

Bridging the Digital Divide in an African Smart City

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Abstract: Sustainable transformation of cities is only possible when conducted in a smart way. This research assessed the impact of rolling out free Wi-Fi networks and online services in Johannesburg, South Africa as it relates to the sustainable development of vulnerable communities. Informed by the early adopters of a free Wi-Fi network provided by the City of Johannesburg, participating in the Johannesburg digital ambassadors training programme, the research evaluated smart city enablement in the City of Johannesburg. The case study reviewed relevant smart city metrics and compared to the standard for sustainable development of communities (BS ISO 37120:2014), evaluate indicators for city services and quality of life to identify design criteria for future developments. The results from this study contribute to the enablement of smart city infrastructure development geared toward capacitating vulnerable and previously digitally disadvantaged communities.

Keywords: Community, Infrastructure, Smart City, Sustainable, Wifi

I. INTRODUCTION

Smart cities apply technologies into much wider scale by connecting smart technologies with smart offices/building, smart homes (ambient intelligent), smart grid, tele-care (health care), smart factories (industrial internet of thing-IoT/industrial internet), telematics etc. The disruption of the fourth industrial revolution (4IR): electrification, digitalisation, industrialization, decentralization describe the vision of a digital economy [1] [2]. The strong rooted on the IoT and physical systems-enables manufacturing, disruptive paradigms of future and 4IR envision of intelligent environment [3]. The IoT, big data, wireless network, intelligent equipment, cloud computing are the emerging technologies that are the major drive to the 4IR smart city [4]. The internet and digital technologies are driving forces in what Rifkin referred to as the industrial revolution [5]. Yet, while urban communities around the globe embrace savvy vitality frameworks and assemble sensor-driven canny vehicle frameworks, numerous networks are actually abandoned in the

computerized dim. The divide in living standards and economic opportunity in cities will continue to grow if vulnerable communities are not digitally activated. These challenges are also a burden in developing countries such as South Africa. The country is well-positioned to become a leader in developing technology, systems and policy on the African continent impacting the Sustainable Developmental Goals [6] specifically relating to sustainable cities and clean energy. To understand this potential, social advancement and business enterprise must be bolstered through innovation improvement, specialized instruction and commercialisation activities.

The research assesses the impact of rolling out free Wi-Fi networks to previously digitally disadvantaged communities in Johannesburg, South Africa. In a partnership between the City of Johannesburg and the University of Johannesburg, a systems engineering approach for developing a smart city is considered. As part of an initial assessment of existing programmes of the city, the value of commercially free and freely available online services are considered in terms of developing a sustainable smart city. The research pose the question: In a smart city environment, how does free online services impact the capability needs of vulnerable communities if they are considered as the user or customer while applying a systems engineering approach towards sustainable development? The purpose of the research is to apply *a systems engineering approach to smart city enablement*, informed by the early adopters of the free Wi-Fi provided by the City of Johannesburg, participating in the Digital Ambassadors pilot programme.

Shrewd urban communities can be viewed as frameworks with streams of vitality, materials, administrations, individuals and financing. Also, urban arranging is firmly identified with the financial and social digestion of networks, for example innovation is viewed as an empowering agent of good life. Comprehensively working asset productive urban communities are better ready to respond to changes. Multifunctioning frameworks make cost investment funds as well as increment wellbeing and unwavering quality through better use of keen, incorporated and enhanced systems. Shrewd city the board is the

way to keeping up individuals' prosperity under the weight of asset effectiveness [7].

With a systems engineering focus of defining customer capability needs early in the development cycle, there are many lessons to be learnt from early adopters of new technologies. The study evaluates the behaviour of resident's knowledge transfer in using free Wi-Fi in the City of Johannesburg as per *ISO 37120* indicators [8]. *ISO 37120* blueprints the definitions and philosophies for a lot of city markers to control and quantify conveyance of city administrations and personal satisfaction. The standard sets an all encompassing and coordinated way to deal with supportable advancement and strength in urban areas. The institutionalized pointers give a uniform way to deal with what is estimated, and how that estimation is to be embraced to track and screen a city's advancement on city administration execution and personal satisfaction and help urban areas in setting targets and observing accomplishments. This is likewise adjusted to the manageable improvement objectives to make urban areas "comprehensive, protected, versatile and maintainable" [9]. Brilliant city structure, activity and the board should be done at frameworks level. Sub-streamlining of individual parts won't prompt ideal execution of the general framework. Multi-target improvement isn't a simple errand, however it winds up vital as various parts and frameworks are interlinked and interconnected [7].

