

Bridging Lab to Life: Pedagogical Impact of Remote Sensing Training on Secondary Teachers

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Abstract

Whenever it comes to experiencing, analysing, and effectively evaluating the effects of climate change, environmental degradation, and environmental sustainability—that is, “how much lost and how much retained of our natural resources by our activity now”—geospatial technology is the best tool available. The objective of this study is to evaluate the current knowledge, need for teacher training, and various creative activities and explore an attractive pedagogical process as well as their effect on selected teachers. The various pedagogical interventions (such as explanation, model preparation and demonstration, ICT-integrated learning materials, experiential learning, ICT-integrated hands-on, and analytical thinking) are provided in the classroom for enhancing the competency among teachers. A pre- and post-training assessment was conducted to evaluate the effectiveness of the program. The findings indicated a significantly positive impact on teachers from five western states of India. Due to their limited prior knowledge related to the content, participants were highly focused throughout the program. Notably, teachers of Chhattisgarh scored 48.11 percent more in the post-test as compared to the pre-test scores. Teachers from Maharashtra, Gujarat, and Goa got 31.44 percent, 40.33 percent, and 12.88 percent more score, respectively, due to prior knowledge about ICT and lack of syllabus of remote sensing in the textbook of Gujarat. Therefore, these results suggest that the study will be immensely beneficial for students, curriculum developers, and stakeholders across the field of remote sensing in educational sectors.

Keywords: Remote sensing, pedagogical intervention, ICT-integrated hands-on, experiential learning, analytical thinking.

Introduction

Dynamic and holistic understanding of the environment or the world (earth) is possible after understanding the geography practically, then producing learners (Dejene and Tilahun, 2024) with ample experience, concern, and the ability to act sustainably upon any environmental problem (Pandey, 2018). Geography without practical works (scale, map, map projection, data collection, data representation, data analysis, weather map, instruments, fieldwork, remote sensing, GIS, etc.)

looks like a doctor without medical tools (Brown et al., 2024). Well-planned learning of remote sensing in practical works in geography adds clear value to learning in the subject (Di et al., 2002) as well as providing a positive contribution to the wider curriculum and its implementation from the classroom to each corner in real life (Fargher et al., 2021). For example, field-based location awareness and critical thinking about spatio-temporal analysis (Bikar et al., 2022). In this context, students can integrate concepts from many different

areas of science, social science, and the humanities and apply critical thinking to understanding and dealing with current issues of local, national, and international importance (Mier, 2024). Therefore, in contemporary times, under the aura of the National Education Policy 2020 of India, the arts of mapping, environmental studies, technology, holistic development, global citizenship, etc., can be influenced and assessed under the aura of remote sensing in geography (Dannwolf et al., 2020). In this context, the fundamentals of remote sensing have been practically tried to understand through attractive pedagogical intervention during the training program by teacher-learners (Mier, 2024). The integration of ICT in experiential learning demonstrates considerable importance in the application of knowledge management theories (Hailye, 2019, and Alemu, 2017). These pedagogical interventions have the potential to enhance the knowledge, awareness, and practicing attitudes (Jang, 2020) among teachers. This study explores the way to gain first-hand, practical experiences that reinforce knowledge, skills, and concepts about remote sensing in geography among learners in either indoor or outdoor classrooms. Moreover, this approach enhances the overall learning experience by merging theoretical knowledge (Woreta et al., 2013) with practical application, thereby enabling students to effectively implement their learning in real-world scenarios (Alemu, 2017). In this study, learners will be able to understand and put into practice that educational interventions are very basic tools. Additionally, learners will be able to develop the ability to reflect on the learning outcomes about the core concepts through these pedagogical interventions. The study will also explore ways of pedagogical interventions to make the subject matter of remote sensing easier for learners.

All teachers have been possessing the requisite training by these pedagogical interventions (Wan et al., 2019). This research work explores the different ways of pedagogical interventions, i.e., explanation, model preparation and demonstration, ICT-integrated learning teaching material, experiential learning, ICT-integrated hands-on, and analytical thinking. All these kinds of interventions are making it easy to understand the core content of the fundamentals of remote sensing in practical geography for the teacher of the Western region states of India. These pedagogical interventions are to ease the content difficulties and resolve the queries for teachers (Jang, 2020), like why we use satellite imagery as a false-colour composite (FCC) image while we have a true-colour composite image (TCC) in Google Earth Image (Mier, 2024). Moreover, this research study explains the need to understand the fundamentals of remote sensing and its implementation for teachers in modern days. This study also analysed the effect of five days of training on teachers of western region states (Chhattisgarh, Maharashtra, Madhya Pradesh, Goa, and Gujarat) of India about the various mechanisms of remote sensing with its implications and implementations. The effect of training on teachers was evaluated using the pre-test and post-test approach (Zarabi, 2019). This technique also indicates the prior knowledge of teachers, notably their engagement in classroom activities (Sims et al., 2025) and their ability to absorb content during the sessions (Zarabi, 2019). In this way, this research study has the potential to increase interest, knowledge, and competency by DAY (Doing action by yourself), which has been engaging in an easier way to learn. In the context of DAY, teachers are able to exchange basic knowledge, develop a scientific and ethical mindset, and develop analytical comprehension to address real-world problems (Dare

et al., 2021). The National Education Policy (NEP) 2020 suggests that in the 21st century, teachers should not only be equipped with the skills to use digital tools but also to effectively integrate technology into their teaching-learning process. Therefore, in accordance with the NEP's recommendations, the PAC training program provided training on content-ICT-pedagogy integration, focusing on experiential learning and ICT integration. Hence, this study includes the various interventions and their outcomes of this training program.

