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A Sustainable Development Neural Network Model for Big Data in Smart Cities

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Abstract

The study aims to prepare a neural network model considering predictor variables such as big data in urban planning, effective governance, resource management, and knowledge based economy for sustainable development in smart cities. A sample of 212 survey responses was collected randomly from Oman and analysed in a neural network model. The predictors' contributing to sustainable development in smart cities are big data in knowledge based economy (.299), big data in governance (.251), big data in urban planning (.225), and big data in resource management (.224). Overall the neural network model consisting of predictors' was able to predict 60.0% correctly during training and 72.6% during testing for sustainable development in smart cities.

Keywords: neural network model; urban planning; governance; knowledge based economy; sustainable development; smart cities; Big data

1. Introduction

The United Nations predicts that by 2100, the number of people living on Earth will increase to more than 10 billion [1]. The urbanization challenges can be tackled with IT-enabled city planning. A number of researchers looked into how smart city initiatives may positively help in the growth of developing countries and further proposed a framework that takes into account factors such as, data, services, infrastructure, cultural aptitude and context. The modern cities have been actively integrating technologies, such as- Big data, Internet of Things (IoT), and Artificial Intelligence (AI) for smart governance, smart economy, intelligent energy management, and resource

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optimizations to cite a few examples. Smart cities offer new possibilities to address the energy, security, and human development challenges. In smart cities cost and energy consumption are reduced, to even more than 40% [2].

The sustainable development aim is to provide a sustained livelihood, training digitalization, and meeting the urban communities' demands. Sustainable development and quality of life form the core of smart cities transformation [3]. Bibri and Krogstie [4] investigated and developed a model for smart sustainable city planning and development. They reported a need for understanding between social, technological, and scientific solutions for smart cities development. It is necessary to develop a model that is both theoretically and practically convincing and robust. The existing studies are mainly on the opportunities and challenges of advanced technologies in smart cities solutions. The conceptualization of a smart city is based on the notion that a traditional city cannot meet the needs of future generations due to rapid urbanization, thus promoting the need for sustainable development, resource optimization, knowledge economy, technological innovation, and governance. Therefore the present study proposes a sustainable development neural network model for smart cities. There are five sections. Section 2 corresponds to literature review. Section 3 illustrates the method and findings. Section 4 presents the discussion. The last section summarizes the outcome of the study.

2. Literature Review

Smart cities' potential and advantages include smart governance, smart economy, smart living, smart environment, quality of life, smart mobility, and sustainable development. The benefits in a smart city are gained by data-driven decisions [5]. Big data consists of a large volume of data collected from Internet of Things devices and other digital sources in structured/unstructured formats for extracting meaningful information by applying AI/machine learning techniques [6]. Big data technology helps in urban planning by data driven decisions [7, 8]. The smart mobility concept such as traffic and route can be planned and automatically managed and directed by applying AI/machine learning on Big data in real-time [9].

Fernandez-Anez et al. [10] conducted a study in Italy on smart city implementation. They identified the importance of governance and stakeholders. Big data technology is used in effective governance [11]. For instance, crime management and tracking by using camera analytics [12, 13], real time traffic management and control via sensors and CCTV, management of traffic warnings and navigation systems through satellites. A smart city efficiently and effectively manages a resource base [14] utilizing Big data technology [7, 15, 16]. For instance, chip-based tollgate payment, smart grids with smart meters, electricity and water supply monitoring via sensors. The knowledge based economy and technological aspects are the key determinants to smart cities' initiatives. For instance, online payment, contactless payment and card less payment [17], intelligent advertisement and promotion [18], intelligent shopping [19]. The developing countries face a number of challenges in sustainable development including inadequate infrastructure, technical resources for implementation, finance, political stability, inequality, and a comprehensive approach to sustainable city development. A city should take initiative for efficient functioning and sustainable development. Smart city promotes sustainable development [20, 21], however it needs initiative to reach the sustainable development goal by identifying the key determinants [22].

