Environmental Informatics: Educational Opportunities at Bachelors level - International Context and Indian Potentialities

P. K. Paul[1], A. Bhuimali[2], P. S. Aithal[3], Tiwary K. S.[4], & Ripu Ranjan Sinha[5]

[1] Executive Director, MCIS, Department of CIS, Raiganj University, India

[2]Vice Chancellor, Raiganj University (RGU), West Bengal, India

[3]Vice Chancellor, Srinivas University, Karnataka, India

[4]Dean (Science & Management), Raiganj University (RGU), West Bengal, India

[5] Pro Vice Chancellor (Asian Region), Commonwealth Vocational University, Kingdom of Tonga, Oceania

Corresponding Author Email: pkpaul.infotech@gmail.com

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ABSTRACT

Environmental Informatics is an interdisciplinary subject and it is the combination of Environment related subjects and Informatics related subjects. It is the utilization and applications of Informatics and IT principles and tools in Environmental Management, Environmental Monitoring, and Science. In other words, it is the practice of Sustainable Computing and Information Technology. Environmental Informatics is responsible for the applications of Information Technology in Environment, Nature and various allied subjects and areas like Geology, Agriculture, Forestry, Geography, Climatology, Oceanography and all these are valuable stakeholders of Environmental Informatics. Ecology Informatics in some contexts is related with Eco Informatics. Environmental Informatics is broader than Environmental Information Technology; as it interconnects both environmental as well as information science for the complete natural processes with language common to both humans and computers. Internationally Environmental Informatics has become a field of study in many universities. Apart from PG degree in recent past Environmental Informatics has also started at Bachelors level and many universities have started an initiative on this. This is a conceptual paper and also analytical study regarding Environmental Informatics including its basic feature and importance as an academic program. The paper shows about the universities which offer Bachelors degree in brief.

Keywords: Environmental Informatics, Environment and Ecology, GIS Applications, Academic Degrees, Emerging BSc Degrees, Indian Education Systems.

1. INTRODUCTION :

As an interdisciplinary field, Environmental Informatics is incorporated with different subjects like agriculture, oceanography, climatology, ecology, biology, geology, zoology, soil science, atmospheric sciences, physics, chemistry, etc. [01], [07].

Informatics is a broad field and consists with principles, tools, components and technologies of allied subjects like Computing, Information Technology, Information System. Thus, Environmental Informatics is an Applied Science and incorporated with different subjects and disciplines and as a whole responsible for better environmental planning, designing and development [02], [03], [09]. Environmental Informatics comes as a broad field than Geo Informatics and incorporated with different components of IT. Due to its importance universities are offering Environmental Informatics degrees ranging from BSc, MSc, MPhil and PhD [06], [20].

2. OBJECTIVE :

The aim and objectives of this paper is not limited to the following :

- To know the fundamentals of Computing related fields with reference to the Informatics.

- To get an overview of Environment and related areas and also components of the Environmental Sciences.
- To learn fundamental aim and features of Environmental Informatics including its evolution.
- To find out the nature, characteristics, stakeholders of Environmental Informatics, etc.
- To get the scenario and importance of Environmental Informatics in different sectors.
- To learn about the allied and similar branches related to the Environmental Informatics as a glance.
- To learn about the educational programs available on different universities on Environmental Informatics and allied areas.
- To learn about the Bachelors degree in Environmental Informatics in detail with analysis of the sample curricula.
- To learn the potentialities of offering Bachelors degree in Environmental Informatics and allied field in India with possible nomenclature.
- To get the possibilities of research based Environmental Informatics program at Bachelors level, but has something extra information.

3. METHODS :

The present paper is theoretical in nature and conceptual as well and thus different secondary sources are used to get a concise picture of the Environmental Informatics and allied field. Further, different primary sources are used to get a more nascent picture of Environmental Informatics. Web review is undertaken and here search strategy (in Google Search Engine) used with used title and keywords are used 'Degrees on Environmental Informatics' 'BSc Environmental Informatics', 'MSc Environmental Informatics' 'MPhil Environmental Informatics' 'PhD Environmental Informatics' and 'Academic Programs on Environmental Informatics'. And the best result considers up to 20 pages (if any). Then the analysis is incorporated in the related pages.

