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Sustainable Cities and the Internet of Things (IOT) Technology

IOT technology improves the development of smart cities' infrastructures and reduces over-population stresses

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ABSTRACT: In this paper, I aim to understand how IOT technology can improve the development of smart cities' infrastructures and alleviate the strains of population growth. In order to understand this inquiry, I will begin by defining IOT technology. Then I will examine the function and capabilities of IOT technology and how it helps smart cities' urban development in areas such as architectural, agricultural, safety and surveillance, and health and sanitary needs. I will develop a prognosis that provides targeted solutions for how IOT can specifically reduce urban population strains and challenges in particular urban sectors, and analyze the environmental implications of IOT technology. Lastly, in the discussion section, I propose applying sustainable frameworks, that can incorporate IOT technology, and showcase IOT weaknesses. This research concludes with describing the impact of implementing IOT technologies to address specific urban infrastructure and overcrowding problems. It can allow readers to view the interdisciplinary potential of sustainability with the use of technology, environmental science, and engineering, and social science through urban development and planning. Internet of things technology, through a cross disciplinary approach, can alleviate and resolve humanity's rising problems.

Keywords: sustainability, Internet of Things (IOT) Technology, overpopulation, city infrastructure, urban development, planning, overpopulation stresses

AUTHOR'S NOTE: I am a graduate candidate in the Master of Science Negotiation and Conflict Resolution program at Columbia University. I am interested in resolving conflict in numerous dimensions, including urban overpopulation, environmental pollution, and threats to sustainability. My graduate research is a comparative case study examining international conflict and the persistence of attractors threatening peace agreements in common areas of conflict. My previous undergraduate research relates to areas of ineffective governance to environmental sustainability. The culmination of my research and studies can be used to change policy, inform future research, reduce conflict, and improve urban planning initiatives to create a peaceful and sustainable future.

Introduction

Society has progressively demanded an increased power of data computing, processing, and analytics to find solutions to current problems. One current problem is alleviating the stresses of overpopulation and reducing overcrowding in urban regions. One study states that "more than half of the global population now live in a city. The United Nations estimates that by 2050 this percentage will rise to 66 percent" (Tanda, 2018, pp.77). According to another study, the World Health Organization predicts growing urban challenges, with cities having a larger proportion of the burden of health, environmental, and security issues (World Health Organization, 2016).

The Internet of Things (IOT) technology can provide innovative solutions to these growing population trends. The definition of IOT technology has been re-written and conceptualized by various scholars. According to Haller, IOT technology is "a world where physical objects are seamlessly integrated into the information networks, and where the physical objects can become active participants in the business process" (Zhang, 2014, pp.1). Yet Zhi-Kai Zhang defines IOT technology as a physical or virtual object that connects to the internet and can communicate with human users and other objects (Zhang, 2014, pp.1). In this article, I define IOT technology as representing virtual or physical objects that are integrated across a system to form a network of communication with beings or things.

The interconnectivity of IOT technology can enhance society's capacity in creating smarter and more efficient cities. It can assess and address problems and provide solutions to sustainability challenges within the sectors of architecture, agriculture, safety and surveillance, and sanitation. It balances these sustainability challenges by processing and facilitating the exchange of information, communicating the needs and problems of each sector through technical sensors. IOT technology can increase our efficiency by allowing objects to work together, increase our decision making through greater data collection, and improve our environment through better resource savings, application, and distribution. This research expands on four elements: (1) how IOT functional capabilities create smart cities; (2) solutions to reduce and alleviate overpopulated cities' stresses; (3) sustainable implications; and (4) a discussion of IOT weaknesses and applying sustainable frameworks.

