

# Smart Clean City – Kuwait

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**Abstract - Waste scheduled generation has been increasing tremendously over few years worldwide and in GCC countries in specific owing to many factors; such as growth in economy, changing lifestyle, modern life approach and many more. Sustained illegal dumping by waste generators is being practiced at a large scale due to lack of proper direction and awareness. This paper reviewed and discussed about service and provided for scheduled waste management a scenario of scheduled waste management in developing smart clean cities by an authority and international. An expert system was developed to integrate scheduled waste management in Kuwait smart cities associated with IoT technology. The knowledge base was acquired through different resources including journals, books, magazines, annual report, and websites. The overall development of this project has been carried out in several phases: problem identification; problem statement and literature review; identification of domain experts; prototype development; knowledge acquisition; and knowledge representation. Scheduled waste expert system (SWES) is developed based on five types of scheduled waste management. These are label requirements, packaging requirements, impact of scheduled wastes, recycling of scheduled wastes, and recommendations. Besides, it contains several sub modules by which the user can obtain a comprehensive background of the domain. The output is to support effective integrated and smart scheduled waste management.**

**Keywords:** Smart cities; Scheduled wastes; ES; IoT; QoL; MSWM.

## I. INTRODUCTION

Middle East and the Gulf area are witnessing tremendous economic activities in development towards new era of smart cities. Recently, Kuwait Government announced the "New Kuwait 2035" to boost the economy and reduce the counties dependency on oil revenue. One of the plans is to develop many smart cities connected with the latest network technologies. Saad Al-Abdullah city will be the first smart and environment-friendly city in Kuwait in line with international standards and will spread over 59 square kilometers to accommodate 400,000 people [1]. The environment-friendly smart city based on the city's dependence on modern technology through connecting its services and roads by an

internet network. Information and communication technologies, ITCs, make cities more effective and efficient in urban population areas such as "Saad Al-Abdullah smart city". Smart cities will play important role in future in many fields such as physical, social and economic roles [2]. It's about smart infrastructure that will help develop smart clean cities.

This research project aims to fulfill the main ideas in implementing a smart clean city focusing on smart scheduled waste management system using expert systems as the government vision is planning to build nine new cities other than South Saad Al-Abdulla in 2019 that will serve as the nation's template. This is clear from the growing active population in the Middle East and the gulf region transferring major cities into secure and digitalized sustainable cities [3] [4]. Several Gulf Cooperation Council (GCC) cities in Arab countries experienced a rapid urban growth [5], and even moved towards "smartest" cities like the case of "Smart Dubai" initiative [6]. Other than being smart, urbanization processes play major role in improving people's standard of living in important sectors in modern cities such as education, transportations, health services, residential and business buildings, sewerage systems and solid wastes [7]. The new urbanization in the GCC major cities creates new challenges and issues in municipal solid waste and its management. Scheduled waste management issue is the main confront to the authorities of both small and large cities. This is mostly due to the increasing generation of such scheduled waste and the load created on the municipal budget. In addition to the increasing costs, the scheduled waste management is associated by not having of understanding over different issues that involve the whole conduct system. An analysis of literature and reports related to the scheduled waste management in developing countries showed that a small number of articles complete quantitative information [8-10]. The objective of the mentioned studies was to determine the stakeholders' action/behavior that have a role in the scheduled waste management and to analyze different factors that affect the system. A combination of variable methods that were used in this study was mentioned in details in order to encourage the stakeholders and to assess the factors influencing the performance of the solid waste management in Kuwait as smart and clean cities. Increase in population, fast urbanization, active economy, and the increase in the standard of living in developing countries have really speed up the rate,

quantity and quality of the municipal solid waste generation [11].

## II. SOLID WASTE MANAGEMENT REVIEW

Solid waste generation rates related to both population and prosperity, but data are lacking or questioning for many countries. Health and safety issues also arise from improper Municipal Solid Waste Management. Municipal solid waste landfills are the third-largest source of human-related methane emissions in the United States, accounting for approximately 16 percent of these emissions in 2016. Hazardous wastes are either specifically listed as hazardous by Environmental Protection Agency, EPA, or a state, or exhibit one or more of the following characteristics: ignitability, corrosivity, reactivity, or toxicity. [12]