4. ENVIRONMENTAL INFORMATICS: BASICS :

Environmental Informatics is the solution of Information Science and Technology in Environmental solutions and monitoring various other activities related to the environment and ecology [04], [10], [21]. As far as educational programs and fields are concerned, *Computer Science* is theoretical and mathematical in nature; it is responsible for studying the evolution, designing and development of computer systems. *Computer Application* is software centric and dedicated to the design, development of software systems. *Information Technology* is broader than these two and incorporated with following technologies responsible for information activities viz.—

- Database Technology
- Networking Technology
- Multimedia Technology
- Software Technology
- Web Technology etc

Informatics is interdisciplinary in nature and closely related with the Information Technology but wider in the sense that it is applicable in different subjects and fields viz. Business, Ecology, Society, Commerce, Healthcare, etc. Hence Informatics is broader and field specific; it is closer with the Environment and Ecology [05], [06], [11]. Apart from the components of IT, the following emerging technologies are applicable in different areas of Environmental Informatics—

- Cloud Computing
- Big Data
- Geographic information system
- Web and Usability Designing
- Machine Learning and Deep Learning
- Artificial intelligence
- Decision support system
- Genetic algorithm
- Software Applications, etc [18], [19].

These technologies are responsible in Environment and other allied subjects' operation viz. agriculture,

oceanography, climatology, ecology, biology, geology, zoology, soil science, atmospheric sciences, physics, chemistry [08], [09], [14].

5. ENVIRONMENTAL INFORMATICS: THE EDUCATIONAL PROGRAMS AND THE OBJECTIVES AND AVAILABILITIES :

Environmental Informatics is a field of study in many universities and interdisciplinary programs are available as following level of degrees—

- BS/ BSc Environmental Informatics
- MS/ MSc Environmental Informatics
- MPhil Environmental Informatics
- PhD Environmental Informatics

There are different reasons to offer such degrees and mostly these degrees come as interdisciplinary. The main reason for Environmental Informatics educated and skilled manpower includes—

- The skilled on Environmental Informatics is needed for the activities in planning of energy, environmental and ecological systems using different tools [06], [13], [23].
- Environmental Informatics professionals are is needed environmental decision support systems including simulation, optimization.
- The skilled on Environmental Informatics is perfect in Environmental geomatics by using GIS, Remote Sensing, spatial information technologies.
- Environmental Informatics skilled and educated is required for environmental chemistry and biochemistry related affairs [08], [12], [22].
- Various Environmental applications of functional materials are only possible with the skilled on Environmental Informatics educated.
- Atomic, molecular and macromolecular scales etc of the environment and ecology are possible with the skilled on Environmental Informatics.
- Designing, developing, implementing and modeling of different facets viz. chemical, biological and environmental processes can be done with skilled professionals in Environmental Informatics and proper support.
- Designing, developing, managing of websites and portals related to the environments are only possible with skilled professionals.
- Environmental Informaticist if helpful in modeling of biotechnological systems including enhanced pollution mitigation.
- Multimedia tools, graphics and visualization are useful in environmental decision support systems including Ecological interface and such tool can only useful by the Environmental Informatics professionals.
- Artificial intelligence, expert systems, machine learning, deep learning, cloud computing are useful in Environmental related affairs and here skilled Environmental Informatics are important.
- Environmental is also concern with managerial aspects such as Environmental statistics and risk analysis, etc and here skilled and educated are important [15], [23].

Apart from these, Climate modeling, downscaling, etc are another example for Environmental Informatics practice and here skilled professionals are important. Further, the research programs can lead to be a good researcher and scientist to solve environmental related affairs. It is important to note that, many IT and Environment related departments offer research facilities in Environmental Informatics and allied areas [03], [16], [24].

6. ENVIRONMENTAL INFORMATICS AT BACHELORS LEVEL :

There are different universities worldwide that offer programs and degrees on Environmental Informatics at a Bachelor level most of these universities offer the Environmental Informatics program as a Science stream with BS/ BSc Degree. Some of them offer the subject as a specialization as well in Environment and Informatics/IT related degrees [07], [17], [25].

There are potentialities of getting the education after school and can be up to Masters degree with the integrated degree model or dual degree model as well. Even some universities offer Environmental Informatics and another relevant and related subjects viz. The University of Applied Sciences, Germany.

Even University of North Carolina at Chapel Hill, US offers Bachelors in Environment and Masters in Information Science and offered these as Joint/ Dual Degree with research/ dissertation focus on Ecological or Environmental Informatics. Details on this type of degree that offers Bachelors in the field itself and also as dual degrees referred in Table 1.

