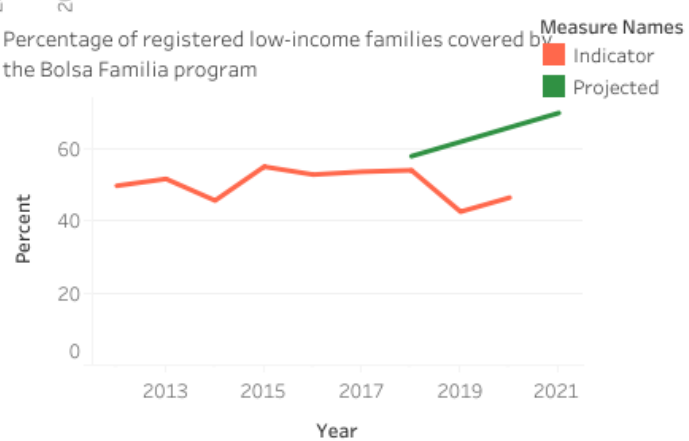
30.78% increase in food service sector

$134,949 Workday Savings

Economic Benefits of **$1.1 billion**

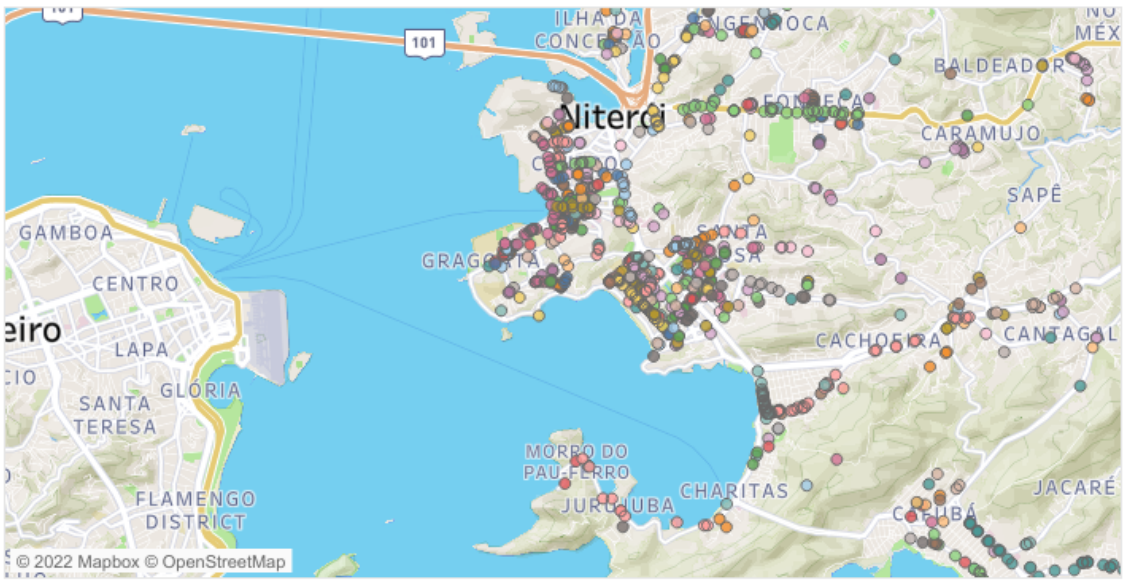
Share of population below poverty line

Percentage of registered low-income families covered by the Bolsa Familia program

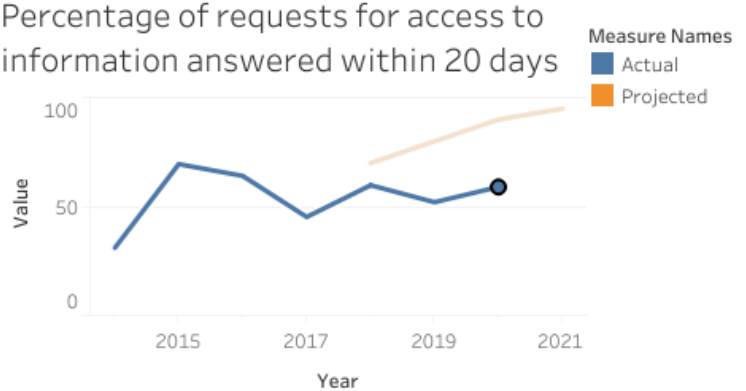


Note: GDP Growth Rate and Below Poverty Line charts are based on Brazil's country wide data
Text Improvements are based on case study data.

