Environmental Informatics Vis-à-Vis Big Data Analytics: The Geo-Spatial & Sustainable Solutions

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ABSTRACT

The merging of Environment and allied subjects such as Informatics has led to the development of Environmental Informatics. Environmental Informatics is a perfect solution for Environment related activities with different tools, techniques and sub-technologies of IT, Computing, Computer Science or allied branches. However, among the emerging technologies most prominent is the Internet of Things (IoT) and Cloud Computing (Big Data Analytics). This paper provides a comprehensive study on Environmental Informatics with special reference to the applications of Big Data Analytics. This paper describes the basics of Environmental Informatics, including features, functions, nature, including basics of the Big Data, Analytics as well.

Keywords: Environmental Informatics, Ecological Informatics, Big Data, Emerging Technologies, Analytics Applications, Analytics in Environment.

1. INTRODUCTION :

Environmental Informatics is related with the Geo-Informatics and dedicated to environmental solutions in different contexts with the help of IT Solutions. It deals with the areas viz.—

- ecology,
- agriculture,
- oceanography,
- climatology,
- forestry and
- anthropology

The tools and components that are useful in this process include the Database Technology, Web Technology, Network and Communication Technology. Environmental Informatics is a perfect solution for Environment related activities with different tools, techniques and sub-technologies of IT, Computing, Computer Science, or allied branches. Environmental Informatics has become a field of study and subject in many countries [1], [5], [10]. Environmental Informatics uses various technologies for its solutions; however, in the recent past, the use of Big Data analytics is noticeable. An environmental study needs various information supports in a different form; therefore, Big Data Analytics is the solution for managing a large amount of environmental complex data effectively. Therefore Environmentalist, Environmental Technology experts and IT experts are using Environmental Informatics with a focus on Big Data Analytics by different means [2], [3], [18].

2. OBJECTIVE :

This paper entitled 'Environmental Informatics using Big Data Analytics for Intelligent Environmental Development' deliberates upon -

- The evolution, concept and features of the Environmental Informatics in a concise manner.

- To find out the main functions and role of Environmental Informatics for environmental, social development, etc.
- To find out the technologies involves healthy Environmental Informatics practice and to know about its subfields as well.
- To learn about the existing educational and research programs in the field and also in allied areas.
- To oversee the emerging technological applications in Environment and ecological management.
- To find out the basics of Big Data Analytics with reference to the features, functions and role in environmental development.
- To learn about the applications of Big Data Analytics in environmental and allied activities.

3. ENVIRONMENTAL INFORMATICS: THE SOLUTION FOR ENVIRONMENT AND ECOLOGIES :

Environmental Informatics requires different environmental activities such as energy, agriculture, forest management, water and oceanography and ecological systems. It helps by information-related activities with the help of technologies viz. environmental information management, environmental decision support, environmental geospatial services are also an essential beneficiary of Environmental Informatics [4], [14], [23]. Among the most common technologies are used in this regard are GIS, Remote Sensing and GPS. Various branches and subjects even environmental chemistry and biochemistry are also significant users of Environmental Informatics. By the use of Environmental Informatics environmental phenomena vis. Atomic, molecular and macromolecular scales, etc. can also be effectively managed with its various stakeholders (Refer fig: 1). The following description about the Environmental Informatics is essential in this context.

- In designing, developing, modeling, implementing, evaluation of chemical, biological, environmental processes, Environmental Informatics directly and indirectly applicable.
- Websites related to the Environment, ecology, agriculture, etc. can be built with the help of Environmental Informatics [7], [16], [22].
- In Modeling of biotechnological systems, Environmental Informatics by its tools, technologies, etc. can be used effectively.
- Various kinds of multimedia tools, graphics, 3D tools, visualization systems of environmental and ecological management (with monitoring) can be possible with Environmental Informatics.
- In Environmental Informatics various computational sciences are widely used viz. Artificial intelligence including machine learning, deep learning, etc.
- The primary IT components include but not limited to Database Technology, Web Technology, Network and Communication Technology; and Software Technology [8], [12], [21].
- Managerial Sciences were also helping in Environmental management, risk analysis, etc. with the help of Environmental Informatics.

