

Environmental Informatics and Educational Opportunities in Post Graduate level—Indian Potentialities based on International Scenario

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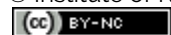
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ABSTRACT

The academic sector is changing rapidly and different components have been added in the academic components. The education systems including academic bodies, programs, educational institutes change different aspects in the recent past. The interdisciplinary sciences are booming internationally. Among the interdisciplinary subjects, Environmental Sciences is an important one. On the other hand, Information Science is also truly interdisciplinary. This Information Science is also called as Informatics. The fusion or combination of these two subjects led the new academic body called 'Environmental Informatics'. Environmental Informatics is very close with exiting field Geo-Informatics and thus it is also called as an extension of Geo-Informatics. Environmental Informatics is the solution to different environmental affairs, issues, problems, etc. Internationally, many universities have started academic programs on Environmental Informatics leading to Certificate, Diploma, Bachelors, Masters, MPhil, PhD in the subject. The present paper is an overview of Environmental Informatics including its features, functions, stakeholders emphasizing the availability of Post Graduate Programs in the field. Paper highlighted the course contents, job prospects, carrier opportunities in brief. Paper also proposed the possible programs at Masters levels; which can be a good solution both for abroad and the Indian education system.

Keywords: Environmental Informatics, Information Science, Informatics, Environment, Environmental Science, India, Higher Education

Introduction

Environmental Informatics is the emerging practicing domain and applications of Information Technology and Computing applications in Environment, Nature and Ecology also partially related areas like Geology, Agriculture, Forestry, Geography, Climatology, Oceanography, etc. Environmental Informatics also called as Eco Informatics and Ecology Informatics in some contexts. Environmental Informatics is broader than Environmental Information Technology and may also deal with manual information management related to environment and ecology. Environmental Informatics deals with completely natural processes with language common to both humans and computers [1], [5], [911]. Different emerging technologies are applicable in different sectors allied areas of the studies related to the environment (but not limited to) following—

- Environmental Science
- Environmental Studies
- Environmental Management
- Environmental Engineering etc.

Objective

The present paper is conceptual and reviews based and intends with the following aim and objective—

- To gain knowledge on Informatics and overview of Environment and related areas including the components of the Environmental Sciences.
- To learn about the features, characteristics, stakeholders of the Environmental Informatics including its evolution.
- To get the job scenario and carrier opportunities in Environmental Informatics in different sectors.
- To find out the similar branches related to the Environmental Informatics at a glance.
- To learn about the educational programs on Environmental Informatics and allied areas in different international universities using the proposed methods.
- To learn the potentialities of offering a Masters degree in Environmental Informatics with possible nomenclature.
- To get the possibilities of research-based Environmental Informatics programs at the Masters level.

Methods

This paper is theoretical as well as educational in nature. For thus different secondary sources are used to learn about the Environmental Informatics and allied fields. Various primary sources such as journals are used to get the current scenario of Environmental Informatics. Web review is undertaken to get the universities offering Environmental Informatics programs; and here search strategy used title and keywords are used 'Degrees on Environmental Informatics', 'MSc Environmental Informatics', 'Academic Programs on Environmental Informatics'. Further, the result considered up to 20 pages (if available). Then the analysis is incorporated in this paper.

Environmental Informatics: Overview with Features and Stakeholders

Environmental Informatics is the applications, design, development of IT and Computing for the environmental and ecological areas viz. ecological analysis, synthesis, including forecasting and management. Environmental Informatics is applicable in different areas of the natural systems and environment including the river systems, lakes, marine systems, forestry, disaster management agriculture, etc [2], [3], [12]. Information technology components and Computer Science components viz. AI & ES, artificial neural networks, genetic algorithms, fuzzy logic are also important in Environmental Informatics practice. Moreover, in the conservation of biodiversity and fishery management also it is important. The branch is very close to the Computational Ecology, Environmental Data Sciences as well. The following are the core features of the Environmental Informatics—

- It is a field of interdisciplinary sciences and incorporated with different fields of environment and information science.
- Environmental Informatics is an applied science field and also responsible for the different solutions in the environment and ecology.
- Environmental Informatics is about technological and manual documentation and procedure in environmental management.
- Contents, information systems are prime for health Environmental Information systems designing and development.
- Environmental Informatics is broader than Geo-Informatics or closely allied Environmental Information Management [4], [7], [13].

