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Resilient Solutions for Health of Planet Earth from Data-Driven Models and AI-Embedded Science and Engineering

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ABSTRACT: *The mankind in the present day planet earth is facing many challenges. The health of the ailing planet earth is, therefore, one of the most important issues. The vision of scientists and engineers is centering on mitigating this issue. It is necessary to create a sustainable future using science, engineering and technology for the benefit of humankind and the planet with its flora and fauna. In this paper, the innovative ides of the use of data-driven science and AI-embedded engineering in the fields of climate change with clean and secure energy, energy conversion and renewable storage, including efficient carbon capture, smart power systems, low emission propulsion and green buildings have been discussed. Advances in multi-scale and multi-physics modeling and other data-driven models in the fields of thermal hydraulics, heating and thermal transport, food security, clean unpolluted air, AI-embedded usable water management with efficient desalination capability have found their places in this paper. AI-based smart irrigation and digital agriculture including AI-embedded sustainable aquaculture and harvesting have been discussed. AI and machine learning, rapidly advancing capabilities of high-performance computers and associated solution algorithms and simulation methodologies are making it possible to simulate highly-complex systems with much higher fidelity. This was not possible in the past days. The impact of these data-driven models and AI-embedded engineering cannot be over emphasized now for the health of the planet. An integrated focus on computing, modeling and simulation is the need of the hour. The need of fundamental and applied research in integrating dynamical models for intelligent environmental sensing with integrated smart sensors, monitoring, forecasting and risk management is being increasingly felt to solve the problems of sea-level change, flooding events, droughts, coastal pollution, heat waves, biodiversity threats affecting human health. ANN based deep machine learning methods are to be applied to do all what are needed to protect our planet. Sustainable mobility and transportation give valuable and indispensible data for estimation, prediction, autonomy and control, autonomous vehicles, clean transports and ocean environmental systems. Diversity, equity, inclusion and a sense of belonging in the minds of scientists, engineers, and technocrats must play an important role for the health of the Planet Earth.*
KEYWORDS: *Artificial Intelligence (AI); Data-Driven Models; Deep Machine Learning; Planet Earth Health; Artificial Neural Network (ANN); Diversity; Equity; Inclusion; Sense of Belonging.*

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I. INTRODUCTION

Data-Driven air pollution control, prediction of usable water characteristics and quality, prediction of possible food insecurity, climate change and energy security status, heating and transport, multiscale and multiphysics modeling and thermal-hydraulics have been discussed in this paper. Also, Artificial Intelligence (AI) based sustainable aquaculture, smart irrigation; digital agriculture and crop-harvesting and AI-embedded water management, and energy conversion and renewable storage, including efficient carbon capture, smart power systems, low emission propulsion and green buildings are discussed. In the last section, it has been established that a sense of unity in diversity, belonging, equity and inclusiveness can only keep the health of the planet well and this only would foster Global Peace. These societal issues are very challenging.

II. EXAMPLES OF DATA-DRIVEN AND AI-EMBEDDED SYSTEMS MODELING

Data-Driven Air Pollution Control

Air pollution is a global environmental threat for human health, morbidity and premature mortality. Reliable monitoring and control systems are necessary to combat the threat. Present day monitoring is inadequate. Microwave links for cell phone towers can be harnessed to map rain. Rainfall causes a decrease in the signal strength allowing the built-in sensor network to map the phenomenon. There is a relationship between

pollutant wash-off and rainfall and the air quality may be monitored using existing cell-phone tower signals. Since the density of microwave communication networks is high relative to any dedicated sensor arrays, it could be possible to rely on this for studying precipitation scavenging on air pollutants.
The monitoring stations are geographically sparse and the available data are incomplete; machine learning-based computational data-driven mechanisms can accurately predict the air quality index, using environmental monitoring data together with meteorological measurements. The air quality estimation framework may be obtained by using non-linear autoregressive ANN technique with exogenous input model for time series prediction. Other data-driven standard machine-learning based predictive air-quality control algorithms also may have the feasibility to yield robust performance for different topological areas.

