Abstract

Environment is an important concern and also treated as a knowledge field viz. Environment Science, Environment Studies, Environment Engineering, Environment Management, etc. Environmental Informatics is the combination of Environment; which includes allied branches and subjects from the environment side and Informatics include all allied branches and subjects from informatics and IT side. All the environment related subjects can get the benefits of Environmental Informatics for its different sorts by different means. Environmental Statistical applications also need Computational tools thus Environmental Informatics is the right solution for such concern. Environmental Informatics uses different tools, techniques and sub technologies of Information Technology and few also from the Computer Science or allied branches. Due to its wider benefits and different applications many educational institutes offering the field with Bachelors, Masters and Research Degrees in the concerned field and allied field. As far as research is concerned the researchers in different forms is conducting by academicians, researchers and scientist. This paper provides comprehensive details on Environmental Informatics research opportunities and potentialities in Indian and international context.

Keywords

Environmental Informatics, Ecological Informatics, Geo Informatics, Emerging Technologies, Educational Programs, Research Degrees

Introduction

Environmental Informatics is responsible with wider aim, objective than Geo Informatics and similar branches. Environmental Informatics is responsible for complete environmental solutions in a different context and also comes with the solution of environment, ecology, agriculture, oceanography, climatology, forestry, anthropology, etc [1], [5], [9]. For Environmental solutions and services, different types of Information Technology tools and components are being used. Various IT components viz. Database Technology, Web Technology, Network and
Communication Technology are using for various activities in the environment and ecology. Various educational programs viz. Certificate, Bachelors, Masters, etc are offered in Environmental Informatics and related programs internationally [2], [3], [11]. Even in other allied departments and centers also Environmental Informatics related research is noticeable in some countries. There are different ways and policies in which at research level this field or its sub field can be introduced [4], [18], [20].

Objective

As the paper entitled ‘Research activities, opportunities & possibilities in Environmental Informatics: International Scenario & Indian Potentialities, so this paper intends with following aim and objective—

- To learn about the basics of Environmental Informatics including its background, features, characteristics in brief.
- To dig out the benefits and functions of Environmental Informatics for various environmental affairs and also in social development and management.
- To learn about the technologies which help in better Environmental Informatics practice and also its sub fields as well.
- To learn about the existing educational and research programs in the field and also in allied areas.
- To know about the possible research programs at Doctoral level including Post Doctoral or Higher Doctoral Degrees.
- To learn about the possible degrees and nomenclature even at Masters level in different streams.
- To oversee sample courses in Environmental Informatics and also possible emerging technologies in which research can be conducted.

Environmental Informatics: The fusion of Environment and Information Science

Environmental Informatics is about the planning of different activities viz. energy, environmental, agriculture and ecological systems, etc by environmental decision support systems and with proper Environmental Informatics practice. Environmental Geo spatial services viz. GIS, Remote Sensing, GPS, etc can be useful; directly. Different allied areas viz. environmental chemistry and biochemistry can get the benefit of the field [6], [8], [16]. Environmental applications viz. in Environmental phenomena vis. atomic, molecular and macromolecular scales, etc Environmental Informatics practice tools or technologies may be used. Further candidates with other allied degrees can also enter into the subjects by gaining skills, knowledge and research as the field further applied in other disciplines as well [12], [21].
- Designing, developing, modeling and implementing of chemical, biological, environmental processes, etc are required by Environmental Informatics support.
- Activities of the websites related to the environment, ecology, agriculture, etc is possible with the help of Environmental Informatics [5], [12], [22].
- Modeling of biotechnological systems is required by the support of Environmental Informatics.
- Multimedia tools, graphics, 3D tools, visualization systems are required for environmental systems and ecological interface, etc and here Environmental Informatics tools are used.
- Artificial intelligence including machine learning, deep learning, etc can be used by Environmental Informatics.
- Managerial aspects viz. Environmental management, environmental statistics and risk analysis become easy [13], [23], [26].

Due to such benefits and functions, Environmental Informatics is thus useful for different sectors and areas and this is still growing.