Environmental Informatics is the solution for different environmental allied subjects viz. Geology, Agriculture, Forestry, Geography, Climatology, Oceanography, Anthropology, Disaster Management, etc. There are following stakeholders of Environmental Informatics—

Content and Information—

Content and information are an important concern of Environmental Informatics as without content designing of Environmental Information Systems, Monitoring Systems become useless or not possible [19], [24].

People—

People are important stakeholders in Environmental Informatics and in this context, people mean the professional who design and develop Environmental Informatics systems and users of the systems [6], [9], [19].

Environmental Affairs and Facets—

Nature including aspects, objects and systems of Geology, Agriculture, Forestry, Geography, Climatology, Oceanography, Anthropology, Disaster Management and its stakeholders are the important aspects of Environmental Informatics

Technologies –

Environmental Informatics consists of both Environment and Informatics and thus within Informatics following are important components (sub-technologies of IT)—

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

The stakeholders in Environmental Informatics is increasing rapidly and growing. The advantages are noticeable in different context [18], [22], [23].

Environmental Informatics: Possible Positions and Educational Programs

Environmental Informatics educated and similarly skilled professionals can get a different kind of job opportunities viz. as remote sensing specialists, ICT enable area foresters, ICT based refuge managers, environmental ICT consultants, wildlife information specialists and also in Natural resource agencies. The figure: 1 shows few possible jobs in Environmental Informatics [8], [10], [26].

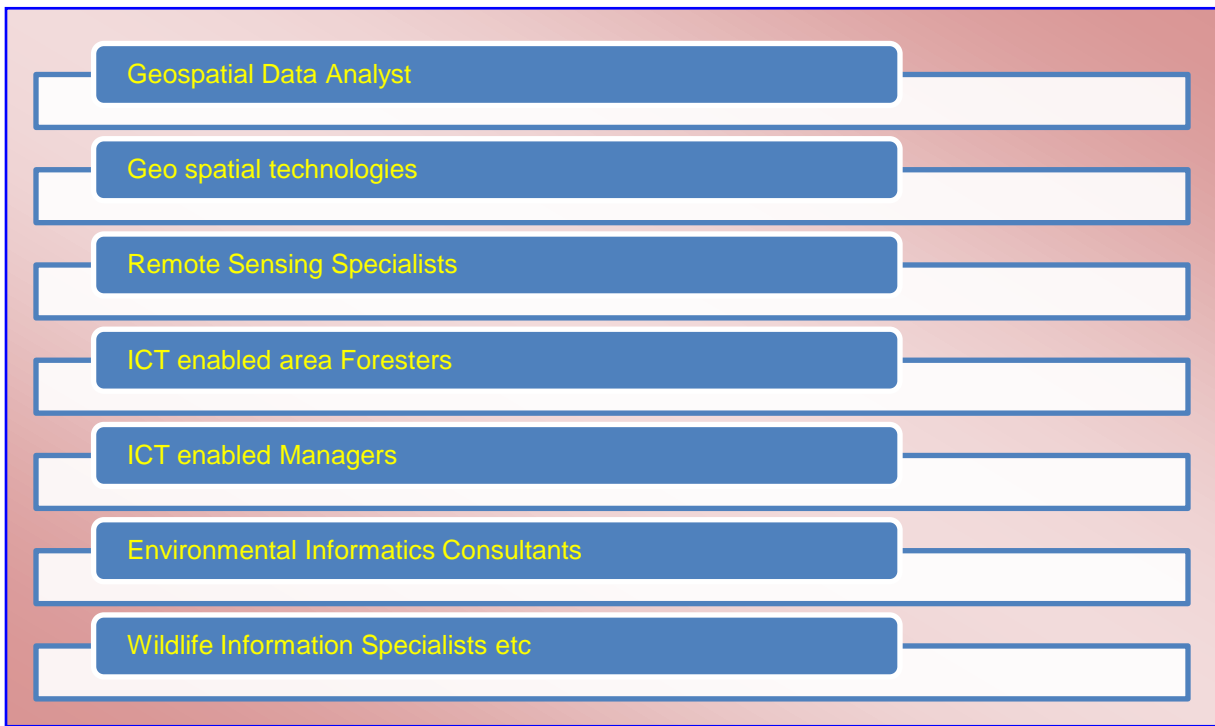


Fig:1 Few common job positions for Environmental Informatics Educated/ Skilled

The jobs and opportunities can vary in Environmental Informatics from country to country. As far as the University of Michigan’s (it offers degrees in the field: <https://seas.umich.edu>) official website is concerned some of the featured companies in US/ Internationals are include as follows—

