The Establishment of Smart Cities in Mauritius: Requirements, Challenges and Opportunities

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ABSTRACT
54% of the world’s population live in cities nowadays and this figure is expected to reach some 66% by 2050 as 60 million people are added to the cities every year. With such phenomenon, it will become a major challenge in the future to provide quality services to the residents due to resource constraints. In its 2015 budget, the government of Mauritius proposed “13 mega projects” including 8 smart cities and 5 techno-parks as a means to boost the economy and drive the competitiveness of Mauritius in both the regional and international arena. The government is indeed promoting smart cities in terms of national benefits: promoting the business sector, improving of living standards of its citizens, as well as making a judicious use of resources. However Mauritius does not need to start this venture from scratch. There are examples of smart cities around the world where many smart ideas have been implemented from which the country can learn and adapt. In this paper we will look at essential elements that form a smart city and how they have been implemented in existing smart cities and furthermore how can we use these ideas to build smart cities in Mauritius, or in other countries ready to make the leap.

KEYWORDS
Smart city, Innovation, Efficiency, Sustainability, Reliability, Internet of things.

1 INTRODUCTION
If we look up the word “smart” in the dictionary, we will come across “intelligent”. And indeed, intelligence at all levels including government, policy making institutions, private sector, academia among others is needed. According to Deloitte [1], a city can be defined as smart when investments in human and social capital, traditional and modern information and communication technology (ICT) communication infrastructure fuel sustainable economic development and a high quality of life, with a wise management of natural resources, through participatory action and engagement. This definition sums well the interaction of the various stakeholders required to make it work.

Smart cities are essential if the world is to respond effectively to the critical challenges it faces. The number of people living in cities is increasing every year; by 2030 it is estimated that 60% of the human population will be living in cities and 66% by 2050 [1]. The concept of a Smart City goes way beyond the transactional relationships between citizens and service providers. It encourages the citizen to become a more active and participative member of the community, for example by providing feedback on the quality of services or the state of roads and the built environment, adopting a more sustainable and healthy lifestyle, volunteering for social activities or supporting minority groups. Furthermore, citizens need a monthly income and “Smart Cities” are often attractive locations to live, work and visit.

The development of a ‘smart city’ consists of three layers [2]:

1. **Human Capital**
   - Education and training
   - Employment
   - Income
2. **Social Capital**
   - Civil society
   - Community
   - Social networks
3. **Physical Capital**
   - Infrastructure
   - Public space
   - Public services

These layers are interconnected and require alignment and coordination to achieve the desired outcomes of a smart city. The establishment of smart cities in Mauritius presents an opportunity to address these challenges and leverage the potential benefits of technology to improve the quality of life for its citizens.
1. The physical layer, incorporating human capabilities and knowledge-intensive activities.

2. The institutional layer that incorporates proper institutional mechanisms for social cooperation towards knowledge and innovation development. (More specifically it involves institutions and mechanisms for information diffusion, transfer of technology, cooperative new product development).

3. The digital infrastructure layer that incorporates a range of ICT infrastructure, tools, applications and content in support of both individual and collective action.

These multiple elements of a smart city makes the implementation a challenge that cannot be resolved by a few stakeholders only. It will take all the components of the city to decide what the smart city should look like. As Deloitte points out [1], the primary objective of the smart city is to enhance the quality of lives of its citizens. While cities across the world will likely share common traits, there are also some specificities that should be considered.

2 CRITICAL FACTORS FOR GOING “SMART”

According to [3], a smart city is based on 3 aspects, namely: the communication means (network infrastructure and technology), the process (networking of various actors), and the goal (public involvement or others). Smart cities are also commonly defined by 5 critical success factors which are deployment of broadband communication infrastructure, effective education and training of local labor force, policies and programs that promote digital democracy, innovative capacity and marketing (see figure 1):

1. Deployment of broadband communication infrastructure is used as an evaluation of the local capacity for digital communication. The evaluation takes into consideration both the city’s local vision and the affordability of costs incurred by the users.

2. Effective education and training of local force, to increase the rate of adoption of new technology infrastructures. This increases the capacity of the workforce to perform knowledge-intensive activities and enhances knowledge processes.

3. Policies and programmes that promote digital democracy, which are then applied across the society to benefit from the broadband revolution.

4. Innovative capacity, which assesses the level of creation of an innovation friendly environment. This provides the ability to attract highly creative people and businesses.