3. Method and Findings

Artificial neural network was used to find the non-linear relationship between dependent and predictor/independent variables. SPSS 26.0 provides a function for neural network analysis. It consists of input layers, hidden layers, and output layers. These layers can be customized depending on the need. Several ethical norms were followed during this research including voluntary participation, brief on study purpose and methods. The existing literature and team members' experience were used to design the survey questionnaires based on five point Likert scale. The study collected 212 relevant samples from IT engineers, managers, policy makers, and end users in Oman. There were 46% female and 54% male. The age were divided into six groups: 20-25 (52.6%), 26-31(13.6%), 32-37 (10.8%), 38-43 (15.0%), 44-49 (5.2%), and above 50 (2.8%). The 20-25 age group corresponds to the maximum responses 52.6%. The sustainable development goal (*Mean* = 2.17, *SD* = .952, *N* = 212) was chosen as dependent variable and (1) Big data technology enables resource management (*Mean* = 2.02, *SD* = .779, *N* = 212), (2) Big data technology enables urban planning (*Mean* = 2.04, *SD* = .856, *N* = 212), (3) Big data technology enables effective governance (*Mean* = 2.03, *SD* = .859, *N* = 212), and (4) Big data technology enables knowledge based economy (*Mean* = 2.06, *SD* = .896, *N* = 212) were the independent varaibles. Furthermore, The Cronbach's Alpha (α) was .809 (recommended value .5 and above) and calculated values of Kaiser-Meyer-Olkin measure of sampling adequacy were .729, with Bartlett's Test of Sphericity as Chi-Square 299.460, df = 6, $p < .001$. For modelling the sample was divided into testing and training as 70.8% and 29.2% respectively and fed into a multi-layer perceptron network of SPSS 26.0. The input layer consisted of four (04) units of independent variables viz. Big data technology enables resource management, Big data technology enables urban planning, Big data technology enables effective governance, Big data technology enables knowledge based economy. The number of hidden layers chosen were one (01) with four units (H (1:1) to H (1:4)) and hyperbolic tangent (1) was used as activation function. The output layer consisted of dependent variables (Sustainable development goal) with Softmax (2) as activation function and Cross-entropy as error function. The Softmax has vector of real-valued arguments as domain and transforms it into to a vector whose elements lies in the range (0, 1) and sum to 1.

$$\gamma(x) = \tan(x) = \frac{e^{x}-e^{-x}}{e^{x}+e^{-x}}\text{, Domain} = (-\infty, \infty)\text{, Range} = (-1, 1);\ \gamma(x_k) = \frac{e^{x_k}}{\sum_j e^{x_j}}$$

Figure 1 shows the sustainable neural network model for Big data in smart cities. The labels in the figure is referred as; Management = Big data technology enables resource management, Planning = Big data technology enables urban planning, Governance = Big data technology enables effective governance, Economy = Big data technology enables knowledge based economy, SD = Sustainable development, blue line = when synaptic weight equals to zero, green line = when synaptic weight is < 0, and grey line = when synaptic weight is > 0

