BIG DATA ANALYTICS-INDISPENSABLE FOR PREDICTING AND CONTROLLING CLIMATE CHANGE

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Abstract:

Erratic climate change has been attracting a lot of attention recently. The adverse effects of climate change is being felt everywhere. Since 1880, global sea levels are 8 inches higher today and are expected to rise another 2 to 7 feet during this century. Moreover glaciers are melting, cities are experiencing recurring floods and deforestation is on rise. Weather Analytics, a Company providing climate data, estimates that 33% worldwide GDP is impacted by weather. To handle this issue, countries need good action plan. It is naïve to believe that only industry and enterprises contribute to climate change. There is a great need for scientists to harness those elements of technology that have potential to hasten our understanding not just of the drivers of climate change but also help find out relevant solutions so that requisite actions can be taken. Everyday huge amount of data are created in term of terabytes to petabytes from climate through various environment observation systems. Climate related data is considered to be Big Data as it is multidimensional, multi-approach and multisource. Big Data provides ability to rapidly process and extract information from massive and diverse environmental data records, which can aid in mitigating impacts of natural disasters and also help in managing limited resources effectively. This Global Monitoring System also provides early warning of potential ecosystem degradation, including changes in biodiversity, water quality, disease risk, vegetation stress and food security. This paper discusses the challenges being faced in effective implementation of Big Data Analytics and suggests strategies to overcome these. It reveals how Pairing Big Data insights with in-depth qualitative research can reveal greater understanding of climate vulnerability and ultimately lead to better adaptation responses.

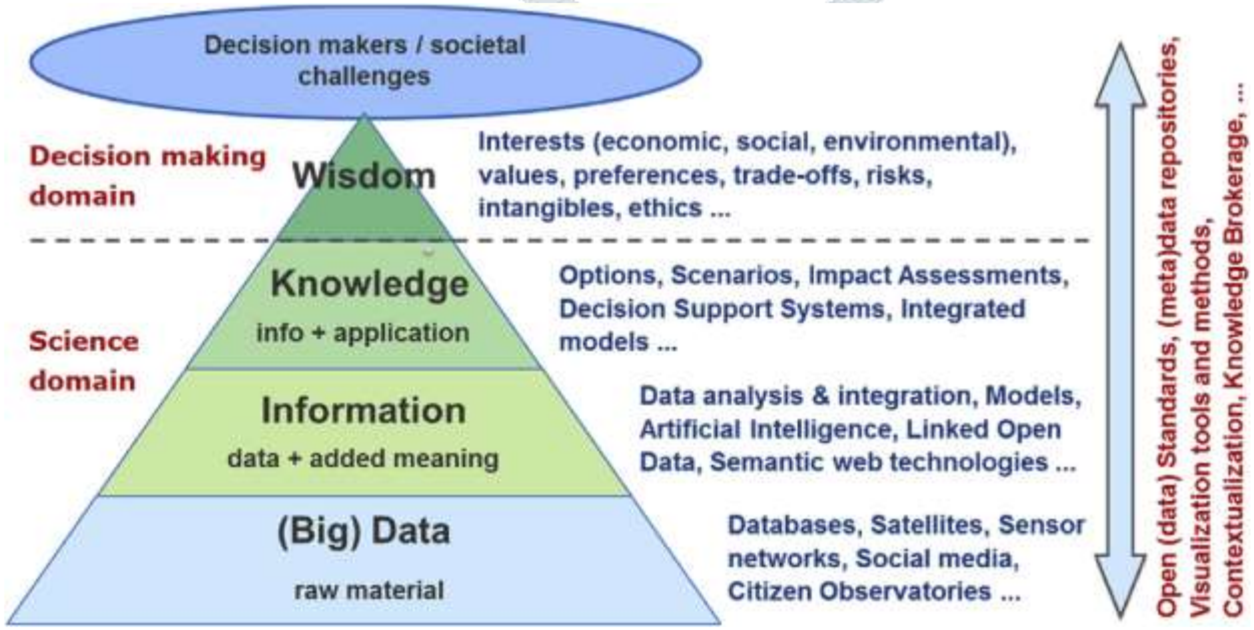
Keywords: Big Data Analytics, Climate change, Adaptation, Global Monitoring System, Data Simulation, Data Assimilation, Decision Support System, Ecosystem, Data Security, Global Data Sharing

