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INTERNET OF THINGS (IOT) APPROACH TO COMBATING ECONOMIC AND ENVIRONMENTAL ISSUES

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ABSTRACT

Global warming, pollution and costs of power production are the major environmental and economic issues faced by the planet today. Many research works have been done and are ongoing to reduce the adverse effects that may arise due to these issues. With these issues plaguing much of the planet, the rapid proliferation of the Internet of Things (IoT), efficient, economical, and sustainable solutions are within reach. There have been various researches carried out in energy generation, agriculture, automotive, and so on. Also, there is a growing awareness among organizations that going green—taking measures to reduce carbon footprint, conserve resources, and protect the environment— have enormous advantages and benefits, as it is also good business. This paper aims at providing an insight into Internet of Things (IoT) and its applications in combating global warming, by conducting a literature review to highlight various ways via which IoT is being applied, and discussing the various benefits, whether economical or environmental, that comes with adopting IoT; as well as challenges hindering IoT adoption. It concludes by looking at the exciting potential of IoT to deliver solutions that are both economically and environmentally smart.

Keywords: *Internet of Things, Global Warming, Internet, Climate Change, Pollution*

1. INTRODUCTION

The scientific and environmental community is on the same page regarding the bitter reality of economic and environmental issues such as global warming, climate change, pollution and so on, and the role played by humans in it. These issues are hazardous to the planet and suitable measures must be deployed to tackle it. As it is detrimental to not only humans but animals and plants too. For example, melting of the polar ice caps causing floods; rising sea levels destroying agricultural and fishing activities. There are many causes of economic and environmental issues. The diversity of these causes makes it hard to clearly outline the causes and effects of environmental dilapidation. These causes and effects are often intertwined in intricate networks of social, technological, environmental and political factors. Nevertheless, some causes of environmental dilapidation include population growth, economic growth and technology advancement. Although population is vital for development, it still is the major cause of environmental dilapidation when the threshold limits is exceeded. The prevailing impact of undesirable demographic puts a strain on the resources and ecosystems. Combined with poverty and underdevelopment, creates a circumstance where the populace is forced to live in filth which further degrade the environment. Also, a poorly managed development process can lead to environment dilapidation [1]. To resolve these problems, some corrective steps must be taken timely which include but are not limited to the application of sustainable and renewable energy source and ending deforestation. Also, innovative solutions such as Internet of Things (IoT), must be considered to bring these issues to an end [2]. IoT offers several resources and different tools that can help organizations and governments reduce the negative impact of human activities on the planet. In recent times, IoT advancements has allowed organizations, governments, and consumers to reverse these economic and environmental issues without the need to forfeit one's convenience. It's anticipated that more consumers will partake in activities that allow organizations and governments to collect and analyze data for the benefit of the environment [3]. It is noteworthy to state that this research may only scratch the surface of what is a very elaborate line of

scientific and engineering exploration. Furthermore, given the increasing number of collaborations IoT has created between diverse industries and sectors, there is an instantaneous reduction of industries' environmental and carbon footprint; due to energy savings and smarter solutions.

2. ECONOMIC AND ENVIRONMENTAL ISSUES

Due to advancement in technology and rapid industrialization, the planet is faced with hazardous economic and environmental issues such as.

2.1 Global Warming

Global warming begins when the radiation of the sun reaches the Earth. Subsequently, 30% of the sun's radiation is reflected back into space by the clouds, atmospheric particles, reflective ground and ocean surfaces, while the residual radiation is absorbed by oceans, air and land. However, some of the expelled radiation is re-absorbed by carbon dioxide (CO_2), water vapours, ozone, methane and other atmospheric gases; and radiated back to the planet's surface. These gases due to their heat tapping capacity are commonly known as greenhouse gases. It is noteworthy that this re-absorption process is essential as the planet's average surface temperature would be very cold without it. The problem began when the greenhouse gases in the atmosphere increases artificially at an alarming rate [2].

