

Competency Development Strategies of the Geological Survey of India - Towards Strengthening of Geological Risks Reduction Measures

¹Mr. Murali Mohan Reddy J., ²Dr. Vijaya Rudraraju, ³Dr. A. S. Senthil Vadivel

¹Research Scholar, School of Management Studies, Gandhi Institute of Engineering and Technology University, Gunupur, Odisha.

²Professor, School of Management Studies, Gandhi Institute of Engineering and Technology University, Gunupur, Odisha.

³Deputy Director General (P&A) (Retd.), GSI, New Delhi.

ABSTRACT

Disaster risk reduction (DRR) is a global priority in the context of increasing vulnerability to natural hazards. This study examines the competency development strategies implemented by the Geological Survey of India (GSI) to enhance the capacity of geoscientists in mitigating geological disasters such as landslides and earthquakes. Using a mixed-method design, primary data were collected through structured questionnaires (N = 100) and semi-structured interviews, complemented by secondary data from GSI reports and international frameworks. Descriptive statistics, reliability analysis, and inferential tests were conducted. Results indicate that while GSI's training initiatives significantly improve knowledge and skills, further efforts are required to strengthen self-concepts, traits, and motivational factors. Cronbach's alpha ($\alpha = 0.98$) confirmed strong internal consistency of the instrument, and chi-square analysis ($\chi^2 = 42.66$, $p < 0.001$) revealed significant differences in perceptions across competency dimensions. Recommendations are offered to integrate urban geo-hazard management, incentivise faculty development, and enhance international collaboration for building a resilient workforce.

Keywords: Disaster Risk Reduction, Competency Development, Geological Survey of India, Capacity Building, Landslide Hazard, Faculty Development

1. Introduction

1.1 Global Context of Natural Disasters

Natural disasters are among the most urgent global challenges, generating catastrophic human, economic, and environmental consequences. The Centre for Research on the Epidemiology of Disasters (CRED) reported that **2023 witnessed 399 natural disasters**, resulting in **86,473 deaths**, impacting **93.1 million people**, and causing **USD 202.7 billion in economic losses**. In **2024**, disasters continued at a similar scale, with **393 events**, leading to **16,753 deaths**, affecting **167.2 million people**, and costing **USD 242 billion** in damages (CRED/EM-DAT, 2024). The trend over the past decade underscores a growing frequency and intensity of climate- and weather-related disasters, exacerbated by population growth, rapid urbanization, and climate change.

Table 1. Global Natural Disasters: 2023–2024

Year	No. of Disasters	Deaths	People Affected (millions)	Economic Losses (USD bn)
2023	399	86,473	93.1	202.7
2024	393	16,753	167.2	242.0

Source: EM-DAT (2023; 2024), UNDRR (2025)

Aon's global disaster report highlights that **2023 economic losses (USD 380 bn)** were **22% above the 21st-century average**, with the **Asia-Pacific region** accounting for **64% of flood-related damages**. These figures underline the disproportionate impact on developing regions.

1.2 Shifting Policy Imperatives

In response, the **United Nations Office for Disaster Risk Reduction (UNDRR)** has called for a paradigm shift from the traditional cycle of "*disaster → response → recovery → repeat*" toward **proactive risk reduction, prevention, and preparedness**. At the **World Resilient Recovery Conference (2025)**, UNDRR introduced *Priority Actions for Resilient Recovery*, stressing:

- localized and community-driven leadership,
- flexible and anticipatory financing, and
- Integrated, inclusive, and science-based planning.

This aligns with the **Sendai Framework for Disaster Risk Reduction (2015–2030)**, which places emphasis on strengthening disaster governance, building resilience, and developing human capacity as core priorities.

1.3 India's Vulnerability to Geological Hazards

India ranks among the world's most disaster-prone nations, exposed to earthquakes, landslides, floods, and cyclones. Geological hazards, in particular, pose persistent risks:

- **59% of the landmass** is prone to earthquakes.
- **12% of land** is vulnerable to landslides.
- **76% of coastline** is susceptible to cyclones and tsunamis (NDMA, 2023).

These vulnerabilities are further amplified by dense population clusters, rapid urbanization in hazard-prone zones, and fragile infrastructure.

