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REVIEW ARTICLE

Smart Earth Technologies: a pressing need for abating pollution for a better tomorrow

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Abstract

Standing at the cusp of an augmented age facilitates a glance into the future of a cybernetic world aligned with planetary wellbeing. The era of exponential technological revolutions has brought with it a plethora of opportunities expanding in a multi-faceted dimension with an added emphasis towards nurturing a mutual synergy of nature with a daily dose of digitalization. The paper is written with an intent to lay out an accumulated comprehensive review of different literary works which lay the grounds for how different Smart Earth Technologies aid in monitoring and tackling the degradation of air and water resources. If an intertwined state-of-the-art centralized research source could be created, it would become a boon for seasoned researchers and neophytes succeeding portion of the article expands itself to a wide variety of research literature complimented with real-time models, case, and empirical studies which help heighten the previous limit to the research done on these Technologies tinkering the present monitoring systems. The primary aim of this work is to fuel the need of theoretical, practical, and empirical evolution in the ways the intelligent technologies help blossom a pollution-free environment. The secondary intention was to ensure that in-depth study of Smart Environmental Pollution the Monitoring Systems provisioned a multitude of prospects for upgrading one's knowledge on environmental management through current world technologies. By looking at these trends of the past, the enthusiast of technology could collaborate with the researchers of Environmental Pollution to assist in proliferation of diverse 'smart' solutions creating a Smarter, Greener, and Brighter future for research and developments in Sustainable Technologies devising a pollution-free environment.

Keywords Smart Earth · Artificial intelligence · Technology · Pollution

Introduction

A present-day question to enquire — how has the so-called futuristic generation of the modern era grown up in response to one of its biggest undesirable by-product, i.e., pollution which has held it captivated since centuries together? The need for developing control strategies in order to keep a check on pollution has been well recognized by the population worldwide. The fundamental purpose of this article is to weave out a collective literature depository on how Smart Earth Technologies like AI and Machine Learning, IoT, Robotics, Big Data, and Cloud Computing have monitored, checked on, and maintained the basic necessity of life on the planet, air, and water, assisting the readers to create a deeper comprehension of their responsibility towards mother Earth. Through this centralized source, they would be in the position to deploy the acquired information elsewhere, and have clarity on what works and what doesn't.

The degradation of air and water can be witnessed right in front of our eyes, perfected beautifully bit by bit into a piece of the picture captured intelligently by a constellation of the satellites, variable in shapes and sizes orbiting around the 'blue' geoidal residency (Viatte et al. 2020) 'An artificial intermix of natural and anthropogenic impurities' is now the ground for defining the condition of air in cities of developing countries (Mayer 1999). 'Water is Life' but is the current life in crisis? The studies carried out are filling the gaps that the mortality and morbidity of

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Homo sapiens is not the only bane of 'water pollution' but, it also is the demon behind the disintegrating ecosystem. Industrialization, overpopulation, urbanization, and soil erosion are a few of the central plotters behind the red curtain (Khatun 2017). Eradicating pollution may seem to be an enigmatic notion but confining its effect by monitoring and forecasting systems is definitely possible. In this era of ICT revolution, although Industry 4.0 has unfolded different layers of automation and digitalization, it is not environmentally sound and poses numerous environmental challenges (Oláh et al. 2020). Traditional monitoring systems have low precision and entail laboratory analysis (Dhingra et al. 2019). In view of achieving the crucial objective of Smart-Sustainable Cities with zero emissions, there is a pressing need for smart monitoring systems that enable real-time tracking capability of different pollutants (Bibri 2020). With the advent of IoT, it has become easier to procure environmental polluting parameters and thereby keep an eye on environmental pollution from various potential sources (Swain et al. 2017). ANNs have eliminated the loopholes of deterministic statistical approaches with their ability to predict complex environment parameters and generalize non-linear patterns with the requirement of less complex computational tools to implement them (Cabaneros et al. 2019)(Isiyaka et al. 2019).Wireless Sensor Networks have become interesting attributed to their automation and cost efficiency, superseding the conventional monitoring stations with multiple sensors(Boubrima et al. 2017). Various machine learning and deep learning algorithms have promising contributions to pollution monitoring and prediction (Nosratabadi et al. 2020).

This is an analytical and descriptive study that analyzes the monitoring of environmental pollution through various ICT technologies prompted by manifold human activities and is based on secondary data. The data has been collected from authenticated websites, research papers, and various reports of International Organizations. The paper initially begins by taking up the task of introducing the various technologies contributing in making the Earth smarter and listing out how they have positively impacted the Environment and its domains, enumerating the different types of projects, movements, and initiatives taken up by amalgamation of innovation within Smart Earth Technology with nature to the readers. Then comes the structured comprehensive review of the existential literature containing ICT embedded structures monitoring air and water resources present on Earth's surface and accumulating information on its quality and quantity. The follow-up tables are yet another face of the variety and multitude of roles that the technologies have played in keeping check of air and water pollution. The individual views of the authors regarding the undertaken literature review are presented and its significance is pointed and discussed. Although the paper does not intend to point out at the loopholes that the models mentioned in the literature reviewed may present, it does open up the challenges that the current world technologies playing a critical part in managing and maintaining air and water impose. But, the vision the upcoming future holds on is brighter and wonders can be achieved if these minute patches in these technologies are fixed. The paper closes itself by the hope that the notion of "smarter" and "greener" Earth can be realized efficiently by the democratization of these Sustainable Technologies. Before jumping on to the reviews of literature that have shaped the current pollution monitoring systems it helps to touch upon the technologies actually governing the Smart Earth. The successive section assists in doing the same.

Moving towards a sustainable-Smart Earth: what are Smart Earth Technologies?

AI and its subsets designing intelligent machines by machine learning affect every facet of mortal life, enhancing efficiencies and augmenting human capabilities through its broad advancement in computer vision and virtual and augmented reality (Shah et al. 2021a, 2021b, 2021c). AI plays its role in influencing Business, E-governance, enriching lifestyles, preserving the privacy of citizens and treading towards a sustainable environment (Desai and Shah 2020). AI includes ML, NLP, machine and computer vision, speech and biometric identification (Gupta et al. 2021; Naik et al. 2021). It increases market efficiency and eases out tasks for analysts and market participants interpreting highly complex phenomena—from the behavior of electrical power grids to climate change (Depuru et al. 2011)(Ramchurn et al. 2012)(Li et al. 2019). With the help of advanced technologies like AI, we are able to oversee air and water pollution explicitly. AI helps in the identification of sources to monitor air quality more quickly and precisely. AI has the potential to significantly enhance the quality of water, its usability, management, and forecast maintenance requirement.

ML systems apply its supervised and unsupervised learning to improve the ability of maps to recognize the size and the number of underground deposits of oil and gas making their extraction economical (Dodiya and Shah 2021). The amalgamation of machine learning and Computational Intelligence in Smart Cities works out wonders. As embedded algorithms become more pervasive at different levels of the energy network (from smart meters usages to real-time phasor measurement units along the transmission lines), their combination becomes significant for taking automated decisions and reacting to changes in system dynamics (O'Dwyer et al. 2019). Various ML methods are also employed for air pollution and water pollution monitoring systems. According to the design prospect, CI and ML approaches could be leveraged to overture Zero Energy (Xin et al. 2018). Energy production/

resolution and its demand depend on multiple data-driven factors (Alahakoon and Yu 2016) (Voyant et al. 2017) (Jung and Broadwater 2014). ML/CI methods are useful for modeling and prediction of these quantities (Thakkar et al. 2020).

IoT (Internet of Things) has facilitated simple everyday objects to become an integral part of the internet and environment (Panchiwala and Shah 2020). The Environmental Monitoring Systems (composed by IoT) give their bit by keeping a check on air or water (the quality of water is monitored real-time with buoy connected sensors communicating by a GPRS network) and find out hidden details about sewers and garbage disposal systems; detecting weather shifting patterns, monitoring climatic changes, highlighting atmospheric – terrain – soil conditions, protecting rivers-lakes-oceans, making a note of the movements of the wildlife about their habitat. These are put into action by the efficient use of microcontrollers, transceivers, and standard protocol stacks. Profound use of pollution monitoring sensors along with checking the quality of air at crowded and busy public places has been traced. The synergy of IoT with Agriculture has given rise to the employment of programmed water systems (Southern California) along with proper use of compost due to the sensor collected data of soil nature. Energy efficiency today is an IoT synthesized product of Smart Homes and Smart Cities. Early risk identification systems are designed to hack disaster management issues (such as a Tsunami or Earthquake) for prior preparation and protection from the life-threatening issues.

Remote sensing, in contrast to in situ study, refers to the acquisition of data from distance thereby ensuring data driven decisions. It amplifies the understanding of ecological and environmental interactions (tracking wildlife, measuring glacier melting and revealing seafloor topology and underwater mountains. Environmental Sensor Networks (ESNs) comprise sensors and actuators that communicate the collected data to a Sensor Network Server (SNS) assisting the development of hazard management system (Hart and Martinez 2006). Variety of sensors (moisture sensors, rain sensors, vibration sensors and tilt sensors) have been implanted into the natural networks.

Computer vision could be a computing property of the 3D world from one or more digital images. Visual recognition tasks like image classification, localization, and detection are the components of Computer Vision. Three-dimensional (3D) sensing and imaging technologies are widely researched for several applications within the fields of environment, medicine, robotics, manufacturing, security, surveillance, and defense. Food printing manufacturers are already lauding the potential of 3D food printers to develop creativity, nutritional and ingredient customizability, and food sustainability(Barnard et al. 2016). Using the complicated Computer vision algorithms and its techniques, we determine air and water pollution. Computer Vision technologies are used to detect waste materials in water and to maintain its quality.

