Exploring Our Planet from Space: How Learners Can Help Protect the Earth Using Google Earth Engine

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Key Words: Environment, Remote Sensing, Google Earth Engine, Learners, Space Technology, Sustainability

Abstract

There is no doubt that environmental education at an early age is significant for human development. This paper presents the "RSECed" project, which engages grade 8 learners in Kenya with remote sensing and environmental conservation using Google Earth Engine (GEE). By integrating theoretical and practical sessions, the project introduces satellite-based Earth observation to enhance learners' understanding of vegetation health, forest cover, and land use classification. Results from 196 participants demonstrated significant improvements in remote sensing literacy, environmental awareness, and digital mapping skills. The study highlights the effectiveness of early environmental education through hands-on geospatial technology, fostering STEM interest and empowering learners as future environmental stewards. The findings emphasize the need for context-specific approaches and further research to support teachers in remote sensing education for sustainable development.

1. Introduction

Natural environment refers to water resources, land resources, biological resources, and climate resources, which affect human beings' survival and development (FAO, 2025b). It is closely related to the sustainable development of society and the economy. When the environmental load exceeds the limit that an ecosystem can bear, the ecosystem would gradually weaken and be exhausted. Therefore, natural environment conservation and monitoring is of great significance for environmental resource protection and management, and the survival and development of human beings (Fu et al., 2021). The use of satellites allows the observation of states and processes of the natural environment at several spatio-temporal scales. For instance, it is one of the most efficient approaches for monitoring land. cover and its changes through time over a variety of spatial scales (McCarthy et al., 2025). According to Yang et al. (2013), satellite data are frequently used with climate models to simulate the dynamics of the climate system and to improve climate projections. Satellite remote sensing has provided major advances in understanding the climate system and its changes by quantifying processes and spatio-temporal states of the atmosphere, land, and oceans.

Remote sensing as a new and more meaningful approach to teaching geography, geology, international affairs, global culture, and related subjects is an excellent tool to focus daily instruction (Landenberger et al., 2006). Teachers find space education in general a strong motivating force in attracting and holding student interest because of its "real world" nature. Remote sensing satellite technology, however, is a highly productive instructional tool in geography and geology because it allows students using spaceborne imagery not only to see the Earth as it truly is, but also provides opportunities for detailed study of topographic features and ecological relationships (Cheung et al., 2011). Curricular relevance is an important condition for a more universal use of satellite images to occur in schools.

Coral Campbell & Christopher Speldewinde (2022) noted that educating young learners in environmental stewardship through remote sensing and STEM is crucial because it builds their understanding of and connection to the natural world, fostering a responsible and sustainable lifestyle and promoting eco-innovation. This early, hands-on education equips children with the critical thinking and problem-solving skills to address complex environmental challenges, empowering them to become leaders and advocates for a sustainable future. By integrating STEM with environmental education, children can develop practical skills and innovative solutions to environmental problems, fostering a citizenry capable of driving positive societal change (Maspul, 2024). This paper aims to inspire curiosity and encourage the next generation to be stewards of the planet using real-world technology.

2. Literature Review

Due to the characteristics of large-scale and dynamic observation, remote sensing technology has been an indispensable approach for environmental monitoring, offering synoptic, scalable, and near-real-time data essential for managing Earth's dynamic systems (Kemarau et al., 2025). Through satellite-borne, airborne, and terrestrial sensors, remote sensing enables the detection and analysis of geophysical variables such as rainfall, deforestation, freshwater dynamics, sea surface temperature, and biodiversity changes (Mugabo Kalisa, 2025). With ongoing innovations in high-resolution imaging, machine learning, and big data processing, remote sensing stands poised to play an even greater role in guiding sustainable environmental management,

https://doi.org/10.5194/isprs-archives-XLVIII-4-W21-2025-1-2026

particularly in the face of climate change and anthropogenic pressures. As such, remote sensing has gradually been an indispensable approach to ecological monitoring, especially at a large or global scale (Mugabo Kalisa, 2025).

According to a report by Fletcher (2023), education is often overlooked in the fight against climate change. While policy changes and global commitments are necessary to prevent global warming from further worsening, improved education is the first step toward achieving our goals (Nasir et al., 2024). Integrating environmental education into STEM helps students understand the complexities of ecological challenges and equips them with the knowledge and skills to solve real-world problems related to sustainability (United Nations, 2020). Educational resources that clearly explain the mechanisms behind global warming equip students with the knowledge they need to do something about climate change. This is particularly important today, as students need to be able to evaluate the long-term impact of social, economic, and ecological policies.