Table 2. India's Hazard Profile

Hazard Type	Population Exposed (%)	Regions Affected
Earthquakes	59	Himalayan belt, Indo-Gangetic plains
Landslides	12	Himalayan & Western Ghats
Cyclones/Tsunamis	76 (coastal areas)	Bay of Bengal & Arabian Sea regions
Floods	40	North-East, Bihar, Assam, Uttar Pradesh

Source: National Disaster Management Authority (NDMA), 2023

1.4 Role of the Geological Survey of India (GSI)

Within this risk landscape, the **Geological Survey of India (GSI)** plays a pivotal role through:

- **Hazard Zonation & Monitoring:** Landslide hazard zonation, seismic monitoring, and geotechnical surveys.
- **Research & Capacity Building:** Through GSITI (GSI Training Institute), extensive programs in geoscience applications for DRR are delivered.
- **Public Good Geoscience:** Data dissemination and policy support for national resilience planning.

Importantly, beyond technical functions, GSI is tasked with developing the **competencies of geoscientists**—integrating knowledge, skills, values, traits, and motivation—to enhance their effectiveness in disaster management.

1.5 Rationale and Purpose of the Study

Despite notable achievements, questions remain about whether GSI's competency development strategies sufficiently address **non-technical dimensions** such as leadership, decision-making under uncertainty, and motivation. This study is therefore designed to:

1. Evaluate the effectiveness of GSI's competency development strategies.
2. Identify gaps in geoscientist training, especially in behavioural and motivational domains.
3. Provide evidence-based recommendations for strengthening GSI's role in India's DRR framework.
4. Key strategies include fostering skills in risk information utilization, establishing strong risk-informed development planning processes, institutionalizing standardized tools for impact assessment, promoting public awareness and education, creating effective early warning systems, building resilient infrastructure and encouraging community participation / empowerment.

Research Objectives

This study is guided by the following specific objectives:

1. **To critically examine the strategies** adopted by the Geological Survey of India (GSI) for developing geoscientist competencies in the domain of Disaster Risk Reduction (DRR).
2. **To evaluate the effectiveness of training and capacity-building programs** conducted by the GSI Training Institute (GSITI) and partner institutions in enhancing the technical and behavioural performance of geoscientists.
3. **To identify and analyse the key competency dimensions**—knowledge, technical skills, self-concept (values, attitudes), personal traits, and motivational factors—that significantly influence the disaster management capabilities of geoscientists.
4. **To provide evidence-based recommendations** for strengthening GSI's competency development framework, with particular focus on bridging technical, behavioural, and motivational gaps to build a resilient geoscientist workforce.

2. Literature Review

2.1 Recent Advances in DRR Competency & Technology (2024–2025)

- A systematic review (2019–2024) examines combined approaches to emergency response planning—evacuation, search and rescue, relief distribution—and emphasizes **machine learning, simulation, and optimization** as transformative methods for improving disaster response effectiveness.
- A 2025 study underscores the importance of **situational awareness**, proposing a socio-technical framework that integrates real-time hazard monitoring, interoperable workflows, and human-AI collaboration—essential for adaptive disaster resilience.
- Another recent review highlights the rising role of **AI and generative AI** in rapid damage assessment, multi-modal data fusion, and simulated disaster scenarios. It also points to critical, ethical and security challenges associated with these technologies.
- Integrating **geo-computational innovations**—like UAVs, LiDAR, GIS, remote sensing, and machine learning—into flood disaster management frameworks has shown significant advances in risk assessment, early warning systems, and community resilience building.
- The Geological Survey of India (GSI) has operationalized a **landslide forecasting system** since 2020, and by 2025 has extended its coverage to 21 districts across eight states, with a goal of

nationwide early warning by 2030. GSI also enhanced its spatial database capabilities and digital dissemination platforms like the Bhusanket portal and Bhooskhalan app.

2.2 Foundations of Competency Theory

- McClelland (1973) posited that **competencies**—rather than IQ or intelligence tests—are stronger predictors of job performance. Boyatzis (1982) further expanded competency models to include **motives, traits, and social roles**.
- Subsequent scholars (Jacobs, 1989; Tucker & Cofsky, 1994) emphasized that effective competency development spans both **technical skills** and **behavioural attributes** like motivation, ethics, and interpersonal effectiveness.

