Digitalization of Solid Waste Management

Mapping Shifts in Urban and Sectoral Governance in Mangaluru

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1. Introduction

1 The global "digital turn" (Ash, Kitchin, and Leszczynski 2018) in the last decade has accelerated the use of technology in urban service delivery.[1] Monitoring technologies such as city dashboards (Bayat and Kawalek 2021; Kitchin, Coletta, and McArdle 2017) and data collection (Yang 2020) are becoming increasingly common in cities across the world. This is especially true for basic urban services with the spread, for instance, of smart meters, contactless ticketing, and smart grids, among others.

2 In the solid waste management (SWM) sector, many cities across the world tried to optimize their operations using information and communication technology (ICT) in as early as the 1990s (Algarni and Ali 1998; Leao, Bishop, and Evans 2001). Digitalization in this sector has often involved the deployment of sensors, bar codes, and spatial technology such as virtual maps and global positioning systems (GPS)[2] to monitor the collection and movement of waste. Most of the existing research on the digitalization of SWM either remains centered on prescribing particular technological solutions or speculates about the changes digitalization may bring to the SWM services (cf. Biswas et al. 2021). This is partly the outcome of a narrow understanding of digitalization as the technology intervention that transforms physical and manual processes into computer-readable format. In this paper, we aim to go beyond a technology-centered reading of digitalization to argue that the shifts in processes, practices, and power relationships that are brought about by digital components in service management are central to the digitalization process.

3 The paper's objective is to develop an encompassing understanding of the outcomes of SWM digitalization in urban and sectoral governance. We analyze the various digital components introduced as "instruments of public action" that have performative

effects on administrative procedures, work cultures, and power relationships within municipal administrations (Lascoumes and Le Galès 2007). With this objective in mind, we seek to bridge the gap between technology-centered debates and the lack of reflection on the impacts of the digitalization of municipal waste collection on city governance, labor management, and accountability. We do so by tracing the ongoing digitalization of Mangaluru's SWM that includes establishing an Integrated Command and Control Center (ICCC), installing QR (Quick Response) codes on property premises, use of GPS and geofencing[3] in waste-collection vehicles, and developing a smartphone app that would act as a one-stop grievance redressal point. All these components are heuristic analyzers of the roles of actors, changes in decision-making, and shifts in governance that SWM digitalization brings about.

4 In India, many cities have begun to digitalize solid waste. Bengaluru, for example, employs a basket of ICT-based interventions that include geotagging of routes, geofencing, monthly data analysis through algorithms, and a smartphone app (Biswas et al. 2021). Kakinada, a municipal corporation in Andhra Pradesh, collects waste collectors' attendance using facial recognition software (ibid.). Delhi and Nagpur have implemented QR code based solid waste tracking (Chakraborty 2021; Express News Service 2022). However, the case of Mangaluru is of particular interest for a set of reasons. Despite being a thriving small town since the 15th century,[4] changes in its urban management remain understudied. The Mangaluru City Corporation (MCC) has an estimated population of around 720,000[5] and there are 211,578 properties[6] registered with the corporation. The city is also known for its well-run civic institutions (Budhya and Benjamin 2000) and calls itself a "bin-less" city for its one hundred percent door-to-door collection of waste (The Hindu 2012). In 2011 and 2018, the city also won two awards for its solid waste management practices.[7]

5 In India, the launch of the "100 Smart Cities Mission" in 2015 has played an accelerating role in the push for digital innovations in urban governance (Parkar, Zérah, and Mittal 2023). If transport has been the main area for the deployment of digital applications, solid waste management, along with energy and surveillance, has not been far behind. To fast-track projects, each Smart City has to incorporate a special purpose vehicle (SPV) to implement the mission at the local level, adding a layer to a complex municipal governance (Prasad, Alizadeh, and Dowling 2021; Khan, Taraporevala, and Zérah 2018). Mangaluru was selected as a "Smart City" in 2016, and its SPV, Mangaluru Smart City Limited (MSCL), was established in 2017. The SPV is in charge of implementing a digital component in MCC's collection and transport of solid waste.

6 Based on our grounded analysis in Mangaluru, the paper makes three arguments. First, the digitalization of the SWM system results in the entry of several new private players, such as local system integrators and technology vendors that transform procurement and contract management. It also ends up complicating an already fragmented urban governance as SWM is now being embedded in a dual governance structure of Smart City and municipal corporation. Second, solid waste collection is a highly labor-intensive sector and the digital solutions adopted are neither suitable for the working conditions nor are they sufficiently deployed to bring effective change in the collection. Third, the imagination of a one-stop online grievance redressal system as a game changer is misplaced since it does not improve (and might even aggravate) the trust deficit among the residents.

7 The paper is based on qualitative fieldwork undertaken during two visits in February and April 2022 and a follow-up visit in January 2023. Repeated interviews (more than 40) with various stakeholders were conducted to trace the perception and the evolution of the project over time. The stakeholders included officials in MCC and Smart City, local politicians, and the employees of consultants, vendors, and contractors involved in the project. Interviews with the waste collectors employed by the private company handling SWM, and participation in a training session organized for them were central to assessing how digitalization impacts labor. The fieldwork also included observation of the operations at ICCC, one of the solid waste collection points, and at the landfill site. The paper, however, is mainly focused on the collection of waste and does not include the potential impact of digitalization on treatment and recycling.

8 The rest of the paper is divided into six sections. The second section presents the justifications for the digitalization in the SWM sector, and its adoption in Mangaluru by the Smart City. Third and fourth sections discuss how various digital components are being implemented by a range of new actors but have limited impacts in finding solutions to sectoral issues. The fifth section focuses on the impacts on workers having to use a scanning device to prove that the waste is being collected, and on the perception of this practice by the administration and the private companies. The sixth section critically highlights the absence of residents from the conception and implementation of this project, while the seventh section provides concluding remarks.