**Academic Degrees in Environmental Informatics with reference to the Research Degrees: International Scenario**

Environmental Informatics as an interdisciplinary field gaining rapidly and many universities started PhD program in the field of the Ecology or Environment oriented department. However, in a few universities, this is also offered by the Computing oriented department as a research area. Table: 1 in this regard offered details herewith.

| Table: 1-Existing Research Degrees in Environmental Informatics and allied field |
|---------------------------------------------------------------|
| **Existing Degrees of Research Level on Environmental Informatics**                          |
| MPhil                                                        |
| PhD                                                          |
| **MSc-PhD Integrated**                                      |
| **Post Doctoral Fellowship**                                |

Even Post Doctoral Fellow position also offered by some of the universities and institutes and most the scholars works in different areas such as (these are also offered the Degree programs in most of Bachelors or Masters programs)—

- Digital Earth
- Introduction to Environmental Informatics
- Environmental Modeling
- Applications in Environmental Informatics
- Spatial Statistics for Natural Resources
- Partial Statistics for Natural Resources lab [10], [17], [24].
- Land Processes and Climate Interactions
- Digital Earth and Big data
- Climate Modeling, etc.

As far as leading universities are concerned a few important educational institutes that offer programs in this field are depicted in the table: 2.

| Universities                                    | Degree                                                                 |
|------------------------------------------------|------------------------------------------------------------------------|
| Auburn University, Alabama, US                  | BS Geo Spatial Environmental Informatics                               |
| Wuhan University, China                         | BSc Geo Environmental Informatics                                      |
| Northern Arizona University, United States      | BS Informatics (Environmental Informatics)                             |
| Georg August University of Göttingen, Germany   | BSc-CS and MSc-Environmental Informatics Integrated                    |
| University of North Carolina at Chapel Hill, US | BS-Environmental Science & MS-Information Science                       |
| Virginia Polytechnic Institute and State        | Offered jointly by College of Environment, Ecology and Library Science  |
| University, US                                  | BS Environmental Informatics                                            |
| The University of Applied Sciences, Germany     | BSc Environmental Informatics and Business Information Systems (Dual Degree) |
| Joma Kenyatta University of Agriculture and     | MSc Environmental Information Systems                                  |
| Technology, Kenya                               |                                                                        |
| Georg August University of Göttingen, Germany   | MSc-PhD Environmental Informatics Integrated                           |
| University of Leicester, UK                     | Post Graduate Certificate in Environmental Informatics                 |
| University of Michigan, US                      | Regular On Campus Only                                                |
| University of Kassel Germany                    | Full Time/ Part Time                                                  |
| Tennessee Tech University                       | Masters in Environmental Informatics (Professional)                    |
Environmental Informatics degrees in Asian countries still limited only a few are offered allied programs i.e. Geo Informatics. However, at the Research level some institutes offer this research area in their offering [14], [19], [25]. Though, here not entitled the degree specifically on Environmental Informatics. In India, one institute called Indian Institute of Information Technology and Management (IIITM), Kerala, India offering an MPhil program in allied branch i.e. Eco Informatics.

Table: 3- Sample Courses of Ecological Informatics at MPhil Program at IIITM, Kerala

| Universities                                      | Degree                        | Papers/ Courses                                                                 |
|--------------------------------------------------|-------------------------------|--------------------------------------------------------------------------------|
| Indian Institute of Information Technology and Management (IIITM), Kerala, India | MPhil Ecological Informatics 1 Year | Core Courses  
Research Methodology  
Literature Review & Seminar  
Informatics (Information Systems, Spatial Informatics, Programming and Database)  
Ecology  
Urban Ecology  
Biodiversity and Conservation  
Application of Remote Sensing and GIS in Environmental Management |

This program is mixed with the courses and research methods and research components. The candidate thus also can go for industry and practical job sector with this degree apart from the research areas/ jobs.

Environmental Informatics and Technologies and research areas

It is already learned that Environmental Informatics is a combination of Environment which include allied branches and subjects from the environment side and Informatics and which includes all allied branches and subjects from informatics and IT side. Among the components of IT, few important are include—

- Web Technologies.
- Database Technologies.
- Network Technologies.
- Multimedia Technologies
- Software Technologies, etc.

As far as the latest components of IT is concerned few important with possible research areas mentioned in Table: 4.
### Table: 4- Emerging technologies in Environmental Informatics and possible areas

| Technologies                  | Possible topics/ areas                                                                 |
|-------------------------------|----------------------------------------------------------------------------------------|
| Big Technologies             | Basics/ Overview/ Challenges/ Issues/ Trends Potentialities in Environment/ Agriculture/ Forest Management, etc |
| Data Science and Analytics    | Challenges/ Issues/ Trends Potentialities in Environment/ Ecology/ Agriculture/ Forest Management, etc |
| Advanced Networks             | Trends/ Possibilities and Potentialities in Ecology/ Environment/ Agriculture/ Forest Management, etc |
| Cloud Computing               | Challenges/ Issues/ Trends Potentialities in Environment/ Ecology/ Agriculture/ Forest Management, etc |
| Internet of Things (IoT)      | Challenges/ Issues/ Trends Potentialities in Environment/ Ecology/ Agriculture/ Forest Management, etc |
| Converged Networks            | Challenges/ Issues/ Trends Potentialities in Environment/ Ecology/ Agriculture/ Forest Management, etc |
| Statistical Tools             | Challenges/ Issues/ Trends Potentialities in Environment/ Ecology/ Agriculture/ Forest Management, etc |

However, in respect of research areas from the environment possible areas may be from (but not limited to) environment, ecology, agriculture, oceanography, climatology, forestry, anthropology etc.

