International Cartographic Association
Association Cartographique Internationale

Cartography, Quantitative Geography, and Earth Observation for Sustainable Development

Lorenzo De Simone [a] , Britta Ricker [b,*]

[a] *Agrifood Economics and Policy Division, Food and Agriculture Organization United Nations, lorenzo.desimone@fao.org*
[b] *Copernicus Institute for Sustainable Development, Utrecht University, b.a.ricker@uu.nl*

* Corresponding author

Keywords: Earth Observation, cartography, statistics, SDG

In the context of sustainable development, maps function as quantitative representations of the world rather than purely descriptive products. Cartography has long been central to quantitative geography through spatial measurements, data aggregation, classification, generalization, and considerations at different spatial scales. Map elements and visual variables are used to represent measured data that are aggregated, compared, and validated against statistical standards necessary to accurately convey information for decision making in an effort to achieve sustainable development. Reliable and accurate spatial data are needed to make accurate maps to inform local and global sustainable development agendas and help facilitate sustainable interaction with the environment (Le Sourd and Ricker, 2025). Countries are responsible for collecting and analyzing their own data to evaluate sustainability in terms that are relevant locally. Through the United Nations (UN) Sustainable Development Goal (SDG) Indicator Framework, countries are invited to share their data with the UN to monitor progress globally. A significant challenge for governments is collecting, accessing and analyzing data necessary for monitoring progress towards sustainable development, and is particularly challenging in resulting in data missingness (Gosling-Goldsmith et al, 2020). In addition to traditional data sources, alternative data sources are increasingly being encouraged and accepted for authoritative sustainable development monitoring by the international community and the UN (Arnold et al., 2019).

Earth observation (EO) data are continuously and ambiently being collected by satellites orbiting the earth, and are often publicly available (Gorelick et al, 2017). Unlike traditional manual survey methods, satellite systems deliver globally continuous coverage with regular temporal frequency. Every pixel is an observation. EO data can be used to identify spatial pattern on the Earth's surface both natural (i.e. forest health, crop type identifying mineral deposits and other land cover) or manmade (i.e. crop yields, urban heat islands, night lights). EO infrastructures offer systematic sampling across spatial scales, enabling dense temporal observations that capture seasonal dynamics and consistent measurements across regions necessary for comparative analysis (De Simone et al, 2025). These data can be used to identify where specific interventions are required to address sustainable development that otherwise would be impossible (Ferreira et al., 2020; Mondal et al, 2020). Satellite derived maps represent measured spatial variables, enabling repeatable and comparable analysis over time. This temporal regularity make it possible to monitor crop phenology, land use changes over time, including seasonal variations, as well as urban growth, industrial changes and more. Several workflows have been identified for using EO data for SDG indicator monitoring (Kussul et al., 2020; Mondal et al, 2020). For governments and individuals to use and analyze these open data, is a valuable form of data sovereignty (Hummel et al, 2021).

While advances in technologies have vastly improved data collection, storage, and parallel computing power necessary for quick analysis of big datasets, challenges related to spatial data collection remain. Data analysis methods are fragmented across research domains and scholarly literature, algorithms or analysis methods are not always open, transparent or reproduceable, links to official statical standards remain weak, uncertainty in quantification absent, validation against ground truth data is inconsistent (De Simone et al, 2022 & De Simone et al., 2025). Cartographers and mapping agencies need guidance to ensure EO derived maps are statically robust, reproduceable and policy relevant. Standardization methods are necessary; otherwise, maps are not reliable for official use. Analysis methods ought to match the phenomenon being analyzed (Maxwell et al., 2018). To address these challenges, the *United Nations Handbook on Remote Sensing for Agricultural Statistics* (Camara, De Simone & Jansen, 2025) provides practical guidance for incorporating EO data into operational workflows necessary for statistics and mapping including reproducible methods essential for generating reliable and accurate maps. Conceptual descriptions of EO strategies including potential applications(agriculture planning and monitoring, forest management), operational workflows including step-by-step instructions in the form of interactive tutorials, example code and data, and suggestions for integration into official standards required for national statical systems and quality frameworks are all included. Examples include crop type and land use maps, yield and productivity surfaces, survey- supported mapping, and calculating official UN Sustainable

https://doi.org/10.5194/ica-abs-11-5-2026

Development Goal indicators. The aim is to reflect the maturation of earth observation from experimental technology into an established tool for official cartography and agricultural intelligence.

