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General Intelligence for Climate

# How the Next Generation of Geopark Communities Can Best Take Advantage of AI

Artificial Intelligence · Community Empowerment



# How the Next Generation of Geopark Communities Can Best Take Advantage of AI

As we navigate the 21st century, global geoparks stand at the intersection of heritage, sustainability, and innovation. These unique landscapes—rich in geological, ecological, and cultural value—serve not only as conservation sites but also as platforms for education, community development, and sustainable tourism. The rise of Artificial Intelligence (AI) brings an unprecedented opportunity to elevate the mission and management of geoparks, particularly by engaging youth, bridging urban-rural divides, and addressing educational gaps in remote communities.

As artificial intelligence (AI) continues to evolve at an unprecedented pace, it is reshaping industries, economies, and societies worldwide. In the realm of geoparks—areas recognized for their geological heritage and commitment to sustainable development—AI presents transformative opportunities.

## AI Driven Technologies as Opportunities in Advancing Geopark Management Capabilities

Geoparks are often characterized by vast, ecologically sensitive landscapes that demand thoughtful stewardship and innovative management strategies. With limited human and financial resources, especially in remote areas, artificial intelligence offers a powerful toolkit to help address the complexities of conservation, education, and sustainable tourism. From real-time environmental monitoring to the digitization of geological heritage, AI is quickly becoming an indispensable asset in geopark operations.

Geoparks often span vast terrains that are not only ecologically sensitive but also culturally and historically significant. Managing such complex environments requires more than traditional conservation methods—it demands precision, real-time responsiveness, and data-driven decision-making. Artificial intelligence (AI), with its ability to process vast amounts of data and recognize patterns at high speed, is uniquely suited to support these needs. When thoughtfully implemented, AI can enhance environmental monitoring, improve visitor experiences, optimize resource use, and preserve the geological and cultural heritage that makes geoparks globally valuable.

One of the most impactful applications of AI in geopark management lies in environmental monitoring and conservation. In areas where terrain is difficult to access or human monitoring is impractical, AI-powered technologies such as drones and satellite imaging provide an indispensable layer of oversight. These tools, when paired with machine learning algorithms, can track changes in land cover, vegetation health, water quality, and geological structures. This allows for early detection of threats such as soil erosion, habitat loss, or illegal activities like unauthorized mining. Predictive models further help anticipate natural hazards, including landslides, floods, or volcanic eruptions. For instance, China's Fangshan Geopark can utilise AI-equipped drones to survey its rock formations for subtle changes that may indicate structural instability. Similarly, Iceland's Katla Geopark could employ AI models to monitor volcanic activity, improving the accuracy of eruption forecasts and enhancing public safety and preparedness. These innovations support proactive conservation, reducing reliance on human patrols while improving response time to ecological risks.

Managing visitor flow is another area where AI offers significant benefits, especially as geoparks become more popular with eco-tourists. Balancing accessibility with conservation is a delicate act. AI can help by providing real-time and predictive analytics that guide sustainable tourism strategies. By analyzing data

from mobile networks, surveillance systems, and entry logs, AI systems can identify high-traffic zones and peak visiting periods. These insights are crucial for spreading visitor traffic across less sensitive areas and preventing damage to vulnerable habitats. Smart signage and AI-driven mobile apps can further assist in rerouting visitors dynamically to avoid overcrowding. Thailand's Satun Geopark, for example, can leverage AI tools to assess tourist density and inform policy around eco-tourism. This helps reduce strain on delicate ecosystems like coral reefs and limestone caves while maintaining a high-quality visitor experience. Over time, such tools also inform broader tourism infrastructure planning, ensuring long-term sustainability.