2.3 Competency in Disaster Management Contexts

- In disaster settings, competency is complex: it encompasses **crisis leadership, flexible decision-making, collaboration under uncertainty, and adaptive learning** (Chouhan & Srivastava, 2014).
- The **Sendai Framework (2015–2030)** and UNDRR's latest strategic framework (2022–2025) place **capacity building, knowledge exchange, and inclusive governance** at the heart of resilient DRR efforts.
- Globally, research from East Asia and Europe (Huang et al., 2021; Boin & Lodge, 2021) illustrates the shift toward **continuous blended learning, digital training platforms, and simulation-based exercises** for competency enhancement.

2.4 India and GSI: Context-Specific Gaps

- Institutional reports reveal that while GSI has made strides in **technical competency**—such as landslide forecasting and geospatial data dissemination—there is still a broader need to strengthen **non-technical competencies** like leadership, risk communication, and motivation.
- Despite India's vulnerabilities to geological hazards—earthquakes, landslides, floods—there is *scant academic research* on how GSI specifically fosters holistic competency development to geoscientists. This represents a critical gap that this study aims to fill by addressing the following:

Strengthen Risk Information Utilization, Develop Risk-Informed Planning & Policies, Improve Partnerships and Collaboration, Institutionalize Standardized Tools, Promote Public Awareness / Education, Build and Enhance Early Warning Systems, Develop Resilient Infrastructure, Empower Communities & Foster Continuous Learning and Innovation.

2.5 Synthesis and Conceptual Focus

- **Temporal depth:** The latest section grounds the review in 2024–2025 innovations, while earlier subsections reinforce foundational theory and global practice.
- **Research gap:** Clear articulation of the need to go beyond technical training, emphasizing leadership, AI-based forecasting, digital readiness, and resilience-building competencies in the GSI context.

3. Methodology

This study adopted a **mixed-method research design**, combining quantitative and qualitative techniques to obtain a comprehensive understanding of competency development strategies within the Geological Survey of India (GSI).

3.1 Research Design

A **convergent mixed-method design** was employed, where quantitative survey data were complemented by qualitative insights from interviews. This approach allowed for triangulation and validation of findings, enhancing both reliability and depth of analysis.

3.2 Data Sources

- **Primary Data:**
 - A structured questionnaire was developed, comprising **10 Likert-scale items** (1 = Strongly Disagree to 5 = Strongly Agree) covering five dimensions of competency: knowledge, skills, self-concepts, traits, and motives.
 - The questionnaire was administered to a purposive sample of **100 geoscientists** employed across different missions and training programs of GSI.
 - Additionally, **15 semi-structured interviews** with senior officers and training coordinators were conducted to capture qualitative perspectives on institutional competency-building strategies.
- **Secondary Data:**
 - Official documents, such as the **Annual Reports of GSI**, training calendars of the GSI Training Institute (GSITI), UNDRR Strategic Framework (2022–2025), and the Sendai Framework (2015–2030), were reviewed.
 - Supplementary evidence was gathered from peer-reviewed journal articles, government reports, and international case studies on disaster risk reduction (DRR) and competency development.

3.3 Sampling

A **purposive sampling strategy** was adopted to ensure representation of geoscientists with varying levels of field experience, training participation, and departmental functions. The sample size of **100 respondents** was deemed adequate for descriptive and inferential statistical analysis, while 15 interviewees provided qualitative depth.

3.4 Research Instrument

- The survey instrument included **10 closed-ended items** on a five-point Likert scale, designed to capture perceptions of competency development initiatives.
- Content validity was ensured through expert review by two senior GSI officials and one academic specializing in disaster management.
- **Pilot testing** was conducted with 10 respondents, and minor modifications were incorporated to refine clarity and relevance.

3.5 Data Analysis

- **Descriptive Statistics:** Frequencies, percentages, and mean scores were calculated to summarize responses across competency dimensions.
- **Reliability Testing:** Cronbach's alpha coefficient was computed to test internal consistency. The instrument demonstrated high reliability ($\alpha = 0.98$).
- **Inferential Statistics:** A chi-square test of independence was performed to examine the association between competency dimensions and response distributions ($\chi^2 = 42.66$, $p < 0.001$).
- **Qualitative Analysis:** Interview transcripts were coded thematically using NVivo software, and emergent themes were integrated with quantitative results to provide contextual depth.