II. METHODOLOGY

The research will review a case study of online activities relevant to metrics identified in the standard for sustainable development of communities (BS ISO 37120:2014) [8]. By evaluating indicators for city services and quality of life, design criteria for future developments can be identified enabling smart city infrastructure development *geared toward capacitating vulnerable communities*. The research will evaluate sustainable, smart city enablement, informed by the early adopters of the Maru-A-Jozi platform offering zero rated internet solutions to residents participating in the Jozi Digital Ambassador (JDA) pilot project.



Fig 1. Maru-A-Jozi cloud-based platform showing available online services.

The pilot project forms part of a digital infrastructure expansion plan which is said to be the most ambitious programme to roll-out digital infrastructure ever achieved in Africa [10]. More than 900 km of new fibre-optic network have been laid across the city, bringing the city within reach of becoming a smart city. The development offers free Wi-Fi through the Maru-A-Jozi platform and improved access to broadband services.

Firstly, data was collected on the Maru-A-Jozi [11] cloud-based platform, illustrated in Fig 1, where Google analytics was used to track user behaviour on the site. Secondly, core indicators directly influenced or impacted by digital activation of an unconnected community were identified, based on a literature review of sustainable, smart cities. Thirdly, the possible impact, as supported by literature as compared to the user activity during JDA activation, were evaluated. Finally, recommendations regarding smart city infrastructure development geared toward capacitating vulnerable communities are presented in light of the findings of the JDA pilot project.

III. JOZI DIGITAL AMBASSADORS

The case study presented and evaluated the use of free online services available through the Wi-Fi network in Johannesburg, the largest city (by population) in South Africa and one of the 50 largest urban agglomerations in the world. The neighborhood region, the City of Johannesburg, as a major aspect of its formative administration conveyance model [10], is concentrating on structure the abilities of its occupants so as to empower them to give administrations that meet the city's asset needs. As a component of the take off of 1000 Wi-Fi hotspot or passages all through Johannesburg, the City of Johannesburg was to capacitate roughly 3,000 (3000) JDAs to prepare its occupants to use and profit by the broadband associations in their territories and free online administrations given by the City. These JDAs were guided and mentored by university postgraduates and prepared in advanced, business and fundamental abilities for smaller scale endeavor enablement. They were given Wi-Fi empowered advanced tablets, marked apparel and showcasing material to arrive at a focused on 720,000 inhabitants of the City of Johannesburg over a 18-month time span. Occupants were prepared to get to online administrations, including banking and advanced guide route, just as communicate with the Maru-A-Jozi (cloud) entryway to connection up with a scope of online administrations including work and pursuit of employment apparatuses as given by the City of Johannesburg.

IV. SUSTAINABLE SMART CITIES

The United Nations [9] describe cities as hubs for commerce, culture, productivity, science and social development. Cities enable people to advance socially and economically by creating opportunities of synergy for its inhabitants. However, cities are challenged to manage its growth in a sustainable way which continues to create job opportunities and prosperity while not depleting resources and straining land usage. Urban troubles join blockage, nonattendance of resources for give principal organizations, an absence of adequate cabin

and declining structure. The difficulties urban communities face can be defeated in manners that enable them to proceed to flourish and develop, while improving asset utilization, contamination and neediness. Future urban areas should display open doors for every one of its inhabitants, with access to essential administrations, for example, vitality, lodging, transportation, and instruction.