City Wi-Fi Hotspots



Percentage of requests for access to information answered within 20 days



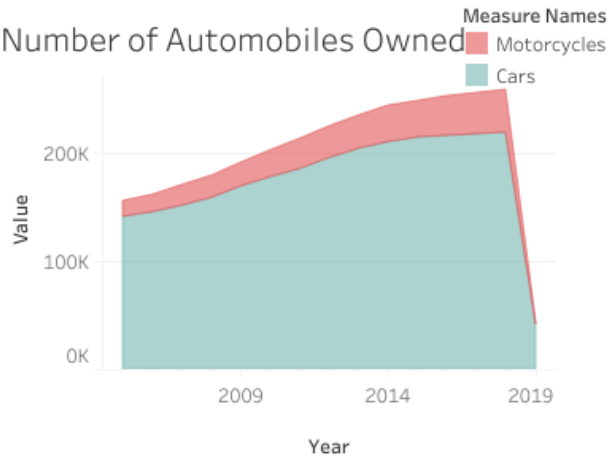
27% of buildings with smart electricity meters

54% of payments to city paid electronically

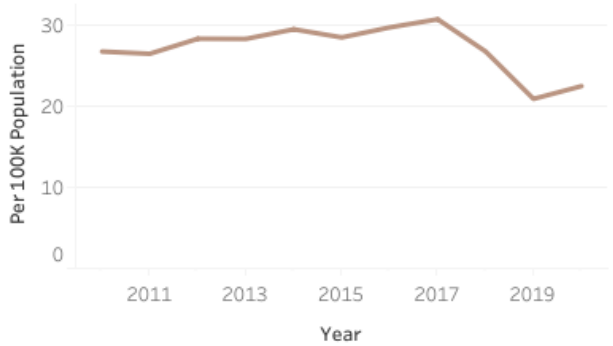
Average Internet Bandwidth **44,503 Bits/sec**

Note: City Wi-Fi Data is modelled off of restaurant location data in Niteroi
Text Improvements are based on case study data.

