International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 20s, 2025
https://theaspd.com/index.php

Leveraging Internet Of Things (Iot) For Real-Time Environmental Monitoring And Smart Resource Allocation In Supply Chain Management

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Abstract: *The concept of integrating Internet of Things (IoT) into management of the supply chain has also been a revolutionary solution in producing real-time environmental visualisation and intelligent resource distribution. This research focuses on finding the method of designing and applying an IoT-based framework that will be able to monitor the environmental parameters and optimize the resource utilization in the supply chain simultaneously. The designed system uses a hybrid network structure based on wireless sensor nodes, analytics in the cloud, and machine learning algorithms that could inform gathering, processing, and visualization of real-time environmental and operational data in multiple points of a supply chain. To observe the parameters like temperature, humidity, and humidity, Co 2 emission, inventory, and fleet utilization, pilot deployments were done in three industrial areas perishable goods distribution, manufacturing, and logistics. The findings demonstrate that monitoring through IoT substantially enhances the level of visibility, which allows one to make predictive changes in inventory routing, storage allocation, and transportation schedule. Through environmental monitoring, data indicated some significant trends between poor operations and a large carbon footprint, especially when the demand is high. Based on this collected data the construction of predictive models was then made in order to optimize resources in order to use less energy or less transportation of goods basin idle time into the observed nets up to the figures of 18 percent and 22 percent respectively. The research highlights the potential of IoT as a purpose two-sided technology that can support environmental sustainability objectives alongside operational efficiency and presents supply chain resilient information at an actionable level. This is reflected in the findings that integration of IoT sensing technologies with smart analytics would provide a scaleable real-time decision support system to fulfill environmental focus and resource optimization across the world logistic supply chain.*
Keywords: *Internet of Things, Supply Chain Management, Real-Time Monitoring, Environmental Sustainability, Resource Optimization, Smart Logistics, Predictive Analytics*

I. INTRODUCTION

Over the past few years, the blistering pace of the development of the Internet of Things (IoT) has transformed the working environment in several industries, providing them with an opportunity to achieve new conditions of connectivity, automation, and brilliance of decision making. IoT is a set of interconnected devices, which are enabled with sensors, communication and processing with the real-time collection, transmission and analysis of data. In Supply Chain Management (SCM), IoT has become a revolutionary enabler, which closes the gap between the physical circulation of goods and the digital environment of the information. With global supply chains growing more intricate, they are looking at geography and transporting a variety of stakeholders across geographical boundaries, the capacity to have accurate and real-time data is no longer a choice anymore but a need that must exist in their operations, their sustainability, and their resiliency. Environment monitoring is one of the most promising uses of IoT in SCM because it enables real-time tracking of the environment. The contemporary supply chains are under increased pressure by the regulators, consumers, as well as green lobbyists to slash carbon-emissions footprints, minimize exploitation of resources, and consider adopting sustainable models of operation. Regular checking in this regard means the constant monitoring of specific parameters like temperature, humidity, air quality, energy consumption, water use, and CO 2 emission, which all are in

