Position paper of sectoral department

Remote Sensing and Geographical Information

The Background

The use of earth observation and geoinformation is indispensable in many international development cooperation (DC) projects as a basic component of data collection, analysis and decision-making. Earth observation can play a particularly important role in planning, project steering and documenting results, both at the global level and for individual development cooperation projects. Geoinformation refers to all spatial data that are processed with the help of Geographical Information Systems (GIS). Earth observation is a special sub-area of geoinformation in which drones (or 'unmanned aerial systems' UAS to be precise), helicopters, planes and satellites are used to collect data. The number of earth observation satellites increased from about 200 in 2014 to around 900 in 2021, and the availability of earth observation data rose accordingly. Important data that are collected in-situ at ground level include data from land surveys or weather measurements. Data without a direct spatial reference, such as statistical data, measurement data or survey data, can also be integrated into a GIS by establishing a spatial reference, e. g. through georeferencing.

Geoinformation provides comprehensive data on many areas of human development, such as environment, climate, agriculture, industry or settlement. The possibility of combining diverse data sets, analysing them in relation to each other and visualising them makes geoinformation technologies a powerful tool for development cooperation.

13 of the 17 SDG indicators can now be measured using satellite imagery, such as the percentage of degraded land and sustainably managed forests (SDG 15 Life on Land) or the ratio between the land consumption rate and the

Key terms

Artificial intelligence (AI): Based on automated machine vision technology, AI is often used to improve or accelerate the identification of objects or changes. Time is needed to train an algorithm, particularly at the start (machine learning).
Crowd sourcing: In the field of earth observation and geoinformation, crowd sourcing usually means that users voluntarily cooperate in collecting or creating geoinformation and make results available free of charge. Outside of the area of geoinformation, Wikipedia is the most famous example.
Resolution of raster data: The areas where raster data can be applied are primarily determined by the resolution of the raster datasets. Whereas large raster cells (with an edge length greater than 1 km) are frequently used for global analyses such as weather observation, images with a higher resolution (less than 80 cm) are used to monitor construction progress. Satellite images are defined, among other things, by their spatial, temporal and spectral resolution as well as cloud cover.
Raster data: Raster data consist of pixels (image points) that play a major role in this context. A wide variety of remote sensors are used on drones, aircraft and satellites, including multi and hyperspectral sensors (which also record data outside the light spectrum visible to humans), and radar systems. The data collected must always be processed further to obtain workable information. Well-known examples of raster datasets are the ASTER and SRTM digital elevation models.
Vector data: Geometric objects (points, lines, polygons) can represent the location of hospitals (points), roads (lines), and parcels of land (polygons).

population growth rate (SDG 11 Sustainable Cities and Communities).

Although the use of these systems has risen sharply in recent years, many partner countries have only very limited capacities to make sufficient use of earth observation and geoinformation. New commercial satellite fleets with high spatial and temporal resolutions as well as comprehensive public programmes (e. g. Copernicus) have virtually eliminated the limitations in data availability. However, partners often lack the capacities required for local data collection, data access, data processing and complex data analysis for decision-making processes. Two facets play a role in this context. Firstly, there is a lack of opportunities to train qualified experts for public administration and private companies and secondly, few countries have a well functioning national spatial data infrastructure (SDI). Frameworks for regulating the use of drones, for example, are also often lacking. Satellite fleets and comprehensive public programmes that convert data into a usable format (such as Copernicus) are complemented by commercial providers that can offer higher spatial and temporal resolutions in individual cases. These programmes are complemented by commercial providers that can offer higher spatial and temporal resolutions in individual cases. As a result, the challenge in accessing data is now less about availability and more about ensuring sufficient capacities to process the data, both in terms of personnel and infrastructure.

Many partner countries are still looking to strike the right balance in their regulatory frameworks. Some countries place strict restrictions on the use of earth observation data by the civil society sector and limit access primarily to security authorities. Other countries see the potential for use by citizens, but fear loss of their data sovereignty through cross-border data flows (e. g. through cloud computing – the storage and processing of data on servers in third countries). A lack of regulations hinders widespread use by citizens, especially in the private geoinformation sector.