IOT Technology & Smart Cities

IOT technology can advance smart cities in six domains: "smart economy, smart people, smart governance, smart mobility, smart environment, and smart living" (Tanda, 2018, pp. 79). Smart cities, with the implementation of IOT technology, can allow the process of "an intelligent infrastructure [by] linking objects, information, and people through computer networks" (Tanda, 2018, pp.79). In order to successfully implement IOT technology, sensor-related issues such as precision, accuracy, bandwidth, and cloud computing must be consistently maintained. Data receptors can affect the data acquisition sample, numerical variables, and infrastructure inferences. The Internet of Things technology consists of billions of interconnected nodes that cooperate simultaneously, similar to a system of functionalism, in that these nodes transform environmental adaptations into compressed versions of data. IOT technology categorizes data through ubiquitous cloud computing through the extension of internet connectivity by communicating with devices and everyday objects. Many scholars have attempted to describe the nature of IOT technology. Fleish describes it with the words "things do not turn into computers, but they can feature tiny computers" (Fleisch, 2010, pp.3). Objects can act like tiny computers through various methods of data compilation. IOT technology can foresee logical patterns, evident with machine learning, and signal learned information from sensors via wireless cloud platforms. IOT technology is significant because it can advance the development and prosperity of smart cities.

IOT Functional Capabilities Create Smart Cities

IOT technology provides numerous benefits to the environment. It promotes the progression of future sustainability by developing smarter and more efficient cities. In particular, it can reduce challenges and population stresses occurring in architecture, agriculture, safety and surveillance, and health and sanitation sectors. This section provides an overview of the IOT technological capabilities and how it can function within different urban sectors.

Architecture Sector

IOT technology performs operations through the integration of multiple devices in any setting such as homes. These multiple devices involve technological applications such as "audio and video equipment, lighting, curtain control, air-conditioning control, security systems, digital cinema system, video server, shadow cabinet system, network appliances and more" (Zhang, 2015, pp.1). Smart homes facilitate the exchange of information systems that are time and cost-efficient. The integration of information commences mobile computing with a microSD (micro secure digital card) and/or IC (Integrated Circuit) card. The flow of information begins with interconnected nodes that sense and share data through the internet. IOT technology enables smart cities' housing development through its technical foundations. The technicalities rest in numerous layers: the perception layer, center control platform, middle layer, and application layer.

The perception layer manages tasks that rely on the sensor signal and monitoring equipment. For example, sensors can convey photosensitivity, chemicals and chemical composition, and physical conditions. In a setting where the chemical composition is smoke, and the physical conditions are light and heat, the sensors can internalize the physical stimuli and respond to this data. In particular, in detecting light, photosensitivity generates an output signal that detects the range of light energy in altering frequencies. Photosensitivity sensors convert photons into electrons, which can utilize photoemissive and photovoltaic cells to convert light energy into electrical energy. This process allows the sensors to experience efficient savings on energy consumption. Other instruments used in light detection are pyroelectric sensors to ensure housing surveillance and safety. The sensors are sensitive to the temperature of a human body that radiates infrared energy with a wavelength between 9 and 10 micrometers. The perception layer involves sensors that detect a range of 8 to 12 micrometers of infrared energy, and the control center can relay to individuals

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if there is an intruder or high motion sensitivity. Zhang summarizes this informative process with the words "first, the central controller receives the information passed from the perception. Then the central controller would send the control information to the command execution of a simulated launcher" (Zhang, 2015, pp. 2.)

After the functions of the control system are complete, the middle layer acts on this information. Middleware technology detects data sharing and allows the exchange of information between household equipment. One example of using the middleware layer in IOT technology is in detecting water shortages. IOT technology can connect to a city's cloud computing public service centers to detect water shortages or fluctuations in temperature. The cloud computing software can then transmit information on water shortages and reduction of water usage during periods of drought. Access to the city's data can enable IOT technology to guide individuals and their housing conditions by translating that information into both device and consumer knowledge. IOT technology has the potential to convey knowledge in an actionable matter in languages that both humans and technological devices understand.

The middle layer highlights how the cloud's housing system becomes an 'intelligent village.' This intelligent village utilizes the application layer to access a user interface that operates on a variety of household appliances and services. The application layer, with the intermix of the middle layer, relays information to the cloud housing system. IOT can employ the house's cloud computing data and further transmit signals to the city's mainframe cloud by notifying police, ambulance, and much more with the time, water usage, location, and any incident occurring within a matter of seconds. The interrelation of devices computing and connecting data allows these devices to tell a story and fill in knowledge gaps.

Agriculture Sector

IOT technology can help the development of smart cities' agricultural sectors by streamlining production, increasing efficiency, reducing resources, and cultivating farming transparency. IOT technology in the agricultural sector has numerous components. IOT technology establishes agricultural cloud-based computing, the storage of agricultural information, the construction of IOT technological plant factories, and smart agricultural farming. In the agricultural sector, the construction of IOT technology is divided between user management (access license, user interaction management, user accounting), task management (image management, task dispatching, task performance, life cycle management), and resource management (load, failure detection, recovery from failure, monitory statistics).