Citizen sensing is yet another emerging domain that has revolutionized the notions of environmental awareness by the participation of citizens in environmental data acquisition. Citizen data is also leveraging the scope of Big Data Analytics as it enables the generation of new data and data practices, and thereby addressing environmental problems in a more efficient manner(Pritchard and Gabrys 2016).

Big data refers to a sheer amount of structured and unstructured data which leads to better decision and strategic relocations (Thakkar and Shah 2021; Shah et al. 2021a, 2021b, 2021c). It is a powerful tool in controlling sustainable development. Various platforms (for protecting the environment) use big data analysis like the Copenhagen Wheel, Trash Track Project, the Crisis Mappers Net Company and the Solar Roadways Company. Big Data devotes itself in Conservation of Biodiversity and Optimized Resource Use.

Cloud Computing primarily refers to the delivery of computing services ranging from storage to processing power over the internet (Cloud). The utility of cloud computing is not confined to cost reduction and business user convenience. It has made remarkable contributions in reducing carbon emissions, energy consumptions and e-waste and prompts an inclination towards a greener and smarter future.

Cyber security refers to the defence of electronic gadgets and its system from malicious attack. A strong and proven cyber security program is essential for the protection of public health and safety. It has revolutionized the vast domains like aerospace, conveyance, design of security metrics, modeling, and cyber sustainable awareness. CAVE (cyber analysis visualization environment) is one of the projects which employs cyber security to ensure a user-interface to connect with the system model network graph (The New Space Race: Cyber Security for Space Missions) (Viswanathan and Pecharich 2016) (Fig. 1).

Table 1 discusses the global initiatives towards enhancing the environment aided by the concept of Smart Earth.

Cracking the code between Smart Earth Technologies and air pollution to boost AQI

Idrees et al. 2018 explored the computational intricacy, foundation, issues, and methodology for establishing real-time air quality checking frameworks at a multitude of locations, i.e., comparing the various sensors placed in IoT network on a qualitative and quantitative basis. The IBM Watson edge-computing based IoT and Arduino boards were the components of the proposed model under study. The detecting module utilized eight unique air quality parameters as measuring indices which were temperature, moistness, O3, SO2, NO2, CO, PM2.5, and PM10. The crucial task of the method was to

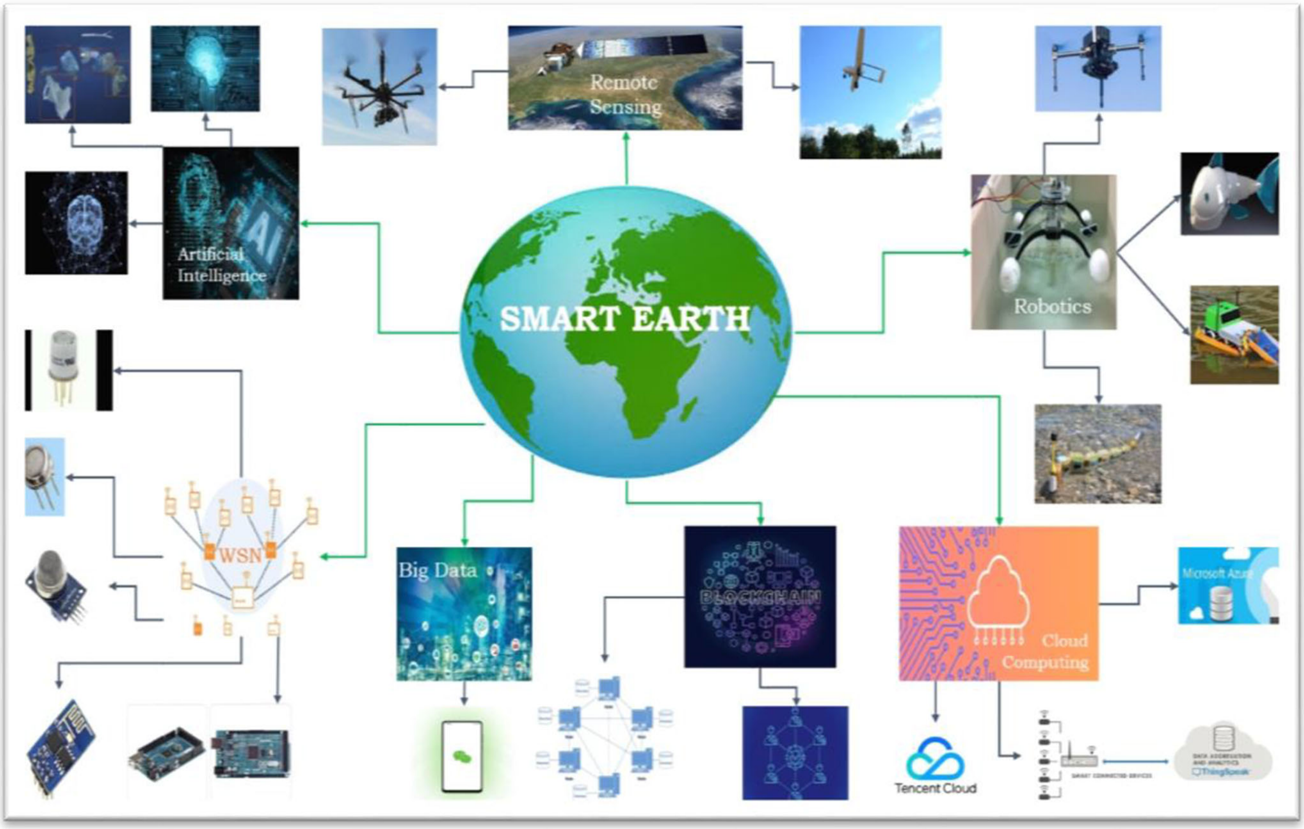

Fig. 1 Smart Earth Technologies governing air and water preservation

mitigate the computational weight of the impurity detecting sensors by practically 70% hence prompting extended battery life. Creators utilized programmed adjustment arrangement to guarantee higher exactness of sensors and an information transmission technique to limit the force utilization alongside excess network traffic that was faced during information transmission. This system revealed a decrement of 23% in force utilization and the exhibition was approved by setting the system in various conditions. It was concluded by the authors that monitoring through such newly upgraded sensors shall be extremely useful in crowded indoors, households, and offices, though a little upgradation and higher accuracy was required for industry based sensory devices.

The author (Duangsuwan et al. 2018) reviewed the most crucial problem humans and the world is facing today, which is the type of quality of air they breathe. Air quality is important for human health and earth, because it is responsible for global warming. With the growing advent of technological advancements in IoT sensors which helps to detect the air contamination rate for existing smart cities, the NB — IoT network is preferred because of low cost, long battery lifetime, and long coverage, and supports a wide range of devices.

Monitoring air pollution is undertaken by utilizing chief five standard detectors some of which are CO, O_3, and particulate matter PM_{10}, NO_2, and SO_2. The framework development consists of the air detection sensors, microcontroller, NB-IoT module, database, and web monitoring. To perceive the ambient air-quality, the process of data is undertaken by utilizing Arduino MEGA2560 and Raspberry Pi 3 to interface with Narrowband Internet Of Things (NB-IoT) module organization with LTE network. The web portal used to address the user interface through a monitoring website which displays on-screen a list of Air Quality Index (AQI) parameters, sensor functional status, and statistical analysis. The experiment was carried out at five locations in Thailand for eight hours per day and a real-time data of the resulting curve of five pollutants was displayed on the web. The current developing smart cities use complex networked connected NB-IoT devices for regulating the quality of lifestyle, forecasting weather, treatment of waste products, traffic on the board, noise monitoring, parking management, energy utilization, and to observe clean air is significant. The authors have realized the importance of quality of air, so they developed smart multi sensor detectors with the help of NB-IoT network for measuring real-time air pollutants.

Corno et al. 2017 presented an IoT Crowd Sensing platform that proffered a lot of services to the citizens by utilizing a network of bikes as IoT probe. The paper aimed at describing and showcasing a platform for smart-sustainable mobility, with mobile sensors fitted across bicycles, aggregating information in the city of Turin, Italy. According to their article, crowd sensing is a substitute to the old method of social

Table 1 World-wide initiatives and organizations specifically working towards enhancing the environment aided by the concept of Smart Earth

Name of the initiative	Supporting platform/ organization	Subset of ICT domain used	Description of the initiative	Country(if any) specifically being impacted
PLEASED(Plants Employed As Sensing Devices)	A FP7 Research Project, partial support of The PLEASED FET Project	IoT (Internet of Things)-[Environmental Monitoring, Plant Telemetry-Cyber Plants]	Plants being efficient biosensors of an omnipresent and organic wireless sensor network (Manzella et al. 2013) (Bakker and Ritts 2018)	Florence
the Planetary Skin Institute	A Collaboration in between NASA and Cisco Inc.	IoT - Worldwide Network of Sensors [real-time Global Monitoring]	Gather data from space, airborne, maritime, terrestrial and people-based sensor networks and represent, review, Forecast and articulate in basic formats over openly networked platforms (which would further be able to deeply examine issues which are Land Management, Water Scarcity, Food Security, Deforestation, Climate Change, Rise of the Energy Demand).	Copenhagen (initially held conference) and the seven peer regional hub & spoke networks - Brazil, India, China, Africa, Japan, EU, and the US
The 'Notes from Nature' Project	It is a Project Blog By Zooinverse	Web-based prototype (an open-source web transcription tool)	Interrogates citizen scientists to facilitate the historical data from collections about biodiversity in the near past, for observing change patterns and predicting the forthcoming biodiversity on the human domineering planet (Hill et al. 2012) (Arts et al. 2015).	Global Platform
iTuna (Biomimetic Fish Robot)	Developed by Robotics & Cybernetics Research Group	Robotics	The underwater fish which guards the underwater living conditions and monitor them via high-efficiency movements so that the robot does not disturb the living fisheries in the water body (Hern 2015) (Arts et al. 2015)	Madrid
Green Information Technology (Green IT) Initiative	Launched by Japan's Ministry of Economy, Trade and Industry (METI) along with five IT-related industry groups and two government-affiliated organizations	Sustainability (GREENING OF IT) Tackling E - Waste	The motive of this initiative was to acquire environmentally sustainable economic growth with help of green IT by enhancing and advocating IT and electronics technologies which would make efforts towards downsizing the environmental burdens. The PC Green Label Standards are classified up in four areas: 1. Company system to design and manufacture personal computers following environmentally conscious principle 2. Environmental information	Japan