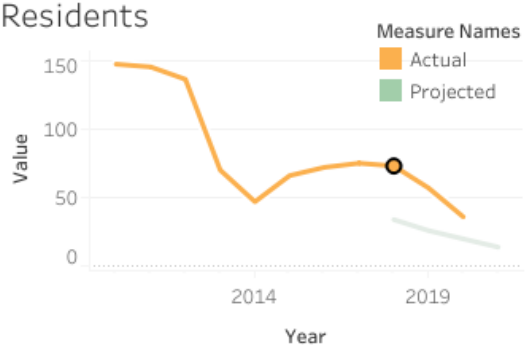
Number of Automobiles Owned



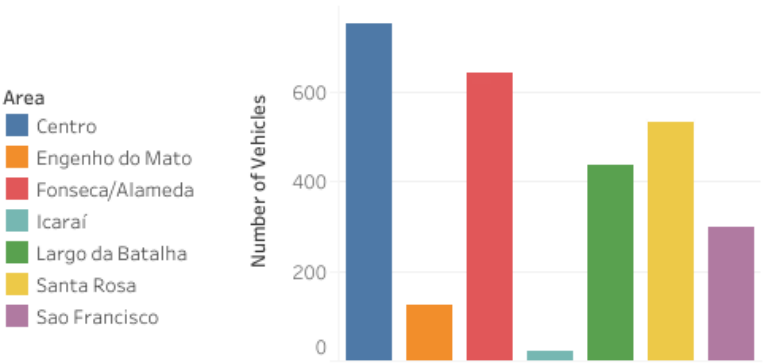
Crime Rate in Niteroi



Traffic Fatality Per 100,000 Residents



Vehicle Entry on 12th Dec,2022



Note: Vehicle Entry assumes random data

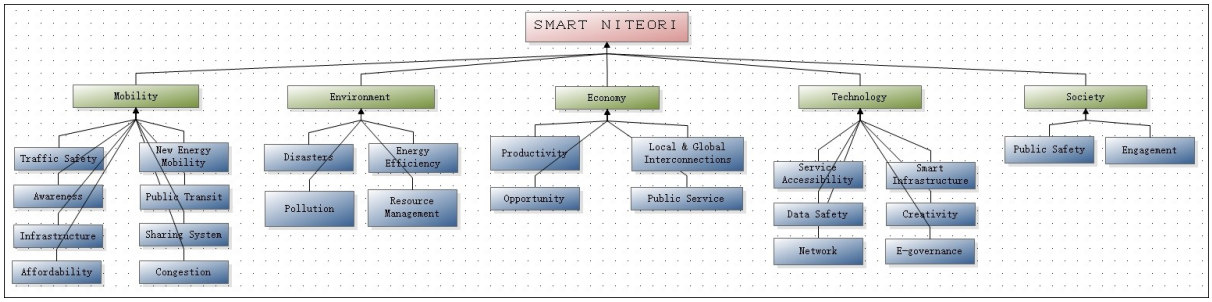
Smart City Objectives	Definitions	Dimensions	Weights	Indicators
Mobility 0.2606	Services focused on measuring commuting in the city, decreasing city traffic density and citizen driving times, and optimizing public services routes.	Sharing System (example: SIMM from Medellin)	0.0204	Existence of integrated ticketing option across transport modes(T/F)
				% of private car dependency
				Existence of open data or APIs for transport(T/F)
				Carsharing/Bikesharing system in the city(T/F)
				Number of users of sharing economy per 100 000 populaton
		Traffic Safety	0.0458	% reduction in crash rate per 10,000 vehicles
				the crash rate per 10,000 vehicles % reduction in crash rate
				% reduction in accident rate per 10,000 vehicles
				% reduction in response time to traffic crashes
				% negative events (responses to false alarms) decreased
				% population that feel safe walking alone at night around the area they live
				% fewer drivers were fined for running red lights
		Awareness	0.0308	% fewer drivers were fined for speeding
				% reduction in photo detections for speeding
				%vehicles need to undergo photo inspection
				Response time to incidents of 15 minutes or less increased by %
		Infrastructure	0.0374	# of visualizations with video analytics camera
				# of electronic traffic violation detection cameras
				Total # of camera
				Coverage % of facilities and integrated management of the smart system
				Coverage and Utilization of Integrated ICT
				Automating pricing depending on traffic
		Congestion	0.0412	hours of congestion time saved
				# of smart traffic lights
				Driving time to city center (10 km drive from each cardinal direction, peak hours)
		Public Transit	0.0542	% of metro/tram/bus delays
				Average waiting time for public transit (in minutes)
				Dedicated bus lane in km
				Rail system length in km
				Accessibility of public transport (types and coverage of public transport)
				Dedicated bus lane in km
				Rail system length in km
				Number of rail system stops
				Accessibility of bus fleet (in %)
				Metro/bus average peak frequency
		Affordability	0.204	Modal share divided into percentage of transportation methods
				Monthly public transport cost (in US$)
				Fuel price per liter (in US$)
				Average parking price (in US$)
				Average cost of taxi (in US$)
				Minimum daily wage (in US$
				Modal share divided into percentage of transportation methods
		New Energy Mobility	0.0102	share of environmental sustainable transportation (public transport, walking, cycling, etc)
				Number of Low CO2 vehicles (BEV or PHEV) registered
				% EV adoption

Smart City Objectives	Definitions	Dimensions	Weights	Indicators
Environment 0.0643	Services whose main motivation is to reduce energy consumption (GHG, electricity, oil and gas, water, etc.), to better manage waste, or to improve environmental indicators.	Disasters	0.0226	# of Sensor
				# of monitoring network
		Energy Efficiency	0.0122	gy can be produced when Replacing 70W bulbs that consume 81W with 40W LED bulbs
		Pollution	0.0226	% improvement of Environment over the 2014 target
				Distribution of noise monitoring and management facilities
		Resource Management/ Material Footprint	0.007	% of Garbage Collection/ % of waste recycling
				Electricity production from renewable sources (%)
				Automation Coverage of electrical, solar, tidal, and wind network
				Modal share of renewable energy (solar power & wind power)
				Change in land consumption per capita (squared metre per capita)
Economy 0.3595	Services focused on modernizing how city businesses are performing and enabling city growth, and increase the quality of life for citizens	Public Service	0.1523	
		Productivity	0.0816	% of Colombia's gross domestic product (GDP)
				% of Gross National Product (GNP)
				Grew by % with a per capita GDP of $8,489
				GDP/capita evolution
				Total amount of research output
				Gini index of disposable income (after taxes and transfers) (from 0 to 1)
				Change in the unemployment rate
				Change in population structure (Rate of death, births and migration)
				Change in poverty rate
				Change in unemployment rate
				Per Capita Consumption (PCC)
				Ratio between average disposable income of top and bottom quintiles
		Opportunity	0.044	Improvement of employment % thanks to the intelligent system
		Local & Global Interconnectedness	0.0816	Growth % of the total development of the regional economy
		Network		% of Medellín's population is an Internet user
				Total amount of community centers with access to ICTs
				The amount of citizens connect to free WIFI that support the community progress
				Engagement % for workshops and courses
				Utilization % of public information (disclosure) platforms
				% households equipped with internet, wireless broadband coverage
				% of households who use digital apps of platforms to connect local communities
				% of social media accounts penetration
				% of active mobile (fixed) broadband subscribers
				% of households with computers
				% of mobile subscribers