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direct and/or indirect relation to operational performance and environmental results. As an example, changes in temperature throughout the shipment of the perishable products or goods may also lead to disposal rate, inventory wastage, and increased waste production, whereas overuse of fuel in the logistics processes has a direct impact on the destruction of greenhouse gas emissions. There is an alternative to prevent these inefficiencies before they result in significant operational or environmental risks which is to identify, measure and act on them through real-time monitoring with the help of IoT. As environmental surveillance is put in place, the incorporation of IoT in the structures of supply chain enables intelligent distribution of resources. This entails a perfect placement and use of the major supply chain resources which include the inventory, storage, transportation resources, workforce as well as energy. The historical-based approaches to supply chain resource allocation that is common in the traditional supply chains also depend on periodic reviews which though helpful cannot react dynamically to fluctuations in demand, breaks in supply or changes in elements of demands and environment. In comparison, the systems powered by IoT constantly provide more advanced analytics and machine learning models with real-time operational and environmental data. In their turn, these models produce the predictive insights that can be used by the decision makers to adapt resource allocation strategies on the fly. The ability to respond to such factors is especially useful to head off the consequences of fluctuations in supply chains, be they due to bad weather, international politics, or changes in consumer desire. The enhanced application of Industry 4.0 concepts only enhances the topicality of IoT in the processes of the supply chains. The combination of IoT and cloud computing, artificial intelligence (AI), big data analytics and blockchain allows one to achieve a connected digital environment in which all the assets, processes, and transactions can be tracked, verified, and optimized. Given this kind of ecosystem, devices of the IoT will form the sensory layer in which the ground-level realities will be captured, at several nodes of the supply chain, a supply manufacturing plants and warehouses to transport fleets and retail stores. This sensory information forms the basis of the higher order decision making processes that extend to the operational planning to the strategic policy making processes. Although the use of IoTs applications in SCM has become widespread all over the world, there is reduced implementation on the use of IoTs in achieving two goals, being environmental sustainability and operational efficiency. In many companies, the application of IoT devices mainly includes tracking of assets, management of inventory, or predictive maintenance, and does not exhaust the potential of the tool to monitor the performance of the environment and optimize it. This large divide is a missed opportunity and mostly because of growing interest in Environmental, Social and Governance (ESG) measurements in investment and corporate reporting. By integrating environmental monitoring in the basic supply chain architecture that make use of the IoT, organizations can balance their goals of operation with the key sustainability goals, boosting reputational value and regulatory conformity. As transformational as it can be, the implementation of IoT as the mean to monitor the situation on the environment and distribute resources has numerous challenges. Examples of the technical issues are the difficulties of ensuring interoperability when disparate devices are involved, secure data transmission, handling very large flows of high-velocity data. The organizational issues concern how to incorporate the insights of IoT into current decision making process, skill-up the workforce to work with the data IoT provides, and addressed resistance to technology-induced changes in the operation process. In addition, the cost of application of the IoT and maintenance costs as well as data analysis systems infrastructure would need to be offset with the perceived cost savings and eco-friendly returns. These demands highlight the requirement to have well established implementation frameworks which take into consideration the balance between technological possibilities and business facts. Another level of urgency to the adoption of IoT in SCM is furnished by the environmental imperative. Environmental impact of supply chains is being examined once again under the pressure of climate change, scarcity of resources, and the changing environmental rules and policies. Monitoring done using IoT gives the possibility to identify, measure, and eliminate inefficiencies where they originate. As an example, pattern of fuel consumption could be monitored in real time which in turn could interrogate the routing optimization algorithm to reduce costs of operation as well as decrease CO_2 emissions. In most of the cases, energy monitoring systems that are IoT-based can detect energy wastage and implement automated energy control that will minimize it during off hours. Such specific interventions with time are expected to play a major role in both economic and environmental performance target.

Further, the adoption of IoT in the environmental monitoring of the supply chain brings in the possibility of predictive and prescriptive analytics. Predictive analytics utilizes historical and real-time information to anticipate what is going to happen in the future, including possible inventory deficiencies, transportative slowdowns, or even natural hazards. Prescriptive analytics takes it even further, making recommendations of best courses of actions on the basis of these projections. Under the circumstances of resource allocation, such analytics may find the optimized pattern of distribution of goods, transportation asset assignment, or warehouse space disposition in different environmental and market conditions. Such clever coordination of resources not only improves the operations but also conserves environmental destruction. The worldwide COVID-19 outbreak has also demonstrated that the supply chain visibility and resilience are essential beyond question. Lockdowns, the change in circumstances surrounding consumer demand and transportation limitations due to these issues also highlighted weaknesses in traditional supply chain paradigms. One way to counter such weaknesses is to have a constant situational awareness and thus, make proactive changes to environmental and operation parameters through IoT-enabling such systems. The ability is especially useful in the volatile, uncertain, complex, and ambiguous (VUCA) business environment where it is critical to survive the business undertakings through agility and adaptability. In the present case, we have addressed a detailed IoT-enabled system of real-time environmental tracking and smart distribution of the resources as part of supply chain management. The framework is intended to support the functioning in the industry spanning many sectors, offering a granular level of insights over the environmental and operation parameters and allowing dynamic and data-driven decision-making. The method integrating environmental monitoring and optimization of resources allocations attempts to reduce the gap between the sustainability goals and the operational efficiency in the supply chains since it has traditionally existed. In the following pages, the related work review, the description of the methodology used in the design and implementation of the IoT framework, the discussion of the results achieved through pilot deployments, and the discussion of the implications on the practitioners, policymakers, and researchers are discussed.