- Ducks Unlimited
- ENVIRON

- ESRI
- Michigan Tech Research Institute
- National Oceanic and Atmospheric Administration (NOAA)
- Quantum Spatial
- The Nature Conservancy (TNC)
- United States Bureau of Land Management
- United States Forest Service
- World Resources Institute

Environmental Informatics professional and their job responsibilities thus also vary from profession to professions, herewith few brief job descriptions—

Ecoinformatics — Environmental Informatics professionals are responsible for developing the ideas and ways to access as well as in integrating repositories and databases of environmental-related content and information to solve environmental problems to different stakeholders.

Environmental data scientist —Weather, climate, agricultural problems can be solved by using integrated data analytics products and services, data delivery systems, and allied tools.

Ecological forecasting specialists — They are responsible for data and information delivery to the needy using different technologies of Computing and IT [3], [14], [25].

Ecosystems services consultant — Plans and executes environmental monitoring efforts through the design, evaluation, and installation of monitoring stations such as electronic data loggers, remote samplers, and remote communications systems.

Environmental modeler — Environmental Informatics is responsible for Integrating modeling, geo data analysis using IT components.

Geospatial technician — They utilize data in different settings and dedicated to building, maintaining, and accessing geographic information system databases [7], [15], [16].

Sustainability system analyst — They are responsible for system designing and development for the implementing policies and procedures for environmental management.

Hence, environmental informatics educated may enter in the job market and maybe the organizations related to the Agriculture, Space, Weather and Climatology, Environmental Protection Agency, Geological Survey, Central and State Agencies and Ministries, Departments and Organizations offers Forest Management and allied solutions, Marine Technologies, Disaster Management company and organizations, Environmental consulting firms, nonprofit organizations work on environment and ecologies, etc [10], [17], [20]. Due to this wide range of existing and future job potentialities many universities have started educational programs and as per the revealed few programs and universities listed in Table: 1.

Table: 1 Few universities offering Environmental Informatics programs

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)

Environmental Informatics programs are available in a wide range of titles viz. MS/ MSc with full concentration in Environmental Informatics, MS/MSc as specialization in Environmental Informatics in allied programs of Environment and also in IT/Computing. Even Post Graduate Diploma and Post Graduate Certificate also started by the universities. Most of these programs are the On-Campus only but come with facilities of Full Time and Part Time candidacy. Refer Table: 2 to learn a detailed university offers PG programs as per the result of the study/ method adopted.

Table: 2 Few universities offering Post Graduate level of Environmental Informatics programs

Universities	Degree
University of Leicester, UK	MSc (Environmental Informatics) Regular On-Campus Only Full Time/ Part-Time 1 Year to 2 Year 180 Credit
University of Leicester, UK	Post Graduate Diploma in Environmental Informatics Regular On-Campus Only Full Time/ Part-Time
Joma Kenyatta University of Agriculture and Technology, Kenya	MSc Environmental Information Systems
Georg August University of Göttingen, Germany	MSc-PhD Environmental Informatics Integrated
University of Leicester, UK	Post Graduate Certificate in Environmental Informatics Regular On-Campus Only Full Time/ Part-Time

University of Michigan, US	MS Environment & Ecology (Environmental Informatics)— <i>Geo-Spatial Data Science</i>
University of Kassel Germany	MSc Environmental Informatics
Tennessee Tech University	Masters in Environmental Informatics (Professional)

It is worthy to note that most of these Masters are MSc only, while there are potentialities in MTech/ME degrees as well, and such possible programs are depicted in the next section.

Environmental Informatics: Program Contents

Environmental Informatics programs are interdisciplinary, so that it combines with various aspects of Informatics/IT viz.

- Content and Information Management
- Database Technologies
- Network and Communication Technology
- Multimedia Technology
- Software Technology etc.

However, as far as Environment and allied areas are concerned, possible knowledge gradients in Environmental Informatics include the basics of as follows—

- Geology
- Agriculture
- Forestry
- Geography
- Climatology
- Oceanography, etc

It is further and detailed possible to study from the table: 3 in which different Environmental Informatics related Masters programs are listed with courses.

