Geomatics: Technology and Applications - A Training Programme for Women Scientists

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Abstract

Geomatics, also known as geospatial technology and geomatics engineering, analyzes spatially referenced geographical information. Geomatics is a scientific term. It consists of tools and techniques. Technology is advancing, and modern Geomatics has the utility of maps by analyzing it with many coverages, each with interrelated themes combined to give meaningful answers for decision-makers.

A multidisciplinary approach is essential to analyze spatial and nonspatial parameters together for decision-making at the local and global levels. Spatial information represented in the form of thematic maps about the respective attribute data, the system called, Geographical Information System (GIS), has been more popular during the last decades in government and private sectors. The decision support system can take input of data from these sources and analyze multiple parameters together to plan and manage available resources.

This training program was intended for women scientists, researchers, academia, and professionals who were engaged and using spatial information, and who wanted to add and upgrade their skills. It was anticipated that a proportion of the trainee participants would come from research and academia. This training program helped participants generate interest in the use of GIS technology in their respective research and professional domains.

This paper elaborately describes the process, and structure of the short-term capacity-building training program, and its usefulness for young scientists and professionals, specifically a target group is ‘women in science’ who have not been able to remain in the continue its use and are interested in building a career in geospatial technology field.

1. Introduction

In today's world, geomatics research is crucial for swift resource evaluation and surveillance, identifying changes, assessing plans, and maintaining comprehensive records of resources, facilities, and databases. These records serve various professionals, including researchers, planners, engineers, administrators, and academics. The importance of geomatics-based studies lies in their proven ability to provide more precise, scientific, unbiased, and interdisciplinary results. This enhanced accuracy allows for more effective and efficient decision-making across various fields. Consequently, training programs in geomatics play a vital role in developing these essential skills and knowledge.

The decision-makers need various kinds of data sets to arrive at appropriate decisions, which is possible through the use of these technologies. An integrated approach to decision-making with a scientific database is more accurate and effective for the management of natural and manmade resources. The availability of experts in the above-mentioned areas is very sparse. The need for training in this area is expected to increase.

To ensure efficient and optimal use of geospatial technology, it is crucial to acquire up-to-date knowledge among stakeholders. The young researchers are engaged in day-to-day learning but the other type of users update their respective knowledge through the refresher courses or the capacity-building programs, often proposed by and offered by academic and scientific institutions. A Geographical Information System (GIS) is defined, captures, stores, manipulates, analyzes, manages, and presents data geographically on maps for decision-making. It consists of integrating cartography, statistical analysis, and computer science to achieve meaningful outcomes through processes. Earth science, planning, engineering, management, transportation, logistics, insurance, telecommunication, and business (Lal S. et al. 2008) are all areas in which GIS can be applied. The goal is to achieve the most effective and impartial spatial decision-making.

Remote Sensing and GIS, location-based systems, and database management are the areas of Geospatial Technology. This technology makes it possible to use spatial variables, their characteristics, patterns, trends, and future predictions (Ademola At. 2015). Generally, humans view through a terrestrial, horizontal, and not always vertical perspective. But if viewing the real world scenario, it is required to create 3-dimension, the use of space, and use of the land surface is

required. Location identification and respective changes can be viewed with coordinates representing longitude, latitude, and elevation. It is essential to note that the relative accuracy would depend upon the data source and its encoding.

Considering the increasing level of the use of geospatial data for decision-making in government and industry, the topics identified for the short-term capacity-building training program were emphasized more on the learning of Spatial Analysis. Major topics included were, surface analysis, slope, and aspect, its uses with a case model; spatial data analysis; creation of topological modeling; geometric networks; hydrological modeling; cartographic modeling; map overlay; geo-statistics; address geocoding; multiple criteria decision analysis; data output graphic display techniques; data extract, transform, load; data mining (MacEachren AM 2000). A project-based learning approach was adopted. The active participation of each trainee was sought.