Research Objectives

- To explore the numerous pedagogical interventions to understand the fundamentals of Remote Sensing
- To analyse the effect of pedagogical interventions on enhancing the competency of secondary school teachers regarding the content in remote sensing

Literature Context

When it comes to applying knowledge management ideas that were covered in class lectures to team experiences, ICT-integrated experiential learning is quite beneficial (Dutta et al., 2025). Learners can understand the learning outcome regarding the laboratory-to-life process from classroom to real life (Amanuel et al., 2022). Experiential learning and integrated ICT are fundamentals of remote sensing, described as a way to think about applying what learners had learned, assessed, and analysed to "real-life" actions (Tibebu et al., 2009). Geospatial technology is the best way to experience, analyse, and assess practically the impact of climate change, environmental degradation, and environmental sustainability (Cox et al., 2014), which means 'how much is lost and how much retained of our natural

resources by our activity now' (Jahn et al., 2010). Intentional steps taken by teachers to improve learning outcomes through organised teaching techniques are referred to as pedagogical interventions. Intellectual imagination in practical geography is enhanced through very low-cost, effective miniatures or models among learners (Howard et al., 2022). In the early 1960s, the word "remote sensing" was coined and defined as the procedures used to obtain and quantify data based on properties of earth surface phenomena by using a sensor that is not in direct contact with the phenomena being studied (Gerner and Pause, 2020). An object surface, a recording device, and information-carrying energy waves are the main components of remote sensing (Lillesand et al., 2015). Remote sensing is the science and, to some extent, the art of obtaining information about the Earth's surface without any real physical contact (Gibson, 2013; Campbell and Wynne, 2011). This is done by sensing and recording the reflected or emitted energy (Joseph, 2005). This recorded energy is processed, analysed, and applied to obtain that information (Pateraki and Baltasvias, 2005, and Sabins and Ellis, 2020). Human eyes are real-life-based examples of natural sensors, and the human brain collects and analyses (Ketema and Nirmala, 2015, and Lixi and Dahan, 2014) and produces the sets of data in remote sensing in which, without any physical contact with the object (Haliye, 2019; Hodam et al., 2020; Jones and Vaughan, 2010), we take information after sensing (Coops and Tooke, 2017), whereas mobile CCTV cameras are also daily routine-based techniques in which we can collect very important hidden information without touching the object (Adaktylou, 2020). In this research work, nine easy paths essentially provide the teacher with an understanding of the fundamental mechanism and utilisation of remote sensing in the daily life of people. The

fundamental mechanism of Remote Sensing is understood by following nine steps with sequential interaction among the phenomena (Figure 1). The energy source (sun and satellite) is the base of remote sensing mechanism from which an analysis begins; the features of illumination (electromagnetic radiation) are the path of mechanism to observe the object and procedure ran for analysing the object; Across the attitudes of atmospheric elements (radiation, scattering, absorption): It focuses on the style/behaviour of medium from where energy reached towards object; Character of objects (rough, Smooth, transparent type of target/object): It is focus on the character of object through which energy interact; Detected by satellite (satellite types and multispectral scanner): Reflected energy recorded by satellite; Processing and interpretation (catching, analysing, processing, interpretation): Recorded energy ready to process the object character after analysing (Figure 1); Information

(knowledge for application): Analysed information regarding change detection of land use by human interferences are available as knowledge regarding the object after catch, analyse, process and interpret (Figure 1); Critical analysis of the technique of Remote Sensing: An analysis needs to observe the potential for managing interrelation (Bhatta, 2008) between the natural resource and human-induced activities (Figure 1); Analytical implementation of remote sensing: very useful and analytical information ready to maintain (Figure 1) the natural resource (Lillesand et al., 2015). Pedagogical intervention is a way to feed the information into the brain of the learner (Molina et al., 2018). Issues with learning in the sphere of education are crucial placemarks (Naumann et al., 2009), and numerous research studies are needed to reduce the difficulty level for learners after using the attractive and easy pedagogical intervention (Sanchez et al., 2019).

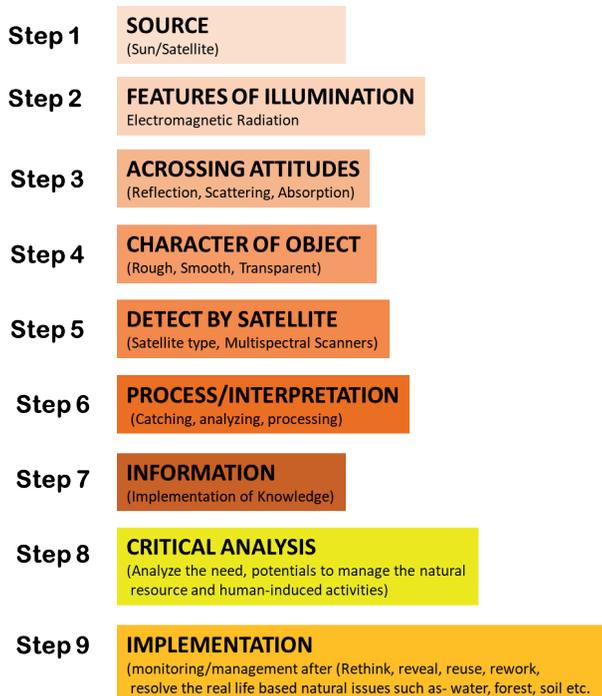


Fig. 1: Fundamental mechanism of Remote Sensing

Study population

This study is based on primary data, collected from senior secondary (Class XI and XII) school teachers. They were teaching the geography subject in the states of the western region of India, namely Chhattisgarh, Maharashtra,

Madhya Pradesh, Goa, and Gujarat (Figure 2). These teachers were selected for training at the Regional Institute of Education by concerning sates SCERTs (State Council of Educational Research and Training) of the western states of India.