Data-Driven Modeling of Water Quality Parameters and Artificial Intelligence (AI) Embedded Smart Water Management System

The evaluation of water characteristics in general and water quality in particular are necessary to enhance the health of humans and ecosystems. Data-driven models are computing methods for extracting different system states without using complex relationships. Prediction and simulation are two branches of data-driven modeling that use previous and previous-current data sets to fill gaps in time series. The adaptive neural fuzzy inference system (ANFIS) and genetic programming (GP) are two data-driven models to predict and simulate water quality parameters. Implementation of the ANFIS and GP models has shown that GP may have more flexibility in time series modeling relative to ANFIS. GP modeling is an effective tool for determining water quality parameters. By harnessing the power of artificial intelligence algorithms and big data analytics, water utilities can maximize information and data available to make better decisions while enhancing service delivery and reducing costs and pilot artificial intelligence toward the prognosis of unaccounted-for-water.

Data-Driven Food Security Estimation

In the planet earth, approximately a billion people face food insecurity. Statistical models badly fail to systematically incorporate readily available data on prices, weather, and demographics due to which policymakers fail to rapidly identify food insecure populations. The end result is the hunger, serious malnutrition, emaciation, cachexia and unfortunate untimely death. The replicable, near real-time data-driven model incorporating spatially and temporally granular market data, remotely-sensed rainfall and geographic data, and demographic characteristics can very well mitigate the food insecurity problem. The powerful accurate modeling of food insecurity provides early warning and data-driven model approaches could dramatically improve food insecurity crisis response.

Data-Driven Combating of Climate Change

Knowing where, how and whether to drill a well, for example, amid extreme conditions wrought by climate change poses a serious challenge. Complexities of rising temperatures, shifting precipitation patterns and extreme weather have led to new data-driven approaches to the toolkits to drill the well, plant a sustainable farm or preventing the waterborne deadly diseases like malaria, cholera and other enteric endemic diseases with mostly priceless child mortality. Satellites, sophisticated data-driven computer modeling and data analytics will define the future of global development. Thus growing challenges of food and water insecurity, power generation, education, and economic growth in the world's most vulnerable regions can be successfully dodged. Data may be drawn from satellite imagery, history and on-the ground conditions. Equipped with the right information, the onsite experts interpret the data to customize solutions that fit community and cultural needs and deliver the most effective, climate-resilient approach. Transparent data can help earn the trust of decision makers and communities while locally based staff brings understanding of cultural context.

Data-Driven Energy Security, Energy Conversion and Renewable Storage

Freely available data from reliable sources can be a powerful input to innovation. Open data-driven secure system can spur entrepreneurship, empower citizens, and create jobs. As an example, data from the Global Positioning System (GPS) can be utilized by entrepreneurs to power navigation systems, precision crop farming tools, and other innovations that add value to our economy each year and can improve the lives of citizens in many ways. The launch of a series of Open Data Initiatives in energy is a real value-addition. The Energy Data Initiative (EDI) aims to help citizens benefit from entrepreneurial innovation enabled by open energy data from the government and other sources. New products and services continue to emerge to help citizens' families and businesses save energy and money, protect the environment, and ensure a reliable energy future. Energy Data Jam is a serious unfortunate bottleneck. This has to be obviated at all costs. Publicly available datasets might be put to use in the continuing transition to a clean energy future. Ingenious new ideas for products, services, features, and apps can be built using open energy data as an input. Open data can also include companies that make private-sector data more accessible to their own consumers using open industry formats. Electricity customers are to be provided with easy and secure access to their own energy usage information in a consumer-friendly and computer-readable format. The energy data can play in lowering the cost of and improving access to energy financing, especially around commercial building upgrades.

Let us take a system to generate regulated and controllable AC electricity from renewable sources of energy that is intermittent in their power output. The whole configuration comprises a renewable energy source and an appropriate conversion mechanism, an electrolyzer to produce hydrogen from water, a hydrogen storage tank, fuel cells to generate DC electricity using hydrogen as the fuel, and an electromechanical energy conversion system, comprising a DC motor in series with an AC generator to convert the DC electricity output of the fuel cells to controllable, regulated, harmonics-free AC output, directly connected to the power system grid. Other features of the system include the capability to modify the system, so as to generate electricity from natural gas, propane and hydrogen that was produced by off-peak electricity. In this example, a Data-Driven model can do the job very efficiently.