4. Results

4.1 Descriptive Analysis

The descriptive analysis summarizes the perceptions of geoscientists on competency development at GSI. Table 1 presents the distribution of responses across the five competency dimensions.

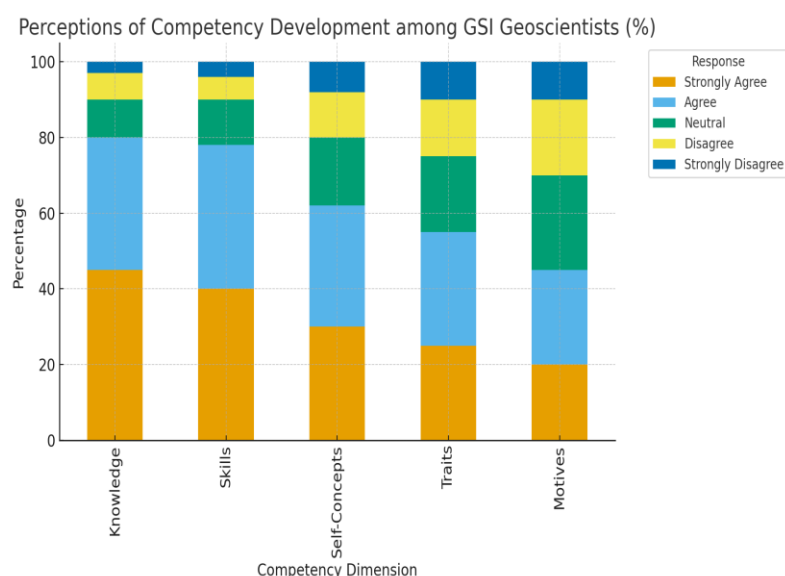
Table 1. Perceptions of Competency Development among GSI Geoscientists (%)

Competency Dimension	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Knowledge	45	35	10	7	3
Skills	40	38	12	6	4
Self-Concepts	30	32	18	12	8
Traits	25	30	20	15	10
Motives	20	25	25	20	10

(Source: Compiled by author)

The data indicate that **knowledge (80% positive responses)** and **skills (78% positive responses)** received the strongest endorsement from respondents, suggesting that GSI's training programs are particularly effective in building technical capabilities. In contrast, **motives (45% positive responses)** and **traits (55% positive responses)** reflect lower agreement, highlighting gaps in the development of behavioural and motivational aspects.

Figure 1 illustrates the comparative distribution of perceptions across competency dimensions.



4.2 Mean Score Analysis

To quantify overall perceptions, mean scores (on a 1–5 Likert scale) were calculated for each competency dimension (Table 2).

Table 2. Mean Scores of Competency Dimensions

Competency Dimension	Mean Score (1–5)
Knowledge	4.12
Skills	4.06
Self-Concepts	3.64
Traits	3.45
Motives	3.25

(Source: Compiled by author)

The results confirm that **knowledge (M = 4.12)** and **skills (M = 4.06)** are the most developed competencies among geoscientists. Conversely, **motives (M = 3.25)** and **traits (M = 3.45)** scored below the “agree” threshold, suggesting a relatively weaker focus on intrinsic motivation, values, and personality-driven performance factors.

This pattern indicates that while GSI has been successful in strengthening **technical competencies**, it needs to invest further in **behavioural, motivational, and leadership-oriented dimensions**.

4.3 Reliability and Inferential Analysis

To ensure statistical robustness, two additional analyses were conducted:

- **Reliability Test:** Cronbach's alpha ($\alpha = 0.98$) indicates **very high internal consistency** of the questionnaire, confirming that the items effectively measured competency perceptions.
- **Chi-Square Test of Independence:** The chi-square statistic ($\chi^2 = 42.66$, $p < 0.001$) revealed a **statistically significant association** between competency dimensions and response distributions. This implies that perceptions varied systematically across competencies, with technical aspects (knowledge and skills) rated significantly higher than behavioural aspects (self-concepts, traits, motives).