Introduction:

The story of modern Big Data started in the year 2000 with the interest in how much data people produce. It was found that each year 1.5 billion GB of data was produced by each person. In 2004, due to introduction of SaaS(Software as a Service) cloud storage came into picture and that was the time when climate science started utilising big data analytics on large scale. Climate data is being collected continuously from everywhere - from space through Remote Sensors and from Ground through Ground Sensors, which are used to monitor and measure weather, land use, vegetation, oceans, cloud cover, ice cover, precipitation, drought, water quality, sea surface temperature, and many more geophysical parameters. These comprehensive data collections give us increasingly deeper and broader coverage of climate change, both temporally and geospatially. This huge data qualifies to be Big Data as it has following four features which characterizes Big Data:

- Volume: Data is gathered every second and it is measured in petabyte, Exabyte, zettabyte and yottabyte.
- Variety: Existing technologies make it possible not just to acquire enormous sets of data but also makes it possible to capture structured as well as unstructured data.
- Velocity: The data is stored at the enormous speed at which it is generated.
- Veracity: The data collected is accurate and verifiable through the source from where it was collected.

The following diagram shows DIKW Hierarchy of Big Data Analytics. It conceptualizes the process of turning the enormous mass of data, which as a raw material has little or no significance to end users, into compact, structured and contextualized, manageable 'chunks' that are applicable in a specific decision making context.



It is projected that the global population in 2060 will be 9 billion. This means stress on agriculture sector. Big Data has the ability to monitor environmental change and assess risk at regional and global scale. This technique can be utilized for cropping adaptation-adjusting crop sowing and cultivation dates to account for changing growing season. Predictive analysis will help farmers cope up with increasing climate variability. Moreover, passively collected digital data, through call records of people, credit/debit transaction allow large scale tracing of people's movement consumption trends in changing climate. This data has huge potential to enhance the monitoring of climate-related threats and vulnerabilities and can provide appropriate information to decision makers and emergency services.

Big Data and the analytical tools used in its processing is able to process and analyze more past data than ever before. Previously, this too was limited by resources but with its increased access and availability, it is expected to permit easier presentation and reporting, delivering more confident results and therefore, better to aid decision makers and policy development professionals. Scientists and government can work together more efficiently in future, not just to react to the environmental problems of today, but work with greater foresight today to make better decisions for tomorrow.

Present Scenario:

Enormous volume of data on different variables such as temperature change, sea levels, forest cover and carbon emissions are collected every moment and analyzed. These tools can establish the correlation between different variables, provide actionable insights, predictions and patterns based on which proactive actions or precautions can be taken. How big data and predictive analytics are influencing the fight against climate change can be best understood by the contributions of a few tools and technologies, as described below:

Surging Seas

Surging Seas provides information on the rising sea levels in the United States. One can use the map to see accurate sea levels at different places, view flood warnings, action plans, sea level patterns, historical data, embedded widgets etc.

Google Earth Engine

The Google Earth Engine compares the state of environment across years or decades, identifies problems so that it can be fixed. The engine compiles publicly available satellite imagery to identify environmental damages across the earth.

Global Forest Power

It is a tool that helps track the forest cover across the world. It offers an interactive map which provides an array of information such as forest cover, deforestation in any specific region, forest fire etc.

Citizen Science

This is accumulation of data reported from people in various geographical locations all over the world voluntarily offering information on conditions where they live. When many people report a phenomena, it reduces possibility of hoax, misinterpretation and fake reporting.

Climate Model

Simulations are used to predict climate behavior over the next 100 years and beyond. Huge simulations are run daily now. These simulations have higher vertical and horizontal resolution covering more span of time and area as well. Consequently, we update the climate model daily with latest input data. A climate model can predict weather over periods of decades and centuries. This is done through data assimilation, a process by which the latest observational data is incorporated into current model.