2.2 Climate Change

Climate change also fuels discussions mostly because it inspires the consideration scarcity. Such that if the existence of the problem is admitted, steps can be taken to reduce their carbon footprints. The main cause of climate heating up and weather going wild, is swamping the planet's atmosphere with CO_2 by human. When fuel (such as petroleum, coal, or natural gas) is burnt; CO_2 is generated. Thus, there is need to be more energy-efficient and remove carbon from the energy generation process, as well as, when applied in various ways [3]. Furthermore, climate change is accountable for a temperature changes and rainfall that impacts the planet's agriculture at dissimilar intensities. The planet is been faced with a crucial need to intensification agricultural production and adapt to the changing climatic condition impacting agriculture at diverse geographical locations. Subsequently, the unavailability of sufficient water is only increasing in more regions of the world. Thus, there is need for compulsory optimization and rationalization to conserve the use or even increase the harvests of agricultural production [4].

2.3 Pollution

In nature, pollution is a crucial issue which occurs when impurities mix with air, water, and soil. To preserve nature, there is need to keep track of the pollution level of air, water and soil. Such that, when the pollution level increases beyond the safe bounds, there is need to purify the air, water and soil. And the need to be notified before the pollution level cross safe bounds. Specifically, the main causes air pollution are pollutants such as harmful gases and fine dust released into the atmosphere from industrial sites. These pollutants are very detrimental to our health as it can penetrates very deep into the lungs and circulatory system; causing heart, lung and respiratory diseases as well as cancers. Government via agencies, takes into account the importance of monitoring and controlling the pollution levels at any industrial site [5].

2.4 Cost of Energy Generation

Furthermore, fossil fuels which constitutes about 80% of final global energy is highly dependent on by the energy sector. Extreme mining and combustion of fossil fuels has adverse impact on the environmental, health, and economic due to pollution, climate change and so on. Energy efficiency and implementation of renewable energy sources are two main replacements to reduce the adverse impacts of fossil fuel use [6].

3. UNDERSTANDING INTERNET OF THINGS (IOT)

Internet of Things (IoT) can be simply defined as a universal structure that enables service advancements by interconnecting (whether physical or virtual) things based on prevailing and developing interoperable information and communication technologies. But, detailed definitions of IoT technologies also comprise of ambient intelligence and smart environments. In the early 20's, the advancement of IoT in our interconnected planet covered a set of technological developments from different fields such as wireless and mobile connectivity, nanotechnology, radio-frequency identification (RFID) and smart sensor technologies. A combination of these technologies could help realize a scaled-down, embedded, automated Internet of connected devices communicating recurrently and fairly effortlessly. In recent times, the use of IoT and Big Data has introduced new

business models to improve service delivery, increase production efficiency, and enhance human wellbeing. Consequently, the objective of vendors, operators, and policy-makers is to make the most of the benefits in IoT implementation while curtailing possible risks to security and privacy.

Figure 1: Internet of Things (IoT)

IoT comprises of interconnected devices and environments, such as Person-to-Person (P2P), Machine-to-Person (M2P), and Machine-to-Machine (M2M). Person-to-person (P2P) communications are direct interactions between people made possible by Internet Protocol, such as emails, video conferencing, SMS and phone calls. Machine-to-person (M2P) interactions are machine-generated information communicated to people, such as automatic text messages regarding account updates. Machine-to-machine (M2M) interactions are machine-generated data communicated to other machines which processes the data and ascertain whether or not further actions are needed. Such as telemetry, robotics, status tracking, traffic control, logistic services and telemedicine. Another important point is the purpose of IoT applications in driving social and economic advancement. IoT range of services can improve the world's development through the deployment of Internet Protocol enabled sensors and actuators. Such that, in the emerging world of today, IoT is already being incorporated to help improve some of the world's most persistent issues. A typical example of IoT in automotive includes onboard vehicle sensors which transmits data, containing engine, transmission and wheel performance, to a central processor. Which in-turn governs when the vehicle may require service to avert a breakdown [7]. For the purpose of reporting wearables are a big part of IoT, because most wearables either communicate directly with another device, such as heart rate monitors, or connect directly to the Internet to upload data [8]. At the macro level, three areas where IoT development and investment is prominent are smart cities, smart power, and water grids.

