Course: Exploring citizen engagement for Smart Sustainable Cities

Topic: Towards a Smart Sustainable Future: Tartu Estonia's Road to Urban Development

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1.0   Introduction

Tartu, Estonia's second largest city, and home to a lot of smartness stands as a model for smart and sustainable urban development. Maybe not globally recognized yet, but in Europe the intellectual capital of Estonia is renowned for its smart city initiatives, ranking 15th in the European Smart Cities benchmark for smart people. The city aims to promote energy efficient solutions, the use of renewable energy and environmentally aware citizens (SmartEnCity, n.d). The city's developments have been driven by the needs of its citizens and not the adoption of technologies for appearance. With the European project SmartEnCity, Tartu has retrofitted its old Soviet-era buildings into energy-efficient smart homes, implemented a bike sharing system to reduce traffic intensity and environmental problems, commenced the usage of environmentally friendly gas buses, and sustainable district cooling system that uses residual heat and reduces carbon emission. Tartu's role in offering developments that meet the needs of the citizens while actively engaging them in the developmental process makes it a city that several cities around can take a lesson from in their pursuit of smart city development. Thus, making it relevant for this study.

Understanding that participation and collaboration between government, citizens and organizations is essential for a city to become truly smart, Tartu uses social innovation experiments, participatory budgeting, studies on resident's attitudes towards technologies and environments and regular meet-ups as mechanisms to engage its citizens in the smart city initiatives. Additionally, creating a balanced relationship between researchers, universities, and citizens has helped various stakeholders to learn, share and solve the city's problems collectively ensuring that they are all informed and involved. It is this cooperation between the different stakeholders that differentiates Tartu from other cities.

Tartu's smart city achievements are however not free from challenges. Like many cities pursuing smart city goals, Tartu faced various obstacles which included budget constraints as Estonia municipalities are required to provide 70% of all services which implies that Tartu's budget must be targeted at essential social needs making expenditure on smart city initiatives less. The city also for years has continued to face heavy car dependence from residents despite being a small city there is an extremely high number of private car use in the city. Despite efforts to make residents utilize public transport and active travelling such as cycling and walking more, it failed for years.

Modal share of car use against cycling and walking continued to be on the rise. However, Tartu's innovative solutions such as bike sharing and the design of city networks coupled with its citizen engagement through participatory budgeting and stakeholder collaboration has helped the city's transition into one of Europe's highly referred cities in terms of smart sustainable living. The overarching aim of this case study is to examine Tartu's strategies and progress towards smart sustainable city development by evaluating the city's innovative approaches to urban planning, technology adoption and the use of modern approaches which is inclusive of its citizens in its smart city initiatives. By exploring Tatu's smart city initiatives, this study offers insight into smart city frameworks and urban sustainability of Tartu while identifying the challenges faced by the city in its effort towards transitioning to a smart sustainable city.

2.0 Background

2.1 Smart City

The concept of smart city is characterized by a lack of widely accepted definitions. For several years, there have been debates on what constitutes a smart city. Smart city can be defined from both a technology-driven and citizen-centric perspective. The technology-driven perspective regards it as an advanced technology intensive city that connects services, information and people (Mora, Bolici, and Deakin 2017). The citizen-centric definition regards it as a city where workers, service consumers and residents are protagonists who shape the city through continuous activity and interactions (Albino, Berardi, and Dangelico 2015). While there is a slight difference in the definitions, both definitions emphasize citizens as important factors in achieving a truly smart city, making citizen engagement and participation an integral part of any smart city initiative. Simply put, a smart city can be perceived as a modern urban environment that utilizes various technologies, innovation, and data to enhance the quality of life of residents while addressing economic and environmental challenges. This definition covers both the technology-driven perspective and citizen centric-perspective described by the two studies.

2.2   Citizen Engagement

Participation and collaboration between citizens, government and organizations is an important component in the development of smart cities (Coe et al., 2001). Importantly, a city is considered smart only if it puts people at the core of the technologies, innovations and developments that it embraces citizen-centric orientation in its smart city initiatives. Politechnika Gdanska (n.d) intimated this definition by stating that smart city initiatives should start from the city by putting people at the core instead of technologies, and avoid reducing citizens to mere active users of the services. Participation and collaborations between citizens, organizations, are essential in the development of smart cities (Coe et al., 2001). Numerous activities involved in smart city projects are poised to benefit greatly from citizen participation and engagement (Yang and Pandey, 2011).

It is essential to note that citizens within the concept of this study are drawn from the study of Gil-Garcia, Pardo, and Nam (2015) to include individuals, communities, organizations, residents and social groups with their respective needs and interests within the city environment.

2.3   Sustainable Development and Smart Cities

A popular definition of sustainable development in literature is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Modern cities face different challenges such as population growth, climate change, and environmental pollution, and smart cities have been deemed as a veritable tool to respond to these challenges (Rudewicz, 2023). Smart city solutions are increasingly seen as an effective and sustainable way to tackle some of these challenges and reach various goals set in a wide range of agreements in environmental, international and other contexts of several cities around the world.

As a result, there has been an emergence of smart sustainable cities in recent years as smart cities have been regarded as major drivers of sustainable development. Viale Pereira and Schuch de Azambuja, (2022, p.6) defines this concept as a territory (urban and rural) in continuous transformation, empowered by digital technology and innovation, stakeholder engagement and collaboration, constructing human, institutional and technical capacities to solve problems and

create novel development opportunities, to raise and maintain the quality of life in communities, and pursuing sustainable development.

Tartu exemplifies the trio of sustainable development, smart city, and community engagement in the city's development serving as a model for other cities in Europe.

3.0   Methodology

This study uses a case study approach to assess and explore Tartu's smart city initiatives. The methodology uses secondary sources as well as empirical research. In addition, it utilizes literature reviews, international organization reports (European Commission), a range of online sources, infographics, Tartu Estonia's government website and reports and the SmartEnCity report.

4.0   Case Study Analysis

4.1   City Background

Tartu is Estonia's second largest city with a moderately sized town of 98,247 residents (urbact.eu., n.d). For years it has continued to be the center of attraction for all of Southern Estonia. The city's small size favors walking, cycling and driving of private cars. It is a university town, and maintains the position of the academic center of the country, that promotes and welcomes smart and state-of-the-art initiatives in Estonia. The city has held the lead position in sustainable mobility in the last few years in Estonia since the inception of its bike sharing system in 2019 and the establishment of its new gas bus network. Embracing feedback from users has helped the city to design user-centric smart city initiatives that meet local needs of the residents. Crucially, Its green and safe living environment, world-class cultural life, active communities, diverse entrepreneurship and top-level education institutions have undoubtedly made the region attractive in Estonia and internationally (Tartu, 2022).

