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Determinants of Smart Digital Infrastructure Diffusion for Urban Public Services

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ABSTRACT

The Government of India's 'Digital India' initiative intends to build a robust digital ecosystem that fosters innovation and entrepreneurship enabling better citizen service and citizen empowerment. Digitization in India involves geo-demographic and socio-economic dependency, choice of smart technologies undergoing rapid innovation, strategic roll-out planning, and flawless implementation as prerequisites of technology diffusion and benefit realization. This study identifies technical and non-technical determinants of smart digital framework roll out that can accelerate digital diffusion in urban public services in India. This study follows inductive exploratory method, combining grounded theory and text mining for primary data analysis. The study reveals digitization is an ecosystem of private and public enterprises and citizen participation, identifies integrated use analytics and IoT can enable connected smart city, whereas technology cost, digital literacy, and sustainable innovation are identified as non-technological determinants towards resilient urban digital infrastructure in India.

KEYWORDS

Digital India, Digital Infrastructure, Rapid Innovation, Smart Technologies, Social Entrepreneur

1. INTRODUCTION

Government of India launched the Digital India program in 2015, encouraging innovative use of smart digital technologies by public and private enterprises, promote social entrepreneurship to bring in speed and transparency in public services delivery. This nationwide program vision is to empower citizens through robust digital infrastructure leading to on-demand services and governance delivery (DigitalIndia, 2020). Digital India has seventeen sub visions as explained in Figure 1, whereas there are numerous technology initiatives under Infrastructure programs Digital Identity, Center of Excellence for Internet of Things (IoT), DigiLockers, MyGov, SmartCity are a few noted ones. Complementary

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programs like Start-up India, Skill India in addition to Digital India created a framework to encourage social entrepreneurship, knowledge-intensive innovative usage of smart technologies, the ecosystem of public-private -participation in digitization, incubate localized applications leading to efficient and transparent public service delivery.

Figure 1. Digital India Program (Source: https://csc.gov.in)

1.1. India's Digital Journey

Several factors motivated India's digital drive recently. Post 2015 India's technology and scientific innovation got linked to sustainable development objectives (Surana et al., 2020), government's self-reliant India policy triggered local innovation and entrepreneurship (Goyal & Garg, 2021), Covid19 amplified reliance digital platform's capability and availability impacting impacted citizen' life and livelihood (Lai & Widmar, 2021). Saxena (2018) cited anti-corruption and transparency in service delivery motivates government driven innovation, but Kumar and Kumara (2018) pointed out that

motivations vary on maturity level, socio-economic strata, urban, semi-urban and rural demography, education and computer mobile penetration. On the other hand, India's flagship IT industry of 191 B US $ contributes to 8% of India's GDP employing nearly 5 million knowledge workers (Nasscom, 2020). However, 70-80% of the IT sector is focussed on international business (Statista, 2020), which reoriented to domestic business due to global geo-political factors. Domestic digitization increased lately with private and public sectors adopting technology for better quality, competitiveness and efficiency, rapid technology innovations whereas Government pushed for cost effective, high quality and transparent digital delivery of citizen services. This resulted domestic digital industry growing over next 5 years, where Research and Markets (2020) predicted nearly 75% growth of Indian digital industry advancing to a 700 billion US$ market size.

1.2. Digital Transformation and Governance

It is important to note that Digital India program is not about digital governance or e-Governance. Digital India is a technology platform initiative by Government but involving many public and private players, who can build various digital applications that is transactional and does vertical and horizontal integration of multiple industry sectors (Tripathi et al.,2014). E-governance and digital governance is one of the many applications of Digital India initiative. However, to differentiate between digital governance and erstwhile e-governance one should note that digital transformation is a continuous process unlike erstwhile timebound electronic computerization projects (Mergel et al., 2019). OECD/ Inter-American Development Bank (2016) defined eGovernance as IT adoption in governance whereas digital governance is not just putting government information online but paradigm shift towards uses of digital technologies across government and non-government actors and ecosystem to create public value, brings efficiency in managing public resources through use of telecom infrastructure and online services (Moreno-Enguix et al., 2019).

1.3. Challenges of Digital India

However, large scale digital technology roll out in large country like India has its own challenges. First major challenge is diverse socio-economic and geo-demographic variance. Second, rapid pace of innovation of smart technology that is difficult to cope up with, inadequate local R&D and product development, limited domestic focus by technology sector. Finally, core sectors like manufacturing, transportation, and farming have resistance to change, commercial and capability constraint towards adopting digital business models. Several studies by Kumar et al. (2017), Sachan et al. (2018) found the need of well designed, technologically advanced software technology platform capability is needed to adoption and proliferation of digital engagement of citizens. Rana et al. (2019) cited technology integration and convergence as critical factor, Shareef et al. (2014) pointed out security and reliability as key determinant.

1.4. Urban Digitization

Digital India drive focussing on urban India has certain significance. First of all, India's 400 million Urban Millennials contributing to 46% of workforce and 70% of household wage earner (Morgan & Stanley, 2017), are the prime consumer of digital service. This high urban concentration having 2.5-time per capita income than rural India (FinancialExpress, 2019), has the ability and intent to subscribe to commercially viable Digital Services. Second the priority of urban digitization is also manifested through Governments earlier form of urban development priority through SmartCity mission (SmartCities, 2020), which also helps achieve United Nations Sustainable Development Goals. This has been further Accelerated by India's ICT capabilities, very promising start-up incubation coupled with rapid innovation in disruptive technologies like IoT, AIML, cloud, Blockchain etc. Various urban digital use cases are waste management, municipal services, water and electricity, transportation and traffic, healthcare, public safety and security, disaster and crisis management, pollution control led to Smartcity initiatives.

1.5. Digital Technology and Innovation

It is important to understand the contours of digital transformation in context of various emergent digital technologies. Verhoef (2021) suggested digital transformation is combination of traditional technology like Internet, Mobile along with disruptive technologies like Big Data, Analytics, Blockchain, IoT, AIML. Riera and Iijima (2019) called it SMACIT, extending erstwhile Social, Mobile, Analytics and Cloud with IoT recently as digital business value enabler. Covid19 accelerated digitization through adoption of cutting-edge technologies like AIML, IoT, Blockchain, especially in financial sector (KPMG, 2020). Digital technology innovation unleashed new business models and entrepreneurship, Google, Apple, Amazon on one hand and social media and entertainment companies like Netflix and Facebook on the other hand dominating financial markets (Business Insider, 2017), is a testimony of this fact. India also became 2nd largest start-up hub globally where more than 4700 are technology start-ups out of 20000 in total in the areas of e-Health, E-Education, ecommerce (StartupIndia, 2021). Governments' policy encouragement along with availability of disruptive technologies promoted technology innovation driven start up ecosystem in India. Institutional knowledge, human capital, talent and capability influences successful business incubation (Bendickson et al., 2021), that exists within knowledge workforce in Indian IT and ITES sector in abundance.

1.6. Research Outline

Multiple factors like emergent technologies, Government policy shift, pressing urban development needs and innovation in business ecosystem calls for holistic urban digital initiative. Prior research points to availability of innovative, affordable, secure, well designed, integrated advanced technology solution and digital infrastructure is pre-requisite towards citizens digital engagement. An well thought innovative technology design and flawless implementation of digitization framework towards a long term sustainable and resilient digital journey is important for maximizing citizen's benefit realization. Past literature survey by Rana et al. (2012), Tan and Taleihagh (2020) in areas of city governance shows coverage of commercial, social, regulatory, governance, human factors in successful adoption. However, this leaves a scope of study into determinants of digital technology infrastructure, used by an ecosystem to deliver public services in India. This study reveals Sustainable innovation at an affordable cost of technology together with digital literacy and knowledge dissipation are non-technical factor of urban digitization. Whereas combined and integrated use of IoT and Analytics, that connects various SmartCity applications are technical determinant of urban digitization. It also finds smart technology driven digital platform creates cross industry ecosystem that encourages social entrepreneurs to incubate new business models. This study is useful for public policy makers involved in urban digitization; private sector embarked in digital transformation projects and academia with interest in Digital India program.

Paper follows inductive research, primary data collected through interviews are analyzed using grounded theory (Corbin & Strauss, 2014) and using text analytics tools. The structure of the paper includes the literature review, research gap and research question, research design, analysis and discussion, implications and conclusion.