Table1 : Universities offers Bachelors and beyond (joint) in Environmental Informatics

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 Dual Degree Offered jointly by College of Environment, Ecology and Energy with School of Information and Library Science
Virginia Polytechnic Institute and State University, US	BS Environmental Informatics
The University of Applied Sciences, Germany	BSc Environmental Informatics and Business Information Systems (Dual Degree)

Among these universities, a sample can be checked i.e. Wuhan University China which offers an allied and joint discipline 4 Year B.Sc. in Geo Environmental Informatics, which has 120 Credit itself with following credit components.

- General Courses: 41 credits
- Major courses: 79 credits
- Major foundation courses: 25
- Major compulsory courses: 14 credits
- Major elective courses: 32 credits

As Environmental Informatics is a broad field, so most of these universities offer different components into the curricula viz.—

- Environmental Components
- Computing Components
- Informatics Components
- Basic Science Components
- Communication Skills and Management Components for complete professionalism.

In table 2 depicted the universities that offer Bachelors in Environmental Informatics with their complete courses and curricula in detailed.

Table 2 : Universities offers Bachelors in Environmental Informatics with curricula

Universities	Degree	Papers/ Courses

Auburn University, Alabama, US	BS Geo Spatial Environmental Informatics	**Core Courses** Digital Earth Introduction to Environmental Informatics Environmental Modeling Applications in Environmental Informatics Spatial Statistics for Natural Resources Partial Statistics for Natural Resources lab Land Processes and Climate Interactions Digital Earth and Big data Climate Modeling
Wuhan University, China	BSc Geo Environmental Informatics 4 Years 120 Credit General Courses: 41 credits Major courses: 79 credits Major foundation courses: 25 Major compulsory courses: 14 credits Major elective courses: 32 credits	**General Science and Humanities Course (41 Credit)** **Foundation Courses** Introduction to Environmental Science & Engineering Physical Geography Principles of Geographical Information System Principle and Application of Remote Sensing **Geography Core Courses** Regional Analysis and Planning Environmental Geography and Global Change Lushan Comprehensive Field Practice Three Gorges - Shennongjia Field Practice **Environmental Core Courses** Inorganic and Analytical Chemistry Laboratory Experiments of Inorganic and Analytic Chemistry Environmental Chemistry Laboratory Experiments of Environmental Chemistry **Information System Courses** Cartography Spatial Analysis Remote Sensing Practice Practice of Geographic Information System **Electives (32 Credit)** Land Information Analysis and Modelling

		New Science of Cities Urban Computing Land Management and Sustainable Development
		Land Reclamation Environmental Monitoring Experiments of Environmental Monitoring Environmental Microbiology Experiments of Environmental Microbiology Environmental Planning and Management Industrial Ecology Spatial Information Visualization Principle of Spatial Database Smart City GIS in Public Health Urban Traffic Geographic Information System **Thesis (8 Credit)**
Northern Arizona University, United States	BS Informatics (Environmental Informatics)	**Core Courses** & Programming for Engineering Science Computer Science I Computer Science II Computer Organization Data Structures Database Systems Software Engineering Operating Systems Intermediate Programming Informatics Research I Informatics Research II Informatics Capstone I Informatics Capstone II Calculus I Calculus II Discrete Mathematics Statistical Analysis Intermediate Statistics Technical Writing **Eco Informatics Courses**

		Unity of Life I **Unity of Life II** **Ecology** **Informatics Elective Courses** **Introduction** to Ecoinformatics Ecoinformatics tools and data Mechanistic Ecological & Environmental Modelling Disease Ecology Informatics for Community Food, Energy and Water Systems **General Electives** Microbiology Environmental microbiology Conservation Biology Ecosystems and Climate Change General Chemistry I General Chemistry II Organic Chemistry I Organic Chemistry II Fundamental Biochemistry General Physics I General Physics II Introduction to remote sensing Spatial Analysis & GIS Applications Programming with GIS Machine learning climate change Foundations of Environmental Science Physical and Chemical Processes in the Atmosphere and Hydrosphere humans and the hydrosphere

Most of these universities offer basics of biological sciences as a component. Further it has noticed that in some curricula only courses/ papers/modules/ areas from two different field combined but in some curricula the papers or courses itself combined viz. Urban Computing, Spatial Analysis & GIS Applications, Digital Earth, GIS in Public Health, Spatial Statistics for Natural Resources.

