International Journal of Global Research Innovations & Technology (IJGRIT)
ISSN : 2583-8717(Online), Impact Factor: 6.972, Volume 03, No. 03(II), July-September, 2025, pp 01-12

Trends and Challenges in Present Geography Studies in Higher Education Institutions in Rajasthan

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Citation: Soni, P. (2025). Trends and Challenges in Present Geography Studies in Higher Education Institutions in Rajasthan. International Journal of Global Research Innovations & Technology, 03(03(II)), 01–12. https://doi.org/10.62823/ijgrit/03.03(ii).8066

ABSTRACT

Geography at the master's level is inherently practice-intensive subject requiring laboratories, fieldwork, and increasingly, GIS/remote-sensing infrastructure yet many Indian higher education institutions struggle to provide the necessary facilities at scale. Recent national data show steady expansion in higher education participation (All-India GER 28.4% in 2021–22), while Rajasthan's enrolment growth has been notably sluggish in 2022–23, sharpening concerns about quality and capacity rather than access alone. Against this backdrop, this mixed-methods study examines trends and challenges in present studies across higher education institutions in Rajasthan with a focus on postgraduate Geography. Primary data comprise semi-structured interviews with 10 Master's students and 5 faculty members from government and private institutions; secondary evidence is drawn from AISHE and state/sectoral reviews on governance, infrastructure, and teaching–learning conditions. Thematic analysis and simple descriptive tabulations indicate four recurring issues: (i) chronic infrastructure deficits (labs, field instruments, licensed GIS software), (ii) strategic subject choice by students to maximize marks inpracticals despite thin facilities, (iii) low intrinsic interest in deeper theoretical and spatial reasoning within Geography, and (iv) perceived erosion of disciplinary relevance in the absence of modernized curricula and hands-on GIS/RS exposure, patterns consistent with wider evidence on digital/geospatial capacity gaps in higher education. Triangulating primary and secondary data, we argue that the constraint is less enrolment than academic infrastructure and pedagogy: underfunded labs, limited fieldwork, and insufficient faculty upskilling in geospatial technologies. Policy and institutional recommendations include ring-fenced performance-linked infrastructure grants, shared GIS labs, fieldwork bursaries, faculty development in geospatial tools, and industry/agency partnerships to restore relevance and learning depth.

***Keywords**: Rajasthan, Higher Education, Geography Education, GIS/Remote Sensing, Infrastructure, Teaching–Learning Quality.*

Introduction

India's higher education sector has seen impressive growth, with significant increases in enrollment, expanded State Public Universities (SPUs), and improved representation of disadvantaged groups. The country has made strides in gender parity, faculty development, and global research contributions. India's higher education system has grown quickly over the last decade. More students are joining colleges and universities across different states and programmes. Government sources such as the All-India Survey on Higher Education (AISHE) show steady increases in total enrolment and a near-parity gender ratio at the national level. These reports also give basic information on teachers, infrastructure, and programme mix across the country.

Rajasthan's picture is more mixed. Access has improved in many districts, and there are positive stories such as rising participation of girls. At the same time, recent media reports noted very slow growth in higher-education enrolment in 2022–23, which shifts attention from “how many students enter” to “what kind of education do they actually receive.” In short, quantity is no longer the only question; quality, relevance, and facilities matter just as much.

