

Unlocking Earth's Secrets: Innovative Applications of Google Earth Engine

¹Aishwarya Vilas Desai and ²Prachi Pratyasha Jena

¹PhD Research scholar, Department of Soil and Water Conservation Engineering, Dr. Annasaheb Shinde College of Agricultural Engineering and Technology, M. P. K. V., Rahuri - 413722, Maharashtra

²Assistant Professor, Department of Soil and Water Conservation Engineering, College of Agricultural Engineering and Technology, O.U.A.T., Bhubaneswar-751003, Odisha

Corresponding Author: aishwaryadesai8160@gmail.com

In today's world, monitoring and understanding the Earth's changing environment is more critical than ever. From deforestation and urbanization to climate change and natural disasters, there is a growing need for tools that can analyse vast amounts of geospatial data to provide insights into these complex challenges. Google Earth Engine has emerged as a revolutionary platform that harnesses the power of satellite imagery and geospatial datasets to address these pressing issues.

Background

Google Earth Engine was launched by Google in 2010 with the goal of making planetary-scale environmental data accessible and useful for scientists, researchers, and policymakers. The platform provides a vast archive of satellite imagery and geospatial datasets, along with the computing power needed to analyse this data at scale.

One of the key features of Google Earth Engine is its ability to process petabytes of satellite data quickly and efficiently. This capability is made possible by Google's cloud infrastructure, which allows users to run geospatial analyses on a massive scale without the need for specialized hardware or software.

Over the years, Google Earth Engine has been used for a wide range of applications, including monitoring deforestation, tracking urban growth, assessing crop health, and mapping global carbon emissions. Its ability to provide timely and accurate geospatial information has made it an invaluable tool for addressing some of the most pressing environmental challenges facing our planet today.

As we move forward, Google Earth Engine continues to evolve, offering new features and datasets to support research and decision-making in the field of Earth sciences. Its impact on our understanding of the Earth's changing environment cannot be overstated, and it remains a cornerstone in the field of geospatial analysis.

Applications

Google Earth Engine (GEE) is designed to facilitate storage, processing, and analysis of large geospatial datasets, enabling users to make informed decisions based on the results. More and more satellites are taking pictures of Earth from space. NASA and ESA, two space agencies, share these

pictures with everyone for free so that scientists and students can learn. Special computer systems called cloud computing systems use very powerful supercomputers to store, process, and study the huge amount of data collected by these satellites and help people use this data to do their work (Chi et al., 2016). GEE is a useful online tool that can handle lots of satellite data. It's used in many different areas to help with different kinds of work. GEE uses its large collection of satellite images to make it easy to study how the environment and land are changing. This is helpful for keeping an eye on the climate and checking on different kinds of plants and animals.

GEE is great for analysing Earth's surface because it has lots of different types of satellite images, climate and weather data, and vegetation index products like EVI and NDVI. It's a top choice for remote sensing experts because it's free and offers many advantages, especially for less developed areas. GEE is used in Earth science and environmental studies to look at how land is changing, check on the health of ecosystems, monitor disasters, track diseases, ensure food security, and understand the effects of climate change. GEE is used a lot in Earth and environmental sciences to help map land use and cover, track carbon emissions, and measure environmental indicators. This helps with planning for sustainable development (Gorelick et al., 2017).

After Landsat data became free in 2008, Google stored all the data and connected them to a cloud computing system for anyone to use and also added data from other satellites, along with GIS maps, social and demographic information, weather data, elevation models, and climate data. The front-end of GEE is easy to use and to interact with data and create algorithms easily. Users can also add their own data and manage it, while Google's cloud does all the hard work. This means that scientists, researchers, and even hobbyists from any part of the world can use this huge collection of data to study changes on Earth's surface, track trends, and measure resources without needing expensive computers or software. It levels the playing field so that even researchers in less wealthy countries can do the same kind of analysis as those in wealthier countries. Various wide applications can be explored using the GEE in research studies.

1. Mapping and Monitoring Vegetation (Flora Mapping and Surveillance)

GEE is useful for mapping and keeping an eye on vegetation. It is used to estimate important biodiversity factors like Leaf Area Index (LAI), Fraction of Absorbed Photosynthetically Active Radiation (FAPAR), Fraction Vegetation Cover (FVC), and Canopy Water Content (CWC) using older MODIS data. Researchers used GEE with MODIS data to map vegetation and track changes over time. They could see if vegetation was getting worse or better and how government efforts to help were working. A study of a nature reserve used Landsat images from different seasons to map vegetation and land cover to predict the type of vegetation with more than 70% accuracy by combining different types of data. GEE is used to create a detailed map of vegetation health over the past 30 years using NDVI data with a resolution of 30 meters to make the map more accurate. A climate-based model is used to fill the missing information due to clouds and produce data at different levels of detail. In dry area GEE is used to study the ecosystem using very detailed satellite images (from Worldview) for more accurate results and to classify different types of land cover like trees, shrubs, and bare land with a lot of detail, which was hard to do with older datasets. Researchers used long-term satellite data in a cloud computing system to monitor rangelands. The accuracy of these maps was above 80%. GEE is used to map seagrasses in the Aegean and Ionian seas and able to map the changes in seagrasses over seasons and years, even up to 40 meters deep in the water.

