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ENVIRONMENTAL JUSTICE AND SMART CITIES

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Smart City Overview

The concept of a smart city may conjure images of the Jetson's with their flying cars, people movers, and automated everything. While we aren't quite there yet, today's smart cities use information and communication technology (ICT) to connect and improve infrastructure, create operational efficiencies, share information, improve the quality of government services, and increase the quality of life, equity, and prosperity of its citizens. Examples of the benefits of smart cities include improved transportation, social services, and sustainability.

Smart cities collect, process, analyze, and share a large amount of data. This data can enhance the quality, performance, and interactivity of urban services; reduce costs and resource consumption; and increase contact between citizens and government. The insights gained from the data are used to manage assets, resources, and services more efficiently, thus improving operations across the city. Smart city data include data collected directly from citizens and remote sensors in buildings and other infrastructure. The data could be used to monitor and manage a variety of community systems including transportation, energy, water, and waste.

The main goal of a smart city is to enhance the quality of life of its citizens through smart technology and informed decision-making. Smart cities give its citizens a voice. This is why smart city strategies start with people, not technology. Smart cities put technology and data to work to make better decisions and deliver a better quality of life. Quality of life has many dimensions including the air that residents breathe, the water they drink, and how safe they feel in the community. Smart cities can use technologies and data to improve some key quality of life indicators by 10–30% (McKinsey, 2018). Quality-of-life improvements include lives saved, reduced health burdens, reduced crime, and clean air and water. A smart

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city can take on a number of forms given the diversity of technology and priorities of the city government and inputs from its citizens. Regardless of the form it takes, a smart city should increase civic participation and create sustainable cities with healthy, happy citizens.

Smart Cities Address Civic Problems

Today, 55% of people around the world live in cities. This proportion is expected to increase to 68% by 2050 (Department of Economic and Social Affairs, 2018). Population growth and increased urbanization will add another 2.5 billion people to cities over the next thirty years. With this rapid expansion already straining our cities resources, cities must adapt to the population growth to provide environmental, social, and economic sustainability. In the developing world, the rapid growth of urban area includes more than 1 billion people in overcrowded and polluted slums. In developed countries like the United States, urban areas continue to present a number of challenges for residents and include concentrated pockets of low-income and minority populations that are disproportionately affected by these challenges. To become resilient cities, smart cities must improve energy distribution, streamline waste collection, decrease traffic congestion, and improve air and water quality resulting from increased urbanization. Technologies such as connected traffic lights can reduce traffic congestion by receiving data from sensors and adjusting the timing of traffic lights in response to real-time traffic changes. Smart trash cans send alerts to public services for trash pickup as needed vs. predefined schedules and routes. Smart city sensor technology with wide coverage can identify areas with poor air quality and excessive temperatures. Smart city technology and data can be used to help identify and address inequity issues in urban areas.

Smart Cities Use Data-Driven Approaches

Historically, governments kept data private and shared very little with its citizens. This was due in part to the inability to collect data, data collected in isolated systems, and lack of ability to share data. Smart cities are redefining information sharing through open data. Data is easily collected and shared with smart devices known as the Internet of Things (IoT), a core component of smart cities. The IoT is a vast collection of smart devices that collect, monitor, analyze, and share data from its environment. Smart city IoT devices include sensors to monitor energy distribution and consumption such as smart meters, highway sensors that alert to changing road conditions such as snow and ice, and sensors on city trash cans that alert when they need emptying. The data collected from IoT devices is transmitted and shared using wireless technology and the cloud. Cloud-based applications receive, analyze, and manage data in real time to help cities and its citizens make informed decisions and improve quality of life.

Many smart cities have incorporated open data portals to share the data with its citizens. Open data can facilitate government transparency, accountability, and public participation. Open data also supports technological innovation and economic growth by enabling organizations to develop new kinds of digital applications and services. Smart city open data portals include information such as water consumption data, crime data, public transportation maps and data, bicycling maps and data, community garden and famers market locations, green infrastructure data, tree inventories, sea level rise maps, greenhouse gas emissions, and air quality data (City of New York, n.d.).