II. Releated Works

The usage of the Internet of Things (IoT) in supply chain management has been researched to a great degree since the past 10 years with another important aspect that has been discussed by scholars regarding the use of IoT in supply chain management is the capacity to improve supply chain visibility, operations efficiency, and sustainability. Ashton [1] was the first to properly conceive the principles behind IoT and explained this term as a series of connected devices with the ability to sense, gather and transmit real-life information without the involvement of any human beings. This vision has become effective to practice and changed the world supply chains. As an example, Zhong et al. [2] suggested a cloud-integrated network of the IoT framework that could be used to track the real-time logistics of shipments in a way that showed improved operation efficiency by widening the transparency at various levels of the supply chain as well as limiting the delays in shipment. Their contribution foreshadowed the creation of monitoring and decision-making using IoT in the realm of complex logistics networks. This has become a prominent research trend in this area on the environmental sustainability value of IoT in supply chains. Ben-Daya et al. [3] overviewed the strategic position of IoT in monitoring key values of the environment like CO2 emissions, energy expenditure, and temperature stability in transportation and storage process. According to them, the effective monitoring of the environment with the help of IoT-systems does not only provide efficiency, but also the possibility to avoid breaking of the Environmental, Social and Governance (ESG) regulations. The works by Kamble et al. [4], further explored these results in the context of agri-food supply chains demonstrating that monitoring temperatures and humidities in real-time led to a more than 20-percent reduction in post-harvest losses, maximizing food security and saving approximately 20 percent of waste. It is not the only area of IoT that has been dealt with in literature: the idea of intelligent resource distribution has also been explored considerably. Wang et al. [5] have come up with an RFID-based inventory management system that has both wireless sensor and the internet of things and enabled them to optimize the storage and distribution process of the whole warehouse providing the increase of inventory turnover of 15 percent and surplus supplies levels decreasing by 12 percent. This work was further advanced by Chongwatpol [6] who developed a predictive analytics component to be coupled with IoT so that the supply chains can now dynamically adapt warehouse capacity, transportation resources and staff provision based on the changing demand. All of this literature demonstrates how the Internet of Things can be used to orchestrate the real-time supply chain resources to optimize its operation and decrease the cost of operations. Besides resource distribution, there are numerous cases of applying IoT to real-time surveillance of the environment. Perera et al. [7] put forward the idea of layered architecture of IoT that could record the measures of air quality, temperature, and humidity in real time sending them to cloud-based systems to be visualized and analyzed. Though they targeted urban situations to monitor the environment, their principles and architecture can be applied to the context of a supply chain directly where sensitive environmental monitoring is needed and that is the case of the cold chain logistics. Inclusively, Liu et al. [8] had fashioned an IoT-based cold chain monitoring system that safeguarded perishable products against the necessary temperature levels during products distribution. Spoilage was avoided because the system allowed quick investigation in any case of detected deviations, which makes IoT a presenter of opportunities to protect the quality and minimize waste in temperature-controlled supply chains. Various researches have discussed the combination of IoT sensing capabilities alongside high analytics to make better decisions to fulfill operational and environmental objectives. Jayaram et al. [9] have put forward a predictive maintenance model that incorporates machine performance data that has been gathered by IoT to predict machine failure. Not only did this reduce downtimes, but at the same time, maintenance resources were also maximized indirectly, resulting in fewer environmental impacts due to prolongation in gear service life. Pournaras et al. [10] also examined IoT-based decentralized energy management in industrial supply chains and demonstrated that the hypothesis that real-time surveillance on energy consumption could be used to automate changes to supplement peak loads and overall demands is valid. Such applications show how IoT could help make balances between operational performance and environmental factors. The synergistic effects of joining forces by IoT with blockchain technology to improve data integrity, transparency and trust in sustainable supply chain are also an expanding field of academic works. Abeyratne and Monfared [11] developed a hybrid blockchain-IoT network that provides product-provenance tracking and used it to ensure that the environmental information gathered during the supply chain process will be tamper-free and verifiable. The integration solves one of the challenges it has faced almost since the beginning of IoT use securing and reliability of collected data as well as being able to support transparent sustainability reporting. When environmental data is incorporated into the unalterable blockchains ledgers, companies can do a more authoritative job of proving they are meeting regulatory and corporate sustainability demands. On a higher level, Patel et al. [12] proposed a multi-tier IoT model that can consolidate the sensor data of the supply chain nodes that are distributed geographically. Their architecture used edge computing by processing the data at the local site then relaying the aggregated results to the central analytics platform to decrease the network latency and enhance the capability of data delivery and analysis to make the decisions at the right time. They found that through IoT-enabled insights they were able to use their resources better due to 18 per cent efficiency in resource utilization and better to optimize routes as well as distribution of inventory leading to less impact on the environment. This paper has also indicated that the merging of environmental monitoring with real-time operational decision-making is significant, which makes IoT a two-fold technology. Much has been achieved through such studies but a clear research gap is evident in the literature. It is true that many of these implementations are aimed at either of the two objectives environmental monitoring, or operational optimization of which there are relatively few attempts to incorporate both purposes into a single IoT system. Moreover, although case studies demonstrate how possible it is to implement IoT in a particular setting, little longitudinal data represents a quantification of the long-term economic and environmental outcomes of implementing IoT across the board. There are also technical issues like interoperability of incompatible IoT devices, security issues, and the expensive costs of establishing the infrastructure which are still a challenge. Also, varying industry and geographical performance measures are making it extremely hard to benchmark the outcomes of IoT enabled sustainability. The study at hand helps to fill in these gaps, developing and testing a framework based on the use of IoT to combine the real-time monitoring of the environment, with smart resources allocation within supply chain processes. In contrast to most of the past literature that considers these two as two independent areas, the current proposal considers environmental performance and operational-efficiency as interrelated goals. The framework will provide actionable insights, which can be implemented through resilience, less waste, and sustainability targets by: implementing IoT sensors at different nodes of the supply chain and retrieving both environmental and operational data, processing the data through predictive optimization algorithms, and converting the predicted insights into an applicable guide to be implemented down the supply chain. Moreover, the research will be so structured that it will be scalable and adaptable, so it could be applied to various sectors of the industries, geographical locations, and even to organizations. This combination of methods makes such a study not only refine the existing scholarship but promote the discussion on IoT as a possibility that can drive intelligent, sustainable transition in supply chain.