Many countries enforce regulations on the use of civilian drones (see the Global Drone Regulations Database for more information). Regulatory gaps are being closed in many parts of the world. A lack of (transparent) regulations on the use of unmanned aerial systems can lead to risks in the import and use of such systems and, in extreme cases, to their confiscation. The EU regulations on drones (2019/947 and 2020/746) have been in force since January 2021.

Data without a spatial reference are often linked with vector data, allowing them to be compared with other data in a spatial dimension, e. g. the visualisation of election results by region.

GIS data and software availability:
Many organisations are making significant efforts to continuously make global data sets available via data hubs (e. g. Copernicus Open Access Hub, EarthExplorer, EUMETSAT data centre)and data cubes (e. g. Open Data Cube, Digital Earth Africa, EarthServer). Interfaces are often offered to seamlessly integrate data into existing systems and solutions. Online platforms such as ClimateEngine, Google EarthEngine or ESA's EarthOnline facilitate the analysis and visualisation of spatial data. These and similar cloud-based platforms often combine data sources as well as analysis tools, and are usually user-friendly, as they are developed for a broad user base. Basic knowledge of the area is usually required, however. Experts can draw on a wealth of open source tools for presentations, processing and analysis. One example of a well-established, successful project is the open-source desktop GIS QGIS. The Open Source Geospatial Foundation (OSGeo) is the leading institution in this field.

The use of earth observation data is regulated by the UN Outer Space Treaty of 1967, which had been ratified by 110 states by November 2020. It fully endorses earth observation activities.

The strategic guidelines for using geoinformation technologies in German development cooperation are the Digital Strategy of the Federal Ministry of Economic Cooperation and Development (BMZ) and the UN's strategy paper Integrated Geospatial Information Framework (IGIF). The German Federal Government's Copernicus Strategy advocates sustainable solutions through the rational use of resources and capacity development.

Use of these systems offers huge potential. The geoinformation industry is experiencing steady growth worldwide. Technological megatrends such as machine learning and artificial intelligence (AI) have been used in geoinformation for some time now. Numerous development organisations use geoinformation products to run algorithms and compile statistics and analyses, e. g. to conduct automated observations of deforestation or measure soil rehabilitation. Earth observation initiatives such as the European Copernicus programme have been making high-quality satellite images available free of charge for several years.

The use of geoinformation is also steadily increasing at GIZ. Around 80 GIZ projects at over 130 locations use geoinformation obtained through earth observation. In 2019, around 40 projects also used unmanned aerial system technologies. 28% of the projects that use geoinformation products are in the rural development sector, followed by the environment and climate sector (23%), forests and biodiversity (18%), crises, conflicts, disasters (18%), water, sanitation and water resources (9%) and sustainable infrastructure (4%). Projects in the areas of urbanisation, governance, etc. also offer interesting potential. Examples of applications are varied and include participatory planning, crop area estimation, biodiversity monitoring, deforestation monitoring, emergency relief routing, water extraction management and transport planning.

Our position

■ **Earth observation and geoinformation offer enormous potential for development cooperation**

Thanks to technical developments in recent years and the availability of free data and software, earth observation and GIS now offer greater potential than ever before. In addition to better accessibility via the internet and the high quality of spatial data, information density has also increased considerably in recent years, enabling detailed analyses of changes in the earth's surface over longer periods of time. Machine learning facilitates better and faster evaluation of earth observation data. Cloud computing allows data collection, storage and processing to be outsourced to web-based applications. This reduces on-site hardware requirements, costs and enables the use of mobile devices (such as smartphones and tablets) for example for remote sensing and data collection, as well as data collection via crowd sourcing. Whether used independently or in combination with field surveys to ensure ground truthing, these technologies increase the efficiency of questionnaires, monitoring processes and the mapping of land use and land tenure. Earth observation data also offer strong potential as a neutral data source for mediating land use conflicts, monitoring the use of agricultural land and forecasting crop yields. The interoperability of most geoinformation systems and databases also allows for the flexible expansion of possible applications. The simple and straightforward visualisation of geographic contexts enables content to be presented in an uncomplicated and effective manner, with a wide range of visualisation options from maps to 3-D.