Smart Cities Can Support Environmental Justice

The Environmental Protection Agency (EPA) defines environmental justice as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. This goal will be achieved when everyone enjoys the *same degree of protection from environmental and health hazards, and equal access to the decision-making process to have a healthy environment in which to live, learn, and work*.

Environmental burdens include any environmental pollutant, hazard, or disadvantage that compromises the health or quality of life of residents. Examples include pollution dumping and inadequate access to healthy, affordable food. Smart cities support environmental justice efforts through data collection, sharing, and civic engagement. Smart cities can collect and analyze data to ensure adequate water and energy supplies, proper sanitation services, clean air and water, efficient and affordable public transportation, Internet access, and neighborhood safety and security.

Smart cities facilitate civic engagement and meaningful involvement through a variety of two-way communication opportunities between local government and citizens. Many city agencies maintain an active and responsive presence on social media networks and many of them developed their own citizen apps. The apps can be used to share information and include functionality for citizens to report concerns, collect data, and participate in planning issues. For example, Paris has implemented a participatory budget, inviting anyone to post project ideas and then holding online votes to decide which ones merit funding. Many cities are using third party apps such as MyTown (Realterm Energy, n.d.) and SmartAppCity (n.d.) to enable civic engagement and improve city services. Some cities have developed their own customized app to foster citizen engagement such as the City of Charlottesville's MyCville app (City of Charlottesville, n.d.).

Smart city open data portals also support environmental justice concerns by collecting and sharing data for analysis. Open data can be analyzed to identify problems that need to be addressed. For example, the air quality data may indicate a certain neighborhood is suffering from high levels of toxins, or food accessibility

data may indicate food desert areas or lack of access to community gardens or farmers markets for healthy, affordable food.

Smart City Air Quality Monitoring Case Study

The World Health Organization has estimated 91% of the global population lives with pollution above recommended limits and over 4.2 million deaths per year are attributed to outdoor air pollution (World Health Organization, 2021). People living in low- and middle-income countries disproportionately experience the burden of outdoor air pollution with 91% of the 4.2 million deaths occurring in low- and middle-income countries. Smart cities use wireless sensor networks to collect and analyze environmental data such as temperature, humidity, and air quality. Smart technologies can collect highly localized environmental data throughout the city. The air quality data is sent to a cloud-based application for analysis and public viewing. The smart city air quality data can help policymakers identify the areas that need improvements and help citizens to avoid areas that may be especially high on certain days or certain times of the day.

There are many ways smart city technologies can help address outdoor air pollution across a variety of sectors:

- **Industrial:** Smart technologies can help reduce industrial smokestack emissions.
- **Energy:** Smart cities prioritize renewable combustion-free power sources such as solar, wind, or hydropower and the use of low-emission fuels. Smart cities include cogeneration of heat and power and distributed energy generation such as mini-grids and rooftop solar power generation. For consumers, smart cities offer rebates for smart home solutions such as energy efficient appliances, Heating, Ventilation, and Air Conditioning |(HVAC), and lighting.
- **Transportation:** Smart cities prioritize rapid urban transit, walking, and cycling networks as well as rail interurban freight and passenger travel. They include public transportation that uses clean modes of power generation, cleaner heavy-duty diesel vehicles, and low-emission vehicles and fuels.
- **Urban planning:** Smart cities improve the energy efficiency of buildings and make cities greener and more compact, and thus energy efficient.
- **Municipal and agricultural waste management:** Smart cities incorporate strategies for waste reduction, waste separation, recycling and reuse or waste reprocessing. They also include improved methods of biological waste management such as anaerobic waste digestion to produce biogas and low-cost alternatives to the open incineration of solid waste. Smart cities include improved management of urban and agricultural waste, including capture of methane gas emitted from waste sites as an alternative to incineration (for use as biogas).

A case study for air quality monitoring and environmental justice includes a Houston, TX air quality study (Demetillo et al., 2020) performed by several university researchers, NASA, and NOAA. The researchers used satellite data to measure air pollution and found that the levels of nitrogen dioxide (NO_2) were 32% higher in Latino residents, 10% higher for Black residents, and between 15% and 28% higher for residents living below the poverty line. Nitrogen dioxide pollution is linked to higher rates of childhood asthma, increased hospitalizations, and development of cardiovascular diseases. The results can help leaders identify environmental injustices and create policies that specifically target high pollution areas. Although Houston has one of the most robust air quality monitoring sensor networks in the country, only 3% of its residents live within 1.25 miles of an air monitor.