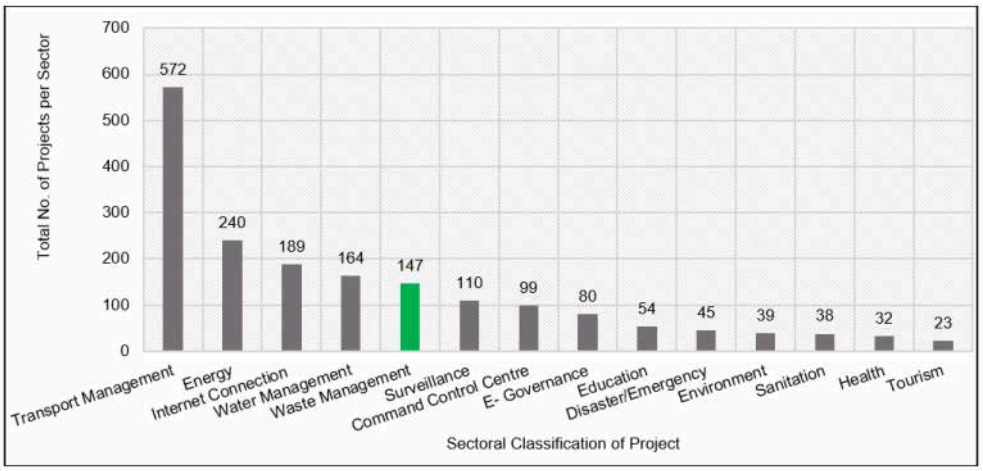
2. Rationale for digitalizing solid waste management in Mangaluru

9 Solid waste management emerged as a major urban governance issue in Indian cities in the mid-1990s (Chaturvedi and Gidwani 2010; Doron and Jeffrey 2018; Furedy 1995). Following the Supreme Court of India's decision in the Almitra Patel case, a Public Interest Litigation against municipalities that were not collecting waste, the Solid Waste Management Rules were enacted in 2000 and later amended in 2016 (Ahluwalia and Patel 2018). These rules laid down basic duties of the local bodies and waste generators (Reddy and Kumar 2018). They also recommended that a technical modernization of the sector should go hand in hand with organizational changes to remedy issues such as the lack of public awareness, inadequate infrastructure, poor institutional capacity, and financial constraints (Sharholy et al. 2008; Kumar et al. 2017). Consequently, in the last three decades, many changes have been introduced by municipalities to streamline the governance of SWM. They include the subcontracting of collection and transport to private players (Hanrahan, Srivastava, and Ramakrishna 2006), the involvement of residents in segregation and door-to-door collection (Kudva 2013), or even, as is the case in Pune, the formalization of waste workers (Chikarmane 2012). More recently, a new set of reforms focuses on the use of digital technology. Advocates of these interventions argue that this would lead to better management and efficient service delivery as well as stronger monitoring, tracing, and surveillance of private operators and workers (Joshi and Ahmed 2016; Sharholy et al. 2018).

10 To understand the impact of digitalization in SWM, its two characteristics are of importance. First, even though municipal governments in India have historically had very limited powers (Sivaramakrishnan 2014), SWM is the only basic service that is

fully controlled by them (Zérah 2009; Schindler and Kishore 2015). Therefore, the introduction of digital instruments by the SPVs created under the Smart Cities Mission (SCM) is bound to have some governance and sectoral impacts. As figure 1 points out, the digitalization of SWM is one of the most common projects adopted by Smart Cities under the Mission. A database of digital projects under SCM prepared by our team found that 72 out of 100 cities have at least one project relating to SWM.[8] It shows that 147 out of 1,867 digital projects across all Smart Cities are related to SWM, making it one of the highest sectors in terms of the number of Smart City projects. Therefore, lessons from Mangaluru can help with drawing lessons for the SWM sector as a whole. Second, SWM is a sector that is extremely dependent on workers who collect (and recycle) the waste. These waste collectors mainly live and work in very harsh conditions (Gidwani and Reddy 2011). While they are often seen as "abject and invisible residents", their manual skills are useful in disaggregating the waste (Reddy 2015). Keeping this in mind, many scholars have cautioned that in SWM, technology should not be perceived as a "magic bullet", as it obfuscates the labor-intensive nature of the sector (Reddy 2015; Schindler, Demaria, and Pandit 2012).

Figure 1: Sector based classification of digital projects under the 100 Smart Cities Mission



Note: Total number of projects = 1,867. Source: The database prepared by Sushmita Rai as part of the CPR-IRD project.

11 Before engaging in our analysis, it is important to describe how waste was collected before the digitalization of SWM in Mangaluru. The door-to-door collection and transport of the 330 tons of waste produced every day[9] have been subcontracted to a private company, Antony Waste Handling Cell Private Limited (Antony Waste).[10] The contract between MCC and Antony Waste was signed in 2015 for a period of seven years to achieve a more streamlined system (Kamila 2014), and later extended by one more year. Prior to 2015, SWM was handled by multiple private companies and self-help groups (Kudva 2013). Antony Waste manages the collection of waste according to the work plan provided by the municipal corporation. They have six designated collection points across the city to park their compactors (big vehicles) and high-lift tippers (small vehicles). They employ more than 800 people (drivers, waste collectors, and supervisors) and operate more than 100 vehicles (see figure 2). The small vehicles go door to door to collect waste from each household[11] and bring it to the collection point. The waste is then transferred to big vehicles and taken to the landfill. The employees

report to these collection points everyday early in the morning, and at the end of their working days, when supervisors check their attendance by taking their pictures and uploading them to the contractor's App. Antony Waste has also installed GPS in collection vehicles to track their movements and ensure that all locations are covered.