5. Marketing of the smart city as an advantageous place for living, working and setting up businesses. This increases the city’s potential to attract talented employment and investments.

3 DIGITAL DIMENSIONS OF SMART CITIES

The smart city can offer citizens and businesses with a range of tools and applications. These applications can be classified into 6 respective groups [3] (see figure 2):

![Figure 1: Critical success factors for cities ‘going smart’](image)
- E-information: providing a vast sea of information to a wide range of audiences.
- E-business: potential exploitation of opportunities and adoption of new business strategies offered.
- E-marketing: supports a range of e-marketing possibilities for a city
- E-Government: provide more effectively services, businesses, and governmental institutes.
- E-innovation: refers to the potential for e-corporation as on-line development of new products.
- E-participation: strengthening active participation in the process of decision making.

Figure 2: Dimensions of smart city development [3]

The use of digital technologies is to enhance the performance and well-being of citizens as well as reducing cost and resource consumption. In order to engage more effectively and actively with the citizens, a smart city should be able to respond faster to city and global challenges. It has been suggested that smart cities use information technologies to make a more efficient use of physical infrastructure such as intelligent lighting and smart building controls to support a strong and healthy economy. Energy-consuming city lighting can become sustainable with the use of renewable energy sources. Smart energy in solar panels, fuel cells and wind turbines can further be used to produce electricity and generate power. Such initiatives will boost the “green” into our lives. In addition, the cities of tomorrow must not only be improved in terms of ergonomics and technological comfort, but they also must be disaster-proof. The recent earthquake in Nepal and the earlier Tsunamis hitting the Indian Ocean are testimony to this need.

4 THE KEY PILLARS FOR CITIES

Cities all share some common traits since they all strive to achieve three objectives, presented here as the city sustainability pillars. The first is economic sustainability, i.e. a dynamic, productive city with numerous business opportunities that generates wealth. This requires on one hand high productivity of the private sector and on the other hand a healthy and well-financed public service. The second is social sustainability, guaranteeing access to all citizens to basic services and avoiding social exclusion. The third is environmental sustainability, guaranteeing environmental services and a healthy living environment [4]. An additional challenge, closely linked to economic sustainability would be financial sustainability so that the objectives of the city are achieved based on a financially sound plan, ensuring that costs are fully covered and the city is not at risk of insolvency. While it may be difficult to properly assess the ROI of such investments, it would be wise to lay ahead structures that will contribute to job and wealth creation of these new smart cities.

4.1 Economic Sustainability

The development of smart cities and the fullest adoption of innovations by city inhabitants, require an understanding of the economic fabric of the city and the market for smart solutions. Understanding the market allows for the development of new approaches to
infrastructure financing, as well as influencing the citizen’s behavior through these approaches. For cities requiring public private partnerships (PPPs) and systems of cost recovery using user charges, this knowledge is of paramount importance [4]. Smart city services contribute to the economic sustainability and the resilience of cities to economic shocks, as those generate a new level of economic diversification. Economic sustainability is also closely linked to financial sustainability, particularly in the wake of the financial crisis. Many cities have seen their access to capital curtailed and their credit rating deteriorate, while financial institutions have restricted access to credit [4]. Nevertheless, investing in the city structures of the future can be done using novel financial models, which monetize savings and use them to finance the reimbursement of capital expenditures. In addition, the cities of the future are expected to have much more decentralized energy services and supply provision systems thereby creating new economic activities. Most importantly, financing models must be based on solid cost benefit analysis, including wider socio-economic benefits where necessary.

4.2 Social Sustainability

City authorities have a key interest to ensure social inclusion, which starts with a basic level of services for all citizens. In a smart city, it is important to take into account the risks of alienating important groups of citizens. This may happen because smart services are limited to richer areas of the city, or because user charges make many important services unaffordable for certain parts of the population. All models of development of cities must ensure that public transport, water, sanitation, electricity, and telecommunications are affordable and accessible to all population groups [4]. In particular, smart city infrastructures or services will need to respond to the following questions:

- How can it be guaranteed that basic city services remain affordable?
- Who is paying for the services? Are the users that can afford them the right target group?
- Can the new services and infrastructures be understood and used by all citizens targeted?
- Are the social and cultural values of the citizens taken into account?

Ideally, smart city projects should be carried out only if they help cities to meet their needs, with a quantifiable added value facilitated by technology integration, usability or cost reductions [4].