AI is also revolutionizing how geoparks preserve and present their natural and cultural heritage. As physical features degrade due to environmental factors or human impact, digitization becomes a vital strategy for preservation. Using AI-assisted 3D modeling, geoparks can create detailed virtual replicas of geological formations, fossils, and archaeological artifacts, ensuring that they remain accessible for future generations, even if damaged or eroded in reality. These models can be integrated into augmented reality (AR) or virtual reality (VR) platforms, allowing visitors to interact with the site in new and immersive ways. This approach not only enhances educational engagement but also reduces the need for physical interaction with sensitive areas. Furthermore, AI-powered translation and narration systems enable geoparks to present information in multiple languages, including regional or indigenous dialects. A compelling example of this integration is how visitors can scan QR codes to trigger AI-generated 3D animations and multilingual narratives that explain complex geological processes. Such tools significantly broaden the accessibility and inclusivity of geopark education, making it more engaging for diverse audiences.

In addition to conservation and education, AI is streamlining the day-to-day operations of geoparks through resource optimization. Energy, water, and waste management are crucial to minimizing a park's environmental footprint, especially in remote areas with limited infrastructure. AI can help monitor and regulate these systems in real time. Smart grids powered by AI algorithms can adjust lighting, heating, or cooling in visitor centers based on usage patterns, reducing energy consumption and costs. In areas with water scarcity, AI sensors can detect leaks, monitor quality, and optimize irrigation systems to support native flora. Waste management is also becoming smarter through the use of AI-driven route planning and sensor-enabled bins, which improve efficiency in collection and recycling efforts. These technologies not only lower operational costs but also reinforce the sustainability credentials of geoparks, aligning them with national and global climate goals.

Finally, AI plays an increasingly vital role in risk and emergency management, particularly in geoparks located in geologically active regions. Natural disasters such as earthquakes, volcanic eruptions, or landslides can have devastating effects on both ecosystems and communities. AI enhances preparedness through early warning systems that draw on vast datasets from geological surveys, seismic monitors, and weather stations. These systems can identify anomalies and alert authorities before disasters strike, giving residents and tourists time to evacuate. AI can also simulate various emergency scenarios, helping park managers develop and test evacuation routes, communication protocols, and resource allocation plans. In the aftermath of a disaster, AI tools assist in damage assessment, prioritizing areas for recovery and conservation. These capabilities are invaluable in ensuring that geoparks not only protect their natural heritage but also safeguard the people who live in or visit them.

## **Bridging Educational Gaps Through AI**

Geoparks are often located in rural or marginalized areas—places rich in natural and cultural heritage but frequently underserved in terms of infrastructure, particularly in education. In many of these communities, students face barriers such as limited access to qualified teachers, poor digital connectivity, and a lack of educational materials tailored to local languages or cultural contexts. This is especially pronounced in

science, technology, engineering, and mathematics (STEM) fields, which are critical for understanding geological processes and environmental sustainability. However, the thoughtful integration of artificial intelligence (AI) into these settings is beginning to transform educational landscapes, making learning more equitable, personalized, and engaging.

One of the most transformative elements of AI in education lies in its ability to deliver highly adaptive and context-aware learning tools. Natural language processing (NLP) enables the development of personalized tutoring bots that can respond to students' questions in real time, simulating the presence of a one-on-one tutor. These AI tutors are capable of breaking down complex scientific concepts into digestible explanations and adapting their approach based on a student's learning pace or style. Additionally, NLP-powered translation apps and voice assistants can bridge linguistic divides, making it possible for learners in geopark communities to access science education in their native or indigenous languages. This is particularly valuable in areas where mainstream education systems may not offer multilingual support. For example, geopark information centers and museums can use voice-enabled AI tools that could be piloted to deliver lessons in multiple regional dialects, providing an inclusive learning experience for students who might otherwise be excluded due to language barriers as well as visual impairment.