Table 1 (continued)

Name of the initiative	Supporting platform/ organization	Subset of ICT domain used	Description of the initiative	Country(if any) specifically being impacted
			3. Environmentally conscious product design and manufacturing processes 4. Design and manufacture of products while conscious of the 3Rs (Reduce, Reuse, Recycle) (Reimsbach-kounatze 2009)	
Bees with Backpacks' Project	This emerged as a broader Partnership between CSIRO and the Victorian Government Department of Education and Training	Micro sensing technology (high-tech micro sensors working like a vehicle e-tag system	This mini piece of technology can be placed upon the back of the bee manually to record the time it would spend in its hive, the distance it may cover while its travel and activities it would perform - collecting all the important data which would facilitate the understanding of factors resulting in a decline in the bee population and contribute towards the wellness of the Ecosystem (Bakker and Ritts 2018)	Australia (Victoria)
Green Horizons	Launched by IBM(International Business Machines) in relationship with Beijing Environmental Protection Bureau(EPB) during 2014	Utilization of IoT (Internet of Things) and AI (Artificial Intelligence-advanced Machine Learning) to consume Big Data to point at the details	The system is compiled in such a way that it produces high resolution 1 Km - by - 1 Km pollution prediction 72 Hours beforehand and gives a picture of pollution trends that would occur up to 10 days in advance (Bakker and Ritts 2018).	The city of Beijing, China
'Elowan'	Built by an MIT(Massachusetts Institute of Technology) “cyborg botany” researcher (Harpreet Sareen) - research affiliate at MIT Media Lab's Fluid Interface Group together with help of lab founder Pattie Maes	Robotics and IoT(ESNs) [a plant-robot hybrid]	The hybrid augmentation of nature possesses a wheeled robot connected to the base of the plant and there are electrodes ingrained in its leaves and stems - these extension wheels drive the plants towards light	United States (Cambridge)
Small Wildlife Tracking Collars (for Black Handed Spider Monkeys)	A Ph.D. student Grace Davis (University of California, Davis) along with Monkey Project Manager Lucia Torrez	Smart GPS (GPS Receiver) with VHF (Very High-Frequency range) Transmitter	The use of radiotelemetry (while gaining access to GPS) in watch sized tags (connected to their legs) for appropriate data collection because of the ability of collars to hoard the location of these animals (information downloaded from the tag) (Strong 2013)	Barro Colorado Island, Panama
‘Smarter Planet' Project	Envisioned by IBM	Involves diverse areas such as mobile web, nanotechnology, stream computing, analytics and cloud	The project is a follow-up compilation of varied initiatives taken on the same platform • "Smarter Buildings"-reduction in energy usage via advance intelligence • "Smarter Cape Cad"-effective management and protection	New York City, USA

Table 1 (continued)

Name of the initiative	Supporting platform/ organization	Subset of ICT domain used	Description of the initiative	Country(if any) specifically being impacted
			of region's natural resources via diverse ICT fields • "Smarter retail for Smarter Consumers" • "Education goes to School" • "Intelligent Marketing" • "The Smarter Cities Challenge"- combines infrastructure, human services, and city management tricks via power-instrumentation and interconnected and smart metropolises. . (Bakker and Ritts 2018)	
"Animal Observer"	Development of the app by Fossey Fund scientist(Dian Fossey Gorilla Fund) Damien Caillaud with the supported funding of Oracle	App (Software Package-Data Collection)	The app collects and integrates data on their behavior, social interactions, locomotion, health and day-to-day activities it can store pictures, videos and audios information from which can further be mapped and the animal (Gorilla here initially) can be monitored and population can be maintained	Forests of Rwanda (Africa)
Vibration Health or Alternative Monitoring Technologies (HUMS)-Wind Turbine Health Management	A workshop on wind turbine condition monitoring was organized by the National Renewable Energy Laboratory (NREL) in 2009 (which suggested the idea)	Possesses a variety of onboard sensors, data acquisition systems, and signal processing and analysis algorithms	The helicopter community has made sophisticated health and usage monitoring systems (HUMS) to trace damage accumulation on necessary parts of the machinery and detect nascent faults. The acquired data is processed onboard the rotorcraft or on a ground station or both in a combined form providing the ways to measure against defined criteria and form instructions for the maintenance staff and/or flight crew for intervention. Application of HUMS technology to wind turbine drive trains has the potential to decrease maintenance costs and increase turbine availability by the usage of condition-based maintenance (CBM). (Sheng 2011)	Golden Colorado, USA
'Save the Rhino'	South African National Park (SANParks) in partnership with Nature Conservation Trust and a South African Public Benefit Organization(PBO) Funded by Google [$ 5	Drones, Predictive Analysis, DNA Analysis, Hidden Cameras, GPS Location Devices, and Apps	The entire domain of ICT focuses upon trying and anticipating, locating, tracking and capturing the questionable poachers to decrease the number of animals (Rhinoceros) being	South Africa (Kruger National Park)

Table 1 (continued)

Name of the initiative	Supporting platform/ organization	Subset of ICT domain used	Description of the initiative	Country(if any) specifically being impacted
	Million to World Wildlife Fund (WWF)]		hunted for outlawed wildlife trade	
BeachObserver	This application was designed by Coastal and Ocean Resources	App	Beach Observer gives a hand in the recording, sharing, and networking of conceivable shoreline inspections of wildlife, plants, beach cast animals, and marine remains with geo-tagged observations and pictures. When containers, accidentally discarded cargo or oil at sea, or when junk of any kind is cast afloat on the ocean, the flotsam, and jetsam reach near shore. In most cases affected landowners, neighborhoods, and communities will be the first to notice the accumulation on local beaches. But this app counters this problem by providing the data beforehand.	British Columbia
GasFinder 3	Discovered by Boreal Laser Inc.	Remote sensing	GasFinder3 applies laser-based remote sensing to keep on monitoring gas concentrations in the way of the laser (Bakker and Ritts 2018)	Oil and gas sites Arctic region
Enevo One	Launched by Enevo the Progressive Waste Technology Company	Waste Bin Sensor (IoT) patented IoT Tech Suite	The service operates by the use of sensors to overview the fill level and operation data about waste container - then this information is sent to the company for analysis which in turn aids the other Waste Management Companies and Municipalities to better approximate how much waste needs to be moved-how much fuel is required- how much is charged for this service (Jada et al. 2016)	started at Espoo, Finland has gained acceptance in 25 countries

gathering and conveying data from and to the environment. Sensing is "disseminated over an enormous number of (regularly versatile) people instead of fixing it to an individual or an array of sensors." This platform was primarily designed to monitor and collect data about the toxicity of city air conditions, relative humidity, temperature, and atmospheric pressure to make mobility more sustainable to users and institutions. ST X-Nucleo-IKS01A1 is an environmental and motion sensor shield used for measuring temperature, humidity, pressure, and motion used in the platform proposed by the authors. The conclusion that could be drawn out from the written work was that the SmartBike put forth designed services whilst matching the accuracy of pollution prediction of the system actually installed in Turin (ARPA Station).

With a view of enabling real-time air pollution monitoring, authors (Fioccola et al. 2016) presented an Arduino-based sensor device that can measure various environmental parameters mainly carbon dioxide (CO2), nitrogen dioxide (NO2), methane (CH3), hydrogen sulfide (H2S), ozone (O3), ammonia (NH3), particulate matter (PM), benzene (C6H6), ethanol (C2H5OH), toluene (C7H8), and propane (C3H8). The amalgamation of technologies included ESP8266-01 (a low-cost wifi module), twelve gas sensors, five environmental sensors (for monitoring temperature, humidity, light-intensity, presence of flames, and rains), and a Step-Down module. PaaS (Platform as a Service) approach has been adopted by deploying Node-RED software program and data gathered from sensors was stored in Cloudant, a NoSQL Database as a Sevice. The prototype of this system has been deployed in Marigilano, Napoli, Italy. The future work of this research intended to further leverage the efficiency of the system by replacing the permanent power supply with a battery source coupled by carrying a comparison between MQTT and CoAP Protocols.