Scheduled waste management has different meanings and classifications according to the country. For example, most of this waste is classified under hazardous waste (HW) because of their physical characteristics that suits HW. In United Nations Environment Programme (UNEP) hazardous wastes are defined as: “wastes other than radioactive wastes which, by reason of their chemical reactivity or toxic, explosive, corrosive or other characteristics causing danger or likely to cause danger to health or the environment, whether alone or coming into contact with other wastes, are legally defined hazardous in the state in which they are generated or in which they are disposed of or through which they are transported” [13]. In Germany, hazardous waste definition is: “wastes from commercial or trade companies which, due to their nature, composition or quantities, are especially hazardous to human health, air or water, or are explosive, flammable or may cause diseases” [14]. From the above definitions, it shows that scheduled waste management is part of the HW. HW can be classified on the basis of their hazardous nature which includes toxicity, flammability, explosively, corrosively and biological infectivity as given in Table 1 below:

**TABLE I**  
**Classifications of Hazardous Waste**

Category	Source
Toxic chemicals	Chemical industry, heavy industries, coal-based thermal power plants, pharmaceuticals, pesticides, plastics and polymers.
Flammable	Oil sludge, solvents, plasticizers, and light metal discards
Explosives	Ordinance factories, oil tankers, safety match, and pyrotechnics
Corrosives	Acid slurries
Infective/ biological	Hospital wastes, wastes from vaccine and serum institutes, fermentation industries and biotechnology

Source: Moustafa A. Chaaban, [13]

This requires serious attention when building new cities especially in industrial and developing countries. According to Chinese law, solid waste is classified into three types: industrial solid waste (ISW), municipal solid waste (MSW) and hazardous waste (HW). According to the environmental statistics for the whole country, the quantity of ISW generated in China was 945 million tons, of which 50.4% was reused as source material or energy; 16.7% was disposed of simply, 30.2% was stored temporarily, and 2.7% was discharged directly into the environment. The quantity of ISW generated in China has been increasing continually. Compared with 1989, the quantity of ISW generated in 2012 had increased by 66% [15]. The largest amount of municipal solid waste per person on a daily basis is generated in the United States [16]. Waste generation rates are related to affluence as well as population – richer societies are characterized by higher rates of waste generation per capita, while less affluent societies generate less waste and practice informal recycling/re-use initiatives that reduce the waste per capita to be collected at the municipal level [17].

Kuwait, which is considered one of the richest countries in the region, is among the highest per capita waste generators in the world. Each year more than 2 million tons of solid waste is generated in the tiny Arab nation. The average municipal solid waste generated and disposed at all active sites estimated to be around 0.9 million ton per year (for the period of 2002-2007). On the average, a sample household generated 7.1 kg of solid waste each day. Along with acute increase in resources consumption, the daily average municipal waste estimated to be around 1.4 Kg/person, which almost doubled during the last ten years [18]. EcoMENA reports shows that the total land area of Kuwait is around 17,820 sq. km, out of which more than 18 sq. km is occupied by landfills. The area of the landfill sites ranges from tens to hundreds of hectares with waste deposition depth varying from 3 to 30 meters [19]. EcoMENA is one of the most popular sustainable advocates in the Middle East, with wide following and high degree of credibility across the Arab world [20-21].

## III. EFFECTS OF WASTE DISPOSAL ON ENVIRONMENT AND HEALTH

Health and safety issues also arise from improper municipal solid waste management (MSWM). Mainly the workers in waste management field are considered of high risk and need protection. Waste from hospitals, industry and residential areas for the public are indirect and arise from the breeding of disease vectors, primarily flies and rats [22]. The effect of wastes are damaging the environment due to lead-acid batteries, waste oil and electronic waste without environmental protection facilities and waste water, waste gas

and solid waste that were discharged directly. Besides, chromium residues which had been dumped on open land can pollute the groundwater while the inappropriate treatment of electronic waste has created serious air and water pollution problems [23]. In addition, inadequate collection and disposal of solid waste is a major factor in the spread of disease and environmental degradation. The wastes are exposed to rain, sun, and winds, which results in littering and the creation of unhygienic conditions as the leachate and odour come out from waste which is a risk to public health [24]. Ming-Lang Tseng [25] reviewed that municipal solid waste management has an impact on air, soil, and water pollution. Indiscriminate dumping of wastes contaminates surface and ground water supplies. In urban areas, solid waste clogs drains, creating stagnant water for insect breeding and floods during rainy seasons. Uncontrolled burning of wastes and improper incineration contributes to urban air pollution. Greenhouse gases are generated from the decomposition of organic wastes in dumpsites and untreated leachate pollutes surrounding soil and water bodies. According to Hiroaki Ozaki et. al, failing to manage hazardous wastes leads to groundwater pollution, resulting in a health hazard to the public who use the groundwater as the source of their domestic water supply and for irrigation [26]. R. R. A. M. Mato and M. E. Kaseva reported that the health impacts of direct and indirect exposure to hazardous wastes include carcinogenic effects, reproductive system damage, respiratory effects, central nervous system effects, and many others [27].