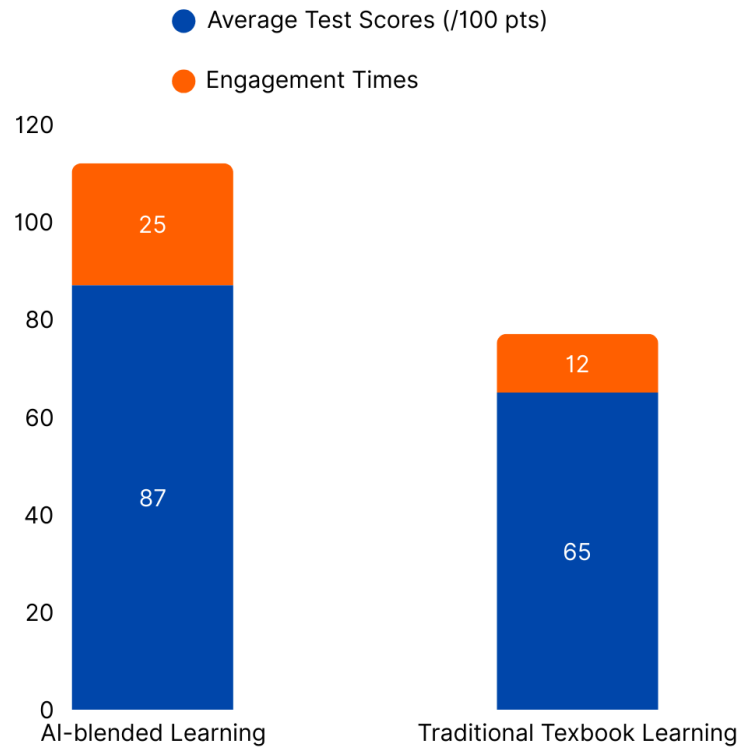
Beyond linguistic accessibility, AI is helping rural students overcome the physical constraints of distance and infrastructure through remote learning platforms. Unlike traditional online education, which can be static and one-size-fits-all, AI-based adaptive learning systems analyze each student's progress and learning behavior to provide tailored content that evolves with their needs. This approach allows students in geopark communities to engage with material at their own pace, whether they're catching up or moving ahead. Platforms powered by AI can also function in low-connectivity environments by storing content offline or operating via solar-powered devices—tools that can quickly be deployed in Indonesia's Batur Geopark through our GeoAI Labs initiative. These innovations help level the playing field, ensuring that geographic isolation does not equate to educational deprivation.

Equally important is the potential of AI to enhance field-based, experiential learning in geoparks — an area where traditional textbook education often falls short. Geology and environmental science are inherently tactile disciplines, yet many students struggle to grasp abstract geological timescales or complex earth systems through classroom instruction alone. AI-driven educational apps can address this gap by introducing gamification, interactive maps, and augmented reality (AR) tools that transform real-world environments into dynamic learning platforms. For instance, students can use AR apps to visualize how tectonic plates shaped a mountain range millions of years ago, or interact with AI-generated simulations that show how climate change might affect local biodiversity. These tools not only reinforce classroom learning but also spark curiosity and engagement by allowing students to experience science in a hands-on, immersive way. AI chatbots can be successfully deployed to guide children through fossil exhibits, significantly boosting comprehension while reducing the instructional burden on teachers.

Geoparks are leveraging AI to make geoscience education interactive and accessible. In China's Yunnan Stone Forest Geopark, students could use AI-driven apps to scan QR codes on rock formations, triggering 3D animations that explain 200-million-year-old karst geology in Mandarin or ethnic minority languages like Yi. A 2023 pilot study showed that students using these tools scored 32% higher on knowledge tests compared to traditional textbook learning (**see Figure 1**). Similar programs in Brazil's Araripe Geopark employ AI chatbots to answer questions about fossils, reducing teachers' workload by 40% while maintaining accuracy.



**Figure 1. Student Test Scoring Performance with AI-supported learning models vs traditional textbook learning models.**



However, while AI democratizes education, risks remain:

- **Language Bias:** Most AI tools prioritize dominant languages (e.g., Mandarin, English), marginalizing indigenous knowledge.
- **Over-Screen Time:** Teachers in Turkey report students spending 60% less time outdoors when relying on AI simulations.
- **Data Privacy:** Apps collecting student performance data must comply with local laws (e.g., China's PIPL, EU's GDPR).