According to Kang et al. 2018, with the increasing development of technologies like IoT, Big Data, and Machine Learning the Real-Time Air Quality Evaluation, Monitoring, and Supervision Management has become prudent. The authors have described the manual collection and assessing of the raw data in their paper. The prediction incorporates different areas taken into consideration by evaluating the air quality standards, reviewing and comparing M.L. model-based work, and finally utilizing Big Data and M.L.-based air quality analysis. The Air Quality System (AQS) contains quantitative details of air contamination gathered by EPA or pollution control offices. AQS additionally contains meteorological information, expressing data about each monitoring station (including its geographic position and operator along with quality affirmation data). Big Data can be employed for developing models that are spatially expansive, significantly dynamic, and behaviorally heterogeneous. The four major components of the model are a linear regression-based temporal predictor for measuring local factors(of air quality); Neural Network-based spatial predictor for measuring global factors; dynamic aggregator for fusing temporal and spatial predictors; and an inflection predictor for capturing abrupt changes in air quality. Different M.L. algorithms were used for air quality prediction models, mainly Genetic Algorithm, Random Forest Model, Decision Tree Model, Deep Belief Network, and LS-SVM model. This paper is concluded by jumping into the depths of included literature and case studies, finally letting Machine Learning and Big Data techniques and models having an upper hand while evaluating the air quality of the surroundings.

Ameer et al. 2019 documented a real-time checking of contamination information empowers the metropolitan area to examine the current traffic of cities. This paper presents a comparative analysis of ML models for predicting the quality of air by deploying the IoT-based sensors with credentials to the size of data input and time interval caused. The authors utilized Apache Spark for performing trials and pollution assessment by utilizing numerous accessible data collections. Mean Absolute Error (MAE) and Root Mean Square Error (RMSE) have been utilized as assessment rules for the correlation of multivariate analysis to find the optimum model in terms of time processing and least fallacy rate. Their proposed architecture has 4-layer predicting air pollution:

Layer 1 - Data gathering

Data collection in smart cities is obtained from different heterogeneous devices. The collection, aggregation, pre-processing, and initial filtration of data collected through sensors.

Layer 2 - Communication

Data transferring to the data processing layer by gathering data from the IoT devices undertaken by using different technologies like 4G, LTE, ZigBee etc.

Layer 3 - Data Management

Data analyzing and storing is undertaken in this layer in the HDFS system. In-memory, real-time processing, offline data analysis, prognosis, and pattern discovering execution is carried out in this layer.

Layer 4 – Application of Techniques

It is connected with real-time devices. In this layer, reports and information of data is coordinated as chart diagrams and dashboards are shown by using this layer.

The formulation of method and estimation models include the following:

1. Statistical Regression Techniques of ML
2. Random Forest Technique
3. Gradient Boosting Regression
4. ANN multi-layer Perceptron Regression

Y. Lin et al. 2018 proposed a novel algorithm, Performance Prediction Algorithm (PPA) revolving around Cloud Model Granulation (CMG) for predicting and anticipating the quality of air in and around one's surroundings. The data resourced out was non-linear, heterogeneous, uncertain, and modeled out on the basis of decisive pollutants which included NO_2, PM_{10}, O_3, and PM_{25} through data exploration in various parts of Wuhan city. Investigation was carried out as a plan to create an algorithm for evaluating the air-quality which could oblige the vulnerabilities in the information at lower computational expense and great speculation performance. It could be portrayed by the carried out research that the proposed algorithm demonstrated the vulnerabilities amidst sampling of data coalesced via time series, boost a speculative execution, and lastly, cost an overall lower computational expense. The put forth algorithm is capable of foreseeing the AQI (a single air quality index) and the IAQI (individual air quality index). A regression prediction algorithm inherits the strong generalization performance along with inexpensive running cost of SVR depending upon the cloud modeling granulating process and supporting vector machines. The research methods were carried out in macOS Sierra, MATLAB R2016b Neural Network Toolbox (nntraintool), a Library for Support Vector Machines (LIBSVM-3.22). For time series along with vulnerabilities, solutions are based on state space transformation and cloud model granulation. This is the latest at that time when it proposed an idea with AQIs by cloud model granulation also the main point of this article to propose the new solution for time series with uncertainty on state space transformation and cloud model granulation.

Authors (Karatzas et al. 2008) attempted to inspect air quality parameters of Thessaloniki (a city in Greece) in light of the fact that atmospheric air quality has its direct aftermath on human health. This article encompasses numerous Computational Intelligence methods mainly-Fast Fourier Transformation and Construction of Periodogram, Principal Component Analysis (PCA); Self-Organizing Maps (SOM); and ANN based on Multi-layer Perceptron (MLP) for measuring Ozone Concentration. The article has also stressed the crucial importance of forecasting air quality parameters for early warning systems and health risk of population. These methods could also deliver services pertaining to providing public notifications, warnings, and alerts on the basis of estimation of different parameters. The outcomes were verified with their high ability of methods to manage environmental concerns.

Suganya and Vijayashaarathi 2016 centralized on the measurement of the gas level of air pollution around cities and decreases the labor and increase the adaptability of sender and recipient. The primary target of the proposed framework for the kinetic motion of vehicles is to measure determinative air pollutants using sensors. The researchers have utilized MANET (Mobile Ad Hoc Network) routing algorithm. The data collected by the sensor is sent to smart phones for evaluation after evaluation it sent an alert to user. The aftereffect of the proposed technique incorporates the accompanying boundaries, for example, data collection type, speed transmission, area and system coverage, and number of vehicles to intently screen the proffered framework. The proposed system architecture includes the levels which are collecting information from PIC Microcontroller fixed and environment sensors to monitor real-time giving scopes of contaminations parameters. This static level through the zigbee module in association with the LCD display and appeared in the gas level of the vehicles. So according to the working principle of the framework sensors like NO_2, humidity, temperature sensor senses the level of gas which is further reported to the Programmable Interface Controller and then the assessments are linked to the Zigbee module. The simulation window will provide a humidity level and NO_2 levels on air contamination in travelling vehicles. As Node-Id determines the vehicle location and pollution emitted by determining humidity and NO_2 range in the table. The measured gas value stores the vehicle details and by utilizing cloud network, where substantial amounts of information is recorded which can be used for future purposes and we can view analyze data anywhere in the world also we can see the pollution level through the cloud network.

Nayak et al. 2017 proposed a framework using MQ135 and MQ6 sensor which measures accurately the amount of harmful gases present in air like NH_3, NOx, alcohol, Benzene, smoke, and CO_2 and measure the quality of air over a web server. Air quality can be measured in PPM, and it can be accessed by a web-page from anywhere and pertaining to it, an alarm would be triggered when it goes beyond limit. The functional principle of the model is to collect data recognized by the MQ135 air gas sensor, which detects NH_3, NO_2, Alcohol, Benzene, Smoke, and CO_2. For air pollution monitoring, the dynamic gas sensor connected to the Arduino will provide its PPM value for the pollution level. The LCD and web page will then display results according to the PPM value obtained. The different components of the monitoring system are Arduino UNO R_3 microcontroller, MQ135 Gas Sensor, ESP8266 Wifi Module, and LCD. The results are displayed by setting a local server demonstrating its working. For this reason, we use IoT to enable efficient and effective technology to upgrade air quality monitoring. MQ135 gas sensors were used for detecting different contaminated gases and the Arduino was the integral unit for this process. The information is then transmitted on the Internet and the results are displayed on the website. The system can be installed anywhere but especially in industries and homes where gas is most often to be found and gives a warning message when the system crosses the limit

In light of overcoming the shortcomings(such as sensitivity, cross-interference) of gas sensors, the authors (Elen et al. 2012) developed Every Aware project which can be employed for community based ambient quality of air monitoring in Belgium, Italy, and the UK. The hardware consists of a sensor board which can be envisaged as the array of sensors; the control board for obtaining sensors' data and GPS position and transferring data to external system via Bluetooth; and an Arduino Mega 2560 microcontroller board. In order to evaluate sensor' response, preliminary tests were conducted in traffic associated air pollution, which exhibited inconsistent response of sensors. In contemplation of addressing the aggregation of sensors' signals, semi-mobile approach and mobile sectoral approach were propounded. Semi-mobile approach involves user to move with Sensor Box at any location of his interest, stay for some interval and then move to another locations while mobile sectoral approach involves user to move from any location to entire section of the street. Future scope of study encompasses quantifying traffic pollution by on-field calibration using non-linear modeling (like Gaussian Process Regression).

Choi et al. 2017 in their work describe how Olfactory Recognition Technology as one of the remarkable Information and Communication Technology integrates with itself, the minute notions of Internet of Things to create a multi-faceted electronic nose system. In addition to its multiple sensors, which are important in terms of user friendliness, connectivity, and accuracy, the olfactory contents technology consist of olfactory information recognition (accumulation of sensory signals, the examination of gathered information via olfactory sensors, and use of this analyzed data to identify patterns) and olfactory contents representation (provision of points like aroma and flavor with a range of multimedia and virtual reality constituents, enhancement of user's experience and emotions). The electronic nose has been mounted by nano-structure gas (acetone, hydrogen sulfide, toluene, and nitrogen monoxide detection), temperature, humidity, and air containment sensors (real-time sensing). The system communicates the information it catches over the internet through a well-connected Wi-Fi network.

The sensed data is sent through the web network and the tester gains all the required information on their phones, computers, and laptops hence finding a multi-fold of applications in the field of environmental air monitoring and the health care sector for measuring the exhaled breath of the suffering patients (Table 2).