2. LITERATURE REVIEW

Over last 30 years Indian IT and ITES sector generated 70% of their business from international markets, several significant outsourcing projects managed by Indian ICT majors is a reflection of this successful phenomenon (Choudhuri et al., 2009). In 2015 Government of India launched Digital India program combining Digital infrastructure, Digital Services and social empowerment. Several initiatives under Digital India program are Digital Identity, Digital Payments, ePathshala, CoWin, Arogyasetu (Digital India, 2020), which align with United Nation's Sustainable Development goals (SDG) which suggests digital infrastructure is a critical enabler to eGovernance (Osman & Zablith,

2020). EGovernance Development Index (EGDI) published by United Nation (2021) shows India stands at 100 out of 193 in Development Index but 29 out of 193 in E-Participation Index, shows citizen's willingness to e-Participate is more than digital infrastructure development and readiness. Government's Digital India program is expected to build that digital infrastructure as umbrella program of several subprojects has potential for employment generation and better citizen services (Siwach & Kumar, 2015).

Digital governance is not delivered by government but it is an ecosystem of private and public entities alongside citizen participation (Misra et al., 2018), which requires horizontally and vertically integrated, collaborative and unified use of technology working beyond boundaries rather than standalone IT project implementation. Erstwhile static information exchanged between government, business and citizen changed to interactive and dynamic multi-party transactions, despite challenges like techno commercial complexity, change resistance and interoperability (Sachdeva, 2002). Lee (2010) proposed maturity models involving interaction, transaction, participation and involvement from citizen services perspective that leads to maturity levels of presenting, assimilating, reforming, morphing and finally eGovernance. There are regulatory and policy aspects involving smart technologies like Machine Learning and Artificial intelligence and data security and privacy (Misra et al., 2020). However several deterrents to digitization in social and public sector exist - Hooda-Nandal and Singla (2019) mentioned lack of governments campaign and citizens emotional attachment, Chatterji (2018) cited infrastructure and manpower shortage and complexity in technology implementation, Sharma et al. (2021) mentioned inadequate awareness, accessibility and high transaction cost, Shareef et al. (2014) highlighted lack of high quality, reliable and secured digital technology platform as some of the major limitations.

Innovative use of digital platform enables new business models and creates platform-based digital ecosystems (Nambisan & Baron, 2019), which presents entrepreneurship opportunities (Cenamor et al., 2019). Technology start-up and Social entrepreneurship trigger socio-economic change (Rey-Martí et al., 2016), although technology entrepreneurship in emerging economies is special due to resource constraints (Ge et al., 2020). Importance of digital platform innovation, skill and knowledge and entrepreneurship in policymaking is manifested by several government initiatives like Digital India, Start-up India, Skill India to name a few. StartupIndia (2021) created a platform of digital entrepreneurs leveraging emerging technologies like IoT, AIML, Blockchain across industry sectors, together with numerous entrepreneurial programs, accelerators, incubation hubs, funding, mentoring which Bliemel et al. (2019) sounded as infrastructure and accelerator towards promoting start-up and entrepreneurship.

Ismagilova et al. (2019) hinted urban digitization is also known as SmartCity, Digital City, Information City but it fulfills United Nation's sustainable development goals (SDG) through Smart Mobility, Governance, Environment, Citizens, Safety and Security to name a few. Rana et al. (2019) found thirty-one barriers to SmartCity consolidated into six categories. Praharaj et al. (2017) found smaller Indian cities with localized initiatives addressing local issues has greater citizen participation despite infrastructure limitation. Vijai and Sivakumar (2016) felt usage of smart technologies like IoT and Analytics leads to successful implementation of various SmartCity applications. Post et al. (2018), Rao et al. (2020) studied social Media influence on citizen engagement in crisis and disaster management (e.g., Covid19), public priorities, law and order situation, whereas Verma et al. (2017) found limited Social Media usage in governance in India due to lack of indigenous platform and lack of inclusivity. Study of several Indian urban public services like municipalities, police and traffic, utilities like water and electricity supplies, single-window citizen service (eDistrict), social media shows newer establishments offered participative and transactional citizen services, but older establishments are stuck in static information dissipation portal. This necessitates continuous technology upgrade rather than one-time ICT infrastructure, with speed and flexibility in governance especially in post-Covid 19 scenario (Janssen & Voort, 2020).

Singh et al. (2021) studied Covid19 impact on digital divide, Bala (2018) studied implications of digital literacy and information asymmetry on digital adoption. GhoshRoy and Upadhyay (2017), Ghosh (2019) observed knowledge deficit around transaction security and legality causing anxiety amongst citizen despite willingness and need to use digital platforms. Potnis (2015) felt mobile devices and data access, information processing capability impacts digital divide, in addition, Yu (2018), Mubarak et al. (2020) pointed factors like socio-economic (for instance, education, income), geo-demographic (like age, gender), purpose and types of digital usage leading to social inclusion or exclusion. Technology and automation induced Unemployment another concern, with 9% unemployment rate in India (CMIE, 2020), whereas it is 9% only in labor-intensive jobs in OECD countries (Arntz et al., 2016), although BCG (2017) reported digitization will generate new employment opportunities shifting from labor to technology-intensive jobs. Several Digital knowledge and competence frameworks in Europe and India are studied by (Carretero et al., 2017), Nedungadi (2018), Shubha (2017) highlights importance of job oriented professional and behavioral skill build-up framework, address digital divide by mobile-based content access.

SMAC (Social, Mobile, Analytics, Cloud) drove early digitization at personal, enterprise and governance space a decade back (Dewan & Jena, 2014), with recent addition of Internet of Things, AIOps, MLOps, CICD and DevOps, 5G telecommunication network, distributed cloud computing, cloud-native, cyber security, Drones and Robotics (MoneyControl, 2020). Key component of SmartCity connectivity is enabled by 5G telecom standard and Edge computing (Chatterjee et al., 2017), which will make IoT mainstream to many businesses and industries by connecting billions of devices and running Analytics on data generated by IoT devices (Joseph et al.,2017). Ismagilova et al. (2019) emphasized integrated Smart Architecture of SmartCity technologies like IoT, Cloud, Zhang et al. (2021) indicated importance of Converged Smart Mobile App as cornerstone of SmartCity. Almeida et al. (2020), He et al. (2021) examined role of emergent technologies like IoT, AIML, Blockchain, Big data, Robotics as accelerator of post Covid19 digitization. Deloitte Technology Trends (2020) predicted Blockchain, Security, Analytics and Cognitive, Cloud and Quantum computing as future emerging technology, saying few of these being enablers or foundational and few other are future disruptor, however, these technologies show significant year on year movement on Gartner's hype curve indicates velocity and pace of Smart Technology innovation (Gartner, 2020).

Matt (2015), Reddy and Reinhartz (2017) felt digital transformation is about emerging technology innovation beyond organization boundary, dynamic data-driven, creates new business model and business value compared to erstwhile business process reengineering which achieves process optimization only. Schallmo et al. (2017) highlighted digitization is about data, connectivity, automation and customer experience, but its implementation is preceded by assessment of its current reality and aspiration, execution viability and finally potential benefit realization. Value realization extended beyond organization into governance and society through usage of innovative technologies like AIML, IoT, Blockchain being an asset for digital governance and complexity can be tackled by collaboration and participation of various ecosystem players led by local government (Criado & Gil-Garcia, 2019). Anthony et al. (2020), Ehiance et al. (2019), Maestre-Gongora & Bernal (2019) studied open enterprise architecture platforms based on emerging technology covering Data and IT infrastructure to enable innovation and collaboration among citizens and agencies as part of eGovernance strategy.

Selected prior work conducted in last 5 years is summarized in Table 1, indicates the relevance and recency of this topic.