In essence, AI offers a powerful solution to one of the most persistent challenges facing rural geopark communities: access to quality, inclusive, and relevant education. By overcoming logistical barriers, addressing linguistic and cultural diversity, and transforming passive learning into active exploration, AI is not merely a substitute for traditional education—it is an enhancement. As these technologies continue to mature and become more accessible, they have the potential to not only bridge the educational divide but also to inspire a new generation of geoscientists, conservationists, and local leaders rooted in the knowledge of their own environments. In doing so, AI helps geoparks fulfill one of their core missions: to serve as centers of learning and cultural empowerment for the communities they call home.

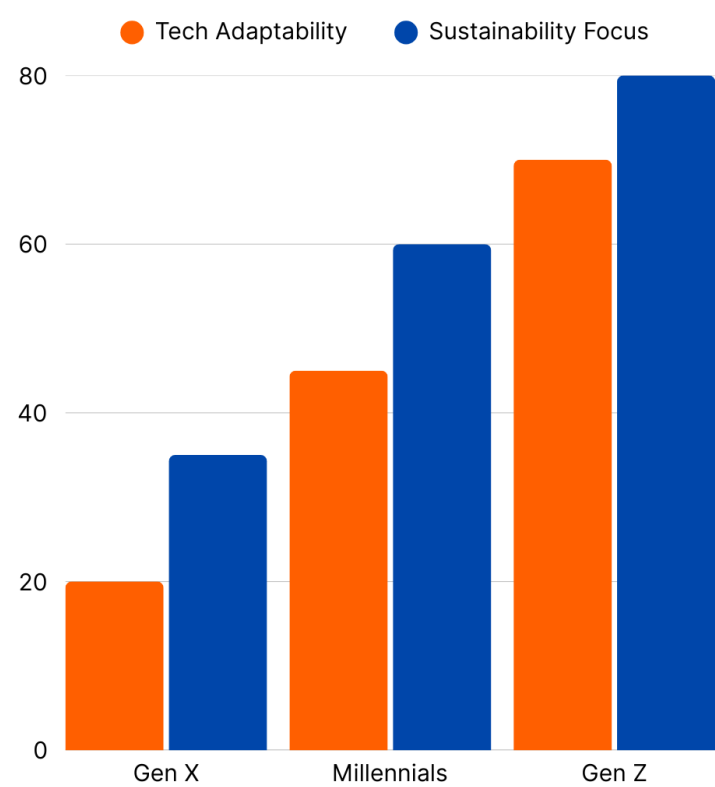
## Youth and AI: Empowering the Next Generation for Sustainable Geopark Futures

The younger generation holds immense potential to become catalysts for sustainable development within

geopark communities—and artificial intelligence is a natural extension of their digital fluency. Today’s youth are growing up immersed in technology; smartphones, social media, and on-demand digital services are second nature to them. This native familiarity with digital tools positions young people as uniquely equipped to both understand and innovate with AI, especially when it comes to solving environmental challenges and engaging with geopark conservation efforts. Far from being passive users of technology, youth can be empowered as active developers and decision-makers, using AI not only as a tool for learning but as a platform for advocacy, creativity, and systemic change.

Across the globe, young innovators are already leveraging AI for sustainability projects—from developing machine learning models that predict water scarcity, to designing drones that monitor deforestation. According to the Tech for Good Report (2023), nearly 78% of AI startups focused on sustainability are founded or co-led by individuals under the age of 35. These youth-led initiatives highlight the deep alignment between technological literacy and environmental commitment, especially among Gen Z and younger millennials. However, while younger people often have the creativity and adaptability to use AI tools effectively, they frequently face challenges such as a lack of access to funding, limited mentorship, or institutional barriers that inhibit the scaling of their ideas. In rural and geopark communities, this can be further compounded by digital divides or educational inequities. While youth excel in innovation, older generations bring critical expertise in systemic implementation. The disadvantage for younger AI practitioners lies in navigating bureaucratic and industrial frameworks, where seasoned professionals have established networks. Conversely, older experts may lack AI literacy, slowing sustainability projects (see: Figure 2).

