The Internet of Things for Sustainable Smart Cities in the Sub Saharan Region

Abstract

The aim of the research is to explore on the problems which are predominant in urban development settlements in developing countries and how internet of things can be exploited in addressing some of the challenges which are prevalent in developing countries to achieve sustainable smart cities.

Introduction

According to the United Nations, an estimate of 70% of the total world population is expected to be living in urban setups by 2050 (fig 1) [1].

The rapid urbanisation is posing challenges on the city infrastructure that is the, transport network, water and sewer reticulation, waste management, energy demand, housing and education, health and recreation [2]. The cities consume about 80 % of global energy demand and contribute more to harmful greenhouse emissions (75%) [2]. The development of Information Communication Technology has enabled governments around the world to come up with models for sustainable smart city development [3].

Fig 1 [4]: Source Smart Sustainable Cities – Reconnaissance Study.
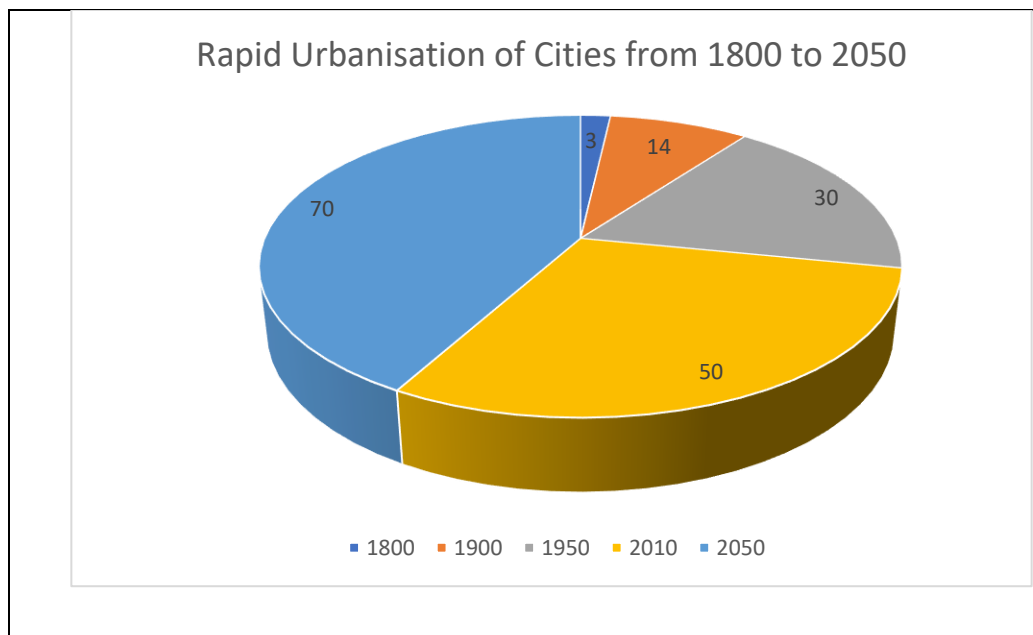International Development Research Centre (IDRC), http://www.idrc.ca

Rapid Urbanisation of Cities from 1800 to 2050

Fig 2 [1]: Urban Population Growth by Region

Region	% Population in 2014	% Population in 2050
Africa	40	56
Asia	48	64
Europe	73	82
Latin America	80	86
North America	81	87

Urban Challenges in Sub-Saharan Africa

Urbanisation in developing countries is growing at a fast pace as shown in table 1 above. However, most cities in the sub-Saharan region are characterised by complex challenges, development of slum settlements, inadequate clean water and energy, pollution and downgrading of the environment, poor sanitation, lack of healthcare and education and high unemployment [5].
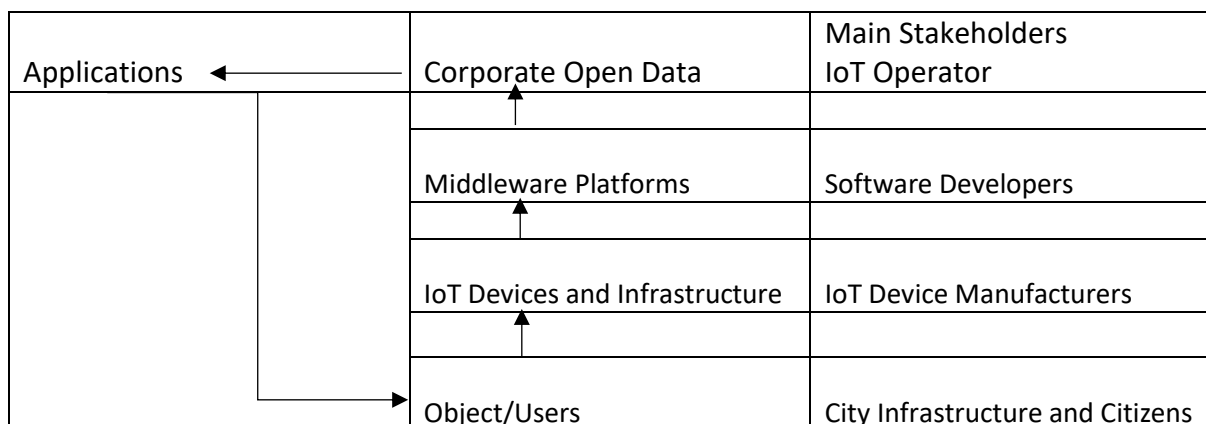
Sustainable Smart City