To govern its nearly hundred thousands of residents, Tartu's governance structure encompasses legislative and executive branches which brings about effective local administration. The legislative branch is referred to as the Tartu Linnavolikogu which in English is the city council. The city council consists of 49 members elected by residents every four years through proportional

representation and are responsible for the approval of budgets, establishment of policies and oversees the executive branch's actions (Tartu City Council, 2024). The other arm of government, which is the executive branch, consists of the mayor, five deputy mayors and other members who are responsible for the implementation of the policies made by the city council, oversee public services, and manage daily operations.

4.1.1 Tartu's Urban Development Goals

Tartu aims to increase the wellbeing of its residents and provide an excellent living and business environment for both current and future residents. Tartu's Integrated Action Plan (IAP) is one of the most ambitious urban development goals that can be set by any city. The action plan is an integration of three action plans which includes the Cycling Action Plan, the Climate Action Plan, and the Tartu Comprehensive Action Plan (Tartu, 2021). The Cycling Action Plan's goal is to increase the number of cyclists among daily commuters to at least 26% and decrease the proportion of vehicle commuters to 26%. The Comprehensive Action Plan determines a two-type network for cycling paths with the main colored in black and the secondary in blue as presented in figure 1.
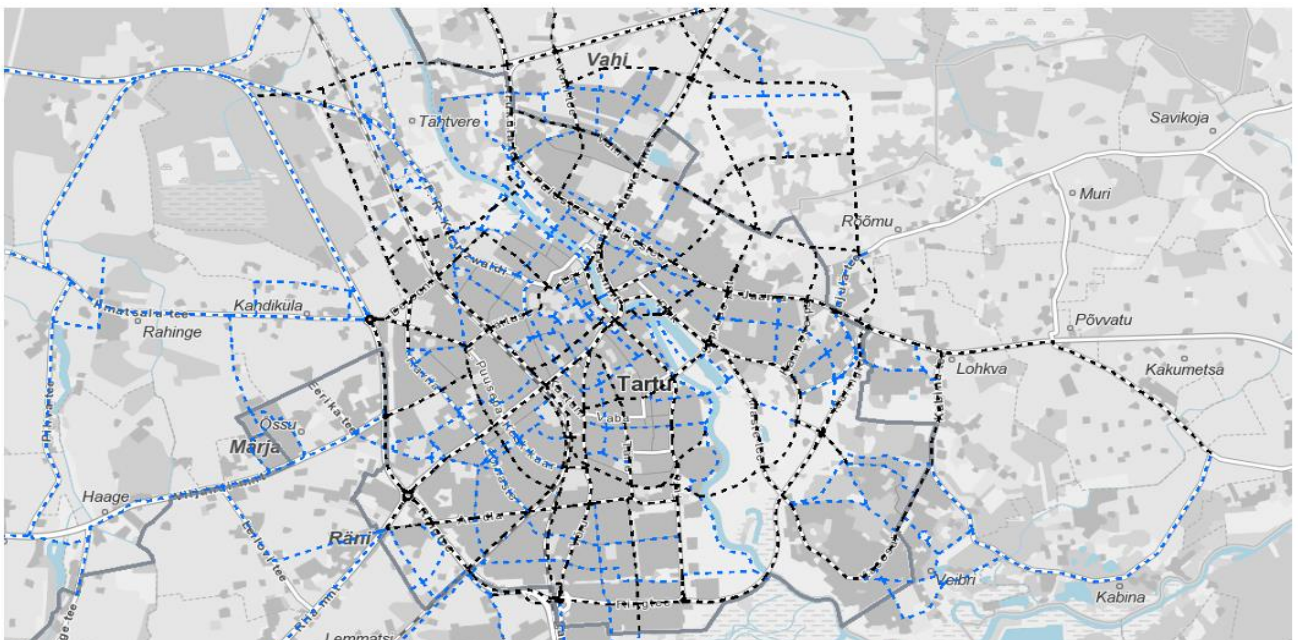

Fig 1: Tartu's Cycling Path: Source Tartu (2021)

The Comprehensive Action Plan is focused on diminishing car dependency in Tartu and compensate for the Cycling Action Plan by creating more and better cycling networks through the

borders of central Tartu, the neighboring municipalities and the entire suburban area. One of the exciting initiatives of this action plan is the Car-free Avenue initiative which is an annual municipality-initiated public event focused on reserving one of Tartu's main streets for pedestrians and cyclists only.

Tartu also has other plans such as the Urban Master Plan, the Climate and Energy Action Plan 2020 (Mobilize, 2022). With the climate and Energy Action plan, Tartu set the goal of reducing its carbon emissions by 40% (216,320 tonnes per year) by 2030 compared to 2010 and achieve climate neutrality by 2050. This will help the city to not only mitigate the impact of climate change and design activities towards climate adaptation but also experience enhanced production of renewable energy and shift away from non-renewable energies in the municipal sector including public transportation.

To reduce dependence on personal automobiles, Tartu utilizes the urban master plan. This plan is focused on making transport options more appealing to the residents, implementing 100% carbon neutral public transport options and upgrading neighborhoods to reduce travel distances within the city to 15 minutes. The plan is designed to shift away from the 90s urban sprawl dynamics that placed new university buildings in the outskirts. Instead, it focuses on mobility centers that reduce reliance on personal automobiles, favor active and public transit through pedestrian-oriented street redesigns and introduction of bike-sharing schemes reducing noise and air pollution while overall offering residents' better quality of life and relief from traffic density issues.

4.1.2 Challenges Faced by Tartu

No doubt Tartu generally offers a good living environment which offers it a competitive advantage compared to other urban regions. However, with its many successes and transition towards being a smart city, there are many challenges and failures limiting its effort towards achieving its strategic goals. These challenges include the constant increase in the use of cars in the last few years and the deterioration of the condition of its natural resources (water bodies and forests). Tartu has also been facing an increase in its greenhouse gas which has increased by 31% in the past decade (Tartu, 2021) due to power consumption by the public and private sector and the increasing use of private vehicles in the city. This is portrayed in fig 2 presented below:

Energiaallikas	2010	2017	Change	Change (%)
Energy source	71	61	-10	-14%
District heating	101	124	23	23%
Fossil fuels	369	524	155	42%
Electricity	541	709	168	31%
TOTAL				

Fig 2: Co2 Emission by Energy Source (Thousand tons): Source Tartu (2021)

The incessant increase in the number of private vehicles has also contributed to this rise in greenhouse gas emissions, creating a challenge for

Another major challenge that Tartu is facing is the city traffic which has been on the rise. Compared to other road users, cars have continued to take up a huge share of the streets, restricting the movement of cyclists, pedestrians and public transport as well as street maintenance. The need for parking spaces has been on the rise, leading to reduction in the attractiveness of the city landscape and making private courtyards turn from recreational areas into parking lots. This has fostered a decline in active mobility in the city with pedestrians and cyclists perceiving the traffic as unsafe due to increased car traffic. Fig 3z presents a graph showing the steady increase in the number of passenger cars in Tartu city according to Tartu (2021).