Since 1987, CEPT University in India has provided education in geomatics. The institution houses an OSGEO Lab, which aims to cultivate a population well-versed in remote sensing and geographical information system applications. CEPT University organized a 3-week training program designed to offer a thorough understanding of GIS technology and its uses. Participants were expected to develop a robust foundation in Geospatial Technology architecture and functionality, as well as learn how to incorporate GIS into various processes. The program explored techniques for identifying the necessity of GIS in specialized research areas. The curriculum combined lectures, paper exercises, and computer practicals. Trainees gained practical experience with open source GIS software. The intensive learning environment, which included interactions with field experts and other participants, created an engaging educational experience. Participants' active involvement and acquired knowledge were assessed through examinations and feedback.

Free and open-source geospatial technologies are very useful and accessible for education, government, professional, and industry applications. In academic institutions open geospatial science and applications are becoming important for the learners, capacity building, and creation of education in geospatial technology, as it has a benefit of cost and priority of the respective institutions. The CEPT University, India has introduced remote sensing and GIS since the year 1987. It has introduced a Masters (M Tech) level program since 2006. It has been recognized as the Best Geomatics Education University by ESRI, India. It has been rated for exemplary teaching faculty. The University has established an ICA-OSGEO Lab. The activities carried out are academic programs at the master’s level and short-term capacity-building training programs. Its Centre for Applied Geomatics is carrying out research projects in the field of Geospatial Technologies Applications and Development. The academic and relevant activities include offering short-term training programs, organizing summer and winter schools, teaching and research to enhance the knowledge base among not only the enrolled students but also the younger generation, students from other academic institutions – national and international, officials from the government and private sectors and prepare them, motivate them, train them to cater the objective of the capacity building in the field of Geospatial Technology. One of the initiatives to train women scientists, who have an interest in learning, who have left their jobs for personal, social, and family reasons and now want to start once again a career, after a time gap, was offered a training program on “Geomatics: Technology and Applications” for them, the Women Scientists.

2. Objectives of the Training Programmes

The program sought to inspire and spark interest among female participants in applying scientific technology to real-world scenarios. Participants would develop technical expertise and proficiency in utilizing Geomatics. Through a combination of theoretical and hands-on training, they would establish a foundation of knowledge for employing geomatics technologies in research endeavors and rebuilding their careers after significant hiatuses. The primary objective of this "Geomatics: Technology and Applications" program was "Breaking the Break" (Dyer et al 1991).

After completing the training program, participants would acquire a thorough grasp of GIS technology and its uses. They would develop a robust foundation in its capabilities, comprehension, and proficiency in integrating the technology into various processes. The program delved into methods for identifying GIS needs in specialized research domains. Instruction was delivered through a combination of lectures, paper-based exercises, and computer labs. Participants also gained practical experience with open-source tools and software. The women scientists engaged with field experts in an immersive learning setting, creating an invigorating educational experience. Trainees were required to demonstrate their learning through an examination.

This program was designed for women scientists, researchers, academics, and professionals who were either currently unemployed due to various reasons, employed in fields utilizing spatial information, or seeking to expand their knowledge of GIS technology. It was expected that a portion of the participants would come from research and academic backgrounds. The enrolled women represented diverse fields such as earth sciences, engineering, planning, and architecture, with prior experience as academics or scientists in research institutions.

The curriculum covered specific application areas including site suitability analysis, facility location, natural resource management, land information systems, topographical analysis for infrastructure planning, analytical decision-making alternatives, and other scientific and research applications as needed. The training program successfully sparked interest among participants in understanding and applying GIS technology to real-world, real-time scenarios. It effectively enhanced skills and knowledge in geospatial technology applications.

The program encompassed specific application areas such as site suitability analysis, facility siting, natural resource management, land information systems, topographical analysis for infrastructure planning, analytical decision-making alternatives, and other scientific and research applications on demand. This training program successfully generated interest among participants in understanding and utilizing GIS technology in real-world, real-time application areas. Indeed, it resulted in skill development and knowledge enhancement in geospatial technology applications.