4.3 Environmental Sustainability

Environmental concerns are also growing in cities. Three challenges arise. The first is on resource limitations, such as water scarcity and quality. The second is on quality of life and health. The third is on risk management and resilience to environmental shocks (disasters caused by climate change) [4]. One of the first steps to address environmental sustainability is to increase resource efficiency in all domains, such as energy efficiency in buildings and networks, fuel efficiency in transport, water efficiency and new methods to transform waste to energy. Technology is not the only aspect required for sustainability, but is an important and necessary one. Efficiency gains may need significant investments, and the integration of different technologies can be complex [4]. Resilience and risk management also need to be integrated in city planning, based on estimated future risks. The smart city is essential and possibly our best bet to move towards the required environmental sustainability [4].

5. EXAMPLES ILLUSTRATING THE DIFFERENT CHALLENGES & ASPECTS OF EXISTING SMART CITIES
This section illustrates the different challenges that cities from the different parts of the world face. The speed of urbanization, levels of social inequality, infrastructure needs are highly different and complex. However these examples can serve as valuable references for building the smart cities of Mauritius, or elsewhere.

5.1 Barcelona
With the aim of becoming a good example for Smart Cities, Barcelona is working to merge urban planning, ecology, and information technology to make sure that the benefits of technology reach every people and improve the lives of its citizens. Barcelona’s transformational approach follows a long-term vision based on building productive, human-scale neighborhoods within a hyper-connected, high-speed and zero-emission metropolis [5]. Barcelona Smart City proves smart in terms of the efficiency of its processes and the quality of life of its city residents. For example, 50 percent of Barcelona’s lighting power is controlled remotely. With the long-term impacts of these measures, it is clear that the Barcelona Smart City has already and will continue to serve as a best practice for other global cities seeking to employ the best available technologies to develop durable sustainability initiatives in the best interest of their citizens [5]. The initiatives, failures and successes of Barcelona can indeed teach everyone valuable lessons regarding the deployment of smart cities.

5.2 Vienna
Smart City Vienna is a longstanding initiative by the city of Vienna to improve the design, development and perception of the federal capital. Vienna looks at a cross-section of the city, masking all areas of life, work and leisure activities in equal measure, and includes everything from infrastructure, energy and mobility to all aspects of urban development [6]. The city has set itself the task of systematically and uninterrupted modernize the city in order to reduce energy consumption and emissions without having to forego any of the advantages of mobility. Vienna has also accomplished bold smart-city targets and tracked their progress to reach them, with programs like the Smart Energy Vision 2050, Roadmap 2020, and Action Plan 2012-2015. Vienna’s planners are incorporating stakeholder consultation processes into building and executing carbon reduction, transportation and land-use planning changes in the hopes of making the city a major European player in smart city technologies [8]. Such consultation processes with all classes of stakeholders represent an important activity that ensures the smart city meets the expectations of its users.

5.3 Santander
The Spanish city is embedded with more than 12,500 sensors to help the government operate as efficiently as possible. It is an adaptation of the way Europe thinks about cities [9]. Santander was chosen four years ago to become Europe’s test bed for a sensor-based smart city. Since 2010, 12,500 sensors have been placed in and around the city’s downtown district, where they quantify everything from the level of trash in containers, to the number of parking spaces available, to the size of crowds on the sidewalks. Furthermore, sensors on vehicles such as police cars and taxicabs measure air pollution levels and traffic conditions [9]. Dubbed SmartSantander, the project, which received an $11 million grant from the EU, started when Luis Muñoz, an engineering professor at the local University of Cantabria, and his development team of 20 technicians, researchers and programmers.

5.4 Birmingham
The affirmation statement of Birmingham’s Smart City Commission sets out the huge ambition for Birmingham that will define the technological solutions and partnerships to
meet the city’s immediate and future challenges using smart city concepts.

Birmingham, like many cities, faces outstanding challenges. They need to move to a low carbon economy and adapt to climate change. Furthermore, the national and financial situation has intensified many of the inequalities of the city; some areas are extremely deprived; wages are lower, more people are unemployed, and the health outcome of residents are poorer in these places [10].

The aim of Birmingham was therefore to embed a capability for smart and sustainable reinvention of the way the city runs and in the way new businesses are created to deliver a step-change in Birmingham’s economic growth, well-being and prosperity [10].

Birmingham City Council and Virgin Media Business thus initiated free public Wi-Fi across the city center, giving residents, shoppers and tourists access to unlimited data services on the go. Access points – roughly the size of a shoebox – have been mounted on lamp-posts and other street furniture across the city center and connected back into Virgin Media Business nationwide fibre optic network to ensure unlimited, super-fast connectivity [11].