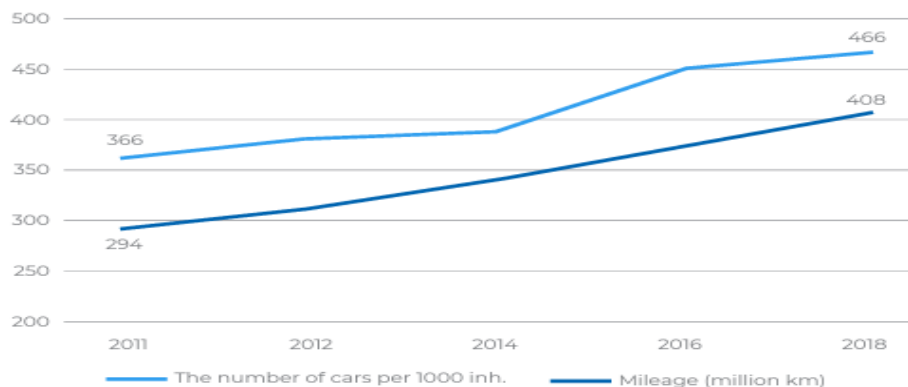*Fig 3: Number of passenger cars per thousand residents and kilometers travelled, Source Tartu (2021)*

In a similar vein, Tartu has experienced an increase in cross-border traffic due to urban sprawl presented in the Tartu city traffic load report conducted in the year 2017 by Stratum OÜ, traffic load in suburbia has increased by more than tenfold in the last 30 years and has not ceased to increase.
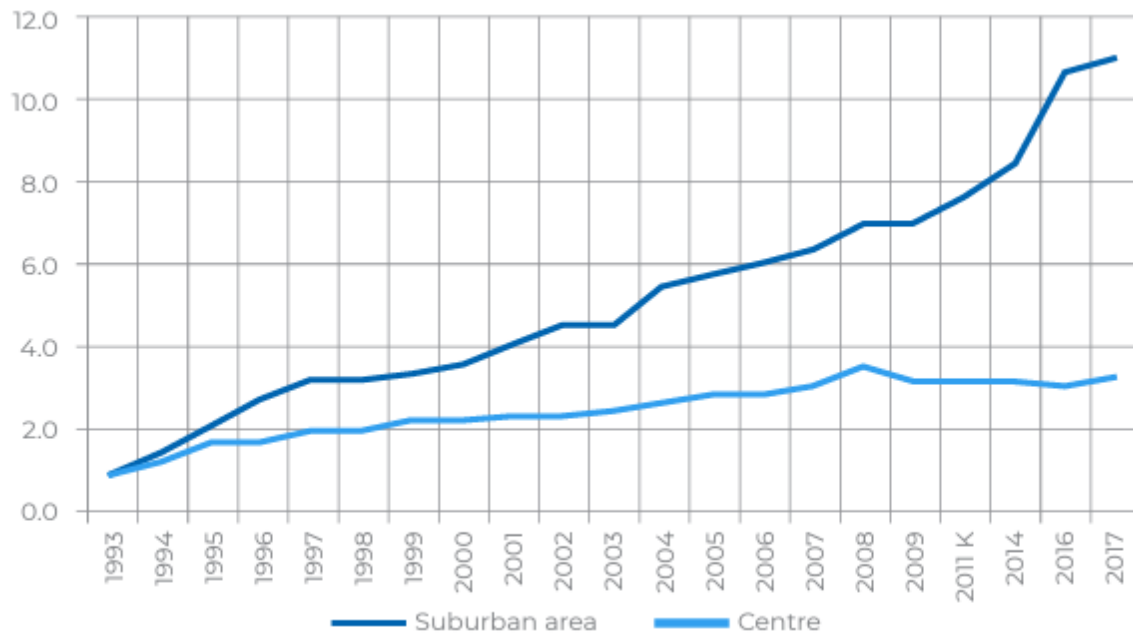
Fig 4: Developments in Tartu traffic load 1993-2017 (multiplication compared to the 1993 value) during the evening rush hour, total of both traffic directions

In addition to the increase in cross-border traffic, the energy consumption and environmental impact of transport in Tartu has increased by a third when compared to the year 2010 value, and energy use in the private sector has undergone the most rapid increase due to the increment in the number of private vehicles in Tartu. The graph below offers insight into the energy use and consumption in Tartu's private transport.

	2010	2017	2030
Energy consumption (GWh/mln km)	0,906	0,842	0,723
Carbon emissions (kg CO_2/km)	0,234	0,214	0,178

Fig 5: Energy Consumption in Tartu and projected Consumption, Source: Tartu (2021)

Tartu has also faced significant climate challenges in the last few years. According to urbact.eu (n.d), Tartu has faced cold spells, heat waves, strong winds and snowstorms in the last few years

with the city experiencing increase in hot days with temperatures above 27 degrees between 1961-2017 from average of five days to an average of 13 days, reaching 20 and more hot days during the summer. Experiencing an unusually hot summer but short showers with extreme rainfall is another clear evidence of a clear climate change in Tartu requiring a need to design initiatives that will mitigate the current and impending impacts of climate range on the city.

4.2   Tartu's Smart City Vision and Strategy

Tartu is a smartly developing community with good energy, and a green pioneer. By prioritizing renewable energy and technology, the city is tackling some of its challenges and boosting the livability of the city.