#### IV. SMART CITIES SERVICES AND SCHEDULED WASTE MANAGEMENT

After the successful experience in industrial and developed countries, many developing countries started building new cities and moved towards smart and digital ones. More than half of the world's population nowadays is living in cities and the world is still changing into an "urban world" [28]. The rise of "cities of bits" [29], "e-cities" [30] or "cyborg-selves in the networked city" [31] ranges from small to mega cities and expediting their "smart city" development.

Information and Communication Technology (ICT) revolution dramatically solved many urbanization issues in building smart cities that became more digital and information-based. Urban information is increasingly expanded through integrated and inter-related large data sets. Big data (BD) are actually collected from wireless networks such as Wi-Fi networks that cover most of the cities services emerging the frameworks of Internet of Things (IoT). IoT allows objects to be sensed and controlled remotely across existing network infrastructure, creating opportunities for more-direct integration between the physical world and

computer-based systems [32-34] that make smart cities efficient and responsive.

The main vision of this research paper is mainly focusing on Smart Cities Services in Scheduled Waste Management proposed to "new Kuwait 2035" in implementing Kuwait Saad Al-Abdullah smart city. The basic aim is to improve standard of living in the ongoing development of Saad Al-Abdullah smart city. The vision can be achieved by using an assortment of sensors, microcontrollers, central database and connections of Internet of Things associated in an expert system [35]. The enhancement of mobility within the smart city; the advanced connectivity between citizens; and applications and infrastructures are promoted as key priorities in the developing the proposed smart expert system. [36-37]

#### V. OVERVIEW OF THE PROPOSED EXPERT SYSTEM

Expert systems have offered explanation to diverse issues ranging from strategic planning of marketing [38] to consulting in process reengineering [39]. There are great tools for the making of expert systems. In this article, a framework for the development of expert systems based on a knowledge representation model that is easy to understand for people without specific training in has been proposed. A sequence of steps is introduced for the selection of treatment processes for a given waste stream, listing a variety of ways to approach the problem of selecting the appropriate process.

- ❖ Nature of the waste
- ❖ Objective of treatment
- ❖ Technical adequacy of treatment alternatives
- ❖ Economic consideration
- ❖ Environmental considerations
- ❖ Energy considerations
- ❖ Overall evaluation

##### a) Visual Basic Expert System

By analyzing the past and present experience of scheduled waste management system in the worldwide and also in the Arab Gulf area, Visual Basic Expert System (VBES) is used for integrating the scheduled waste management system. This expert system is used for the better management of scheduled waste composting at local authorities.

##### b) Expert System Development

It is necessary to define several entities in the integration of scheduled waste management system development smart city Saad Al-Abdullah.

- ❖ Types of waste generated

- ❖ Impact of poor waste management
- ❖ Transportation used to transfer the waste
- ❖ Types of waste management
- ❖ Recommendation

The conceptual structure of the relational database model on “scheduled waste management system” is graphically summarized in Figure 1. The model is designed in such a way that a series of general and specific questions can be answered by a proposed conceptual structure of the relational database:

- ❖ What are the types of waste generated?
- ❖ What are the observable effects of poor waste management?
- ❖ What are the transportations used in waste management?
- ❖ How can waste be managed?
- ❖ What are the actions taken to improve waste management?

## VI. THE SCHEDULED WASTE EXPERT SYSTEM RESULTS

The scheduled waste expert system is able to know the scheduled waste management. When starting-up the system, the main menu of the scheduled waste expert system consists of the following sub modules: expert system part; help; about us; contact us; and exit button. All Graphic User Interface

(GUI) is in the English language. The user then can request information or get help about the program by clicking the Help button. The About Us screen is illustrated to show to the user the developers of this program while Contact Us screen is illustrated to show to the user the contact number of this program developer. As for exit button, this button prompts exit SWES. Finally, the user can click at any button of the sub modules and the expert system to know the information about scheduled waste management.

