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Analysis of project-level elements of a smart city: A case study

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Abstract: As a part of the Smart Cities Mission, the Government of India in 2015 embarked upon the development of 100 existing cities as smart cities. In this study, the authors selected Ahmedabad city as the smart city development in India and presented project-level elements of the city based on the secondary data availability. At first, the authors focused on peer-reviewed articles, policy documents, and technical reports. Next, the authors collected the secondary data of project-level elements of the Ahmedabad city from the years 2015 to 2019. The findings show no significant improvement in the sewage system and waste collection as compared to the level of investment made in these sectors. The study showed that the water supply system outperformed revenue generation based on the government investment made in that sector. As a lesson learned, these findings indicate that significant improvement should be addressed in sewage management and waste collection. These study findings could help government officials, investors, developers, and city planners in making the appropriate decision before and during smart city execution. The lesson learned from this study could be used as a reference to improve revenue during the future smart city implication.

Key words: Smart Cities, Urban Development, Infrastructure, Construction

INTRODUCTION

The global population has reached 7.7 billion and out of this more than 50% people are living in urban areas today [1]. United Nations forecast this number grow to 68% by the year 2060. Currently in many parts of the world, basic infrastructure needs are still unmet, and the challenge is to develop cities with sustainable infrastructure, which are meant to be technically viable, financially feasible and socially acceptable. The evolving concept of smart cities integrates infrastructure and technology to improve the quality of life of citizens. The development of smart cities has gained much traction in the last decade with the evolution of new technologies.

In 1994, the concept of "smart city" was introduced [2], which later got boosted since 2010 after the appearance of smart city projects and the European Union support [3]. Smart city is an urban area where the use of technology both in hardware and software applications are developed for providing various urban services to the citizens [4][5]. Correia and Wunstel [6] (2011) defines smart city as "able to link physical capital with social one, and to develop better services and infrastructure".

With an urban population of about 500 million and a growth rate of 2% per year, India is one of the big contributors to the global urban population [7]. To foster this potential growth sustainably the Government of India in 2015 embarked upon the development of 100 existing cities as Smart

Cities under a federally driven Smart Cities Mission in a phased manner [7]. In the first phase 20 cities were selected based on their past performance and future planning as put across in the completion. Since 2015 these cities have embarked on the transformation to a smart and sustainable future with various projects ranging from urban redevelopment, capacity building, citywide infrastructure including water supply, transport etc. Most of the projects are already under way and the change in the level of services and enhancement of quality of life is expected. However, there is a gap in literature that analyses whether the smart city movement has been a good investment and whether it has enhanced the quality of life in every aspect. The objective of this study is to find out those gaps between the government investment and the revenue generated from those investment. The study presents its findings from a case study of the Ahmedabad city in India. The result could help government officials, policy makers, developers, and investors to better understand the potential impact of the smart city. The results could also help to identify the potential room of improvement in smart city implications in India and guide as a lesson learn from current smart city projects running in India.

LITERATURE REVIEW

The elements of smart cities have started getting significant momentum and integration into the conventional urban planning and development sphere with the use of internet technologies acting as the catalyst [8][9][10]. The use of these technologies is bringing about a positive change in the quality of life of the citizens of the areas where it is being deployed [11]. Tam and Zeng [12] highlights the importance of sustainable construction – the set of processes by which a profitable and competitive industry delivers built assets, which enhance the quality of life, offer customer satisfaction, and maximize the efficient use of resources – in residential buildings, but suspects that the organizations do not have enough experience and knowledge to perform well on sustainability. Although current top-down building energy benchmarking approaches are useful for identifying overall efficient and poor performers across a portfolio of buildings at a city scale, they are limited in their ability to provide actionable insights regarding efficiency opportunities [5].

As stated earlier, smart cities integrate infrastructure and technology to improve the quality of life of citizens. However, how much city movement such as smart cities and integrated network has enhanced the quality of life in every aspect is still a challenge. The launch of the smart cities and its impact to the citizens could be a lesson learn for government officials, policy makers, developers, and investors.

Components of smart cities

The realm of urban services is increasing by the day with the horizon widening from mere water supply, sewerage, electricity, solid waste management etc. to services like Wi-Fi networks, smart systems for public transport, smart parking, smart automatic traffic regulation to name a few. Integrated systems for urban management have become the rule of the day with most cities/towns using them on having a long-term road map for adoption [10].