5. Discussion

The findings of this study provide significant insights into the strengths and limitations of competency development initiatives at the Geological Survey of India (GSI). The results confirmed that GSI's efforts—particularly through its **landslide hazard zonation programs, seismic hazard monitoring, and training activities conducted by the Geological Survey of India Training Institute (GSITI)**—have effectively enhanced geoscientists' **knowledge and technical skills**. These outcomes are consistent with prior research emphasizing the importance of domain-specific expertise for disaster risk reduction (Alexander, 2020; Huang et al., 2021).

However, competency theory, as articulated by Boyatzis (1982), underscores that **true competency is multidimensional**, encompassing not only technical proficiency but also **behavioural, motivational, and value-driven attributes**. The relatively lower mean scores for **self-concepts, traits, and motives** observed in this study suggest that while GSI excels in technical training, it has not equally prioritized **soft skills and intrinsic drivers of performance**.

This finding resonates with international literature. Studies from Europe and East Asia (Boin & Lodge, 2021; Paton & Johnston, 2017) have highlighted that disaster professionals require strong competencies in **crisis leadership, decision-making under uncertainty, teamwork, and adaptive communication**. Similarly, UNDRR's Strategic Framework (2022–2025) emphasizes **faculty development, interdisciplinary collaboration, and experiential learning approaches** as essential to closing the competency gap in disaster management.

Another important implication arises from the significant chi-square results, which confirmed that perceptions of competency development varied significantly across different dimensions. This indicates a **systematic imbalance** within GSI's competency framework: technical aspects are relatively well supported, whereas **behavioural and motivational dimensions remain underdeveloped**. Addressing this imbalance is crucial because research shows that **motivation, resilience, and ethical judgment** often determine how effectively technical knowledge is applied in high-stress disaster situations (Kapucu & Garayev, 2016; Singh & Sharma, 2023).

The **qualitative findings** from interviews further reinforce this perspective. Respondents expressed appreciation for GSI's technical training programs but pointed to the need for greater investment in **leadership development, faculty incentives, and opportunities for international collaboration**.

These insights echo the Sendai Framework's call for **capacity development at multiple levels—individual, institutional, and systemic**—to achieve sustainable DRR outcomes.

Taken together, the results suggest that GSI stands at a critical juncture: while its technical competency-building strategies are commendable, future efforts must adopt a **more holistic approach** that integrates technical expertise with **soft skills, motivation, and interdisciplinary knowledge**. Only then can the organization ensure that its geoscientists are not only skilled practitioners but also resilient leaders capable of responding effectively to the complex and evolving challenges of disaster risk reduction.

6. Conclusion and Recommendations

This study set out to evaluate the competency development strategies of the Geological Survey of India (GSI) in the context of disaster risk reduction (DRR). The findings confirm that GSI has made notable achievements in building **technical competencies**, particularly in enhancing knowledge and skills related to landslide hazard zonation, seismic monitoring, and geotechnical studies. These technical strengths are well aligned with India's vulnerability profile and demonstrate GSI's commitment to serving as a **national leader in geological disaster management**.

However, consistent with competency models proposed by Boyatzis (1982) and echoed in the UNDRR Strategic Framework (2022–2025), **true competency must extend beyond technical expertise**. The relatively lower scores in self-concepts, traits, and motives reveal gaps in **behavioural, motivational, and leadership dimensions**, which are critical for effective crisis response and resilience building. Addressing these gaps would allow GSI not only to strengthen the scientific expertise of its geoscientists but also to empower them as **leaders, communicators, and motivators** in disaster risk reduction.

Strategies for competency development should incorporate DRR into formal education to build a "culture of safety" from a young age, sector-specific training to ensure incorporation of risk reduction in their daily work and planning, specialized training for emergency managers for identifying and addressing the gaps in their community's readiness, training and simulation exercises to test and refine contingency plans, early warning systems and emergency response protocols.

Recommendations

Based on the analysis, the following recommendations are proposed:

1. **Expand training to urban geo-hazard management** – With India's rapid urbanization, there is a critical need to integrate training on urban landslides, seismic risks in cities, and infrastructure vulnerabilities into GSI's competency development framework.
2. **Incentivize faculty development** – Faculty members may be supported through structured professional development programs, international exposure, and reduced administrative burden, thereby improving the quality and sustainability of training delivery.
3. **Introduce soft-skill modules** – Training Managers may consider to incorporate modules on **leadership, ethics, crisis communication, and decision-making under uncertainty**, in training curricula equipping geoscientists to function effectively in dynamic disaster environments.
4. **Strengthen international collaborations** – Establishing partnerships with global agencies and universities, along with **visiting scientist programs**, would facilitate knowledge transfer, benchmarking, and capacity building at an international level.