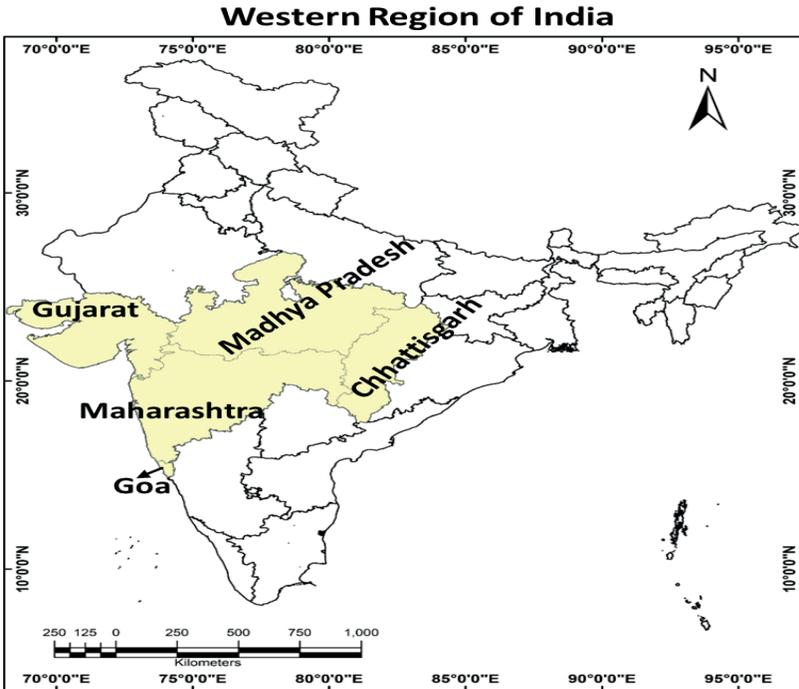


Fig. 2: Fundamental mechanism of Remote Sensing

Methodology

Data source: 39 teachers participated in this training programme, in which nine, eight, ten, six, and six participants selected from the state of Chhattisgarh, Maharashtra, Madhya Pradesh, Goa, and Gujarat, respectively. In this training program many tools were used; such as computers, software like Google Earth Pro, Bhoonidhi account, Survey of India, springs, paper, pencils, net wire, cardboard, colours, satellite imagery, etc. to provide pedagogical interventions for key resource persons (teachers) to enhance their knowledge for real-life application through remote sensing (Beker et al., 2022 and Ketema

and Nirmala, 2015). These pedagogical interventions were based on NCERT Class XI and XII Practical Geography textbooks, National Education Policy 2020, and the National Curriculum Framework for School Education 2023. Apart from that various methods were used for explanation, ICT-integrated hands-on, model preparation and demonstration (Figures 3, 4, 5, and 6), ICT-based LTM (learning teaching material), experiential learning (Figure 7), and analytical thinking (Figure 8). Google Earth Pro, QGIS, MS Office software, numerous literatures, etc., were used as tools to understand the fundamental mechanism of remote sensing.

Variables of the study

Independent Variable—Pedagogical interventions such as computers, software, Google Earth Pro, Bhoonidhi account, Survey of India, springs, paper, pencils, net wire, cardboard, colors, and satellite imagery are independent variables.

Dependent Variables—Learning level difference between pre and post-tests of teachers.

Data sampling technique: This study is based on primary data collected through the multistage random

sampling technique from five states of the western region of India. Data was collected using the pre-test and post-test method. A pre-test was administered (Table 1) before giving pedagogical interventions to all teachers to assess previous knowledge of participants. After that, a pedagogical intervention was given for selected KRPs (teachers) through seven sessions, and finally, a post-test was administered (Table 2) at the end. The questions/statements remained the same during the pre- and post-tests. Nine multiple-choice questions/statements were formulated for the tests (Zarabi, 2019).

Table 1: Question of Pre-test (before pedagogical interventions) for teachers

No.	Items
1.	Which scanner holds a large swath?
2.	What is a key benefit of using satellite imagery for agricultural monitoring?
3.	What is the main application of thermal remote sensing?
4.	Which one of the correct sets of 'M' is used in data analyzing in remote sensing and GIS?
5.	What is the term for the process of transforming raw remote sensing data into information?
6.	Which term refers to the ability of a sensor to detect and record different wavelengths of light?
7.	What is 'georeferencing' in remote sensing?
8.	Which technique is used to measure the Earth's surface elevation?
9.	Which of the following is a limitation of passive remote sensing?