The citizens are now able to do everything from streaming videos, to staying in touch with friends on Twitter or Instagram, to looking up the latest bus timetables via Wi-Fi. With no usage limitation, people are also capable of downloading content or browsing the web as long as they need [11].

6. ESSENTIAL ELEMENTS IDENTIFIED IN MAJOR SMART CITIES.

In this section, some of the salient features of the smart cities depicted in the previous section are pointed out and summarised.

6.1 Smart Transportation

A smart bus network is a desired feature of a smart city, particularly one that is easy to understand, intuitive, faster and better connected, so travellers can save time and move around the city in a simpler and more sustainable manner. What is more, bringing onboard improvements to technology ensures the system is managed more efficiently: “right-of-way” traffic lights, transfer points, in-bus and bus stop information, smart management to improve speed, frequency and service provision across the city, as well as the optimisation of resources based on people needs [12].

Barcelona has therefore decided on a New Bus Network based on vertical, horizontal and diagonal routes, where users of public transport are informed and benefit from the improvements that have been made [12].

The city of Santander is also opening up its data so that programmers can create apps that help citizens find bus arrival times or let tourists find out who is performing at concert halls simply by pointing their mobile phones at a bus stop or building. The collecting of data through numerous sensors could lead to significant improvements in how city infrastructure is used and lead to a better understanding of urban issues [9].

6.2 Broadband

The city of Seoul launched Broadband City/Broadband Metropolis, where fibre optic backbones were established in the city and enabled the interconnection of households and local enterprises to ultra-high speed networks [13]. Connections to the backbone were established with fibre optic channels. Other cities that can be classified in this category are Beijing (China), Antwerp (Belgium), Helsinki, Amsterdam and Geneva. Antwerp and Amsterdam collaborated and interconnected their broadband networks. Geneva MAN (Metropolitan Area Network) was a pilot project that was envisioned in 1998 and installed in Geneva city in 2003 [13]. Combined with 100MBps a small urban area, it offered VoIP and TV services.
6.3 Parking Management

Santander introduced the parking management system coined Mobypark that provides drivers with a rapid solution to the issue of where to park and helps city officials reduce congestion and air pollution. Information about parking is displayed on special panels located at main intersections in the city, so anyone who is heading downtown will have an estimation of how many spaces are currently available and where they are situated [9].

Mobypark brings up the idea of Amsterdam’s Smart parking. Parking a car in big cities is indeed becoming a complex process. Drivers spend on average 20 minutes while looking for a parking spot. This increases CO₂ emissions and wasting the time of users.

With Mobypark, private parking lots, public parking garages, hotels, and hospitals all make their unoccupied parking spots available for drivers. They offer their available parking spots on a platform where it is possible to check real time availability and book these parking spots ahead. As a result, drivers spend less time searching for a single spot and reduce CO₂ emissions. Mobypark also ensures that one may easily rent a parking place for several days of a private individual, hotel or another institution. The service of Mobypark consists of a website and an app (Android and iOS).

6.4 Smart Waste Management

In Finland, the Enevo One solution uses a system of smart sensors and cloud computing to cut waste collection costs, while saving both time and money [14]. Wireless sensors are used to measure and forecast the amount of waste and recycling containers. The facility combines fill-level forecasts with a set of collection parameters order to calculate the most low cost collection plan. This latter can be accessed by the driver through a tablet [14].

In general, Intelligent and efficient waste logistics consists of the following [15]:

- An embedded system and communication networks.
- Real-time information on the fill level of containers.
- Monitored truck routes.
- Remote and dynamic configuration of the routes of vehicles on the road.
- Use of centralized real-time control and analysis applications.

This service is already available in the European market, but could be easily adapted for other countries.

6.5 Some Other Elements Identified from an Exemplary Barcelona

Smart Lighting: Barcelona came up with a master plan in 2012 that includes projects to control street level lighting in addition to transitioning 50 streets and a total of 1,155 lampposts to LED technology [5].

Smart Energy: From smart grid projects the same city has also developed a program to achieve greater energy efficiency and has currently deployed more than 19,500 smart meters in the Olympic Villa [5].

Smart Water: Barcelona is well on its way to set a program that includes remote irrigation control for the City’s green spaces. Thus far, 77 fountains are controlled remotely.