Figure 2: Digitalization of Solid Waste Collection in Mangaluru Smart City

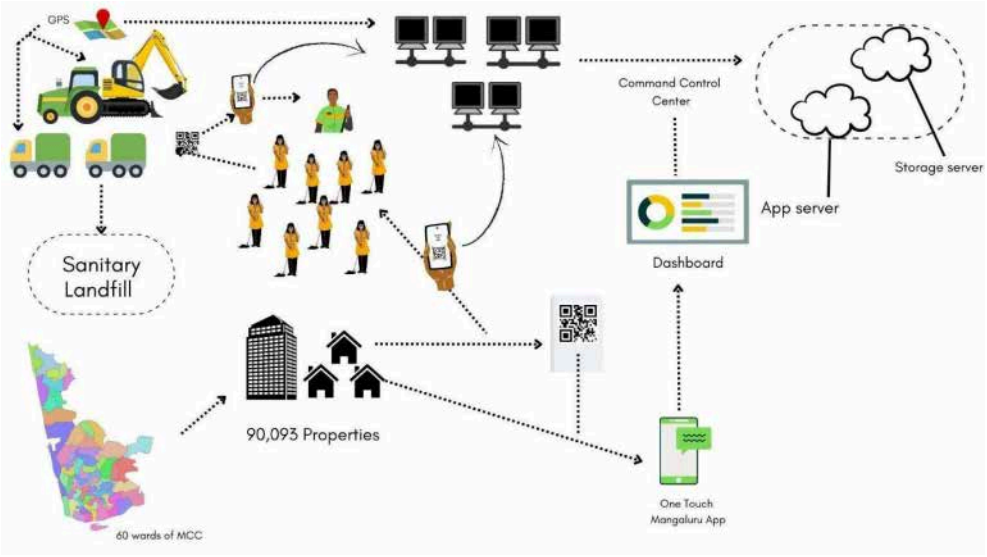


Figure by Barathi Nakkeeran based on interviews conducted by the authors with Smart City officials, corporation officials, contractor, and vendors in Mangaluru Smart City.

12 The SWM digitalization project seeks to introduce a more efficient technology-based system.[12] It entails a set of the following interventions: (i) installation of unique QR codes at each property, which waste workers should scan while collecting the waste; (ii) real-time updating of scanned data on the ICCC dashboard, where monitoring of vehicle location can also be done; (iii) GPS-based devices installed on the waste collection vehicles to track their movement and the geofencing feature to show on the dashboard if the vehicles have moved out of their pre-designated area; and (iv) OneTouch Mangaluru app to enable the residents to file complaints about any issues with the waste collection.

13 As with many other Smart Cities in India, the ICCC is the nerve center of all the ICT-based interventions (Praharaj 2020). The ICCC dashboard is supposed to provide a bird's-eye view of the city's SWM by displaying daily information on the number of waste collectors working, the number of properties covered, the number of vehicles plying their routes, and the amount of waste collected. The ICCC personnel can check these data on their monitors and alert the Antony Waste supervisors if they find any issues.

14 The project has been decided, designed, and introduced by the Smart City rather than by MCC.[13] The Smart City company is governed by a board of directors constituted of state government officials and municipal corporators, and is directly responsible for implementing all the projects funded by SCM.[14] Most of this investment has been for classic infrastructure such as roads, underground drainage, and hospitals, and the digitalization of SWM represents a very marginal share of total outlays under the

Mission.[15] When asked about the rationale behind this project, the General Manager of Mangaluru Smart City told us:

> We have come up with a robust solution, a way through which citizens can complain and all the vehicles are fitted with GPS and geofencing... the Smart Cities Mission guidelines provide that we should have IT solutions for pan-city solutions, therefore we have chosen to digitalize the solid-waste-management system. All Smart Cities in Karnataka have more or less chosen similar projects... ITMS [Integration Traffic Management System], SWM, Environment and Disaster Management and Emergency ... there was a push from the state.... (January 27, 2023)

15 In other words, a combination of factors, such as a national push for digitalization and a regional strategy[16] spearheaded by the Karnataka Urban Infrastructure Development Finance Corporation (the state-level nodal agency), have led to the selection of the project for digitalizing solid waste management. This digitalization was also approved by the Municipal Commissioner, who expected that some issues with Antony Waste regarding the amount of waste collected and the covering of routes would be monitored through the project (interview dated March 29, 2022). Consequently, the consensus between the municipality and the Smart City suggests the likelihood of a solid coordination for the success of the project, that the following sections aim to assess.

3. Effects of digitalization on sectoral and city governance

16 There is a wide consensus among scholars that the digitalization of urban infrastructure has coincided with the corporatization of urban governance (Söderström, Paasche, and Klauser 2020; Rebentisch et al. 2020). Söderström et al. (2020) argue that the Smart Cities narrative has been captured by private companies, who instead of providing a spatialized planning solution to urban problems, propose an optimization of city systems and infrastructures through code. Companies such as IBM, Siemens, and Cisco act as urban consultancy firms and reduce complex urban issues to management problems (McNeill 2015) that can be easily solved with the idea of "solution" (Wiig 2015; Hollands 2008; Kitchin 2015). Similarly, in the Indian case, even though consultants played a key role in previous urban missions (Sadoway et al. 2018), Smart Cities have led to an increased reliance on a wide range of consultants (Purandare 2021; Khan et al. 2018), especially IT consultants, as an effect of the digital turn spearheaded by the Smart Cities Mission (Parkar and Purandare 2023). These IT-driven solutions are often packaged as simple, clean, and one-size-fit-all fixes for complex social settings (Ho 2017).

New kids on the block: local system integrators and vendors

17 In Mangaluru, Antony Waste's contract with MCC is an integrated contract that includes door-to-door collection of waste and its transportation among other activities. [17] This type of delegation of service is a classic case of subcontracting, which has been the norm for SWM in many Indian cities (Zérah 2009; Harriss-White 2020). Antony Waste is in charge of manpower and equipment and is partly paid on the basis of the amount of waste collected. This furtive form of private delegation is part of what

Mehta (2013) calls "the contractor state," where contractors have benefitted from the retreat of the state and the financing of infrastructure.

18 In this context, we argue that digitalization along with SCM brings in two important changes. The first change is of an institutional nature with a shift towards a corporate form of governance. In addition to the establishment of a SPV, which is registered under the companies' act, Smart Cities also have to appoint project management consultants (PMCs) for the overall assistance in design, development, supervision, management, and procurement of projects. In Mangaluru, there are multiple consultants for different projects. StepnStones, a Bengaluru-based company specializing in IT/ICT solutions, is the PMC for all digital applications that are integrated in the ICCC infrastructure. Since the Smart City has a limited number of employees with an IT background, StepnStones works closely with the Smart City Deputy General Manager for IT, who is himself employed by the SPV on a contractual basis.