Data-Driven Heating and Transport

Data-Driven supervised machine-learning (ML) model can predict heat load for buildings in a district heating system (DHS). The algorithms may be Support Vector Regression (SVR), Partial Least Square (PLS), and Random Forest (RF). Data may be collected from buildings at several locations for a certain period. The accuracy of predicting the heat load may be ascertained using mean absolute error (MAE), mean absolute percentage error (MAPE), and correlation coefficient. In order to determine which algorithm gives the best accuracy, the performance among these ML algorithms may be compared. Average carbon intensity of buildings must be within the allowable limit. Data-driven models may be used for strategic planning of building energy retrofitting. The approach is to be based on the urban building energy model (UBEM), using data about actual building heat energy consumption, energy performance certificates and reference databases. The energy performance of each building is used for holistic city-level analysis of retrofitting strategies considering multiple objectives, such as energy saving, emissions reduction and required social investment. The retrofitting packages like heat recovery ventilation; energy-efficient windows; and a combination of these are to be considered for multi-family residential buildings. This identifies potential for decreasing heat demand and consequent emissions reduction and allows the change in total energy demand from large-scale retrofitting to be assessed and explores its impact on the supply side. It thus enables more precisely targeted and better coordinated energy efficiency programs. It demonstrates the potential of rich urban energy datasets and data science techniques for better decision making and strategic planning.

Data-Driven Multiscale and Multiphysics Modeling

Multiscale Informatics (MSI) approaches may be used for analysis of the physics of complex systems. Multiscale, multiphysics models may transform molecular interactions to macroscopic observables measurable experimentally relevant to engineering design. MSI can then use inverse uncertain quantification to assimilate data from varied sources and scales. MSI’s unique capabilities allow the analyst to extract meaning from complex data that pose challenges for traditional methods. MSI models can accurately predict behavior at both molecular and macroscopic levels. MSI can create full multiscale kinetic mechanisms for combustion and pollutant emissions of carbon-free fuels, to test hypotheses, to define and push the limits of data-driven approaches for chemical kinetics, to serve as a platform for automated scientific discovery, and venture into new disciplines.

Data-Driven Thermal Hydraulics

Nuclear power plant safety requires a practical and systematic approach to identification of accident scenarios. Risk-informed safety margin characterization (RISMC) requires computationally robust and affordable methods for sufficiently accurate simulation of complex multi-dimensional multi-phase flow. The CFD-like codes with 3D simulation capability and full treatment of momentum transport terms ensure computational efficiency using coarse mesh size and the sub-grid phenomena in the boundary layer that can be captured by adequate constitutive correlations like wall functions and turbulence models. It would be useful to have a “smart” data-driven multi-scale framework in which the low-resolution models can be tutored to emulate high-resolution models. A physics-based data-driven mesh-model optimization approach may be taken to estimate the simulation error. This approach takes advantages of computational efficiency of coarse-mesh simulation and application of Machine Learning (ML) algorithms. Current computer codes have limited capabilities to simulate real plant conditions, especially for extrapolative conditions, since the empirical correlations applied are mostly determined by curve fitting and strongly depending on geometry and boundary conditions. Although some advanced coarse-mesh codes are widely used in system-level safety analysis due to their balance on computational efficiency and simulation accuracy, the Verification & Validation (V&V) of these codes still suffers from the lack of prototypic validation data. In view of mesh size as one of the model parameters for these coarse-mesh codes with simplified boundary-layer treatment, the mesh-induced error and model error makes it difficult to analyze the mesh effect or the code/model scalability separately. A data-driven approach establishes a technical basis to overcome these difficulties by exploring local patterns with the usage of machine learning.