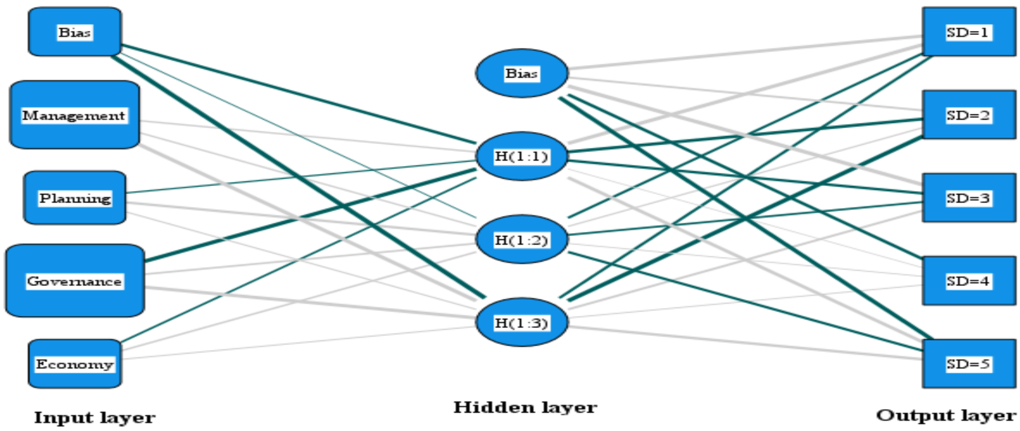

Figure 1. Sustainable development neural network model for Big data in smart city

While training and testing the percent incorrect predictions were 40.0% and 27.5%. The Cross entropy error was 15.748 during training and 50.931 during testing. Overall the model was able to predict 60.0% correctly during training and 72.6% during testing. Table 1 shows the neural network model summary.

Table 1. Neural network model summary

Training	Cross Entropy Error	156.748
	Percent Incorrect Predictions	40.0%
	Stopping Rule Used	1 consecutive step(s) with no decrease in error[a]
	Training Time	0:00:00.04
Testing	Cross Entropy Error	50.931
	Percent Incorrect Predictions	27.4%
a. Error computations are based on the testing sample. Dependent Variable: Sustainable development goal		

The output of neural networks also includes the importance of independent variables with respect to dependent variables. Generally, it is available both in tabular and graphical forms. In the present study, figure 2 shows the importance of independent variables both in units and normalized form.

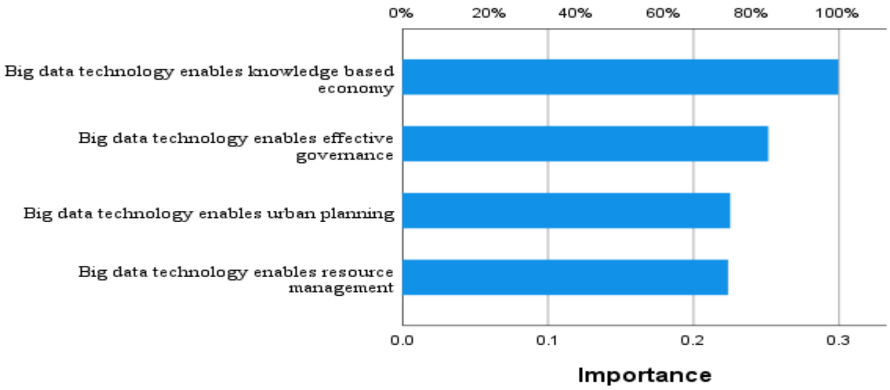

Figure 2. Independent variables importance both in units and normalized form (in %)

Furthermore, on closer look at the data on sustainable development goals and Big data technology in the knowledge economy and effective governance found more respondents agreeing on the subject than disagreeing. The respondents believe in importance of Big data in knowledge base economy. For instance, strongly agree (28.2%), agree (45.1%), unsure (21.6%), disagree (3.3%) strongly disagree (1.9%). The respondents also believe in importance of Big data in effective governance. For instance, strongly agree (30.0%), agree (40.8%), unsure (25.4%), disagree (2.3%), and strongly disagree (0.9%). The sustainable development goal and Big data technology in the knowledge economy and effective governance are plotted in figure 3 and 4.