Tartu's smart sustainable vision is divided into the following:

i.   **Green Energy**: To transition into green energy and reduce CO_2 emissions, Tartu has incorporated alternative renewable energy resources. Tartu currently uses wood chips in its district heating, the system is almost 100% renewable energy with only the top load covered in natural gas. Through the Sustainable Action Plan, Tartu is ensuring a sustainable supply of district heating and cooling used its renewable energy sources (RES), offering at least 52000 MWh of RES to cool district, using natural gas in heating only district heating, solar and geothermal energy is impossible, producing 100% of its electricity from RES and reducing heat energy in public buildings, and decreasing energy consumption in the housing sector by 20%. It is also making the building energy efficient by turning Khrushchyovkas which are panel type buildings into Smartovkas (smart high-quality living homes). This has helped to offer the residents a stable interior climate through temperature control and ventilation as well as make it aesthetically appealing.

ii.   **Sustainable Transportation and Mobility**: Sustainable mobility is a major priority in Tartu's smart city goal. One of its sustainable mobility approaches is the bike-sharing system which commenced in the year 2012, accompanied by improved infrastructure to incorporate cycle and pedestrian paths throughout the city. The bikeshare system featured electric bikes in well-located stations through the use of existing mobility patterns and the installation of new charging points and docks (SmartEnCity). The city

has also created a bicycle rental system to make active transport appealing to citizens offering a greener and cleaner city environment, economical transport system and smart urban space, and improving citizen's mobility opportunities and health. For pedestrians, Tartu created safe crosswalks with smart-controlled LED lights to encourage active travelling (Vihma, 2023).

Asides improving its cycling through bike sharing to encourage active transport and sustainable transport, it has also rolled out Baltic Biogas Bus in the year 2012 which run on locally produced biogas offering residents a fossil fuel free option than passenger vehicles, and making Tartu one of the first fully carbon neutral public transport cities in Europe (Mobilize, 2022). In a similar vein Tartu is making transport sustainable by recycling old electric vehicle batteries for EV taxis making production of new batteries require less resources.

iii. **Digital Infrastructure**: While designing its energy efficient buildings Tartu integrated IoT into the creation of the smart home systems in each apartment. The system incorporated gateways which help in communicating with the sensors, meters, and devices in the apartments through radio and cable communication, a control panel which consisted of a tablet computer to control the devices and run the smart home app, smart thermometers to control room temperature and CO_2 detector to control ventilation. Overall, the system is synched to the Cumulocity cloud platform offering exchange of data between various residents, housing associations, city of Tartu, University of Tartu, Tartu Regional Energy Agency), devices and platforms. This has made it possible to use the data to improve smart homes. Tartu's smart street light control system based on wireless mesh technology is another outstanding digital infrastructure of Tartu. The smart controllers are capable of network and device-related decision-making and rely on wireless communication making information exchange between the controllers and sensors possible. This helps to offer intelligent data processing and build a network of collaborating self-aware devices that takes local weathers and traffic conditions into consideration and adjusts accordingly. Crucially, it offers energy savings to Tartu while also lighting up the city.

iv. **Environmental Sustainability**: Tartu aims to reduce not just its ecological footprint through the use of renewable energy and mobility but also by increasing green spaces in the city. Tartu's continuous and functional green network with river Emojogi, its banks and adjacent floodplains which serves as its backbone is the city's pride. However, the functioning of this network is contingent on when it is comprehensively joining public green areas, private gardens, school yards, cemeteries and wastelands. Bearing in mind the importance of biodiversity and improvement of air quality through green spaces, Tartu preserved and redesigned enough green spaces providing flood relief, reducing heat stress and guaranteeing a healthy and biodiverse environment for residents.

4.3   Technological Infrastructure

Technology is an essential component in the design of a smart sustainable city. Technology offers better opportunities to improve its urban infrastructure and achieve its smart city goals. In this section, the technological infrastructure that supports Tartu's smart city initiatives are highlighted and discussed.

I. **Smart Energy Systems:** Tartu while carrying out the retrofitting of old Soviet blocks of flats (Khrushchyovka) utilized technologies such as IoT to rejuvenate the buildings into smart buildings that are energy-efficient.

II. **Smart Traffic System**: The city of Tartu has implemented intelligent traffic system solutions to reduce the challenge of traffic congestion. According to Vihma (2023), Tartu has commenced an exciting project on vehicle-to-infrastructure focused on improving traffic management by going past the visual signals of green, yellow and red lights to the establishment of a direct link between vehicles and traffic control centers to make the system efficient. Additionally, this will help the city in its transition towards the use of autonomous or connected vehicles that are able to interact seamlessly with traffic control systems. By utilizing autonomous vehicles such as self-driving minibuses and traffic management systems as part of its public transport system, the city is strategically moving towards reducing traffic congestion. The traffic management system through the integration of vehicle-to-infrastructure and IoT sensors Tartu is optimizing traffic flow and

reduce bottlenecks. It is noteworthy to state that Tartu's traffic system is undergoing a number of developmental processes and is not widely used across the city yet.

III.   **Smart Mobility Solutions:** Across Estonia bus ridership and access has been facilitated through the use of technology and Tartu is not an exception. Estonian cities incorporate advancements in mobile technology to make the usage of bus networks easier to navigate. This is achieved by using an online route planner, combined with multi-platform electronic ticketing and contactless ID-card validation creating a simplified payment system that can be used on the go (Mobilize, n.d). In its effort to improve mobility, using data Tartu carries out anonymized mobile tracking to see into people's movement throughout the city. This helped in the revamped bus routes design shortening commuting times, helped determine locations of bikeshare stations.

4.4   Citizen Engagement and Participation

Citizen engagement and participation is central towards improving living standards and transitioning towards a smart and sustainable city. Moreover, facilitating citizen participation in decision making is integral to the functioning of a smart city. Tartu, understanding the importance of citizen engagement in achieving its smart city goals is the first city in Europe to adopt participatory budgeting which allows residents to have a say in the allocation of municipal funds. Using an online platform, Tartu receives suggestion each year on how to invest 1% of the city's budget on projects suggested by residents and this project has seen a number of projects such as upgrading of the city sidewalks to eliminating curbs that may hinder those with trolley and wheelchairs from crossing and other annual projects that meets the immediate needs of the residents executed. By involving the residents in this project, Tartu ensures that the changes made in the city and also to its master plan is well received and long utilized by the residents.