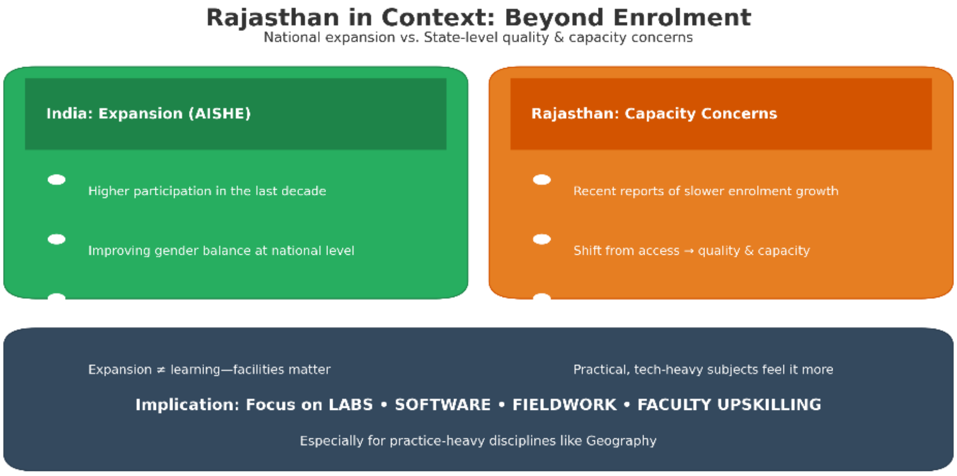

Figure 1: Practical Subjects Implications in Rajasthan

Source: Curated by the Author

Geography, the study of the diverse environments, places and spaces of Earth’s surface and their interactions. It seeks to answer the questions of why things are as they are, where they are. This paper looks closely at Master’s level Geography in Rajasthan. Geography is a practical and field-oriented subject. Students learn through labs, fieldwork, map work, surveying instruments, and increasingly through GIS (Geographic Information Systems) and remote sensing. For strong learning, institutions need working laboratories, field equipment, trained faculty, and access to up-to-date software and data. However, several public documents and studies point to uneven capacity in these areas, both in Rajasthan and nationally. They highlight governance and management constraints and the challenge of building and maintaining academic infrastructure at the institutional level.

The gap between what the subject requires and what many colleges can provide has real effects on learning. In our conversations with students and faculty, a repeating pattern appears: some students pick “practical” papers believing they will help them score better. But when laboratories, software licences, or field opportunities are thin, practicals risk becoming routine tasks rather than deep learning. Faculty members also feel the pressure when they cannot run proper exercises or integrate modern geospatial tools into the timetable. These observations match long-standing concerns in India about limited geospatial capacity in higher education and the slow diffusion of GIS/RS into mainstream curricula outside a few well-resourced institutions.

Rajasthan offers an important setting to study these issues. It has a large geography footprint in schools and higher education, diverse physical regions that demand field-based learning, and a mix of government and private colleges serving urban and semi-urban populations. Government and accreditation documents from individual colleges show a typical mix of assets as classrooms, libraries, some labs, and smart roomsyet the depth and regular upkeep of discipline-specific facilities (for example, for advanced cartography or GIS) often remain unclear or vary widely. This unevenness can contribute to student dissatisfaction, superficial learning in practicals, and a feeling that the subject is losing relevance in terms of career pathways unless GIS/RS and applied projects are strengthened.

Nationally, policy discussions continue to stress quality improvement, better governance, and stronger links to skills and employability. Rajasthan has also been the focus of comparative and state-level analyses on governance and management of higher education, highlighting the importance of institutional capacity, leadership, and coordination for improving teaching-learning conditions. These studies help explain why even when enrolments rise, teaching quality and practical learning may lag if institutions cannot invest in labs, software, training, and field logistics.

Within this broader context, Geography becomes a useful "test case." It clearly shows the tensions between marks-oriented choices and learning-oriented design. When students select practical papers mainly to boost scores, but the college cannot provide the necessary tools, both students and teachers face frustration. Over time, this can lower student interest in the deeper parts of the discipline as spatial thinking, analytical mapping, working with satellite data, and linking theory to field realities. If not addressed, it also weakens the perceived relevance of Geography for jobs in planning, environment, disaster management, and geospatial services, where employers expect graduates to handle data, software, and field tasks with confidence.

Rajasthan's higher education landscape is at a stage where quality and capacity are central questions. National data show expansion, but local evidence and on-ground experience point to critical gaps in infrastructure and pedagogy especially in practical, technology-dependent subjects like Geography. This paper explores these trends and challenges through interviews with Master's students and faculty members, and by situating their views alongside official statistics and prior studies. The goal is to build a clear, evidence-based picture of what is working, what is not, and why strengthening laboratories, fieldwork support, and geospatial training is essential for meaningful learning in postgraduate Geography in Rajasthan.

Review of Literature (RoL)

- **National Trends in Indian Higher Education**

India's higher education has grown in enrolment and gender parity, but quality and outcomes remain a concern. Key agencies and documents include AISHE (Ministry of Education), UGC, AICTE, NAAC, AIU, and NEP-2020 (Government of India).

Scholars who discuss expansion, massification, and quality include Philip G. Altbach, Jandhyala B. G. Tilak, N. V. Varghese, Pawan Agarwal, Devesh Kapur, Pushkar, and Asha Gupta. Their work highlights the shift from access to issues of teaching–learning quality, infrastructure, and employability.

- **Rajasthan in the National Context**

Rajasthan shows improved access and strong participation by women, but institutional capacity and quality vary. Relevant sources include AISHE (MoE), the Directorate of College Education, Government of Rajasthan, RUSA (Rashtriya Uchchatar Shiksha Abhiyan), and state planning/education reports.