3. Department of Science and Technology

The Department of Science and Technology (DST), Government of India plays an important role in the promotion

of science and technology in the country. It possesses a large spectrum of activities such as research and development of cutting-edge technologies, development of skills, training, and outreach programs. These are appropriately designed and developed for every spectrum of society: academia, researchers, young scientists, professionals, government, and NGOs. The Department functions as a nodal department for organizing, coordinating, and promoting science and technical activities across the country. DST has major responsibilities for specific programs ranging from formulation of policies; advisory responsibilities; promotion, coordination, and integration of S&T; National Spatial Data Infrastructure and promotion of GIS; capacity building; support through grants and financial assistance to professional science academies. A very special initiative that has been taken up by DST is the Women Scientists Program. Considering the women's constraints in the professional field and their situation of ‘break in careers’ the option of the revival of their professional career through providing an opportunity to undertake research in their respective areas of specialization. Through this endeavor of the Department, a concerted effort is being made to give women a strong foothold into the scientific profession, help them re-enter the mainstream, and provide a launch pad for further forays into the field of science and technology, both from the point of view of pure science and its application to societal development. Under this scheme, women scientists are being encouraged to pursue research in frontier areas of science and engineering, on problems of societal relevance and to take up S&T-based internship followed by self-employment (Rout et al 1999). The Scheme is meant to encourage women candidates, preferably those having a career break and not having regular employment.

This Scheme was introduced in 2003 and since then the number of research proposals has increased. However, when a review was carried out, it was found that a very small number of researchers use geomatics in their research. This may be due to the lack of knowledge of the subject, lack of skill to use GIS or not having practice to use the software and tools. This may be accounted for a break in the continuation of the job, and not able to access the learnings during the career break. This situation calls for a training module to be developed and offered to these women scientists to improve their research quality. Considering the need to fill this gap and enhance knowledge, the DST has granted four cycles of the training program on ‘GIS Technology and Applications to CEPT University, Ahmedabad.

4. CEPT University, Ahmedabad

CEPT University, more than six decades old, is one of the premier academic institutions. Since its inception, it has focused on understanding, designing, planning, constructing, and managing human habitats. Its teaching programs build thoughtful professionals and its research programs deepen understanding of human settlements. CEPT University also undertakes advocacy and advisory projects to further the goal of making habitats more livable. The University comprises five faculties. The Faculty of Architecture was established as the ‘School of Architecture’ in 1962. It focuses on design in the private realm. The Faculty of Planning focused on planning in the public realm, was established in 1972 as the ‘School of Planning’. The Faculty of Technology, which concentrates on engineering and construction, was established in 1982 as the ‘School of Building Science and Technology’. The Faculty of Design was established in 1992 as the ‘School of Interior Design’. It deals with habitat-related interiors, crafts, systems, and products. Faculty of Management is a newly established faculty from the Faculty of Technology Management and it focuses on Habitat and Project Management. CEPT University takes its name from the ‘Center for Environmental Planning and Technology’ (CEPT). The Government of Gujarat incorporated CEPT as a university in 2005. The University Grants Commission recognized CEPT University under section 2(f) of the UGC Act, 1956 in 2007. The Department of Scientific and Industrial Research (DSIR) of the Government of India recognizes the University as a Scientific and Industrial Research Organization (SIRO).

The teaching programs at CEPT University focus on building professional capacities and therefore it’s centered on ‘studios’ or ‘labs’. The students engage with well-designed life-like problems. Coursework, seminars, and research assignments aimed at developing the conceptual and analytical abilities of students, and skill-enhancing workshops support learning in studios and labs. Students also have to enroll in travel and documentation programs and intern in professional offices to widen their exposure. It cherishes the individual interests and abilities of its students. To enable each student to chart a unique course of study and realize his or her potential, programs mandate only three-quarters of the total credits that students have to complete. Students can complete the remaining credits by choosing from the wide range of elective courses offered by any of the five faculties of the university. The Faculties also make all attempts to ensure that even within the mandatory portion of the program, students can choose courses to suit their practice orientation. The belief that educating professionals requires practicing professionals and academics to work closely together firmly underpins the university’s pedagogic philosophy. Therefore, it works as a collaboration of academia and practitioners. Practitioners’ adaptions to decision-making bring their experience to classrooms and academics impart a more thoughtful and critical approach. Teachers at CEPT University, see themselves as coaches. Their role is to support individual students in their explorations and their capacity-building quests. Geomatics is one of the Master’s programs introduced in 2007. It offers an M Tech degree under the Faculty of Technology. The faculty members are engaged with teaching and research in Geomatics, having good experience and expertise in-house.