Within the context of Arnstein's ladder of citizen participation that classifies citizen's involvement into eight ladders from non-participation to citizen power. This is described in the image below
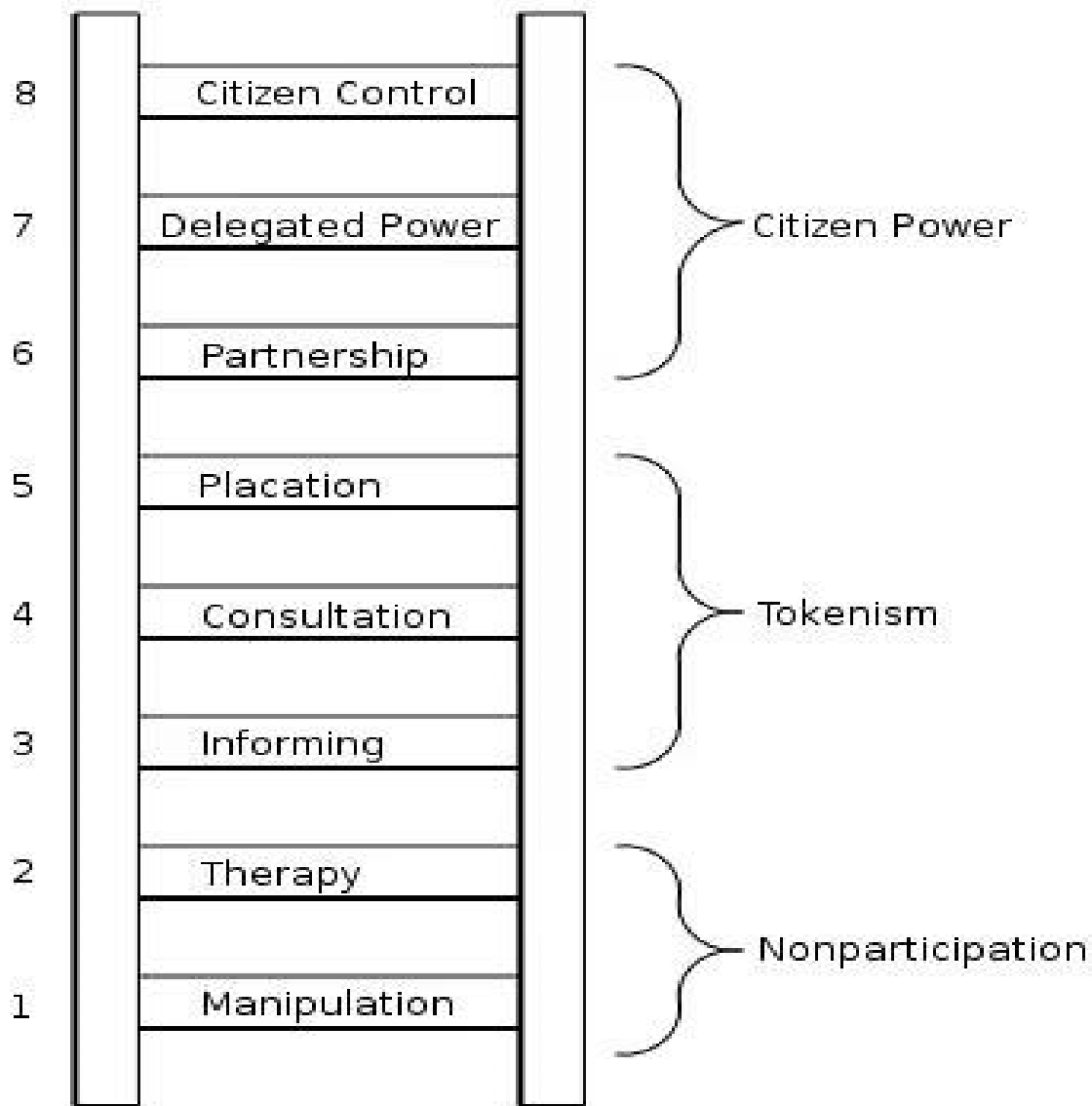
Fig 6: Arnstein's ladder of citizen participation, Source: Martel (2024)

Tartu ensures citizen engagement through partnership and a bit of delegated power which occupy position 6 and 7 on the ladder above. According to Arnstein, partnership is the first rung where citizen's input is considered important (Martell, 2024). Tartu partners with its citizens through its online platform. Citizens submit their ideas about what could be done in the city, and these ideas are voted for in an online tool called VOLIS, and the top two ideas usually get implemented every year. Asides the participatory budgeting, the idea collection map is another way Tartu engages residents. Through this, people share their proposals for major investments and improvements with few words on a city map. This offers investment ideas to city planners that might not emerge

through participatory budgeting because the idea is locally specific or expensive, hence missing out under the participatory budgeting scheme. In addition, it engages with researchers and companies to develop and test smart technologies which ensures their effectiveness. Furthermore, it utilizes consultations and surveys to know resident's views about different intended smart city projects. A typical instance is in the energy efficient building initiative where the residents and the government co-created solutions and decided on the improvement and challenges faced with the energy efficient buildings. Thus, it can be seen that Tartu's partnership with residents on smart city projects permits them to influence decision making about the city.

From the lens of the delegated power, residents are able to provide their point of view on projects, report challenges and suggest improvements and consultations. No doubt, delegated power requires residents to take full control of decision-making. Tartu empowers residents to be involved in the decision-making process but without full control over its implementation, indicating partial delegated power. Therefore, Tartu does not operate at Arnstein's highest ladder which is the citizen control but with its amazing partnership and a little bit of citizen control, it continues to remain as a powerful example of a city that puts the people at the heart of its urban development even though it does not completely operate a full citizen-controlled urban governance structure.

4.5   Sustainability Efforts

This section of the study provides insight into the sustainability practices of Tartu with special focus on the green spaces, the waste management and energy practices of Tartu.

4.5.1 Energy

As a city focused on reducing its ecological footprints and ensuring efficiency of its energy usage. Tartu has set several plans and goals through its Master plan and other plans. However, "Tartu Energy 2030" emphasizes the city's development and implementation plans as regards energy, especially renewable energy. This is the city's visionary action plan to become energy neutral by 2050 with strategic goals towards achieving them until 2030. One of the ways Tartu is currently bringing its energy plans to fruition is through the district cooling station which uses traditional industrial equipment and cold river water from Emajõgi River to supply and produce cooling for hotels, commercial buildings and shopping centers (Tartu, n.d) Using the river water for district cooling offers Tartu a number of present and future benefits which includes reducing traditional

cooling costs by about 90% compared and reducing Co2 emission by 70% indicating its economic and environmental impact on Tartu.

Additionally, with the Tartu power station, the city generates heat and electricity simultaneously through the cogeneration plant. By using local fuels which are 80% renewable biomass and 20% peat which is non-renewable energy source but local, the city not only generates electricity and heat sustainably but also improves local living conditions and provides employment.

The city also runs a one-of-a-kind energy competition where energy-efficient construction solutions are presented by the public to the government. This helped in the construction of a number of energy efficient buildings as novel solutions that improved energy efficiency and indoor climate were presented by the public based on the building's function, offering residents better quality living.

4.5.2 Waste management

Tartu boasts of an environmentally friendly waste collection, sorting and storage system. It also utilizes innovative methods to recycle and reuse waste. In Tartu residents use exchange platforms such as smart swap and Facebook pages to exchange leftover or second-hand goods such furniture, textiles and leathers to ensure reuse of items (Raya et al., 2024). Tartu also has green points for different types of household wastes. This helps to reduce landfill use, promote recycling and contribute to a cleaner Tartu.