Recent prior work captured in Table 1 indicates the importance and recency of this topic and enlightens that digital transformation is rapid innovation of several smart technologies, builds cross industry integrated ecosystem, encourages entrepreneurs to create value by newer business process and models. Whereas digitization in urban citizen services is encouraged by governments like in India through programs like SmartCity, Digital India that facilitates framework to build innovative technology solution across industry that leverages ICT capabilities, knowledge and literacy, private-

Table 1. Summary of recent literature

Reference	Purpose	Methodology	Conclusion and outcome	Limitations
Anthony (2020)	Digital city Enterprise Architecture	Literature review	Integrated enterprise data architecture across organizational boundary involving business, application, information and technology is essential for SmartCity.	Only based on secondary data without any primary data collection
Apeksha and Singhal (2019)	eGovernance Adoption	TAM framework and empirical study	Citizen's adoption is dependent on their involvement rather than education and geographic presence	Conceptual model based on limited literature and study conducted on small sample
Cenamor et al. (2019)	Digital Platform and innovative Entreprenurship	Primary data through Survey and SEM for data analysis	Digital Platform capabilities can trigger innovative entrepreneurship in SME segment	Impact of other operational capabilities on entrepreneurship is not considered.
Chatterji (2018)	Urban digitization with municipal systems	Secondary data review and content analysis	Small towns have inadequate digital network infrastructure and skilled resource, complex implementation model involving state and national and international private firms.	Result derived from small sample of secondary data.
Criado and Gil-Garcia, (2019)	Public value creation using smart technology	Theoretical and conceptual review	Open and collaborative innovation of emergent smart technologies will transform public service	Conceptual model lacks empirical research validation
Ehiance et al. (2019)	Digital public service delivery in Nigeria	Theoretical and conceptual review	Use of emerging technology necessary for efficient and quality public service delivery	Conceptual model lacks empirical research validation
Ghosh (2019)	Digital adoption among senior citizen	Mix of survey and interview	Risk, anxiety and ease of use are determinants of digital adoption among senior citizens	Homogenous data sample from urban India with higher existing literacy and gender agnostic
He et al. (2020)	Post Covid Technology solutions	Data People-system framework to examine technology	AIML, Analytics, IoT, Robotics, Digital Contracts and Blockchain, Robots, 3D Printing, HPC are emerging post covid technologies.	Long term post Covid Technology solution relevance is excluded from study
Janssen and Voort (2020)	eGovernance and crisis response	Opinion Paper	Speed and flexibility in Technology innovation and policy is key in Governance to respond to crisis.	Dutch governance model may not be generalizable to all countries without broader data set.
Misra et al. (2018)	Participative digital governance model	Sentiment analysis and text analytics	Innovative and localized use of ICT tools can increase citizen and community participation in digital governance	Single secondary data source from India Government is used to derive result.
Mubarak (2020)	Digital Divide and socio-economic indicator	Multivariate regression	Education and income, especially poverty has implication on digital divide	Single secondary data source from World Bank is used to derive result.
Rao et al. (2020)	Twitter role in government crisis management	Text extraction and statistical analysis	Crisis management in situation like Covid 19 through social media can be effective for both citizen assurance and also for generating alerts	Text analytics on social media content did not consider emotion and linguistic factors.
Sharma et al. (2021)	Challenges eGovernance delivery in India through CSC	Interpretive Structural modelling and MICMAC	Lack of Digital literacy, awareness, cost, accessibility is deterrent for CSC success.	Factors used in models may have bias of opinion and sample is based on convenience.

public-citizen participation and social entrepreneurship. Following section derives research design based on the findings of literature review.

3. RESEARCH DESIGN

The literature review has given insights on this topic of digital transformation and its relevant research gap leading to research question. This section covers relevant theoretical framework suitable to explain the research questions and applicable research method adopted in this paper.

3.1 Theoretical Background

Rana et al. (2012) found due to diversity and complexity of such topic more than one theory needed to explain this phenomenon. This paper finds Diffusion of Innovation Theory (Rogers, 2003) as the appropriate primary theory framework to explain Digital Innovation. In addition, technology innovation success depends on its application in business and social ecosystem along with user group's cognitive ability to adopt and use innovation. Therefore, two more supporting theoretical framework, Actor Network Theory (Walsham, 1997) and Social Cognitive Theory (Bandura, 2011) can be considered as additional secondary theory framework.

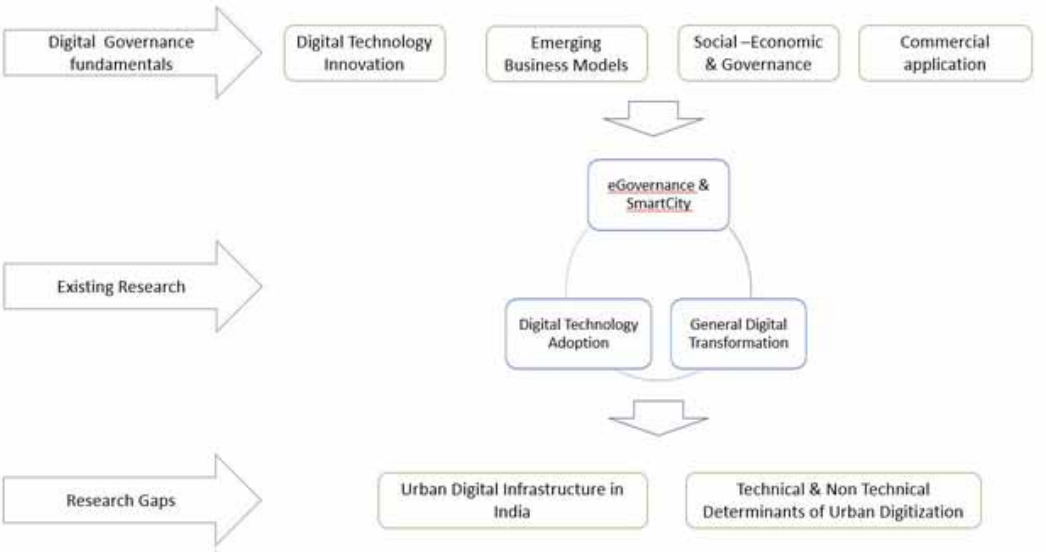
Ignat (2017) found innovative use of emerging technologies are fundamental factor towards successful digitization and availability of rapid technology innovation is fundamental of Digital India initiative too. Diffusion of Innovation is a popular practice-oriented theory that introduced Innovators and early adopters at the fore front of innovation -who are niche, risk taker, financially sound and having access to scientific resource, then early and late majority- who adopt innovation with skepticism and finally laggards-who lacks leadership and financial power (Rogers, 1995). This classification is based on factors like Innovation, adoption, Communication, Time and society. This also refers to 5 stages of innovation adoption - Knowledge and Awareness, Persuasion, Decision, Implementation, and Confirmation and Continuation. The theory itself was further extended to encompass policy and technology, making it relevant for Digital India. This paper explores additional dimension that can enrich the theory while applying in context of Digital India program.

However, it is not about technology alone, rather usage of technology to create new business model and various commercially and socially relevant application use case is more important. Digital transformation is about multiparty transaction across cross industry ecosystem formed by private, public enterprises along with citizen participation which can be explained using the Actor Network Theory (Walsham, 1997). Once technology innovation is identified for a social and business application, then individual and collective cognitive ability to use technology dictates efficacy Digital Transformation. Bandura (2011) suggested Social Cognitive theory which connects personal factors (cognitive and knowledge), individual behaviour (Skills, Practice, efficacies etc) and external environment (Social and community influence and change).

3.2 Research Gap

Prior work shows Digitization involves Emerging Technologies, business process maturity, social governance framework and Commercial application. Some academic work exists covering digital transformation process and technologies within organization, eGovernance and general technology adoption. Some academic work on SmartCity exists but entirely focussing on physical infrastructure and global context, which lacks attention to digital infrastructure in Indian context.Digital India topic, especially on urban India, which is technology and economic nerve centre of India lacks academic attention, despite being a topic of national importance. Studies highlighting technological and non-technological factors affecting digital infrastructure and service roll out in urban India almost non-existent, which is found as a major research gap as depicted in Figure 2 Below.

Figure 2. Research coverage and research Gaps



3.3 Research Question

Research question derived from above research gap for this exploratory study is "***What are the technical and non-technical determinants of successful smart digital infrastructure roll out in urban public services in India***". These determinants, both technical and non-technical, are needed for industry practices and policy makers, who can work on these factors to enhance diffusion of digital infrastructure in Indian cities. These set of determinants are also needed by academia for conducting deeper future research on each of these independent variables for future research towards acceleration of digital diffusion in India. This research is expected to be a practice-oriented and problem-solving research addressing dominant national issue.