With the development of new technological innovations – mainly in Information and Communication Technologies (ICTs) – the concept of the “Smart City” emerges as a means to achieve more efficient and sustainable cities [12]. Although there is general agreement that a smart city is characterized by innovation in city management, the services and infrastructures available in the city, a common definition of the term has not yet been stated. The elucidations and definitions utilized by various intrigue gatherings, partners and locales change. The term “Smart City” relates the interconnection of urban aspects (including technological and ecological considerations) to a new approach for urban management. Infrastructure is a central point of the smart city and digital technology is the enabler that makes it much possible. It is the combination, connection and integration of all systems which becomes fundamental for a city being truly smart [13]. According to Hao et al., (2012) [14], a smart city integrates urban information systems and fulfills high intelligent urban management through the utilization of next generation ICT, the internet and cloud computing. Wang (2015) [15] postulates that to make cities smarter, its residence should be operate smarter, be connected and supported by smart sensors, cloud computing, the internet of things and intelligent response by e-governance. Monzon (2015) [12] defines smart cities as “an integrated system in which human and social capital interact, using technology-based solutions. It aims to efficiently achieve sustainable and resilient development and a high quality of life on the basis of a multi-stakeholder, municipality based partnership.”

Building on the definition of a sustainable smart city, development and resilience of cities are considered when evaluating this pilot project. ISO 37 120 [8] identifies 21 metrics which are relevant for evaluating sustainable development and quality of life. These are, in alphabetical order, the economy, education, energy, environment, finance, fire and emergency response, governance, health, recreation, safety, shelter, solid waste, telecommunication and innovation, transportation, urban planning, wastewater and water and sanitation. Each metric has core indicators and supporting indicators which are be measured. The core indicators described are considered essential for steering and assessing the performance management of city services and quality of life.

V. ONLINE CITIZENS AND DIGITAL ENABLERS

The first step to evaluate sustainable, smart city enablement for this case study is the evaluation of the data collected on the Maru-A-Jozi cloud-based platform. During the pilot project, 85 trained JDAs were deployed over a 3 month period to train and activate local residents of the City of Johannesburg. The JDAs

approached residents who were in range of the free Wi-Fi access points supplied by the city typically near public hospitals and clinics, libraries and along public transport routes. During each 10 minute activation and training session on the secure online platform, user activity were recorded. The JDAs had 3346 successful training interventions where residents were activated and trained. The residents were introduced to the 9 services available on the platform and had to select 3 of the 9 services to be trained on in order for the activation session to be considered as successful. A list of the most visited online services is presented in

Table 1, with work/business opportunities the most frequently visited service link.

TABLE 1. City of Johannesburg resident service usage during 10 minutes training session

Service Page	Number of visits	Status
Work/business opportunities	8754	Functional
Information services	6225	Functional
Call/message	6202	Functional
Transport	6180	Functional
Education	4051	Not functional, demonstration only
Bank	3881	Functional
Emergency	3599	Functional
City services	1912	Not functional, demonstration only
Voucher & deals	1480	Not functional, demonstration only

The work/business opportunities service gave the trainee access to the city’s jobs portals, job search functions and information relating to tenders and job opportunities. The second most visited link was the information service, followed by the call and messaging function, education and banking services. The least visited links were advertising links for vouchers and deals, city services and emergency services. Next, considering the services available to the residents, the core indicators directly influenced or impacted by digital activation through the Maru-A-Jozi portal, were determined.

The 21 indicators were evaluated on three criteria, namely, immediate impact on core indicator; online services which would impact core indicators; and service available on online Maru-A- Jozi platform. Indicators relating to recreation, shelter, and urban planning were not considered since there were no direct link to the Maru-A-Jozi platform and the core indicators. Three of the services were not active during the pilot project as indicated in

Table 1. Evaluating each of the 21 profile indicators for sustainable development of communities listed in ISO 37 120 against the digital activation of the city’s inhabitants on the Maru-A- Jozi platform, 17 profile indicators were identified to be directly influenced or impacted by this project. These indicators are listed in Table 2.