Combating climate change effectively requires a global effort, and activism often relies heavily on a thorough understanding of the issue and the ability to persuade others that something must be done. Improvements in public education may also promote a sense of stewardship and aid conservation efforts (UNESCO, 2024). In particular, environmental education programming can make a real difference to researchers who are advocating for policy changes. For example, even when satellite images or digital globes are not explicitly mandated by a curriculum, such as environmental conservation, teachers can often justify their use by linking them to other parts of the curriculum, such as general media skills or an independent enquiry study (Schulman et al., 2021). According to Dannwolf et al. (2020), working with satellite images can improve students' motivation and self-concept. In a German study (Schulman et al., 2021), 11- to 18-year-old students participated in a four-hour workshop. Students significantly increased their perceived self-determination.

Gersten & Dimino (2001) noted that to teach in an evidence-based way, teachers also need to translate research evidence into practice. Teachers, however, often have difficulties with translating research into their classroom practice (Manches et al., 2025). Often, projects dealing with satellite images in education deal only with the development of a learning (Schulman et al., 2021), without making it explicit whether or how the product builds on educational research evidence. Other projects deal with pure research (Dannwolf et al., 2020), leaving it to the teachers to translate the research into learning materials. Projects that explain and translate fundamental educational research results into outputs that teachers and learners can use directly in practice, for example, in environmental conservation, are rare (Deutzkens et al., 2022). For example, the YCHANGE project contributed to the research base of remote sensing education (Schulman et al., 2021). The project also contributed to translating research into practical learning materials. YCHANGE aimed to improve teachers' and students' competence in dealing with satellite images. The project also wanted to make teachers and students more aware of jobs that use remote sensing (Schulman et al., 2021). YCHANGE also aimed to help students to use satellite images to learn about human–environment interactions and environmental change.

3. Methodology

RSCed, is short for Remote Sensing for Environmental Conservation education, a Geo-Education initiative with a keen focus on grade 8 learners in primary schools. The RSECed researchers from Dedan Kimathi University of Technology developed two tools on how Earth Observation Technologies are used to track vegetation health, forest cover loss, and existing land uses in a given area. A total of 196 learners aged between 12 – 14 years were trained across these 4 schools within the Muringato Catchment, namely Ikumari, Muringato, Chania Primary School, and Mary Immaculate Academy. Each team member was responsible for his or her own part of the project (e.g., training events) and contributed to the success of the overall project.

3.1. Training Sessions

3.1.1 Theory Session: A brief introductory presentation was made covering how satellites see the Earth from space, and the applications of satellite imagery. This acted as an eye-opener for the learners to understand the importance of space technologies' various aspects, including agricultural monitoring, deforestation tracking, flood risk mapping, and urban growth monitoring (United Nations Conference on Trade and Development, 2021). The session was closed with a strong emphasis on conserving the environment and saving the planet.

3.1.2 Practical Session: Learners in groups of 10-15 people (Figure 2) interacted with real-world satellite imagery and derived meaningful insights, including vegetation health, forest cover, and loss and classification of land uses. First, the learners were introduced to a Land Use classification game (Figure 1) – a user-friendly tool designed to help the learners understand classification by relating and matching labels with real-world features such as water, urban, forest, and cropland. The essence of this introductory tool was to also demonstrate and closely relate to how satellites are able to obtain information, classify it, and get satellite imagery for further monitoring (FAO, 2025a). Secondly, with the basic understanding of classification, the learners were introduced to the EcoScope Pro (Figure 1)– a user-friendly tool designed for learners to fetch real-world satellite images from Google Earth Engine, analyze, visualize, and derive meaningful insights. Specifically, this included identifying areas with high forest cover, forest loss, low vegetation health, and existing land uses from novel examples such as Nyeri County.