Sustainable Smart City, can be defined as a community which meets the needs of the inhabitants without depleting the resources for the next generations and is extensively supported by Information Communication Technology [6, 5]. Development of the Sustainable Smart Cities should strive to balance the three aspects, that is, social, economic and environmental [7].

Internet of Things (IoT)

Interconnection of sensors and actuators embed on physical objects such that information can be shared across platforms [8]. The IoT has three main components, that is the, hardware, middleware (storage and data analysis) and presentations (visualisation and interpretation tools) [8]. Cities around the globe are developing smart sustainable cities basing on IoT.

Fig 3: IoT Ecosystem [8]

Applications	Corporate Open Data	Main Stakeholders IoT Operator
	Middleware Platforms	Software Developers
	IoT Devices and Infrastructure	IoT Device Manufacturers
	Object/Users	City Infrastructure and Citizens

Application of IoT in addressing Urbanisation Challenges

Energy Management

Acute shortages of energy in urban areas is one of the biggest threats in the Sub-Saharan Region due to inadequate generation coupled with ill-conditioned transmission and distribution networks, and this has left some major cities such Harare the Capital city of Zimbabwe experiencing an average of sixteen hours of power cuts [9]. IoT demand-side management can be used to monitor power consumption. Sensors are embedded at the point of consumption, for example, commercial buildings, public institutions etc [10] [11]. Consolidation of data from different sites is done for the customers to have a real-time view of what they are consuming and as a result, try to find methods to reduce consumption [12]. Monitoring of the distribution networks can be implemented by applying IoT. Voltage and Load profile data is collected from sensors connected to the network system. The data is transmitted for further analysis and as result operators will make informed decisions and improved response to maintenance and attending faults [12].

Traffic Management and Control

Traffic congestion and poor flow is a concern in Sub-Saharan cities mainly due to poor walking and cycling infrastructure coupled with ineffective use of public transport system. In many sub-Saharan cities mini-buses and small imported vehicles are the major modes of public transport and the number of people ferried per trip is less compared to busses or trains [13]. Inadequate maintenance on the existing traffic control lights and most of them do not work contributing to poor road discipline hence traffic congestion [13]. IoT can be incorporated to tackle the challenges by the installation of sensors on traffic lights, road intersections and public transport. Analysis of the collected data can be of paramount importance to city planners to maintain traffic lights. In addition to this, the city authority will be able to make informed medium to long term plans such as modification of public transport routes, the addition of traffic signals and better budget allocation for road infrastructural development [14]. Application-based technology may also be developed for real-time navigation alerts to motorists on empty parking lots and best routes [14].