3.4 Research Methods

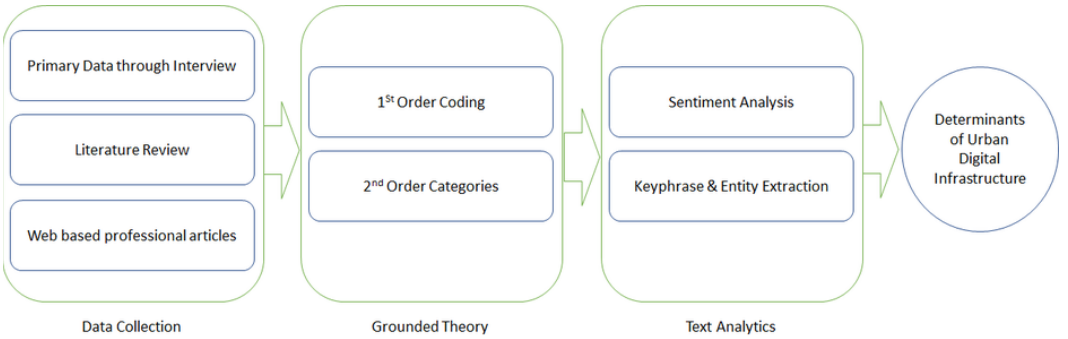
Rana et al. (2012) found sixty-one out of seventy eGovernance prior work relied on survey based primary data. Deeper insight, highlighting the reasons behind such phenomenon is needed in this research through inductive study ad interviews of people having domain exposure. Telephonic interviews were conducted of 15 urban middle-aged professionals with prior experience of the subject as homogeneous sample between 12 to 20 respondents is found optimum for data saturation, sufficiency and information quality (Crouch & Mckenzie, 2006; Guest et al., 2006). Semi structured interview questions covered technologies and factors affecting urban public services delivery. Coding process of Grounded Theory (Corbin & Strauss, 2014) used to decompose and then categorize unstructured interview data, thereafter various Text Analytics methods like sentiment analysis, key phrase and entity extraction is applied using Microsoft's Azure cloud-based cognitive package to analyse the response data (Microsoft, 2021).

Grounded Theory is used as it was found suitable to systematically extract data from interview transcripts and analyse the data using multi order coding and categorization process (Corbin & Strauss, 2014). The process first assembles unstructured interview transcript into several concepts through first order coding process. The 1st order coding leads to grouping of raw data extracted from interview transcripts into large number of codes that captures the essence of data. Thereafter it is narrowed down to 2nd order categorization based on central themes of 1st order codes. Second order categories emerge from large number of codes further consolidated into limited set of categories

that can represent the views of interviewees. Singh Et al. (2020) supported mixed research methods of augmenting Grounded Theory with Machine Learning technology to enrich data interpretation process. While there are several tools available that helps process interview transcript through coding process of grounded theory, those tools also use Text Analytics as underlying technologies. This paper uses Microsoft Azure's Cloud based Cognitive application specifically Text Analytics module to interpret and validate manual coding and categorization process.

This practice oriented exploratory research is three step process, primary data collection through interviews, interview data transformation using grounded theory and finally data analysis and validation using Text Analytics as explained in Figure 3.

Figure 3. Research method



On the other hand, this topic combines technology innovation, business model evolution and socio – economic development in recent times. These industry and practice driven development and evolving at a very rapid pace, these are not yet well captured in academic literature. Secondary data from various website, professional articles, white papers and brochures are also studied to gain insight of recent trends and developments.

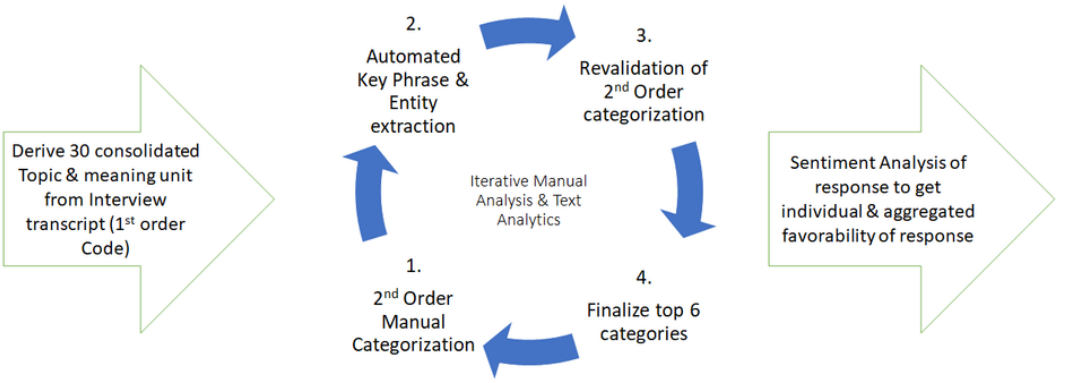
4. DATA AND ANALYSIS

As defined in the research design in earlier section, data collected through interview and codification process using Grounded Theory (Corbin & Strauss, 2014). Manual codification process is validated and supported by software based automated keyphrase and entity extraction. Thereafter categorized interview output is processed to derive sentiment of the respondents along the first and second order categories. The text Analytics is done using Microsoft's Azure cloud-based cognitive modules Text Analytics programs (Microsoft, 2021). Following section covers the step-by-step analysis as mentioned below Figure 4

- Interview response coding and categorization through a manual key process
- Automatic data validation through key-phrase and entity extraction
- Sentiment analysis to derive favourable or unfavourable influence of the determinants

The first and second step of manual coding and categorization along with automatic data validation using software have been iterative process to refine the accuracy of analysis outcome as explained in Figure 4. Qualitative unstructured text data is manually coded into several meaning unit which

Figure 4. Data analysis process



has been the starting point and output of coding and categorization is processed through sentiment analysis to derive favourability or unfavorability of the impact on urban digital infrastructure.

4.1. Interview Response Data Analysis

Data analysis starts with unstructured textual interview transcript where common topics are grouped in form of meaningful statements according to open coding or 1st order coding process of Grounded Theory (Corbin & Strauss, 2014). Data from interviews are corelated and common messages are captured into approximately 30 main topics which is defined as 1st Order codes. Thereafter the central focus of those 30 observations are extracted and similar central focus topics are grouped into following six groups.

- Custom Software cost, Software maintenance cost, ability to pay for service, Hidden cost of technology, Funding of government service - These are all related to technology cost and its monetization.
- Data Analytics Application, Analytics based application, Data Security, Data privacy, Digital Data analytics -These are all related to Data Analytics application and data security.
- Connected things, Telecom connectivity, Connectivity failure, Smartphone connectivity, IOT and connected device – All these topics are related to IOT and connected device and connectivity
- Proficiency in technology use, Training for all, Technology use among seniors, Digital Literacy for poor and seniors, IT knowledge in India – All these topics are related to Knowledge and literacy
- SmartCity integration failure, Technology integration, SmartCity platform coordination, SmartCity complexity and cost, Integrated platforms, SmartCity Process and efficiency – All these topics are related to SmartCity Platform integration
- Employment impact of Digital, Sustainability of Digitization, Technology benefit realization, Technology change sustainability, social welfare and regulation – All these topics are related Sustainability of Digital Innovation.

The coding process of extracting central theme from 30 first order codes and their grouping into similar subject topic mentioned above. These similarly grouped topics then categorized further into six categories based on their related central themes. Grouping process narrowed down the categorizes into Technology Cost, Data Analytics, IOT and connectivity, Integrated Smartcity, Digital Literacy, Sustainable Innovation. These six categories are the determinants of Urban Digital infrastructure as derived from the interview transcripts. The evolution of 1st order codes, extraction of central theme

from these 1st order codes and then grouping of these themes into categories are captured in the Table 2 below.