**Environmental Informatics and Possible Degrees: International & Indian Context**

Environmental Informatics research degrees mainly offered as PhD in Environmental Informatics or in allied branches but mainly PhD Geo Informatics or similar nomenclature. And the universities offering Masters program are mainly coursework based but there is a potentiality to offer Research based Masters degree in Environmental Informatics and sub field. And in a country like India instead of MS, the MSc/MTech can be offered. Sample and possible degrees are depicted in Table: 5.

### Table: 5- Possible Degrees in Environmental Informatics subfields at Masters level

| Masters by Research Degree Track (Sub Field of Environmental Informatics) |
|-------------------------------|--------------------------------------------------------------------------|
| MSc/ MS/MTech by (Research)-Environmental Informatics |                                                                 |
| MSc/ MS/MTech by (Research)-Ecology Informatics      |                                                                 |
| MSc/ MS/MTech by (Research)-Forest Informatics       |                                                                 |
| MSc/ MS/MTech by (Research)-Agricultural Informatics |                                                                 |
| MSc/ MS/MTech by (Research)-Irrigation Informatics  |                                                                 |
Environmental Informatics as interdisciplinary program so that can also be offered as a specialization in Informatics or Information centric degrees or in Computing or Computing track. Some of the sample degrees are proposed and suitable in western countries and in India also depicted in Table: 6.

| Masters by Research Degree Track (Field of Informatics & Computing) |
|--------------------------------------------------------------------|
| MSc/ MS/MTech by (Research)- Informatics (Environmental Informatics) |
| MSc/ MS/MTech by (Research)- Information Science (Environmental Informatics) |
| MSc/ MS/MTech by (Research)- Information System (Environmental Informatics) |
| MSc/ MS/MTech by (Research)- CS/CSE (Environmental Informatics) |
| MSc/ MS/MTech by (Research)- Computer Applications (Environmental Informatics) |
| MSc/ MS/MTech by (Research)- Computing Environmental Informatics |

Environmental Informatics is broad field and consists with different sub fields related with the Agriculture, Forestry, Ecology, etc. Thus mentioned (in Table: 7) areas can be offered at PhD degree as well.

| Environmental Informatics & Sub Fields |
|----------------------------------------|
| PhD-Environmental Informatics |
| PhD-Ecology Informatics |
| PhD-Forest Informatics |
| PhD-Agricultural Informatics |
| PhD-Irrigation Informatics |

It is recommended that these programs should consist with courses of masters level for real output and make the educated for the industry as well. Further, in the Informatics MPhil/PhD programs the Environmental Informatics can be started. Refer Table: 8 for more details.
While Environmental Informatics concentration-based Computing/Computer sciences possible programs are listed in Table: 9. It is worthy to note that, Information track programs would be more suitable for industrial output as it is less designing and development centric.

Environmental Informatics is high-end program, truly interdisciplinary in nature thus also available in different universities as Post Doctoral Fellow programs. Further, it may be offered as Post Doctoral Degrees in such countries where such degrees are allowed and recognized. Moreover, the researchers and academicians working in Environmental Informatics or allied areas may also avail such degrees based on their credentials and contribution. Few possible such programs are listed in Table: 10 herewith.

Conclusion

Environmental Informatics as a branch of the study of informatics, is gaining rapidly internationally due to its wider benefits. There are numerous topics and branches within Environmental Informatics ranging from the environment to informatics. Even societal and
anthropological areas can also be part of this area. Different universities are making efforts to offering this interdisciplinary for important to different stakeholders. Emerging technologies viz. big data analytics, cloud computing, IoT, converged network and communication can be good areas of research in Environmental Informatics and also its other sub fields. Research degrees still mainly offered as PhD but there are potentialities to offer other degrees viz. MPhil, Masters by research in different streams and in different sub fields of Environmental Informatics. Countries like India and other developing nations may start easily this field either as a full-fledged manner or as specializations in different subjects.

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