**Figure 2. AI Adoption and AI and Sustainability-based Skills across Different Generations**



To unlock the full potential of youth in AI-driven sustainability, it is critical to invest in capacity-building programs that nurture both technological skills and environmental consciousness. Initiatives like Google's Advancing AI for Social Impact, AI for Social Good and UNESCO's support for the Nepal-based Youth and Innovation Lab are already demonstrating what is possible. These programs not only provide training in digital transformation that can leverage AI and showcase its more ethical use but also offer mentorship from experienced scientists, conservationists, and policymakers. For instance, in Indonesia's mangrove restoration projects, young software developers have worked alongside seasoned ecologists to design AI-powered drones that monitor tree health and detect illegal logging, all while ensuring alignment with local biodiversity regulations. These intergenerational collaborations bridge the gap between innovation and implementation, combining youthful energy with deep expertise to accelerate sustainable outcomes.

Beyond technical development, AI also gives youth a voice in global and local conservation discourse. Tools such as AI-powered storytelling platforms, environmental data visualization apps, and real-time ecological simulators allow young advocates to communicate complex sustainability issues in compelling, accessible ways. Social media algorithms, when used responsibly, can amplify youth-led campaigns that promote conservation awareness in geoparks, turning local action into global impact. This is especially important in geoparks that depend on public engagement and ecotourism to fund conservation initiatives. Youth involvement in AI-based content creation—whether virtual tours, educational apps, or community data collection—ensures that these tools are not only technologically sophisticated but also culturally relevant and community-rooted.

Equally important is the opportunity AI provides for young people to reimagine the future of education and employment within their communities. As AI transforms global job markets, youth in geopark regions can gain a competitive edge by acquiring skills in data science, robotics, and environmental analytics—skills that are increasingly in demand across sectors. Educational programs that integrate AI with local geoscience and sustainability challenges can help retain talent within rural areas, reversing urban migration trends and fostering a new generation of eco-entrepreneurs. With the right support systems, these youth can build AI-based businesses or research initiatives that contribute directly to the resilience and economic vitality of their geoparks.

## AI as a Bridge Between Urban and Rural Communities

In an increasingly interconnected world, the gap between urban and rural areas is becoming more pronounced. While urban centers are hubs of innovation, knowledge, and resources, rural communities, including those in geoparks, often remain isolated due to geographical distance, limited access to technology, and lack of infrastructure. However, artificial intelligence (AI) holds the potential to bridge these divides in profound and meaningful ways, connecting isolated geopark communities with urban knowledge centers, decision-makers, tourists, and broader global networks.

### *Smart Tourism Ecosystems*

One of the most powerful ways AI can bridge the urban-rural divide is by transforming the tourism sector. Geoparks, often located in rural or remote areas, can benefit from AI-driven tourism solutions that personalize visitor experiences while fostering more meaningful interactions between tourists and local communities. Smart tourism ecosystems leverage AI technologies such as chatbots, recommendation algorithms, and real-time data analytics to enhance both the visitor experience and the management of tourist flows.

For instance, AI can tailor travel itineraries based on individual preferences, climate conditions, and local events, ensuring that visitors engage with the geopark in ways that are both immersive and responsible. By

analyzing visitor behavior patterns, AI can identify peak times and suggest alternative, less crowded routes or locations, reducing environmental stress on sensitive sites like caves, rock formations, or coastal ecosystems. This not only preserves the geopark's ecological integrity but also promotes sustainable tourism practices that benefit local economies without compromising natural heritage.

Moreover, AI-powered platforms can foster deeper connections between urban visitors and rural geopark communities by creating opportunities for cultural exchange. Virtual reality (VR) and augmented reality (AR) experiences allow tourists to "visit" remote or restricted areas of the geopark digitally, deepening their understanding of the landscape without physically impacting it. In turn, rural communities can benefit economically from more efficient tourism management, while urban visitors gain a richer, more informed travel experience. As a result, AI becomes a tool for building sustainable tourism ecosystems that respect both the environment and the communities that depend on it.