District heating and Cooling: Two networks provide hot water in 64 buildings spanning an area of 21 km [5].

Smart Transportation: The City unfolded a master plan in 2012 to make public transport better by deploying orthogonal bus lines, five of which began running in October 2012 [5].

Zero Emissions Mobility: As part of an extensive plan to encourage the use of electric
vehicles, Barcelona is setting electric charging stations, as well as electric vehicle fleets and car rentals. To date, the city has more than 500 hybrid taxis, 294 public electric vehicles, 262 recharging points, 130 electric motorbikes and an estimated 400 private electric vehicles on its streets [5].

Open Government: The City has developed a program to make municipal government activities more open to its citizens, starting with the deployment of 44 “citizen’s attention” kiosks and the launch of an Open Data portal in 2010 [5].

As can be noted, Barcelona has a lot to show to the world in terms of its bold initiatives to move the smart city agenda forward.

7. IMPORTANT THINGS TO BE WATCHED

In this section, we give a brief overview of some of the technologies and techniques that may need consideration in smart cities endeavors. We also provide a glimpse of some countries actively pursuing the establishment of smart cities and how we can learn from them.

7.1 Internet of Things

The Internet of Things (IoT) involves technology in which objects, animals or people are provided with unique identifiers and the ability to transfer data over a network without requiring human intervention. IoT has evolved from the merging of wireless technologies, micro-electromechanical systems (MEMS) and the Internet [16].

So far, the Internet of Things has been most closely been associated with machine-to-machine (M2M) communication in manufacturing and power, oil and gas utilities. Products built with M2M communication capabilities are often referred to as being smart [16]. Examples are smart label, smart meter and smart grids.

IoT, with its arrays of sensors could be embedded everywhere in the cities. Data analytics could then be used to extract and generate valuable information from sensor data and helping the various systems to become more intelligent.

7.2 IPv6

IPv6’s huge increase in address space is an important factor in the development of the Internet of Things [16]. Building a smart city requires connectivity of thousand of nodes talking seamlessly with one another and transferring important data; thus, extreme reliability and scalability are essential [17]. Some models of connectivity that can be find in a smart city are smart metering communication, street lighting control and traffic lights control. Typically, these networks can spread several miles of distance while serving thousands of nodes per edge router or data concentrator [17]. IPv6 offers a highly scalable address scheme which is quite enough to address the needs of any present and future communicating device still allowing it to have many addresses. In fact, one could say that IPv6 enables IoT, which in turn enable smart cities.

7.3 Co-creation

Co-creation is a business strategy focusing on customer experience and interactive relationships. Co-creation allows and encourages a more active involvement from the customer to create a value rich experience [18]. With co-creation, the participants such as granting customers, suppliers or the general population all contribute to the design of the final solution. Through a series of well-grounded steps, stakeholders of the project are invited to contribute, evaluate, and refine ideas and concepts [19].

We believe this may be a very important factor in any city that wishes to enhance its services. Indeed a city cannot become smart if some of
its stakeholders do not have their say. Co-creation will ensure that the city meets the actual needs of the citizens and is not just an adaptation of a solution that worked somewhere else.

7.4 Cloud Computing

Cloud computing is a general term for anything that involves delivering hosted services over the Internet. These services are broadly divided into three categories: Infrastructure-as-a-Service, Platform-as-a-Service and Software-as-a-Service [20]. Smart cities are a relatively new concept and their basic goal is the efficient use of natural resources as water, electricity, air quality, waste management among many services to the citizens. One such smart city in particular, Dublin, supports cloud computing as a natural resource [21]. The city policy-makers argue that cloud computing was quickly adopted by companies. In addition, city university initiated new curricula around the theme of cloud computing.

Another city, Guadalajara in Mexico followed a similar journey. This city has been recognized as model city to create smart guidelines established by National Digital Strategy announced by the Mexican government to promote the adoption and development of Information Technology and Communication [22]. Digital services that will be implemented in the city are:

- Type of Service
- Cloud Data storage
- Crowd sourcing traffic information
- Cloud based creative software for educational users
- Intelligent urban security systems
- Smart parking
- Remote global education opportunities
- Advanced consumer analytics

These services, in general, need an elastic, flexible and economic infrastructure to support workflows that demand a high performance computing resources. Hence a remote cloud service is used to classify the processes footprints and schedules.

7.5 Countries to Watch

Some countries that could easily be added to a watch list in the area of smart cities are India, China and Japan. They are bringing massive developments indeed.