Smart cities need the help of satellite data to fill the gaps between monitors while they are improving their sensor networks. The European Union satellite, Sentinel-5P, carries the TROPOspheric Monitoring Instrument (TROPOMI) which measures environmental quality data such as NO_2. Cities can access this open data for free. As the cost of ground-based sensors decreases, some cities will have sensors on every smart lamppost to provide complete monitoring coverages. Until then cities like Galena Park, part of the Houston metro area, has only one air quality sensor. Galena Park is home to 11,000 residents and is located next to the heavily polluted Houston Ship Channel. Based on data from the study, Galena Park is a hotspot for NO_2 pollution and is also a community of predominantly working-class people of color.

The implementation of widespread air quality monitoring programs can help bridge the gap between the level of exposure to air pollution among communities by identifying areas of higher concentration of pollutants and reducing them through strategies such as including both technologies and policies and regulations.

Smart City Temperature Monitoring Case Study

Cities often experience the urban heat island effect, where areas with little tree cover and high use of materials such as asphalt, concrete, and black roofs absorb the sun's energy and radiate it back out, causing high temperatures than its cooler suburb or rural areas. The Centers for Disease Control and Prevention estimate that more Americans die from heat waves every year than from all other extreme weather events combined. Heat also increases the health impacts of ozone pollution. As climate change causes rising temperatures and cities get hotter, smart cities must find ways to address problem areas (New York City Council, n.d.).

A case study for temperature monitoring in Nature Communications (Hsu et al., 2021) shows that lower income communities and people of color are disproportionately exposed to urban heat island effects and related health issues. The research found that in all but 6 of the 175 largest US cities, people of color have higher heat exposures than white residents. Researchers used satellite temperature

readings over the span of four years along with demographic data from the US Census Bureau to compare the temperature in different urban areas. The study showed that the heat island effect temperature was 47% hotter for people of color and low-income residents.

Smart cities collect, analyze, and act upon temperature environmental data, whether ground-based or satellite, to create policies to protect the vulnerable. Areas with higher urban heat island temperatures will benefit from increased tree canopy, green roofs, white reflective roof materials, cool pavement, and cooling centers. Smart cities can use the data to prioritize resources for solutions and address the disparities. For example, the New York City MillionTrees (MillionTreesNYC, n.d.) initiative is preferentially planting trees in six environmental justice neighborhoods that the city's Parks Department identified as neighborhoods with the greatest need for trees. The identified neighborhoods have fewer than average trees and higher than average rates of asthma among young people. The six neighborhoods include Hunts Point, Bronx; Morrisania, Bronx; East New York, Brooklyn; East Harlem, Manhattan; Rockaways, Queens; and Stapleton, Staten Island. The increased tree canopy will help reduce both the heat island effect and air pollution.

Smart City Mobility Case Study

Cities face many mobility challenges that involve both environmental and equity concerns. Smart cities offer high-tech, sustainable solutions, known as smart mobility, that address climate change, advanced social equity and environmental justice, and support economic and community development. Smart mobility can take many forms including public transportation, biking, walking, ride-sharing, car-sharing, and more.

In 2016 Columbus, Ohio won a $40 million Smart City Challenge grant from the US Department of Transportation to demonstrate how modern, integrated transportation options can empower residents to live their best lives (Smart Columbus, 2021). Columbus has implemented a number of technologies under the grant award for safer, cleaner, more equitable transportation options to create opportunity for residents and innovate for the future. Many projects focused on the Linden neighborhood, and opportunity neighborhood with lower income and underserved residents, to show how these technologies can address some of the damage caused by decades of redlining, disinvestment, and isolation caused by interstate construction. The program was built on input and participation from Linden residents and other impacted neighborhoods. Residents worked alongside city staff to show how mobility innovations can be implemented in an equitable way, setting an example for other similar neighborhoods across the United States.