What's more, Tartu has incorporated the (Wo)men's shed association initiative, an initiative which originated from Australia in the 1980s focused on helping older men find something meaningful in their life. In Tartu, the association consists of men and women who are finding purpose in life by doing something meaningful for the society (Raya et al., 2024). The city council provides means and support for building something out of second hand and waste materials while socializing.

4.5.3 Green Spaces

Tartu is committed to preserving its green spaces. Through the Tartu ROHEring initiative and several other initiatives, Tartu is increasing its biodiversity, creating a network of interconnected green areas, mitigating the effects of climate change and making the city more livable. Some of

the activities through this initiative involved the cleaning of the Supilinna pond to improve habitat conditions for the amphibians with riparian vegetation and the planting on the banks. Less moving has also been encouraged in some parts of the city as they prevent some plants from flowering. Nonetheless, there are certain parts of the city that are frequently mowed, especially for picnic and leisure time. This has helped to increase the number of flowering plants in the city in areas needed. Apart from the care for plants, the city provides shelters for birds by providing nesting boxes for bird species and installing shelter boxes for bats. These activities have helped the city to preserve its green spaces.

4.6   Equity and Inclusivity

No doubt developing smart city initiatives are important, but what is even more important is if they are inclusive for the city inhabitants. One of the ways Tartu ensures inclusion is through participatory budgeting which offers residents the opportunity to present ideas either as individuals or as a group based on the city needs. This not only puts residents at the center of decision-making but also addresses the needs of diverse groups of residents, creates social cohesion and fosters inclusivity.

5.0   Discussion and Critical Analysis

Tartu's road to becoming a smart sustainable city like every city has been fraught with several challenges and barriers. In spite of these challenges, the city still stands as an example for several cities trying to transition towards becoming a smart sustainable city because of the innovative solutions adopted to overcome these challenges. This section details some of the challenges and barriers faced by Tartu in its smart city efforts and the solutions and innovations used to combat these challenges.

5.1   Challenges and Barriers

This section of the study highlights the barriers that Tartu is facing in the realization of its smart and sustainable goals and initiatives. This section highlights and explains these challenges which is followed by innovative solutions used by the city to tackle some of these challenges.

I.   **Financial Constraint**: In Estonia, municipalities have little financial autonomy as they are charged with providing 70% of all services including social assistance and education (Krenjova and Reinsalu, 2013). Specifically, this has limited the number of initiatives

funded through participative budgeting as they have to deliver important services to the community. This is one of the reasons why participatory budgeting takes just 1% of the local government's budget. It has posed a bit of limitation to engaging citizens on a number of fascinating projects that meet their local and city-wide needs.

II. **Adoption of Sustainable Transportation**: Tartu for years has faced the challenge of high private car use. Despite the city's small population there is high dependence on private car use by residents compared to the public transport system. One of the main challenges of using public transport according to the residents is the frequency of the transport, the lack of suitable routes, and the possibility to arrive and leave at a suitable time specifically for residents in the vicinity of Tartu. The increased traffic density caused by motorization has had a huge negative impact on the sense of security of cyclists and pedestrians. Understanding that car use could be reduced through better cycling and pedestrian paths, faster public transport connections and suitable public transport routes. Tartu offered a number of sustainable mobility alternatives such as the introduction of a bike sharing system, car-free avenue event and the reconstruction of the railway bike road to get to their desired places or pick cycling as a hobby (Duratna, 2023). Unfortunately, these efforts instead of increasing the number of cyclists has failed to do so with Tartu recording a 5% decline in cycling between 2018 and 2021 while car use has continued to increase.

5.2   Innovations and Solutions

To reverse the negative trend, Tartu through its participatory budgeting transformed the port railway into a pedestrian and cycle path along the green door of the port railway opening up the opportunity for safe transport, sport and urban recreation. The construction of the project, specifically the smoothening and laying of the final surface was done using reused and recycled materials further demonstrating Tartu's commitment to sustainability. The government also filled the road edges with soil and grass based on the feedback of the locals creating a safe and continuous path without cracks and dangerous holes for users. This complemented the existing bike sharing initiative in Tartu increasing the possibility of increasing the number of cyclists in Tartu.

To further reduce the number of residents using cars, the city also used data-driven technology to create a data-driven bus route network. This according to Positium (2019) offers the below benefits described in fig 7.
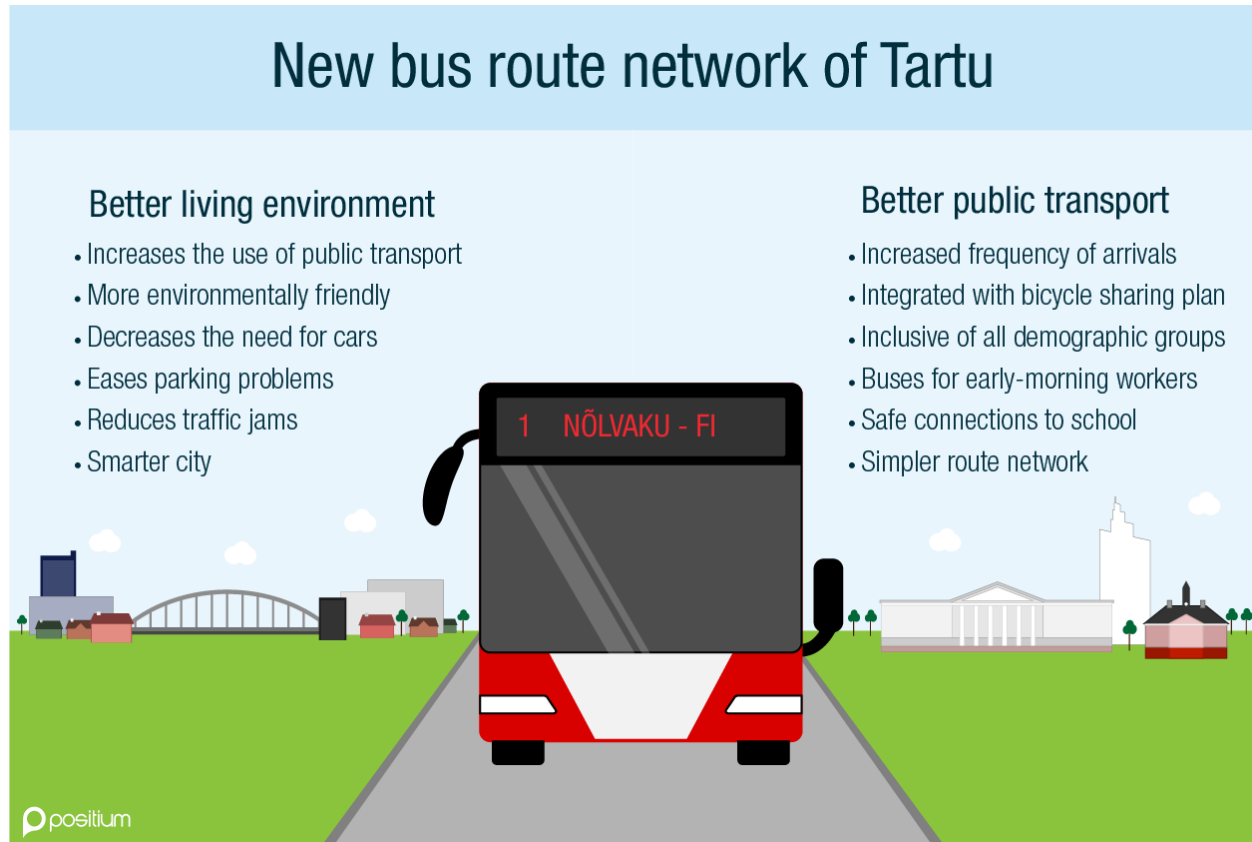