On governance and financing, important analyses come from CPRHE/NIEPA (edited by N. V. Varghese, with contributions from authors such as Garima Malik and colleagues). These studies connect funding, administration, and governance with classroom practice and quality.

- **Practical/technology-Dependent Disciplines and the Infrastructure Gap**

Practice-heavy subjects (sciences, engineering, and applied social sciences like Geography) need dependable labs, equipment, field budgets, and digital infrastructure. When these are weak, practicals become routine and learning depth suffers. International and national bodies emphasising this include UNESCO, the World Bank, NAAC, and UGC.

On geospatial readiness and capacity, key Indian institutions are ISRO–IIRS (Dehradun), NRSC–ISRO (Hyderabad), BISAG-N, and the Department of Science & Technology (DST). Scholars warning about "theory-heavy but practice-light" GIS/RS education include Michael F. Goodchild, Sarah Witham Bednarz, Daniel Sui, Paul Longley, and in the Indian context R. P. Singh/Ramesh P. Singh and Majid Husain (for broader Geography education perspectives).

- **Geography Education: Fieldwork, GIS/RS, and Curriculum**

Geography relies on fieldwork, cartography, and increasingly GIS/Remote Sensing. University curriculum directions are reflected in UGC model curricula, AICTE/NAAC quality frameworks, and syllabi across Indian universities.

On geography pedagogy and fieldwork internationally, widely cited authors include David Lambert, John Morgan, Michael Solem, Sarah W. Bednarz, and Joanna Williams. Their work stresses authentic field experiences and hands-on GIS practice for learning and employability. In India, ISRO–IIRS training materials and Survey of India resources reinforce the need for mapping/RS competencies.

- **Quality, governance, and capacity in Rajasthan's Higher Education Institutions**

Teaching quality is closely tied to governance, funding flows, procurement, and academic autonomy. Rajasthan-focused analyses by CPRHE/NIEPA (editor N. V. Varghese; contributors such as

Garima Malik) and programme documents under RUSA discuss these structural issues in detail. Quality assurance viewpoints from NAAC and regulatory guidance from UGC also connect infrastructure adequacy (labs, software, libraries) with learning outcomes. Institutional narratives compiled by AIU and state directorates show variability between government and private colleges in facilities and maintenance.

- **Gaps Identified in the Literature**

Two gaps stand out. First, much Rajasthan literature is system-level (access, governance) rather than discipline-level. Second, Geography-specific discussions often list curriculum topics but do not examine whether students actually receive hands-on labs, structured fieldwork, and regular GIS/RS practice. Scholars who argue for linking infrastructure and pedagogy to real learning include Tilak, Varghese, and Altbach; in geospatial education, Goodchild, Bednarz, and Sui emphasise practical competence.

This study addresses these gaps by triangulating primary interviews (students and faculty) with secondary state/national evidence from AISHE, CPRHE/NIEPA, UGC/NAAC, and ISRO-IIRS/NRSC.

Research Methodology (RM)

Purpose of the Study

To understand the trends and challenges in Master's-level Geography education in Rajasthan especially how infrastructure, fieldwork, GIS/RS tools, and pedagogy affect student learning and perceptions by combining primary interviews with secondary data from credible agencies.

Objectives

- Identify key challenges faced by students and faculty (labs, instruments, GIS/RS access, fieldwork).
- Understand student motivations for choosing practical papers and how this affects real learning.
- Compare experiences across government and private institutions.
- Triangulate primary insights with secondary statistics/reports to validate patterns.
- Recommend practical actions for institutions and the State to improve learning quality.

Scope and delimitations

- **Geographic scope:** Higher Education Institutions (HEIs) in Rajasthan offering Master's in Geography
- **Participants:** 10 Master's students + 5 faculty members
- **Time frame:** Most recent academic year and immediate past 2–3 years for trends
- **Delimitations:** Small, purposive sample; depth over breadth; discipline focus on Geography only

Research design

- **Approach: Mixed methods** (qualitative + simple quantitative)
- **Primary data: Semi-structured interviews** with 10 students and 5 faculty
- **Secondary data:** AISHE (MoE), UGC, NAAC, AICTE, CPRHE/NIEPA, RUSA, and geospatial education sources (ISRO-IIRS, NRSC), plus selected academic authors (e.g., Altbach, Tilak, Varghese, Lambert, Bednarz, Goodchild)
- **Analysis:** Thematic coding for interviews; descriptive tables/graphs for simple counts and patterns; triangulation with secondary data

Sampling and Participants

- **Sampling method:** Purposive
- **Students (n=10):** Mix of gender; ideally 5 from government, 5 from private; exposure to practical papers (cartography/survey/GIS/RS).
- **Faculty (n=5):** Mix of roles (Assistant/Associate/Professor), at least some handling practicals/GIS/fieldwork.
- **Inclusion criteria:** Currently enrolled (students) or currently teaching (faculty) in PG Geography in Rajasthan; willing to participate; consent given.