Smart Earth Technology: a robust solution for draconian water pollution

The wetland ecosystems which once were so full of life and shades of green are now in the grave danger of possessing a ratio 1:1 of the fish dwelling in those waters to the garbage dumped on a daily basis by human beings. Hence in their article, the authors (Panwar et al. 2020) discuss about a solid waste detecting model proposed by them operating on the grounds of state-of-the-art deep learning. The archetype given the name of AquaVision works on the principles adopted from the TACO dataset, named as AquaTrash. The processes of detection and classification of wide range of pollutants floating over, inside water bodies along with the seashores, aid in mapping out harmful waste items (mean Average Precision - 0.8148) hence contributing their bit in cleansing the marine or fresh waters. The writers compare a multitude of datasets circling out TrashNet and TACO dataset to produce accurate performance over the proposed machine learning classifier RetinaNet (composed of ResNet50 and FPN) which is a one stage approach model (neural networks) outperforming even the ones with two stages like faster RCNN's average precision to detect images inside ocean (Image Recognition). Finding an open-source dataset containing an abundant number of garbage pictures involved a comparative inspection of the two picked out datasets wherein the results portrayed the lack of some specifications (such as annotations) in both, leading to the creation of a novel dataset AquaTrash (consisted of 369 images of TACO and manually annotated rubbish object categories: glass, metal, paper, and plastic).When the released model was put to work and tested, it was found that though AquaVision had been trained over a mere handful of images and captured non-aquatic images, the model was able to recognize water trash (along with aquatic photographs) with 88.1% confidence. Automated devices and drones could hence utilize this for waste collection and recycling purpose over the water bodies.

Moparthi et al. 2018 tried to sketch out a water quality tracking system using IOT which finds pH of water and alerts the associated stakeholders.

In the article, the entire system is based on working of an Arduino board for measuring pH values of water in the municipal and drinking water reservoirs in sync with GSM (Global System for Mobile Communications) module for ease in communicating messages. The pH content in water was calibrated with the assistance of pH sensors and a particular pick of gadgets were utilized to host sensors which assembled information upon the Arduino (coded and tested) and then sent the collected data to cloud. Outputs were obtained on the LED and the monitoring screen (the estimated pH value). The alerting calls are sent to the user's mobile checking the claimed pH and the project undertaken can be extended to measure turbidity, temperature, and level of oxygen breakdown. The users are prompted with the obtained pH value of the water. Along with this the authors scaled up their project by sending data from the sensor to the cloud for global/comprehensive water quality monitoring.

The authors (Y. Chen and Han 2018) have pointed out a WSN (Wireless Sensor Network) based solution (which utilizes Electronic sensors and Big Data) for remote real-time high-frequency water quality monitoring system which comprises five steps: acquisition and transmission of data, data processing, its storage, and redistribution and provides data for precise assessment of water quality like diurnal cycles in water temperature, DO (dissolved oxygen), and pH while documenting their project. This was a collaborated effort which aimed to relieve the burdens placed on by the manual lab-based monitoring methodology due to the lack of efficient tools and skilled personnel, requirement of a sizeable manpower, economically infeasible, and considerably low

Table 2 Enlistment of a few tested prototypes constructed using Smart Earth Technologies for tackling air pollution

Sr. No	Aim	Model name/description	Application	Oblique technology	References
1.	To measure pollution levels accurately in a cost effective manner using a mobile with cloud based service.	Haze Watch	Government monitoring station	Crowd sourcing or Participatory sensing	(Sivaraman et al. 2013)
2.	It intended to monitor air pollution and simultaneously contribute in creating a map of the urban areas	Maker friendly urban air quality monitoring system	To gain insights about the urban area air quality	UDOO or Arduino, OOCP programming, NoSQL	(Capezzuto et al. 2014)
3.	A tested reliable mobile system has been designed that can obtain data pertaining to air quality of urban areas and concentrations of different gases can be viewed on the map of city	Mobile sensors in air pollution measurements	To track air pollution around the city.	C, WinAVR compiler, interface ,MySQL	(Dan 2011)
4.	To maintain the indoor air quality and Monitor the O_3 levels using a semiconductor sensor connected to IoT devices.	Indoor air quality monitoring system	To detect ozone concentrations and monitor indoor air quality.	Arduino BT IoT prototyping Board And cloud computing	(Sudantha and Karunaratne 2017)
5.	To monitor the air quality of air using low-cost intelligent device	Air quality monitoring using low-cost sensing devices.	To estimate the air quality using mobile.	Android application, Arduino mega	(Mondal et al. 2016)
6.	To develop a device that can track concentrations of different air quality parameters in a cost effective approach	IoT based Real time Air Quality Monitoring device	To monitor quality of air for any particular area to appraise the pollution levels.	IoT and cloud computing, Arduino	(Moharana et al. 2020)
7.	To develop a device using LoRaWAN network with low-cost sensors and low power for measuring the pollution	City Scale particulate matter monitoring using LoRaWAN based Air quality IoT devices.	To measure the pollution of an area using mobile and web sites	LoRaWAN network, IoT	(Johnston et al. 2019)
8.	It attempted to present the relationship between air pollution, meteorological factors, and the health of adult citizens.	CITI-SENSE	To realize the association between concentration of Particulate Matter(PM) and its aftermath on intensifying asthma and chronic obstructive pulmonary disease (COPD)	Web development, app development, land use regression	(Stojanović et al. 2016)
9.	To develop a device that measures pollution with latitude & longitude, humidity, and temperature	Air quality measurement system using raspberry pi	To measure the pollution in the city	IoT, Arduino, raspberry pi, Zigbee	(Muhamad et al. 2018)
10.	To develop a system that can measure air pollution and display data on the web site.	Air quality measurement system for city	To measure pollution around city or town	IoT, cloud computing, Arduino	(Landge and Harne 2018)
11.	To develop bike that collects the data of air pollution	Canarin II: Designing a smart e-bike Eco-system	It eases the task to choose a path that has low pollution levels compared to that of others	MySQL, JavaScript, web development, app development	(Aguiari et al. 2020)
12.	To develop monitoring system that can measure the pollution with USN-based monitoring system	Pilot project	It is used in smart city development.	USN gateway, zigbee	(Jongwon Kwon 2013)

frequency of sampling with respect to humongous data availability and deficiency in provision of systematic real-time monitoring along with being an superior alternative to the evaluation of water quality by acquiring the assistance of remote sensing technology (owing to the estimated spatial resolution being at an lower end, hence making it tougher to observe the water's quality (freshwater) in ponds, rivers, and channels in urban locations. This multiple variable water standard monitoring network of the floating harbor of Bristol was aided by the architecture of Bristol Is Open (BIO) for wireless networking and communication whilst being the center of collected vital information's acquisition, storage, visualizing it, processing it, transmission, and redistributing, collected real-time with assistance of a Wi-Fi connected network, cloud computation, open source forum, and a software made web while holding on to IoT as a base.

The work by Chi Zhou et al. 2020 proposed a Particle Swarm Optimization (PSO)-based Artificial Neural Network (ANN) model to predict the water quality in view of inefficiencies of classical approaches. The ANN model was prepared from the data gathered from Yangtze River (the largest river in China). The ANN model was trained using PSO and applied on two processes- classification and prediction. For analysis, 476 water samples were used, out of which 300 were employed for training process and other 176 for classification. Additionally, river length proportion, and the data pertaining to volume of total flow and volume of wastewater in the span of ten years from 1995 to 2004 was taken into account. In ANN, four input layer nodes represent four water quality parameters namely dissolved oxygen (DO), per magnetic acid salts (CODMn), ammoniac nitrogen (NH_3-N), and pH, 6 output layer nodes represented 6 categories of water quality; and 10 hidden layers were considered. It has also been disseminated that PSO-based ANN assures better performance than that of back-propagation (BP) Algorithm and Genetic Algorithm(GA).The experimental results predicted that water pollution would be more severe in future and showed an abating trend of portable water.

In their write-up, H. Chen et al. 2020 suggested a novel logistic based kernel honing LS-VM via deep learning improvising a multitude of machine learning methods for determining water pollution quantitatively across regions of agro-economic and sub-economic natures where water support a major portion of income, providing various options for tackling complications in water safety. Chemical oxygen demand (COD) of contaminated water samples are detected with the fusion of the technology of machine learning and the near-infrared spectroscopic technique (a technology serving the purpose of detection of water pollution). Multilayer networks of least-squares support-vector machines (LS-SVM) kernels were being scrutinized for polishing up the LS-SVM model's prediction ability. The logistic-based neural network (deep learning) was constructed having 5 hidden layers (12 neurons each) with optimal parameters L and H (which had been modulated in a synergized manner). The functionality of being operated logistically gained a noticeable upper hand over other simplistically put together kernels (advantages in sigmoid, linear, radial basis, and polynomial functions) on the basis of three defined reasons: number one being that the general parameter grid had been deeply optimized, next that even though the inputs were picked up on a random basis the conclusions were optimally global and the last was abstaining from excessive-fitting for allowing cross-authentication.

The Aware Project financed and supported by LIFE a European fund (environmental program) proposes a traceability system composed of pesticide sprayers embedded with ICT Technology aiming for creating decision aid systems under necessary circumstances, enhanced tuning of sprayers, and precise spraying whenever and wherever significant. The article documented by (Rudnicki 2009) enumerates the efficacious use of an economic sensory device monitoring consistent pesticide application over the vineyards, in the regions where the farmers practiced viticulture.

Cornering three fundamental objectives, one and two being to put the capabilities of Smart Earth Technologies to test when functioning as a system minimizing the pesticide use and abuse that nearby water basins abject and the third pointing to the necessity of implementing the Aware Project to real time applications, the device was constructed out from two main segments: The Aware Mobile Device and The Aware Server. The former was again broken down into two embedded electronic sensors MPU unit (GPS reference, climatic conditions, displayed data and machine-user interface) connected to a tractor's cabin and APU box (tank level of sprayer and flows from right and left) implanted upon the sprayers both operating as recorders for the purpose of spraying data collection. The latter on the other hand collects and processes data it gains via Wi-Fi performing fusion of received information and calculating trajectories of the pesticide flow at the same time producing plots of relevant data such as graphs and maps. The farmers and agriculturalists were given training on the use of this device.