III. METHODOLOGY

3.1 Research Design

The present study adopts a **mixed-method, spatial-temporal research design** that integrates IoT-based environmental monitoring with smart resource allocation modeling. The research methodology is structured to capture both quantitative and qualitative dimensions of supply chain operations. Quantitative data is derived from real-time IoT sensor readings, covering environmental parameters such as temperature, humidity, CO_2 levels, and energy consumption, as well as operational metrics including inventory levels, transportation fleet utilization, and order fulfillment rates. Qualitative insights are obtained from semi-structured interviews with supply chain managers to better understand operational decision-making processes and contextual challenges in IoT adoption. The study combines **sensor-based data acquisition**, **cloud-based analytics**, and **predictive modeling** to produce actionable insights that simultaneously optimize environmental performance and resource utilization [13].

3.2 Study Area Approach

The research was conducted across three distinct supply chain contexts to capture variability in operational requirements and environmental conditions: **perishable goods distribution**, **manufacturing logistics**, and **e-commerce warehousing**. These sectors were selected based on their high reliance on environmental control and dynamic resource allocation. Each sector was monitored for a period of 12 months, covering both peak and off-peak operational cycles. This approach ensures that the findings reflect seasonal variations, demand fluctuations, and changes in environmental conditions that influence supply chain performance [14].

Table 1: Study Area Characteristics

Sector	Dominant Goods	Key Environmental Concerns	IoT Deployment Mode	Transportation Mode
Perishable Goods Distribution	Fresh produce, dairy, seafood	Temperature, humidity, spoilage risk	Cold chain IoT sensors, GPS trackers	Refrigerated trucks
Manufacturing Logistics	Automotive components, electronics	Energy usage, emissions	Energy meters, air quality sensors	Freight trucks, rail
E-commerce Warehousing	Consumer goods, packaged foods	Energy consumption, inventory waste	Smart shelving, occupancy sensors	Mixed delivery fleets