Agricultural cloud-based computing involves utilizing a cloud database to manage data and data analytics. The cloud can identify "management defects, measurement, and analysis of productivity and property based on a productivity curve" (Tongke, 2013, pp.3). The productivity curve can be developed by creating initial productivity and target productivity points. These points can be transmitted through cloud computing to aid farming processes. It can help farming through: (1) managing planting; (2) measuring productivity effects and management measures; (3) tracing and controlling farm produce security; and (4) monitoring plant growth. In plant management, cloud computing can analyze behavior trends per crop and per plant. Furthermore, it can document the plant given specific subsections such as date, sunlight, humidity, location, species breed, soil quality, and production yield. Cloud computing data can also analyze the success of plants based on tagging, analyze trends within the data, and enforce meta-data compilation and assessments to improve productivity and agricultural decisions.

Another element of cloud computing is assessing plant productivity effects and the management of resources. Cloud computing can calculate a production function per input measurement through computer simulations and mathematical modeling. The movement of the production line contingent upon x inputs portrays to farmers a visual and mathematical measurement of their errors and successes. For the purposes of farm produce security, cloud computing creates a system of monitoring and is able to track the produce from farm to farm to consumers' tables. Furthermore, it encourages plant growth by monitoring and motivating farming transparency by analyzing data constituents stored on an agricultural cloud.

IOT technology can construct dynamic plant factories. As TongKe states in the article, "Smart Agriculture Based on Cloud Computing and IOT," a plant factory is a "highly efficient agricultural system that achieves continuous production of crops around the year through highly accurate control of the environment within the facility. It uses computers to control temperature, humidity, carbon dioxide concentration automatically, and culture solution of crops, to achieve labor-saving production of crops which are subject to no or little natural condition limitation" (TongKe, 2013, pp.5). IOT technology can develop a successful plant factory through the intermix of a sensing, delivery, and intelligent control subsets.

The plant factories can construct a sensing structure through environment testing sensors, biosensors, global

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positioning systems, and radio frequency identification. For example, in sensing systems, IOT technology can document specific details like the germination period, growth spurt, and development stages. The spectral analysis of botany can determine the plant's condition and the environment the plants must acclimate to. The sensing layer collects pertinent information, whereas the delivery layer is concerned with reliable conveyance and transmission of data. For quick and short- term delivery preferences, wireless connections such as WLAN802, Bluetooth, and ZigBee can transmit data at different speeds and at low costs. Lastly, the intelligent control layer is composed of elements that could include a "PDA or controller, regulation equipment, and operating terminal" (Tongke, 2013, pp.5). For instance, the system can create parameters based on internet data, such as regulating weather and irrigation patterns. IOT technology can specialize each day, directing a plan given the daily parameters of wind, weather, soil, and sunlight per crop.

Smart agriculture consists of measuring subsystems to achieve a holistic data center. There are components to measure in a given subsystem. Agroecological systems can be developed to include three subsystems. The first is water quality monitoring, fertilization, and soil monitoring: soil humidity, light, wind, and air. The second subsystem includes automated greenhouses, water irrigation, and pest monitoring. The third agroecological subsystem consists of agricultural equipment and facilities that monitor, control, and operate farm machinery. The implementation of these systems is completed through the IOT technology's management system, resource pool, presentation layer, and user interface. Smart agriculture advances the development of smart cities and IOT technology, and can further develop feasible solutions to agriculture's multiplicity of problems.

Safety and Surveillance Sector

IOT technology offers viable safety and surveillance measures for smart cities, such as "network security, encryption, PKI, security analytics, and API security" (Press, 2017, pp.1). It can change the interface of smart cities by providing safer street lighting, transportation methods, traffic-easing solutions, and surveillance..