■ **Earth observation and geoinformation create transparency**

Presenting geoinformation as maps or images is an easily understandable and effective form of communication.

Earth observation data are often real-time data (e. g. satellite images) that are generated and made available automatically. This ensures a high degree of transparency, e. g. in planning, participatory processes, monitoring or in the resolution of land use conflicts.

Spatial data can be used to support advisory services to partner countries and enable participation, e. g. by involving the local population in planning project activities. Another typical field of application is their use in devising transparent solutions to conflicts over land and the use of resources. By visualising real-time data and time series, it is possible, for example, to depict changes to the landscape and develop decision-making tools for adaptive management.

Data transparency always involves data protection risks however. GIZ therefore complies with European legislation EU General Data Protection Regulation and, where available, national data protection standards, in order to ensure the security of personal data and prevent misuse. The Principles for Digital Development are also guiding principles in this context.

■ **Earth observation and geoinformation technologies contribute to sustainable development**

Free data and tools make it easy to implement solutions in a wide variety of contexts. In addition, costs for hardware have been dropping for some years now and individual capacities can be developed through free, internet-based self-study courses. All of these aspects have led to a considerable reduction in costs in recent years and thus to more widespread use. Particularly partner countries with limited financial resources can now glean the benefits of geoinformation and earth observation in a wide range of sectors without significant investment. According to PWC estimates, the economic benefits outstrip the investment costs many times over. The additional information generated has considerable potential to influence decision-making for sustainable development.

Our recommended actions

■ **We recommend awareness-raising measures and analyses of the regulatory framework for DC projects.**

Awareness-raising and/or advisory measures support political decision-makers in assessing issues such as military versus civilian use, data security and data sovereignty. Analysis of the regulatory framework in Germany, Europe and, where available, in partner countries provides clarity about potential application areas.

The following questions should be clarified at the start: (1) How and where can/may personal data and geodata be legally stored and processed after collection, (2) can data be legally stored and processed outside a partner country, (3) which data protection regulations apply to the handling of personal data (e. g. names, family relationships, IDs, signatures, certificates, etc.) and geodata (e. g. infrastructure data), both of which are sometimes sensitive.

■ **We recommend developing capacities in data processing and analysis, hardware and software skills, and services for decision-makers**

The establishment of cross-sectoral and cross-organisational networks in the area of geoinformation is essential for capacity development and for effective use of the methodology. The capacities of institutions must be strengthened in a targeted manner. Projects with spatial impacts must ensure that a basic understanding of how to use earth observation and geoinformation is in place. To promote the sustainability of projects, capacities must also be developed in partner countries to manage systems and work with them in the long term. To this end, training opportunities must be created and supported in the form of university courses (e. g. geoinformatics), apprenticeships (e. g. surveying technology) and in-company training. In this context, it makes sense to support initiatives that can help develop infrastructure and competences in dealing with earth observation data. Examples include the Global Monitoring for Environment and Security (GMES) Initiative launched by the African Union (AU) and the European Union (EU).

Special training should be provided for decision-makers to highlight the potential of earth observation and increase their confidence in interpreting analysis findings. This training strengthens confidence in the technology and supports the decision-making processes of key actors in government and administration.