Environmental Informatics is very practical and useful in various other areas of social development, and such concerns are increasing gradually.

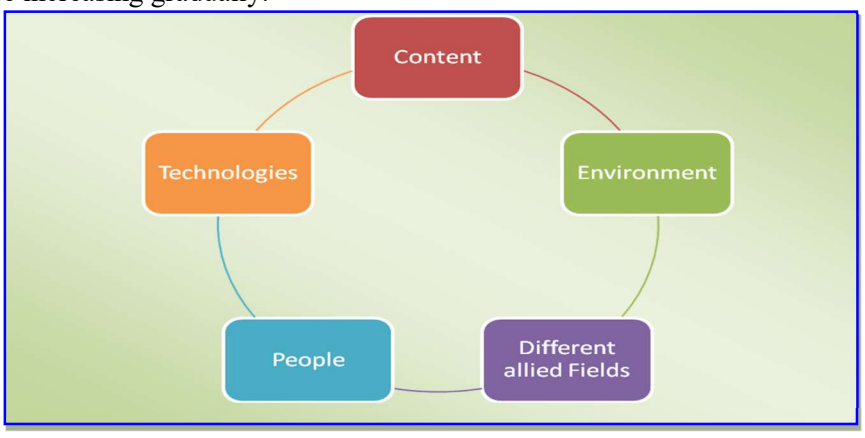

Fig. 1: Depicted the Stakeholders of Environmental Informatics (Paul, PK, 2020)

4. BIG DATA: MANAGING LARGE & COMPLEX DATA :

Data is valuable in our daily life in different areas such as Health Care, Government, Agriculture, Horticulture, Education and Training. Therefore, various technologies are being used for Data Management. The concept of Big Data is applicable for Managing not only Complex data but also a large amount of data. Since various analytical tools are used, therefore, it is also known as Big Data Analytics or Simply Analytics.

The term Bigdata was coined in 1990 but gained its popularity after the massive growth of data in different domains due exponential penetration of low-cost Internet services. The 'Tera Data Corporation' the concept of Big Data was taken a new shape (parallel processing DBC 1012) in 1984. After that, various kinds of structured and unstructured data, etc. are used for proper data management. Seisent IMC in 2001 also did a good job for the development of the Big Data and allied fields. Though the initiative of the Google, Apache, Map-reduce techniques (by Google) and Hadoop (by Apache) important in the growth of the Bigdata management. Even many other Big data techniques are also developed by the tech giants viz. Oracle, IBM, EMC, DELL, etc [6], [15], [20]. It is primarily responsible for Mining Data within a time frame, and that can be from the Database as well as Data Warehouse. Here the availability of required as well as user data is an important concept for managing and also reducing the complexity of data. With the help of Big Data, pin-pointed data management become easy using various kind of tools and technique. Data becomes vital for each, and every organization and therefore big data and its application in other sector-led newer nomenclature and branches viz Business Analytics; for business sector applications, Health Analytics for health sector applications, etc. This way, Big Data and its integration in other subjects have to lead various other subjects and domains.

5. CHARACTERISTICS AND NATURE OF BIG DATA ANALYTICS :

Big Data is gaining its popularity not only in the business sector but also in other sectors including government, administration, management, etc. Regarding its size, it is worth to note that it is increasing day by day. The concept of Big Data is changing rapidly and widely useful in environmental and related in addition to other allied technologies (Refer Fig 2)—

- Big Data is helpful in Health and better integration of data management with diversity, complexity and massive scale.
- Various kinds of database management systems, including high-level programming platforms such as Python and R programming are as crucial in Big Data Management.
- In Big Data management proper and scientific foundation in mathematical science and intelligence system become easy and vital due to various concerns of artificial intelligence, expert system, machine learning, deep learning, etc. applications.
- Big Data is surrounded by parallel computing for a large number of data.
- Big Data lies in discrete mathematics, fuzzy logic, and descriptive mathematics; further here inductive statistic for low information density also essential to note.
- Here is proper and scientific Big Data Management operation research also plays a vital role in complete information management.

Due to the exponential growth of the application of Big Data Analytics in different sectors, its nature and role are changing. Regarding environmental applications and its emergence, the next section described a lot on this.