AI and IoT-Based Sustainable Aquaculture

Farmers have a perennial challenge since feed costs account for a majority of their operational overhead. IoT devices and machine learning offer farmers a solution to improve their feeding operations. Fish Appetite Index, FAI, uses efficient machine learning and image analysis techniques to extract relevant data from video streams that can then be used to accurately quantify fish appetite. FAI is an important tool that can be used to increase productivity and reduce waste. Thus aquaculture is empowered through technology. Farmers improve farm efficiency, manage environmental risks, and in turn increase business revenues by using IoT, satellite remote sensing, and artificial intelligence (AI). FAI algorithm takes in the same visual information that humans would and then scores fish appetite and presents it in an easy to understand chart. When used in tandem with a smart feeder, the feed time intervals and amounts can be automatically adjusted with minimal human interference. FAI combines several algorithms into a single index; as a result it can be used under a range of environmental conditions and for a variety of camera mounting positions including both underwater and above water.

Artificial Intelligence (AI) and Internet of Things (IoT) in Smart Irrigation, Digital Agriculture and Crop Harvesting

Agriculture and farming is a core economic sector. It needs a smarter approach and become more efficient about how the farming can be most productive. The challenges faced by farmers using traditional methods of farming can be reduced by using Artificial Intelligence (AI) and IoT, the Internet of Things. AI is making a revolution in agriculture by replacing traditional methods. Preparation of soil, sowing of seeds, adding fertilizers, irrigation, weed protection, harvesting and storage are several sequential jobs a farmer undertakes. In farming climatic factors such as rainfall, temperature and humidity play an important role in the agriculture lifecycle. Every crop requires specific nutrition in the soil. Weed protection plays an important role. The agro-industry is turning to Artificial Intelligence technologies to help yield healthier crops, control pests, monitor soil, and growing conditions, organize data for farmers, help with the workload, and improve a wide range of agriculture-related tasks in the entire food supply chain. Weather forecasting data, soil and crop health monitoring system, analyzing crop health by drones, Precision Farming and Predictive Analytics are very important for successful economic farming. AI applications in agriculture have developed applications and tools which help farmers. While using the machine learning algorithms in connection with images captured by satellites and drones, AI-enabled technologies predict weather conditions, analyze crop sustainability and evaluate farms for the presence of diseases or pests and poor plant nutrition on farms with data like temperature, precipitation, wind speed, and solar radiation. The automation (AI and IoT) in agriculture protects the crop yield from various factors like the climate changes, population growth, employment issues and the food security problems. Spraying with the help of sensors and other means embedded in robots and drones are also done.

Data-Driven Carbon Capture Technology, Smart Power System, Low-Emission Propulsion and Green Buildings

Current and anticipated legislation throughout most of the developed world suggests that a reduction in the amount of CO_2 that industry will be allowed to emit in the future is inevitable. Fossil fuels such as Coal and Natural Gas are likely to be a significant portion of the world's energy mix for many years to come. CO_2 capture technology utilizes a regenerable amine that offers cutting-edge performance, including low parasitic energy consumption, fast kinetics and extremely low volatility. The system captures the CO_2 from the flue gas and releases it as a pure stream, which is delivered to the client for sale into the EOR/IOR and commodity markets or for eventual sequestration.

Data-Driven strategies are interdisciplinary in nature and are used in a wide variety of areas of Smart Grid, Power system Stability and Security, Renewable Energy Systems, Microgrids, and Energy Management Systems. A system can generate regulated and controllable AC electricity from renewable sources of energy that are intermittent in their power output. The whole configuration may comprise a renewable energy source and an appropriate conversion mechanism, an electrolyzer to produce hydrogen from water, a hydrogen storage tank, fuel cells to generate DC electricity using hydrogen as the fuel, and an electromechanical energy conversion system, comprising a DC motor in series with an AC generator to convert the DC electricity output of the fuel cells to controllable, regulated, harmonics—free AC output, directly connected to the power system grid. Other features of the system may include the capability to modify the system, so as to generate electricity from natural gas, propane and hydrogen that was produced by off-peak electricity.

The fluctuation of the oil price and the growing requirement to reduce greenhouse gas emissions have forced ship builders and shipping companies to improve the energy efficiency of the vessels. The accurate prediction of the required propulsion power at various operating condition is essential to evaluate the energy-saving potential of a vessel. A data-driven propulsion system can predict the propulsion power of a vessel. Support vector regression (SVR) can be used to learn from big data obtained from onboard measurement and the relevant database. The data-driven approach shows superior performance if the big data are secured.
Certified green buildings within a specified geographic region have sustainability strategies and they stack up against the performance of other buildings. Existing data aid designers and builders in adopting smart, practical and achievable sustainability strategies.