Figure 3: Two Faces of Mangaluru's SWM System

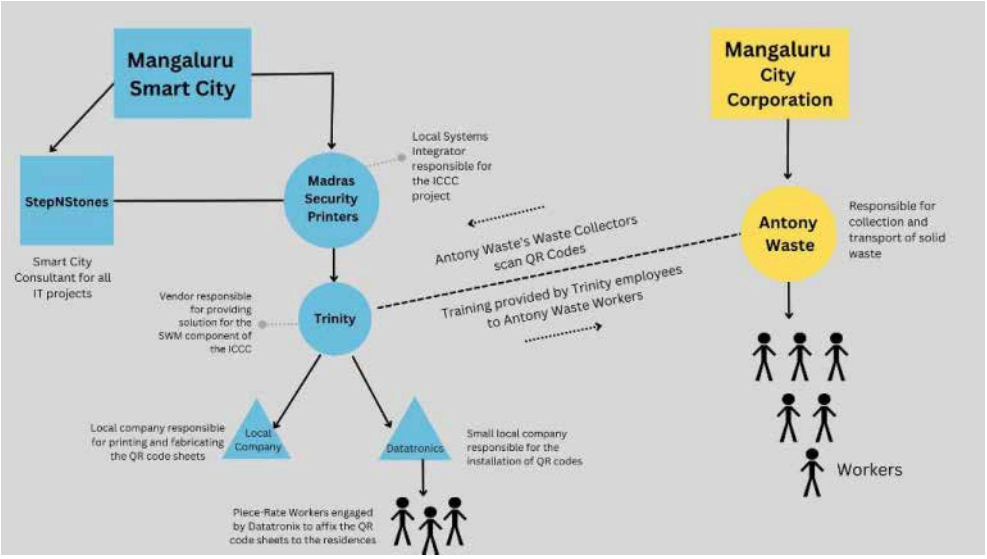


Figure by Barathi Nakkeeran based on interviews conducted by the authors with Smart City officials, corporation officials, contractor, and vendors in Mangaluru Smart City.

19 The second change relates to the arrival of two new types of private stakeholders. The first is the local system integrator[18] who was awarded the contract to deliver the ICCC project. In Mangaluru, the local system integrator is a Chennai-based company, Madras Security Printers Private Limited (Madras Security).[19] This integration of all digital interventions into the ICCC is done through multiple vendors. For SWM, the services are provided by a Bengaluru-based company, Trinity Mobility Pvt Limited. (Trinity).[20] As Figure 3 illustrates, the digitalization of SWM involves various components. For example, the GPS component requires fitting GPS machines to all the vehicles collecting solid waste and transferring the GPS data to the ICCC. Trinity undertakes some of these tasks using its in-house resources or through other vendors. For example, for the QR code installation, Trinity relied upon Datatronics, a small Mangaluru-based company. Datatronics, in turn got a local company to manufacture the QR code sheets and hired the gig-workers to affix the sheets to the houses and vehicles and collect household information to create the database.

20 Unlike Antony Waste's role as a contractor for MCC, which has been a standard in Indian cities for the last two decades, the presence of companies such as Trinity, Datatronics, and Madras Printers brings in a new category of private actors to urban governance. Local system integration through a chain of vendors introduces a major shift. These vendors provide very specific ICT-based tools to the cities, calling them "solutions." Not only this turn in governance has rarely been paid attention to, the difference that technology vendors bring in urban management is also hardly understood. When asked about the distinction between a contractor and a vendor, an engineer from Smart City gave us the following definition:

> A contractor is someone who gets one's hands dirty, otherwise one thing will not move. And a vendor is someone who sits in an A.C. room. (February 1, 2023).

21 This quote is not isolated. Other engineers express this perception in other words, hinting at the idea that technology vendors conceive, design, and supply digital interventions but are not in touch with ground realities, whereas contractors are involved on the ground and understand the local conditions well. What these observations also point out is their sense of government officials' lack of control over these actors, which is partly related to their skills as public works engineers that leave them ill-equipped to supervise these new types of digital projects.

4. Limited results of a complexified decision-making process

22 Since the introduction of the digitalization project, collection of solid waste in Mangaluru has been embedded in a dual institutional framework which can be described as being made up of the Urban Local Body / Contractor on the one hand, and the Smart City / Vendors on the other (Figure 3). This means that contracts, procurements, and accountability are dealt with through two different institutional routes. In the following paragraphs we trace the implementation of the GPS/ Geofencing and QR codes components of the project to assess how this relationship plays out.

The GPS/geofencing component: duplication of infrastructure and ill-fitted digital features

23 The GPS/Geofencing "instrument" is considered both by the Smart City and the Municipal Commissioner as a success, leading to a more transparent tracking of vehicles. We find that the GPS component embodies the issue of duplication of infrastructure. This component requires the installation of GPS devices in all of Antony Waste's waste-collecting vehicles. However, the contractor has its own GPS devices already attached to them (field notes, March 31, 2022). According to Antony Waste's employees, though the Smart City informed the contractor about the digitalization project, the details of the design were not shared. While meetings are held that include the consultant and the vendors, during these meetings Smart City officials merely check the status of project implementation rather than discussing processes that underline them. The meetings and discussions are also irregular and uneven. According to a senior Antony Waste employee, while they were called for the initial meetings, later the Smart City stopped inviting them. Consequently, the chain of nested

companies formed by StepnStones, and the Smart City technology vendors involved in designing digital interventions ended up replicating the GPS infrastructure of Antony Waste, incurring additional costs to collect data that was already being collected by the contractor before digitalization. Such incidents highlight a lack of coordination among various actors that neither the municipal corporation nor the Smart City acknowledges or considers as an issue since they understand them as two different projects and contracts.