6. BIG DATA AND ANALYTICS APPLICATIONS IN ENVIRONMENTAL MANAGEMENT :

Big Data is applicable in diverse areas of Environment and allied areas, and this is rising rapidly. It can be noted both in developed as well as developing countries as well (refer Fig: 3). Worldwide the data is generating numerously, and in 2017 alone, we generated more data than in the previous 5,000 years. It is applicable in analyzing the data and information and solutions as well. The Big Data applications in the Environment are helping in optimizing efficiency. Application of Big data to curb global warming is known as green data. It is an essential fact that 90% of the data having today on the online or internet base was generated only since the year 2016. Big Data is applied widely in medicine, agriculture, gambling and environmental protection. As far as environmental applications are concerned, few important are include (but not limited to)—

6.1 In Climate Change, Global Warming—

Big Data and Analytics is widely applicable in one of the current challenges of the modern world, i.e. Climate Change The application of big data to curb global warming is what is known as green data. Different countries have developed various projects on Big Data applications in Environment, and among them, Copernicus can be considered as the important one developed in Europe. This is based on satellite earth observation, and numerous data collected from the satellite here with the help of Big Data and Analytics are effectively managed [9], [13], [17].

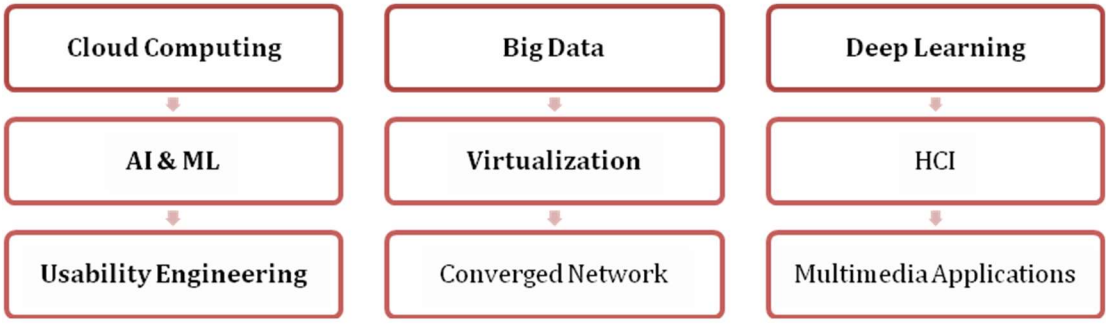

Fig. 2: Depicted different emerging technologies of Environmental Informatics (Paul, PK, 2020)

Copernicus is dedicated to proving information on various aspects and issues viz. water resource management, quality of the air, biodiversity, agriculture, forestry, fishing, etc. and in all these, Big Data technologies are widely applicable. As far as other international projects are concerned internationally, important are—

6.2 Aqueduct is another project responsible for the data collection and analysis of the water-related hazards, to get and analyze water quality and quantity. This is also applicable in making interactive risk maps to the public as well.

6.3 Global Forest Change This is also dedicated to forest management and applicable in deforestation by counting trees and here high-resolution satellite imagery is basically used for.

6.4 Danger Map, this international project is dedicated to determining pollution and based on data provided by the users.

6.5 In Smart Cities, Towns and Urban Planning—

It is worthy to note that worldwide the scenario of applications regarding the residence in cities and urban areas are changing and according to UN two-third of the world population by 2030 maybe live in the cities due to the general, more extensive and advanced benefits from the cities.

The environmental challenges and with Big Data it is resulting in the green data to solve the emerging problems. The uses of the analysis of big data to the creation of smarter and sustainable are increasing. And as far as Big Data and Analytics applications in smart cities, urbanization is concerned, few important are include—

- The GPS sensors are useful in waste management and also in the enhancement of the recycling pathways.
- In public transport planning location identification becomes possible, and here for future data management, Big Data and Analytics are widely applicable.
- The satellite images, geospatial platforms, etc. can be nicely manageable with the help of Big Data and Analytics, and it may be helpful in natural disasters management.
- The Copenhagen Wheel is a bicycle wheel that collects data on air quality, noise levels and road conditions.
- The solar panel-based road is also emerging, and this is applicable that generate energy.
- There are different devices that are emerged which are responsible for pollution in the city traffic flows, etc. and in all these Big Data and Analytics are effectively useful.