4. THE ECONOMIC AND ENVIRONMENTAL BENEFITS OF INTERNET OF THINGS

The power of IoT in tackling environmental issues lies in its ability to gather precise data and, through analytics, turn it into actionable information that drives smarter decisions about business strategy, operational efficiency, and resource allocation. Recent reports and researches have illustrated how smart solutions can help the mobile telecom industry contribute to energy savings. Thus, focusing on smart solutions for wireless communications such as smart metering for power grid optimization, coordinated traffic monitoring, and alert systems. And also, virtual products and services to enable remote working possibilities and reduce commuting and office space costs. With close connection to both business systems and operational technology, IoT can drive efficiencies in the process flow of the entire operation. The most promising areas for savings occur in IoT-enabled applications in the energy, transportation, building, and agriculture sectors [9]. For example, the adoption of a "smart grid" approach, allows more real-time data, control, and actionable energy savings. In terms of reporting, these smart grid technologies such as smart meters and analytics provide the capabilities to set hourly pricing, current demand, and the ability to balance and optimize the grid infrastructure load. Like other IoT concepts of linked systems, smart meters provide the data from embedded devices to IT analytics engines and then to control mechanisms. This allows manual and automated control of various operations in the energy process. The benefit of smart grids is huge in terms of generation and transmission of energy, providing more control and transparency over energy consumption. Applying IoT technologies in real-world scenario, the use of wind turbines with real utility delivery systems, pioneering research on energy storage batteries, and power monitoring, can accelerate the commercialization of turbines. Furthermore, IoT technologies can be applied to the energy systems—heating, cooling and ventilation, lighting, electronics and appliances, and security systems—of smart building to reduce energy consumption. Buildings of the future must connect these energy systems in an integrated, dynamic, and functional way. The goal is a smart building that effortlessly achieves its task while curtailing energy cost, supporting a robust power grid, and abating environmental impact. Consequently, realizing the benefits of IoT in improving the health of the planet will sustain resourcefulness and innovation. Today, more companies are applying advanced technologies to

develop innovative products that deliver both economic and environmental benefits [9].

5. INTERNET OF THINGS APPLICATION ACROSS DIFFERENT DEVELOPING SECTORS

IoT gives the opportunity to capture data that optimizes operational efficiency, transforms processes, and reduces environmental impact. This has the potential to have a transformative effect on many different industry sectors such as waste management, traffic and transportation, smart city and so on. River [9] highlighted some application areas of IoT in economic and environmental sectors as follows.

5.1 Agriculture

Smart agriculture involves the use of IoT to increase the quality and quantity of agricultural production. IoT enables the integration of data from sensors located in farms with geospatial and other satellite sources to deliver all-inclusive analytics, flagging the way for the application of more efficient processes in agriculture. The use of IoT technologies to monitor, predict, and measure soil and weather conditions, provides valuable insights for farming operations. Operational efficiencies can improve while environmental challenges, such as water usage, are addressed. In climate change scenario, water is an endangered resource, with agriculture as the biggest consumer.

6.2 Automotive

The more cars become automated and interconnected, the more fuel efficiency they can achieve. Sensors and connected devices can monitor issues that affect fuel consumption, such as road conditions, tire pressure, speed, and acceleration; and alert drivers or make automatic adjustments. Undeniably, reduced fuel consumption is a captivating case for autonomous cars. As they will be more capable of holding steady speeds and fine-tuning to varying road and traffic conditions. With the merging of smart technology, hybrid and electric engines, and stringent directives on emissions, dependency on fossil fuels is expected to drop considerably in the conceivable future, intensely reducing automotive carbon emissions.

6.3 Commercial Aviation

This is a highly planned sector that involves constitutional control of airspace and its operations. But despite the conservative nature of commercial aviation, many of today's IoT concepts are already in use here. Commercial airspace operations are driving transformation efforts through programs such as the Federal Aviation Administration's Next Generation Air Transportation System (NextGen) and the Single European Sky ATM Research (SESAR). The aim of these programs is to increase connectivity and information flow, thus, maximizing efficiency and provides IoT-like value to operators and consumers. The main benefit is a more ecologically friendly commercial aviation sector. Other benefits include more efficient flight paths and reduced wait time on takeoffs and landings, leading to increased passenger satisfaction, passenger retention, and revenue for airlines and airports.

6.4 Energy

Although renewable energy sources are gaining traction, fossil fuels still account for majority of global energy production. The future of energy delivery system involves the harnessing of energy from diverse sources such as wind, solar, hydro, wave, and geothermal. IoT-enabled smart grids provides an easier way to combine traditional and emerging power sources, making energy delivery cleaner, safer, and inexpensive. Thus, providing a means for energy producers to monitor and analyze energy flow and analyze consumption patterns via two-way communication with smart meters; as well as planning for contingencies. Smart IoT devices will manage the energy delivery based on real-time data rather than historical data patterns. Renewable energy sources such as solar panels and wind turbines, can feed unused energy into the power grid, creating bi-directional energy supply. This offers huge ecological rewards, allowing connected devices to achieve power-management tasks with greater accuracy and faster response times, this in turn, saves energy, prioritizes consumption, and setting better policies in response to outages.