India is building 100 smart cities across the country. The city of 2 million people, commonly known as Vizag, geared up to become one of India's first smart cities. Its officials admit that much more must be done to help it cope with increasingly extreme weather - a challenge being recognized in many fast-growing metropolises worldwide [23]. India has many inspiring ideas against natural disasters from which other countries can learn. These 100 smart cities are thus a global laboratory where many of the smart city technologies deployed could be replicated.

China's urbanization and Chinese cities' eagerness to "go smart" could mean great business opportunities for enterprises. More than 260 prefecture-level Chinese cities are building digital geographic systems to provide better services to citizens. The Internet of Things (IoT) is becoming a major new industry in China. IT services provider Digital China Holdings mentioned that it aims to have 100 billion yuan ($15.8 billion) in sales revenue during China's 12th Five-Year Plan 2011 to 2015 [24]. As china rushes into the smart city competition, a lot can be learnt about their smart city deployments for existing or legacy cities.

In Japan, the Ministry of Economy, Trade and Industry (METI) has been investing in Smart City projects since 2010. The promotion of smart energy initiatives is now one of the goals established by the Fourth Energy Strategic Plan, released in April 2014. Smart Cities are a booming market in Japan. The growing economic importance of cities and the necessity of addressing environmental issues have
brought Japan to develop local solutions. The smart cities of this country will definitely provide interesting case studies as new methods are deployed to cater for early warning systems for earthquakes and other calamities often affecting the region.

On another note, European and Japanese companies are also contemplating the benefits from advanced cooperation on Smart City development and management. The two economies wish to improve their models and intensify their competition at a global scale [25].

7. MAURITIUS SMART CITIES

The government of Mauritius has recently launched in its 2015 budget ‘thirteen mega projects’. These projects include bringing the concept of smart city to eight different regions across the country along with another five high-tech manufacturing and information-based industrial zone, also coined as ‘technopoles’ [26]. The main aim to this development is to promote and ease the Mauritian lifestyle, create jobs and bring a boost to the construction sector. These cities will be designed to be environmental friendly and will produce their electricity while making an efficient use of water and smart modern transportation to ease the crisis of traffic congestion the country currently faces.

The regions that were selected for these projects are: The Omnicane airport city in the south-east, St Félix Village in the south, The Médine Integrated Park in the west, Roches Noires in the north-east, The Azuri Phase 2 project in the north, The Terra project in the north, The Highlands City in the center, The Richeterre Project in the vicinity of Port Louis. The 5 ‘Technopoles’ will be located at Highlands, Rose Belle, Flacq, Rivière du Rempart and Bambous. These projects will exploit roughly up to 7,000 acres of land and will required an investment of approximately 120 billion Mauritian rupees (about 3.5 billion USD), to be essentially drawn from private and foreign investments [26].

The Omnicane Mont Tresor Airport City will extend over 400 hectares of land near the airport of Mauritius. It aims at the developing the movement of airport activities with the African continent and the rest of the world while pressing on green energy. The CEO of Omnicane sees it also as an opportunity to launch a bioethanol distillery and a carbon burn out project. The city will consist of an industrial and technological activities park and is conceptualized as a hub of services including hotel and leisure activities [27]. The St Felix Village project is an ecovillage project which will provide office and housing facilities for foreigners. The Médine Integrated Park is a three phase project and the infrastructures will be mainly of IT projects, a University and a Hospital. Extending over 800 acres of land will be the Roche Noires project which has not been finalized however. The Azuri Phase 2 project will be a residential project which consists of 132 accommodation, leisure areas, gymnasiums and shopping centers. The Terra project in the north will consist of the culture of sugar cane along with business parks and residential portions. The Richeterre project will extend over 500 acres of land and will consist mainly of industrial zones and business parks. The Highlands City project is called for as a massive project that will help to decongest the city of Port-Louis, and become the new administrative center of the country. Port-Louis will then be transformed into a regional bunkering hub.

To support these smart cities, a new submarine cable linking Mauritius to the rest of the world will be installed [28]. Provision for a full broadband connectivity and FTTH is expected within the next 3 years while Free Wi-Fi Hotspots will be increased from 15 to 350 [28].
8. ESSENTIAL ELEMENTS OF MAURITIUS SMART CITIES

Many of the projects announced in the budget 2015 are not yet concrete. As such, it is important that we consider some of the priorities the country is currently facing when developing the concept of smart cities around the island. In this section, we provide some of the elements that needs particular attention.