TABLE 2. Identified impact profile indicators [8]

Metric	Core indicator	Supporting indicator
Economy	City's joblessness rate. Evaluated estimation of business and mechanical properties as a level of complete surveyed estimation all things considered. Level of city populace living in poverty.	Level of people in fulltime work. Youth joblessness rate. Number of organizations per 100 000 populace. Number of new licenses per 100 000 populace for every year.
Education	Level of female school-matured populace took a crack at school. Level of understudies finishing essential training. Level of understudies finishing auxiliary instruction. Essential training understudy/instructor proportion.	Level of male school-matured populace joined up with school. Level of school-matured populace joined up with school. Number of advanced education degrees per 100 000 populace.
Energy	Absolute private electrical vitality utilize per capita (kWh/year). Level of city populace with approved electrical administration. Vitality utilization of open structures every year (kWh/m ²). Level of absolute vitality got from inexhaustible sources, as a portion of the city's aggregate. Vitality utilization.	All out electrical vitality utilize per capita (kWh/year). Normal number of electrical interferences per client every year. Normal length of electrical interferences (in hours).
Environment	Fine Particulate Matter (PM2.5) fixation. Particulate Matter (PM10) fixation. Ozone harming substance emanations estimated in tons per capita.	NO ₂ (nitrogen dioxide) fixation. SO ₂ (sulfur dioxide) fixation. O ₃ (ozone) fixation. Clamor contamination. Rate change in number of local species.
Finance	Obligation administration proportion (obligation administration consumption as a level of a region's own-source income)	Capital spending as a level of all out consumptions. Claim source income as a level of complete incomes. Expense gathered as level of assessment charged.
Fire and emergency response	Number of firemen per 100 000 populace. Number of flame related passings per 100 000 populace. Number of catastrophic event related passings related passings.	Number of volunteer and low maintenance firemen per 100 000 populace. Reaction time for crisis reaction administrations from beginning. Call. Reaction time for local group of fire-fighters from starting call.

TABLE 2. (CONT) Identified impact profile indicators [8]

Metric	Core indicator	Supporting indicator
Governance	Voter investment in last city race (as a level of qualified voters). Ladies as a level of all out chosen to city-level office.	Level of ladies utilized in the regional government workforce. Number of feelings for debasement as well as pay off by city authorities per 100 000 populace. Natives' portrayal: number of nearby authorities chose for office per 100 000 populace. Number of enrolled voters as a level of the casting a ballot age populace.
Health	Normal future. Number of in-persistent clinic beds per 100 000 populace. Number of doctors per 100 000 populace. Under age five mortality for each 1000 live births.	Number of nursing and birthing assistance work force per 100 000 populace. Number of psychological well-being professionals per 100 000 populace. Suicide rate per 100 000 populace.
Safety	Number of police officers per 100 000 population Number of homicides per 100 000 population	Crimes against property per 100 000 Response time for police department from initial call Violent crime rate per 100 000 population
Telecommunication and innovation	Number of web associations per 100 000 populace. Number of PDA associations per 100 000 populace.	Number of landline telephone associations per 100 000 populace.
Solid waste	Level of city populace with normal strong waste gathering (private). Complete gathered metropolitan strong waste per capita. Level of the city's strong waste that is reused.	Level of the city's strong waste that is discarded in a clean landfill. Level of the city's strong waste that is discarded in an incinerator. Level of the city's strong waste that is scorched straightforwardly. Level of the city's strong waste that is discarded in an open dump. Level of the city's strong waste that is discarded by different methods. Risky waste age per capita. Level of city's risky waste that is reused

TABLE 2. (CONT) Identified impact profile indicators [8]

Metric	Core indicator	Supporting indicator
Transportation	Kilometres of high capacity public transport system per 100 000 population Kilometres of light passenger public transport system per 100 000 population Annual number of public transport trips per capita Number of personal automobiles per capita	Percentage of commuters using a travel mode other than a personal vehicle Number of two-wheel motorized vehicles per capita Kilometres of bicycle paths and lanes per 100 000 population Transportation fatalities per 100 000 population Commercial air connectivity (number of non-stop commercial air destinations)
Wastewater	Percentage of city population served by wastewater collection Percentage of the city's wastewater that has received no treatment Percentage of the city's wastewater receiving primary treatment Percentage of the city's wastewater receiving secondary treatment Percentage of the city's wastewater receiving tertiary treatment	N/A
Water and sanitation	Percentage of city population with potable water supply service Percentage of city population with sustainable access to an improved water source Percentage of population with access to improved sanitation	Total water consumption per capita (litres/day) Average annual hours of water service interruptions per household Percentage of water loss (unaccounted for water) Total domestic water consumption per capita (litres/day)

The second part of the evaluation identified which of the services on the Maru A Jozi platform could impact the core indicators for sustainable development of communities. Enablers that were or should be in place to influence the core indicators were also considered. The results are listed in Table 3.