### *Virtual Exchange Programs*

AI can also bridge the urban-rural divide by facilitating virtual exchange programs, where students, professionals, and citizens from urban and rural areas collaborate on environmental, cultural, and educational projects. The power of AI-driven tools, such as translation software, automated scheduling, and virtual collaboration platforms, enables these exchanges to overcome geographical and linguistic barriers. For example, students from rural geoparks can collaborate with peers in cities on joint research projects about local geological features, biodiversity, or climate change impacts, without needing to leave their communities.

These virtual programs not only enrich the educational experiences of students but also allow for cross-cultural exchanges that foster understanding and respect between urban and rural populations. AI-enhanced tools like virtual reality can simulate field trips to remote sites, allowing urban students to experience the challenges and unique ecosystems of rural geoparks, while rural students gain exposure to city environments and knowledge hubs. By leveraging AI, such exchanges can be both scalable and accessible, democratizing opportunities for learning and cross-regional collaboration that would otherwise be limited by geography, infrastructure, or cost.

For instance, in the context of a geopark like Indonesia's Batur Geopark, students in urban centers can virtually "visit" the park through VR simulations, while engaging in real-time discussions with local students about sustainable agriculture, volcanic activity, and indigenous practices. This fosters a two-way exchange of ideas and creates a stronger sense of shared responsibility for environmental stewardship.

### *Inclusive Storytelling*

Another vital aspect of AI's role in connecting urban and rural communities lies in its ability to amplify marginalized voices. Many geoparks, especially those in rural areas, are home to indigenous communities whose stories and traditions have often been overlooked in mainstream narratives. AI tools can help uncover, preserve, and amplify these voices, ensuring that the stories of local communities are shared with a global audience, including urban populations who may have little knowledge of rural cultures or the challenges they face.

AI-driven storytelling platforms can collect and curate oral histories, cultural practices, and traditional knowledge from indigenous peoples living within geoparks, making these narratives accessible to a wider audience through digital media. AI technologies like natural language processing (NLP) can translate these stories into multiple languages, allowing them to reach urban communities both within the country and internationally. Moreover, AI-powered content creation tools such as video production software or virtual



reality (VR) experiences can bring these narratives to life in immersive formats, enabling urban audiences to experience the landscape and culture of the geopark as told by its own people.

This kind of inclusive storytelling does more than just preserve heritage—it also promotes cultural sensitivity and empathy. When urban populations engage with the stories of marginalized communities, they are more likely to appreciate the unique values, challenges, and perspectives that shape the stories of geoparks. AI can, therefore, be a powerful vehicle for social change, fostering greater understanding between rural and urban populations, and ensuring that indigenous knowledge contributes to broader global conversations about conservation, climate change, and sustainable development.

## **Building the Future: A Call for Collaboration**

As artificial intelligence continues to reshape our world, its potential to transform the management and preservation of geoparks is undeniable. However, for AI to truly benefit geopark communities, it must be developed with inclusivity, sustainability, and ethical considerations at its core. To ensure that AI serves these communities meaningfully, a comprehensive approach is needed—one that considers the rights of local people, the protection of cultural heritage, and the unique environmental challenges of geoparks.

### *Ethical Use of Data and Protection of Local Communities' Rights*

Data is at the heart of AI. For AI to be effectively integrated into geopark management, it relies heavily on the collection and analysis of various forms of data, from environmental monitoring and visitor behavior to cultural and heritage preservation. However, this data must be gathered and used ethically, respecting the rights and privacy of local communities.

Local communities, particularly in rural and indigenous areas, should have control over the data generated within their regions. They must be consulted on how their data is used, ensuring transparency and accountability in AI applications. Additionally, AI tools must be designed with robust privacy protections, safeguarding sensitive information from misuse. The ethical use of data also involves protecting the environment—AI must not only optimize visitor flows and resource use but also promote responsible conservation practices. Data-driven AI systems should support conservation goals by preventing over-exploitation of natural resources and ensuring that the benefits of AI-driven tourism or educational programs reach the local community.