5. Training Programme

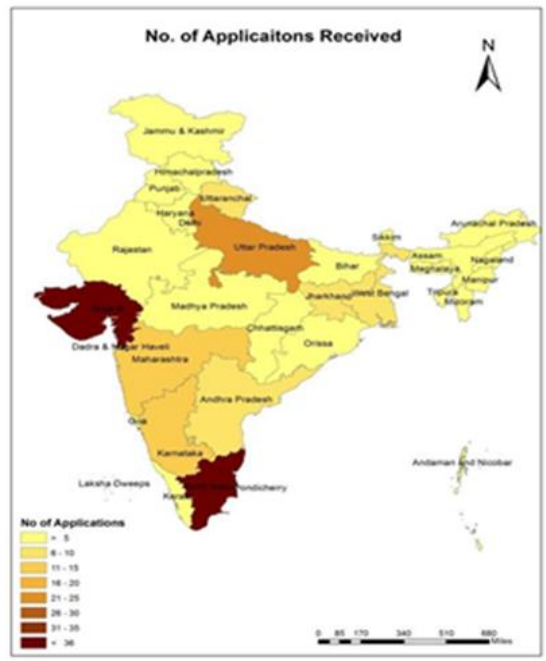
The Training Proposal on ‘Geomatics: Technology and Applications’ was sanctioned by the Department of Science and Technology (DST), Ministry of Science & Technology, Government of India, and has approved and sponsored four cycles of a six-day long training program on GIS Technology and Applications.

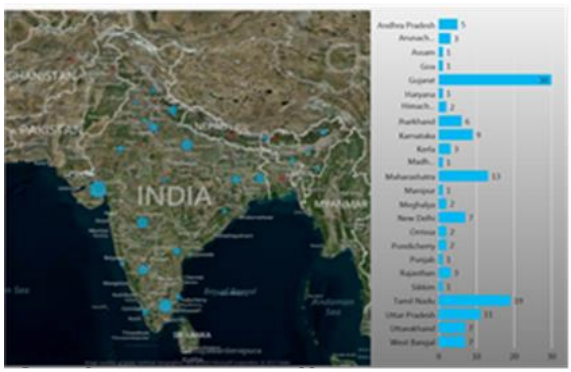
The training program's aims were threefold: firstly, to spark enthusiasm among female scientists for learning and utilizing Geomatics, a scientific technology; secondly, to enhance their technical expertise and proficiency in applying Geomatics; and thirdly, to provide practical experience through hands-on training with open-source GIS software, laying the groundwork for implementing Geomatics technologies in research endeavors.

The brief course was designed to cultivate a technical comprehension of Geomatics Applications and to inspire participants to employ scientific technologies, specifically GIS and Remote Sensing, in practical, real-world scenarios.

A nationwide training program was conducted, and a total of 199 applications were received from all the states of the country. Of the total applications received, the highest number of applications received were from Gujarat state, followed by Tamil Nadu, Maharashtra, and Uttar Pradesh. Applications received from remaining states range from one to nine. Applications received from Karnataka were nine. whereas from New Delhi, Uttarakhand, and West Bengal were seven each. It is important to note that applications from all North-Eastern states were also received. This reveals that irrespective of the distance, the women are interested in developing their skills in technology and science.

Further, an analysis has been carried out to understand the pattern of the academic qualification of the women who had applied and shown interest in learning geomatics during the short-term training program. It was observed that a large number of Ph. D and Post Graduate (science) students have applied, it was 77 each. Other applicants were mostly with postgraduate degrees (M. Tech, M.A, M Plan, postgraduate diploma, and M.B.A) with specializations like information





technology and Engineering, environmental science, Geoinformatics, Geography, Geology, and Computer Science. Applications were also received from other specializations like Hydrology, Environment and Climate, Planning, Architecture, Forestry, Medical, and Botany.