Table 2. Codes to Category conversion using Grounded Theory

Codes	Central Theme	Categories
Localized technology application is needed but cost & time to build custom software is high.	Custom Software cost	
Technology keeps changing, software product & maintenance cost is high for each city to build it.	Software maintenance cost	
Urban population can pay for technology adoption & quality of service , can be a good model.	Ability to pay for service	
Hidden cost of technology & sustainability of free services is not convincing.	Hidden cost of technology	Technology
Funding pattern & motivation unclear, may reduce leakage,corruption & cost of government services.	Funding of government service	Cost
Finding Real life application of AIML & analytics use cases can be very useful.	Analytics application use case	
Many data Analytics based applications are being built, social media can be used too.	Analytics based application	
Clarity on Data security, privacy, legal framework, trust on service provider is inadequate.	Inadequate Data Security	
Use of AIML & data analytics can be useful & increase, if data privacy & financial transaction security ensured.	Privacy of Data Analytics	
Data analytics requires digital data which is timeconsuming & difficult to collect.	Digital Data analytics	Data Analytic
Business case & peoples benefit for Connected vehicle, connected home, connected health is unclear.	Connected things	
Telecom infrastructure & service is average, device & connectivity availability & affordability is good.	Telecom connectivity	
Back up needed If connectivity fails, mixed approach of online & offline rather than full digitization.	Connectivity failure	
Smartphone penetration is around 30% , mostly in cities, good device & connectivity options.	Smartphone connectivity	IoT &
IOT & connected devices in healthcare, traffic & logistics, energy management are useful in cities.	IOT & connected device	Connectivity
Digitization increased efficiency, top level officers are proficient in using technology than at lower level.	Proficiency in technology use	
Training & user friendliness needed for both service providers & consumers specially for citizen services.	Training for all	
Public sector not flexible to adopt technology, younger employees are favourable than older ones.	Technology use among seniors	
Digital literacy inadequate bottom of pyramid & senior citizens, alternate option is needed.	Digital Literacy for poor & seniors	
IT industry has lot of global experience & knowledge that can be utilized in India.	IT knowledge in India	Digital Literac
Many Smartcity projects failed as they are not integrated & application use case is unclear.	SmartCity integration failure	
IoT, blockchain & other technology if integrated through various department, can be useful for Urban digitization.	Technology integration	
SmartCity dont have uniform technology platform & coordination between multiple agencies.	SmartCity platform coordination	
One single design for entire country is inefficient, customizing each Smartcity is complex & expensive to build.	SmartCity complexity & cost	
International SmartCity designs of large connected platforms across various sector can be useful.	Integrated platforms	Integrated
Smartcity Converting old manual system & process into efficient digitized mode will be really good for user experience.	SmartCity Process & effieicency	SmartCity
Digitization, Automation impacts employability, but it creates new jobs through right innovative usage.	Employment impact of Digital	
Consultant driven digitization has a conflict of interest, digitaization to generate sustainable benefits.	Sustainability of Digitization	
Many technology, but desired result for all not beneficial for all in society, needs better planning.	Technology benefit realization	
Technology infrastructure is fast changing, difficult to handle, expensive & skill is limited.	Technology change sustainbility	Sustainable
Digitization with private participation needs strong regulatory framework for social welfare.	Social welfare regulation	Innovation

While the above coding process, theme extraction and categorization is a manual process performed by the researchers, these require software tool-based validation to minimize error due to manual subjectivity, which is performed in the following section.

4.2. Automated Validation of Analysis

Coding and category mapping being manual and error prone process with scope of mis-interpretation required additional automated data validation. To revalidate manual categorization and minimize errors Microsoft Azure cloud-based text analytics software is used in an iterative way to generate key words and entities. Table 3 shows most key phrase and entities in first category can be linked to cost and commercial value, 2nd category key phrases refer to topic related data and analytics, 3rd category key phrases are related connected device and connectivity, 4th category key phrases are linked to capability and knowledge and literacy, 5th category key phrases are mostly linked to SmartCity and platform integration, and finally the 6th category key phrases mostly refer to social benefits and impacts of technology. This automated data validation shows the codes to category mapping process gives similar outcome by both manual and automated process, increasing reliability of analysis.

The output of key Phrase extraction for coded statement of each category is captured in Table 3 matches with the manual categorization of coded response. A combination of step 1 of manual categorization and step 2 of software driven key word extraction conforms to each other, ensuring the accuracy and validity of the analysis.

Table 3. Category wise Key Phrase and Entity extraction

Categories	Key phrase & Entity Extraction
Technology Cost	"Hidden cost of technology", "maintenance cost", "technology adoption", "cost of government services", "Localized technology application", "software product", "custom software", "sustainability of free services", "leakage", "corruption", "time", "motivation unclear", "quality of service", "Funding pattern", "Urban population", "city"
Data Analytics	"Data Analytics", "data privacy", "Data security", "digital data", "analytics use cases", "financial transaction security", "Real life application of AIML", "legal framework", "trust", "increase", "service provider", "applications", "time-consuming", "Clarity", "social media"
IoT & Connectivity	"Connected vehicle", "connected devices", "connectivity availability", "connectivity options", "good device", "cities", "logistics", "healthcare", "traffic", "energy management", "service", "mixed approach ", "home", "peoples", "affordability", "Telecom infrastructure", "Business case"
Digital Literacy	"technology", "level officers", "lower level", "pyramid", "younger employees", "service providers", "senior citizens", "Digitization increased efficiency", "knowledge", "lot of global experience", "user friendliness", "consumers", "Digital literacy inadequate", "older ones", "alternate option", "citizen services"
Integrated SmartCity	"SmartCity", "Smartcity projects", "International SmartCity designs of large connected platforms", "technology platform", "various sector", "various department", "process", "efficient digitized mode", "old manual system", "coordination", "entire country", "single design", "multiple agencies", "application use case", "user experience", "Urban digitization", "IoT"
Sustainable Innovation	"Consultant driven digitization", "Technology infrastructure", "strong regulatory framework", "private participation", "new jobs", "social welfare", "fast changing", "conflict", "Automation impacts employability", "society", "digitaization", "innovative usage", "desired result", "better planning", "sustainable benefits", "skill"

4.3. Sentiment Analysis

Manual coding and categorization performed on interview response followed by automated validation in earlier sections gives broad topics and categories that influences the urban digital infrastructure. However, to understand if these factors influence favourable or unfavourable, sentiment analysis is performed for each coded response and aggregated at the category. The sentiment analysis uses Microsoft Azure cloud based cognitive services, under language sub category and Text Analytics

Table 4. Sentiment analysis applied on 1st order codes derived using grounded theory

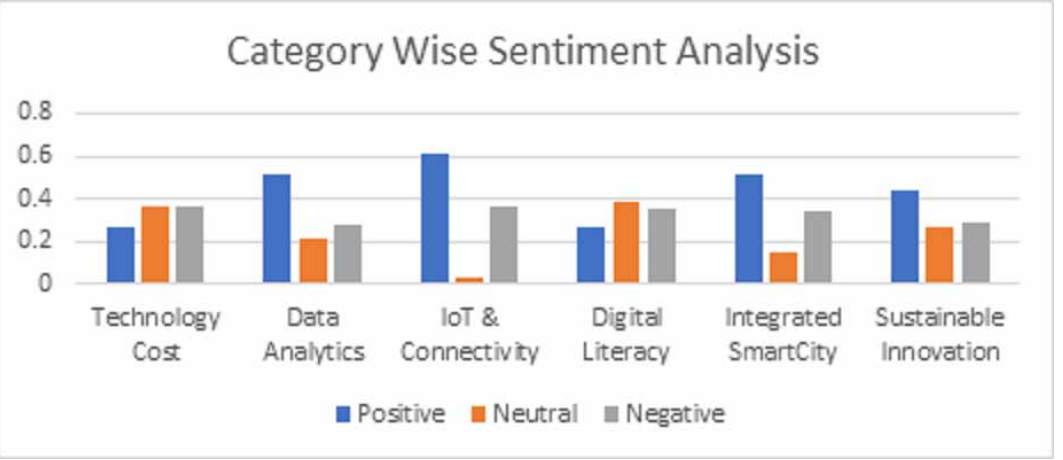
Codes	Positive	Neutral	Negative
Localized technology application is needed but cost & time to build custom software is high.	0.16	0.8	0.04
Technology keeps changing, software product & maintenance cost is high for each city to build it.	0.05	0.94	0.01
Urban population can pay for technology adoption & quality of service , can be a good model.	0.93	0.07	0
Hidden cost of technology & sustainability of free services is not convincing.	0.2	0.03	0.77
Funding pattern & motivation unclear, may reduce leakage,corruption & cost of government services.	0	0	1
Finding Real life application of AIML & analytics use cases can be very useful.	1	0	0
Many data Analytics based applications are being built, social media can be used too.	0	1	0
Clarity on Data security, privacy, legal framework, trust on service provider is inadequate.	0.61	0.02	0.37
Use of AIML & data analytics can be useful & increase, if data privacy & financial transaction security ensured.	0.95	0.05	0
Data analytics requires digital data which is timeconsuming & difficult to collect.	0	0	1
Business case & peoples benefit for Connected vehicle, connected home, connected health is unclear.	0.11	0.1	0.79
Telecom infrastructure & service is average, device & connectivity availability & affordability is good.	0.98	0.02	0
Back up needed If connectivity fails, mixed approach of online & offline rather than full digitization.	0	0	1
Smartphone penetration is around 30% , mostly in cities, good device & connectivity options.	0.98	0.02	0
IOT & connected devices in healthcare, traffic & logistics, energy management are useful in cities.	0.98	0.02	0
Digitization increased efficiency, top level officers are proficient in using technology than at lower level.	0.89	0.11	0
Training & user friendliness needed for both service providers & consumers specially for citizen services.	0.18	0.81	0.01
Public sector not flexible to adopt technology, younger employees are favourable than older ones.	0.23	0.03	0.74
Digital literacy inadequate bottom of pyramid & senior citizens, alternate option is needed.	0	0	1
IT industry has lot of global experience & knowledge that can be utilized in India.	0.04	0.95	0.01
Many Smartcity projects failed as they are not integrated & application use case is unclear.	0	0	1
IoT, blockchain & other technology if integrated through various department, can be useful for Urban digitization.	0.95	0.04	0.01
SmartCity dont have uniform technology platform & coordination between multiple agencies.	0.18	0.78	0.04
One single design for entire country is inefficient, customizing each Smartcity is complex & expensive to build.	0	0	1
International SmartCity designs of large connected platforms across various sector can be useful.	0.94	0.06	0
Smartcity Converting old manual system & process into efficient digitized mode will be really good for user experien	0.99	0.01	0
Digitization, Automation impacts employability, but it creates new jobs through right innovative usage.	0.67	0.31	0.02
Consultant driven digitization has a conflict of interest, digitaization to generate sustainable benefits.	0.16	0.05	0.79
Many technology, but desired result for all not beneficial for all in society, needs better planning.	0.84	0	0.16
Technology infrastructure is fast changing, difficult to handle, expensive & skill is limited.	0.39	0.17	0.44
Digitization with private participation needs strong regulatory framework for social welfare.	0.16	0.82	0.02