III. DIVERSITY, EQUITY, INCLUSION AND A SENSE OF BELONGING IN THE PLANET

We, one and all humans belong to the planet earth and we have to housekeep the planet well for our wellbeing. We have to embrace diversity, sense of equity, inclusion and belonging for the good health of the planet earth.

The present day world is not getting any scope to circumvent itself from the crisis. There is never-ending series of crisis; no respite from this whatsoever. It is flush with crisis of one form or the other. There are threats to food security, water resource security, health security, environmental security, energy security, housing security, as well as threat to the security of sustainable development, threat to Mother Nature Herself as a whole. Worldwide threat from Global Warming and Green House Gases (GHGs) emissions is lurching before the world. Most recently, at the time of writing this article, the threat from monstrous "COVID-19-the Novel Corona Virus, the Pandemic with its varied ugly forms, the latest being the Omicron" is ravaging the whole mankind at every corner of the human habitation. Verily, the danger is so serious that world leaders are overwhelmed and they are not finding any way to come out of the grave situation present everywhere; from one continent to the other. Virologists and the entire Medical Profession have been challenged. There are political tensions which have flared up and military and diplomatic pressure is being mounted upon the leaders.

Energy is becoming increasingly scarce economic resource. There is a real threat to food supplies. The entire human population all over the world is suffering from the accumulated effects of such crisis. Our economies are in the peril. Societies are more and more interdependent these days. Demographic growth and urbanization have reached unprecedented levels; the news and information are diffused through the entire globe at a rocket speed through immensely improved media. People are desperately looking for good to better quality of life. In the process, the suffering and strife are becoming more intense and brutal.

There is a loud call for global peace. The people are now looking for the ways of living with human dignity. Peace and dignity in a fairer world depends primarily on (1) opportunities for development (2) natural world. Mother Nature has to be protected at all costs and this must be a conscious effort. For this, mutual respect is needed and we must restrain ourselves from unjustifiable greed and we must not covet unnecessary over exercise on natural resources and we must protect them. We must not condemn entire population to be excluded from development and fundamental human rights to live peacefully must be ensured. Our claim on the natural resources must not be irrationally excessive. For this, we must rely on human ingenuity and the ability to constantly innovate and come up with new solutions.

Technological advances and its applications in the right direction would enable us to speed up the roll-out of new, smarter, more efficient, more environment friendly, more sustainable, and fairer solutions to all our current and future problems. At the same time, we have the need and obligation to take right political action with right and justified goodwill. The higher the political echelon in the political ladder, the more the necessity of doing well the politician's job to take the lead, to implement and oversee the natural resources, which is five fingered like water, energy, food, health and environment. The sustainable development in the world is possible only through proper education. Education with basic ethics, morality and sense of responsibility is of utmost necessity. The key strategic challenges faced by our planet at the moment, in addition to what has been already written above; are climatic security, nuclear security and maritime security. Scarcity of any basic resource makes human societies more vulnerable and leaves entire global population in an extremely fragile situation.

Global resource security has now become integral part of every country's national security and foreign policy. The art of building peace is based on the vital natural resources at a global level, the security of which cannot be toyed with. This is possible only with proper education that a single citizen of this globe is holistically entwined and she/he is an integral part of the entire humanity as such; any problem of any single person is bound to reflect on the other, just as in the case of conjoined twins. The nature cannot bear with resource-diplomacy anymore to safeguard the security of mankind along with her/his extended family existence with animaldom, flora and fauna, etc. We must have the adequate sense of rights and everyone must be vigilant about ethics and transparency in political action. The Mother Nature with its puissant executive power has rightly proclaimed and ordained this to the humanity and we must enforce this with a firm conviction. We must have international pact(s) on each and every major resource issue for sustainable living of every species. The UN would be the Custodian and Ombudsman for this. Everyone everywhere must have the unwavering commitment with unflinching grit to achieve this goal. We must have vision, leadership and contribution to the cause of ensuring access to all natural resources, with determination and firm resolve of the mind and sense of purpose.