24 Further, aside from redundant infrastructure, some of the features that were planned have not been implemented, revealing the disconnect between design and execution. Trinity had intended to implement a ward-level geofence. The goal of this feature was to compare the effectiveness of a ward's waste-collection operation to that of other wards. The main idea was to geofence the 60 existing wards so that no truck could go and collect from another ward. However, Antony Waste objected to the project's geofencing feature since it was difficult to adhere to ward-level boundaries given that their routes for waste collection crisscrossed different wards. As the employee of the local system integrator (Madras Printers) mentioned, Antony Waste's demand was accepted since this is a simple feature to disable in the application. However, what it highlights is the techno-fetishism pushed through the consultant and the vendor. They assumed that the digitalization would almost "naturally" solve the issue of the lack of monitoring of solid waste movement, without understanding the complexity of the urban fabric, where the neat boundaries of ward maps may not hold much meaning for the delivery of an urban service. This illustrates two ways of seeing the city. For tech companies it is a "solution" that is easily scalable and relates to an understanding of the city as a flat space, while a contractor, who operates in a complex urban fabric made of neighborhoods and different groups of citizens, understands the city as a rhythm that require constant, daily adjustments.

The QR code component: complexification of the decision-making process with very limited impact

25 A careful analysis of the QR code component raises another set of issues. It demonstrates how the projected simple and straightforward image of an automated future of cities does not remain as seamless when implemented. At the time of the preparation of the initial detailed project report, an RFID (Radio-Frequency Identification) system was preferred for the purpose of scanning instead of a QR code system. RFID has been used in many cities and was favored by Smart City's Deputy General Manager for IT, but due to debates on the cost of the solution and its requirements (such as real-time internet connectivity in scanning devices), this technology was abandoned. Understanding these choices is very important because they show how "solutions" that appear as evident are actually contested and debated, but once chosen they lock an entire sector into implementing them. The knowledge that the consultants and vendors are assumed to hold gives them power in the municipal space. However, while this chain of implementation agency (Smart City), consultants (StepnStones), local system integrator, and vendors (Madras Printers, Trinity, and Datatronics) seems to be a well-organized way of delivering the project, the one crucial element that is often overlooked is that none of them is involved in day-to-day SWM service delivery.

26 Moreover, the functioning of the QR code requires some coordination in administration. The SCM guidelines do not shed much light on the intricacies of the responsibilities that arise when the Smart City intervention is applied to the existing system. Trinity and Antony Waste engage with each other for various SWM-related tasks. Trinity's employees conduct training sessions for Antony Waste's collectors. Similarly, Antony Waste provides Trinity with feedback about the on-ground operations of its technologies. However, these tasks are not specifically provided in either of these companies' contracts. Yet, both Antony Waste's collectors scanning the QR codes and Trinity's operation of dashboard in ICCC are critical for the success (or failure) of the project. Because of this dual structure, the smooth functioning of the project is dependent on the interpersonal rapport between Trinity and Antony Waste's employees, and the ability of MCC and Smart City officials to ensure that these interactions take place. From a pure institutional reading, these interactions fall in a gray area and depend upon the rapport between these two private companies. The absence of contractual relationships also means the absence of organizational tools and processes that would help with coordination. These relationships can hardly be documented in any formal way and result in speculation and rumors regarding the main goal of digitalization among the various stakeholders. From a larger theoretical viewpoint, this could be read as an expression of the idea of "informality" as a tactic to allow for flexibility and *ad-hoc* decisions (Roy 2009). However, we argue that this fuzzy decision-making process is better understood as an embodiment of the recurrent tension within India's urban governance between the formal (but complex) institutional structures and the importance of key officials' agency (Zérah 2020).

27 The collection of QR code data is dependent on several other factors. The workers employed by Antony Waste are responsible for the day-to-day scanning of the QR codes and they face several hurdles while collecting this data, causing complications to their already physically arduous jobs. These workers are often blamed for the failures of the project. The next section discusses the implications of digitalization in a labor-intensive sector.

5. The paradoxes of digitalizing a labor-intensive basic service

28 Globally, Solid Waste Management is an area of work where the workers are likely to come from marginalized communities (Beall 2022; Blincow 1986; Hartmann 2012; Poletto et al. 2016; Uhunamure, Edokpayi, and Shale 2021). In India, workers directly handling waste mostly come from historically stigmatized communities intertwined with caste-based hierarchy (De Bercegol and Gowda 2019; Gill 2009; Harris-White 2020). In Mangaluru, waste workers are made up of people from scheduled caste and scheduled tribe communities. Though the digitalization of SWM is an IT project, the data fed into the system is generated through a labor-intensive process of scanning every premise from where waste is collected. That makes it highly dependent on the workers and the constraints they face on the ground since they are the ones who have to scan the QR codes at each household. Waste collectors employed by Antony Waste follow a designated route to collect waste in their allotted neighborhoods. The collection is done by groups of two (sometimes three) workers: one gathers the waste in buckets and puts it in the truck, while the other drives the vehicle.

Figure 4: Size of the QR Codes in Property Premises

Source: Authors.

29 The successful functioning of the digitalization project is contingent on the routine scanning of the QR codes. Thus, the waste collectors are the most critical component of this solution. However, these workers face many impediments on the ground. When asked if the scanning of QR codes was working, one of the Antony Waste supervisors said:

> See, this is dependent on the waste collectors. On some days they scan the codes, while on others they ignore it. For instance, on Fridays, which is the dry waste collection day, it is a very busy day for the workers. ... there is a heavy workload for them, so they don't have much time to scan. On other days they scan "fully" (sic). In some areas there are connectivity issues. ... in those areas scanning does not happen often. (March 30, 2022)

30 The difficulties are of two types. First, problems stemming from the sector's labor-intensive nature. The QR code scanning adds to the physically arduous nature of waste collectors' everyday work. These QR codes are printed on tiny fabric sheets which are fixed onto the walls of houses (Figure 4). Waste workers are thus required to stand extremely close to the sheet with steady hands to obtain a legible scan. This process makes the whole activity time-consuming and unreasonable, especially when the workers are pressed by the supervisors to cover more households in less time. Moreover, the scanning device must be held with hands and the fact that the waste workers wear slippery, rubber gloves creates more issues.[21] The same supervisor quoted above added:

> Many times, they [workers] have two buckets in which they "hold the waste" and then they have to hold this device in their hands. ... so, there are many problems. Now [in March] it is still okay but imagine the same situation during the monsoon. ... [the workers face] too many issues while collecting waste. The device can get drenched in the rain. The workers can slip. Majority of Mangaluru landscape (around 70%) is hilly, streets are narrow. There are many areas where there are no

> roads. If workers fall in these areas, then the device can stop working. (March 30, 2022)

31 The waste collectors are required to do a lot of ergonomic maneuvering to scan the QR codes. Often, they have to walk twice toward the house: once to collect the waste, and again to scan the code. These actions are further complicated by Mangaluru's geographical conditions. The abundant rains and steep roads make carrying heavy loads difficult. Moreover, neither MCC nor the Smart City provide charging facilities for the scanning devices. Most of the workers live in informal settlements with poor access to electricity. Still they have to bear the burden of charging the devices at home. These issues make it clear that the project is far from being a "solution" to the material and social conditions of waste collection work.