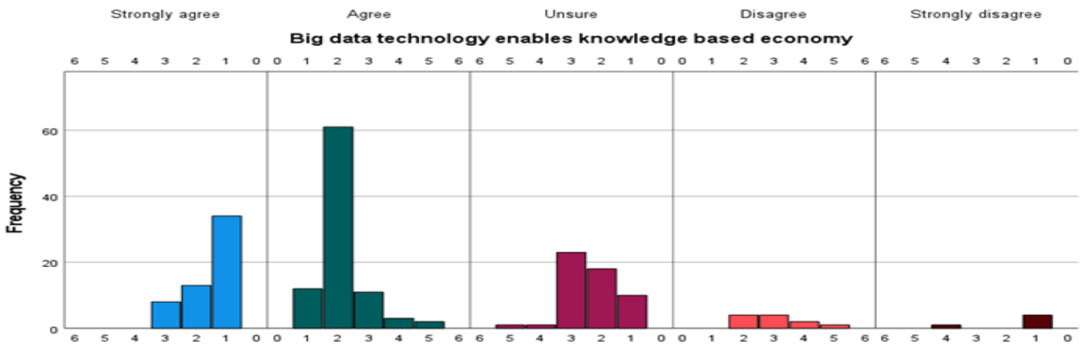

Figure 3. Sustainable development goal and Big data technology in knowledge economy

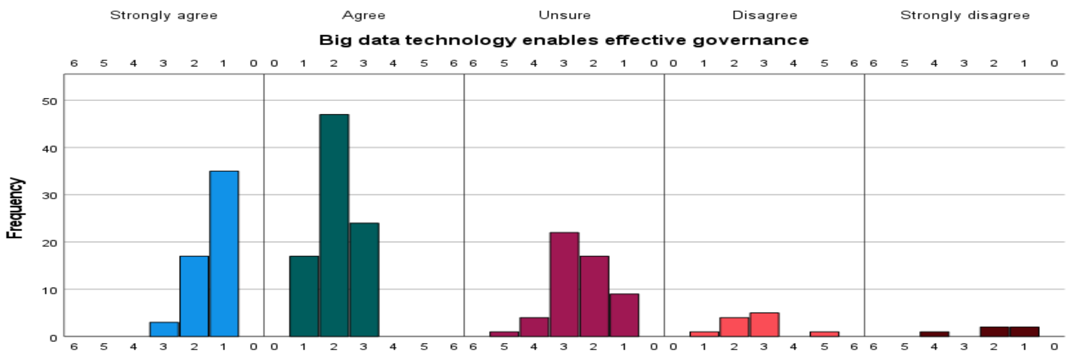

Figure 4. Sustainable development goal and Big data technology in effective governance

4. Discussion

The result shows that the independent variables including 1) Big data technology enables resource management, 2) Big data technology enables urban planning, 3) Big data technology enables effective governance, and 4) Big data technology enables knowledge based economy have influence on sustainable development goals. The knowledge based economy recorded the highest importance (.299) towards sustainable development. In the changing world, sustainable development should be the part of every city [22]. Big data technology contributes to a knowledge based economy [23] with diverse economic opportunities [24, 25]. The second highest importance corresponds to effective governance (.251). The past studies have shown the importance of Big data technology in effective governance such as [11], controlling crime (camera analytics for illegal intrusion) [12], e-governance for the benefit of all its residents [3], e-services (electronic voting, signature) [26]. Additionally, the urban planning is multifaceted, linked to environment, health care, lifestyle, energy usage, education, communication, transport, etc. Big data technology enables urban planning (.225) and effectively contributes to sustainable development. According to Hao et al. [8] Big data technology helps in urban planning, in various forms such as renewable energy networks, automatic traffic management, etc. Similarly, the resource management is another independent variable which contributes to sustainable development. In the current study the derived importance of this variable is .224 in sustainable development goals. Several researchers have studied the area. For instance, Big data technology enables resource management [16], efficiently and effectively manages its natural resource base [14]. Figure 5 shows the relationship between predictors and sustainable development goals in smart cities.