Considering that the work and business opportunities service was by far the most visited, it is deduced that employment (and therefore the economy) is the most *important* indicator for the trainees. Indicators linked to the economy metric is education, energy, finances, health, telecommunication and innovation, and transportation. These linked metrics can all be linked to a service on the Maru A Jozi platform. The Information and call services, which were the second and third most frequented service, also supports the Economy metric as a linked indicator.

TABLE 3 Services and digital enablers

Metric	Service on Maru A Jozi Platform	Active Online Citizen and Digitalization Enabler
Economy	Work and business opportunities	Online economy activated Entrepreneurial activity - job creation in digital space Tech start-ups in digital space Vocational training & Academies
Education	Education	Massive open online courses and varsity (MOOC/V) Adult education Exam rewrites
Energy	City services/ My account	Smart energy grids Smart metering
Environment	City services/ Report a problem	Smart sensors
Finance	Banking services	Access to online tax submissions (eFiling) Tax on cash transactions Online banking Cashless transactions
Fire and emergency response	Emergency services	Online emergency services Geolocation to assist emergency services
Governance	City services education / My Government	Online voter registration Voter education and advocacy
Health	Education / Hello doctor	Online help lines Online emergency services Geolocation to assist emergency services
Safety	Emergency services	Online help lines Online emergency services Geolocation to assist emergency services
Solid waste	City services/ Report a problem	Report illegal dumping online Online smart logistics for waste management - activated recycling, circular economy
Telecommunication and innovation	Call / Message service	Increase internet connections via free Wi-Fi Internet calls
Transportation	Transport service	Online access to public and private transport systems
Wastewater	City services/ Report a problem	Smart meters
Water and sanitation	City services/ Report a problem	Smart meters
Recreation	Information	Information made available online

VI. SUSTAINABLE SMART CITY DEVELOPMENT

Wicked problems, as defined by Rittel and Webber in the early 1970's [16] are still around today. Wicked issues have no authoritative detailing as they are hard if not difficult to explain with no glorified end state to touch base at. Ways to deal with insidious issues should join sensible techniques to improve a circumstance as opposed to unravel it. Insidious issues never have a solitary, effectively recognizable reason and are one of a

kind, and interlinked. Typically, the problems faced by smart cities could be described as wicked problems. Based on these characteristics, not all hard-to-solve problems are wicked, but by definition most social problems—such as inequality, poverty, unemployment, and political instability—are wicked [17]. As a developing nation, South Africa is well-positioned to become a leader in developing technology, systems and policy that can impact on these wicked problems. To understand this potential, social advancement and business must be upheld through innovation improvement, specialized instruction and commercialisation activities. Based on the profile indicators evaluated, indicators relating to unemployment, education, energy, finances, health, telecommunication and innovation, and transportation have shown to be elements that could help to address wicked problems in smart cities. The following section will highlight specific indicators that are supported by services available and mostly accessed on the on the Maru-A-Jozi platform.

(A) *Employment and opportunities*

Center markers on the economy metric identifies with the city's joblessness rate; the surveyed estimation of business and modern properties as a level of absolute evaluated estimation everything being equal; and the level of the city's populace living in neediness. Supporting markers incorporate the level of people in fulltime work, youth joblessness rate, number of organizations per 100 000 populace, and the quantity of new licenses per 100 000 populace for every year. The primary driver of joblessness – thinking about auxiliary, genuine compensation joblessness and request lacking joblessness - are considered and assessed in connection to the administrations that are/ought to be accessible on the Maru–A-Jozi stage.

Basic joblessness happens because of a bungle of abilities in the work advertise and are ascribed to word related and land stability, or innovative and auxiliary change in the economy. Genuine compensation joblessness happens when wages in a focused work market are pushed over the harmony. Request insufficient joblessness happens when the economy is beneath full limit, with a decrease in yield, firm utilize less laborers bringing about joblessness rate rising quickly during a retreat [18].