The basic intonation of what has been written above is the global peace and how to ensure this. The spirit of writing this article is to make the world aware of the present precarious situation and how we can come out of this daunting development. We must appreciate that each individual in the globe must be taken with due dignity, for we are like the unit beads of the same garland adorned by the 'Reality' and we must be responsible and sensible individuals to live peacefully and leave the world with a satisfaction that we have lived rightly and played our role with minimum faults; we must leave the world making the world sustainable for future generations. This is possible only through proper consciousness, education and unselfish love for the Existence, the Being. Let us not cause our own peril and devastation. The reader of this article has been kept all along on the shoulder of the author and taken toward the goal of attaining global peace through several words, sentences, and paragraphs of the article.

The world has come to a point, where if the people who matter in taking the major policy decisions right across the whole world, do not perceive the gravity of the situation and take right decisions to avoid the destructive threat, the nature would teach us, the humanity and all the living creatures and, of course, the inanimate objects as well, a lesson the hard way. What we must do, right at this moment, is to share all resources, economic goods and services as well as the precious human resources equitably with a sense of inclusiveness, unity in diversity and a sense of belonging for global peace as a whole.

We are all in this Hotel of the Planet Earth in which we have the VISA for certain years; there is no world embassy to extend this VISA in any manner whatsoever. Our stay in this Planet Earth is just a sojourn, at the end of which we are destined to go back to our Natural Habitat. Then what is the essence of making cacophonic sound and pandemonium in the Earth's surface?

The Food Security is by all means the most important issue. You know, why? The Creator was tremendously hungry right after the Creation. There must be a complete security to each and every one. Yes, even for the children of the unlawful mid-night passion. Why and for what on earth, they should be forsaken as unwanted souls. Who creates them? Don't we have the responsibility to share their woes? It is the responsibility of us to give them a better treatment. Otherwise, we the privileged souls would not be pardoned by the Mother Nature.

Then comes the water security issue; let it be potable water or the water for other uses. It must be appreciated here that the scarcity of food and water causes the threat to the security in other human issues as well. There must be a well-knit plan for proper utilization of water. Then there is the issue of health security. Who knows not, that health of all is a sine qua non for peaceful living? Let us put serious thoughts to guard the health security. Also, the environmental security, the energy and housing security and the sustainable development security issues can never be undermined.

Then the synthesis of science, philosophy and religion is to be made and understood, the synthesis shows us that there is no room for the people of different professions, may them be saints, monks, nuns, scientists, philosophers, theologians, social scientists, politicians becoming belligerent. Consciousness has by and large the most important role to play for global peace. The finer is the development of individual minds; the better the chances of her/his playing more valuable role in this planet under the Sun. Global Peace can be attained by doing justice to the inclusiveness, unity in diversity, equity and a sense of belonging. The author has gone through several peace-related journals. But to the amazement of the author, it has been an unfortunate experience of the author; no research paper is dealing with the root cause of all the global turmoil, and the strife. The root cause is the selfish way of dealing with the things; I and those who would be docile to my wishes and wills, are only good and they only would enjoy the globe; and the others are bad and let them be banished forever. Utter foolishness indeed! Let us emancipate ourselves from the darkness of the Goliath of Ignorance.

IV. CONCLUSION

In this paper, we have discussed that Data-Driven air pollution control, prediction of usable water characteristics and quality, prediction of possible food insecurity, climate change and energy security status, heating and transport, multiscale and multiphysics modeling and thermal-hydraulics. Also, Artificial Intelligence (AI) based sustainable aquaculture, smart irrigation and digital agriculture and crop-harvesting and AI-embedded water management, and energy conversion and renewable storage, including efficient carbon capture, smart power systems, low emission propulsion and green buildings are discussed. In the last section, it has been established that a sense of unity in diversity, belonging, equity and inclusiveness can only keep the health of the planet well and this only would foster Global Peace. The reader is advised to get the relevant information from the references given below. The societal issues discussed in this paper are very serious.

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