8.1 Traffic Management

Providing modern transportation system and reducing traffic congestion across the island is a must. Traffic congestion indeed costs the country around 4 billion rupees per year, according to [35]. Furthermore, buses are always crammed in the morning with bus attendants often having difficulties to make their way through and attending each and every passenger. This is very time consuming. Another issue arises with money change which is not always available when customers tend notes. This issue could be resolved with the introduction of NFC (near field communication devices) compatible readers in buses. People would simply to tag their cards when they enter buses and tag again when getting off. The cost would be deducted from their cards automatically depending on their journey. This will reduce cash transactions and also bring a boost to one-man operation system. Wifi availability in buses could also help people to stay connected. Applications can be designed and be available to citizens, giving information about bus routes, planning and even keep track of buses they need to get onto. These applications could also be designed to indicate availability of sitting seats as per number of people that tagged their NFC cards in specific buses.

Parking facilities are also very lacking across the country. A Smart parking a system that would help drivers to quickly find parking spots is very much required. Our cities should manage their parking spaces more efficiently. Information could be sent via smart phones and via electronic street panels. This would reduce traffic density as well as decrease CO₂ emission.

In Moscow, Fastprk, a private company implemented a system where gateways send information via the internet to a database in real time. The parking occupancy in the area is instantly reported to users via apps and illuminated panels in the street. The central control gets real time analytics about the parking space per areas and times of the day. When connected to the payment method system, the authority can even identify non-paying cars with the use of a tablet application. The system relies on embedded sensors in each parking bay in the street. When a car is parked on the sensor, it is detected and the sensor relays that information [29].

Bringing efficient solutions to our present bus system as well as to the problem of parking are considered key to a good traffic management system. It is therefore hoped that some of the ideas provided here will be adopted for the traffic system in Mauritius.

8.2 Smart Waste Management Systems

Until now collecting waste has been done using static routes and schedules where containers are collected once or twice every week regardless if they are full or not. It is not only time consuming and of high cost but traffic congestion is also created with the trucks stopping at all times with workers getting down, emptying each and every can in the trucks manually. By turning these static routes into dynamic smart plans, which are based on real data from the field [14] waste management can be efficiently operated. Trashcans could be connected to the internet via embedded sensors monitoring the amount of wastes. Software will then calculate how much trash per region in a daily basis and smart plans will be automatically generated. Even wastes producers like offices, residents and institutions
can track how much the amount of waste they generate. Trashcans could be placed in specific places in the vicinity of the yard or office places so that trucks can have easy access to them. This will allow the truck driver to pick up the containers with the help of automated machine fitted in the trucks without the help of several workers. This could well have a positive impact on the environmental sustainability of our cities and the country in general.

8.3 Smart Energy Use

The Central Electricity Board (CEB) is the main organization responsible for the transmission, distribution and supply to the electricity to the population. 40\% of energy is produced by CEB and the rest is obtained from independent power producers mainly sugar estates. Energy is produced by thermal means (80\%), water, and bagasse (both accounting for the remaining 20\%) from small sugar estates [30]. With the smart city projects, electricity demand should be managed.

Smart grids could help to provide additional electricity to meet the rising demand, increase reliability and quality of power supplies, increase energy efficiency, while even reducing the carbon emissions. Smart grids have the capacity to help balance electrical consumption with supply, as well as the potential to combine new technologies to enable energy storage devices and the large-scale use of electric vehicles. A smart grid will also provide greater control over energy costs and a more reliable energy supply for consumers. Environmental benefits of a smarter grid include integration of more renewable power sources, and reduced CO2 emissions and other pollutants [31].

The use of smart meters should also be introduced along with smart grids. A smart meter is an electronic device that records consumption of electric energy in intervals of an hour or less and communicates that information at least daily back to the utility for monitoring and billing. Smart meters enable two-way communication between the meter and the central system. Smart meters can gather data for remote reporting. This advanced metering infrastructure (AMI) is different from traditional automatic meter reading (AMR) in that it enables two-way communications with the meter [32]. This will record easily the consumption of electricity and facilitate billing information.

The forthcoming smart cities should look forward at producing most (or even all) of their energy. With the help of photovoltaic cells, green energy can be obtained from the sun. Photovoltaic cells basically convert visible light to direct current. Large sets of PV cells can be connected together to form solar modules, arrays, or panels which can produce sources for utility power.