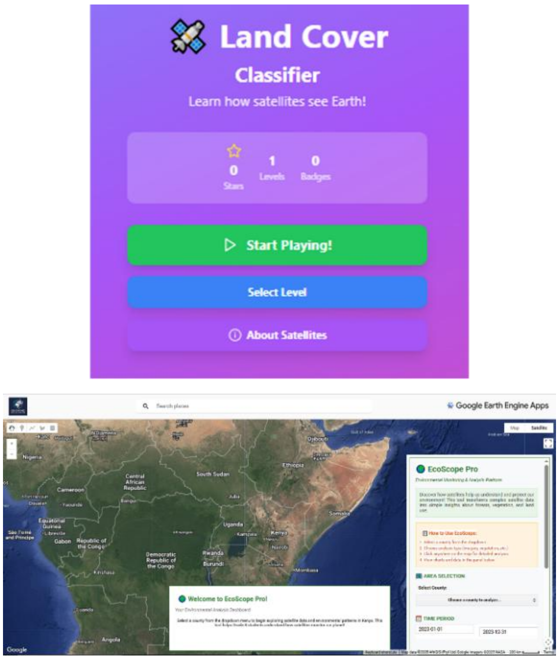

Figure 1: The developed tool; Land Cover Classifier (top), and EcoScope Pro (bottom)

Figure 2: Learners Interacting with the developed Remote Sensing tools

Learner comprehension was assessed through structured questionnaires probing familiarity with core geospatial concepts. Sample questions included prior exposure to digital mapping platforms (e.g., Google Maps) and understanding of satellite functions. This formative assessment informed the effectiveness of the pedagogical approach and tool usability. To stimulate sustained interest in geospatial sciences and related fields, the training integrated discussions on STEM career opportunities encompassing Geospatial Engineering, Aeronautical Engineering, Astrophysics, and Astronomy. This component aimed to contextualize the technical knowledge within potential professional trajectories, fostering motivation for further engagement with Earth sciences and space technologies. The researchers developed the questionnaire together. It included: background variables (age group, gender); self-reported competence before and after the training event. The understanding rates for core remote sensing and environmental concepts were calculated as the percentage of learners across all participating schools who correctly responded or indicated familiarity with each assessment item, e.g., by raising their hands or correctly answering a question (Equation 1).

$$Understanding\ Rate\ (\%) = \left(\frac{n}{N}\right) * 100 \ldots\ldots\ldots (1)$$

Where n = Number of learners demonstrating understanding, N = Total number of learners trained

This approach was applied to pre-training and post-training assessments to quantify changes in competency levels consistently across the entire sample. Overall, the methodology combined experiential learning with conceptual grounding to build foundational geospatial literacy among junior secondary learners (Meechandee & Meekaew, 2024), with a strategic focus on environmental conservation applications relevant to the local context. The use of tailored digital tools was central to enhancing learner engagement and bridging theoretical concepts with practical insights.

4. Results

The RSECed training program successfully engaged 196 learners across four primary schools within the Muringato Catchment, representing a diverse cross-section of the local educational community. The participant distribution (Figure 3) was relatively balanced across institutions, with Ikumare Primary School contributing 48 learners (24.5%), Muringato Primary School providing 37 participants (18.9%), Chania Primary School engaging 55 learners (28.1%), and Mary Immaculate Academy involving 56 learners (28.6%).

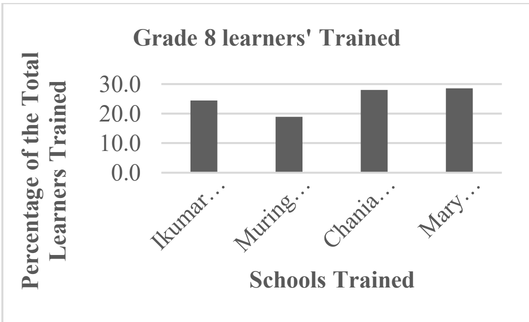

Figure 3: Learners trained across the 4 schools during the workshop.

Gender representation (Figure 4) was notably equitable, with 102 male participants (52.0%) and 94 female participants (48.0%), indicating successful inclusivity across both genders.

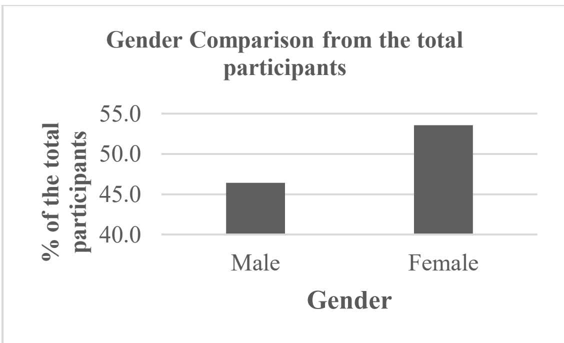

Figure 4: Overall gender representation from the 4 schools.