From the result obtained, the project can be considered as successful as the integrated program for scheduled waste management system had been developed. Scheduled waste expert system is developed based on five types of scheduled waste management which are label requirements, packaging requirements, impact of scheduled wastes, recycling of scheduled wastes, and recommendations. The knowledge base of this system is based on ruled-base expert system which is IF THEN rule and the acquisition knowledge that is gathered for this study is organized into this rules. The development of scheduled waste expert system consists of six main forms or interfaces which are photo gallery, scheduled waste management, literature, legislations, training tool, and scheduled waste expert system itself. It has been incorporated with several user interfaces in order to make the system user friendly as much as possible.

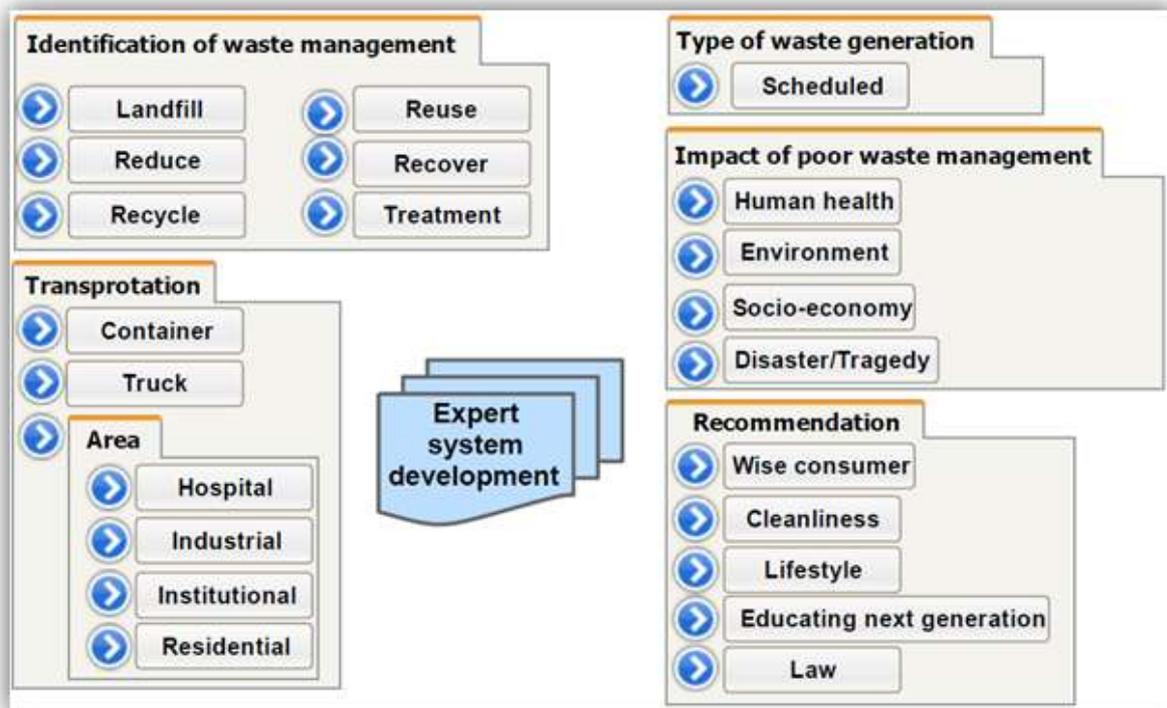


Figure 1: Five Different Entities of SWES Development

The developed SWES will help the decision makers of local authorities to capture all aspects of integrated scheduled waste management system such as recycling of scheduled waste, rules and regulations, and many more. As the SWES converses in the English language the man-machine link will not be a problem and perhaps receive much better attention. In addition to providing information, the SWES has many decision support models so that a user can identify problem faster, examine various alternatives and make a choice.

## VII. CONCLUSION

Scheduled waste is one of the important tests to the environment. The poor waste management cause variation the ecosystems including air, water, and soil pollution, thus it represents a real hostile to human health. Developing smart systems associated with the developing smart cities involving the technology of connecting IoT in a wireless networks as a service is in fact the best practice. The system performs all the functions of a decision support system. SWES can also be used as a stand-alone learning tool in environmental studies and by others. Thus a system of much versatility has been developed. This is use of tools of information technology to help in solve local problems in managing scheduled waste in an informative manner.

System maintenance is required since scheduled waste expert system contains vast information that can evolve rapidly over time and the existences of certain changes are required according to the time. As such, the database has to be regularly updated. All the rules have been designed according to the modules to aid maintenance efforts; it allows rapid access to parts of interest and modification.