2. Land Use Classification

Several studies looked at how land cover changes over time in different sizes of areas using GEE. This method doesn't need a lot of ground data to work, so it can be used in many places. GEE is used to study how changes in land cover affect urban heat islands worldwide by using land surface temperature data. Cloud cover has always been a challenge in remote sensing but with the help of time series data and the GEE platform, it is able to create algorithms that address the issues caused by clouds when mapping land cover. The cloud computing platform helps calculating spectral vegetation indices from Landsat data and normalization algorithms for better land cover classification. Another study to map wetlands on a large scale by using advanced machine learning algorithms and the computing power of GEE, along with the high-resolution satellite data.

3. Farming Utilizations

Google Earth Engine (GEE) for agricultural purposes, demonstrating its utility across different scales. The GEE platform is used to estimate the Gross Primary

Productivity of crops achieving a spatial resolution of 30 meters. The predicted productivity patterns of croplands and their seasonal fluctuations is consistent with national-level crop data. Additionally, high-resolution Worldview 2 imagery can be employed to map smallholder, diverse cropland areas utilizing ensemble rules (Aguilar et al., 2018). The powerful cloud platform allows the use of multiple rules to improve the accuracy of classifications. For the whole continent cropland and other land types can be mapped using a combination of Sentinel and Landsat data.

4. Emergency Response and Geosciences

GEE is used for research on earth sciences and disaster management worldwide. A snow and cloud hydrological model that can be used in various regions and maps snow cover, making it broadly applicable. Disaster management creates a flood prevention and response system using the cloud-based GEE platform. Additionally, GEE platform is used to evaluate drought occurrences globally by using soil moisture as an indicator. This cloud-based engine combines global soil moisture datasets with web-based processing tools to predict drought duration and intensity.

Other applications include using multi-temporal approaches to mask out clouds, monitoring surface sediment, and mapping mining areas using Sentinel satellite data.

Table 1: Summary of GEE Applications

Application Area	Example Datasets	Output Products	Impact
Vegetation Monitoring	MODIS, Landsat	NDVI, LAI maps	Biodiversity tracking
LULC Classification	Sentinel, Landsat	Land cover maps	Urban planning, habitat mapping
Agriculture	Sentinel-2, WV-2	GPP estimates	Food security planning
Disaster Management	Sentinel-1, SMAP	Flood maps, drought indices	Risk reduction

Challenges and Limitations

The quality of the satellite imagery and other geospatial datasets can vary, affecting the accuracy of analyses and results. It has processing limitations, particularly when dealing with very large datasets or complex analyses, which can affect the speed and efficiency of analyses. It effectively requires a certain level of technical expertise and familiarity with geospatial analysis tools, which can be challenging for some users. It provides access to a wide range of datasets some

specific datasets may not be available or may have limited temporal or spatial coverage.

Future Prospects

Google Earth Engine is likely to continue improving its analytical capabilities, enabling more sophisticated and efficient analyses of geospatial data. The platform may expand its range of available datasets, including higher-resolution imagery and additional types of geospatial data, enhancing its utility for a wider range of applications. GEE could further enhance its user interface, making it more intuitive and user-friendly, thereby lowering the barrier to entry for new users. GEE is likely to incorporate more machine learning and artificial intelligence capabilities, enabling automated analysis and extraction of insights from geospatial data.

Conclusion

This publication showcases the GEE platform's ability to handle large datasets and create automated programs that can be used operationally. This advancement is crucial in addressing environmental challenges and achieving the UN's millennium development goals. The applications demonstrated in the publication cover a wide range, including mining, agriculture, ecosystem services, and drought monitoring. With platforms like GEE, it is now possible to monitor phenomena daily, monthly, seasonally,

and long-term, at high spatial resolution and over large areas. Google Earth Engine is poised to continue evolving, offering new features and datasets to support research and decision-making in the field of Earth sciences. With its advanced analytics, expanded data coverage, and improved user interface, Google Earth Engine is set to remain at the forefront of geospatial analysis, helping unlock Earth's secrets and inform more sustainable practices for the future.

References

- Aguilar, R., Zurita-Milla, R., Izquierdo-Verdiguier, E., & de By, R. A. (2018). A cloud-based multi-temporal ensemble classifier to map smallholder farming systems. *Remote Sensing*, 10(5). <https://doi.org/10.3390/rs10050729>
- Chi, M., Plaza, A., Benediktsson, J. A., Sun, Z., Shen, J., & Zhu, Y. (2016). Big Data for Remote Sensing: Challenges and Opportunities. *Proceedings of the IEEE*, 104(11). <https://doi.org/10.1109/JPROC.2016.2598228>
- Gorelick, N., Hancher, M., Dixon, M., Ilyushchenko, S., Thau, D., & Moore, R. (2017). Google Earth Engine: Planetary-scale geospatial analysis for everyone. *Remote Sensing of Environment*, 202. <https://doi.org/10.1016/j.rse.2017.06.031>