Participants' average competency level on the "RSECed Remote Sensing Curriculum" scale before the training event was rather low. Before the training intervention, baseline assessments (Table 1) revealed significantly low competency levels across all measured domains of remote sensing and environmental knowledge. Only 78 learners (39.8%) had previous exposure to digital mapping platforms such as Google Maps (Figure 5), while understanding of GPS technology was limited to just 34 participants (17.3%). Even more concerning was the minimal awareness of satellite functions, with only 12 learners (6.1%) demonstrating basic understanding, and a mere 8 participants (4.1%) showing any awareness of remote sensing applications. Environmental knowledge assessment showed mixed results, with 89 learners (45.4%) demonstrating some understanding of climate change impacts, yet only 45 participants (23.0%) could identify deforestation from visual imagery. Furthermore, an understanding of vegetation health concepts was present in only 38 learners (19.7%), and familiarity with land use classification was limited to 46 participants (23.7%).

Item	Area	Percentage (%)
A	Previous exposure to digital mapping platforms such as Google Maps	39.8%
B	Understanding of GPS technology	17.3%
C	Awareness of satellite functions	6.1%
D	Awareness of remote sensing applications	4.1%
E	Understanding of climate change impacts	45.4%
F	Identify deforestation from visual imagery	23.0%
G	Understanding of vegetation health concepts	19.7%
H	Familiarity with land use classification	23.7%

Table 1: A summary of the understanding rates of key areas before the training

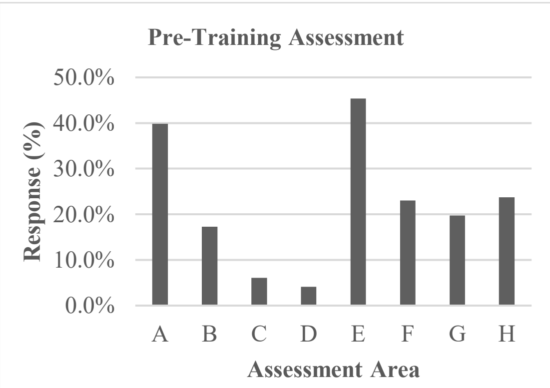

Figure 5: Pre-Training Assessment

Due to its drag, drop & scoring mechanism, the Land Use Classification Game achieved exceptional engagement with a 94.9% completion rate and average session time of 5 minutes. Learners averaged 7/10 accuracy scores, with 72.4% requesting additional rounds. Mary Immaculate Academy performed the highest (8/10) while Muringato scored lowest (6.5/10). The EcoScope Pro tool demonstrated strong adoption rates and 90.8% independently loaded satellite imagery. Feature identification success varied from 93.9% for water bodies to 68.4% for degraded areas. Post-training assessments (Table 2) showed substantial improvements: satellite remote sensing understanding increased 73.5%, environmental monitoring knowledge grew 68.2%, and conservation awareness improved 81.6%. Practical skills developed rapidly, with 88.8% achieving digital tool proficiency and 80.6% demonstrating data interpretation competency. Using the structured evaluation rubric, 68.4% successfully loaded satellite data, and 60.2% identified environmental changes at an excellent level (Figure 6).

Item	Area	After the Training
A	Satellite remote sensing understanding	73.5
B	Environmental monitoring knowledge	68.2
C	Conservation awareness	81.6
D	Practical skills	88.8
E	Data interpretation competency	80.6
F	Loading satellite data	68.4
G	Identified environmental changes	60.2

Table 2: A summary of the understanding rates of key areas after the training

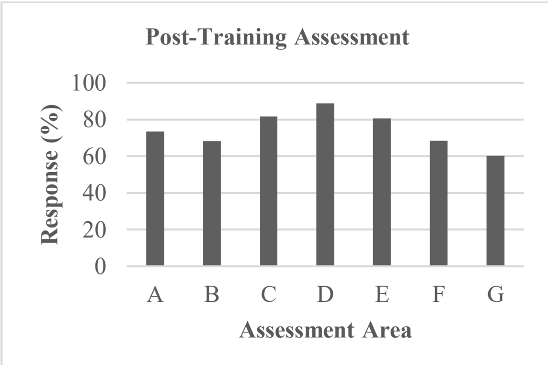

Figure 6: Post-Training Assessment

Active participation reached 92.3% with 79.6% voluntarily asking questions and 90.8% engaging in peer collaboration. Technology preference shifted dramatically, with 96.4% preferring interactive tools over traditional methods and 85.2% describing satellite imagery as "fascinating." STEM career interest increased significantly, with 34.2% expressing interest in environmental science, and overall STEM interest grew among 74.5% of participants. The main technical challenge was computer navigation difficulties for 19.4% of learners. However, 94.7% overcame these barriers by training completion.