REST APIs, using Python Scripts, that tags each Codes into positive, negative and neutral sentiments as mentioned in the Table 4.

Sentiment analysis is aggregated for each category in addition to each first order themes to derive aggregated sentiment value for each category as it is captured in the Figure 5 below, which reveals few critical conclusions.

- IoT, Analytics, SmartCity are clearly carrying highest positive sentiment, where the aggregate positive sentiment value is much higher than negative or neutral sentiment, where it can be concluded these factors having highest favourable influence on digital infrastructure.
- Sustainable innovation shows positive sentiment with positive value being higher than negative or neutral, where positive sentiment trend is marginally ahead of negative and neutral, however significant neutral opinion indicates ambiguity and inconclusively in outcome.
- Technology cost and digital literacy are considered to have in general negative sentiment where aggregated negative sentiment is higher than aggregated positive sentiment. It may also be noted in general technology cost and digital literacy has high neutral sentiment, ahead of positive and negative, which requires further clarification of this ambiguity.

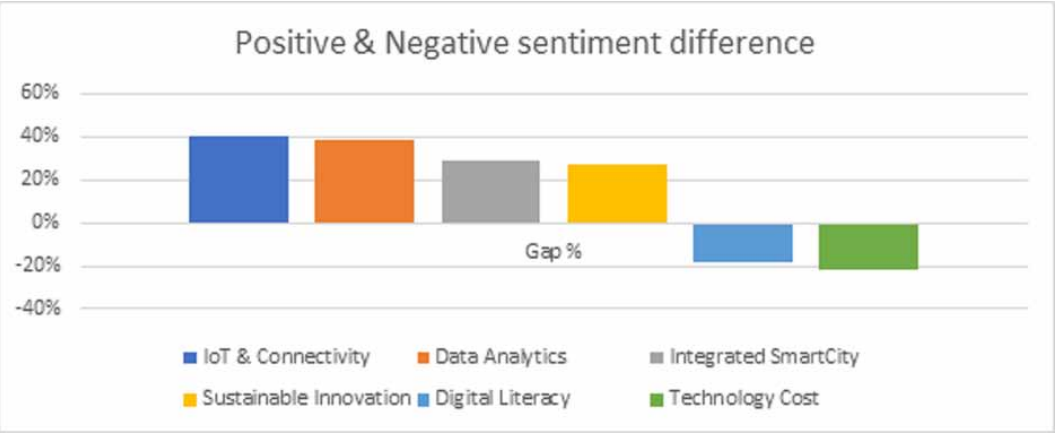
Figure 5. Aggregated Sentiment score analysis for 2nd order categories



As in few cases neutral sentiment is significant and equivalent to either positive or negative, which leads to constraint in decisive outcome. To avoid this and arrive at a conclusive outcome the neutral data is distributed to positive and negative in equivalent proportion and new decisive outcome is created in the Figure 5, which shows percentage difference between positive and negative sentiment outcome. This clearly indicates 3 blocks of outcome, IoT connectivity and Analytics positive sentiment is around 40% ahead of negative sentiment, Integrated Smartcity and Sustainable Innovation the positive sentiment is around 30% ahead of negative sentiment and in Digital Literacy and Technology Cost Positive Sentiment is 20% behind negative sentiment.

From the combined analysis of information in Figure 5 and Figure 6, it can be inferred that IoT and Connectivity and Data Analytics have extremely high favourable influence on urban digital infrastructure, followed by Integrated SmartCity and Sustainable Innovation which has distinct favourable impact on urban digitization, as all four are having net positive over negative sentiment. Whereas Digital Literacy and Cost of technology has distinctively unfavourable influence on urban digital infrastructure, which means these two factors are not favourable for enhanced urban digitization

Figure 6. Percentage difference between Positive and Negative Sentiment



and may adversely affect future initiatives if not addressed immediately. Each of this observation is discussed further with its implication in later sections of this paper.

4.4. Aggregated Trend Analysis

In addition to sentiment analysis for each response an overall aggregated text analysis helps in visualizing overall response and key factors. Therefore, a word cloud of all first order codes from interview transcript is generated, as this will help understand important topics of urban digital infrastructure as a whole. Several trend like SmartCity, Connected Device, Analytics, Integration Framework, Cost emerges from word cloud as in Figure 7, which in coherence with the individual trends derived from coding and categorization process along with the key-phrase extracted from coded transcripts.

Figure 7. Word cloud summary of all interview finding (www.jasondavies.com)

4.5. Secondary Data Analysis

Over and above primary data sourced from interviews, the secondary data gathered from various publicly available material reveals couple of important observations, which can be considered fundamental to digital transformation, and also reinforces some findings of literature review.

- **Ecosystem Integration**: Digital public service is delivered by a network of several private and public enterprises, which requires technological platform integration to be successful. The Table 5 articulates sector wise complex ecosystem, its players and their role, as found through study of secondary data sources available in internet. This emphasizes digital service delivery as more transactional, horizontally and vertically integrated across organization boundaries than erstwhile eGovernance, being standalone electronic information display.