We also have a vast ocean and it can be used to produce two types of energy: thermal energy from the heat of the sun, and mechanical energy from tides and waves. With the appropriate techniques, a certain amount of energy can be produced for specific areas so as to reduce the load from the CEB.

8.4 Smart Water

Water management is essential to any smart city initiative. Currently, Mauritian citizens face frequent water cuts. There is also the problem of water leakage problems across the country. It is indeed estimated that about 50\% of the treated water that goes in the piping system is lost even before reaching the customers’ premises.

Facilities such as sensors could therefore be placed in water treatment processes so that water authority is capable of monitoring the turbidity, salinity, conductivity, pH and chlorine levels in the water at every moment. Alerts can also be received through mobile phones or any smart devices if any issue arises and can be solved in near-real-time.

As an example, IBM has its own solution to the above set of problems. Indeed, IBM intelligent
water is a software that was developed to manage pressure, detect leaks, reduce water consumption, mitigate sewer overflow, and better manage their water infrastructure, assets and operations. It uses advanced data management and technology to monitor the flow of water and also smart metering for easy billing information. IBM Intelligent Water [33]:

- Includes the Intelligent Operations for Water component, which provides extensive visibility and situational awareness spanning water and wastewater operations. This helps improve decision-making, enhance efficiency and reduce risk.
- Includes the Water Efficiency Analytic component, which helps mitigate non-revenue water through pressure optimization and pipe failure prediction.
- Turns data from smart meters into opportunities for recapturing revenue and detecting fraud.
- Delivers insights from big data and smart devices to help operators improve irrigation, flood management and sewer overflows.
- Takes advantage of flexible deployment options by offering multiple deployment models.

The IBM software or its equivalent could therefore be applied to the Mauritian cities, along with the required set of sensors to help monitor the water usage and quality in the country.

8.5 Other Essential Elements

Smart Defence against flooding: Mauritius is currently facing a problem concerning floods. We have experienced it severely on in March 2013 where 13 persons lost their live, mostly due to poor infrastructure planning and drainage systems. Full consideration should therefore be given to appropriate countermeasures. Singapore, for example, has set up a smart defense against flooding. Local authorities should build defense systems so as to prevent floods when storm events occur or when heavy rain hits [34]. Sustainable Urban Drainage systems could be built that replicates the environment’s ability to drain water away at its natural rate prior to development. This is achieved through the storage of water in tanks, collecting water for other uses – such as flushing toilets – and holding some water in ponds or lakes. The water can then be discharged back into the environment at its natural rate and flooding from this flash run-off can be prevented [34].

Smart billboards: It is customary to see a couple of workers working on billboards in Mauritius, to change the adverts. This is time very consuming. With the help of smart billboards, this will be much easier. The adverts can be easily uploaded each week without much the hassle of sending workers across the country to do the job. Energy efficient photovoltaic billboards can also be used to save energy.

Meteorological Services: meteorological facilities can directly accessed from our mobile phones. However, services like weather forecasting requires region setting to operate properly. Unfortunately, these information are not currently sourced from our own meteorological station but are provisioned elsewhere. It would be better if Mauritius could provide this national information on its own.

CONCLUSION

Smart cities in Mauritius have many requirements and have to face several challenges. The thirteen mega-projects presented in the national budget 2015 were designed to ease lifestyle, decrease unemployment and boost the construction sector. The present paper shed light on a few directions we should check out as we venture into country-wide deployment of smart cities.
In particular, it is believed that there is a need for stakeholders to sit together and decide of what smart cities in the country should look like. While we can take stock of the experiences from other cities such as Barcelona or Santander or from countries such as India or China, Mauritius will need to devise its own deployment plan, and this would be best achieved through co-creation processes, where all stakeholders express their opinion so that the smart cities actually meet the needs of all its citizens.

Technologies such as IPv6 and Internet of Things, Data analytics along with cloud computing will need to be thoroughly investigated. These technologies are the essential IT ingredients required to build the platform for smart cities. Training is therefore very important, and it is believed that academia will also need to restructure its role so as to equip the future workforce with the right skills to tackle the many challenges that these cities will pose.

It will be interesting if the factors considered in this paper are taken up in the upcoming National Innovation Framework report 2015-2020, scheduled for release in July 2015 by the Ministry of Technology, Communication and Innovation. It is finally hoped that Mauritius can serve as a valuable example for the African continent in its endeavor to go smart.

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