32 The physically grueling nature of waste collection does not go unnoticed by the vendors. In an interview, an employee of Madras Printers precisely described how it was difficult for workers to optimize their movements since their "hands are occupied" (interview with an employee of Madras Printers, January 27, 2023). However, despite this apparent understanding, he still partly laid blame on workers whom he considered as averse to technology. There is a shared belief among the vendors, the Smart City, and municipal corporation officials that "they [workers] want to run away from the technology" as "we [Smart City] never anticipated that they would not scan. We thought there would be 100% scan" (interview with an engineer from the Smart City, February 1, 2023). Thus, any flaw in the digitalization project is attributed to poor implementation by the waste collectors.

33 These allegations portray the socially disconnected characteristic of the digital solution as subjective unwillingness on the part of the workers. According to the vendors, the app should have worked because they had piloted and tailored the solution to the city's needs. They also consider that regular training is a solution to the problems on the ground. However, our observations, and discussions with supervisors who worked in other cities, show how these training sessions are inadequate. They act as a formality in educating workers about the App. We observed that in training: a Trinity employee would bring one device to show workers how to use it, and most of them were not even able to see what was happening on the screen.

Figure 5: Hand-Held Device for QR Code Scanning

Source: Authors.

34 Moreover, even if the workers learned how to use the app, most of the times they just memorized the navigation, and later got stuck if somehow the navigation did not work as they remembered. The app is only available in English, making even simple navigation a nightmare for the marginalized workers with less educated backgrounds. Furthermore, these sessions are done off-site, instead of accompanying the workers on their waste collection routes. The lack of on-site training that would help the app designers to better grasp the material working conditions remains a key loophole. It means that the clunkiness of digitalization is not considered and instead the workers are treated as the weakest link.

6. Digitalization: an instrument for accountability and a transparent social compact?

35 One of the various arguments put forward for digitalization is the role it can play in improving accountability by making governance practices more transparent and accessible to citizens. SCM seeks to improve accountability by "using mobile services to reduce cost of services and providing services without having to go to municipal offices" (Ministry of Urban Development 2015:7). We understand the idea of accountability as the ability for residents to understand the shifts in the delivery of basic services and their capacity to put forward their grievances. The digitalization of SWM in Mangaluru promises to set up a one-stop grievance redressal mechanism through the OneTouch Mangaluru app in order to make the system more accountable

and enable everyone to file their grievances. However, a close inquiry into how this mechanism works indicates otherwise.

A low-level awareness of a partially digitalized collection system

36 Most of the people we met during our fieldwork were unaware about the use of QR codes installed on their properties. For example, a resident (who happens to be a retired state-level bureaucrat and ex-member of Karnataka's legislative assembly) thought that the QR codes were installed as a part of data collection undertaken by the state education department. A former ward councilor thought they were for the purpose of providing gas connection to residents. Another person thought that these codes had been installed for property tax purposes. Some people were also suspicious of the exercise. For example, a resident thought the information was being collected under the recent controversial amendments to India's citizenship laws.

37 Such lack of information is not simply an issue of awareness but of trust deficit and informed consent. Digital-based interventions necessitate heavy and invasive data collection and this is bound to create confusion and even cause anxiety among the residents, especially in a religious conflict-ridden city like Mangaluru. In the absence of awareness and consent among the public, the whole exercise of data collection becomes problematic and also results in partial or fragmented data. The unawareness about the use of QR codes also resulted in many people being skeptical about their installations. The proprietor of Datatronics, the sub-vendor who was hired to install the QR codes, informed us that many people did not allow them to install the QR codes in their premises or refused to give the information that was required to be collected as part of the QR installation drive (interview with the proprietor of Datatronics, April 1, 2022). Even though the Datatronics employees were carrying a letter from MSCL, there were many instances where the residents did not believe the letter. This has resulted in many households not being covered through the QR codes.

38 In section 4, we discussed the complexification of the decision-making process in relation to the codes component of the project. These complexities also led to partial coverage of QR codes. Datatronics installed only 90,000 codes, which does not cover all households. Moreover, the contract did not specify the methodology to be used in installing these codes. Datatronics, in turn, hired gig workers and private companies to install QR codes at random in all the wards under time constraints. These workers installed the codes in houses that were easily accessible to them, leaving out those that resisted or were simply inaccessible for other reasons. Hence, none of the wards or neighborhoods is fully covered by the system. The Smart City also lacks information on households where the codes are not installed. In the absence of comprehensive QR code coverage, the data are not only incomplete, but also useless for analyzing the overall system's efficiency. That could be the reason why the Smart City is now not looking for comprehensive analysis of data and the scanning of two or three houses per lane is considered sufficient to claim that the whole street has been covered (interview with an engineer from the Smart City, February 1, 2023).

Figure 6: Status of QR Code Scanning—Total Number of Properties Scanned (Daily Average) between September 2021 and July 2022

Note 1: Based on the daily QR code scanning data collected by Mangaluru Smart City, which was provided by the Smart City vendor to the authors in January 2023.

Note 2: The total number of properties in Mangaluru is 90,093.

Source: Mangaluru Smart City Door to Door Report from August 2021 to August 2022.