Fig 7: Advantages of the New Bus Route Network in Tartu, Source: Positium (2019)

Prior to initiating this initiative Tartu had a good public transportation system with modern bus stops and buses and accessible information on the network being available in different forms. The network route dated to the early 1990s and consisted of 27 lines. However, the circular nature of the route, though connecting many places with each line, was the low connection speed that the lines offered making service frequency and usage low. The route network was long overdue because there have been many changes in where residents live, work and move in recent years, necessitating the need to adapt to these new changes in the city. Creating the new bus route network and integrating it with the bicycle sharing plan was aimed at reducing the need for cars in the city center and reducing traffic jams during peak hours and solving the parking problems the city was

facing. Below is the image of the bus route and a real time embedded link that allows for better exploration

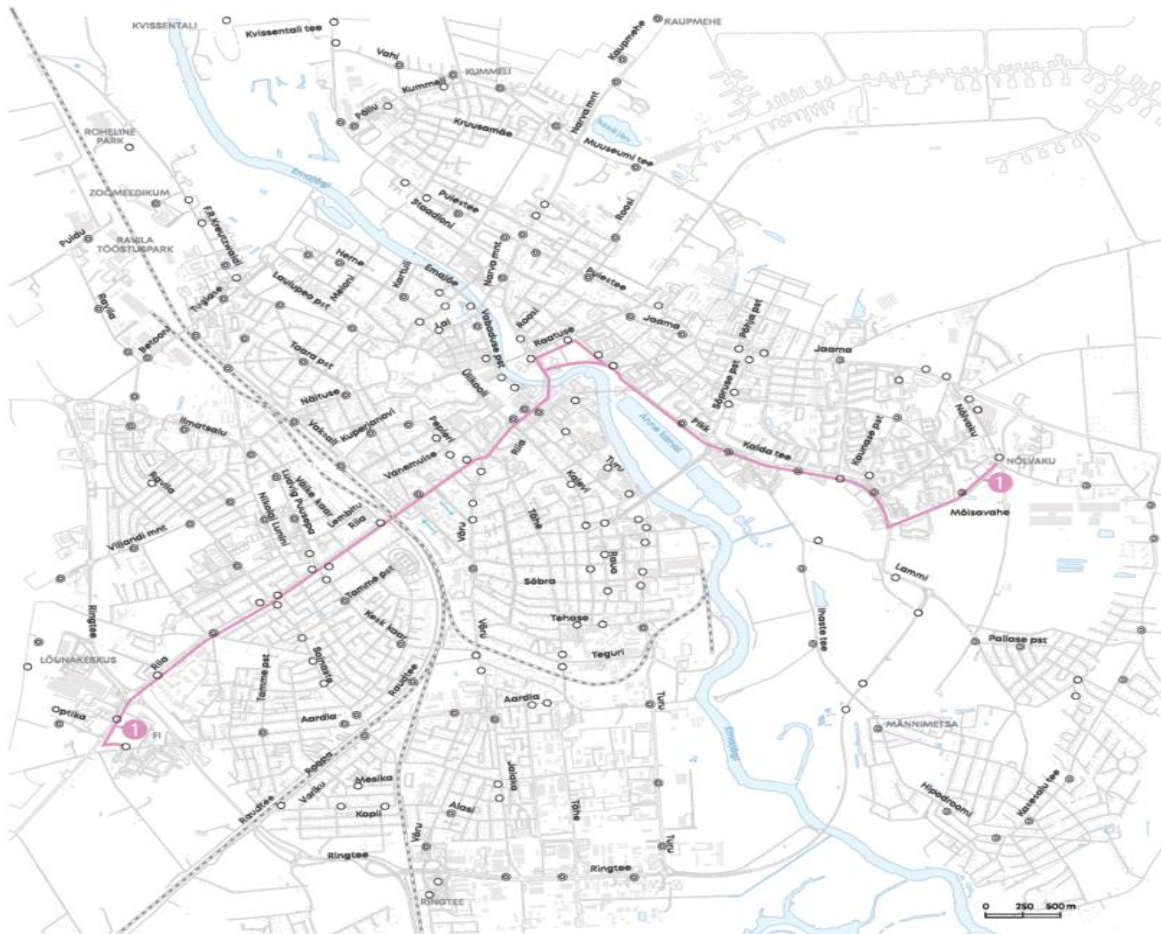
Bus routes in Tartu from 1 July 2019

Fig 8: Bus Routes in Tartu 2019, Source: Tartu (2021).