Smart City Objectives	Definitions	Dimensions	Weights	Indicators
		Engagement	0.0648	% app use for smart collaboration and communication
Technology 0.1895	Services focused on modernizing public administration through IT and mobile solutions to better allocate city resources, increase transparency, and prioritize investments thanks to an integrated view of the city.			
			0.0315	Performance of public transport network (ratio between accessibility and proximity to amenities people)
				People satisfied with public transport (%)
				Average commuting time to place of work (minutes)
				Capability to collect, process and output real-time information/data
		Service Accessibility	0.0336	% of job seekers who have access to e-career centers
				% of children who have access to e-learning platforms
				% of students with digital learning devices (laptops, tablets, etc.)
				% medical appointments conducted remotely
				% of population with online access to their health file
				% of population registered with public alert systems for air and water quality
				% of population equipped with real-time alert system
		Smart Infrastructure	0.0201	Percentage of city area with smart grid
				% of households equipped with smart energy meters
				% of buildings with smart electricity meters
				% of smart street lights
				% of households equipped with smart water meters
				lrinking water under water quality monitoring by real-time water quality monitoring station
				% of buildings equipped with smart waste system
				% change in output of a system
				Existence of Machine readable travel documents (MRTD)(T/F)
				Existence of Personal identity verification(T/F)
				Existence of Secure industrial control systems (ICs)(T/F)
				Numbers of smart censoring devices across city
				Numbers of smart cards (card operating system)
		E-governance	0.0542	# of Phone call to access the mayor's office
				Number of municipal smart stations installed per 100 000 population
				% of payments to the city that are paid electronically
				Digital land-use nad building permits
				% of city services available online
		Data Safety	0.0336	Coverage of telesupervision
				Data transparency, right to know data processing
		Creativity	0.013	# of Citizens' thoughts
				# of Users on public platform
				People from 25 to 64 years old with at least tertiary education (%)
				Total number of research institutions and personnel
				Way for platform composition, and the collection of ideas and inspiration from citizens
Society 0.1297		Public Safety	0.0648	On the surface, the homicide rate declined, at 69.6 per 1,000 people.
				Domestic violence cases decreased by %
				The number of auto theft cases decreased by %
				Burglaries of financial entities decreased by %
				% decrease in the number of homicides compared to the baseline
		Engagement	0.0648	% app use for smart collaboration and communication

Analytic Hierarchy Report of SMART NITEROI METRIC

(2022/11/08)



Ranking weight of the elements in the alternative layer for the Smart Niterói

Alternative	Criterion	Weight
Public Service	Society	0.1523
Local & Global Interconnections	Economy	0.0816
Productivity	Economy	0.0816
Public Safety	Society	0.0648
Engagement	Economy	0.0648
Public Transit	Mobility	0.0542
E-governance	Technology	0.0542
Traffic Safety	Mobility	0.0458
Opportunity	Economy	0.0440
Congestion	Mobility	0.0412
Infrastructure	Mobility	0.0374
Data Safety	Technology	0.0336
Service Accessibility	Technology	0.0336
Network	Technology	0.0315
Awareness	Technology	0.0308
Disasters	Environment	0.0226
Pollution	Environment	0.0226

Sharing System	Mobility	0.0204
Affordability	Mobility	0.0204
Smart Infrastructure	Technology	0.0201
Creativity	Technology	0.0130
Energy Efficiency	Environment	0.0122
New Energy Mobility	Mobility	0.0102
Resource Management	Environment	0.0070

Ranking weight of the elements in the criterion layer for the transformation of Smart Niterói

Criteria	Weight
Economy	0.3595
Mobility	0.2606
Technology	0.1859
Society	0.1297
Environment	0.0643