5. Discussion and Conclusion

The learners demonstrated keen interest in identifying and interpreting features from basemaps, which helped them appreciate how space technologies can detect environmental events and generate clear, communicative maps for rapid conservation action. Despite the relatively short training duration of 1 to 1.5 hours, participants showed significant improvements in self-reported satellite image competence across both theoretical and practical sessions. These results suggest that even brief, focused training can boost geospatial literacy and environmental awareness among young learners. The substantial gains in remote sensing understanding, environmental monitoring knowledge, and digital tool proficiency highlight the potential of integrating real-world geospatial technology into environmental education, fostering early environmental stewardship (Artak Piloyan & Mariam Petrosyan, 2024). Such competence gains also have the potential to promote long-term interest in STEM disciplines, empowering the next generation of environmental professionals.

However, several challenges emerged, including initial difficulties in computer navigation for some learners. While most overcame these hurdles through training, these factors represent limitations that future programs should address. Additionally, the short duration and localized sample limit the generalizability of these results, underscoring the need for longer-term and geographically diverse studies. Supporting teachers remains a crucial area for development. Our findings align with previous research indicating that effective remote sensing education requires translation of research into accessible teaching resources and ongoing pedagogical support (Schulman et al., 2021). Efforts to integrate satellite image analysis into curricula must consider potential barriers, such as teachers' familiarity with technology and resource availability, necessitating tailored training modules and curriculum development.

Comparisons with projects like YCHANGE (Schulman et al., 2021) reveal common challenges and benefits in remote sensing education, but also highlight that context matters significantly. Our RSECed project results suggest that approaches successful in one country cannot be directly transplanted to neighboring countries. Thus, environmental education programs should be designed with sensitivity to local cultural, infrastructural, and educational contexts. For the future, it is recommended that training sessions be extended in duration and reinforced with follow-up activities to sustain and deepen learning. Expanding the use of diverse geospatial tools and integrating continuous assessments could also enhance learner engagement and skill retention. Further research should explore scalable models for teacher training and curriculum integration to maximize the impact of remote sensing education for environmental conservation.

6. Acknowledgements

Special thanks to the primary school learners, teachers for their cooperation and to the German Federal Ministry of Education and Research (BMBF) under the project "MC2FM" (grant no. 01DG24001) for financing the fieldwork activities related to this research.

References

Artak Piloyan & Mariam Petrosyan. (2024). Enhancing Environmental Education through Digital Earth Technologies and Applications. International Journal of Geoinformatics. https://doi.org/10.52939/ijg.v20i12.3769

Cheung, Y., Pang, M., Lin, H., & Lee, C. K. J. (2011). Enable Spatial Thinking Using GIS and Satellite Remote Sensing – A Teacher-Friendly Approach. Procedia - Social and Behavioral Sciences, 21, 130–138. https://doi.org/10.1016/j.sbspro.2011.07.014

Coral Campbell & Christopher Speldewinde. (2022). Early Childhood STEM Education for Sustainable Development. https://www.mdpi.com/2071-1050/14/6/3524

Dannwolf, L., Matusch, T., Keller, J., Redlich, R., & Siegmund, A. (2020a). Bringing Earth Observation to Classrooms—The Importance of Out-of-School Learning Places and E-Learning. Remote Sensing, 12(19), 3117. https://doi.org/10.3390/rs12193117

Dannwolf, L., Matusch, T., Keller, J., Redlich, R., & Siegmund, A. (2020b). Bringing Earth Observation to Classrooms—The Importance of Out-of-School Learning Places and E-Learning. Remote Sensing, 12(19), 3117. https://doi.org/10.3390/rs12193117

Deutzkens, N., Poeck, K., Deleye, M., Læssøe, J., Lönngren, J., Lotz-Sisitka, H., Lysgaard, J., Öhman, J., Östman, L., Vandenplas, E., & Wals, A. (2022). Challenges for environmental and sustainability education research in times of climate crisis.