Table 5. Complex Ecosystem of digital Technology and service providers

Sector Example	Government	Public Sector Undertaking	Private Sector Enterprises	Citizens & Business
Defence, Space & Scientific missions, Shipping	Builds technology & delivers service, consumes too	Major technology provider & selective service delivery	Limited participation	Limited participation
UID, Passport, Tax, Municipal service, Police, Railways	Owns service, delivers few of them	Build, Operate & deliver behalf of Government	Major role in build operates technology & deliver service	Primary consumer
Airlines, Telecom, Banking, Energy, water utilities, Insurance	Gradual deregulation, legacy owner	High involvement in build, operate & deliver	Increasing role in build Operate Technology & deliver service	Primary consumer
Social service (SHG/ NGO/ Cooperative),	Selective role as consumer to implement policy	Moderate involvement in policy implementation	Moderate role in building & operating technology	Primary consumer
Education, Healthcare, Agriculture, transportation	Gradually reducing role	Gradually reducing role	High involvement in building & operating technology & delivering service	High participation & consumption
Manufacturing, Real estate, retail, Media & Entertainment, Web	No contribution	No contribution	Builds technology & deliver service	High participation consumption

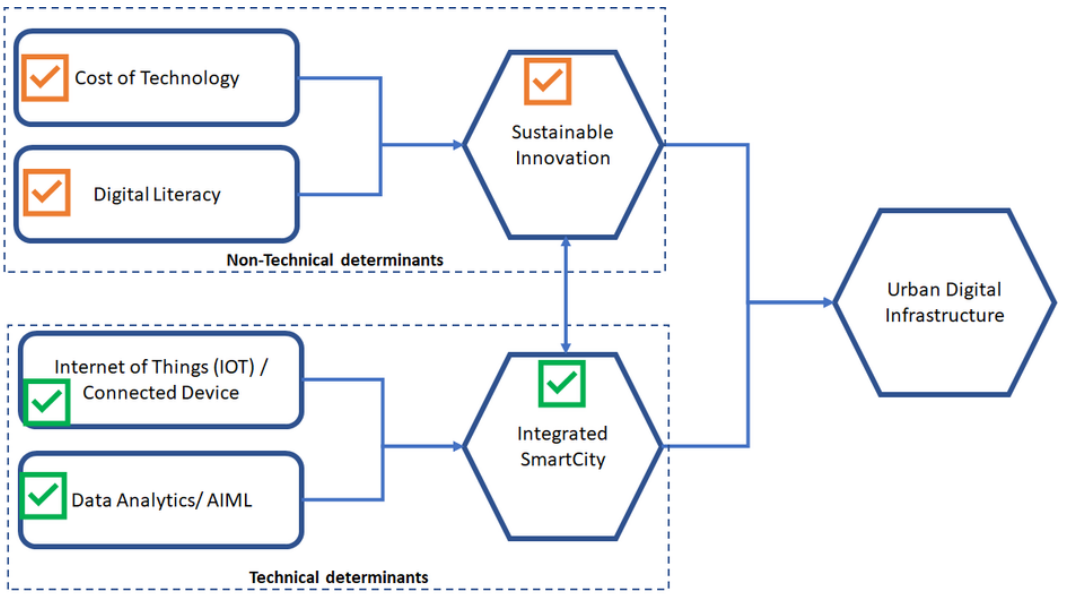
- **Technology Entrepreneurship:** Literature review shows IoT, Cloud, Analytics, Mobile, Blockchains and few other as emerging digital technologies, but the landscape changes year on year. Digital technology enabled many large public and private enterprises to unleash new business model across industry sectors whereas many small entrepreneurs started completely new business and business segments. Predominant use of technology and application industry segments is captured in the Table 6, however there are innovative start-ups globally and India that breaks industry boundary. Technology start-ups like inventory less app-based cab, hotel aggregators, online delivery, OTT media created new industry sub-segment that did not exist earlier and continuously evolving through innovation and entrepreneurship. Many such business incubations transformed social dynamics and public services, urban transportation, education and Movies and Media are prime examples.

Based on the above data comprising of first and second order coding, sentiment analysis, key-phrases and word cloud along with secondary data analysis of technology and industry wide ecosystem of participants, the following section concludes the key findings and its corresponding analysis.

Table 6. Dominant technologies influencing various sectoral user applications

Technology Segment	Emerging Technologies & trends	User, Functional & Industry Applications
Data & Analytics	Artificial Intelligence, Machine Learning, Data Warehousing, Business intelligence	All public & private industries
Computing	Cloud & Edge Computing, Quantum, Edge IoT	All public & private industries
Connectivity & Telecom	Telecom standards (4G-LTE, 5G, WIFI), Internet of Thigs, Machine to machine (M2M), VoIP, Fibre - FTTx	Voice & Data communication (4G), Device communication (5G), Mobile & Laptop users in B2C & B2B, connected anything, IoT
Collaboration	Social Media, Opensource, Digital Twins, Productivity solutions, Mobile Apps	ECommerce, Education & Office Productivity, Logistics & FMCG/ Retail
Automation	Robotics & Chatbots, Internet of Things (IoT), Drones & Wearables	Industry 4.0, Medical & healthcare, Energies & Utilities, Smart City, Vehicle & Transportation
Media & Video	Augmented & Virtual Reality, Content Delivery Network (CDN), Triple play & OTT, Mobile & IPTV, DTH & Cable	Broadcasters, Print & Digital Media, Education, Advertisement, Entertainment & Gaming industry
Security	Blockchain, Cyber Security, Biometrics, Digital Identity, Public Safety & surveillance	Public sector & Law Enforcements & also in private sector specially in BFSI & FinTech

Figure 8. Determinants of urban digital infrastructure



5. FINDINGS AND DISCUSSION

The interview transcript and subsequent coding and categorization process reveals six key determinants of urban digital infrastructure in India as captured in the Figure 8 below. These determinants are clubbed as technology enablers such as Data Analytics, IoT and Connectivity, Integrated SmartCity and non-technical enablers such as Technology cost, Digital Literacy and Sustainable Innovations. It has also been observed that urban digitization is synonymous with Smart City projects rolled out under Digital India initiative. Out of the above six enablers or determinant four of these, Data Analytics, IoT and Connectivity shows significant favourable impact, Integrated Smart City and Sustainable innovation shows an overall favourable impact, whereas technology cost and digital literacy shows a neutral or unfavourable impact.

5.1. Technology Cost

It is observed that technology changes very fast and cost of staying aligned with innovation velocity is very high as technology is mostly built by global technology companies with high cost of ownership. As one size does not fit all, customized software is needed to address local business, geodemographic and socioeconomic priorities, which may be commercially unviable due to lack of scale and local IPR. Funding rational and motivation behind such projects are unclear and without a strong commercially viable business case many of these digitization initiatives are likely to fail. However, since urban population has an ability to pay for service and appreciation and ability to use digital medium if that delivers value then urban digitization may be the right starting point for Digital India program. Study highlights the concern and need to derive a strong commercially viable digital diffusion model and optimize cost of technology.

5.2. Data Analytics and AIML

Data Analytics and use of AIML is considered as an important topic of digital transformation, as this differentiates digital governance from erstwhile eGovernance services. It has been found that there is adequate competency and awareness around Data Analytics and AIML, which can be leveraged to delivery better citizen service. Key success factor towards Data Analytics is identification of appropriate use case and problem statement where Data Analytics can provide maximum benefits. On the other hand, it is also important to have massive amount of data available in digital format, which might take long to convert traditional and old manual data and processes into digital form. However, concern is around data privacy and security and unavailability of a regulatory body and lack of awareness of relevant legislation may reduce implementation of data analytics and AIML. Overall, topic of data analytics is found to be foundational in urban digitization, with good progress so far and greater future potential if regulatory concerns are addressed adequately.

5.3. IoT and Connected Devices

Internet of Things or IoT delivering device to device connectivity enabled by 4G and upcoming 5G mobile connectivity is considered to be most promising technology enabler as found in the interview and sentiment analysis. It has been revealed with nationwide mobile connectivity availability coupled with affordability of the devices it is a great opportunity to build IoT driven use cases and applications that can be of high value add for urban digital infrastructure. There have been various types of sensors that can capture non-human machine to machine communication, thereby eliminating human errors and facilitating speed and automation. Few of the use cases have been identified as traffic and transportation automation by having connected vehicle, automated toll and parking collection, traffic rule enforcement, waste management, smart metering leading to stable power distribution, home security and automation, wearables for elder care and other healthcare services are only a few. While this area has almost no neutral opinion coming from survey, it has word of caution around business case and funding for such connected things project to be rolled out in the cities. Overall connected

devices and Internet of Things are considered to be a key differentiating factor in urban digitization and has significant positive influence on urban digitization.

5.4. Knowledge and Literacy

There are several literatures that highlighted inadequate Digital Literacy as a concern for digital transformation especially in countries like India where geo demography diversity is huge. The same has been reflected through this study, although cities have relatively higher digital literacy compared to rural areas. However, in urban areas there are scope of further improvement mainly in 3 different areas, bottom of the pyramid, senior citizens and public sector employees to effectively leverage the value of digitization. Usage of advanced technology including social media, analytics and cloud (SMAC) can be constrained due to competence gaps and also such literacy can allay fears associated with technology and increase technology adoption. This is another area having serious concern that can adversely affect digitization while the magnitude of this problem is relatively less in urban area but requires attention.