Source: Tools developed by authors with the help of NCERT class XI and XII practical books

Table 2: Question of Post test (after pedagogical interventions) for teachers

No.	Items
1.	What is a key benefit of using satellite imagery for agricultural monitoring?
2.	Which one of the correct sets of 'M' is used in data analyzing in remote sensing and GIS?
3.	Which scanner holds a large swath?
4.	What is the term for the process of transforming raw remote sensing data into information?
5.	Which of the following is a limitation of passive remote sensing?
6.	What is 'georeferencing' in remote sensing?

No.	Items
7.	Which term refers to the ability of a sensor to detect and record different wavelengths of light?
8.	Which technique is used to measure the Earth's surface elevation?
9.	What is 'georeferencing' in remote sensing?

Source: Tools developed by authors with the help of NCERT class XI and XII practical books

Data analysis: After data collection, data analysis was undertaken by the investigators. Percentage analysis and t-tests were used as statistical techniques for data analysis (Tables 3, 4, and 5). MS Office software, numerous literatures, etc., are used as tools to understand the fundamental mechanism and importance of land use analysis of remote sensing in geography.

Results and Discussion

Intervention Tools

An attractive way of pedagogical interventions: This research study offers more reliable, feasible, and sustainable platforms to use geospatial-integrated experiential learning among senior secondary-stage teachers under the circumstances of NEP 2020. A pedagogical intervention is defined

as a collection of activities, tactics, and designs that are transacted into the brains of learners. The novelty of this study is found in the creation and application of simple, cost-effective, and easily reproducible methods to elucidate intricate ideas related to remote sensing and geospatial technology. Abstract scientific principles, such as the wavelength of the electromagnetic spectrum, were showcased using spiral wire, while spatial resolution was clarified through the use of mosquito mesh nets and cardboard cutouts. Spectral resolution was represented with vibrant gift-wrapping paper rolls (Figure 3), and radiometric resolution was illustrated using colour-concentration paper (green) that was manually prepared (Figure 6b).



Fig. 3: Model of Spectral Resolution

These creative, hands-on educational tools convert abstract ideas into tangible visual experiences, enhancing the learning process to be more engaging, comprehensible, and effective for educators. This methodology is particularly beneficial in classrooms

with limited resources. These ways are carried out by educators to enhance instruction and learning by the following:

Explanation: Explain how the core content is the most effective pedagogical intervention and how it should be used

to accomplish the main goals of the entire learning process, which establish a foundation for exposure to real-world situations and experiential learning (Bodzin, 2011). Explanation is the best way to understand the mechanism of remote sensing and the other pedagogical interventions (Dannwolf et al., 2020).

ICT integrated hands-on: Google Earth Pro, QGIS, GRACE, etc. software is used to observe, measure, and analyse the earth's surface features. Area by polygon, length by polyline, and location by point feature are measured through Google Earth Pro and georeferencing (locating the position of earth's object on a map based on real coordinates) on QGIS software to locate the real position on the earth to determine and calculate the real value and location of the earth (Pivarnikova and Trojan, 2023). A map drawn and located correctly according to latitudinal and longitudinal marks, scale, direction, etc., done after geo-referencing and digitised

to a downloaded topographical map, boundaries of the district, and states from the Survey of India (SOI). Teachers are able to learn the process of mapmaking through the ICT-integrated hands-on.

ICT-integrated LTM: Numerous 2-D images, animated videos, documentaries of simulation models (push broom, whisk broom, PSLV, GSLV, etc.) on YouTube, etc., collected from (Ergado et al., 2022) different weblinks. In this way, learners will be able to observe, classify, identify, visualize, and understand the phenomena as well as their process from the aforesaid sources.

Model preparation and demonstration: EMR shown by the spring and their less stretch shows high frequency and shorter wavelength like gamma rays, X-rays, and UV rays, whereas higher stretching of the spring shows the low frequency and larger wavelength like infrared, microwave, and radio waves (Figure 4).

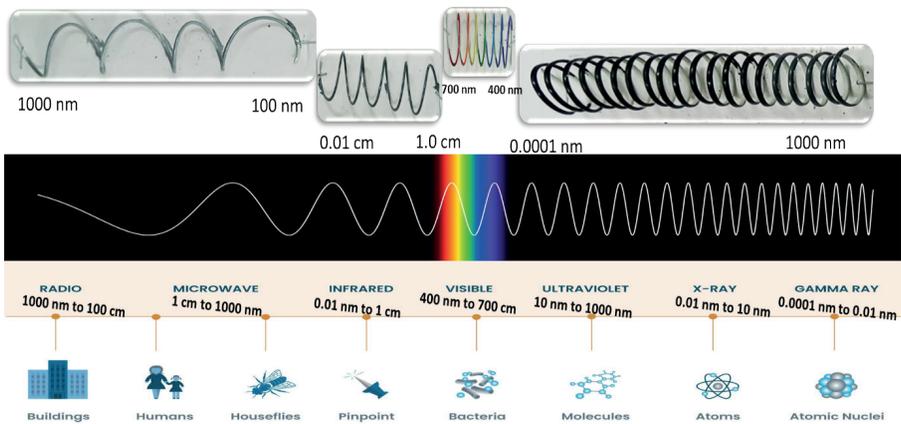


Fig. 4: Miniature of wavelength of EMR

Source: Fundamental of Remote Sensing, CCRS/CCT

Colour spread on steel net wire (2 mm square size and considered as one pixel) shows low spatial resolution with high clarity, whereas cutting of cardboard in a 10 cm square shape represents high

spatial resolution due to one square showing one colour as a pixel, which is represented with low clarity on the image (Figure 5).