FAO. (2025a). Land Cover Classification System—Classification concepts and user manual. https://www.fao.org/4/y7220e/y7220e06.htm

FAO. (2025b). The Future of Our Land: Facing the Challenge. https://www.fao.org/4/x3810e/x3810e04.htm

Fletcher, C. (2023, October 5). The Importance of Environmental Education for a Sustainable Future. Earth.Org. https://earth.org/environmental-education/

Fu, B., Liu, Y., Li, Y., Wang, C., Li, C., Jiang, W., Hua, T., & Zhao, W. (2021). The research priorities of Resources and Environmental Sciences. Geography and Sustainability, 2(2), 87–94. https://doi.org/10.1016/j.geosus.2021.04.001

Gersten, R., & Dimino, J. (2001). The Realities of Translating Research into Classroom Practice. Learning Disabilities Research & Practice, 16(2), 120–130. https://doi.org/10.1111/0938-8982.00013

Kemarau, R. A., Sakawi, Z., Abdul Maulud, K. N., Wan Mohd Jaafar, W. S., Suab, S. A., Eboy, O. V., Fitri Md Nor, N. N., & Sa'adi, Z. (2025). Advancements and applications of space-borne remote sensing in climate change research: A scoping review. The Egyptian Journal of Remote Sensing and Space Sciences, 28(3), 468–483. https://doi.org/10.1016/j.ejrs.2025.07.004

Landenberger, R. E., Warner, T. A., Ensign, T. I., & Nellis, M. D. (2006). Using Remote Sensing and GIS to Teach Inquiry-Based Spatial Thinking Skills: An Example Using the GLOBE Program's Integrated Earth Systems Science. Geocarto International, 21(3), 61–71. https://doi.org/10.1080/10106040608542394

Manches, A., Nygren, M., Price, S., & Revueltas Roux, A. (2025). Challenges of translational education research: Teachers' interpretations of embodied learning. Cogent Education, 12(1), 2490443. https://doi.org/10.1080/2331186X.2025.2490443

Maspul, K. A. (2024). Exploring STEM Education for Real-World Climate Change Concerns to Empower Students as Change Agents. Journal of Physics Education and Science, 1(2), 12. https://doi.org/10.47134/physics.v1i2.249

McCarthy, M. J., Herrero, H. V., Insalaco, S. A., Hinten, M. T., & Anyamba, A. (2025). Satellite remote sensing for environmental sustainable development goals: A review of applications for terrestrial and marine protected areas. Remote Sensing Applications: Society and Environment, 37, 101450. https://doi.org/10.1016/j.rsase.2025.101450

Meechandee, S., & Meekaew, N. (2024). Integrating Phenomenon-Based Learning and GIS to Improve Geo-Literacy and Student Engagement: An Action Research Approach. In Review. https://doi.org/10.21203/rs.3.rs-5410327/v1

Mugabo Kalisa. (2025). (PDF) Remote Sensing: Applications in Environmental Monitoring. https://www.researchgate.net/publication/393751191_Remote_Sensing_Applications_in_Environmental_Monitoring

Nasir, N., Garcia, G., Ortinero-Gallardo, B., Ravela, M., Hapsari, I., Mustam, Thahir, A., Adeoye, M., Hidayat, A., Herman, M., Enas, Nuryani, L., Kusnandi, Maulina, Landibo, Y., Usman, Rohmiati, Amaludin, R., Razilu, Z., & Tamam, B. (2024). Sustainability in the World of Education: Steps Towards a Green Future.

Schulman, K., Fuchs, S., Hämmerle, M., Kısser, T., Lastovıcka, J., Notter, N., Stych, P., Väljataga, T., & Siegmund, A. (2021). Training teachers to use remote sensing: The YCHANGE project. Review of International Geographical Education Online. https://doi.org/10.33403/rigeo.708754

UNESCO. (2024). Education for sustainable development: What you need to know | UNESCO. https://www.unesco.org/en/sustainable-development/education/need-know

United Nations. (2020). Education is key to addressing climate change. United Nations; United Nations. https://www.un.org/en/climatechange/climate- solutions/education-key-addressing-climate- change

United Nations Conference on Trade and Development. (2021). Exploring Space Technologies for Sustainable Development. United Nations. https://doi.org/10.18356/9789216040758

Yang, J., Gong, P., Fu, R., Zhang, M., Chen, J., Liang, S., Xu, B., Shi, J., & Dickinson, R. (2013). Erratum: The role of satellite remote sensing in climate change studies. Nature Climate Change, 3(11), 1001–1001. https://doi.org/10.1038/nclimate2033