1. **Smart Niterói | Consistency ratio: 0.0224; Weight to " Smart Niterói ": 1.0000; λmax: 5.1003**

Smart Niterói	Mobility	Economy	Environment	Technology	Society	Wi
Mobility	1.0000	0.5000	4.0000	2.0000	2.0000	0.2606
Economy	2.0000	1.0000	5.0000	2.0000	2.0000	0.3595
Environment	0.2500	0.2000	1.0000	0.3333	0.5000	0.0643
Technology	0.5000	0.5000	3.0000	1.0000	2.0000	0.1859
Society	0.5000	0.5000	2.0000	0.5000	1.0000	0.1297

2. Mobility | Consistency ratio: 0.0145; Weight to " Smart Niterói "：0.2606; λmax: 8.1430

Mobility	Traffic Safety	Awareness	Infrastructure	New Energy Mobility	Sharing System	Congestion	Affordability	Public Transit	Wi
Traffic Safety	1.0000	2.0000	1.0000	5.0000	2.0000	1.0000	2.0000	1.0000	0.1758
Awareness	0.5000	1.0000	1.0000	3.0000	2.0000	0.5000	2.0000	0.5000	0.1184
Infrastructure	1.0000	1.0000	1.0000	4.0000	2.0000	1.0000	2.0000	0.5000	0.1437
New Energy Mobility	0.2000	0.3333	0.2500	1.0000	0.5000	0.2500	0.5000	0.2500	0.0393
Sharing System	0.5000	0.5000	0.5000	2.0000	1.0000	0.5000	1.0000	0.5000	0.0782
Congestion	1.0000	2.0000	1.0000	4.0000	2.0000	1.0000	2.0000	0.5000	0.1582
Affordability	0.5000	0.5000	0.5000	2.0000	1.0000	0.5000	1.0000	0.5000	0.0782
Public Transit	1.0000	2.0000	2.0000	4.0000	2.0000	2.0000	2.0000	1.0000	0.2081

3. Economy | Consistency ratio: 0.0039; Weight to " Smart Niterói "：0.3595; λmax: 4.0104

Economy	Productivity	Opportunity	Local & Global Interconnections	Public Service	Wi
Productivity	1.0000	2.0000	1.0000	0.5000	0.2270
Opportunity	0.5000	1.0000	0.5000	0.3333	0.1223
Local & Global Interconnections	1.0000	2.0000	1.0000	0.5000	0.2270
Public Service	2.0000	3.0000	2.0000	1.0000	0.4236

4. Environment | Consistency ratio: 0.0039; Weight to " Smart Niterói "：0.0643; λmax: 4.0104

Environment	Disasters	Pollution	Resource Management	Energy Efficiency	Wi
Disasters	1.0000	1.0000	3.0000	2.0000	0.3509
Pollution	1.0000	1.0000	3.0000	2.0000	0.3509
Resource Management	0.3333	0.3333	1.0000	0.5000	0.1091
Energy Efficiency	0.5000	0.5000	2.0000	1.0000	0.1891