6.5 Industrial Automation and Manufacturing

This focuses on showcasing manufacturing progress which combines IoT innovation with green efficiencies. Innovations such as smart sensors can intensely reduce energy expenses in advanced manufacturing. Manufacturing technologies advancement and the increasing use of automation have led to a revolution on the factory floor. United with business intelligence systems, these innovations provide extraordinary efficiencies in the manufacturing process. IoT systems implementation in factories not only produces significant ROI, but also improves greenhouse gas emissions. Advanced smart systems have resulted in more efficient

working environment as well as ecologically cleaner and safer workplaces.

6.6 Cost of Energy Generation

IoT has the following potential benefits in improving health and wellbeing [7];

- Through increased efficiency.
- Improvement of care in existing healthcare settings.
- Empowering better use of remote telehealth provision.
- Empowering individuals to monitor their own health daily.
- Improvement of wellbeing and better manage of health conditions.
- Diagnoses medical conditions more swiftly and promote regiment treatment.

In terms of preventative care, IoT fitness devices and movement sensors are now incorporated into many new smartphones. This allows people to monitor and track themselves, which in turn promotes healthier living.

6. CHALLENGES TO THE DEPLOYMENT, IMPACT AND SCALE OF INTERNET OF THINGS

Rose, Eldridge, and Chapin [10] explored some of the key pressing challenges faced by IoT technology. These include:

6.1 Security

Security considerations in terms of information technology are not new, but many IoT implementations avail new and unique security challenges. Resolving these challenges and guaranteeing security in IoT products and services must be made a priority. Users require certain level of trust that IoT devices and services are secure from susceptibilities, especially as IoT is rapidly becoming a part of our daily lives. An IoT device and services that is poorly secured can serve as the week link for cyber-attack.

6.2 Privacy

The full possible of IoT depends on approaches that upholds individual privacy adoptions across a broad spectrum of opportunities. The data streams and user particularity provided by IoT devices can reveal unbelievable and exceptional value to users, but privacy concerns and possible problems might hinder full-scale adoption of IoT. This means that privacy rights and upholding user privacy requirements are vital to ensuring user trust and confidence in IoT devices and services.

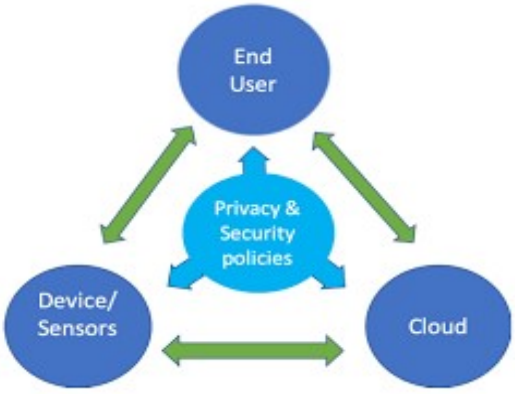

Figure 1: IoT Privacy and Security

6.3 Interoperability

A disjointed situation of proprietary IoT technical implementations will hinder IoT values for users and industry. Where interoperability is not always feasible across products and services, users may hesitate to purchase IoT products and services.

6.4 Standard, Legal, Regulatory and Rights

The use of IoT devices increases many novel regulatory and legal issues as well as intensifies existing legal issues. These issues are broad in scope, and the erratic advancement in IoT technology regularly outruns the adaptation of related policy, legal, and regulatory structures.

6.5 Emerging Economics and Development

IoT holds substantial ability for delivering environmental and economic benefits to emerging and developing economies. This includes areas such as sustainable agriculture, water quality and use, healthcare, industrialization, and environmental management, among others. As such, IoT holds promise as a tool in achieving a nation's sustainable development goals.