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## REFERENCES

- [1] News.kuwaittimes.net (2016), "South Saad Al-Abdullah, Kuwait's first smart city" [online] at <http://news.kuwaittimes.net/website/south-saad-al-abdullah-kuwait-first-smart-city-59-square-kilometers-accommodate-400000-people/> [Accessed 4th April 2019], published on 1/8/2016.
- [2] Abdulrahman Alkandari and Imad Alshaikhli, (2012). Designing a Smart City in Kuwait: an Initial Study. *Journal of Advanced Computer Science and Technology Research* Vol.2 No.3, September 2012, 116-126.

- [3] Miltiadis D. Lytras and Anna Visvizi, (2018). Who Uses Smart City Services and What to Make of It: Toward *Interdisciplinary Smart Cities Research*. *Sustainability* 2018, 10(6), 1998; <https://doi.org/10.3390/su10061998>.
- [4] Yusuf A. Aina (2017). Achieving smart sustainable cities with GeoICT support: *The Saudi evolving smart cities*. *Cities* 71 (2017) 49–58. 0264-2751/ © 2017 Elsevier Ltd. <http://dx.doi.org/10.1016/j.cities.2017.07.007>
- [5] Raffaello Furlan, Laura Faggion (2017). Urban regeneration of GCC cities: preserving the urban fabric's cultural heritage and social complexity. *J His Arch & Anthropol Sci*. 2017; 1(1):14–18
- [6] Salem, F. (2016). A Smart City for Public Value: Digital Transformation through Agile Governance – The Case of "Smart Dubai". *Dubai: Governance and Innovation Program, Mohammed Bin Rashid School of Government, World Government Summit*.
- [7] Davis K. The urbanization of the human population. In: Menard S W, Moen E W, eds. *Perspectives on Population: an Introduction to Concepts and Issues*. *New York: Oxford University Press*, 1987. 322–330
- [8] Omran, Abdelnaser & Gavrilesco, Maria. (2008). Municipal solid waste management in developing countries: A perspective on Vietnam. *Environmental Engineering and Management Journal*. 7. 469-478. 10.30638/eemj.2008.070.
- [9] Dhokhikah, Yeny & Trihadiningrum, Yulinah. (2012). Solid waste management in Asian developing countries: Challenges and opportunities. *J. Appl. Environ. Biol. Sci.* 2. 329-335.
- [10] Ferronato, N., & Torretta, V. (2019). Waste Mismanagement in Developing Countries: A Review of Global Issues. *International journal of environmental research and public health*, 16(6), 1060. doi:10.3390/ijerph16061060
- [11] Zhu Minghua, Fan Xiumin, Alberto Rovetta, He Qichang, Federico Vicentini, Liu Bingkai, Alessandro Giusti, Liu Yi, (2009). Municipal solid waste management in Pudong New Area, China. *Waste Management*, Volume 29, Issue 3, 2009, Pages 1227-1233, ISSN 0956-053X, <https://doi.org/10.1016/j.wasman.2008.07.016>.
- [12] U.S. Environmental Protection Agency. 2018. Inventory of U.S. greenhouse gas emissions and sinks: 1990-2016. EPA 430-R-18-003. See also: *Landfill Methane Outreach Program*.
- [13] Basel Convention (2019). Definitions of Hazardous Wastes. [online] at <http://www.basel.int/Home/tabid/2202/Default.aspx> [accessed 20th May 2019].