CASE STUDY

The Norwegian capital of Oslo was able to reduce its energy consumption through application of Big Data Analytics when examining its energy resources. Similarly, Portland in Oregon used a similar system to analyze stop light changes at intersections in order to manage traffic flow better. After just six years, the city eliminated 157,000 metric tons of CO_2 emissions. Traffic flow varies as a city grows; what was once a sufficient spotlight pattern can change. Citizens are usually influenced by the energy consumption of their neighbors. Opower, a company working on energy analytics, has used this bit of behavioral pattern to do their bit for climate change. Opower sends personalized reports to citizens that compare the energy usage of neighbors. And it is yielding results. Since Opower started in 2007, it has been able to save almost 6 billion kilowatts of energy, enough to provide energy to a city of 1 million citizens in a year.

Challenges in implementing Big Data Analytics:

Like all other emerging technology, there are problems and limitations to keep in mind while extracting the virtues of Big Data Analytics.

- **Continuously changing data:** Despite having an abundance of data, the climate science community faces the significant challenge of dealing with a continuously changing observing system. Just like Google's search engine algorithm goes through changes, so do the instruments and algorithms used to monitor and process observational data, especially for satellites and other remote sensing tools. Changes in instruments and data processing algorithms put into question the applicability of such data to study long-term climate. For instance, it becomes unclear whether there is an actual upward trend in cyclones etc or it is due to change in observational system.

- **Data empathy**: One prerequisite to any big data endeavor is data, lots of them. Requiring large amounts of data has two major drawbacks: first, the prerequisite of an abundance of information is contrary to the way humans learn. In nature, humans learn with relatively small sample sizes of unlabeled data. Second, with large datasets where one measures anything and everything, it can be difficult to understand how that data were collected and for what purpose. The reason for understanding where the data come from is that it shows how the data are generated, their purpose, and generation processes will guide the investigation.
- **Heterogeneity**: Another data challenge is heterogeneity. The Earth system is composed of numerous interacting variables that guide its climate. Different key variables are monitored using various technologies, and some might not be observed at all.
- **Data representation:** Traditional data science, and machine learning specifically, has relied on attribute-value data as input to most learning models. However, numerous climate phenomena cannot be represented in attribute value form. For example, a hurricane is an evolving pattern over a significant spatiotemporal span. Thus, one cannot represent a hurricane with a binary value as it does not simply appear and then disappear.

Recommendations:

Today data access remains a concern. Many datasets are privately held for security reasons. Ethical guidelines will be required to inform how big data are used in adaptation work. Though, ethical and proprietary concerns hinder the use of privately held data, researchers should use open source platforms like cloud storage etc for harnessing the full potential of big data. We also should not underestimate the problems with human error-wrongly entered data, poor processing due to mistakes, and interpretation of that data. To improve the use of Earth observation big data in Global change research, we should strengthen the management of data resources. Big Data technologies together with increased use of cloud based computing, can create new opportunities for data intensive climate research. It should be a huge international collaborative effort, where the global environmental data should be shared freely by every country so as to incorporate this data into reanalysis. The data should be shared freely because there is a dire need to share it freely for betterment of society and globe as a whole.

Conclusion:

Given the rate at which climate is changing, we need to respond fast. Big data and predictive analytics technologies have enabled stakeholders to process huge volumes of data fast and generate accurate insights. While traditional sources of climate data help describe how and to what extent the climate is changing, they do not always illustrate the solutions that are likely to be most effective in reducing emissions and helping build community resilience. New sources of big data from different industries and geographies, can be applied to construct a more complete picture, thereby significantly enhancing the understanding of the deeply interrelated relationships between human action and climate change. Combine this with increasing amounts of computing resources available at a much lower cost than ever before plus the ability to process them on distributed platforms in the cloud and the potential to exploit data and analytics in an important area like climate change is more real than ever before. With these new adaptative or mitigation interventions, innovations can be developed and will lead to, the beginning of a new and enabling ecosystem. Thus, careful applications of big data could revolutionalise our understanding of how to manage risks of climate change.

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