It is better to have such combined courses/ papers instead of two separate, viz. GIS Basics, Fundamentals of Public Health. Few universities offer joint, dual and integrated degrees as well. For example, Georg August University of Göttingen, Germany offers BSc-MSc Integrated program and also MSc-PhD in Environmental Informatics. The table: 3 depicted in detailed on such universities and programs as per the study/ method adopted.

Table 3 : Universities offering Environmental Informatics as integrated program

Universities	Degree
Georg August University of Göttingen, Germany	BSc-CS and MSc-Environmental Informatics Integrated
Georg August University of Göttingen, Germany	MSc-PhD Environmental Informatics Integrated

University of North Carolina at Chapel Hill, US	BS-Environmental Science & MS-Information Science Dual Degree Offered jointly by College of Environment, Ecology and Energy with School of Information and Library Science
The University of Applied Sciences, Germany	BSc Environmental Informatics and Business Information Systems (Dual Degree)

7. POSSIBLE BACHELORS DEGREES IN ENVIRONMENTAL INFORMATICS: INDIAN CONTEXT :

India is one of the largest countries and having 30+ States and Central Territories with 130 Crore of population. Further, it has the largest education system in the world, comprises with 40000+ Higher Educational Institutes (HEIs), 900+ Universities, 100+ Institute of National Importance and so on. In these educational institutes each year, about 3 Crore candidates complete a Bachelors degree. Further, there are different ways and different subjects in which Environmental
Informatics may be offered. This may be offered in Environment related subjects viz.—

- Environmental Science
- Environmental Studies
- Environmental Technology/ Engineering
- Environmental Management
- Environmental Statistics
- Wildlife Sciences etc

In these areas, the inclusion of Environmental Informatics is easy as these are related subjects and specialized Informatics and Computing related courses/ papers can be incorporated easily. Among the possible degrees few important are mentioned in Table: 4.
By this inclusion, Applications of GIS, GPS and Environmental Technologies in Environmental Sciences and related areas are easily possible with existing infrastructure, faculties, research facilities by adding few arrangements in the IT and Computing oriented departments and subjects. And this can be introduced in Science, Arts, Engineering/ Technologies degrees with proper policies and strategies easily.

Table 4 : Possible Environmental Informatics specialization in Environment related subjects

Possible Environmental Science Core UG Degrees in India in Eco Informatics		
Stream/ Subjects	Nomenclature/ Degree	Applications
Environmental Science	BSc-Environmental Science (Environmental Informatics)	Applications of GIS, GPS and Environmental Technologies in Environmental Sciences and related areas
Ecology	BSc-Ecology (Environmental Informatics)	Applications of GIS, GPS and Environmental Technologies in Ecology
Environmental Studies	BA/ BSc-Environmental Studies (Environmental Informatics)	Applications of GIS, GPS and Environment related areas
Environmental Engineering	BTech/BE/ BSc (Tech) Environmental Engineering (Environmental Informatics)	Applications of GIS, GPS and Environmental Technologies

Environmental Management	BSc-Environmental Management (Environmental Informatics)	Applications of Environmental Informatics tools and techniques in Environmental Management
Environmental Statistics	BSc-Environmental Statistics (Environmental Informatics)	Applications of GIS, GPS and Environmental Systems in Ecological and Environmental Statistical affairs
Wildlife Sciences	BSc-Wildlife Science (Environmental Informatics)	Applications of Environmental Informatics tools and techniques in Wildlife Management and related affairs

However, it is important to note that apart from the specific nomenclature of the Environmental Informatics there may be allied areas also in which specialization can be started if not possible in the core areas and among these areas important are Ecological Informatics, Geo Informatics, Forest Informatics or combined Geo Environmental Informatics or Geo Spatial Environmental Informatics, etc.
Further, there are other subjects related to the environment in which Environmental Informatics can be started as a specialization at Bachelors level and among these few important are included (but not limited to)—

- Geography
- Earth Science
- Geology
- Forestry/ Forest Management etc

Most of these possible degrees and benefits of introducing are mentioned in the Table: 5 herewith.