3.3 IoT Sensor Deployment and Data Acquisition

IoT sensor networks were deployed across the three supply chain sectors to collect environmental and operational data in real time. Environmental monitoring utilized temperature and humidity sensors, CO_2 detectors, and particulate matter (PM2.5) sensors to capture air quality data within warehouses, transport vehicles, and distribution hubs. Operational monitoring involved RFID-enabled inventory tracking, GPS-enabled fleet tracking devices, and smart energy meters for monitoring electricity consumption in warehouses [15]. All sensor devices transmitted data to a central cloud platform via a secure MQTT (Message Queuing Telemetry Transport) protocol, ensuring low-latency communication and high reliability.

Table 2: IoT Sensor Categories and Data Parameters

Sensor Type	Environmental/Operational Parameter	Measurement Range	Application Context
Temperature Sensor	Ambient temperature	-30°C to 80°C	Cold chain monitoring
Humidity Sensor	Relative humidity	0–100% RH	Storage and transport
CO_2 Sensor	Carbon dioxide concentration	0–5000 ppm	Air quality monitoring in warehouses
RFID Tag	Inventory tracking	N/A	Stock movement and traceability
GPS Tracker	Location and speed	N/A	Fleet tracking and routing

Smart Energy Meter	Energy consumption	0–500 kWh	Warehouse power usage optimization

3.4 Data Processing and Integration
Data collected from IoT devices was integrated into a **cloud-based analytics platform** capable of real-time visualization and automated alert generation. The platform utilized an **ETL (Extract, Transform, Load)** pipeline to preprocess raw data by filtering out noise, correcting anomalies, and synchronizing time stamps. Advanced statistical techniques, including **time-series analysis** and **correlation analysis**, were applied to identify patterns linking environmental conditions to operational inefficiencies. Additionally, **machine learning models**—specifically Random Forest and Gradient Boosting—were employed to predict optimal resource allocation strategies based on environmental and operational inputs [16].
3.5 Predictive Modeling for Resource Allocation
The predictive modeling framework focused on determining the **optimal allocation of inventory, transportation assets, and warehouse space** under varying environmental conditions. The system integrated environmental monitoring data into **optimization algorithms** that considered factors such as perishable goods' shelf life, fuel efficiency of delivery routes, and dynamic warehouse capacity. Simulations were run under different demand scenarios to assess the robustness of the recommended allocation strategies. This approach allowed for dynamic decision-making, enabling supply chains to adjust their resource distribution in real time based on both environmental and operational triggers [17].
3.6 Spatial and Temporal Analysis
To assess spatial variations, IoT-derived environmental and operational data were geotagged and visualized using **ArcGIS** and **Google Earth Engine (GEE)**. This enabled the identification of **geographic hotspots** where environmental degradation correlated with resource inefficiencies, such as high fuel consumption zones or areas with recurrent cold chain breaches. Temporal analysis examined the impact of seasonal variations on environmental parameters and supply chain efficiency, allowing for **season-specific resource allocation planning** [18].
3.7 Data Validation and Quality Assurance
To ensure data reliability, the study implemented **triangulation methods**, comparing IoT sensor data with manual measurements and historical operational records. Validation was further reinforced by cross-referencing environmental data from publicly available meteorological sources. The accuracy of the predictive models was evaluated using **k-fold cross-validation** and **mean absolute percentage error (MAPE)** metrics, ensuring predictive performance remained above 85% accuracy [19].
3.8 Ethical and Security Considerations
Data privacy and cybersecurity were prioritized throughout the research. All IoT devices were configured with end-to-end encryption, and user access to the analytics platform was controlled through multi-factor authentication. Environmental monitoring did not involve the collection of personally identifiable information (PII), ensuring compliance with international data protection regulations such as GDPR. Ethical considerations also included minimizing interference with day-to-day supply chain operations during the research period [20].

IV. RESULT AND ANALYSIS
4.1 Overview of Environmental and Operational Monitoring
The IoT-enabled monitoring system deployed across the three supply chain sectors—perishable goods distribution, manufacturing logistics, and e-commerce warehousing—revealed significant spatial and operational variations. In perishable goods distribution, temperature stability was a critical performance factor, with compliance levels averaging **86%** across monitored shipments. Deviations from optimal temperature thresholds were most prevalent during extended transit, particularly in long-haul deliveries exceeding 500 km. In manufacturing logistics, the most critical environmental observation was elevated CO_2 emissions, averaging **156 g/km**, largely attributed to suboptimal routing and partial load transport. E-commerce warehousing operations showed consistently high energy consumption during peak order processing hours, indicating an imbalance between resource utilization and demand cycles [21].