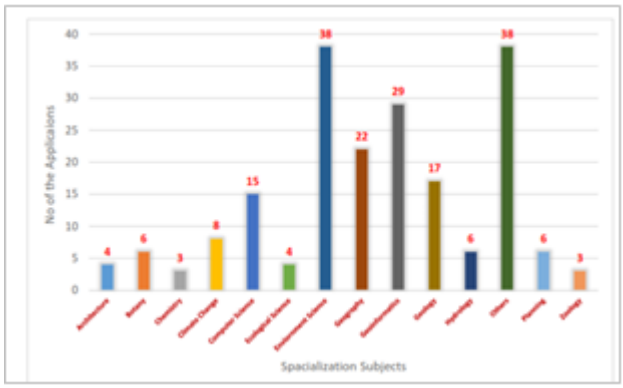


Figure 2 Subject Specialization of the Applicants

Figures 2 and 3 represent the qualification-wise number of applications received.

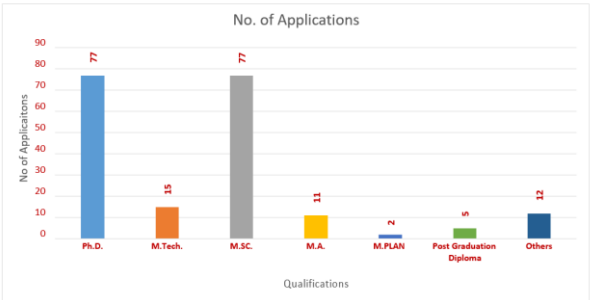


Figure 3 Applicant’s Qualifications

These applicants had various professional backgrounds, such as Professors, Assistant Professors, Junior Research Fellow and Research Scholar, Doctoral students, government departments, and NGOs.

6. Selection Procedure

A panel was formed to choose the participants. The selection process considered four main factors: i) geographical diversity, ii) occupational background, iii) educational qualifications, and iv) research goals. From a pool of 199 applicants, 138 individuals were chosen. Priority was given to recipients of the All Women Scientists Scheme from the Department of Science and Technology. The program also included Research Scholars, Research Associates, and Faculty Members from Universities and Colleges, as well as professionals from Central and State Government Organizations, NGOs, and other institutions.

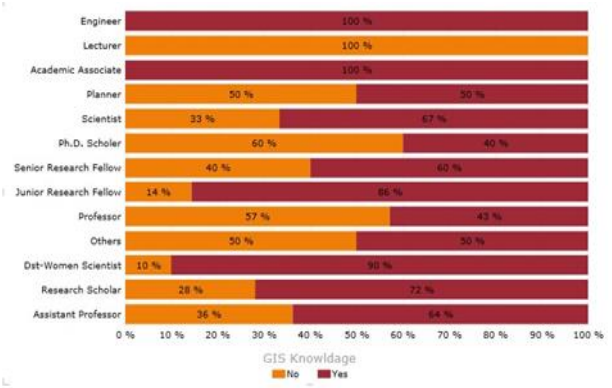


Figure 4 Applicant’s Profession and their GIS Knowladge

This contribution has been peer-reviewed. The double-blind peer-review was conducted on the basis of the full paper.
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6.1 Details of Selected Trainee

The graphs indicate the qualifications, designation, and specialization of the participants. The graph represents the category of professional representation falling in the knowledge domain of the GIS where ‘the red color’ represents ‘yes’ and ‘yellow’ represents ‘no’. A multi-disciplinary batch was enrolled to embed the knowledge of Geomatics.

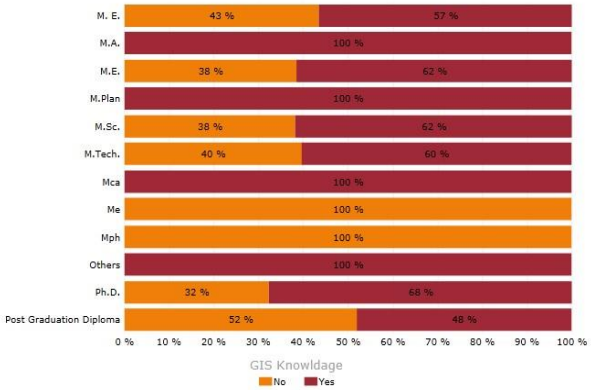

Figure 5 Applicant Qualifications with their GIS Knowldage

7. Content of The Programme

The duration of the training program was six days, carried out four cycles in year. Each day was designed to teach a specific theme. In the morning sessions, theoretical expert lectures were scheduled. Post lunch the trainees had to work on the software on their laptops. Computers were provided to the trainees in case they did not have a laptop or problem with it’s working.