7. LITERATURE REVIEW

The issue of environmental pollution and climate change has become a global concern due to their impact on the environment. The main research objective of Saha, et al. [11] is to find the pollutants in nature by applying Internet of Things (IoT). A UVI-01 sensor, an ultraviolet light sensor, is used to outputs an analog signal of the amount of UV light detected. A 2-in-1 Temperature and PH sensor is utilized in monitoring the water quality, interns of level, temperature, turbidity and PH levels. This

system monitors and collects all these data and sends it to the cloud.

Water pollution is detrimental to green globalization. Such that to ensure the drinking water supplied is safe, there is need for real-time monitoring of water quality. Daigavane and Gaikwad [12] presented a design and development of a low-cost IoT system for real time monitoring of the water quality. The system consists of several sensors used to measure physical and chemical parameters of the water. The parameters such as temperature, PH, turbidity, flow sensor of the water is measured. The measured values from the sensors are processed by the core controller (The Arduino model). Finally, the sensor data can be viewed on internet using WI-FI system.

Carbon dioxide, a vital component of the environment causes a warming effect on the planet's surface. To safeguard the environment, monitoring and controlling of these changes is a challenge. Considering a long-range control of CO2 emission at the source and effective method through preventive and control technologies is needed. Rajkumar, Sruthi, and Kumar [13] implemented IoT to measure the CO2 emission using Raspberry pi which is sensitive to CO2. The CO2 emission level is sensed continuously in a city, as well as, finding the most polluted area. Also, a smart system for early detection of forest or wild fires was implemented. These are then integrated to the IOT which is more securable and allows many services. Thus, enabling a Simple Notification Service (SNS) to a mobile device if the surrounding area has higher level of CO2.

The potential for user-facing innovations to contribute emission reductions for limiting warming to 1.5 °C was investigated. Wilson, Pettifor, Cassar, Kerr and Wilson [14] introduced the concepts of Disruptive low-carbon innovations, which offers novel value propositions to users and change the marketplaces for energy-based products while reducing emissions. And possibly disruptive low-carbon innovations relating to mobility, food, buildings and cities, and energy supply and distribution was identified. It was concluded that disruptive low-carbon innovations that is appealing to users can aid efforts to limit warming to 1.5 °C.

Wildfires are exorbitantly cataclysmic disasters that lead to the destruction of forest cover, wildlife, land resources, human assets, reduced soil fertility and global warming. Therefore, there is a need of an efficient and reliable system for real-time wildfire monitoring to dilute their disastrous effects. Kaur and Sood [15] proposed a collaborative IoT–Fog–Cloud framework based on soft computing techniques for real-time wildfire monitoring, prediction and forecasting. The framework includes classifying a forest terrain into its appropriate wildfire proneness class using fuzzy K-nearest-neighbor classifier; real-time emergency alert generation mechanism based on temporal mining; and estimation of future wildfire proneness levels using Holt–Winter's forecasting model.

Irrigation systems are becoming increasingly important, due to the increasing human population, global warming, and food demand. Sani, Jonah, Jeong-A, and Maria [16] aimed to design a low-cost autonomous sensor interface, which uses sensors and actuator to automate the monitoring and control of irrigation systems in remote locations, and to optimize water use for irrigation farming. The prototype provides power supply, sensing, monitoring and control, and internet connectivity capabilities, to facilitate the autonomous supply of adequate water from a reservoir to domestic crops in a smart irrigation system.

Renewable energy surely gives many benefits, but one of the disadvantages is harvesting these energies, as its dependent on climate, weather, seasons and time. Thus, hybrid system is one of the solutions of combining these energies to a single system. Budiman, Taqwa, and Kusumanto [17] proposed an Automatic Transfer Switch (ATS) enclosure, which can be applied to hybrid photovoltaic (PV) and wind turbine, thus, placing grid ac power and generator set as backup or emergency purposes only. This prioritizes the use of renewable energy as the main power source. Automatic sequential can be programmed into microcontroller for supervision, monitoring and data logging of ATS system by using IoT (Internet of Things) Technology through GPRS GSM internet gateway. These operations can be performed both locally and remotely using IoT technology for historical analysis of data stored in cloud server.

Pollutants generated by industries are the main causes of air pollution, thus, strict control of air pollution is required. Han, Park, and Jeong [5] proposed a real-time air pollution index measurement platform using 5G wireless network and blockchain. This solution disrupts the present passive method and enables real time data collection via IoT sensor based on 5G wireless network. Furthermore, to prevent counterfeiting and tampering of data collected, blockchain technology was used to encrypt and transmit to cloud. And technology-intensive data can be extracted via edge and cloud computing.