Air pollution

Sub-Saharan Region is highly prone to the effects of climate change as it is frequently experiencing droughts and flood. Until recently, the region had the lowest contribution to greenhouse gas emissions. However, the discharges are growing exponentially due to the use of fossil fuel and exhaust fumes from inefficient vehicles [13] . Sensors to monitor air quality can be installed strategically at multiple points. The collected data will be used to identify the major causes and used as a basis for coming up with solutions [14].
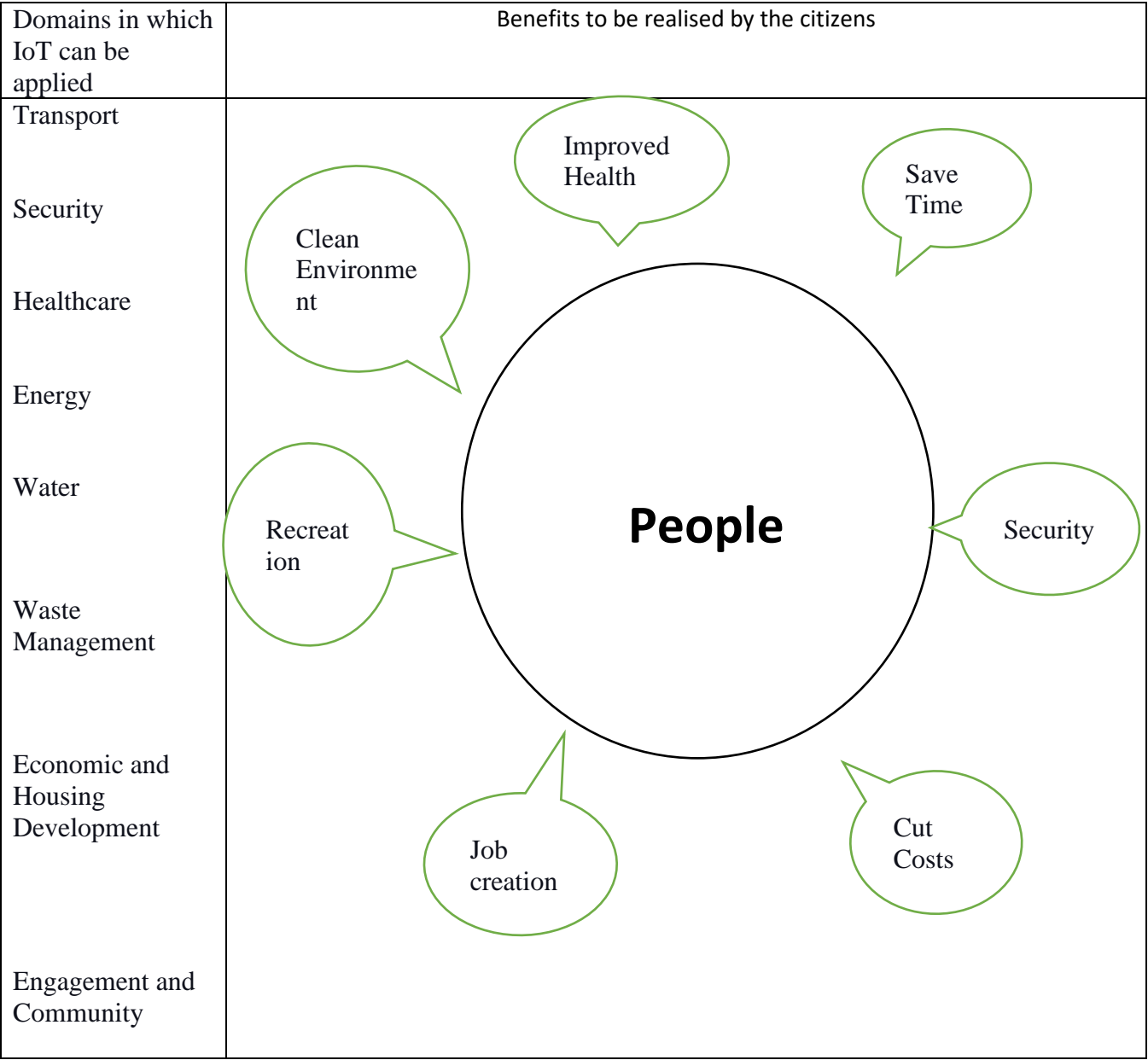
Waste Management

In Sub-Saharan cities, waste management is a threat to the health system and environment. Most suburbs are characterised by overflowing bins and dumpsters. The waste is collected on a routine basis, which is not effective since waste generation varies with location and time of the year [15]. Sensors can be installed to the dumpsters to monitor the level sending the data to waste collectors. Optimisation of route for waste collection would be made feasible by analysing the data collected from the sensors. Further analysis of the data can be done to waste generation patterns to improve collections and recycling efficiency [15].

Conclusion

Given that the rate of urbanisation is higher in Sub-Saharan countries, governments must have a compressive plan for the development of sustainable smart cities [5]. Although adoption of what is being done to achieve the goal can be done, it would be ideal for African countries to do more research such that models and frameworks best suited to African context are employed [5]. For the Iniative to be successful, it calls for active participation from all sectors, governments and city councils should come up with policies that support the initiative. In as much as the Internet of Things plays an important role in achieving sustainable smart cities, it requires integration with other technologies such as 5G, Big Data, Cloud computing, Artificial Intelligence and embedded systems, therefore educational institutions should train highly skilled personnel. Application of IoT in Sustainable Smart development will go a long way in improving the lives of citizens by creation of employment, business opportunities and building resilient societies and communities. Fig 4 summaries the domain in which IoT can be applied and the benefits to be realised.

Domains in which IoT can be applied	Benefits to be realised by the citizens
Transport Security Healthcare Energy Water Waste Management Economic and Housing Development Engagement and Community	

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