5. **Encourage research and innovation** – Competent authority may consider offering Career and financial incentives for **research publications, patents, and innovations** in DRR, ensuring that scientific excellence is recognized and rewarded.
6. **Enhance knowledge sharing** - in best practices, tools, and methodologies for DRR across different regions and sectors.
7. **Harness data and technology** - for hazard / vulnerability analysis for arriving at evidence-based strategies.
8. **Support research and development** - to develop innovative risk reduction technologies and models.
9. **Decentralize planning** - to reflect communities' unique priorities, vulnerabilities and capacities.
10. **Raise public awareness** - on local hazards and promote desired behavioural changes that enhance safety
11. **Empower vulnerable groups** - to address the differing vulnerabilities and capacities of men, women, children, and people with disabilities.

References

- [1] Alexander, D. (2020). *Principles of emergency planning and management* (2nd ed.). Dunedin Academic Press.
- [2] Boin, A., & Lodge, M. (2021). Responding to the COVID-19 crisis: A principled or pragmatic approach? *Public Administration Review*, 81(1), 14–19. <https://doi.org/10.1111/puar.13338>
- [3] Boyatzis, R. E. (1982). *The competent manager: A model for effective performance*. John Wiley & Sons.
- [4] Centre for Research on the Epidemiology of Disasters (CRED). (2024). *2024 disasters in numbers*. Universit  catholique de Louvain (UCLouvain). Retrieved from <https://www.emdat.be>
- [5] Chouhan, V. S., & Srivastava, S. (2014). Understanding competencies and competency modeling – A literature survey. *IOSR Journal of Business and Management*, 16(1), 14–22.
- [6] EM-DAT. (2023). *Disaster data: The Emergency Events Database*. Universit  catholique de Louvain (UCLouvain), Belgium. Retrieved from <https://www.emdat.be>
- [7] Huang, Y., Chen, S., & Li, J. (2021). Building resilience through capacity development in disaster management: Evidence from East Asia. *International Journal of Disaster Risk Reduction*, 60, 102297. <https://doi.org/10.1016/j.ijdr.2021.102297>
- [8] Jacobs, R. (1989). Getting the measure of management competence. *Personnel Management*, 21(6), 28–31.
- [9] Kapucu, N., & Garayev, V. (2016). Structure and network performance: Horizontal and vertical networks in emergency management. *Administration & Society*, 48(8), 931–961. <https://doi.org/10.1177/0095399714541270>
- [10] Kapur, A., & Narain, S. (2022). Competency development in India's disaster management institutions: Challenges and opportunities. *Journal of Disaster Studies and Policy*, 5(2), 45–61.
- [11] McClelland, D. C. (1973). Testing for competence rather than for intelligence. *American Psychologist*, 28(1), 1–14. <https://doi.org/10.1037/h0034092>
- [12] Paton, D., & Johnston, D. (2017). *Disaster resilience: An integrated approach* (2nd ed.). Charles C. Thomas.

- [13] Report on the Functioning of the Geological Survey of India, Government of India, Ministry of Mines, High Powered Committee (HPC), New Delhi, Mar 2009
- [14] Singh, R., & Sharma, P. (2023). Capacity building for disaster risk reduction in India: A review of institutional approaches. *International Journal of Disaster Risk Science*, 14(2), 135–148. <https://doi.org/10.1007/s13753-023-00456-1>
- [15] Tucker, S. A., & Cofsky, K. M. (1994). Competency-based pay on a banding platform. *ACA Journal*, 3(1), 30–48.
- [16] United Nations Office for Disaster Risk Reduction (UNDRR). (2022). *Strategic framework 2022–2025*. UNDRR. Retrieved from <https://www.undrr.org>
- [17] United Nations Office for Disaster Risk Reduction (UNDRR). (2025). *Priority actions to enhance readiness for resilient recovery*. UNDRR. Retrieved from <https://www.undrr.org>
- [18] <https://www.gsi.gov.in>