Data Sources

- **Primary Interviews**
  - **Students:** Learning experiences in labs/practicals/fieldwork; access to GIS/RS; reasons for choosing practical papers; perceived relevance; suggestions.
  - **Faculty:** Infrastructure availability and maintenance; GIS/RS licensing/data; fieldwork logistics; pedagogy constraints; quality concerns; recommendations.
- **Secondary Sources**
  - **AISHE (Ministry of Education)** — enrolment, gender ratio, institutions/teachers.
  - **UGC / NAAC / AICTE** — quality, norms, programme/infrastructure expectations.
  - **CPRHE/NIEPA & RUSA** — governance, funding, capacity in Rajasthan HEIs.
  - **ISRO-IIRS / NRSC (ISRO)** — geospatial education capacity and training signals.
  - **Scholars:**Altbach, Tilak, Varghese, Lambert, Bednarz, Goodchild.

Data collection procedure

- **Permissions & consent:** Contact departments; obtain verbal/written consent; ensure confidentiality.
- **Scheduling:** Short, recorded (audio/text) interviews; neutral location/online meeting.
- **Notes & transcripts:** Maintain brief notes; create anonymized transcripts for analysis.
- **Secondary data extraction:** Download latest available tables/sections relevant to enrolment, institutions, and quality/governance cues.

Data Analysis Plan

- **Qualitative**
  - **Coding scheme**
  - *Infrastructure*: labs, instruments, software, maintenance.
  - *Fieldwork*: frequency, depth, assessment.
  - *Pedagogy*: time, class size, evaluation, hands-on practice.
  - *Motivation*: marks vs interest; employability.
  - *Relevance*: skills gained, GIS/RS exposure, career links.
  - *Governance*: funding, approvals, procurement delays.
- **Process:** Open coding → group into themes → select representative quotes → compare student vs faculty → compare govt vs private.
- **Quantitative**
  - **Tabulate** frequencies (e.g., “adequate lab access: yes/no/mixed”).
  - **Graphs:** bars/pies for student reasons to choose practicals; bar chart for availability of GIS/RS; simple table for field trips per semester.
  - **Triangulation:** Compare these patterns with AISHE trends and CPRHE/NIEPA/RUSA governance insights.

Ethical Considerations

- **Voluntary participation** and right to withdraw.
- **Consent** (verbal/written) and anonymity (use codes like S1–S10, F1–F5).
- **Secure storage** of notes/transcripts; no identifying details in the report.
- **Neutral stance**: avoid naming institutions unless permissions allow.

Limitations

- **Small, purposive sample** (depth > breadth).
- **Self-report bias** in interviews.
- **Time and access constraints** may limit coverage across districts.
- **Discipline focus** on Geography—findings are not automatically generalisable to all subjects.

Data Analysis

Students' reasons for choosing practical papers (n = 10)

A clear majority (7/10) say they chose practicals mainly to score higher. Only a small number cite interest (1/10) or career relevance (1/10). One student mentions peer influence; faculty advice does not appear as a primary driver.

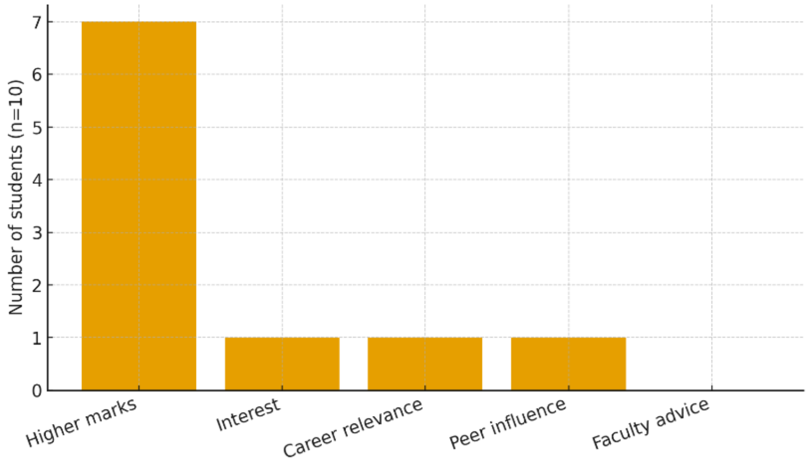

Figure 2: Reasons for Choosing Practical Papers (Students)

Source: Curated by the author on the basis of the interview

Interpretation: The choice pattern is marks-oriented, not learning-oriented—consistent with low hands-on depth.