Farmers were able to monitor spraying procedure, predicting the appropriate time to stop spraying (tank level sensor), notice the external variables hence putting work towards adaptability to speed and detection of a malfunctioning (right, left flows and weather). The data was processed into ordered graphs which gave scope for self-improvement.

The system also sends email to concerned authorities when any of the parameter's value is not in the desired range and therefore urges them to take needful action. The future scope of research has also been presented by extending it by using more quality sensors for measuring other physical and chemical parameters; integrating this system with government and thus enabling faster response from concerned stakeholders; and annexing GPRS module from enabling transmission through 3G and 4G channels for rural access.

In the hope of redressing the loopholes posed by the primitive monitoring methodologies (Satellites or Manned Aerial Remote Sensing) as a consequence of unavoidable natural circumstances (such as heavy mist), not being equipped with specialized apparatus that support quality image resolution, human safety and prohibitive cost. Zang et al. 2012 evaluated in their paper small-scale water pollution using UAV Remote Sensing Technology which encloses applications like pollution event monitoring like oil spills, red tides, thermal pollution along with identification of suspended matter, turbidity and chlorophyll. UAV remote sensing system encompassed fix-wing type UAV, the ground station control software, the flight control system (FCS) and two remote sensors - A Canon 50D and an agricultural multispectral camera. In light of overcoming natural geographic conditions (like foggy weather, complex terrain), some modifications were ameliorated mainly choosing fix-wing UAV, increasing exit velocity of catapult, instating high powered engine, and increasing the size of parachute. In order to interpret and analyze UAV images, interpretation signs were established, thematic map was formed, and a remote sensing imagery classification algorithm was used to obtain quantitative information regarding polluted water surface. The future scope of study intends to implement improved hardware and software and scaling up related theoretical research.

Kumar Koditala and Shekar Pandey 2018 initiated and put forth a real-time water quality monitoring system using IOT, Machine Learning, and Cloud Computing in light of overcoming the drawbacks of traditional approaches. This system incorporated dataset from Data Market comprising of monthly temperature information from January 1701 to May 2011. Sensors mainly a turbidity sensor, LM35 module for measuring external temperature, and DS18B20 Temperature sensor have been used. The sensed values are then transferred to a light weight and cost-effective NodeMCU Microcontroller with inbuilt Wi-Fi module. The data then passes over to Azure Event Hub from where it is stored in structured form in Azure Storage Hub. The data is finally streamed using Stream hub and is visualized in the form of graphs and charts through Microsoft Power I service. The system also sends email to concerned authorities when any of the parameter's value is not in the desired range and therefore urges them to take needful action. The future scope of research has also been presented by extending it by using more quality sensors for measuring other physical and chemical parameters; integrating this system with government and thus enabling faster response from concerned stakeholders; and annexing GPRS module from enabling transmission through 3G and 4G channels for rural access.

The results of the research paper by (El-zeiny and El-kafrawy 2017) proclaim the proficiency of remote sensing and geographic information system (GIS) in tracing and keeping a check on water pollution in Burullus Lake, Egypt. These Smart Earth technologies could conclude that the southern and eastern fragments of the Lake were excessively polluted (because of mindless insignificant human practices and release of massive quantities of contaminated and spoiled water from domestic and agricultural sources into Burullus Lake). Whilst providing sufficient content for study and research, it also played a prime role in water body management. An image (space-borne) Multi-spectral Landsat-8 OLI (2015) was collected. Through techniques of image pre-processing (radiometric and atmospheric calibrations), required data was extracted. Satellite sensors (dependent on absorption and scattering of particles by atmosphere, sensor-target-illumination geometry, sensor corrections, and image information processing strategies) mapping the nature's gifts and numerous human activities are occurring in the region circling the Lake. BOD (biochemical oxygen demand), TN (total nitrogen), and TP (total phosphorus) were the names of three empirical water quality prototypes developed before. These were tested and applied on the graded image and the segments of the river recording surging levels of BOD, TN and TP through a GIS model, demarcated and classified.

M et al. 2017 tried to deal with another such flexible system which can measure water quality based on three more parameters, temperature, turbidity, and flow along with pH using the corresponding sensors in their project. These sensors were mounted on PCB and were connected to MCU Arduino Atmega238 which processed the information and transferred it via the internet. Inbuilt ADC converted the analogue sensor values to digital values and the LCD was used to display the sensors' output. A cost effective Wi-Fi module ESP8266 was used to establish the connections between hardware components and software (an embedded C program) to view sensor data. The BLYNK app (which gave exact same values as those displayed on LCD) was installed in Android version to access real time values of water quality parameters. The scope of the system can be augmented by deploying more sensors to monitor other water quality parameters. Furthermore, the operations of the system can be extended to realize air pollution and industrial and agricultural production.

It is not possible for humans to reach out and scale every nook and isolated bends of massive stretches comprising water while scrounging for samples to test the variable water qualities at different points and places. In the given textual reference, the use of unmanned helicopters (Unmanned Aerial Vehicles) for the process of sampling water is put forward by (Schwarzbach et al. 2014) an automatic system bringing water samples from remotes areas via air. Such structured collection of water samples was crucial for physicochemical and biological surveillance in order to evaluate risks posed by freshwater pollution and requisite management of water ecosystems.

The procedure involved a UAV helicopter with a rotor diameter 1.8 m in size and a commutable autopilot system of

11 kg assisting the robot to adapt to payloads (ability to carry 2 kg supplementary payload) not experienced before. The global position of the helicopter was computed with a differential GPS system (precision position controller helps in execution of automatic landings and take-offs) whilst an IMU (inertial measurement unit) contributes in the estimation of UAV's orientation (rated as 100Hz). The controller also aided the helicopter to hover over a specified location with a positional precision of 10 cm. A pump-based set-up was utilized for lowering the container in which the sampled water was carried. The entire autopilot system was programmed via Simulink/MATLAB and the device was guided by algorithms. This made a relaxed mean for gathering water samples from vicious and challenging regions. Aerial sampling is mostly interesting in dangerous access or dangerous pollution as well as this is opening new era of research and business.

The article given by the authors (Lee et al. 2015) states that Smart Water Grid (SWG) Technology infused with Information and Communication Technology which blends itself into a sole water management strategy is predicted to be a potential solution for straightening the loops induced because of the current global water crisis.

The witty water grid is controlled by auto-diagnosed sensors (IoT) and cooperating networks (ICT-based), GIS (Geographic Information System) caught data of the assets, the history of changes and devising new plans for forecasting and monitoring information. It in turn opens up the gates to five principal research domains, i.e., (1) Urban Region Platforms (a provisional future-generation water architecture, scaling mountains of water-related management limitations, creation of a sustainable water cycle and an inspiration for other infrastructural models based on water), (2) Resources (decentralization of water management system because of conventional and alternative water sources), (3) Intelligent Network (bi-directional communication between ICT and water enabling them to work as mixed as well as standalone procedures), (4) Management (analyzing risk assessment and classification of selected technologies and methodologies as assets), and (5) Energy Efficiency (enhancing energy efficiency in water infrastructure maintenance).

The writers were able to conclude that the technique of SWG constructed using ICT integrated water management system as a base could ensure the safety of water quality and quantity, consumption of water-related energy (interdependency of water and energy) (Table 3).

In conclusion, after analyzing all these studies, there is no gainsaying that pollution is the dominant driver for disrupting the very environmental infrastructure of the planet Earth. There is a loophole in current case studies as they primarily deal with pollution monitoring and these technologies encompass potential to uncover pollution control systems in order to better manage the air and water resources. Above presented strategized automated real-time models also pave the way to mitigate air and water degradation and reconstruct the environmental infrastructure globally and sustain a holistic ecological restoration (Fig. 2).

The 5Rs- Refuse, Reduce, Reuse, Repurpose, and Recycle attitude can leverage environmental sustainability and a collaborative approach can be exercised to mitigate pollution through the integration of smart earth technologies with multifarious sustainable development goals (SDGs) and thereby ensuring smart sustainable cities. Pondering pragmatically, what the above suggested studies fail to look into does construction of architecture, holistically decentralized, possess cloud servers as computing gadgets. Devices those are capable of producing and processing the information locally from one edge device to other hence unburdening the cloud services computing data centrally. A decentralized structure being selective in nature provides an enhanced privacy too. The paradigm has shifted the Earth by accelerating the realms of futurism which is rapidly changing and how we can withstand the tectonic shifts within the world around us how does a society thrive where the globe economy is undergoing constant disruption when information is like light speed? Ultra-modern innovative methods and its solutions also bring out the rapid incursion which creates possibilities like improving quality of life and along with generating challenges like posing threat to human existence.

From the above case studies, it is clear that Smart Earth Technologies encapsulate potential for addressing an array of environmental concerns associated with air and water resources. The amalgamation of these technologies helps in collecting and visualizing air and water quality parameters. Smart strategies possess the ability to transform environmental data collection and its analysis. These technologies not only help in measuring different environmental parameters and thereby enhancing air quality and water quality but also aid in reducing both direct and indirect aftermaths on human health (Fig. 3).