6.6 In Renewal Energy Management—

Big Data and Analytics is helpful in the competitiveness of renewable energies in fossil fuels. The Big Data is useful in the promotion of clean technologies by various means such as—

- In wind power management Big Data and Analytics is effectively useful by collecting the data and possible power to generate.
- In the efficiency of power stations related works, Big Data and Analytics is useful in different means and mode. Hence in photovoltaic power, this is effectively useful.
- Hydroelectric power also Big Data and Analytics is useful for the gathered data management and future uses.

Moreover, these days, in general, electric bill meter also there are different changes can be noted and smart meters are evolved; many of such are well connected with the Internet of Things (IoT) and similar systems. Therefore, the changes in statistics and data in this affair can be managed effectively using Big Data and Analytics.

6.7 In Geographic Data Management—

In Geographic data management, including space, geospatial data management Big Data and Analytics are widely applicable. The areas where Big Data and Analytics are included but not limited to as follows—

- In simple cartographic naval navigation and generated data management.
- In geographic surveying, GIS-based data collection and development.
- In disaster and emergency management, Information Technology and Computing are widely used, and in such Big Data and Analytics are also using. Therefore, it becomes important in environmental management as well. The GIS databases always engaged in Data Management and up-to-the-minute problem, and here Analytics can manage a huge amount of data generated.
- Satellite data are basically collected by the emerging tools such as GPS, Remote Sensing, GIS, etc. and in disaster management activities and here Big Data will further enhance its efficacy [2], [11], [19].

Big Data is engaged in bringing different kinds of data management including air, water, and dry land, socio-economic data; therefore, useful in various Geo related data management effectively. Here the applications of other technologies can also be noted for better results.

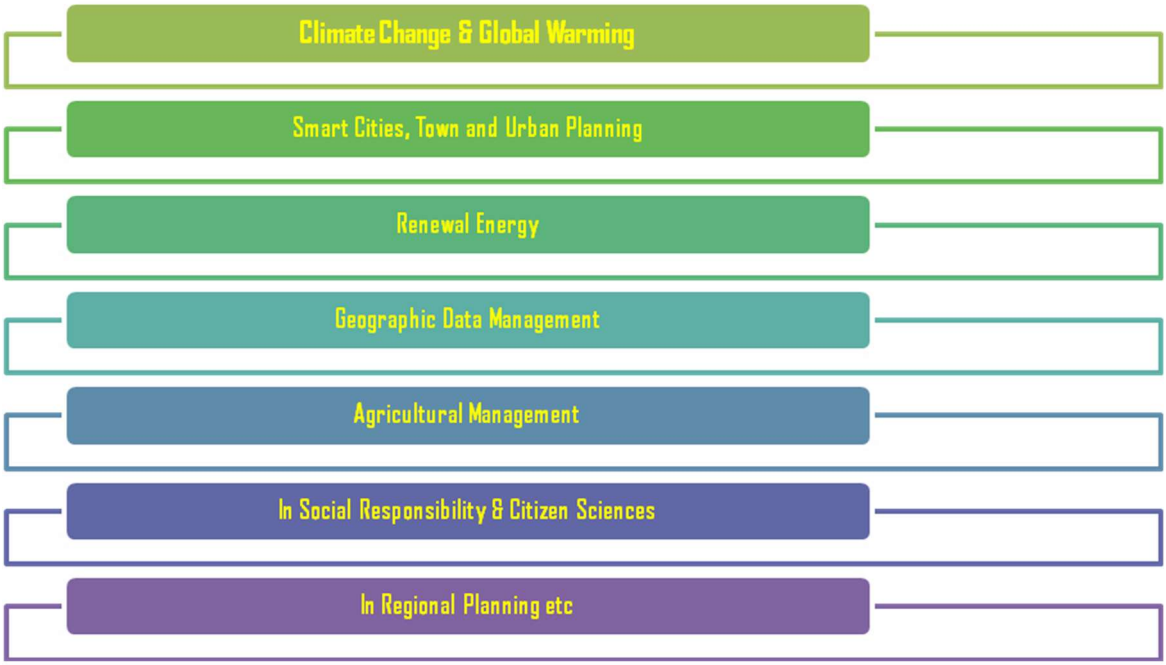

Fig. 3: Applications of Big Data and Analytics in broader Environmental Applications