Image show to understand spatial resolution

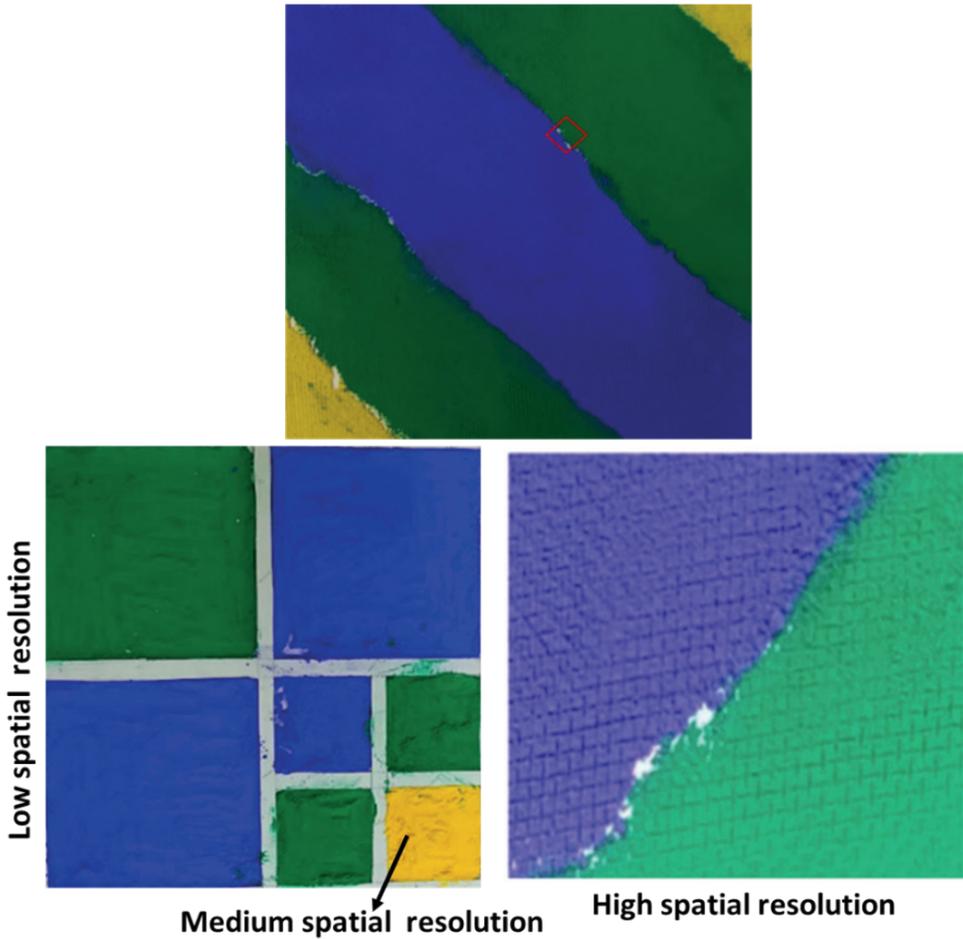


Fig. 5: Model of Spatial resolution

4 shades of green colour light to dark tones, are considered as the 2-bit (2^2) radiometric resolution of a band (single spectrum) and show four types of green colour. It is helpful to identify

and differentiate the weeds and crops in farmland (Figure 6a and 6b). Hence, the learners will be able to detect the transformation in growing crops as well as other phenomena also.

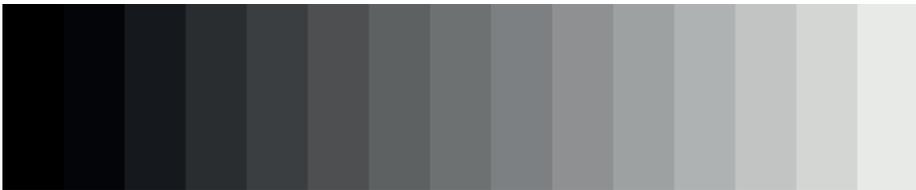


Fig. 6 (a): Radiometric resolution



Fig. 6 (b): Miniature of radiometric resolution

Experiential learning: Human eyes are real-life examples of a natural sensor, and the human brain collects, analyses, and produces sets of data in remote sensing in which, without any physical contact with the object, we take information after sensing. Flashlights in mobiles are used as active sensors in which sensors produce their light on objects and emit energy to detect and provide information about the object. The mobile camera is also used as a passive sensor when it detects an object in the presence of sunlight and other artificial light. CCTV camera is also a daily routine-based technique in which we can collect very important hidden information without touching the object. Use GPS-integrated location and follow a route map, which is also digitised as a polyline and provides information through communication satellite. Therefore, teachers will be able to learn the integrated hands-on for analysing the phenomena in real life without any physical contact.