39 This does not prevent most of the employees of the Smart City to argue that there is full coverage at the city level, indicating the perceptions that shape discourses on the ground. Similar statements regarding the impact of scanning claim that the uptake was initially slow but later picked up. However, the data shared by the Smart City with us contradict the claims made. They show that at its peak (in December 2021), the scanning did not even cover 2% of the properties where the QR codes were fixed (Figure 6). Since then, the scanning shows a downward trend with almost no scans done in August 2022. These numbers indicate how far the project is from its shared objectives. It is neither a pilot nor a test bed, but perhaps an *ad-hoc* component awaiting completion. However, the completion would require a lot of work on the ground: to engage with the daily SWM work and to even start looking at the data produced. Nevertheless, some employees of Smart City and the municipal corporation still believe that the QR code component would improve the quality of SWM services, while others like a municipal corporation engineer remark:

> I... really... don't know... I only joined last year... commissioner said it would be easier to track via this app... Basically every household is integrated by this code. Data on every household is then available. This is useful for micro-planning. It started with solid waste management, but it is just to gather more data... not for solving any problem... (March 29, 2022).

An inefficient grievance redressal system

40 The other objective of the project was to streamline the grievance redressal system related to SWM. It was to be done through the OneTouch Mangaluru app. Discussing the rationale behind this app, the Managing Director of the Smart City told us:

> When you want to "provide a world-class city" these kinds of digital solutions can help. We wanted a system wherein common people can access government officials directly and receive an immediate remedy to their problems. (March 31, 2022).

41 However, when we tried to check how the grievance redressal system worked through the app, we found that the latter is not available on all mobile platforms. While there is

an Android version, it is not available on iOS. Logging into the system is cumbersome and it is not easy to find how a complaint about SWM related issues could be filed. Moreover, at the backend, the grievance redressal system is not integrated with the municipal corporation's system. An employee of Trinity, who compiles the complaints lodged through the app, prepares an Excel file and shares that with the MCC health inspector. There is no mechanism through which he would know what sort of problems could be escalated at what levels. This situation resonates with Datta's (2023) assertion that analog recordkeeping still remains central to the digitalization of urban governance in the Global South. It dismantles the claims that the app would streamline the grievance redressal system and that people would receive immediate remedies to their problems. Moreover, it raises questions about whether the city requires a single-window system for grievance redressal.

42 During our fieldwork we observed that outside the context of this app, Mangaluru's residents pursue a diverse set of options to solve their SWM related complaints. These options include contacting their ward councilor, Antony Waste supervisors, health inspectors at MCC, or even the waste workers who come to collect the waste from the neighborhoods. These actors can be contacted through phone calls, SMS, emails, letters, and WhatsApp messages. People who do not know any of them can either call the MCC control room to file complaints or visit the corporation's office, where an MCC staff member and an Antony Waste employee sit with their registers. All MCC health inspectors and Antony Waste supervisors are part of a WhatsApp group that is used to convey the complaints to the most appropriate person and get them resolved quickly. Residents also have the option to use the Swachhata-MoHUA app launched by the Indian government's Ministry of Housing and Urban Affairs (The Hindu Businessline 2020). Each of these mechanisms have their own processes of grievance redressal. This pluralism is an essential aspect of the everyday city and its diverse milieu. The residents' different preferences are a matter of local context, culture, and the relationship between the resident and the local government (Berenschot and Bagchi 2019, Harriss-White 2020).

43 Even if one were to believe digitalization's array of promises (order, modernity, and efficiency), it is unclear if cleaning the city of these informalities would make the system more efficient. Existing scholarship has argued the empowering nature of these informalities (Berenschot and Bagchi 2019). They embolden urban residents, particularly the marginalized, for whom the bureaucratic terrain is frequently difficult to navigate. In this project, we see that the image of the Smart City as the materialization of the future moral state, i.e., with more sophisticated, accountable, and transparent structures of governance, is not as easily achieved through digitalization (Datta 2019). The notion that technology can accelerate toward this future is defeated at the implementation level. What happens to the image of the clean city, in this context? It seems that the Smart City does not do better than the old system, but simply complicates the existing system by trying to oversimplify it.

7. Conclusion

44 There is a growing concern toward the digitalization of urban service delivery due to its possible implications for a more predictive and algorithmic governance (Kitchin 2015), and for the citizen-state relationships (Sadowski 2021). In this paper, we

sought to understand the ongoing digitalization of governance in Mangaluru through the lens of SWM. In tracing the origins of and the path taken by the project, this paper locates the "digital solution" introduced by Mangaluru Smart City within the larger background of the city's existing SWM practices. The city's recent reputation for its efficient SWM system, along with the push provided by policies such as the Swachh Bharat Mission and the Smart Cities Mission has propelled its desire to move toward a kind of city that is modern, smart, and clean. Digitalization appears as a key feature of this new city. This paper shows that these desired outcomes are far from being achieved. The study of the digitalization of SWM in Mangaluru, instead, leads us to make a few observations.

45 First, it enables us to characterize the shifts that are at work with the arrival of a new type of private players, in particular the local system integrators and the technology vendors. The technology vendor becomes an indispensable technical expert who benefits from knowledge asymmetry and can design "solutions" that lock in municipal administrations. Their role in designing digital interventions in an already fragmented governance tends to dilute the already weak power of the local government further.

46 Second, the specificity of SWM raises a set of questions regarding the introduction of digital projects for urban services where street-level bureaucrats are critical to delivery processes. SWM is an acute case because of its dependence on a large number of employees. We argue that contrary to very optimistic views on the potential of technologies, the very nature of this sector is not conducive to certain innovations, which a cost-benefit analysis would certainly further show. Much greater investment in training, monitoring, and improving working conditions would certainly have a greater impact than the introduction of measurement tools, especially when the latter are only partially implemented. Such an outcome could differ in other sectors (for instance, if one looks at the integration of payments for different modes of transport). This leads us to call for the development of situated analysis of digitalization, across sectors and cities, to go beyond normative postures. It would be important to expand work on other urban services to verify if these shifts are sector specific or also transposed to other sectors where digitalization is progressing rapidly.

47 Third, the supposed promises of digitalization with regard to accountability are far from being fulfilled. What the Mangaluru case shows us is the opposite: a digital veneer that does not solve the problems faced by residents, who still prefer to resort to other means to make their voices heard. But beyond that, fears about the nature of the data collected, even within the municipal administrations, reinforce the mistrust that is already known to be a major feature of relations between citizens and the state in India. In this sense, forced digitalization does not seem to be going in the direction of improving the local social contract.