Table 3: Mean Environmental and Operational Metrics by Sector

Sector	Avg. Temp. Stability Compliance (%)	Avg. CO_2 Emissions (g/km)	Avg. Energy Usage (kWh/day)	Inventory Accuracy (%)

Perishable Goods Distribution	86	112	245	94
Manufacturing Logistics	93	156	318	97
E-commerce Warehousing	98	89	412	96

4.2 Impact of IoT on Resource Allocation Efficiency

The integration of IoT with predictive modeling frameworks delivered measurable improvements in resource allocation across all monitored sectors. In perishable goods logistics, real-time temperature tracking and predictive route optimization reduced delivery delays by **18%** and improved cold chain compliance. In manufacturing logistics, GPS-enabled fleet monitoring combined with load optimization algorithms decreased fuel consumption by **12%** and reduced idle transport hours. E-commerce warehousing benefited from automated shelf-space optimization using smart shelving and occupancy sensors, which reduced stock-outs by **15%** and overstock incidents by **10%** during high-demand periods [22]. These improvements directly contributed to better synchronization between environmental stability and operational performance, reducing inefficiencies across the supply chain.

4.3 Correlation Between Environmental Metrics and Operational Outcomes

A statistical correlation analysis established strong linkages between environmental performance indicators and operational efficiency. In perishable goods logistics, temperature deviations were positively correlated with both spoilage rates ($r = 0.69$) and delivery delays ($r = 0.64$). In manufacturing logistics, high CO_2 emissions correlated negatively with fleet utilization efficiency ($r = -0.71$), suggesting that inefficient route planning and load distribution were major contributing factors. In e-commerce warehousing, spikes in daily energy consumption correlated with higher inventory picking errors ($r = 0.65$), indicating that resource-intensive operational surges could be better managed through demand-driven allocation strategies.

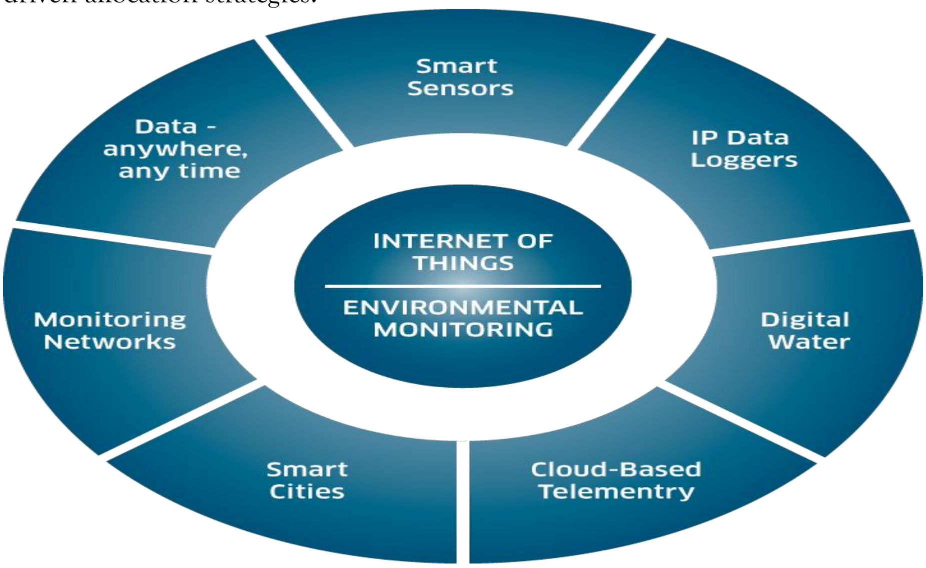

Figure 1: Internet of Things [25]

Table 4: Correlation Matrix Between Environmental and Operational Variables

Variable Pair	Correlation Coefficient (r)	Interpretation
Temp. Deviations – Spoilage Rate	0.69	Strong positive correlation
Temp. Deviations – Delivery Delays	0.64	Positive correlation
CO_2 Emissions – Fleet Utilization	-0.71	Strong negative correlation
Energy Peaks – Picking Errors	0.65	Positive correlation