Challenges

A multiple research expeditions and proposals have been carried forward on Wireless Sensor Nodes (WSN) centralizing around the function of surveillance of parameters like pH value, water level presence, conductivity, and turbidity of the water sample caught up on an Arduino or a microcontroller and the coalesced information is uploaded onto cloud. But, these few proposed prototypes are yet to even touch the market juncture (sky-level costs and poor quality sensors) (Sayed et al. 2019) (Navarro 2020). In the third section of this article, one can note a few examples of environmental robots like fish-shaped ones (Shin et al. 2007), hand-sized helicopter (Schwarzbach et al. 2014) or even robotic eels, and boat robots (Melo et al. 2019) shaping the viewpoint that these

Table 3 Enlistment of a few tested prototypes constructed using Smart Earth Technologies for tackling water pollution

Sr. No	Potential cause	Technology used	Description	Limitation/future Scope	References
1.	Domestic Sewage	Internet of Things	An integrated system of water quality monitoring and management was constructed which can trace abnormalities in the treatment process, analyzes pollutant source and reminds the personnel.	The system can be implemented in smart cities and can be amalgamated with AI, big data, Data Mining and visualization.	(Hong et al. 2020)
2.	Domestic Sewage	Internet of Things	IOT-based automation is proposed in Sewage Treatment Plant (STP) to perceive the level of the tank (using Ultrasonic sensor) and discern harmful gases (using MQ135-sensor) present in sewage.	Automation can be carried forward in different tanks of STP and data can be made accessible cloud using wifi module.	(Rishitha and Ullas 2019)
3.	Domestic Sewage	Internet of Things	An automated and cost-effective system for the sewage treatment plant (STP) was put forth to reduce human intervention in the treatment process. All the water quality parameters are stored in a database and the user can track record of all irregularities that have occurred in STP.	The system cannot be employed for AC motors and there is a scope of ML algorithms by which more efficiency can be achieved.	(Ullas et al. 2020)
4.	Industrial Waste Water	Cloud-based IOT	Integrated cloud-based Wireless Sensor Network (WSN) system is proposed to realize conductivity, Dissolved Oxygen (DO), and pH of discharged water and upload data on ThingSpeak Cloud and alerts the concerned authorities by Telerivet (SMS Gateway Service).	More participation from the community can be achieved in the Industrial pollutants monitoring system.	(Zakaria and Michael 2017)
5.	Industrial Waste Water	Artificial Neural Network(ANN)	An intelligent system using ANN with 2 hidden layers (consisting of 22 neurons each) has been proposed to predict chemical oxygen demand (COD) and 10.8% of mean absolute percentage error (MAPE) was realized.	The scope of the system can be increased by considering other key variables of the wastewater treatment plant (WWTP).	(Arismendy et al. 2020)
6.	Industrial Waste Water	Blockchain Technology	The architecture and key requirements of blockchain technology in the Industrial Internet of Things (IIOT) were identified, mainly-technical expertise, storage, decentralized P2P network, efficient mechanisms, and Policy regulation.	Securing edge nodes, analyzing consensus algorithms and security from vulnerable attacks are key future areas for leveraging blockchain technology for industrial wastewater management.	(Hakak et al. 2020)
7.	Industrial Wastewater and Domestic Sewage	Industrial Internet of Things	A wide area wastewater monitoring and control system based on cost-effective Wechat Applet (Wechat big data platform) and STM32 was proposed. The system used tencent cloud server for data storage and the system can carry out online fault repairing, thereby increasing the efficiency of the Sewage treatment plant.	The current research is a theoretical analysis and IIOT is still in the phase of steady development and maturity.	(Zhu et al. 2020)
8.	Agricultural Waste Water	AEMS Model	A water quality monitoring system based on an agent-based environmental monitoring system AEMS model was proposed. Six types of water quality sensors, mainly-dissolved oxygen, pH, ammonium-NH4, nitrate-NO3, and salinity were introduced and the system alerts the concerned personnel by web and mobile applications and SMS service.	–	(Chi Zhou et al. 2020)
9.	Agricultural Waste Water	Web Application	A web-based application 1622WQ has been developed which provides real-time and high-frequency information in order to better disseminate the connection between farming practices and water quality. An attempt was made to mitigate problems of poor connectivity, poor data quality, and operational issues.	The system is not useful in places that require manual infrequent sampling yields and in locations where concentrations of nitrogen are higher than that of detection limits.	(Vilas et al. 2020)
10.			An integrated framework of IOT and blockchain technology was used for	–	(Y.-P. Lin et al.

Table 3 (continued)

Sr. No	Potential cause	Technology used	Description	Limitation/future Scope	References
	Agricultural Waste Water	IOT and Blockchain technology	real-time identification of Pollution Source and Pathways (PSP). Irrigation water quality parameters were measured via WSN and water quality analysis was used to recognize key pollution sources.		2020)
11.	Urban Runoff	Sun Small Programmable Object Technology (SPOT)	An Accurate Urban runoff monitoring system is proposed using Sun SPOT as the sensor platform. Two sets of tests were performed and accelerometer outputs were collected. 13% and 12% of errors were obtained in the first series and second series of tests respectively which then mitigated to 5% and 6% on applying Kalman filtering.	The system can be extended to applying on several real sewer waterfalls and other platforms like Imote2 can be developed and analyzed using a comparative approach.	(Yu et al. 2010)
12.	Urban Runoff	Artificial Intelligence	An efficient real-time monitoring system (using cloud-based SCADA software) of storm water flow and quality has been documented for the smart water system and automation in hydraulic structures.	The system can have database analysis and matrix decision support in order to integrate it with china's 'five water management' approach.	(Ma et al. 2020)

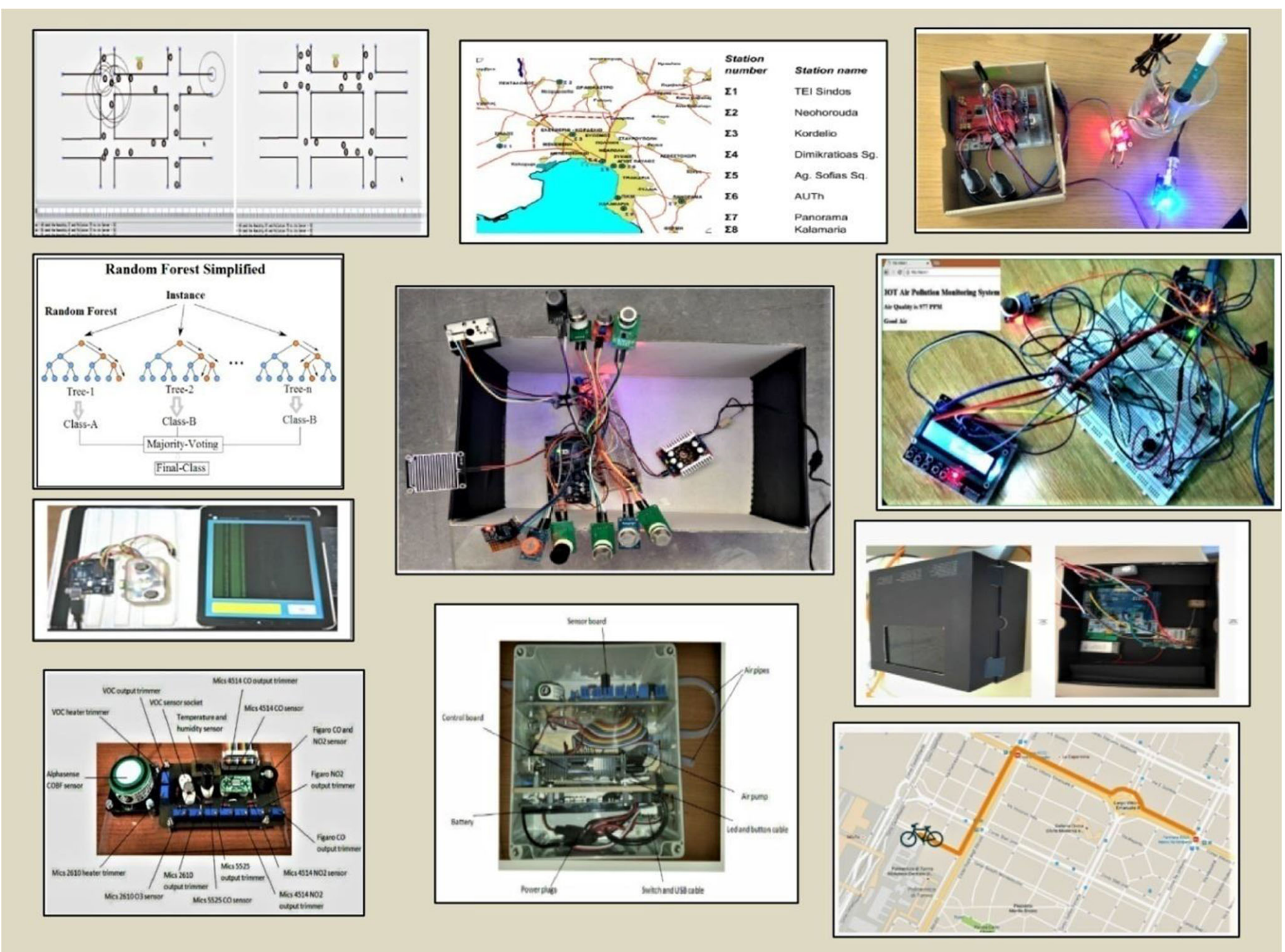

Fig. 2 Depiction of some real-time prototypes designed by incorporating smart technologies for dissecting air quality parameters