Table: 3 Curriculum sample of few universities offering Masters in Environmental Informatics programs

Universities	Degree	Papers/ Courses
University of Leicester, UK	MSc (Environmental Informatics) Regular On-Campus Only Full Time/ Part-Time	Core Modules (All) Sem: 1 (20 Cr) Induction Dissertation Tutorial Introduction to GIS Core Papers (any two) (60 Cr) Earth Observation and Remote Sensing Programming in R Sustainable Management of Biological resources: Ecosystem and Biodiversity Conservation Environmental economics

	<p>1 Year to 2 Year</p> <p>180 Credit</p>	<p>Core Modules (All) Sem: 2 (60 Cr) Geographic Visualization GIS Research Methods in the field Core Papers (any two) Living with Environmental Changes Ecological & Environmental Assessment</p> <p>Dissertation (60Cr)</p>
<p>University of Michigan, US</p>	<p>MS Environment & Ecology (Environmental Informatics)— <i>Geo-Spatial Data Science</i></p>	<p>Core Courses (Environment Core)-(Any Two) Natural System Social System</p> <p>Core Courses (Environmental Informatics Core)- (Any Two) Remote Sensing Principle of GIS</p> <p>Elective Courses (Environmental Informatics Core)-(Any Two) Intro to Rhinoceros 3D Field Remote Sensing & Analysis Advanced Digital Modeling Python Programming Computer Modeling of Complex Systems Sensors, Data, and Intelligent Systems Radio wave Propagation and Link Design Radar Remote Sensing Citizen Design Interaction Data Manipulation and Analysis Information Visualization Data Mining: Methods and Applications Big Data Analytics</p> <p>IA & Skill Course (Any Two) Forest Ecology Management Ecological Restoration Applications Ecological Risk Assessment Decision-Making for Sustainability Principles of GIS Negotiation Skills Mediation Skills Ecosystem Services Diverse Farming Systems Localization Social Vulnerability & Adaptation to Environ Change Environmental Impact Assessment Environmental Economics Sustainability Finance Urban Stormwater</p>

		<p>Environmental Systems Analysis Climate Adaptation Seminar Landscape Planning</p>
<p>University of Kassel Germany</p>	<p>MSc Environmental Informatics</p>	<p>Semester 1 (33 Credit) Critical elements of climate science and climate policy Parallel Algorithms and Programming Systems Ingenieur als Führungskraft Methods for spatial data analysis Machine Learning Pattern Recognition</p> <p>Semester 1 (27 Credit) Introduction to environmental modeling Presentation and Moderation Integrated systems analysis: the water cycle Project Seminar</p> <p>Semester 3 (30 Credit) Master's Thesis</p>
<p>Tennessee Tech University</p>	<p>Masters in Environmental Informatics (Professional)</p>	<p>Background Courses Theory of GIS I Theory of GIS II Informatics (Professional)</p> <p>Management Core Compulsory (12 Credit) Accounting Information for Management Decisions Organizational Leadership Applied Linear Statistical Method Strategic Marketing</p> <p>Concentration Courses (18 Credit) Programming GIS Environmental Social Policy Remote Sensing Environmental Applications of GIS Environmental Statistics Internship</p> <p>Electives (Any One) Agriculture and Biological Statistics Data Mining Web-based Database Systems Data Resource Management Environmental Economics Environmental Management Systems GIS Project Development and</p>

		Management Applied Linear Statistical Methods II Experimental Design I Experimental Design II Data Analysis and Management
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Hence it is noticed that within the Environmental Informatics different areas are booming viz. Agricultural Informatics, Geo-Informatics, Ecology Informatics, Forestry Informatics, etc. Moreover, apart from the independent topics and areas, few are merged and interdisciplinary viz.—

- Environmental Applications of GIS
- Introduction to environmental modeling
- Sustainable Management of Biological resources: Ecosystem and Biodiversity Conservation
- Environmental Social Policy et

Possible Masters Program in Indian Context

India is a developing nation and growing its economy as a knowledge economy. Further, it is to be noted that, India holds a higher number of higher educational institutes comprise of 900+ Universities, 40000+ Colleges, 100+ INI, etc. In many universities, Environmental Science and allied nomenclatures are offered and it is possible to offer academic programs on these subjects as specializations in Environmental Informatics. Table: 4 depicted possible programs in this regard.