5. Technology | Consistency ratio: 0.0158; Weight to " Smart Niterói "：0.1859; λmax: 6.0992

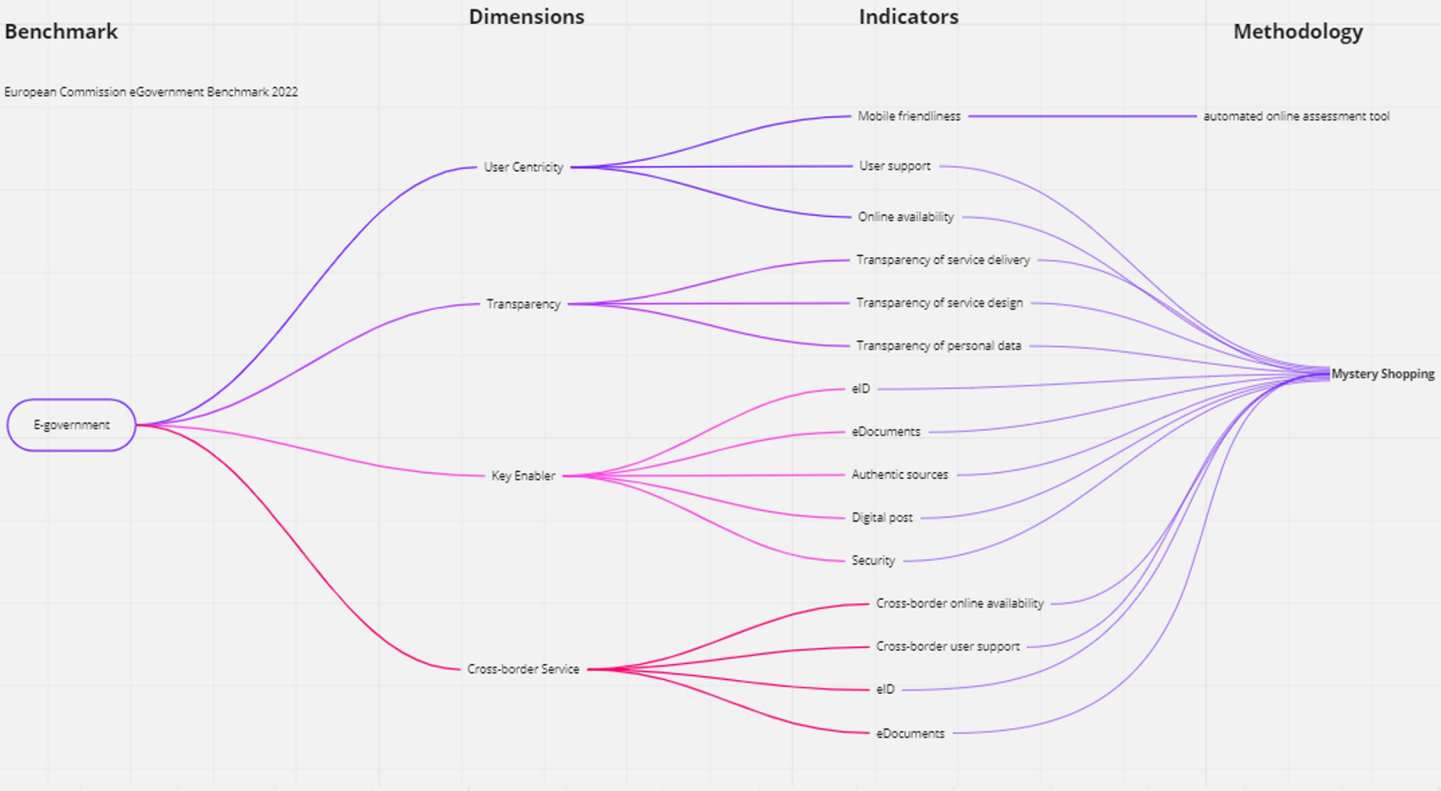
Technology	Service Accessibility	Data Safety	Creativty	Network	E-governance	Smart Infrastructure	Wi
Service Accessibility	1.0000	1.0000	3.0000	1.0000	0.5000	2.0000	0.1807
Data Safety	1.0000	1.0000	3.0000	1.0000	0.5000	2.0000	0.1807
Creativity	0.3333	0.3333	1.0000	0.5000	0.3333	0.5000	0.0699
Network	1.0000	1.0000	2.0000	1.0000	0.5000	2.0000	0.1692
E-governance	2.0000	2.0000	3.0000	2.0000	1.0000	2.0000	0.2916
Smart Infrastructure	0.5000	0.5000	2.0000	0.5000	0.5000	1.0000	0.1080