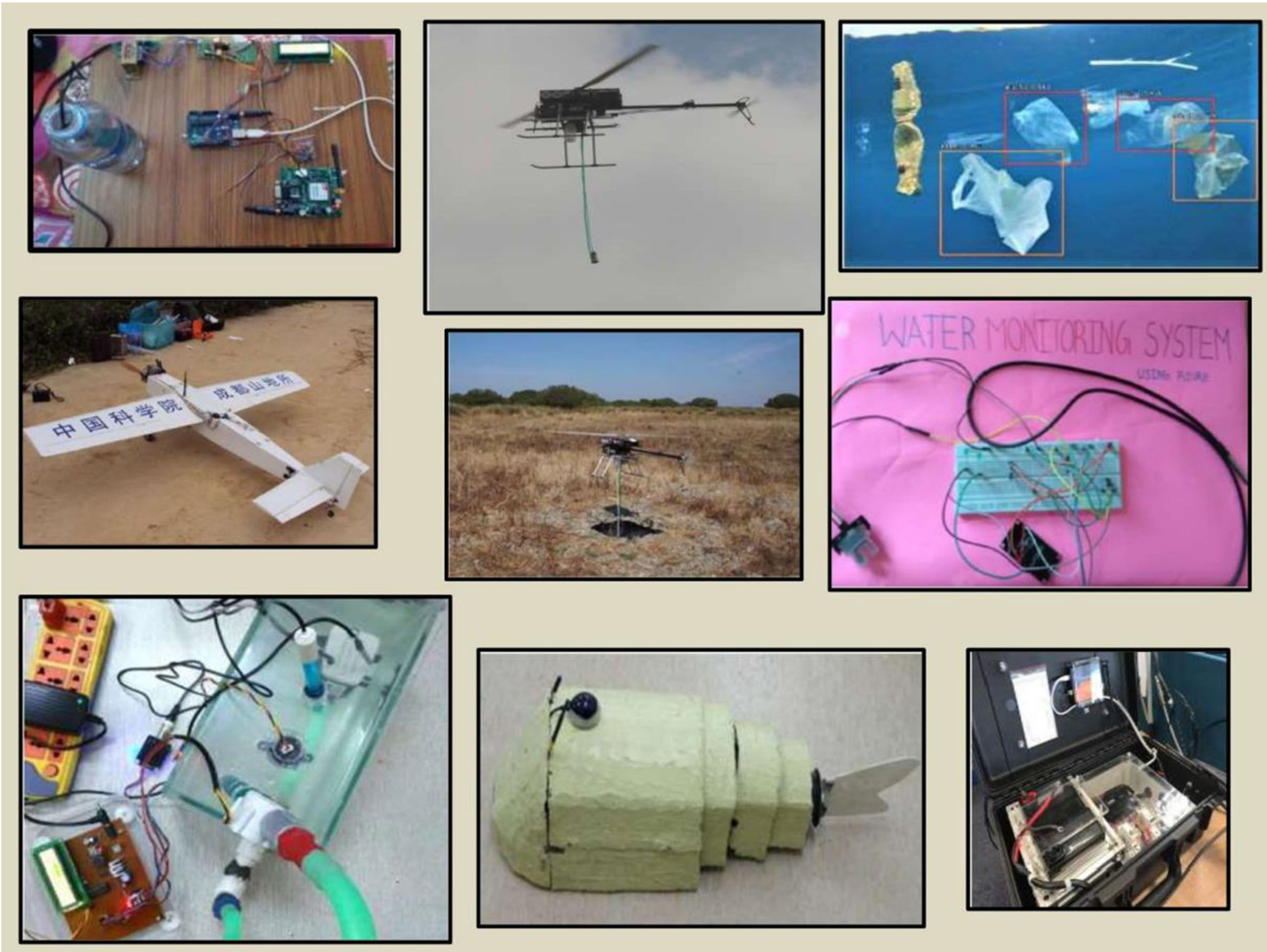

Fig. 3 Depiction of some real-time prototypes designed by incorporating Smart Technologies for dissecting water quality parameters

autonomous technologically-born devices are one of the salient techniques used for collecting samples and monitoring water bodies. Unfortunately, they are composed of minerals present in trace quantities over Earth and complex hardware, have a compounded manufacturing process and their disposal and disintegration would be another complication to pop up (Van Wynsberghe 2018). The weighty role of IoT in the sector of pollution faces threats of security, elevating because of low reliance over the web of networks used for its device's maintenance and low availability of specialists working over this (Skarga-bandurova 2019). The hardware assets are unable to bear intricate cryptography while at times IoT devices have a lower level of memory holding power and computational capacity (Toma et al. 2019). When applied across Environmental Monitoring Systems, the information is transferred across the actual stakeholders and its organization, is analyzed and a solution being thrown up for its management at a 'Smart City' level is a prominent question. Here is a thirst for a multi-purpose platform which is capable of connecting the data to the accurate IoT networks along with an efficient wireless-widespread connectivity because of a series of sensors supervising over different aspects of surroundings and these wide-reaching networks are not monitored on a timely basis (Sayed et al. 2019) (Arora et al. 2019). A proficiently mapped out system for maintaining a periodic check on the source, hence curbing high rate estimation is required (Arora et al. 2019). It is no lie that or the existence of a bond between Big Data and a greener and cleaner world, the challenge to overcome only being the lack of availability of data in quantities GB and TB and a strong connection to a live dashboard (Krishna et al. 2018). Although cloud computing helps in transferring and managing data among concerned personnel or even to the community, privacy and security are two crucial concerns of cloud computing. Sensitive data can be manipulated or altered by any eavesdropper. Additionally, there is performance unreliability in cloud as cloud resources are accessed by users with varying process loads (Islam and Morshed 2017) (Lakra and Kumar Yadav 2015). Artificial intelligence helps us fight against the planet's biggest challenge: Climate change by real-time monitoring and stimulating pollution levels (Sahin and Kirandi 2017). Among the researchers, the need of amalgamation of IoT, AI and ML algorithms to feed data related to the determinative environmental contaminants has been felt (Oprea and Iliadis 2011). Predictive modeling requires high computational power and time, abundant data and the validation of data standardization in the preparation phase. Furthermore, the performance of an ANN and hybrid models is confined because of poor reproducibility and restricted global perceptive ability (Pawul and Śliwka 2016). The framework of robust classification of approaches related to smart environmental methods is required because of the implementation of smart technologies. The data integrity and transparency used to scrutinize environmental pollution by Block-chain technology is a clinging on difficulty with data storing stain over the economy (Kozik et al. 2019). In a proposed observational framework incorporated with Ethereal Block chain and LORA (LOngRAnge) innovation, a Block chain, and IoT-based distribution system, the installation of Block chain full nodes in IoT sensors is cumbersome owing to computational power and minute size (Kozik et al. 2019).

Future scopes

The evolution of an integrated IoT Network could build a wondrous foundation for a Smarter Earth interpolated with a fuller and cleaner natural water and air reservoir (Navarro 2020). For a decent standard of data maintenance, the future provides opportunity to communicate the data to WHO, hence aiming for designing superiorly standardized sensors while implementing interface. These sensory web systems can be implanted upon existing 'smart city' infrastructure as traffic lights in order to monitor the effervescence emitted out of constantly moving vehicles (Toma et al. 2019). Privacy and security issues of information in cloud can be overcome by adopting complex encryption methods. Proper scheduling technique like multi-objective task scheduling algorithm can be used to enhance cloud performance (Islam and Morshed 2017) (Lakra and Kumar Yadav 2015). The deployment of IoT with the blend of Machine Learning Algorithm could expand its current dimensions helping them to stand as a more secure and robust architecture (Arora et al. 2019). The scope of Big Data in the near future is dependent upon the concept of 'Live Dashboard' which highlight the data streaming live and can analyses a good quantity of information coming through a multitude of sources. There is a possibility of foretelling the future data on the basis of the previous one (analyzing and visualization methodologies) (Krishna et al. 2018). AI is leveraging upon us the opportunity by reaching people through a modeled communication monitoring network with the potential of wearable health technology (Ye et al. 2020). Utilizing the information given by an electronically assisting organization can be done by upgrading the administrative viability (Hino et al. 2018). With the hope of enhancing efficiency of public agencies, there is a scope of leveraging data in electronic reporting systems and therefore avoid undesired error propagation (Ullo and Sinha 2020). The precision of the robots set free into water bodies could be scaled to heights by introducing bathymetry (determining the depths of waters in which they are), generation of 3D mappings of the aquifers, and 3G/satellite communication system's collated data can be transferred to the cloud web (Melo et al. 2019). Block chains can open up whole new domain of monitoring the marine ecosystem, if its organ systems Data Validation and User Verification are better looked at, exhibiting the physical world validity with higher throughput and live sensor information.(Czachorowski et al. 2019)

Conclusion

With the ever increasing tempo of technological advancements in this information age, there is no gainsaying that the concern towards air and water resources is more serious than ever. This paper has documented comprehensive analysis of numerous real-time models based on Smart Earth Technologies for better regulation and control of air pollution and water pollution. Unlike the conventional practices, the notions of environmental sustainability are better understood by the way smart strategies have transformed the environmental data acquisition and analysis. Although this research hasn't encompassed every smart technology that constructively contributes in pollution monitoring and mitigation, researchers have attempted to portray the potential of these technologies in abating pollution for a smarter and greener future. This study has addressed an array of environmental pollution concerns associated with the underlying impacts of human activities and its profound consequences which are not confined to city, state, or a country but has it aftermath globally. With the advent of these cutting-edge technologies, the interest of researchers in incorporating these technologies for smarter pollution monitoring systems is escalating, and there is an optimism in authors that by these practices, more cost effective methods for environmental data collection would be available by democratization of these technologies globally.

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Availability All relevant data and material are presented in the main paper.

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Declarations

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The authors declare no competing interests.

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