Due to poor vehicle maintenance and ignition defect, the gases emitted from the exhaust of

a vehicle may increase. Consequently, to reduce environmental pollution and increase vehicles life, Francis, Dhinesh, Lijo, Hariprasad, and Balasubramanian [18] proposed an IoT based vehicle emission monitoring system. When a vehicle exceeds the gases emission threshold limit set by the government, the system alerts the user via LCD. Using IoT, the emission level is displayed and stored in the vehicle owner's database. When the alert is ignored, the report is sent to the transport office with entire details.

Solving the energy problems of the future is not the only goal. Residents must be assured of a comfortable environment. Jang, Kang, Cho, Jang, and Park [19] proposed an IoT-based HVAC and Lighting (I-HVAC&L) system for HVAC system and lighting system management. With the solution energy can be efficiently saved without compromising the comfort of residents

Rapid population growth, environmental pollution, and global warming are reducing the production level of the fisheries (freshwater shrimp) sector. In order to address these problems, Salah, Fatin, Rasadin, and Ruhel [20] presented a real-time freshwater shrimp farm monitoring system integrating technologies such as microcontroller-based physical devices, internet of things, and web applications, that allows remote monitoring, as well as receiving alerts when a water parameter (temperature, pH, dissolved oxygen, salinity level, and turbidity of water) out-of-range is detected. The physical implementation of this system consists of a set of sensors that allow for collecting data about the water metrics of shrimp farm.

Global warming, environmental pollution and power production costs are the major issues that the world is facing and many research works are done in the above areas to reduce the adverse effects arises due to fore mentioned issues. Pradeep, Krishnakumar, and Sowmiya [21] presented a hybrid energy generation by combining thermoelectric Generators (TEG) with solar energy. The proposed solution is intended to generate energy from both solar energy and the heating effect in the solar panel at the same time. This project also implements internet of things (IOT) technology to monitor and manage the electric energy harvested through this technology from anywhere.

Debauche, et al. [4] completed a previously proposed Edge Artificial Intelligence IoT system to optimize the use of water and computing of data at the edge level to aid processing videos locally in the event of limited Internet connection. This local computing power also allows the management of fertilizer supply, plants disease treatment and pest.

When considering the importance of air pollutants, it is crucial to monitor and prediction the air pollutants concentration as well as waste management. Hussain, et al. [22] presented an IoT-based smart bin using a machine and deep learning model. It manages the disposal of garbage and prediction the air pollutant present in the surrounding bin environment. The smart bin is connected to an IoT-based server, the Google Cloud Server (GCP), which performs the computation necessary for predicting the status of the bin and air quality based on real-time data.

Global warming has become a severe planet challenge. Thus, Mahmood, Kama, Azmi, and Ya'acob [23] proposed an IoT based home automation approach. This integrates with smart meter, renewable energy resources and government green awareness program to broadly optimize the need for energy consumption, security, cost, convenience and cleaner environment for the society. Furthermore, a survey was conducted for the purpose of identifying and evaluating its least impact in a sustainable development standpoint. The results revealed that there is a noteworthy impact of home automation thereby contributing to its solution.

Since there is a high population in cities and majority of the populace are too busy in earning a living, it's difficult to find places due to scarcity of land and no time for farming. Gudla, Padmaja, Srikanth, and Anji [24] proposed an IoT based plant monitoring system for healthy growth of the plant. This designed system takes care of the plant and prevents the effect from environmental changes and other kind of damages. The system also uses sentiment analysis to communicate the state of the plant to the user so that necessary actions can be taken. This system helps in increasing and improve farming and greenery in cities, in turn, reducing global warming.

8. METHODOLOGY

The In this section, a comparative analysis of IoT application in various economic sectors across different domain is presented. This helps to provide a basic understanding of the extent to which IoT is being applied. And also, to establish a view that IoT has immersed benefits in combating global warming.

Table 1 highlights various economic sectors where IoT has found its application, the methodology applied, benefits, and gaps. This shows the advantages of IoT in combating the aforementioned issues.

Table 1: Highlight of IoT Applications in Various Economic Sectors and their Benefits.