The sharing of traffic pattern on a digital platform has achieved significant scale across most of the smart cities. The data is collected by smart cameras, smart devices, sensors etc. embedded in the roadways, hung on traffic lights, streetlights [13]. The data is than processed for streamlining of the traffic flow so as toto reduce the travel time, reduce the ensuing pollution level along busy traffic thoroughfares and in the long run enhancing the quality of life in the city. Other city level initiatives include smart water supply systems, smart solid waste management system working with embedded sensors in pipelines, waste bins to optimize on water supply, waste collection etc. [14]. The government of India in its Smart City mission guidelines has specified many such interventions

as being part of the smart cities to be developed under the mission. The components have been classified into six categories such as e-governance, energy management, waste management, water management, urban mobility and the mission objectives and performance of various cities is being monitored using the parameters for adoption and integration of these components into the smart city projects [15].

Progress of a Smart City Development in India

There are more than 4500 urban areas in India and only the top 100 have been identified for development into Smart cities. This selection process was implemented by a group of international organizations led by the World Bank. In the first stage most of the 4500 urban areas were screened based on existing situation and the potential for development. The first list of screened cities amounted to about 920 urban areas and urban agglomerations. These screened cities were then handover over the Smart City guidelines and supported by a group of urban think tanks including the Rockefeller foundation 100 Resilient Cities program, Bloomberg foundation, World Resources Institute USA to come up with a Smart City Plan. This plan was then discussed in extensive stakeholder meetings with general public citizen groups, trade and commerce organizations participating in the consultation and providing valuable feedback [16]. This increased public participation created a heightened sense of citizen empowerment among the urban population. The Government of India, Ministry of Urban Development then selected the top 100 cities by judging the Smart City plan on multiple criteria, which included the components of the plan, long-term sustainability of the projects, potential of creation of economic opportunity, level of public participation. In the India Smart Cities mission the selected 100 cities have come up various projects using the smart city components specified in the guidelines [7].

Evaluation of a Smart City Performance

Smart city requires continuous processes of evaluation and corresponding course correction and improvement [17]. In cities using smart city technology the capital investment and corresponding enhancement of level of urban services has been studied with respect to return on investment in the long run and reduction of maintenance costs almost instantaneously [18]. Factors which indicate the performance of urban infrastructure like water supply and electrical system have helped the urban managers remedy the causes of inefficiencies in the systems [19].

METHODOLOGY

This study conducted an extensive literature review and collected financial data from the government of India [20] as a secondary source. The literature was comprised of peer-reviewed articles, policy documents, technical reports published in the past 15 years. The literature review focused on identifying a list of project level elements used in the Ahmedabad, India which is selected as the smart city for this study. The secondary data collected were financial records related to those project elements of Ahmedabad over five years that were posted under smart cities in the government of India website [20]. Then the study conducted a descriptive analysis on expenditure/investment and revenue cost.

RESULTS

Based on the secondary data and financial documents, the following section shows the summarized information of five project-level elements such as capital projects, water supply, sewage treatment plant, solid waste management, and parking for the city of Ahmedabad.

Ahmedabad is the main city of the state of Gujarat and the commercial capital of the state. The city has emerged as an important economic and industrial hub in India. Ahmedabad's increasing population has resulted in an increase in the construction and housing industries resulting in recent development. Table 1 shows the expenditure and revenue generated by the city of Ahmedabad that are derived from secondary sources and financial documents of Ahmedabad Municipal Corporation from the year 2015 to 2019. All the numbers mentioned in the Table 1 are in 10 million Indian rupees (INR). Table 1 shows the city of Ahmedabad expended more in capital projects (increasing trend from INR 3985.23 million in 2015 to INR 7652.12 million in 2019) and solid waste management categories (increasing trend from INR 120.56 million in 2015 to INR 197.23 million in 2019). The other project level elements such as water supply, sewage treatment plant and parking show less investment as compared to the solid waste management and capital projects.

The revenue column in the Table 1 shows that city collected more revenue from property tax (increasing trend from INR 254.32 million in 2015 to INR 417.78 million in 2019) and water supply system (increasing trend from INR 12.24 million in 2015 to INR 18.23 million in 2019). In fact, Table 1 shows the decrease in revenue generated in solid waste management from 2015 (INR 0.80 million) to 2019 (INR 0.69 million) despite increasing expenditure from 2015 (INR 120.56 million) to 2019 9INR 197.23 million).

Table 1. Expenditure and revenue data for Ahmedabad

Project-level Elements	**Y E A RS**				
	2015	**2016**	**2017**	**2018**	**2019**
Expenditure					
Capital Projects	3985.23	4827.28	5468.95	6145.01	7652.12
Water supply	18.30	19.50	20.50	19.20	20.40
Sewage Treatment Plant	21.80	25.30	15.60	18.90	24.10
Solid Waste Management	120.56	142.75	140.97	171.16	197.23
Parking	0.87	1.05	0.98	1.52	2.60
Revenue					
Property Tax	254.32	383.47	155.35	399.3	417.78
Water Supply	12.24	14.33	22.41	16.63	18.23
Sewage Treatment Plant	5.27	6.17	7.63	6.75	8.14
Solid Waste Management	0.80	0.85	0.77	0.31	0.69
Parking	0.70	1.20	0.80	0.62	1.24