6.8 In Planetary Monitoring—

Uses of technologies, especially Computing and Information Technologies, are significant in advanced planetary monitoring and here large-scale investment in Big Data infrastructure applicable in managing the environmental sector properly. In a program called CEMS (Climate and Environmental Monitoring from Space, large data sets are generated and here Big Data and Analytics useful in higher efficiency. However, here in addition to Big Data the Cloud Computing, IoT, etc. are also applicable and emerging rapidly.

Governments of different countries are using various technologies in better and modern planetary monitoring, and here Big Data is effective, and in this regard, NASA was utilizing Big Data capture and storage for creating climate models, and it is to store as much as 32 petabytes of data/ information for modeling purposes. Different kind of data such as data sets, complex data and accumulated metadata are widely managed using Big Data and Analytics for better and healthy planetary monitoring.

6.9 In Agricultural Technological Management—

Agriculture is an integral part of the Environment and without it surviving is not possible. From agriculture, we get food products, and in the recent past, huge advancement of agriculture is noticeable, especially in methods, types and ways of farming and cultivation. Furthermore, in agricultural systems, information and computing technologies are also increasing rapidly for effective, advanced and productive agriculture. Due to the wider populations, various technologies are increasing. IT and Computing is applicable in the following activities—

- In pre-agricultural activities including in harvesting.
- In websites, web portals development related to the agriculture and allied areas.
- In design, development of the Agricultural Information Systems, Agricultural Information Networks, etc.
- In automated harvesting, spraying with water, chemical, etc.
- Remote and areal observations etc.

Therefore, Big Data Analytics is effectively applicable in a large amount of generated data from the agriculture and allied areas. Therefore, apart from the direct benefits of the agricultural products in is also indirectly helps in agricultural land and effectively using ground nutrients, managing water resources. Crowd sourced data, in conjunction with remote sensing, are widely applicable. According to some expert Big Data, and Analytics can help in providing mitigation and management tools for marginal landscapes already in use. Secondly in identifying the best uses for marginal landscapes in respect of agriculture etc.

6.10 In the field of Genetic Studies—

Big Data Analytics is widely and emerging other emerging areas which are indirectly associated with the Environment and Ecologies as well and among such one important is Genetic Engineering and Genetically Modified Technologies. This leads to the development of agricultural products and its growth, and as a result, it enhances the volume of the agricultural product as well. Hence in the monitoring of such agricultural products using technologies Big Data and Analytics become booming and growing rapidly.

6.11 To be a Socially Responsible Agent—

In another context, Big Data Analytics is also helping in social development, social promotion and welfare as well. In recent years, the corporate sectors are also involving in environmental affairs and for the promotion of the Environment and society as part of the corporate social responsibility. They are also using IT and emerging Big Data Management, etc and, in this context, Green Data becomes essential and valuable for various affairs but among these important are—

- Robust optimization of energy management and resource utilization.
- Reducing carbon dioxide gas emissions from industrial and other sources.

Big data thus become an essential and powerful tool for monitoring and controlling sustainable development; directly and indirectly [10], [20].

6.12 In the field of Citizen Science—

Big Data Analytics is widely applicable and enhancing the promotion of citizen science. The citizen sciences is involved with the development and promotion of the citizen and everyday people-related activities and in this context for the betterment of citizen and society as whole various technologies are widely useful and among these of the important is Big Data Analytics. The enhanced and broader uses of Big Data and Analytics can be helpful in fewer data management efforts, and indirectly it will reduce the environmental impact as well.

6.13 In the field of Anthropology & Archaeology—

Big Data Analytics is applicable in the field of anthropology and archaeology as well. Various studies reveal that these two fields are directly and indirectly associated. Collecting and managing data with various size, complexity, etc. can be effectively managed with the IT and especially emerging Big Data and Analytics. Cultural Studies is another important area where also Big Data and Analytics closely connected and useful.