Literature Review	***Sector(s)***	***Problem***	***Methodology***	***Benefits***	***Gaps***
[11]	Environmental Sustainability	The issue of environmental pollution and climate change has become a global concern due to their impact on the environment.	Internet of Things: sensors for detection of air and noise pollutions	Real-time pollution monitoring Real-time alert generation	Lack of security features
[12]	Environmental Sustainability	Water pollution is one of the biggest fears for the green globalization. In order to ensure the safe supply of the drinking water the quality needs to be monitor in real time.	A low-cost IoT system	Monitor water quality automatically Low-cost and requires little to no human interaction More economical, convenient and fast. Good flexibility	Lack of security features
[13]	Environmental Sustainability	CO_2, a vital constituent of environment, causes a warming effect on the planet's surface. To safeguard the environment, monitoring and controlling these changes is a big challenge	IoT to measure the CO_2 emission using Raspberry pi which is sensitive to CO_2	A Simple Notification Service (SNS) to a mobile device The solution can be extended to detect other dangerous gases Control the CO_2 emission Real-time monitoring of CO_2 concentration	It is not a real-time system. And detects only CO_2
[14]	Environmental Sustainability	The potential for user-facing innovations to contribute emission reductions for limiting warming to 1.5 °C	Disruptive low-carbon innovations	Reduces emissions by relocating higher-carbon practices Engages users in efforts to reduce emissions	
[15]	Agriculture	Wildfires are exorbitantly cataclysmic disasters that lead to the destruction of forest cover, wildlife, land resources, human assets, reduced soil fertility and global warming.	A collaborative IoT–Fog–Cloud framework based on soft computing techniques such as fuzzy K-nearest-neighbor classifier, temporal mining and Holt–Winter's forecasting model	It is highly efficient and reliable for wildfire detection, prediction and forecasting. Real-time alert generation enhances the efficacy of system.	Limited attributes for wildfire detection were considered
[16]	Agriculture	Irrigation systems are becoming increasingly important, owing to the increase in	A low-cost autonomous sensor interface	Flexibility and practical	

		human population, global warming, and food demand.		applicability of the proposed system The expansion of economic activity Remote monitoring and control required to supply irrigation water	
[17]	Energy	Renewable energy surely gives many benefits, but one of the disadvantages in harvesting all these energies are so dependent on climate, weather, seasons and time.	Automatic Transfer Switch (ATS) enclosure can be applied for hybrid photovoltaic (PV) and wind turbine	Reduce time and improve energy efficiency	GPRS GSM has a weakness in it security architecture related to the compromise of confidentiality
[5]	Manufacturing	Pollutants generated by industries are the main causes of air pollution, thus, strict control of air pollution is required.	IoT Sensors based on 5G wireless network and blockchain	Manage and control air pollution Improve the cause of fundamental air pollution in industrial field	Private blockchain is govern by a single entity which is susceptible to hacking
[18]	Transportation	Due to poor vehicle maintenance and ignition defect, the gases emitted from the exhaust of a vehicle may increase.	IoT Based Vehicle Emission Monitoring System	Monitor the gases emitted from the vehicle exhaust Increase the life of the vehicle Reduce environmental pollution Inexpensive and easy to maintain	Lack of security features
[19]	Energy	Solving the energy problems of the future is not the only goal. Residents must be assured of a comfortable environment.	IoT-based HVAC and Lighting (I-HVAC&L) system for HVAC system and lighting system management	Energy is saved efficiently without compromising the comfort of residents	
[20]	Agriculture	Rapid population growth, environmental pollution, and global warming are reducing the production level of the fisheries (freshwater shrimp) sector. Hence environmental and production parameters should be constantly monitored to	This monitoring system integrates technologies such as microcontroller-based physical devices, internet of things, and web applications	Shrimp mortality rate reduction; Disease prevention by alerting the user about water score; Improved production. The IoT technology minimizes the cost of implementation	Lack of security features