Note: All numbers are in Indian Rupee (INR) 10 million

ANALYSIS AND DISCUSSION

Based on the result of secondary data, this study presented expenditure and revenue for five years. Table 2 shows the summary of aggregated expenditure and revenue from 2015 to 2019 based on the result of secondary data. The expenditure row in Table 2 consists of total budget spent in capital project, water supply system, sewage treatment system, solid waste management, and parking infrastructure combined. Similarly, the revenue row in Table 2 consists of revenue generated from property tax, water supply system, sewage treatment system, solid waste

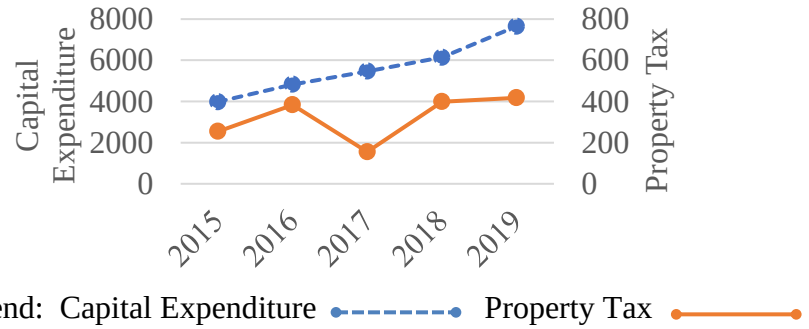
management, and parking infrastructure combined. The amount numbers in the Table 2 shows overall increasing trend from 2015 to 2019 in terms of expenditure and revenue.

Table 2. Consolidated expenditure and revenue from secondary data

	Years				
	2015	**2016**	**2017**	**2018**	**2019**
Expenditure	4146.76	5015.88	5647.00	6355.79	7896.45
Revenue	273.33	406.02	186.96	423.61	446.08

Note: All numbers are in Indian Rupee (INR) 10 million

To clarify how city is performing among each project level elements, the study further analysed the expenditure and revenue generated under project level elements and plotted a chart to visually see the trends. Figure 1 shows the graph of capital investment/expenditure and revenue collected through property tax from 2015 to 2019. The two vertical units: major units and minor units are plotted (refer Figure 1) to accommodate both expenditure and revenue graph together in the same graphs so that it shows clear distinction between the trend of expenditure and revenue at the same time. This is done because the minor unit which belongs to revenue is comparatively far less in numbers as compared to expenditure and to show both trends in a same scale becomes visually not appealing. Providing both scales overcome that visual challenge in the graph.



Note: All vertical units are in 10 million Indian Rupee (INR)

Figure 1. Capital expenditure vs. property tax

Figure 1 demonstrates that the expenditure resembles linear and positively increasing trend for the city of Ahmedabad from the year 2015 to 2019. Similarly, the average property tax trend for the city of Ahmedabad is positive (except a drastic change in 2017). The secondary data did not provide enough information on why the dip happened in 2017 and is beyond the scope of this study.

Similarly, Figure 2 shows a trend of expenditure and revenue over five years span for the city of Ahmedabad in the remaining four project level indicators, such as water supply system (Figure 2(i)), sewage treatment plant (Figure 2(ii)), solid waste management (Figure 2(iii)) and parking infrastructure (Figure 2(iv)).