Analytical thinking: It is a very useful tool to understand the implantation of data from remote sensing techniques. Some reflective questions came from the teachers who were trained during this competency-enhancing programme such as, “Why use this kind of complex and costly technique?” (Figure 8). This method is applied to the teachers (Rajput et al., 2020). They asked many questions about why use benefits and

specialty of this technique (Nunez et al. 2020; Amici, Tesar 2020). Why do people face the problem of water flood and drought in the same region in a single year? This problem is observed and analysed by this technique through Virtual River Rafting (Figure 9). Observe the anthropogenic interferences along the bank of the river and see how the people encroach on the catchment of the river and seasonal dry-out area, observe the potential of farming along the bank, observe the difference between the Himalayan and peninsular Indian rivers and the perennial and non-perennial character, observe the tributaries, observe the humans residing along the riverbank, etc. (Bagheri et al., 2024). In this way, learners will be able to understand the importance of this kind of pedagogical intervention for analysing anthropogenic effects on river basin catchments and consider issues related to floodplains, groundwater contamination, waterlogging, and so forth.

How much sustainability is retained related to our natural resources? It is observing the technique of historical imagery-based analysis (Figure 7). Which observe, measure, and analyse the object (water bodies, forest, farmland, settlement, etc.) and their surroundings a few years ago (1, 5, 10, or 50 years ago) and again observe the current status (Henshaw et al., 2020) and measure the gaps within that period (Figure 7).

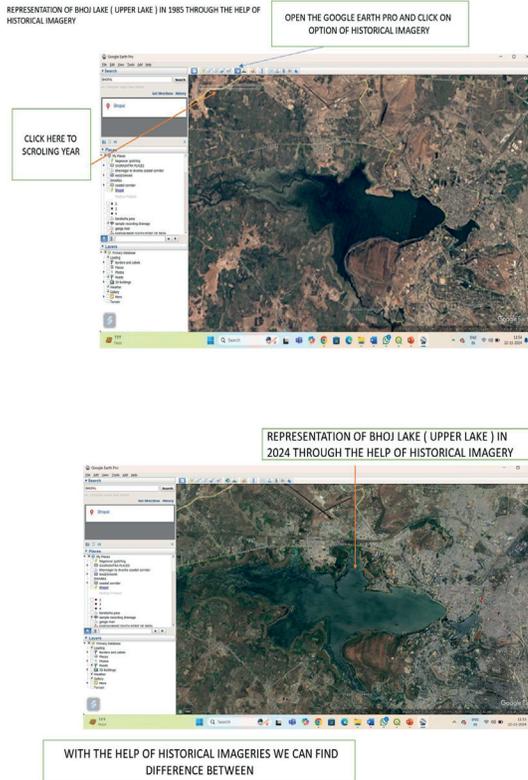


Fig. 7: Analysis of landuse/landcover of Bhopal city area from 1985 to 2024 through historical imagery

What is the need for satellite imagery instead of Google Earth images (real colour appearance of earth features)? A satellite image provides information about visible rays (about the earth's features) in the form of an FCC image (NI – Red, Red – Green, Green – Blue, Blue – Black). Green vegetation shows a red colour due to the presence of chlorophyll. Only the red color reflects, and the green color absorbs. Separation of colour makes it easy to distinguish real colour from false colour, so it enhances the potential to identify features (Figure 8). In the Google Earth image, the sea and river are represented by a bluish and greenish colour respectively, which is not helpful for fishermen, but the availability of fish

in which location in the sea is possible to identify by the satellite image, such as the presence of algae. The attracting site for fish and algae is reflected in red colour whereas water is shown as green to blackish depending on turbidity or depth in the acquiring satellite image and is easy to identify for fishermen for the availability of fish. Oil spills in the sea are reflected in grey or another colour from the water, making it easy to identify the incident of oil spills and other issues. Population crowds, traffic congestion, forest fires, etc. are very easy to identify by this technique in modern times (Simerska, 2023). Thus, it is a total matter of analytical thinking and is critically adopted by us in the modern day (Dziob et al., 2020).

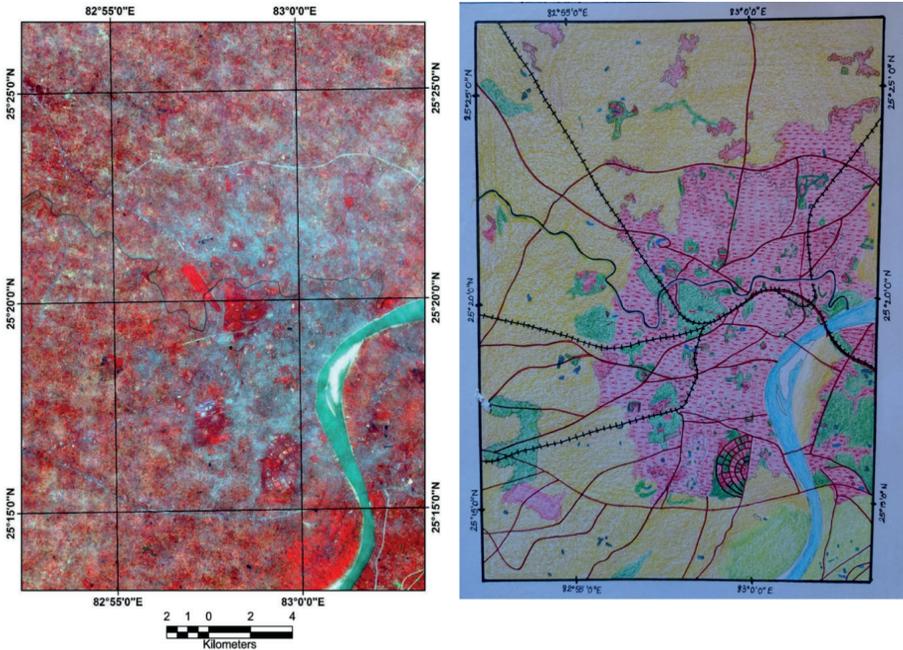


Fig. 8: Interpretation False Colour Composite based Sentinel Satellite image to True Colour Composite image

In this way, learners will be able to learn and understand the process of analysing anthropogenic interventions on natural phenomena through the techniques of

virtual river rafting, historical imagery analysis, and visual image interpretation of satellite images (Figures 7, 8, and 10).