		ensure quality in the production chain.			
[21]	Energy	Global warming, environmental pollution and power production costs are the major issues that the world is facing.	Hybrid energy generation by combining Thermoelectric Generators (TEG) with solar energy	It causes no effect on nature, that is, pollution free. Not prone to any kind of accident due to lightning. Minimize energy supply load, that is, cut short energy charges. Inexpensive energy charges Equipment requires less maintenance charge	Still under development
[4]	Agriculture	Overcoming population growth dilemma with less resources of soil and water.	Edge Artificial Intelligence IoT	Improve water savings by 70% Integrates plant disease and pest recognition	A compromised Master agent brings down the entire system
[22]	Environmental Sustainability	When considering the importance of air pollutants, it is crucial to monitor and prediction the air pollutants concentration as well as waste management.	IoT-based smart bin using a machine and deep learning model	Real-time monitoring of garbage levels Notifications from the alert mechanism.	Detects only CO_2 gases
[23]	Environmental Sustainability	Over the past few decades, global warming has become a severe worldwide challenge.	IoT based home automation approach	The usage of home automation has a great impact in a sustainable development standpoint	
[24]	Agriculture	Since the population of cities are more and majority of the occupants are too busy earning a living, it's difficult to find suitable places for farming due to scarcity of land and time	IoT based plant monitoring system	Monitors plant growth health Prevents the effect of environmental changes Real-time notification on state of the plant	Lack of security features

9. DISCUSSION OF FINDINGS

In this research, we showed that economic and environmental issues such as global warming, climate change, pollution and so on, are real and significantly affecting the planet. With evidences signifying the growing concentration of atmospheric gases due to human activities as the mainly cause of these issues. Furthermore, we shed some light on IoT as an integrated, cost-effective, comfortable and reliable approach to combating economic and environmental issues. The concept of the IoT is one of the essential technologies to attain the objective of affordable energy and environment sustainability. Today, the use of IoT technology is rapidly increasing, thus, the planet can be interconnected

into one network available to all. Also, renewable energy resources (such as, solar, wind and geothermal) and green awareness program can be utilized to minimize the energy demands and achieve the green technology objectives and environmental sustainability. This approach can play an important role in optimizing accessibility, comfortability, cost, environment, behaviour and promote awareness. The important elements of green awareness program can be combined with IoT which could offer assistance to society. For example, smart metering plays a substantial role in managing efficiency and improving consumption of energy resources. Also, management of climate change with recent technologies is just the beginning.

The large-scale application of IoT products and services (as seen in Table 1) has the potential to change many aspects of our lives. Such as:

- For consumers, the vision of a smart home is possible with new IoT products such as Internet-enabled appliances, home automation components, and energy management devices, providing more security and energy efficiency.
- The way healthcare services are delivered is transforming with personal IoT devices such as wearable fitness and health monitoring devices and network-enabled medical devices. With potential benefits for people with disabilities and the elderly, empowering better quality of life and independence at an affordable cost.
- Bringing us closer to the idea of smart cities, IoT systems such as networked vehicles, intelligent traffic systems, and sensors embedded in roads and bridges, which help curtail congestion and energy consumption.
- By increasing the accessibility of information along production value chain using networked sensors, IoT technology provides the opportunity to transform agriculture, industry, and energy production and distribution.

Thus, public and private organizations will need to collaborate to grow the investment ratio in IoT solutions. IoT will provide actionable data and a control to environmental wastes. IoT will continue adapting, as scientist, researchers and technology developers reach new agreement on actions needed to protect against these rising limitations to the adoption of IoT such as security, as well as, the economic and environmental issues. Nevertheless, the scientific and research communities should show a positive attitude for the sake of addressing the economic and environmental issues and suitable measures must be taken to promote and adopt climate-friendly behavior, strategies and procedures.

10. CONCLUSION

The importance of Internet of Things (IoT) in technology, policy, and engineering cannot be overemphasized. This has become headline news both in specialty press and popular media. IoT technology embodied an extensive range of networked products, systems, and sensors, which take advantage of the progressions in computing power, electronics miniaturization, and network interconnections to offer new and unique capabilities not formerly possible. While the concept of monitoring and controlling devices using interconnected computers, sensors, and networks is not new, the current convergence of key technologies is driving new possibilities for IoT. IoT promises a revolutionary, fully interconnected planet. This also brings new strongly intertwined relationships between things and their environment, and things and people. The view of IoT as a global array of devices connected to the Internet might essentially change how we think about the term “online”. While the possible benefits are noteworthy, some challenges still hinder the large-scale adoption of IoT—predominantly in the aspects of security; privacy; interoperability and standards legal, regulatory, and rights issues; and emerging economies and development. IoT encompasses a multifaceted and developing set of technological, social, and policy considerations across a diverse set of participants. IoT is trendy now, hence the need to address its challenges and maximize its benefits while reducing its risks.

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