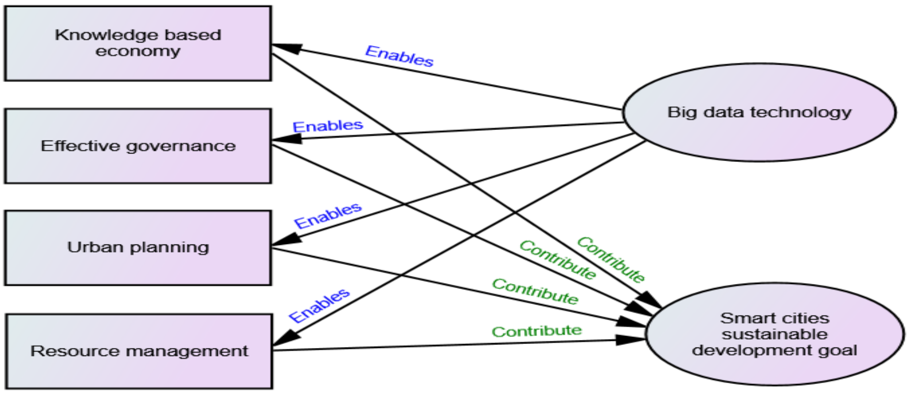

Figure 5. Relationship between predictors and sustainable development goals in smart cities.

5. Conclusion

The research has demonstrated predictor variables and their importance in sustainable development. With the changing world scenario the United Nation is pushing countries towards realization of sustainable development goals. Big data technology acts as an enabler to the predictor variables which are resource management, urban planning, effective governance, and knowledge based economy in the context of sustainable development goals. The order of importance of predictors variables in the sustainable development goals of smart cities are: knowledge based economy > governance > urban planning > and resource management. Nevertheless, there are more predictor variables for sustainable development. Their impact and importance vary from region to region which could be an avenue for future research.

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References

[1] Madakam, Somayya and Ramachandran Ramaswamy, Sustainable smart city: Masdar (UAE)(A city: Ecologically balanced). *Indian Journal of Science and Technology* 2016; **9**(6): p. 5.

[2] Alzaed, Ali and Ashraf Balabel, Experimental Investigations of Solatube Daylighting System for Smart City Applications in Saudi Arabia: Energy Saving, Experimental investigation, Solatube daylighting system, Smart cities, Saudi Arabia. *Environmental Research, Engineering and Management* 2020; **76**(3): p. 16-23.

[3] De Guimarães, Julio Cesar Ferro, Eliana Andréa Severo, Luiz Antonio Felix Júnior, Wênyka Preston Leite Batista Da Costa, and Fernanda Tasso Salmoria, Governance and quality of life in smart cities: Towards sustainable development goals. *Journal of cleaner production* 2020; **253**(2020): p. 1-13.

[4] Bibri, Simon Elias and John Krogstie, Towards A Novel Model for Smart Sustainable City Planning and Development: A Scholarly Backcasting Approach. *Journal of Futures Studies* 2019; **24**(1): p. 45-62.

[5] Al-Badi, Ali, Sujeet Kumar Sharma, Vishal Jain, and Asharul Islam Khan. Investigating Emerging Technologies Role in Smart Cities' Solutions. in *International Working Conference on Transfer and Diffusion of IT*. 2020: *Springer*.

[6] Khan, Asharul Islam and Ali Al-Badi, Emerging Data Sources in Decision Making and AI. *Procedia Computer Science* 2020; **177**(2020): p. 318-323.

[7] Silva, Bhagya Nathali, Murad Khan, Changsu Jung, Jihun Seo, Diyan Muhammad, Jihun Han, Yongtak Yoon, and Kijun Han, Urban planning and smart city decision management empowered by real-time data processing using big data analytics. *Sensors* 2018; **18**(9): p. 2994.

[8] Hao, Jinwei, Jin Zhu, and Rui Zhong, The rise of big data on urban studies and planning practices in China: Review and open research issues. *Journal of Urban Management* 2015; **4**(2): p. 92-124.

[9] Qu, Boting, Wenxin Yang, Ge Cui, and Xin Wang, Profitable Taxi Travel Route Recommendation Based on Big Taxi Trajectory Data. *IEEE Transactions on Intelligent Transportation Systems* 2019; **21**(2): p. 653-668.