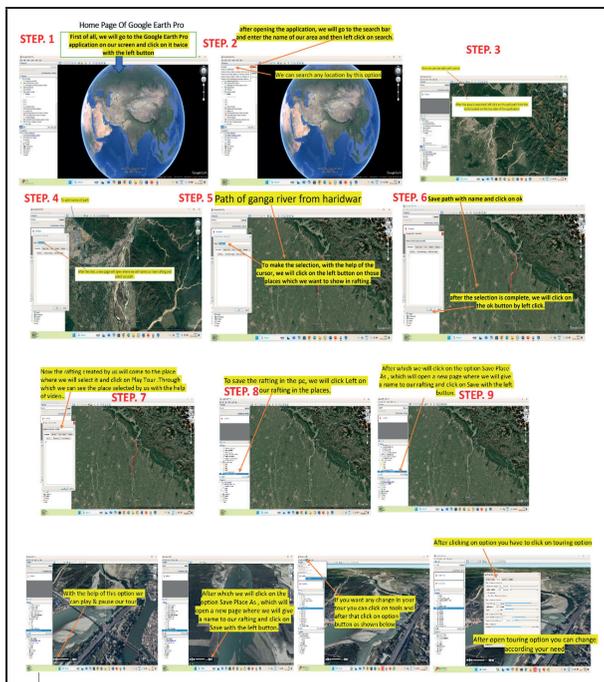


Fig. 9: Procedures of Virtual River Rafting through Google Earth Pro Software

Effect of pedagogical interventions on teachers

This research work can be evaluated through the following steps, for example: enhance the interest and knowledge by DAY (doing the action by yourself); understand the steps of attractive learning; ease the transaction of the fundamental knowledge among the teachers and learners; enhance scientific and ethical temperament; and enhance the analytical understanding among teachers and learners to solve (Lopez Nunez et al., 2020) the real-life-based issues (Figures 2, 7, and 8). In this

context, this study explores the difficulty level through the pre-test method and the effectiveness of pedagogical intervention through the post-test for teachers. This study assumes that the trained teachers will teach learners about the basic principles, procedures, and applications of these approaches in the future in geography, environmental science, or any subject studying various earth phenomena. In this context, this study measured the increased competency as a function of the effectiveness of engaging methods of intervention among all the selected teachers. (Table 3).

Table 3: Increase in scores (pre-test to post-test) of teachers through the pedagogical interventions

Marks in percent	States of Western Region, India				
	Chhattisgarh	Maharashtra	Gujarat	Madhya Pradesh	Goa
Pre-test marks	34.55	48.11	40.22	50	63
Post-test marks	82.66	79.55	80.55	78.89	75.88
Growth	48.11	31.44	40.33	28.89	12.88

Source: Measured the effectiveness of pedagogical intervention in percent through tools

This kind of study was analysed by the average percent of state teachers and calculated by the sum and mean value of all teachers in a particular state (Di et al., 2002). This study revealed that among the selected five states, teachers from Chhattisgarh showed more improvement in the post-test than in the pre-test, the main reason for which can be found to be their prior knowledge. Because during the training, they were most interested in understanding the various interventions, which they were able to learn. This is evident from their post-test (82.86 percent) and pre-test (34.55 percent) marks, which show a difference of 48.11 percentage marks. Apart from this, the teachers of other

states, i.e., Maharashtra, scored 48.11 percent, and Gujarat 40.22 percent in the pre-test, which increased in the post-test to 79.55 percent and 80.55 percent, respectively. Thus, technical proficiency and attention in class resulted in 31.44 percent more marks. Whereas in the practical geography of class 11th and 12th, there were 40.33 percent more marks benefited due to the absence of the subject of remote sensing in the syllabus. Hence, it can be said that the teacher performed commendably due to paying attention to the practical application in the classroom regarding geospatial technology so that they were able to enhance his competency. Goa school teachers performed well in

the pre-test (63 percent marks) due to their prior knowledge and experience of remote sensing. Hence, they scored only 12.88 percent more marks in the post-test (75.88 percent marks). Whereas, the performance of teachers from Madhya Pradesh showed an increase of 28.29 percent in the post-test (78.89 percent marks) compared to the pre-test (50

percent marks). The main reason for this small difference is that the teachers showed moderate performance during both the tests due to their prior moderate level of knowledge about the subject matter and good efforts of classroom interaction (Table 3 and Figure 10).