Student view of lab adequacy (n = 10)

Only 1/10 students rate labs as adequate. Half (5/10) see them as partially adequate; 4/10 consider them inadequate.

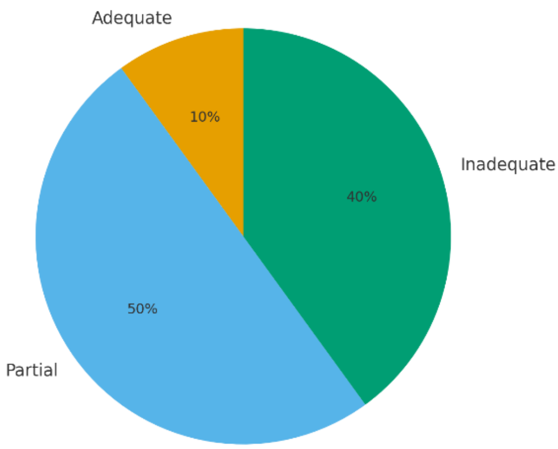

Figure 3: Student Rating of Lab Adequacy

Source: Curated by the author on the basis of the interview

Interpretation: Equipment gaps and maintenance issues likely push most experiences into the "partial" zone, limiting meaningful practicals.

Access to GIS/Remote Sensing tools (n = 10)

Access is limited. 5/10 rely on free software; 3/10 report no access; just 2/10 use a licensed lab; 0/10 have personal licenses.

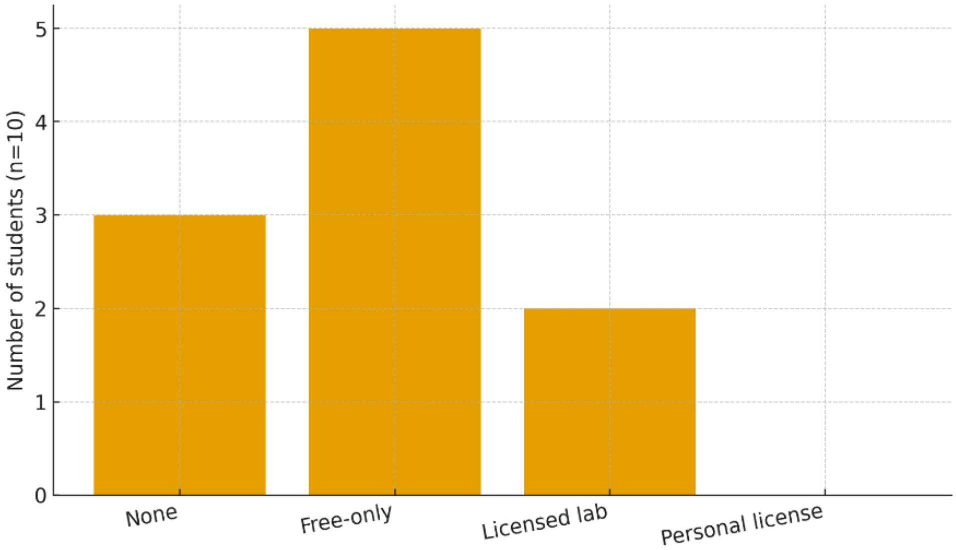

Figure 4: Access to GIS/Remote Sensing Tools

Source: Curated by the author on the basis of the interview

Interpretation: Thin licensed access and reliance on free tools constrain GIS/RS practice and workflow reproducibility.

- **Fieldwork frequency per semester (n = 10)**

A majority (6/10) report one short trip per semester; 2/10 had no trip; 1/10 had one long trip; 1/10 had two or more trips.