IOT technology has changed safety measures by creating a video interface by utilizing unmanned aerial vehicles (UAVs) or drones to provide commercial, governmental, and civilian security. For example, UAVs can aid in environmental disaster relief, as exemplified by the Japan East Earthquake. In the aftermath of the earthquake, UAVs helped by "coordinating disaster relief efforts, [capturing] images of the damager reactors at the Fukushima Daiichi nuclear power plant for site assessment, providing real-time data of radiation levels at the nuclear power plant, and assessing the state of the cleanup and reconstruction efforts taking place in Fukushima prefecture" (Motlagh, 2017, pp.128). IOT technology can deliver information and provide an informative spatial analysis to ensure the safety of the population.

Another example of IOT technology promoting safety is through the Local Binary Pattern History Method that derived from Open Source Computer Vision. The algorithm has roots in 2 dimensions textures. The operating system can summarize an image by comparing pixels with neighboring pixels. The center pixel is measured by the intensity of the pixels in contrast to the neighboring pixels. If the pixel is greater or equal to the neighboring pixel, it is denoted with a 1, or a 0 if it is not. The LBP operator consists of 3x3 cells that follow binary code in classifying facial recognition. IOT technology can detect suspected people by monitoring different facial details and expressions, i.e. open and closed eyes, smiling or not smiling, glasses, or no glasses. Through this, it creates a platform to find individuals and create accurate surveillance and safety systems.

Health and Sanitation Sector

IOT technology can create a better health and sanitation system, namely by preventing various hazards and bad odors generated by garbage. To avoid these outcomes, a system utilizing IOT technology can ensure that garbage disposal happens efficiently. IOT technology can be used to invent a "smart alert system for garbage clearance by giving an alert signal to the municipal web server for instant cleaning of a dustbin with proper verification based on the level of garbage filling" (Kumar, 2016, pp.1028). Cleaner sanitary processes can abide by ultrasonic sensors, which are interfaced with Arduino UNO to monitor the levels of garbage. Furthermore, the system's garbage bins send alerts to the web server once sensors detect the garbage is at high levels. Once the alert transmits to the garbage disposal personnel, the personnel can clean the bin and confirm the completion of the task with RFID tags.

The system adopts essential elements such as an RFID tag, an RFID reader, a micro-controller, liquid crystal display, and a GPRS. A functional diagram can model this process of transmitting the information. The system implementation will involve an RFID tag which "is a tiny device that stores and forwards the data to a RFID reader" (Kumar, 2016, pp.1031). The RFID tag consists of active and passive sensors, with the former having stronger distances than the latter's distances. They do not operate

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with batteries, but they gain power from RFID readers. The RFID tag will identify the radio frequency placed inside the tag and convert it into electrical power to support the transmission of data to the RFID reader. The system of garbage alert will rely on the RFID tag responding to the RFID reader and the ultrasonic sensor responding to Arduino UNO R3, connected to a power supply.

Finally, this process will be placed on the webserver and formulated in an android application. A more concise version of the data process is depicted in Figure 1.

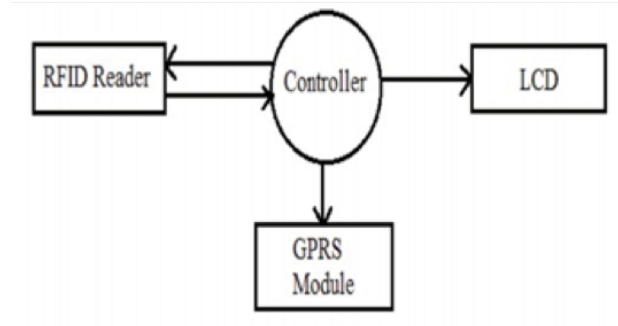

Figure 1: Functional block diagram of the Embedded System (Kumar, 2016, pp.1029)

IOT Technology Solutions to Reduce and Alleviate Overpopulated Cities' Stresses

The demands of growing populations in emerging cities can create distress among numerous stakeholders and government officials. Therefore, it is crucial to see how IOT technology can make real changes in the sustainability and long term growth of overpopulated areas. I have highlighted the urban needs of each sector—architecture, agriculture, safety/surveillance, and health/sanitation—and demonstrated how IOT technology can provide solutions to each sector's sustainability and efficiency challenges.

The adoption of IOT technology has the potential for numerous sustainable development implications. IOT technology has beneficial environmental impacts, can stimulate long term growth, and can reduce monetary, timely, and environmental costs. It can also encourage sustainability as a common and necessary step for future development. Furthermore, IOT technology can encourage the development of the marketplace resources, and expand human and social capital. These environmental implications, along with the following solutions, show how IOT technology can reduce urban population stresses in different sectors.