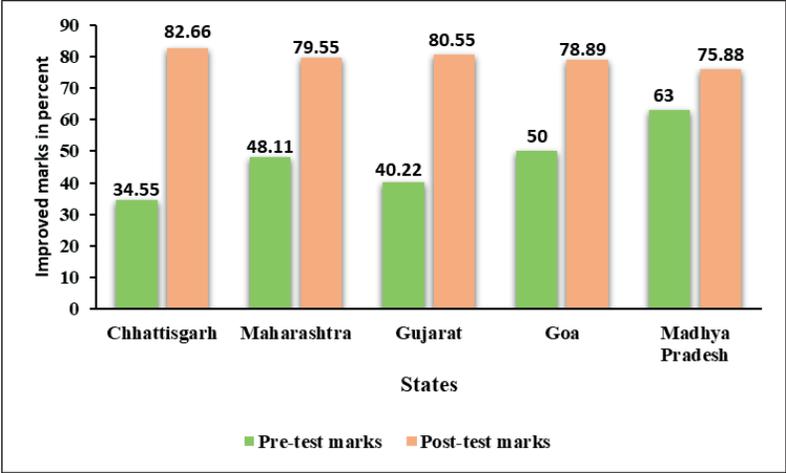


Fig. 10: Effect of intervention on teachers through assessment

Based on the above results, it can be stated that there is a dire need for educational interventions to enhance the proficiency of school teachers in specific subject matter; however, such methods of intervention are not limited to this subject only but can be used in other subjects as well (Environment, Physics, Botany, History, etc.). Based on the above results, it can be said that the increasing scores of pre-tests and post-tests demonstrate the effectiveness of various pedagogical interventions,

indicating an increase in subject matter proficiency among teachers during and after the training. An independent sample t-test was performed to evaluate the pre-test and post-test scores of senior secondary teachers. The mean score for the pre-test was 4.15 (SD = 1.479), while the mean score for the post-test rose to 7.18 (SD = 1.295). The computed t value was -9.613 with 76 degrees of freedom, and the p value was 0.000 (Table 4).

Table 4: Mean difference in score from pre- to post-test

	Group	N	Mean	Std. Deviation	Std. Error Mean
Scores	1	39	4.15	1.479	.237
	2	39	7.18	1.295	.207

The critical t value at the 0.05 level of significance for 76 degrees of freedom is approximately ± 1.99 . Given that the absolute value of the calculated t (9.613)

exceeds the critical t value (1.99), the difference between the pre-test and post-test scores is statistically significant (Table 5).

Table 5: showing significance difference between Pre and Post Tests Scores

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Scores	Equal variances assumed	.820	.368	-9.613	76	.000	-3.026	.315	-3.653	-2.399

This clearly demonstrates that the pedagogical intervention was effective, resulting in a significant improvement in teachers' scores from the pre-test to the post-test. It suggests that the observed difference is not attributable to chance but is a direct outcome of the effective intervention provided to the teachers. Therefore, this study represents a notable suggestion for future educational stakeholders, educationists, curriculum designers, and other competent authorities.

Delimitation

This study highlighted the need for more classroom intervention days to assess the effectiveness of pedagogical interventions in the training program.

This study was part of the NCERT's PAC training program; therefore, there was a constraint to invite only 40 participants from the western states, of whom 39 participated in the training program.

To assess the effectiveness of this training program, a questionnaire consisting of 30 multiple-choice questions was developed. Most of the questions were related to practical geography (such as scale, map projections, weather instruments, etc.),

and only 9 questions were related to remote sensing.

Implications

This research has significant implications for teacher training, curriculum design, and environmental education. The beneficial effects of pedagogical interventions based on geospatial technology indicate that organised training can significantly improve teachers' comprehension of climate change through satellite imagery analysis, for example, encroachment of water bodies, green space, and increase of grey space. The diverse advancements observed across different states underscore the necessity for a consistent incorporation of remote sensing and geospatial principles within school curricula. Enhancing teachers' skills through ICT-integrated, experiential, and practical learning approaches will elevate classroom practices and deepen students' understanding of real-world environmental challenges. The results further emphasise the importance of ongoing professional development initiatives to foster technology-driven, innovative teaching methods.

Conclusion

This research study investigates an effective pedagogical intervention within the domain of remote sensing in education and its analytical applications. The curriculum incorporates fundamental mechanisms designed by various academic institutions for application in real-life integrated sustainable systems. A variety of pedagogical strategies—such as explanations, model creation, demonstrations, ICT-integrated learning materials, experiential learning, hands-on ICT activities, and analytical thinking—simplify the foundational concepts of remote sensing. The adaptability and application of remote sensing are particularly beneficial for educators who impart knowledge to students in schools. This study evaluates the impact of the pedagogical intervention using pre-test and post-test assessments among teachers in the western states of India. Among the teachers selected from the states included in the study, teachers from Chhattisgarh state were able to achieve the highest level of improvement. Their remarkable progress can be judged from the highest increase (48.11 percent) in marks in the post-test as compared to the pre-test. This may be attributed to their limited prior knowledge and

high engagement during classroom activities. Teachers from Maharashtra and Gujarat scored 31.44 percent and 40.33 percent, respectively, due to their prior knowledge in ICT. Gujarat showed keen interest in the training sessions due to the lack of remote sensing topics in the syllabus, while teachers from Goa improved by 12.88 percent, probably due to their existing knowledge base. As a result, this study provides a solid basis for extending current knowledge, training teachers, developing learning materials for students, and informing curriculum designers and other stakeholders. The incorporation of new examples, activities, demonstrations, and illustrations was effectively utilized in the educational context of remote sensing.

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