Table: 4 Possible Environmental Informatics specialization programs in Indian context at Environmental Science and allied subjects

Possible Allied Environmental Science Core PG Degrees in India in Eco Informatics		
Stream/ Subjects	Nomenclature/ Degree	Applications
Environmental Science	MSc/MS/MTech-Environmental Science (Environmental Informatics)	Utilizations of Environmental Informatics tools and techniques in different areas of Environment and Ecology
Environmental Engineering	MSc/MS/MTech-Environmental Science (Environmental Informatics)	Utilizations of Environmental Informatics tools and techniques in different areas of Environmental Technological Solution and Engineering
Environmental Management	MSc/MS/MTech-Environmental Science (Environmental Informatics)	Utilizations of Environmental Informatics tools and techniques in different areas of Environmental Technological Solution and Engineering
Geography	MSc/MS/MTech-Geography (Environmental Informatics)	Utilizations of Environmental Informatics tools and techniques in Geography and related
Agriculture	MSc/MS/MTech-Agriculture / Agricultural Technology (Environmental Informatics)	Utilizations of Environmental Informatics tools and techniques in Agricultural activities
Earth Science	MSc/MS/MTech-Earth Science (Environmental Informatics)	Utilizations of Environmental Informatics tools and technologies in different areas of Earth Sciences

Geology	MSc/MS/MTech-Geology (Environmental Informatics)	Utilizations of Environmental Informatics tools and techniques in Geological affairs
Forestry	MSc/MS/MTech-Forestry (Environmental Informatics)	Utilizations of Environmental Informatics tools and techniques in Forestry, Forest Management, Planning, etc

Further, as there are numerous subjects within Environmental Science viz. Geology, Agriculture, Forestry, Geography, Climatology, Oceanography, and in all these programs Environmental Informatics specialization can be incorporated suitably.

Possible Masters Program in Research Context: Indian Context

Environmental Informatics an interdisciplinary program needs skill sets of different areas, further professionals from allied subjects of the environment and informatics can be interested to join in the field as a research concentration. Hence there may be possible programs with research concentration with following degrees (also refer Table: 5)—

- MSc by Research
- MS by Research
- MTech/ME by Research

Table: 5 Possible Environmental Informatics specialization programs in the Indian context in research concentration

Possible Allied Environmental Science Core UPG by Research Degrees in India		
Stream/ Subjects	Nomenclature/ Degree	Remarks
Environmental Science	MSc/MS/MTech 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	MSc/MS/MTech by Research – Ecology (Environmental Informatics)	Suitable for the future academicians and researchers, a scientist interested in Environmental Informatics tools and techniques in Ecology
Environmental Studies	MSc/MS/MTech 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/MSc/MS/MTech 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	MSc/MS/MTech/ 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	MSc/MS/MTech 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	MSc/MS/MTech 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	MSc/MS/MTech 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	MSc/MS/MTech by Research – Agriculture (Environmental Informatics)	Suitable for the future academicians and researchers, scientist interested in Environmental Informatics tools and techniques in Agriculture
Earth Science	MSc/MS/MTech by Research –Earth Science (Environmental Informatics)	Suitable for the future academicians and researchers, scientist interested in Environmental Informatics tools and techniques in Earth Sciences

Suggestion

- Environmental Informatics as a field is growing internationally and thus in India as well the field can be started at a Master's level with coursework or research.
- The programs can be started at Masters directly with full-fledged manner viz. MSc/MTech, etc on Environmental Informatics.
- Further if possible, subfield specializations may be offered viz. MSc Environmental Informatics (Geo-Informatics), MSc Environmental Informatics (Forest Informatics), etc as a super specialty.
- There are lots of programs in the Environmental Sciences sub-areas viz. Geology, Agriculture, Forestry, Geography, Climatology, Oceanography, and in such areas Environmental Informatics or allied fields can be offered.

- Proper adjustment, procedure, and collaboration with the allied departments (viz. Informatics/ IT departments with Environment related) can be taken to start the programs on Environmental Informatics.

Conclusion

Environmental Informatics is growing internationally due to its wide range of applications not only in core areas of the environment but also in allied areas viz. Geology, Agriculture, Forestry, Geography, Climatology, Oceanography, Anthropology, etc. In India, though Informatics or Information Science departments/ or academic units are limited but can be offered from the initiative of Information Technology, Computer Science or allied departments with the Environmental Sciences or allied departments viz. Environmental Science, Environmental Engineering, Environmental Management, etc. In this context, initiatives from the respective departments from the universities or by the MHRD or by the state government are required. Further Government departments, Ministries, and Organizational initiatives required from the allied branches viz. Agriculture, Forestry, Environment, Disaster Management, etc. Further, if Masters programs are difficult to start initially then the short-term programs, workshops, events can be started for proper development of the field and complete sustainability.

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