Architectural Sector

IOT research allows policymakers to determine a cost and benefit analysis and measure the returns on investment from IOT technology. This technology has numerous drivers, such as "savings on the public budget, a better quality of life of the citizens, and the city's wealth" (Tanda, 2018, pp.77). Furthermore, smart cities provide initiatives to ensure cities' overall growth, as well as their environmental, social, and economic well-being. One way in which the architectural sector can reduce overcrowding is through statistical analysis of demographics and population migration trends. For instance, the city can devise housing grids that ensure the efficient allocation of natural resources per household. IOT technology can then enhance the effectiveness of this system by comparing the cities' geographical and space limitations to its population, and ultimately showcase housing limits.

Another example of how IOT technology can influence overpopulation is in the emergence of transportation limits. IOT technology can detect flaws and limits within smart cities' infrastructures, such as the increased human and car traffic that results from overcrowding and disrupts the transportation system. IOT technology can be utilized for real-time updates on not only car congestion, but also human congestion and over-trafficked areas as well.

IOT technology can improve the architectural sector by transferring data efficiently in order to improve decision-making on policies and projects related to housing, development, and the maintenance of public spaces. It does so by allowing the facilitation of data acquisition to guide future processes. The sustainability implication is that, by improving our decisions IOT technology will lead to better housing and transportation designs, improved construction processes, and healthier lifestyles in cities.

Agricultural Sector

The agricultural sector can reduce the concentration of overpopulated cities first by identifying a concentration of food waste through geotag technology, and second by acknowledging high levels of food waste per area, indicating that overpopulation leads to higher amounts of food waste per square meter. The agricultural sector can provide incentives to diminish food wastes by imposing punitive actions, i.e., tickets targeting areas with high levels of waste. The deterrence and identification of food waste can enable civilians to rectify errors while reducing overpopulation and growing strains of highly populated cities.

In doing so, the agricultural sector can utilize IOT technology to monitor levels of food production and food waste with geotags specifying the zip code, state, and

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city, and can administer a system of accountability with recording which regions account for the most food waste, food storage, and food shortages. It can also help alleviate the growing strains of overpopulation by ensuring the proper resource allocation to eco-sustainable farming. Finally, the agricultural sector can assess food as a valuable asset that must be strategically administered and quantified. Through this, IOT technology can prevent food waste and increase farming fertility, food and resource allocation, and plant yield production.

IOT technology can improve the agricultural sector by allowing a greater ratio of agricultural output to limited input. Further, it can ensure the progression of agricultural tasks, management, and resource allocation. Thus, it can improve the output and management of the agricultural processes and products. The environmental implication is that this leads to a greater number of populations that reduce food waste and have less food shortages.

Safety and Surveillance Sector

The safety and surveillance sector, utilizing IOT technology, can mitigate the stresses of highly populated cities. For example, IOT technology can prevent crime by mechanizing automotive surveillance in urban areas. Surveillance can then reduce the rise of overpopulated cities by monitoring human development and growth. Through spatial modeling, satellite imaging, and geophysical factors, IOT surveillance can mark levels of human growth. Once IOT technology detects growing population demands, it can begin to rectify overcrowding. For instance, IOT technology can influence the economy's social benefit by monitoring or decreasing housing prices and raising the accessibility of housing resources.

IOT tech can help the safety and surveillance sector by detecting problems and the perpetrators of said problems. Surveillance fosters accountability that can prevent the curvature of future actions taken against safety. It can also detect dangerous situations and faulty security operations, as well as monitor areas that are out of reach or vulnerable to humans. This sector can be more sustainable by fostering accountability, transparency, and alternative, non-human, skills that can ensure security. It can create sustainability by allowing problems to be detected quicker and enhances the range of options one can take to sustain security. The greater the opportunities for security the greater chances our society can be sustainable even in the midst of security threats.