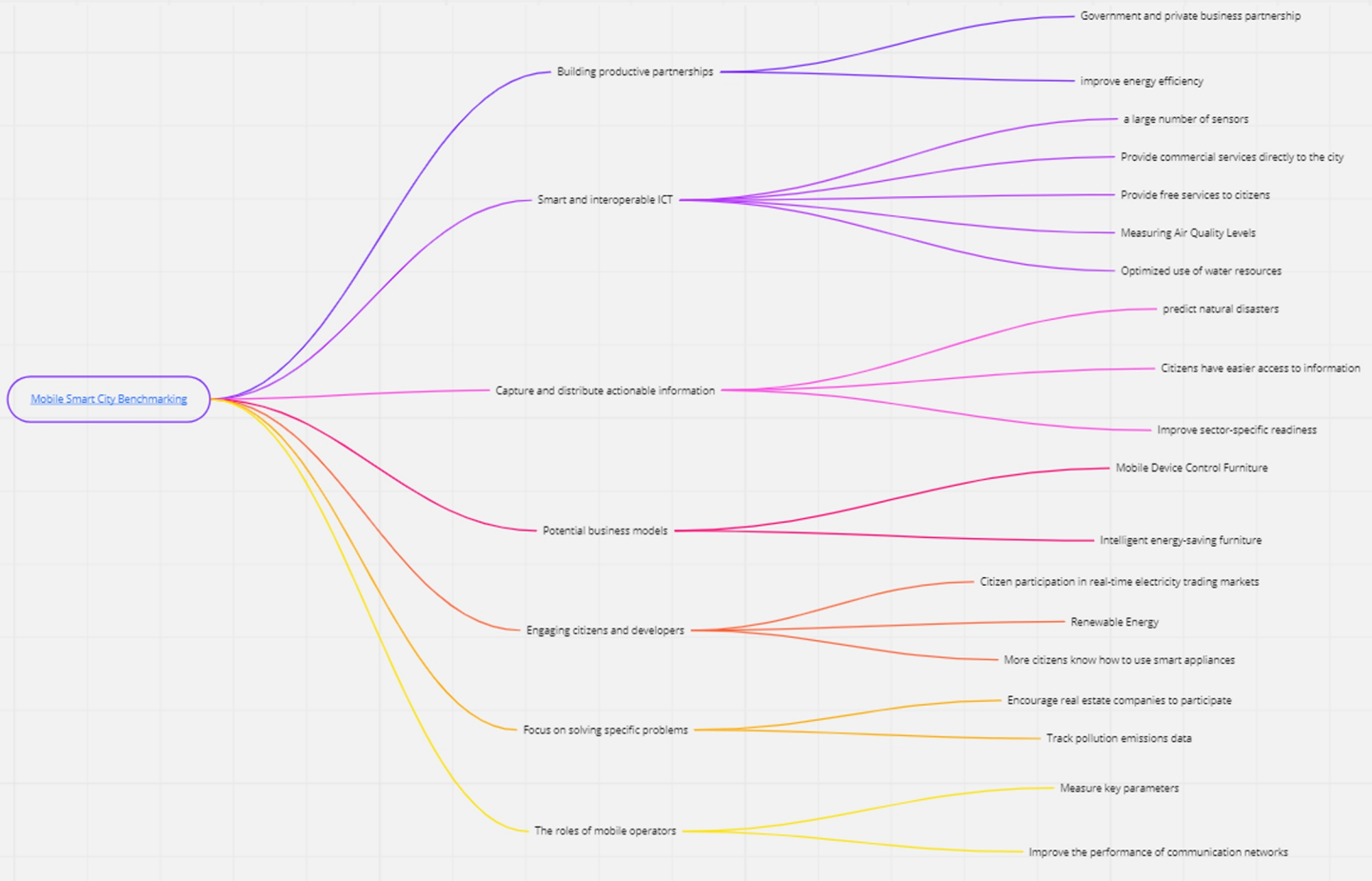
6. Society | Consistency ratio: 0.0000; Weight to " Smart Niterói "：0.1297; λmax: 2.000

Society	Engagement	Public Safety	Wi
Engagement	1.0000	1.0000	0.5000
Public Safety	1.0000	1.0000	0.5000

Dashboard Modules	Definitions	Dimensions	SDG Indicators	Indicators
Economic Status (Priority)	Includes city and regional economic status, in order to track the development of Niteroi	General	/	Niteroi's gross domestic product (GDP)
			/	Grew by % with a per capita GDP of $8,489
		Poverty	1.1.1	Proportion of the population living below the international poverty line by sex, age, employment status and geographic location (urban/rural)
			1.2.1	Proportion of population living below the national poverty line, by sex and age
			1.2.2	Proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions
		Productivity	/	GDP/capita evolution
			/	Total amount of research output
			/	Gini index of disposable income (after taxes and transfers) (from 0 to 1)
			/	Ratio between average disposable income of top and bottom quintiles
		Opportunity	/	Improvement of employment % thanks to the intelligent system
		Local & Global Interconnectedness	/	Growth % of the total development of the regional economy
Traffic Status (Urgent and Next Step)	Monitoring the Traffic system's operation in order to optimize the governance in short term and planning in long term	Traffic Safety	/	monthly car accident case
			/	Daily crash cases reported to Police including geospatial and time
			/	case by case Responce time of Polices including geospatial and time
			/	geospatial and time negative events (responses to false alarms)
			/	Incidents of running red lights including geospatial and time
			/	geospatial and time drivers were fined for speeding
			/	hours of congestion time saved
		Infrastructure	/	Coverage % of facilities and integrated management of the smart system
			/	Coverage and Utilization of Integrated ICT
			/	Automating pricing depending on traffic
		Mixed-model Access	/	Accessibility of public transport (types and coverage of public transport)
		Clean & non-motor-ized mobility	/	% of walking, cycling, public transportation, clean energy transportation, etc.
			/	% EV adoption
Public Service Coverage (Necessary)	Services focused on modernizing public administration through IT and mobile solutions to better allocate city resources, and prioritize investments thanks	Access to Service	/	Utilization % of public information (disclosure) platforms
			/	% population with Internet access
			/	Performance of public transport network (ratio between accessibility and proximity to amenities people)
			/	People satisfied with public transport (%)
			/	Average commuting time to place of work (minutes)
			/	Capability to collect, process and output real-time information/data
			1.3.1	Proportion of population covered by social protection floors/systems, by sex, distinguishing children, unemployed persons, older persons, persons with disabilities, pregnant women, newborns, work-injury victims and the poor and the vulnerable
			1.4.1	Proportion of population living in households with access to basic service
			1.a.2	Proportion of total government spending on essential services (education, health and social protection)