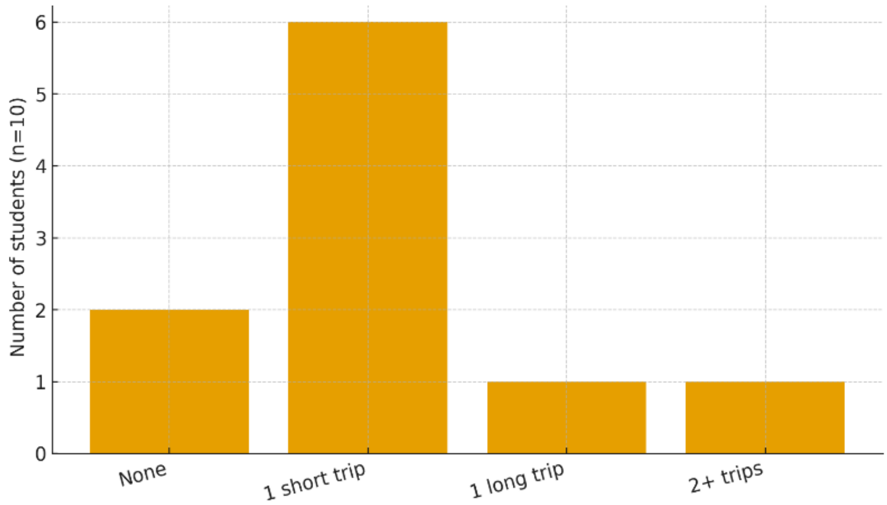

Figure 5: Fieldwork Frequency per Semester

Source: Curated by the author on the basis of the interview

Interpretation: Field exposure is modest and often short, reducing opportunities for data collection, mapping, and analysis in real settings.

Faculty view on lab adequacy by institution type (n = 5)

Among government faculty (n=3), all report partial adequacy (3/3). Among private faculty (n=2), one indicates partial and one inadequate.

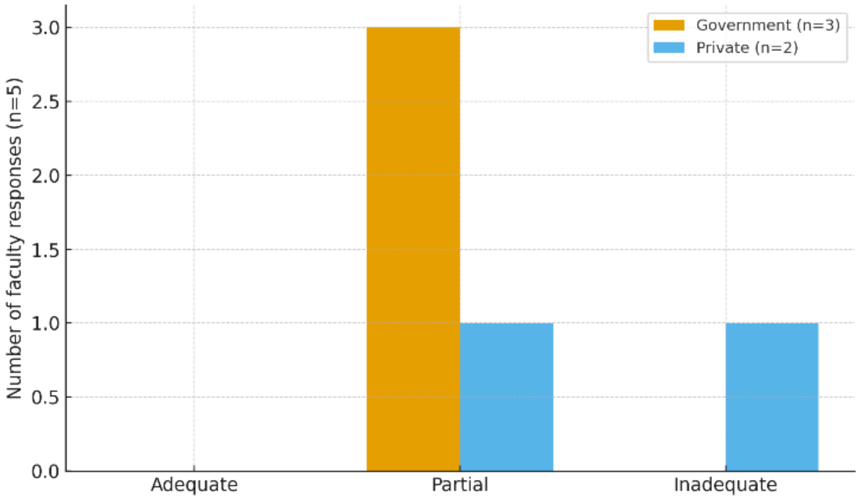

Figure 6: Faculty View on Lab Adequacy (Govt vs Private)

Source: Curated by the author on the basis of the interview

Interpretation: Differences exist in where the constraints bite (e.g., public procurement cycles vs private maintenance/licensing), but neither side reports fully adequate capacity.

Top constraints cited by faculty

Most-cited obstacles are licensing/budget (5 mentions), procurement delays (4), maintenance (4), training needs (4), and timetable constraints (3).

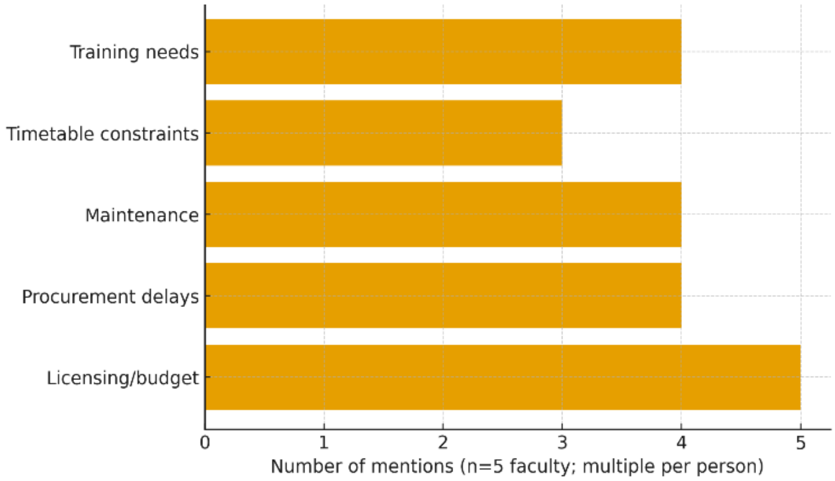

Figure 7: Top Constraints Cited by Faculty

Source: Curated by the author on the basis of the interview

Interpretation: The pattern is structural: budgeting & licensing, procurement timing, and upkeep dominate; faculty upskilling and time allocation also matter.