Health and Sanitation Sector

The health and sanitation sector influences population trends through the strenuous task of decomposition and disposal of waste. In major populated cities, waste and waste treatment pose health risks to air quality, human repository systems, and to sanitation through increased bacteria, animal infestation, and garbage liquid waste that affects water quality. The overflow of garbage and waste can deter overcrowding, but, the management of waste can motivate population wellbeing and population stresses. Furthermore, to deter overpopulation, IOT technology can implement a system of accountability regarding waste and consumption. Each individual consumes at a level contingent upon household income, size, and bodyweight; then, IOT technology can measure healthy standards of the garbage disposal and weight per household and place these standards across a standard mean of deviation. In totality, IOT technology can reduce the strains of a growing population and spread a system of accountability stringent on individuals in crowded cities.

IOT technology can benefit the health sector by reducing the spread of health hazards, improving clean up and sanitary processes, and creating a system of structure and division of tasks. It can expedite waste disposal. Avenues to explore include (a) increased movement of waste to recycle or compost facilitates near one's home through in home transport machines, (b) machines, at home or the workplace, that repurpose materials instantly or carry waste directly to the city's disposal and compost sites (c) and early detection of waste overflow. This process contributes to sustainability by reducing waste and air pollution. By reducing human exposure to harmful waste, the use of IOT technology inadvertently alleviates the stresses of health care systems as well by reducing environment-related health concerns and risks. IOT can speed societal processes, reduce negative environmental impacts, provide a more organized structure to society, and push labor saving strategies.

Sustainable Implications

IOT technology can enable more structural changes in policy and future governmental regulations. According to one scholar, Mazhar Rathmore, smart cities contain multiple tiers of planning. By examining IOT's structure of multiple tiers and their application, we can improve policy making, urban planning, and sustainable practices.

There are multiple tiers to planning. The first bottom tier is responsible for "IOT sources, data generations, and collections"; the second intermediate tier consists of communication between the sensors and relay connections; the third intermediate tier consists of data management and processing; and the top tier is responsible for the application and usage of the aggregated data (Rathore, 2016, pp.1). This model of tiered frameworks can supplement the data aggregation, filtration, and computing data that aid in future decision-making processes. Furthermore, the tiered framework provides us with a model of numerous ways by which IOT technology can prevent overcrowding and alleviate the challenges of overpopulation. It can allow for greater urban planning, decision-making, and intersectionality between technology and human prosperity.

Policies can be amended to enhance the greater usage of IOT technology. One policy is the executive order 13748 of November 16, 2016: Establishing a Community Solutions Council. This order established policies that help develop community solutions. IOT can contribute to "community-driven, locally led vision and long-term plan[s] for clear outcomes [that] should guide individual projects" (National Archives, 2016, pp.1). The community can utilize technology to guide the division of tasks and reach community sustainable goals.

Another policy that can be influenced by IOT technology is the Executive Order 13503 -- Establishment of the White House Office of Urban Affairs. This order impacts the adoption of technology in resolving urban challenges. Various stakeholders were involved in the implementation of this order. One can influence these stakeholders some of which are: the Department of Health and Human Services, the Department of Housing and Urban Development, the Department of Transportation, the Department of Energy, the Department of Education, and the Environmental Protection Agency. These stakeholders can learn how IOT technology can guide future urban planning processes.

IOT can impact a more recent policy called The Executive Order Regarding Efficient Federal Operations. This order states that it aims to "achieve and maintain annual reductions in building energy use and implement energy efficiency measures that reduce costs; meet statutory requirements relating to the consumption of renewable energy and electricity, [and]...utilize performance contracting to achieve energy, water, building modernization, and infrastructure goals" (The White House, 2018, pp.2). IOT technology can encourage the pursuit of these sustainable infrastructure goals and change policies to encourage interdisciplinary solutions to resolve urban sustainability challenges.

Discussion: Applying Sustainable Frameworks and IOT Weaknesses

IOT technology has evolving beneficial and disadvantageous effects. This section expresses weaknesses and strengths to adopting sustainable frameworks that are inclusive of IOT. Sustainable frameworks include corporate social responsibility, stakeholder theory, corporate sustainability, and green economics. These theories can show the application of sustainable frameworks to foster IOT technology usage.