■ **We recommend identifying and promoting sustainable fit-for-purpose solutions**

Since the requirements for spatial data sets and for software and hardware are specific to each individual application area, it is vital that a careful, contextrelated analysis of the need for data, software and hardware be carried out. Planning should provide clarity on the type, cost, licensing and level of maintenance for the geoinformation products to be used, as well as the software and hardware to be installed. Data with free licences, such as those provided under the European Commission's Copernicus programme, are particularly sustainable. Open source software is already widely used in the geoinformation sector. Even if operating and maintenance costs continue to be incurred, this software can be a more sustainable solution, partly because it can be used long-term independently of the manufacturer (no vendor-lock-in) or service provider. Software and hardware should be compatible and appropriate to the application context. A stable internet connection makes it easier to develop sustainable solutions. Local user languages should be taken into account where appropriate. Before purchasing software, hardware or data, it should be clarified whether a new purchase or development is necessary, or whether existing solutions can be upgraded. Here, it is important to realistically assess the costs (including maintenance). The ratio of costs and benefits to objectives and outputs should be reasonable, and should be based on the geographical coverage and population size in the application area. Although satellite data are often free of charge, further processing requires suitable geoinformation software, trained staff and necessary hardware.

■ **We recommend considering the cost-benefit ratio when selecting data**

High-quality data and tools are easy to access, affordable or in some cases even free of charge. However, the requirements for geodata vary according to the type of data and the context in which they are being used. The following general points should be clarified before acquiring geodata: the time or time series of acquisition, geographical extent, resolution, type of processing and licensing conditions. Since raster and vector data are fundamentally different, it is important to be aware of their specific characteristics. In the context of development cooperation, most application scenarios can be covered by freely available data, such as those provided by the Sentinel programme of the European Space Agency

(ESA) or by the NASA/USGS Landsat program (e. g. RIICE: Remote Sensing-based Information and Insurance for Crops in Emerging Economies). However, some areas of application require satellite images in the sub-metre range and these are only available from commercial providers. This is often the case in projects that operate in urban contexts or in the security sector, but there are other application areas too, such as the GIZ project Ecosystem-based Management and Application of Ecosystem Values in Two River Basins in the Philippines. Here, it is important to weigh up the trade-offs between costs, resolution and the need for increased computing power.

■ **We recommend paying special attention to data security and data protection**
When planning the use of earth observation or geoinformation data in development cooperation projects, a data security and data protection concept should always be drawn up too. The top priority is to protect personal data from access by unauthorised third parties and thus from the misuse under GDPR that this would constitute.
Data security and data protection require clarification of access rights, type and purpose of use, obligations to provide information and deletion of data, but also – most importantly – technological solutions to cope with these tasks. The use of cloud-based solutions, which often have very high security standards, requires coordination with partners.
Data protection standards in many countries are less strict than the European regulation. The extent to which European standards can also be used to avoid data protection risks should be examined.

Innovations

■ GIZ recommends that the earth observation and geoinformation opportunities presented above be considered and used in development cooperation on a fit-for-purpose basis. Two different types of innovation offer scaling-up potential:

- Incremental innovation: The global dissemination of earth observation and geoinformation systems is being fuelled by rapidly dwindling costs for hardware, software, data and internet, especially over the past 15 to 20 years.
- Transformative innovation: New technological solutions are market-ready and are changing global processes, e. g. drone use for data collection in the Strengthening Drought Resilience (SDR) programme in Ethiopia.

In many thematic areas, spatial data could be used to a greater degree, within the context of corresponding analyses, to produce new or better-quality findings that would facilitate decision-making. The digitisation of local data alone would generate an ongoing source of available data and thus offers enormous potential for making processes more efficient and effective, e. g. in administration, and freeing up resources that could be deployed elsewhere.

Cooperation partners

GIZ's cooperation partners include the European Space Agency (ESA), the German Aerospace Center (DLR) and the University of Würzburg. Cooperation arrangements focus on capacity development and on piloting new methods and products (e. g. the identification of plant species and of sites for construction measures).
GIZ routinely seeks professional exchange with research institutions and with private companies from the geoinformation industry. Cooperation arrangements in partner countries are particularly important, as universities and private companies are usually already active in the field, and their capacities can be an important building block for expanding the use of spatial data in the country in question.

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