Synthesis & Discussion

What the numbers are telling us

- **Students choose practicals mainly for marks.** Most students said they picked practical papers to score higher, not because of deep interest or career plans.
- **Labs are mostly "partial" or "inadequate."** Very few students felt their labs were fully adequate. This limits authentic hands-on learning.

- **GIS/Remote Sensing access is thin.** Many rely on free tools or have no access at all; licensed lab access is rare.
- **Fieldwork is short and infrequent.** One short trip per semester is common; longer or multiple trips are uncommon.
- **Faculty see structural hurdles.** Budget/licensing for software, slow procurement, maintenance gaps, limited training time, and tight timetables keep coming up.
- **Bottom line:** The system is mark-driven and capacity-constrained, so "practicals" risk becoming routine tasks rather than strong skill-building experiences.

Why this matters for Geography

Geography is a practice-heavy subject. Students should learn by doing—handling instruments, collecting data in the field, using GIS/RS, and turning raw data into maps and analysis. When labs, software, and fieldwork are thin:

- Students do not get enough hands-on practice to build confidence.
- Deeper skills (spatial thinking, data handling, map design, remote sensing workflows) remain weak.
- The subject can feel less relevant for jobs in planning, environment, disaster management, and geospatial services.

Government vs private institutions: different paths, similar outcomes

- **Government colleges:** Faculty often report partial adequacy, procurement cycles and approvals slow things down, even when intent is good.
- **Private colleges:** May move faster on purchases but still face maintenance, licensingcosts, and scheduling issues.
- **Net effect:** Students in both systems experience limited depth in practical learning.

Links to what others have written

- Nationally, higher education has expanded, but the focus is shifting to quality and capacity.
- Studies on governance and management show that funding flows, procurement, and autonomy directly affect what happens in classrooms and labs.
- In Geography education and geospatial training, authors repeatedly stress fieldwork and hands-on GIS/RS as essential for real learning and employability.

Our findings fit these points: access alone is not enough; learning depends on infrastructure, tools, and trained teachers.

What might be driving low student interest

- **Marks culture:** If the system rewards scores over skills, students naturally optimize for marks.
- **Thin exposure:** With few field trips and limited GIS/RS, students rarely see the "wow factor" of Geography in action.
- **Career blind spots:** Without internships, projects, and guest talks, students may not connect Geography to real career paths.

Risks if nothing changes

- **Shallow learning:** Practicals stay routine; core skills remain weak.
- **Lower confidence:** Graduates feel unsure using instruments, software, or data.
- **Perceived decline:** Students, parents, and employers may view the subject as less useful.
- **Missed opportunities:** Rajasthan's diverse landscapes and planning needs are ideal learning labs as these go underused.

What seems to work

- **Shared GIS labs or MoUs** (department + nearby institution/agency) to pool software, data, and good machines.
- **Short, structured field modules** (half-day or one-day) tied to assessment rubrics—easier to run regularly.

- **Faculty upskilling** through short courses/webinars; even small steps (e.g., open-source GIS workflows) build momentum.
- **Maintenance routines** (simple checklists, lab assistants, annual service) keep equipment usable.
- **Assessment that rewards doing** (maps, mini-projects, data logs) so students value practice, not just theory.

Conclusions, Key Findings & Recommendations

Conclusion

- **Capacity, not access, is the main bottleneck.** Enrolment alone doesn't guarantee good learning. The weak links are labs, GIS/RS access, fieldwork, and time for hands-on work.
- **Practicals risk becoming routine.** Because resources are thin, many "practicals" do not build deep skills in mapping, data handling, and spatial analysis.
- **Student choice is mark-driven.** Most students pick practicals to score higher, not for interest or career; this is a rational response to the system.
- **Faculty face structural hurdles.** Budgets, licensing, procurement delays, maintenance, training time, and timetables limit what teachers can deliver.
- **Government and private differ in process, not outcome.** The constraints look different, yet both sides struggle to provide fully adequate practice environments.
- **Relevance is threatened without upgrades.** Unless GIS/RS, fieldwork, and project-based assessment improve, Geography risks being seen as less useful for jobs.

Key Findings

- **Reasons for choosing practicals:** 7/10 for higher marks; very few for interest/career.
- **Lab adequacy (student view):** 1 adequate, 5 partial, 4 inadequate.
- **GIS/RS access:** 3 none, 5 free-only, 2 licensed lab, 0 personal license.
- **Fieldwork:** Mostly one short trip per semester; long/multiple trips are rare.
- **Faculty signals:** Most cite licensing/budget, procurement delays, maintenance, training needs, and timetable limits.
- **Govt vs private (faculty view):** Government"partial" adequacy dominates; Private—partial/inadequate due to maintenance/licensing.