The day-wise topics/ themes have been planned. The first day was to learn about Remote Sensing, the Second day was for Geographical Information Systems (GIS), the third day was for Spatial and Non-Spatial database management fourth and fifth days covered the various applications of GIS and Remote Sensing, and applications-based practical sessions were conducted with that mini-project that was given to the participants to evaluate the practical knowledge which they gain during the training program. On the last day of the training session, the participants had to give the project presentation. During the training, an outdoor exercise with GPS was also carried out, where participants were on the field, understood the GPS instrument, and used it for information collection. The readings collected using GPS were brought to the GIS Lab and with the help of software the trainees had prepared the maps. Academic tours were an interesting part of the program, a day-long visit to the Space Applications Centre (ISRO), State Remote Sensing Centre, and State Level Ground Water Data Centre, was planned and carried out.

Figure 6 Trainees learning GPS and DGPS in the Field

There were 22 topics covered with the help of experts and in-house faculty. The practical sessions were given higher importance to help women trainees develop confidence working on and handling the software. The open source GIS, i.e., QGIS was taught. Firstly the software installation, followed by the operations and commands, and finally geospatial applications. The trainees were provided with spatial and non-spatial data on which they could practice on. The open source software, QGIS was used for training while keeping in mind a specific objective, in case of the absence of proprietary software, such as ArcGIS, MapInfo, etc, at the respective workplaces of the women trainees, still they can work on GIS. Experts were invited from various parts of the country to deliver an apt pool of knowledge. Those have received high appreciation from the participants.

Figure 7 Training are in the Class Room

Specialized presentations covered geospatial techniques and their applications in various fields, including Land Use Planning, GPS technology, Disaster Management, and Agriculture. Additional topics encompassed resource evaluation and surveillance, identifying changes over time, assessing plan effectiveness, and maintaining comprehensive records of resources, facilities, and databases. The use of Geomatics technologies, known for their precision, scientific approach,

Figure 8 Group of the Trainees

impartiality, and interdisciplinary nature, enhances the efficiency and effectiveness of decision-making processes across diverse sectors.

The practical training session encompassed several key components: i. Fundamental understanding of the Software and its setup process, ii. GIS data type classifications, iii. Vector File generation and modification, iv. Management and querying of Spatial and Non-Spatial Database information, v. Utilization of Geoprocessing Tools for analysis, vi. Cartography skills combined with introductory Python programming techniques.

8. Summery

The program focused on enhancing skills, teaching processes, boosting confidence, and raising awareness about geospatial technology usage. Upon completing the course, attendees were capable of (i) showcasing their knowledge and comprehension of geospatial methodologies and techniques, and (ii) employing suitable methods for analyzing spatial and non-spatial data, gaining insights into the dynamics of relevant research and professional practices. These objectives were successfully achieved. The participants provided their endorsement and feedback as follows:

1. ‘I am very excited to write feedback as I have completely enjoyed learning geospatial technology. I wasn’t aware that learning this technology was so simple and useful. I am now confident to use QGIS and will able to complete my doctoral report with the use of GIS in the analysis. Thanks to the organizers, the teachers, and the experts for giving me a new direction. Thank you very much.
2. ‘All work and no play makes Jack a dull boy’, but this training program has a difference, the field study has enhanced my confidence’.
3. ‘Can we come back for the Advanced Level Training? We will benefit from using this technology. Thanks a Ton.’
4. ‘Geomatics the way I learned, I will continue using it. The training gave me a larger opening for building my new professional career.’
5. ‘Excellent. I would extend thanks to DST and then to the faculty members of CEPT University for giving me a new dimension to the research I am going to be engaged in’.
6. ‘Refresher Training and Advanced Training in GIS is a must. Please do it often and allow us to learn more. I am a teacher, the training gave me a 360-degree change. Please let me know about the next training program. Enroll me now itself’.

Acknowledgment

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