By ensuring that AI-driven processes align with the interests of local communities, geoparks can foster trust and ensure that technology works to protect their way of life rather than undermine it. This collaboration between technology developers and local communities will also help mitigate the risks associated with data misuse, such as privacy violations or the exploitation of natural resources without benefiting the community.

### *Designing Technology that Respects Cultural Contexts and Environmental Sensitivities*

AI is not a one-size-fits-all solution. When applied to geoparks, it must be tailored to the specific cultural contexts, environmental characteristics, and conservation priorities of each region. Geoparks are often rich in cultural and natural heritage, and AI technologies must respect and preserve these assets.

This means that AI tools should be designed with an understanding of local traditions, languages, and customs. For example, AI-driven educational programs should include indigenous knowledge and languages to provide a more inclusive and authentic learning experience. Geoparks must ensure that AI applications, such as virtual tours, digital storytelling, and environmental monitoring, are culturally appropriate and sensitive to the values of local communities.

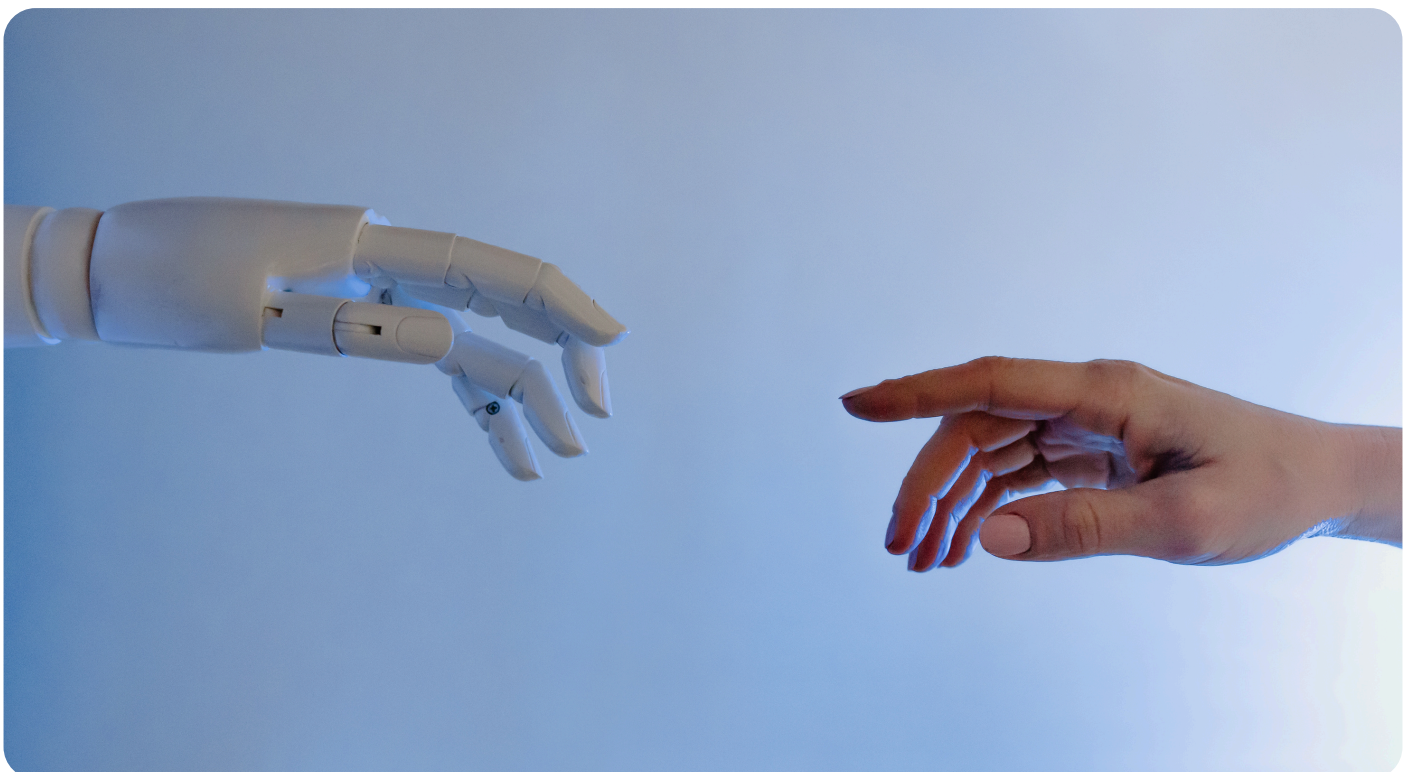
From an environmental perspective, AI technologies should be used to minimize ecological footprints. AI-powered systems should be designed to detect environmental threats, like illegal mining or deforestation, without causing additional harm to fragile ecosystems. Furthermore, AI solutions should be employed in ways that promote sustainable resource use, reduce waste, and protect biodiversity, all while enhancing visitor experiences in a responsible manner. In this way, AI can be an ally in the fight to preserve the environmental and cultural integrity of geoparks.