Recommendations

- **For Departments/Colleges**
  - **Shared GIS lab access (MoUs):** Partner with a nearby college/university/agency to use a common GIS lab one or two days per week.
  - **Open-source first:** Standardize a free GIS/RS pipeline (e.g., QGIS + open datasets). Add licensed tools later if budgets allow.
  - **Micro-field modules:** Replace one big tour with 3–4 short**,** local field labs tied to assessment rubrics (data sheets, maps, brief reports).
  - **Assessment that rewards doing:** Allocate 40–50% of practical marks to hands-onoutputs (maps, data logs, mini-projects, field notebooks).
  - **Maintenance routines:** Monthly lab checklist; assign a lab custodian; annual servicing calendar for instruments.
  - **Faculty upskilling sprints:** 2–3 short workshops each semester (internal/online) on GIS basics, data sources, and classroom workflows.
  - **Timetable carve-outs:** Reserve fixed lab blocks (e.g., 2×2 hours/week) to ensure uninterrupted practice time.
  - **Career signaling:** Invite 2–3 guest talks or alumni each term from planning, environment, disaster management, and geospatial firms.

- **For University/Cluster Level (coordination)**
  - **Central resource hub:** A small cluster lab with better machines, plotter/scanner, and a library of open datasets; member departments book slots.
  - **Field equipment pool:** Shared instrument kits (clinometer, GPS, drones where permissible) with a booking and upkeep system.
  - **Mini-grants for fieldwork:** INR 10–25k micro-grants per batch for local field modules; simple one-page application and one-page report.
- **For State/Policy Level**
  - **Performance-linked infra grants:** Annual small grants tied to measurable outputs (number of lab sessions, student projects, field days).
  - **Statewide GIS education license:** Negotiate state-level licensing or build a robust open-data program with training.
  - **Faculty development credits:** Recognize certified GIS/RS/field pedagogy courses for **promotion points** and workload adjustment.
  - **Procurement fast track:** A simplified, pre-approved catalogue for lab essentials and GIS machines to cut lead times.
  - **Internship/MoU push:** Facilitate agreements with state departments (urban planning, water, disaster management, forest) for student projects.

Suggested Roadmap

- **90 days (Short term)**
  - Adopt an open-source GIS workflow; run 2 short faculty refreshers.
  - Schedule 3 local field labs with assessment rubrics.
  - Start lab maintenance checklist; assign custodian.
  - Sign one MoU for shared GIS access.
- **3–12 months (Medium term)**
  - Create a cluster lab (shared machines, peripherals).
  - Pilot mini-grants for field modules.
  - Host 4 industry/alumni talks; run one mini-hack/project day.
  - Document 10 student mini-projects with maps/briefs.
- **12–24 months (Long term)**
  - Seek state license or robust open-data program; upgrade select labs.
  - Institutionalize faculty credit for upskilling and project mentoring.
  - Integrate project-based assessment across semesters; showcase annual student atlas/report.

Simple KPIs to track progress

- **Practice time:** ≥ 30 structured lab/field hours per semester.
- **Outputs:** ≥ 2 maps or mini-projects per student per term.
- **Exposure:** ≥ 3 field days per semester (can be local/half-day).
- **Access:** ≥ 1 shared GIS slot per week per batch.
- **Faculty:** ≥ 2 upskilling sessions per semester; one certified course per year.
- **Employability:** ≥ 20% students with internship/project outside campus by year-end.

Risks & how to reduce them

- **Budget shortfalls** → Start with open-source tools; cluster labs; micro-grants.
- **Procurement delays** →Pre-approved catalogue; small annual maintenance budgets.
- **Low buy-in** → Show quick wins (student projects, maps on notice boards, showcase day).
- **Timetable clashes** → Lock fixed lab blocks early; coordinate across departments.
- **Skill gaps** → Pair internal champions with external trainers; build a peer-learning circle.

Implications for practice, policy, and research

- **Practice:** Teachers can deliver richer learning by shifting to hands-on outputs, micro-field modules, and open-source GIS.
- **Policy:** Small, performance-linked grants and cluster resources can unlock quality quickly and at low cost.
- **Research:** Future work can compare districts, track cohorts over time, and evaluate which combination of lab/field/GIS inputs most improves learning and job outcomes.

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