The new bus network's design was based on better linked bus lines, increasing the frequency of arrival to the bus stops and decreasing the number of different routes. The circular routes were reduced and replaced with linear pendular lines which allowed for simpler route networks. The design also allowed the possibility of arriving in as many destinations as possible changing the bus only once. Using pendulum routes also enabled the arrival of buses to bus stops more often and prevented buses driving on similar routes from arriving at the bus stops at the same time which was a common problem of the circular line. By using over 20 layers of data, collecting and

preparing mobile positioning data, mobility, planning, bus routes and land use. Information about where people live and work around Tartu was collected using mobile data while validation data from electronic bus cards was used to examine the actual usage of bus lines and several other pieces of information were collected and incorporated into the design of the new bus route. The data collection is detailed in fig 9.
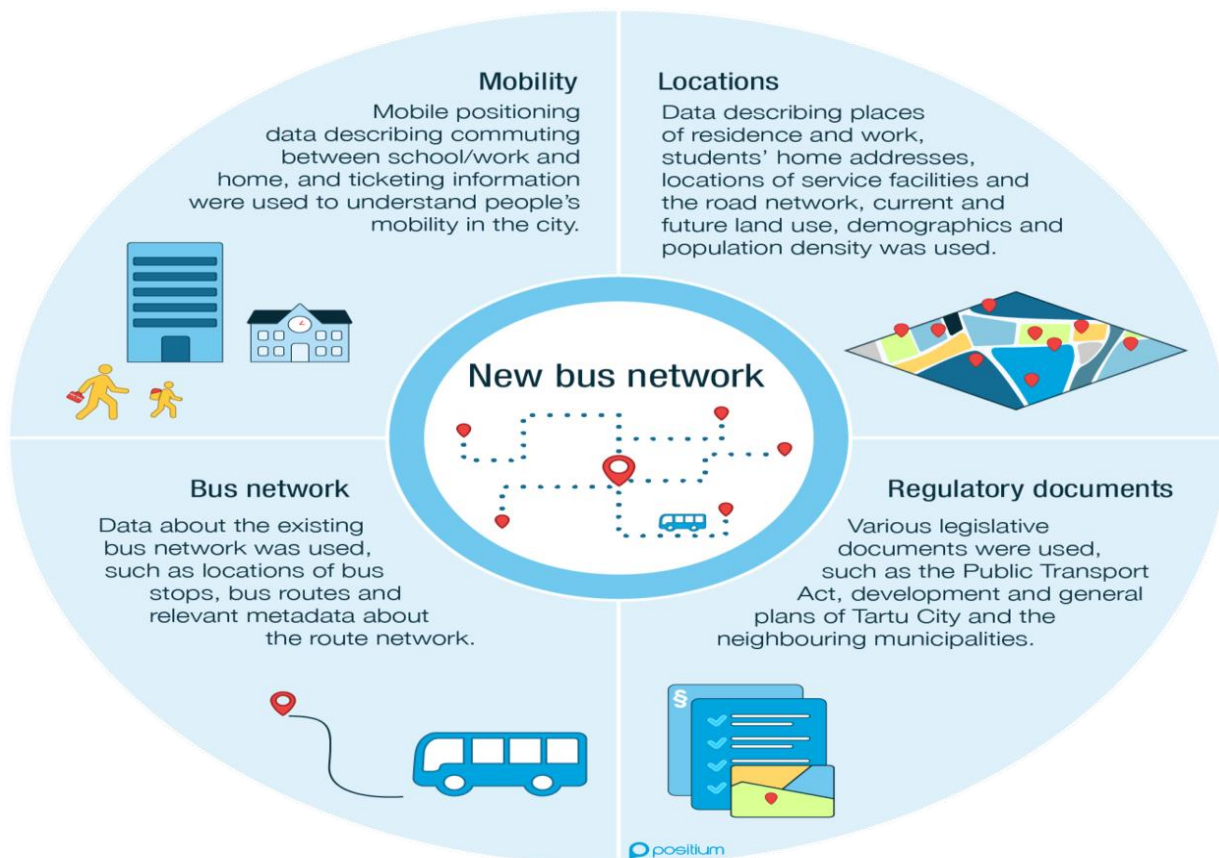

Fig 9: Data collected to benefit the development of bus networks and increase public transport usage in Tartu

It was possible to collect information on where people live, where they go and how they move to different places

Asides using these data collected and analyzing them for the design of the bus route. Qualitative data in the form of citizen feedback was also used to complement the quantitative analysis that was based on the mobile phone data. Being a complex system, it was essential to collect information about the point of view of the users. It helped to shed light on why people working around Lõunakeskus which is a big shopping center on the outskirt and the Tartu prison needed to

take early morning buses. This new route network solution has overall ensured efficiency in the bus networking and timing of buses making it attractive for use to the residents. The mobile data section's integration of anonymized data to further gain insight into how people moved throughout the city helped in designing how best to make the route network better to shorten commuting time and also aided the determination of the locations of bikeshare stations.

This data has continued to aid Tartu's decision-making process regarding traffic patterns, street renovations that benefit its urban mobility plans and has continued to offer insights to the municipality. Additionally, making some of the data publicly available without jeopardizing user's information offers users the opportunity to easily access the forward motion of city officials in their planning processes and implementation (e-estonia, 2024).

Conclusions and Recommendations
Conclusions

Tartu Estonia has continued to present itself as a leader in smart and sustainable city in Europe developing several outstanding sustainable city projects such as the design of energy efficient buildings, bicycle sharing, gas buses and electric vehicle system through the use of different urban development goals and plans which includes the comprehensive action plan with timelines making it accountable towards achieving these smart city goals. Incorporating technology into Tartu's smart city initiative has brought about noticeable differences in the living standard of the residents providing benefits such as energy efficient buildings, bike sharing systems that offers residents the opportunity to borrowing bikes for usage without necessarily purchasing them. Additionally using technology has also helped Tartu to improve its bus network, thereby proving pivotal in improving its bus networks and offering residents better public transport system usage and potentially reducing the city's high dependence on car use.

Tartu's participatory budgeting continues to serve as a good example for any city trying to achieve its smart and sustainable goals as it has evidently offered Tartu the opportunity to leverage on stakeholder's views towards developing smart city initiatives that meet both its local and wider municipal needs. Nonetheless, it has been revealed that the financial challenge has limited the expansion of the share of the allotted amount towards ensuring that the voice of the residents gets heard through this participatory budgeting approach. This is because the city needs to spend the

huge chunk of its budget on social services and other services, limiting the budget for the development of initiatives that directly come from the view of the residents based on the challenges they are encountering in the city.

Recommendations

This section of the study offers suitable recommendations for Tartu to improve its performance.

1. To further improve Tartu's sustainability goal and transition towards becoming a smart sustainable city, the city should offer targeted initiatives for older adults as it seems as if the participatory budgeting focuses more on the youths. Where as adults might as well have local needs that they wish to address but because they are not technologically savvy this might be a challenge making them marginalized. It is thus recommended that targeted initiatives asides the online platform perhaps a public office where projects can be submitted by the older groups to mitigate the digital divide and increase inclusivity.
2. Tartu should invest more in circular economy initiatives and recycling facilities to bring about reduction in landfill waste and promote more reuse.
3. Incorporate technology such as IoT to its waste disposals that will help the collection services to get real time information when wastes are full.
4. The city should improve its budgetary allocation for participative budgeting as the 1% of its budget for the participatory budgeting projects limits the implementation of a number of initiatives that can effectively benefit the city.

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