Dashboard Modules	Definitions	Dimensions	SDG Indicators	Indicators
	to an integrated view of the city.		1.b.1	Pro-poor public social spending
		Data Safety	/	Coverage of telesupervision
			/	Data transparency, right to know data processing
		Creativity	/	People from 25 to 64 years old with at least tertiary education (%)
			/	Total number of research institutions and personnel
			/	Way for platform composition, and the collection of ideas and inspiration from citizens
Environment & Social Justice (Recommend)	Services whose main motivation is to reduce energy consumption (GHG, electricity, oil and gas, water, etc.), to better manage waste, or to improve environmental indicators.	Disasters	/	% improvement of Environment over the 2014 target
			1.5.1	Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population
			1.5.2	Direct economic loss attributed to disasters in relation to Niteroi gross domestic product (GDP)
		Noise	/	Distribution of noise monitoring and management facilities
		Resource Management/ Material Footprint	/	% of Garbage Collection/ % of waste recycling
			/	Electricity production from renewable sources (%)
			/	Automation Coverage of electrical, solar, tidal, and wind network
			/	Change in land consumption per capita (squared metre per capita)
		Public Safety	/	homicide rate
			/	Domestic violence cases decreased by %
			/	The number of auto theft cases decreased by %
			/	Burglaries of financial entities decreased by %
			/	% population that feel safe walking alone at night around the area they live
			/	% decrease in the number of homicides compared to the baseline
			1.4.2	Proportion of total adult population with secure tenure rights to land, (a) with legally recognized documentation, and (b) who perceive their rights to land as secure, by sex and type of tenure
		Network	/	% of Niteroi's population is an Internet user
			/	Total amount of community centers with access to ICTs
			/	Engagement % for workshops and courses
		Engagement	/	% app use for smart collaboration and communication
			/	The amount of citizens connect to free WIFI that support the community progress


Benchmark
Dimensions
Indicators
Methodology
European Commission eGovernment Benchmark 2022
E-government
User Centricity
Transparency
Key Enabler
Cross-border Service
Mobile friendliness
User support
Online availability
Transparency of service delivery
Transparency of service design
Transparency of personal data
eID
eDocuments
Authentic sources
Digital post
Security
Cross-border online availability
Cross-border user support
eID
eDocuments
automated online assessment tool
Mystery Shopping


Mobile Smart City Benchmarking
Building productive partnerships
Smart and interoperable ICT
Capture and distribute actionable information
Potential business models
Engaging citizens and developers
Focus on solving specific problems
The roles of mobile operators
Government and private business partnership
improve energy efficiency
a large number of sensors
Provide commercial services directly to the city
Provide free services to citizens
Measuring Air Quality Levels
Optimized use of water resources
predict natural disasters
Citizens have easier access to information
Improve sector-specific readiness
Mobile Device Control Furniture
Intelligent energy-saving furniture
Citizen participation in real-time electricity trading markets
Renewable Energy
More citizens know how to use smart appliances
Encourage real estate companies to participate
Track pollution emissions data
Measure key parameters
Improve the performance of communication networks

European Smart Cities Platform Indicators (2007) & New KPIs for a Smart City (2016) & The CITYKeys Indicators (2017) & Mckinsey Institute (2018)