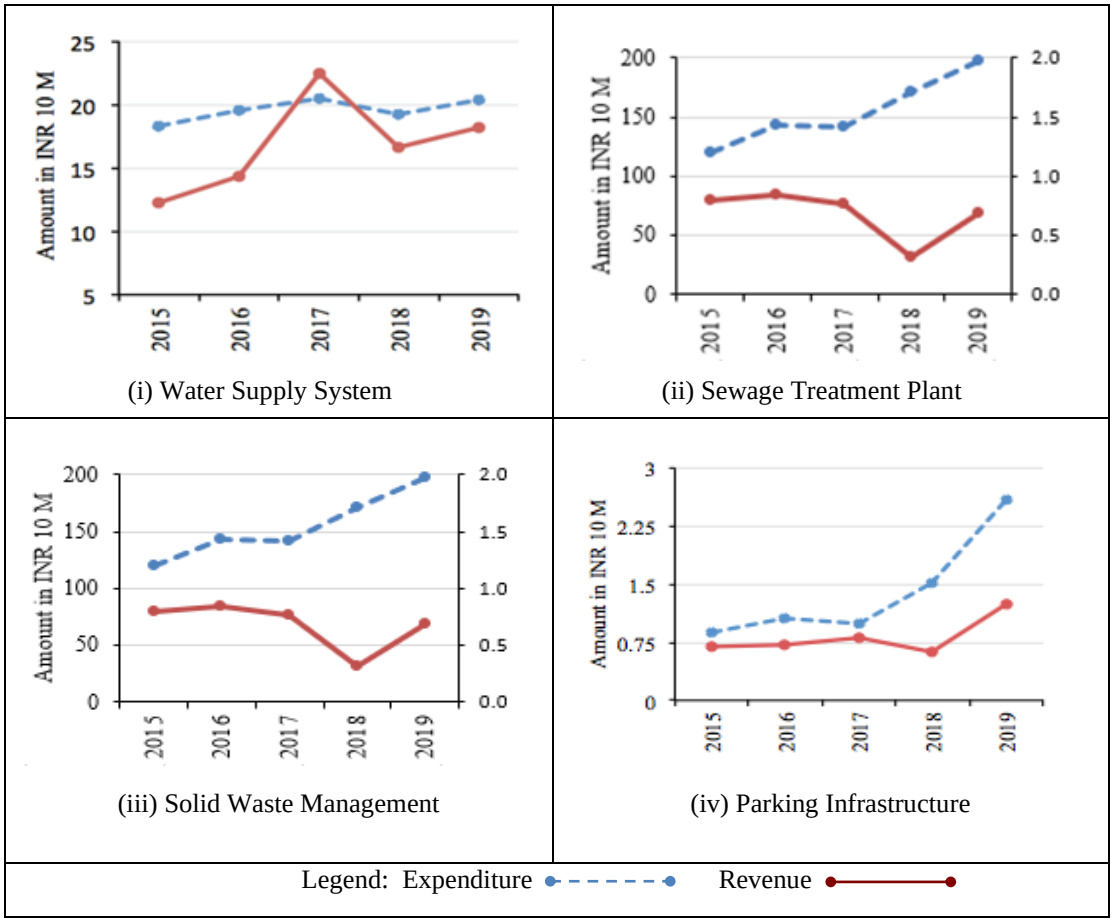


Figure. 2. Expenditure and Revenue chart

The graphs presented in Figure 2 shows that each city expenditure and revenue generated in those four-project level elements are different. The revenue curve has positive trend but not as compared to its investment on all four level elements. The revenue generated from the water supply system (Figure 2(i)) has comparatively outperformed the revenue generated than the other project level elements as shown in the Figure 2 below. The revenue generated from the sewage treatment (Figure 2(ii)) and solid waste management (Figure 2(iii)) were not positive over the years as compared to the revenue generated from the water supply system and the parking infrastructure system (Figure 2(iv)). For example, the revenue generated from sewage treatment plant on 2015 (INR 7.5 million) slightly increased on 2016 (INR 8 million), then decreased in 2017 and 2018, which later increased on 2019 but not crossed the revenue generated before 2019. Likewise, the solid waste management has similar trend as it was for the sewage treatment plant. The revenue generated from the parking infrastructure (Figure (iv)) has relatively positive trend in later years of the study period compared to the investment made on this sector. This study focused on the financial aspects from the secondary data source, however, external factors such as change in population, policies, and utility charges could affect revenue in long term, but this impact analysis is beyond the scope of this study. Future study will focus on the casual relationship between investment and revenue consider those factors.

CONCLUSIONS AND RECOMMENDATIONS

This study investigated the expenditure and revenue generated in Ahmedabad city, one of the smart cities in India. Overall, the relative comparison between expenditure and corresponding

revenue shows the increasing trend from 2015 to 2019. The breakdown result of the individual project level elements indicated that sewage system was not improved comparatively based on the government investment from the years 2015-2019. Similarly, the findings show no significant improvement in the waste collection as compared to the level of investment. The study showed that the water supply system outperformed revenue generation based on the government investment made in that sector. Likewise, the revenue trend in the parking infrastructure also returned positive compared to the level of investment made by the government of India. As a lesson learned, these findings indicate that significant improvement should be addressed in sewage management and waste collection. The findings from this study could help government officials, investors, developers, and city planners in making appropriate decision before and during smart city execution. The findings presented in this study could be helpful to city planners, government officials, and engineers to analyse the challenges and opportunities in smart city development. The result also helps as a lesson learned for future smart city implication.

This limitation of this study is that the result is based on a single smart city, and it may not be generalized for other cities. Another limitation of this study is that the secondary data did not provide enough information on why the property tax dipped in 2017 and is beyond the scope of this study. The study also limits the data collection duration of five years. Besides, the paper focused only on the revenue which could be influenced by external factors such as change in population, policies, and utility charges. The study recommends deriving a causal relationship with the investment made to relate the success of the project. The study also recommends analyzing the impact of the technologies and strategies used in this smart city in addition to the investment cost. In this paper, the impact analysis is beyond the scope of this study.

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