The jobless or underemployed are less ready to contribute adequately to national advancement and have less chances to practice their rights as residents. They have less to spend as shoppers, less to contribute as savers and frequently have no "voice" to achieve change in their lives and networks [19]. The ongoing monetary downturn denoted the biggest stun to the world economy in the post-war period and in the same manner as nations over the globe, South Africa did not get away from the effect of the emergency. The joblessness rate is likely the best-realized work market measure and unquestionably one of the most broadly cited by media in numerous nations as it is accepted to mirror the absence of work at national levels to the best and most important degree. Fig 2 puts the current South African crisis in perspective with the estimated unemployment rate of 5 times worse than that of the USA [19].

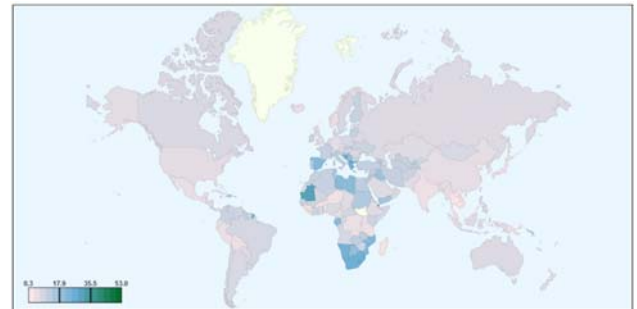


Fig 2. Global unemployment (estimates and projections for 2016, RSA 25.5% compared to USA at 4.9%) [19]

According to Statistics South Africa [20], youth between 15–34 years old record for a bigger offer (55,0%) of the working-age populace than grown-ups (45,0%) and their work showcase circumstance is commonly more regrettable than grown-ups. Because of the retreat, the joblessness rate among youth ascended from 32,7% in 2008 to 36,1% in 2011 and has stayed between 35,0–37% consistently since. The joblessness rate likewise expanded among grown-ups, however by a littler edge. These statistics supports the importance of the work and business opportunities service on the Maru-A-Jozi platform and the data indicate the residents would consider using the platform for this purpose. Connecting more people to opportunities will have a marked impact on the economic indicators which could impact on the identified linked profile indicators. There exist a three-route connection between joblessness, neediness, and social avoidance. Joblessness may prompt neediness, yet it doesn't really do as such. Regardless of whether work advances incorporation relies upon the nature of the business. People are excluded not just because they are currently without employment or income but because they have little prospects for the future, which speaks to social mobility. Access to information, education and opportunity can change the dynamics of this relationship.

(B) *Information and education*

Settled in basic shortcomings in the work advertise because of the confound among aptitudes and accessible occupations are reflected in the high frequency of long haul joblessness among both youth and grown-ups in South Africa which was pervasive in the outcome of the retreat. This likewise features the difficulties in discovering work. The training level of the utilized affects the kinds of employments they can get. The same number of as 55,0% of youngsters who are effectively searching for work have training levels underneath optional level while an extra 36,4% just have a matric capability (auxiliary level capability). Moderately few utilized youth (21,2%) has tertiary training capabilities [20]. These statistics are also mirrored amongst unemployed adults. Even among the people who are fortunate enough to have employment, the level of education for many poses a serious constraint to their position and career prospects on the occupational ladder.



Fig 3. Unemployment by level of educational attainment (estimates and projections for 2014). Unemployment rate of persons with secondary level education (RSA 26.3% compared to USA 7.1%)[19]

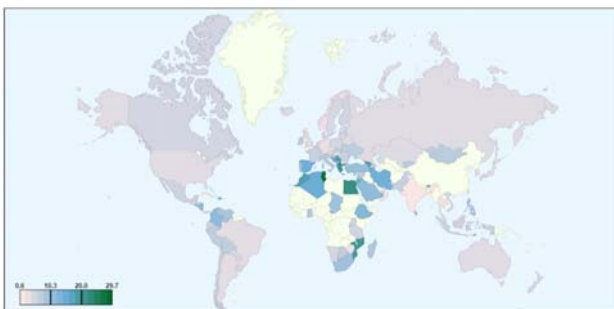


Fig 4. Unemployment by level of educational attainment (estimates and projections for 2014). Unemployment rate of persons with tertiary level education (RSA 9.9% compared to USA 3.4%)[19]