According to Chang, corporate social responsibility consists of legal, ethical, discretionary responsibilities. Such responsibilities relate to social issues such as "consumerism, environment, discrimination, product safety, occupational safety, and shareholders" (Chang, 2017, pp.50). Businesses must notice how they affect civilians' choices and perspectives. Therefore, businesses can affect consumer's knowledge and perspectives of sustainability and its practices. Businesses affecting consumers is similar to the perspective of the theory of coevolution. The theory of coevolution rests on Darwin's fundamental groundings. This theory's definition is founded upon interacting agents. These interacting agents refer to "organizations and their environments [which] evolve in relation to each other" (Chang, 2017, pp.52). As, one organization evolves it contributes to societal evolution. This interaction is similar to the interaction of various devices that IOT incorporates. It is beneficial because IOT technology aims to foster this similar type of co-evolutionary change. As technology advances society advances as well.

Similarly, the green economics theory highlights civilian and business participatory measures. These participatory measures showcase the quality of businesses and stakeholders as they participate in sustainable discourse and ideas. Further, it can be used to analyze how coevolution commences and its effects on businesses and sustainable stakeholders. Stakeholders play an essential role in the way businesses and society progresses its sustainability goals or lack thereof.

Stakeholder theories emphasize business relations, with businesses fostering relationships with non-traditional and traditional populations. For example, it encourages businesses to form relationships with non-traditional actors such as the government, special interest groups, or environmentalists. These groups can serve as change making agents to foster the usage of technology and sustainable practices.

Corporate sustainability plays a role in different sectors, emphasizing four dimensions of sustainability: social, environmental, financial, and economical. These dimensions can give organizations clarity by allowing them to establish a 'bottom line' for each social, environmental, financial, and economic element that can fulfill the businesses' goals. It can also promote the application

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of IOT technology, since corporations, in some manner, have sustainability as one of their central goals.

Additionally, organizations can adopt a triple bottom line strategy that implements coevolution theory, multi-level perspective, and transition management. This strategy stays grounded in environmental, financial, and economic dimensions by bridging principles such as, "shifting from what to how, shifting towards broader systems, and shifting to the growing use of interdisciplinary approaches" (Chang, 2017, pp.53). These suggestions correlate to bridging broader systems of competitors such as shareholders, customers, and media, as well as promoting the inclusion of employees, local communities, social pressure groups, and the government. It allows one to shift from "what" one should do to "how" one can do it. It teaches people how to create a sustainable future through interdisciplinary approaches. Interdisciplinary approaches include utilizing the natural environment, innovation and industrial policies, and natural capital (Chang, 2017, pp.53). In presenting these frameworks, it can show the role that businesses and civilians have on the potential success of IOT technology. It also shows the benefit of adopting sustainable frameworks through the inclusion of IOT technology.

There are alternative perspectives and challenges to IOT technology. According to Zhi-Kai Zhang, IOT technology endures authentication and authorization, privacy, resource constraints, software vulnerability, and malware challenges. It has authenticity challenges due to the multiplicity of devices that make pre-shared keys and key management difficult or not viable options. Another challenge arises in relation to the collection of extensive information about users' lifestyles, which can limit privacy. IOT technology also involves numerous devices, some of which are resource constrained, with limited computing power and battery usage. The whole system can be vulnerable to attacks due to its diverse hardware platforms and no general system of coherence across different operating systems (Zhang, 2014).

According to Patel, there are also challenges to interoperability, data management, and usability standards. The interoperability or the communication these devices have with other devices can be difficult to achieve because some systems may not be 'speaking the same language.' Another challenge is the increased size of the data, which can make managing it a critical and arduous process. Lastly, the costs of implementing IOT technology includes the cost of equipment such as sensing, tracking and other management mechanisms that may be costly and pose costly challenges to increased usage (Patel, 2016).

Conclusion

The internet of things technology has numerous benefits, such as improving traffic, environmental pollution, surveillance, smart parking, weather tracking, water monitoring, and more. IOT technology continues to excel and can be implemented at three levels: the physical level, the intermediate level, and the upper level. The physical level consists of data sets; the intermediate level consists of statistical measurements or correlation chi-square, probability calculation, and graphical analyses; and the upper level relates to future planning derived from the data collected. My research paper is grounded mostly in the higher level, and argues that data aggregated and computed by IOT technology can spur ideas and further human prosperity. Smart cities have numerous sustainable implications for advancing human development, improving societal processes, and reducing environmental costs. IOT technology merges interdisciplinary fields of technology, environmental resources, and urban systems development to enhance human capital and create a sustainable future.

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