EO data offers a necessary data source for scientific operations to measure what is happening on the Earth's surface. New and relevant SDG indicators are needed to meet the SDGs (Hák, et al 2016). Utilizing these ubiquitous innovative EO data could bolster our understandings of human interactions with the environment and inspire new and relevant ways to map SDG indicators and identify localized solutions. Harnessing EO in these ways transforms cartography from an art to measurable science necessary for achieving the Sustainable Development Goals.

References

Arnold, S., Chen, J., & Eggers, O. (2019). *Global and Complementary (Non-authoritative) Geospatial Data for SDGs: Role and Utilisation*. https://ggim.un.org/documents/Report_Global_and_Complementary_Geospatial_Data_for_SDGs.pdf

De Simone, L., Pizarro, E., Paredes, J., Jopia, A., Camara, G., Defourny, P., & Bontemps, S. (2025). Quality control of training samples for agricultural statistics using. Statistical Journal of the IAOS, 41(2), 467–481. https://doi.org/10.1177/18747655251338033

De Simone, L., Navarro, D., Gennari, P., Pekkarinen, A., & de Lamo, J. (2021). Using standardized time series land cover maps to monitor the SDG indicator "mountain green cover index" and assess its sensitivity to vegetation dynamics. International Journal of Geo-Information. ISPRS *10*(7), 427; https://doi.org/10.3390/ijgi10070427

De Simone, L., & Gennari, P. (2022). Earth observations for official crop statistics in the context of scarcity of in-situ data. Statistical Journal of the IAOS, 38(3), 1009–1019. https://doi.org/10.3233/ SJI-220054

Gilberto Camara, de Simone, L., & Jansen, R. (2025). *United Nations Handbook on Remote Sensing for Agricultural Statistics* (First). https://fao-eostat.github.io/UN-Handbook/

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, 18–27. https://doi.org/10.1016/j.rse.2017.06.031

Gosling-Goldsmith, J., Ricker, B., & Jan Kraak, M. (2020). Topographic and thematic (in)visibility of Small Island Developing States in a world map. *Journal of Maps*, *16*(1), 50–56. https://doi.org/10.1080/17445647.2020.1736194

Ferreira, B., Iten, M., & Silva, R. G. (2020). Monitoring sustainable development by means of earth observation data and machine learning: A review. Environmental Sciences Europe, 32(1), 1–17. https://doi.org/10.1186/s12302-020-00397-4

Hák, T., Janoušková, S., & Moldan, B. (2016). Sustainable Development Goals: A need for relevant indicators. Ecological Indicators, 60, 565–573. https://doi.org/10.1016/j.ecolind.2015.08.003

Hummel, P., Braun, M., Tretter, M., & Dabrock, P. (2021). Data sovereignty: A review. *Big Data and Society*, *8*(1). https://doi.org/10.1177/2053951720982012

Kussul, N., Lavreniuk, M., Kolotii, A., Skakun, S., Rakoid, O., & Shumilo, L. (2020). A workflow for Sustainable Development Goals indicators assessment based on high-resolution satellite data. *International Journal of Digital Earth*, *13*(2), 309–321. https://doi.org/10.1080/17538947.2019.1610807/FORMAT/EPUB

Le Sourd, G. L., & Ricker, B. (2025). Cartography for global sustainable development agendas: Informing public policies with geospatial information and knowledge for people, places and planet*. *International Journal of Cartography*, *11*(3), 428–457. https://doi.org/10.1080/23729333.2025.2532942

Maxwell, A. E., Warner, T. A., & Fang, F. (2018). Implementation of machine-learning classification in remote sensing: An applied review. *International Journal of Remote Sensing*, *39*(9), 2784–2817. https://doi.org/10.1080/01431161.2018.1433343

Mondal, P., McDermid, S. S., & Qadir, A. (2020). A reporting framework for Sustainable Development Goal 15: Multi-scale monitoring of forest degradation using MODIS, Landsat and Sentinel data. Remote Sensing of Environment, 237, 111592. https://doi.org/10.1016/J.RSE.2019.111592

Abstracts of the International Cartographic Association, 11, 5, 2026
ICA Cartography and Sustainable Development Workshop, 26–28 January 2026, University of Aruba, Oranjestad, Aruba.
https://doi.org/10.5194/ica-abs-11-5-2026