6.14 In the areas of Environmental Conservation—

Big Data Analytics is effective and useful environmental conservation as well. In climate science and climate modeling, Big Data is useful in various affairs such as in conservation, sustainability and local environmental mitigation; therefore, here Big Data Analytics is effectively useful. Environmental NGOs are also collected various kinds of data from different stakeholders, and in this context, Big Data and Analytics are used in different means. Furthermore, Government bodies in determining policy regarding the ecology and environmental regulation and in such areas Big Data and Analytics are effectively useful. For example, the US, Dutch governments are engaged and also ensuring open data policy for Big Data analytics; therefore, here is the concern of environmental protection.

6.15 In the areas of Regional Planning—

Regional Planning is also an important issue in environmental engineering, and here for various areas, Information Technology and Computing are being used. The ecology, impact the environment, work for residents, etc. creates a huge amount of data, and here Big Data and Analytics are useful. There are wider areas of regional planning where Big Data and Analytics are effective and useful in the countries and areas; where not yet offered or started—

- In traffic and allied concern, Big Data and Analytics are widely and effectively useful viz. decision making on where to place new roads to be created, in crime management including where to focus law enforcement resources, etc.
- In addressing Health-related problems viz. in pollution, poverty, poor access solving Big Data Analytics useful.

Big Data thus helps in improving urban planning and resource allocation and led the "smart urban planning" etc. As urban and regional planning is a big concern and deals with various aspects therefore in multiple areas data are required viz. demographics, geographic information, employment-related, pollution, employment etc. and there are many other data and all such are required in better environmental practice; and here Big Data and Analytics may be widely useful and effective [5], [24].

6.16 Complete and Sustainable Environmental Management—

Big Data Analytics is responsible for making green and sustainable agricultural development due to various concerns. With the advent of information technology, it is useful in broader areas and sectors, and in Environment also it is applicable and increasing. The growing data in the field of Environment and its variety lead the need of the Big Data and Analytics.

6.17 In healthy and better Decision Making—

The Big Data and Analytics helps in smoother presentation and reporting, delivering the environmental and allied data, and it helps in healthy and proper decision and policy development. Scientists and government deals with various environmental-related problems for a healthy future and in this context Big Data and Analytics widely useful and in this regard, other allied technology are also useful and associated with—

- Cloud Computing and Virtualization.
- Internet of Things.
- Robotics and AI.
- HCI and HCC, etc

Therefore, Big Data Analytics is helping in environmental problem solving and helpful for the environmentalist, environmental experts, policymakers, government officers, etc.

7. BIG DATA IN ENVIRONMENTAL SECTORS: CHALLENGES & ISSUES :

Big Data Analytics is applicable in various problem-solving in respect of Environment and ecology. And it worthy to note that like other emerging technology Big Data. Big Data and Analytics, Data Sciences, etc. has various concern and issues in respect of Environment, environmental engineering and management. However, among the issues, few important are include—

- Issues and concern of the methods for capturing data.
- The capacity of data includes storing.
- Analyzing and visualization of the data.
- Searching, sharing as well as transferring data in various processes.

- In some contexts, the environmental data management aspects including the data security, privacy issues, etc. may be considered as important and valuable.
- The Environment is a broad concern, and there are various aspects, but interlinking can be considered as critical challenges.
- There are emerging concerns in the skill development in the field and also in Environment in respect of the big data management as well.

Proper policies, planning, regulation, etc. are highly welcome in the field of environmental engineering and particularly in data analytics and similar applications in the field of ecology and environment as well. Furthermore, due to the interaction and requirement of the Big Data and Analytics with Environmental Science/ Technology, etc. another nomenclature is developed that is called Environmental Data Science.

8. CONCLUSION :

Environmental Informatics as a part or foci of informatics is gaining wider. There are numerous topics and branches associated with the Environmental Informatics, and all these are associated with the societal and anthropological areas. Due to the importance of Environmental Informatics; therefore, various universities have started an interdisciplinary program on Environmental Informatics. There are various technologies and tools are emerging in environmental and ecological solutions, and among these, the prominent are big data analytics, IoT, and Robotics. These are incorporated in ecological and environmental solutions. Developing countries can start an educational program on Environmental Informatics for solving the threats to the Environment.

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