48 This series of observations open up points for a final discussion. Digital interventions are frequently viewed in a binary light. They are either lauded as game-changers, or criticized as being completely vacuous projects—a sheer product of corporate marketing. We argue that these perspectives are neither accurate nor useful in examining the shifts created by digitalization. Smart City technologies have not completely substituted the old systems and the materiality of the urban fabric. Instead, the digital interventions highlight the room for improvement. Through processes of regular and informed consent, such interventions can be accommodated. Such a perspective allows us to see the possibilities held by digital interventions while being

cautious about their harmful effects. In this light, we contend that while Smart Cities in India have not been game-changers, their effects cannot be completely dismissed. Our paper demonstrates a new way of looking at digital infrastructure that is not a zero-sum calculation. Such a middle ground allows us to examine the possibilities of understanding digital interventions as evolving aspects of cities as opposed to static components, where new systems do not completely replace old systems but create contradictions, revealing gaps for the local government to improve on.

49 We understand the limitations of this study, as it was conducted while the digitalization project was still in progress. This prevented us from looking at the complete project. However, studying it in its implementation phase also enabled us to understand the functional problems such undertakings face, which may lead to bigger problems in future. This paper also builds a foundation for future research that could look into the overall impact of the project. Systematic studies of the impact of SWM digitization on citizens could provide extremely valuable insights into the implications of digitalization for urban governance. Studies on the effect of ICT interventions on coordination between various government actors, private parties, and citizens could tell us whether the efficiency of the SWM system lies in information and optimization, or more complex social behaviors.

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NOTES

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2. GPS is a network of satellites and receiving devices used to provide geographic coordinates that give the exact position of things on Earth.

3. A geofence is a virtual boundary that is created around an actual geographical area to control vehicles’ movement and behavior within that boundary.

4. The city of Mangaluru carries its historic importance as a trade center to contemporary times by developing itself as an industrial and logistical hub (Naik 2022). It is also known for its high levels of literacy and educational institutions (Budhya and Benjamin 2000).

5. The Indian population census was due to be conducted in 2021 but was postponed due to the Covid-19 pandemic. Since that census was not conducted, this number is extrapolated from the United Nations’ World Population Prospects 2018 report (https://population.un.org/wup/). As per this calculation, Mangaluru’s population is expected to reach 724,159 in 2023 as compared to a population of 488,968 in 2011 (Census 2011).

6. As per the Mangaluru City Corporation website (http://www.mangalurucity.mrc.gov.in/en). Last accessed in October 2022.

7. Mangaluru won the Green Leaf Award for scientific landfill management in 2011 (Mangalore Today n.d.) and an award as part of the *Swachh Survekshan* in 2018 (The Hindu 2018). The *Swachh Survekshan* is an annual sanitation and cleanliness survey conducted by the Ministry of Housing and Urban Affairs.

8. The database is based on available information from the Smart Cities Mission website. It was prepared by Sushmita Rai as part of the project “Urban governance in India through the prism of the 100 Smart Cities Mission”, undertaken jointly by the Centre for Policy Research and the Institut de Recherche pour le Développement, and funded by the Agence Française de Développement.

9. The number was provided by MCC officials during our interview in April 2022.

10. Antony Waste is a Thane-based company that specializes in a full spectrum of solid waste services, which include collection and transportation of municipal solid waste and the operation of waste treatment plants and landfills in many cities.

11. MCC defines the households by property boundaries, resulting in even large housing societies being counted as one household.

12. The SWM project is a part of six ICT interventions under the ICCC project. The interventions include an air-quality-monitoring system, smart poles, an integrated transport-management system, a disaster management, the OneTouch Mangaluru App, and the digitalization of SWM.

13. We indifferently use the terms “the Smart City,” “Mangaluru Smart City” or “MSCL” to designate the SPV that was created to manage all the smart city projects.

14. Each city is eligible to get Rs. 1,000 Crore funding (co-funded by the central and state governments). For a detailed description of the Smart Cities Mission, see Taraporevala (2018).
15. Despite trying to triangulate different sets of data, establishing a correct cost of the project is not easy. The aggregated data provided by MSCL only provides the overall expenditure related to the ICCC. We estimate the cost of the project at approximately Rs. 1.5 Crores based on an interview with an MSCL official who put the total cost of the six ICT projects at Rs. 8 Crores.
16. The General Manager of Mangaluru Smart City informed us that Belagavi and Hubbali also have similar SWM projects under SCM (interviews dated January 27, 2023 and February 1, 2023).
17. In addition to solid waste collection and transportation, Antony Waste's contract includes manual sweeping, drain cleaning, green cutting, and beach cleaning.
18. A local system integrator is an IT-specialized company in charge of creating computing systems that include hardware and software components, as well as networking and cloud storage for the data.
19. Originally a company that printed security documents such as bank cards and cheques, Madras Printers now specializes in internet-based "solutions" for Smart Cities. Source: https://madrassecurityprinters.com/about-us.php.
20. Founded in 2011, Trinity specializes in digital platforms and apps for cities. For solid-waste management, they have developed an app called trinitySWM. Source: https://www.trinitymobility.com/segment/smart-city.
21. Our interviews revealed that there was a suggestion to make the scanning device similar to a watch, which may have been easier for the workers to handle. However, this option was not taken up.

ABSTRACTS

Digital interventions in urban governance are frequently viewed in a binary light. They are either lauded as game changers or criticized as being completely vacuous projects. Studying the ongoing implementation of a project on digitalizing the solid waste management (SWM) system in Mangaluru, this paper presents a new way of looking at digital infrastructure that is not a zero-sum calculation. The paper makes three arguments: (i) digitalization brings in several new private players to urban governance, who end up complicating an already fragmented system, (ii) digital solutions adopted are neither suited to the labor-intensive working conditions of the SWM sector nor are they sufficiently deployed to bring effective change, and (iii) the idea of a one-stop online grievance redressal system as a game changer is misplaced since it does not improve the trust deficit among the residents. Through highlighting these issues, the paper presents the possibilities of understanding digital interventions as evolving aspects of cities, where new systems do not completely replace the old systems but create contradictions, revealing gaps for the local governments to improve on.

INDEX

Keywords: urban governance, digitalization, solid waste management, urban service delivery, smart cities

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