Table 5 : Possible Environmental Informatics specialization in sub fields of Environment & related subjects

Possible Allied Environmental Science Core UG Degrees in India in Eco Informatics		
Stream/ Subjects	Nomenclature/ Degree	Applications
Geography	BSc-Geography (Environmental Informatics)	Applications of Environmental Informatics tools and techniques in Geography and related
Agriculture	BSc-Agriculture (Environmental Informatics)	Applications of Environmental Informatics tools and techniques in Agricultural activities
Earth Science	BSc-Earth Science (Environmental Informatics)	Applications of Environmental Informatics tools and technologies in different areas of Earth Sciences
Geology	BSc-Geology (Environmental Informatics)	Applications of Environmental Informatics tools and techniques in Geological affairs

Climatology	BSc-Climatology (Environmental Informatics)	Applications of Environmental Informatics tools and techniques in climate management and weather forecasting and allied activities
Oceanography	BSc-Oceanography (Environmental Informatics)	Applications of Environmental Informatics tools and techniques in Marine Science, Sea and Port Management
Forestry	BSc-Forestry (Environmental Informatics)	Applications of Environmental Informatics tools and techniques in Forestry, Forest Management, Planning etc
Disaster Management	BA/ BSc-Disaster Management (Environmental Informatics)	Applications of Environmental Informatics tools and techniques in Disaster Management

Hence simply by using proper educational strategy and policies the field Environmental Informatics can be introduced and may be possible to provide manpower in both these fields and also in Environmental Informatics nicely in a country like India [05], [15], [26]. However, these days a maximum number of educational institutes offers research degrees leading to MPhil/ PhD. Even at Masters levels thesis/ dissertation started in many universities to provide opportunity to the candidates for research at masters level. Here it is worthy to note that like abroad and established universities in few subjects related to the Environmental Sciences and its related areas BSc/ Bachelor by research degrees may be started and detailed possible programs are mentioned in table 6.

Table 6 : Possible Environmental Informatics specialization in sub fields of Environment & related subjects with research focus.

Possible Allied Environmental Science Core UG by Research Degrees in India in Eco Informatics		
Stream/ Subjects	Nomenclature/ Degree	Remarks
Environmental Science	BSc by Research –Environmental Science (Environmental Informatics)	Suitable for the future academicians and researchers, scientist interested in Environmental Informatics tools and techniques in Environmental areas
Ecology	BSc by Research –Ecology (Environmental Informatics)	Suitable for the future academicians and researchers, scientist interested in Environmental Informatics tools and techniques in Ecology

Environmental Studies	BSc by Research –Environmental Studies (Environmental Informatics)	Suitable for the future academicians and researchers, scientist interested in Environmental Informatics tools and techniques in Environmental and Social Issues
Environmental Engineering	BTech/BSc by Research – Environmental Engineering (Environmental Informatics)	Suitable for the future academicians and researchers, scientist interested in Environmental Informatics tools and techniques in Environmental areas
Environmental Management	BSc/ BCom/ BBA by Research – Environmental Management (Environmental Informatics)	Suitable for the future academicians and researchers, scientist interested in
		Environmental Informatics tools and techniques work in Environmental Management
Environmental Statistics	BSc by Research –Environmental Statistics (Environmental Informatics)	Suitable for the future academicians and researchers, scientist interested in Environmental Informatics tools and techniques in Environmental Statistics and Mathematics
Wildlife Sciences	BSc by Research –Wildlife Science (Environmental Informatics)	Suitable for the future academicians and researchers, scientist interested in Environmental Informatics tools and techniques in Wildlife Sciences
Geography	BSc by Research –Geography (Environmental Informatics)	Suitable for the future academicians and researchers, scientist interested in Environmental Informatics tools and techniques in different areas of Geography
Agriculture	BSc by Research –Agriculture (Environmental Informatics)	Suitable for the future academicians and researchers, scientist interested in Environmental Informatics tools and techniques in Agriculture
Earth Science	BSc by Research –Earth Science (Environmental Informatics)	Suitable for the future academicians and researchers, scientist interested in Environmental Informatics tools and techniques in Earth Sciences

As mentioned earlier Environmental Informatics is an interdisciplinary field combines with different areas and here the new comers with research interest can learn more not only the core subject of the field viz. Earth Science but also Environmental Informatics with basics of research in these areas.

8. CONCLUSION :

The environment is one of the important and valuable concerns for the time being and it is also an advanced field of study and research. Environmental Science is close with the few subjects viz. Physical Science, Biological Sciences, Information Sciences, Social & Engineering Sciences. In some contexts, this is a practicing field; though, in a few countries, it is a branch of study. There are different potentialities to offer Environmental Informatics as an academic branch due to its wider scope and utilizations. And of course, this may be introduced directly as a Bachelors Degree or Major. Further, it can be offered as a specialization in the Environmental Sciences including other subfields and areas. As the branch is required for its different benefits so India should think about its potential inclusion in its large number of educational institutes.

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