- [14] Moustafa A. Chaaban. (2001). Hazardous waste source reduction in materials and processing technologies. *Journal of Materials Processing Technology*. 119 (2001): p. 336-343.
- [15] A.Scheinberg, D.C. Wilson, L. Rodic, Solid Waste Management in the World's Cities. Water and Sanitation in the World Cities, *Earthscan Published for UNHabitat, London, UK, 2010*.
- [16] Organization for Economic Cooperation and Development (OECD). 2015. Municipal waste, Generation and Treatment: Municipal waste generated per capita. *OECD. Stat Extracts*.
- [17] Bogner, J., M. Abdelrafie Ahmed, C. Diaz, A. Faaij, Q. Gao, S. Hashimoto, K. Mareckova, R. Pipatti, T. Zhang, Waste Management, In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], *Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA*.
- [18] R. Al-Jarallah and E. Alesa (2013), "Investigating causes contributing to increased municipal solid waste in Kuwait: A national Survey". *Journal of Engg. Research*, Vol. 1(3), pp. 123-143.
- [19] Ecomena.org, (2018) "The Menace of Landfills in Kuwait By: Salman Zafar", [online] at <https://www.ecomena.org/> [Accessed 4th February 2019]
- [20] bioenergyconsult.com, (2018), "Solid Waste Management in Kuwait, By: Salman Zafar", [online] at <https://www.bioenergyconsult.com/solid-waste-management-in-kuwait/> [Accessed 4th November 2018]
- [21] Ecomena.org, (2018) "The Menace of Landfills in Kuwait By: Salman Zafar", [online] at <https://www.ecomena.org/> [Accessed 4th November 2018]
- [22] Pervez Alami and Kafeel Ahmade (2013). Impact of solid waste on Health and environment. *International Journal of Sustainable Development and Green Economics (IJS DGE)*, ISSN No.: 2315-4721, V-2, I-1, 2, 2013.
- [23] Qifei Huang, Qi Wang, Lu Dong, Beidou Xi & Binyan Zhou. (2006). the current situation of solid waste management in china. *J Mater Cycles Waste Manag*. 2006(8): p. 63-69.
- [24] Salha M. Kassim & Mansoor Ali. (2006). Solid waste collection by the private sector: Households' perspective-Findings from a study in Dares Salaam city, Tanzania. *Habitat International*. 30(2006): p. 769-780.
- [25] Ming-Lang Tseng. (2008). Application of ANP and DEMATEL to evaluate the decision-making of municipal solid waste management in Metro Manila. *Environ Monit Asses*.
- [26] Hiroaki Ozaki, Kusumakar Sharma, Chanetta Phanuwat, Kensuke Fukushi & Chongrak Polprasert. (2003). Management of hazardous waste in Thailand: present situation and future prospects. *J Mater Cycles Waste Manag*. 5 (2003): p. 31-38
- [27] R.R.A.M. Mato & M.E. Kaseva. (1999). Critical review of industrial and medical waste practices in Dar es Salaam City. *Resources, Conservation and Recycling*. 25(1999): p. 271-287.
- [28] K. Kourtit, P. Nijkamp, and T. de Noronha Vaz, "Cities in a shrinking globe", *International Journal of Global Environmental Issues*, 14(1/2), 2015, pp. 6-16.
- [29] W. J. Mitchell, City of Bits. Space, Place, and the Infobahn, *MIT Press, Cambridge, MA, 1995*.
- [30] W. J. Mitchell, e-topia. Urban Life, Jim—but not as We Know It, *MIT Press, Cambridge, MA, 1999*.
- [31] W. J. Mitchell, Me++. The Cyborg-self and the Networked City, *MIT Press, Cambridge, MA, 2003*.
- [32] Nikita P., Shrish N., Ankita P., Sharvari N., Samiksha K. (2016). Survey on - Smart City Development Using IOT. *IOSR Journal of Engineering (IOSRJEN) www.iosrjen.org* Volume 8, PP 16-19
- [33] Akshay K., Vineet O., Anita P., Kunal D. (2016). A Survey on Smart City using IoT (Internet of Things). *IJIRSET*, Vol. 5, Issue 2, February 2016.
- [34] M. Kotb, Amin Saleh, Khaled Muhammad (2019). Value Engineering Methodology for Low Income Housing Projects in Egypt. *International Research Journal of Innovations in Engineering and Technology (IRJIET)*. Volume 3, Issue 5, pp 22-30.
- [35] Nassereldeen A. K, Mohammed Saedi, Munif A. Jazzar and Nur Adibah Azman. (2011). Integrated scheduled waste management system in Kuala Lumpur using expert system. *African Journal of Biotechnology* Vol. 10(81), pp. 18781-18787, 16 December, 2011. Available online at <http://www.academicjournals.org/AJB> DOI: 10.5897/AJB11.2752
- [36] Andrea Zanella, Lorenzo Vangelista (2014). Internet of Things for Smart Cities. *IEEE Internet of Things Journal*, Vol. 1, NO. 1, February 2014.
- [37] Zhu Minghua et al. (2009). Municipal solid waste management in Pudong New Area, China. © Elsevier, *Waste Management* 29 (2009) 1227–1233.

- [38] Li, S. (2005). A web-enabled hybrid approach to strategic marketing planning: Group delphi+a web-based expert system. *Expert Systems with Applications*, 29, 393–400.
- [39] Hvam, L., Malis, M., Hansen, B., & Riis, J. (2004). Reengineering of the quotation process: Application of knowledge based systems. *Business Process Management Journal*, 10(2), 200–213.

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