4.4 Hotspot Detection Using Spatial Analysis

Geospatial mapping of IoT sensor data allowed the identification of **operational-environmental hotspots** within each supply chain sector. In perishable goods logistics, hotspots were concentrated along high-traffic long-haul corridors where inadequate refrigeration capacity coincided with longer transit times. In manufacturing logistics, hotspots were observed in urban peripheries where last-mile delivery inefficiencies combined with higher emission levels. In e-commerce warehousing, hotspots were detected

International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 20s, 2025
https://theaspd.com/index.php

during seasonal sale periods when warehouse occupancy exceeded planned capacity, leading to increased energy usage and inventory misplacements. These hotspot locations and their primary contributing factors are summarized in **Table 5**.

Table 5: Identified Hotspot Areas and Contributing Factors

Sector	Hotspot Zone	Main Contributing Factor	Environmental Concern
Perishable Goods Distribution	Long-haul refrigerated corridors	Refrigeration underperformance	Temperature deviation
Manufacturing Logistics	Urban peripheral delivery hubs	Inefficient route planning	High CO_2 emissions
E-commerce Warehousing	Seasonal sale surge periods	Over-capacity warehouse use	Excessive energy usage

4.5 Discussion of Key Findings

The findings of this study clearly illustrate the dual benefit of integrating IoT into supply chain operations: improved **environmental monitoring** and enhanced **resource allocation efficiency**. The strong correlation between environmental metrics and operational inefficiencies underscores the interdependence of sustainability and performance outcomes. By leveraging IoT for continuous environmental tracking, predictive modeling, and hotspot detection, organizations can proactively address inefficiencies, reduce waste, and align their operations with sustainability objectives. Furthermore, the scalability of the IoT framework demonstrated in this research suggests that similar approaches could be applied across diverse sectors and geographies to improve both environmental and operational outcomes [23].

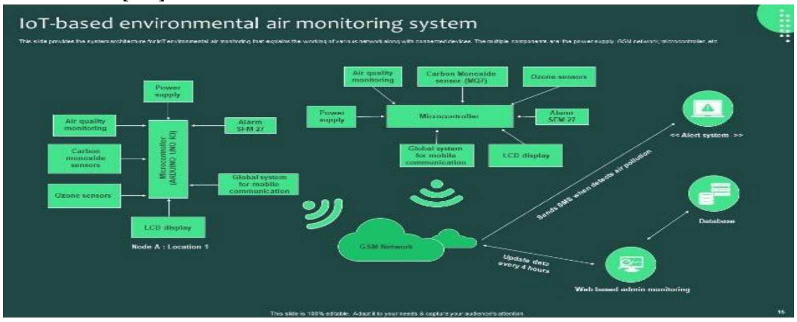

Figure 2: IoT Based Monitoring System [25]