Core indicators highlighted for the education metrics include percentage of female school-aged population enrolled in school; the percentage of students completing primary and secondary education and the primary education student/teacher ratio. Supporting indicators are the percentage of male school-aged population enrolled in school; the percentage of school-aged population enrolled in school; and the number of higher education degrees per 100 000 population. The educational platform and massively online open courses or varsity (MOOC/V) would create opportunities to move into a higher educational level and be better positioned to move up on the occupational ladder. Access to opportunities for completing secondary level education and additional vocational training would have an impact on the lives of this segment of the population. This platform also provide vulnerable communities opportunities to up-skill or re-skill, repositioning themselves for the job market. The value of entrepreneurial training has also been establish, this platform would not only benefit vulnerable communities but could also open up new opportunities of skills development in all communities, specifically through adult education and enabling life-long learning opportunities for the residents of the City of Johannesburg.

But, it is also understood that access is not the only hurdle for these unemployed youths to overcome. Some of the wicked problems that they are faced with are that the online environment would have to be supported by a network of facilitators and

mentors. Access to education remains a major aspect of unemployment, especially for unemployed youths, which would be impacted through open, online courses as made available on the Maru-A-Jozi platform.

(C) Innovation and information and communication technology

Expanded effectiveness and better reaction to occupants needs is conceivable just with the utilization of cutting edge ICT. Inferable from advances in ICT, it is presently progressively conceivable to utilize the online administrations at home or notwithstanding when voyaging. ICT likewise empowers natives to take an interest in basic leadership substantially more than at any other time. While apparatuses now exist to empower data to be gotten, it is significantly more hard for the specialists to keep their work away from plain view. Residents can collaborate with the authorities and the chosen delegates like never before previously [7, 15]. Opportunities and challenges brought on by social media, openness and self-organizing brings about opportunity for collaboration and communication between citizens and public organizations creating an inclusive, participative environment. By crossing over the advanced separation, the improvement of ICT has implied a colossal increment in the intensity of natives. ICT is the empowering agent that, when appropriately utilized for systems administration and combination, gives social, natural and monetary advantages for all [7]. Free access to the most basic ICT services unlocks a myriad of opportunities in the most vulnerable of communities, combating exclusion of the poor.

The center marker for the telecommunication and development metric which is legitimately affected identifies with the quantity of web associations per 100 000 populace and the quantity of mobile phone associations per 100 000 populace. Free Wi-Fi and free internet call services will directly impact on this indicator. It is also clear from the data collected on the Maru A Jozi platform that residents would use this service if made available.

CONCLUSIONS

Brilliant urban communities can be viewed as frameworks with streams of vitality, materials, administrations, individuals and financing. A systems engineering approach for developing a smart city is considered. As part of an initial assessment of existing programmes of the city, the value of commercially free and freely available online services were evaluated. This research assessed the impact of rolling out free Wi-Fi networks and online services in Johannesburg, South Africa as it relates to the sustainable development of vulnerable communities and compares to the standard for sustainable development of communities (BS ISO 37120:2014). The research considered how free online services impacted on the capacity needs of vulnerable communities if they are considered as the user or customer while applying a systems engineering approach towards sustainable development in a smart city environment.

Observing the online behaviour of early adopters in the African context, three services stood out in relation to the Economy metrics

- A. *Work and business opportunities* stood out as the service which residents were most interested in and is aligned with high unemployment rates in South Africa. Unemployment is a core indicator which will be impacted as the economy grows as a result of this intervention.
- B. *Education*. In an online environment, reskilling and upskilling of the unemployed and underemployed is made possible through massive open online courses which could address the mismatch between skills and available jobs.
- C. *Call/Message*.

It is critical to note that these services would not be as accessible, nor would it be as effective if it was not for advanced ICT and infrastructure development in the City. Furthermore, training and mentorship was identified as a key enabler of vulnerable communities and the early adoption of the free online services in the city.

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