The grant enabled Columbus, Ohio to implement the following eight projects:

- **Connected Electric Autonomous Vehicles:** The Linden LEAP was the nation's first daily-operating public self-driving shuttle in a residential area;

it transported nearly 130,000 meals and 15,000 masks from St. Stephen's Community House to neighbors in need during the pandemic.

- **Prenatal Trip Assistance:** 143 Pregnant individuals with Medicaid coverage participated in Rides4Baby, the prenatal trip assistance research study. Access to on-demand transportation and expanded eligibility criteria for Medicaid-covered rides enabled women access to medical appointments, the pharmacy, and grocery stores or food pantries during their pregnancy and eight weeks postpartum.
- **Multimodal Trip Planning Application:** The Pivot multimodal transportation planning app has been downloaded over 1,000 times supporting 447 trips amidst the pandemic, and can be used as travelers return to downtown.
- **Connected Vehicle Environment:** More than 1,000 vehicles participated in the connected vehicle environment, where vehicles could "talk" to each other and to 85 intersections, 7 of them with the highest crash rates in central Ohio, to understand how the technology can help improve road safety. The technology improved emergency response times and slowed participant speeds in school zones during the demonstration.
- **Event Parking Management:** Federally-funded improvements to the ParkColumbus app make it easier to find and pay for street and garage parking in Downtown and the Short North.
- **Smart Mobility Hubs:** Six smart mobility hubs were constructed in Linden, at Columbus State Community College and at the Easton Transit Center to help fill transportation gaps between bus stops and traveler destinations. The hubs added six interactive kiosks, four scooter charging and bike share stations and one electric vehicle charging station to the neighborhood. The Linden hubs also represented the first expansion of bike share into an opportunity neighborhood.
- **Mobility Assistance for People with Cognitive Disabilities:** In 12 months, 31 individuals with cognitive disabilities used the WayFinder app to take 82 trips independently on public transit, rather than relying on a ride from a caregiver, fostering their independence.
- **Smart Columbus Operating System:** The Smart Columbus Operating System was built largely on open source software that is easy and cost-effective for other cities to implement. The operating system now contains more than 2,000 data sets that have been downloaded more than 220,000 times. The operating system is capable of processing near real-time data, streaming connected vehicle environment data every 15 seconds (Smart Columbus, n.d.).

The Smart Columbus projects demonstrate how an intelligent transportation system and equitable access to transportation can have positive impacts on every day challenges faced by cities. An accessibility analysis found that travelers

originating at the Linden Transit Center can now reach at least 20,000 additional jobs and 3,000 additional healthcare services within 30 minutes than using the trip planning tools that existed prior to the introduction of the Smart Columbus projects. Beyond the tangible assets created by the grant, The Ohio State University calculated that investments from the implementation of the USDOT award generated an estimated gross metropolitan product (GMP) of $173.39 million and generated or induced 2,366 jobs (Smart Columbus, n.d.).

Conclusion

Smart cities are resilient cities. They are positioned to address the challenges of increased urban population, climate change, and environmental justice inequities facing today's growing cities. With marginalized communities being disproportionately impacted by environmental issues both historically and in present day, it is important to develop solutions now to work toward a more equitable, sustainable, and resilient future. Smart cities and their associated technologies, open data, and civic participation will pave the way for the future of environmental justice.

Strategies to Help Achieve Resiliency

1. Always include residents in smart city planning and ensure that all voices and communities are heard.
2. Make collected data easily accessed and shared publicly through open data portals.
3. Increase air quality sensor coverage and/or utilize free satellite data such as the TROPOMI.
4. Start early when increasing tree canopy to address the heat island effect as it takes years for trees to mature. When possible plant fast growing trees that also clean the soils such as Poplar.
5. Address mobility challenges for all people including low-income, elderly, youth, pregnant residents, and residents with physical and mental disabilities.
6. Use collected data to prioritize resources for policies, solutions, and disparities.

Discussion/Review Questions

1. What are some hurdles that marginalized communities may face in a developing smart city?
2. What other environmental justice challenges, not discussed in this chapter, can smart cities help address?
3. How can city leaders ensure inclusion so that all residents have a voice in smart city planning?
4. How can smaller cities and towns not located in a large metropolitan area benefit from smart city technologies to address equity concerns?

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