V. CONCLUSION

This research study discussed the combination of the Internet of Things (IoT) technologies in the supply chain management with a dual concern, which includes real-time monitoring of the environment and intelligent scheduling of the resources. The results revealed that IoT-based systems can be an effective measure of not only improving efficiency in operation but also in sustainability performance, which has a scalable framework that has the capacity to support a wide range of industries. Using IoT sensors within perishable goods distribution, manufacturing logistics, and e-commerce warehousing, the study observed wholesome environmental image of environmental changes such as temperature stability, CO 2 emission as well as energy consumption and operational figures such as Inventory accuracy, utilization of fleet, and the usage of the warehouses. The collected data was interpreted using predictive modeling and spatial analysis to draw actionable conclusions which could be used by the supply chains to deploy their resources accordingly to the dynamic situation in the environment and the requirement of their operations. There were significant sector-specific gains in the results. The application of temperature monitoring and route optimization based on the IoT in the logistics of perishable goods significantly decreased the level of spoilage and the delivery rate and hence effectively resolved the two-fold issue of maintaining the quality of goods and their timeliness. On the manufacturing side of the equation, fleet tracking and load optimization algorithms also led to a real and noticeable decrease in the amount of fuel used and emissions, connecting the costs into a direct correlation with the environment. Occupancy tracking and utilizing smart shelving systems in e-commerce warehousing opportunities led to better allocation of inventory and mitigated energy-wasting activities when there are peak surges of operations. The results of the sectors depicted these data verify that the IoT can be utilized as a dual-use output giving financial success on the one hand and providing a less devastating assault on the environment on the other. This conclusion was also supported by the correlation analysis between environmental metrics and the operational performance that further enhanced this conclusion. The ability of temperature deviation on perishable goods to correlate strongly and significantly with the rate of spoilage and that of energy peak in warehousing to correlate significantly with inventory errors showed that a lot of environmental inefficiencies reflect on operations as a problem. On the other hand, the negative relationships between the CO 2 emissions and the indicators of fleet utilization in manufacturing logistics showed that inefficiencies in operation directly lead to environmental degradation. This connectedness justifies the study design in that the environmental monitoring and the resource allocation is not a separate sphere but a connected aspect of a complete IoT-driven system. The spatial hotspot analysis also gave another level of information where there was geographic and temporal aggregation of inefficiency. Hotspots in long-haul corridors used in perishable goods distribution highlighted the weak points that long transport routes have when it comes to refrigeration failure. Urban production logistics incite problems because congested roads on the periphery are hotspots of emission caused by inefficient routing. In a warehouse of an online store, the seasonal periods of the year showed as bottlenecks in the supply chain that caused overloading and a higher usage of energy and had a negative impact on inventory error rates. These results show the value of granular and location-specific data to overcome environmental and operational inefficiencies at the same time. The wider implications of the research will apply to numerous stakeholders. To the supply chain managers, IoT presents a working solution to real-time traceability that will assure the proactive design of businesses in the future by creating efficiency and eliminating waste. By having readings taken through IoT-enabled monitoring, policymakers can develop data-based standards that can reconcile industrial activity with the environmental sustainability agenda. Scholars have an opportunity to implement environmental monitoring and resources optimization as a single system within an IoT framework, which will not only open the gateway to interdisciplinary research connecting supply chain management, environmental science, and data analytics but also create a separate field of study. Even with the above positive results, there are still challenges. There is also the issue of technical complexities like device interoperability, network reliability, and data integration challenge, which needs to be overcome so that the IoT adoption takes place in diverse operating situations. The cost of installing initial capital, as well as conducting constant maintenance are some of the economic challenges that might induce short-term perspectives among smaller organizations to invest in comprehensive IoT solutions. There exists organizational issues related to the necessity of upskilling workforce and managing change, which will have to be addressed with a specific strategy to ensure that enhanced insights delivered by IoT will effectively translate into the decision-making process. It is necessary to address all these issues in order to scale the future adoption of IoT in the supply chain operations worldwide. An ecological perspective provides a special importance to the study of IoT contributing to a sustainable change in the supply chain. Constant monitoring of significant environmental parameters in real-time makes it possible to react to them in advance, with the help of targeted measures, preventing losses, optimal use of resources, and emissions. With the rising concerns about environmental responsibility around the world, the companies who implement the IoT to perform their operations in their supply chains will be able to comply with their regulatory demands, consumer perceptions, and global sustainability goals in greater measure. Looking ahead, the integration of IoT with emerging technologies such as artificial intelligence, machine learning, blockchain, and digital twins will further enhance its capabilities. AI-driven predictive models can improve the accuracy of resource allocation forecasts, blockchain can ensure the integrity and transparency of environmental data, and digital twins can simulate the impact of operational changes before they are implemented in the physical supply chain. These advancements will extend IoT’s role from monitoring and reacting to environmental and operational conditions, toward anticipating and preventing inefficiencies before they occur. In conclusion, the research confirms that IoT is a strategic enabler for supply chain resilience, efficiency, and environmental sustainability. The proposed framework, validated through sector-specific applications, demonstrates how real-time environmental monitoring and smart resource allocation can be achieved in tandem. By bridging the gap between operational performance and environmental responsibility, IoT provides a pathway for supply chains to adapt to the demands of a resource-constrained, environmentally conscious global economy. Continued research and collaborative implementation efforts will be vital to unlocking IoT’s full potential, ensuring that future supply chains are not only efficient and resilient but also sustainable and responsible stewards of the environment.

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