5.5. Integrated SmartCity

SmartCity initiatives by Government of India's Digital India program is found to be synonymous with urban digital infrastructure, and a critical part of urban digital transformation. It shows that utilizing advanced telecom network, Internet of Things (IoT) if designed along with Data Analytics can fuel success of SmartCity projects, which corroborates findings of Tan and Taeihagh (2020) saying Internet of Things (IoT) is one of the main technology enablers of SmartCity. It was also found that siloed and disintegrated SmartCity projects are not beneficial rather common horizontally integrated platform that spans across various industry segment and focussing on end-to-end use cases are the key to success. In fact, one of Digital India vision also talks about seamless integration of services across departments and jurisdiction (DigitalIndia, 2020), which is substantiates by this finding as well. However, one concern largely linked to the other finding of technology cost is valid here as well, the business case and financial viability model of such high-volume technology investment is unclear which may lead to failure of such project. SmartCity topic resonated positively and found to be central topic of urban digitization with need for a cost effective, end-to-end integrated Smartcity architecture.

5.6. Sustainable Innovation

Diffusion of Innovation (Rogers, 2003) at a group level depends on Policy, technology compatibility and complexity and benefit derived. As technology at disposal changes rapidly, it is important to find social or business problem that can be solved by these technologies in a cost-effective way. Also, one size solution does not fit all problems especially due to geo demographic diversity of large country like India, so it is needed to find localized vernacular solution or application of technology that has a social purpose. Automation leading to job loss and employability concern, involvement of consultant and private players working for business gain over social welfare, actual benefit realization by citizens in these digital India project, inclusivity of various social segment in the digitization drive remains a concern. Agility and flexibility of digital framework in line with rapid innovation of smart technologies, coupled with socioeconomic and geodemographic applicability at a micro level appears to be a critical factor towards successful digital journey.

5.7. Ecosystem Integration

It has also been found that many states driven initiatives are in reality being executed by private enterprises and it is an ecosystem of public, private and citizen participation. This ecosystem is multi-dimensional – on one hand integration of various technology providers, vertical integration of private and public player from one industry sector and also horizontal integration of entities across industry, along with citizen participation. This complex scenario requires integrated platform to make urban

digitization successful, which reflects relevance of Actor Network Theory (Walsham, 1997) in this context. Entrepreneurs leverage smart technologies to build innovative use case that integrates multi sector horizontally or vertically resulting new business models that drives social changes.

5.8. Theoretical Contribution

Analysis of five out of these six enablers - Data Analytics, IOT and Connectivity, Integrated SmartCity and Technology Cost, Sustainable Innovation reflects upon Diffusion of Innovation Theory (Rogers, 2003), in different dimensions. First, technology innovation and its implementation use cases has different stage of maturity, early or late adoption of innovation is not the only factor behind innovation diffusion. Innovators and early adopters encounter early challenges and headwind, which may be reduced as technology matures and greater benefits are realized. Second, it indicates Diffusion of Innovation is not a standalone and isolated technology topic, rather it is about integrated use of multiple technology innovation together towards a meaningful functional application, third, innovation outcome must be commercially viable and socially sustainable for its long-term benefit realization. This can enrich the application of the theory by addition of application dimension, those are Innovation maturity, integrated use of several technologies and Socio – Economic viability of innovation application.

The sixth enabler, Digital Literacy is cornerstone of digital adoption is itself a well-researched topic stemmed from Social Cognitive Theory (Bandura, 2011). Start-up ecosystem, ecosystem integration and Entrepreneurship that represent the participatory governance model and new business incubation cutting across various industry boundary reflects extension of Actor Network Theory (Walsham, 1997). These are associated theory that calls for deeper analysis in their respective context for future research.

6. IMPLICATIONS

6.1. Governance and Social Implications

Digital India, supported by start-up India, self-reliant India are pillars of country's future economic growth. Digitization is further accelerated due to covid19 that shifted governance and transaction from physical to virtual mode. Government and policymakers can use this study to design and build resilient, affordable and reliable technology framework that can deliver social value to the citizens. Learnings and limitations of early developments of SmartCity physical infrastructure, is captured here which can be useful for digital infrastructure development. It also provides pointers towards an integrated and cohesive well strategized Digital Strategy for Cities, to use technologies for social good. Other areas where this study can find relevance include technology choice, innovation and entrepreneurship, sustainability planning, monetization of public service, redressal of digital divide etc. which are of economic interest of country.

6.2. Managerial and User Implications

Industry and practice has been in forefront of disruptive technology innovation in IoT, Connected Device, AIML etc., additionally, Covid19 opened up new virtual business and governance opportunities. Right application of these technologies for various functional use case can enable commercially viable business growth, solve socio-economic problem and increasing long term business success. This paper provides insights on areas of improvement of past technology roll outs, user concerns and observations which can be addressed and also areas of new opportunities where emerging technology can be monetized for social good. This study can help enterprises and start-ups to spot entrepreneurial opportunities across the ecosystem, detect sectors with high potential of technology innovation absorption that can help them monetize technology innovation.

6.3. Academic and Research Implications

This practice oriented academic research brings academia and industry together, where academic insight is used to address problems of national interest like Digital India. This paper is primarily based on Diffusion of Innovation theory (Rogers, 2003), where it adds dimension of innovation maturity, multiple technology integration rather than isolated technology and also socio-economic viability of innovation as factors influencing innovation diffusion. Similar path can be pursued by academia by bringing enrichment in Actor Network Theory (Walsham, 1997) and Social Cognitive Theory (Bandura, 2011) in context of business ecosystem and digital literacy aspect of digital India.

7. CONCLUSION, LIMITATIONS AND FUTURE DIRECTIONS

Digital India is Government of India's growth driver but not implemented by government alone rather a platform to bring social change by smart technology innovation and entrepreneurship ecosystem of private-public- citizens. Young urban affluent India equipped with digital knowledge willing to subscribe digital service can make digital innovation produced by many Startups commercially viable. Social entrepreneurs are leveraging Indian ICT knowledge workers and technology innovation to break industry boundaries and integrate ecosystems horizontally or vertically giving rise to new business models. Several technology-driven new business models emerged as a result of Covid19 induced digitization, which called for shift from physical to virtual contactless ways of working. Strategic choice of fast-evolving technology and knowledge-driven innovation and effective implementation in socioeconomic and geodemographic contexts can be helpful in building desired digital infrastructure. Study observes technology platform, knowledge and innovations enables ecosystem beyond industry boundary bringing cross-industry and disruptive business models by start-ups, and also reveals a set of technological and non-technological determinants of a successful urban digital infrastructure.

SmartCity is cornerstone of urban digitization, but lacking an integrated software technology that can eliminate silo between various use cases and interconnect multiple urban use case, which will enhance benefit realization. Smartcity program itself is dependent on two technological innovation, Data Analytics and IoT. Advent of many types of sensors and aggregators that can support meaningful use cases together with proliferation of various telecom connectivity standards has enabled non-human communication between devices that can eliminate errors and introduce automation. It is felt that the data captured and transported by IoT from various connected devices need to be analyzed for relevant use cases and appropriate predictive action needs to be actuated back to the devices. While this can be achieved through AIML, but a data strategy and regulatory framework is needed, which can suggest data storage, sharing and processing across cloud and edge. Careful and well-thought integrated use of IoT and Data Analytics is critical for urban digitization.

There are several non-technological determinants, where sustainable innovation was found to be of high importance especially technology rollout that fulfils vernacular geo-demographic and social needs while inducing speed and flexibility in public service, which is progressing well. Concerns exist about lack of localized products and rapid pace of technology change leading to high total cost of technology ownership, such investment needs to come from private and public jointly along with a viable business case. knowledge and digital literacy although a concern, but relatively less in urban millennials except for the bottom of the pyramid, senior citizen and traditional industry workforce requires knowledge induction for digitization to be successful.

Limited availability of subject matter experts, researcher's subjective interpretation in interviews and coding process may constrain generalizability and accuracy of findings. Intuitive omissions cloud and blockchain, correlation of mobile connectivity and connected device indicates homogeneity of respondent profile. Future research is recommended with a bigger and heterogeneous sample with alternate methodology and theoretical background, which can cover the integrated application of emergent innovations like IoT and Analytics, Cloud and Blockchain in building connected digital society in India.

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