### *Encouraging Cross-Sector Collaboration*

For AI to reach its full potential in geoparks, collaboration is key. The integration of AI into geopark management requires cross-sector collaboration between technology developers, educators, environmental scientists, and local residents. This multifaceted approach ensures that AI solutions are developed with input from those who understand the nuances of geopark management and the unique needs of the communities and ecosystems involved.

Collaboration between tech companies and environmental organizations can result in the creation of AI-powered systems that not only support conservation efforts but also foster sustainable development within geopark communities. Educators, in partnership with tech developers, can help ensure that AI tools are used to enhance educational experiences, creating a more engaging and accessible learning environment for local students, particularly those in remote or underserved areas. By working together, these diverse stakeholders can create solutions that are more than just technologically advanced—they will also be culturally appropriate, socially beneficial, and environmentally sustainable.

Local communities, too, must play an active role in the development and implementation of AI technologies. Their input and participation are vital to ensure that AI solutions address the real needs and concerns of the community. Moreover, when local residents are involved in the creation of AI-driven programs—whether for educational, tourism, or conservation purposes—it fosters a sense of ownership and empowerment, leading to greater long-term success and sustainability.



## Conclusion

As we look to the future, AI presents an exciting opportunity to transform the way we manage and preserve geoparks, enhancing both conservation and the local economy. However, to realize the full potential of AI in these environments, it is crucial that its implementation is driven by inclusivity, cultural sensitivity, and ethical considerations. By ensuring that AI technologies are developed with input from local communities and designed to respect both cultural and environmental contexts, we can build a future where technology supports sustainable development, preserves heritage, and fosters collaboration between urban and rural populations.

The call for collaboration is clear: the future of geoparks lies in the hands of those who understand both the power of technology and the importance of preserving natural and cultural heritage. Together—tech developers, educators, scientists, and local communities—we can harness AI to create a more connected, sustainable, and resilient future for geoparks around the world. Through thoughtful and inclusive collaboration, AI can serve as a powerful tool for both environmental stewardship and the empowerment of local communities, ensuring that geoparks thrive for generations to come.



## About the Author



**Fauzan Noviandy Muslim** is a Senior Associate at the Geoparks Investment Advisory Council, where he leads Growth, Marketing, and Sales Capabilities, supports Artificial Intelligence development, and serves as Principal Advisor for Leather Goods and Footwear Industry. He is also the CEO of the Sunda Aspiring Geopark-based RB Language House, and a passionate advocate for regional development as a representative of Aspiring Geopark Sunda. With experience as a Laboratory Research Assistant at Padjajaran University, he has contributed to cultural and geological studies for geopark development in West Lampung, blending business strategy, AI, and heritage preservation in his work.