[10] Fernandez-Anez, Victoria, José Miguel Fernández-Güell, and Rudolf Giffinger, Smart City implementation and discourses: An integrated conceptual model. The case of Vienna. *Cities* 2018; **78**: p. 4-16.

[11] Letaifa, Soumaya Ben, How to strategize smart cities: Revealing the SMART model. *Journal of Business Research* 2015; **68**(7): p. 1414-1419.

[12] Feng, Mingchen, Jiangbin Zheng, Jinchang Ren, Amir Hussain, Xiuxiu Li, Yue Xi, and Qiaoyuan Liu, Big data analytics and mining for effective visualization and trends forecasting of crime data. *IEEE Access* 2019; **7**(2019): p. 106111-106123.

[13] Xu, Chunfa, Xiaoyang Hu, Anqi Yang, Yimin Zhang, Cailing Zhang, Yufei Xia, and Yanan Cao, Crime Hotspot Prediction Using Big Data in China, in *Handbook of Research on Managerial Practices and Disruptive Innovation in Asia*. 2020; *IGI Global*. p. 351-371.

[14] Fu, Liping, Xiaodi Jiang, and Lanping He, How Natural Resource-Based Industry Affect Sustainable Development? An Evolutionary Study of China. *Sustainability* 2020; **12**(1): p. 1-14.

[15] Silva, Bhagya Nathali, Murad Khan, and Kijun Han, Integration of Big Data analytics embedded smart city architecture with RESTful web of things for efficient service provision and energy management. *Future Generation Computer Systems* 2020; **107**: p. 975-987.

[16] Zhou, Junling, Pohsun Wang, and Lingfeng Xie, Research on Resource Allocation Optimization of Smart City Based on Big Data. *IEEE Access* 2020; **8**(2020): p. 158852-158861.

[17] Xu, Bing, Darong Huang, and Bo Mi, Research on the application of mobile payment security system based on the Internet of Things. *Concurrency and Computation: Practice and Experience* 2020: p. e5779.

[18] Mogaji, Emmanuel, Sunday Olaleye, and Dandison Ukpabi, Using AI to personalise emotionally appealing advertisement, in *Digital and Social Media Marketing*. 2020; *Springer*. p. 137-150.

[19] Fagerstrøm, Asle, Niklas Eriksson, and Valdimar Sigurdsson, Investigating the impact of Internet of Things services from a smartphone app on grocery shopping. *Journal of Retailing and Consumer Services* 2020; **52**: p. 101927.

[20] Shulla, Kalterina, Walter Leal Filho, Jan Henning Sommer, Amanda Lange Salvia, and Christian Borgemeister, Channels of collaboration for citizen science and the sustainable development goals. *Journal of cleaner production* 2020; **264**(2020): p. 1-13.

[21] Wondirad, Amare, Denis Tolkach, and Brian King, Stakeholder collaboration as a major factor for sustainable ecotourism development in developing countries. *Tourism Management* 2020; **78**: p. 104024.

[22] Yigitcanlar, Tan, Hoon Han, and Md Kamruzzaman, Approaches, advances, and applications in the sustainable development of smart cities: A commentary from the guest editors. *Energies* 2019; **12**(23): p. 1-11.

[23] Wang, Xiaojun, Leroy White, and Xu Chen, Big data research for the knowledge economy: past, present, and future. *Industrial Management & Data Systems* 2015; **115**(9).

[24] Kuru, Kaya and Darren Ansell, TCitySmartF: A comprehensive systematic framework for transforming cities into smart cities. *IEEE Access* 2020; **8**(2020): p. 18615-18644.

[25] Chechina, Oksana S and Svetlana A Nikonorova, The Impact of the Digital Economy on the Quality of Life. *Digital Economy: Complexity and Variety vs. Rationality* 2019; **87**: p. 417.

[26] Meng, Weizhi, Wenjuan Li, Steven Tug, and Jiao Tan, Towards blockchain-enabled single character frequency-based exclusive signature matching in IoT-assisted smart cities. *Journal of Parallel and Distributed Computing* 2020.