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Historical and Time Stamped GeoData for Sustainable Development Goals

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"Historical and Time Stamped GeoData for Sustainable Development Goals"

EuroSDR Workshop, 23th - 24th April 2024, Zagreb, Republic of Croatia

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HISTORICAL AND TIME STAMPED GEODATA FOR SUSTAINABLE DEVELOPMENT GOALS

EuroSDR Workshop

23th - 24th April 2024, Zagreb, Republic of Croatia

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Abstract

Reference geodata are a core asset to produce comparable indicators about the place we live in, at different granularities, from local scales to the planet. This is particularly true for the indicators of the United Nations Agenda 2030, specific quantitative measures associated with the 17 Sustainable Development Goals. Historical geodata can be used to compute indicators back in time and grasp the dynamics of the underlying phenomena. It requires specific methodologies to cope with it because of its heterogeneities, and also specific expertise to discover, process and interpret it. Approaches have been developed to valorise historical and time stamped geodata to contribute to compute sustainable indicators back in time and are presented in this report. Some have now reached a certain maturity. Beside technology, an important stake is to engage with all legitimate stakeholders and to define the appropriate governance and partnership to improve the usage of historical geodata to reach Sustainable Development Goals.

1 INTRODUCTION: Geohistorical Data for a Common Sustainable Future

Achieving a sustainable future is an essential challenge for our societies. A first step is to achieve a shared vision of what is a sustainable future for humanity on earth. The “nine planet boundaries” scheme identifies different global change processes and corresponding boundaries that should not be overpassed to avoid dramatic disruption of conditions on planet earth (Rockström et al. 2009). These processes are: climate change, ocean acidification, stratospheric ozone depletion, biogeochemical flows in the nitrogen cycle, excess global freshwater use, land system change, the erosion of biosphere integrity, chemical pollution, and atmospheric aerosol loading. The DoughnutEconomics, illustrated in Figure 1, adds to that “9 planet boundaries” scheme humanity requirements, like for example social equity and education (Raworth 2012). In that vision, a sustainable future is a situation where change processes are kept below the thresholds of the planet boundaries, and where each human is living above core social foundations.

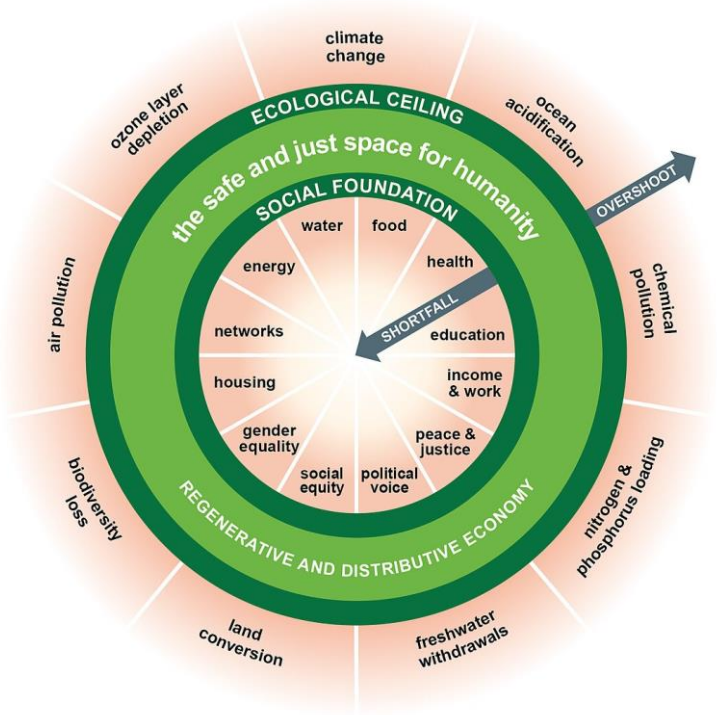

Figure 1: The DoughnutEconomics represents sustainability as a situation below the ecological ceiling (i.e. planet boundaries) and above the social foundation for humanity.
Copyright: Raworth K., CC BY-SA 4.0

That Doughnut scheme has been adopted by the United Nations to define their Agenda 2030 to eradicate poverty, protect our planet and improve our daily lives. UN Agenda 2030 aims at getting all countries into the green area of Figure 1 (UN 2015). To guide actions, UN Agenda 2030 defines seventeen so-called Sustainable Development Goals (SDGs), see figure 2. For example, SDG 11 “sustainable cities and communities" is defined as follows: “make cities inclusive, safe, resilient and sustainable” . Goals are associated with targets and indicators to guide the action, like target 11.3: "by 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries". An indicator for the above target 11.3 is 11.3.1: "Ratio of land consumption rate to the population growth rate".

Figure 2: The 17 Sustainable Development Goals of the UN Agenda 2030. After (UN 2015)

There are altogether 231 indicators to be computed year after year and for each country, and to be associated with details about how the national value was computed. Indicators at subnational scale can guide national action. Indicators computed at different times are used to monitor progress and evaluate trends. They can also be used to compare situations across places and benchmark experience. Last, they also are an opportunity to study trade-offs and synergies between the different targets, and to revise the agenda.

Historical and time-stamped geographical data range from scans of very old maps to five years old digital born topographic data. They are a key asset to model landscape back in time and represent for example past buildings, wetlands, natural watercourse, chemical industry, unexploded bomb craters and mass graves that were visible decades ago and that can no longer be observed. When they are available at different timestamps, they can provide temporal depth to some aspects of SDG dashboards, for example to model a series of land consumption rates, shifts of coastlines or of glaciers. Surveys from the past combined with other data can be used more generally to observe trends, detect correlations, in place and time, between evolutions of societies and of our planet and understand different dynamics on the ground. Portals that support the visualisation of different geo-historical data meet tremendous success. As Europe offers a variety of landscapes, institutional context and cultures, such a capacity to go back in time, to establish possible correlations, in European territories is a wealth to inform sustainable land planning and other activities.

Valorising historical and time stamped geodata to provide temporal depth to SDG dashboards is hindered. The global process of identifying which data exists, how to access it is still complex because of the many different authorities and portals. Moreover, this data requires different processing technologies and specific expertise to evaluate uncertainties of derived data and interpret results. The high heterogeneity of data calls for advanced integration methods.

The EuroSDR workshop Historical Data For SDGs was organised to exchange findings on the relevance of historical geodata to observe past landscapes and inform our actions for a sustainable future. These findings can relate to applications in different areas of sustainable development or to methodological findings on the processing of such data. It was organised with no specific focus on one SDG or another nor on a type of geodata. Presented works embrace different types of geodata, from scanned historical maps to versioned vector data dating back one or two decades ago. Addressed SDGs mainly are SDG 11 about sustainable cities, SDG 13 about climate action, SDG 15 about Life on land, and SDG 16 about peace, justice and strong institutions.

2 The need for core historical and time stamped geodata for analysing SDGs across Europe

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The United Nations have created specific committees to organise knowledge exchange between countries about how to model physical geography and society in a way comparable across countries and in time. These are the regional UN Global Geospatial Information Management (UNGGIM) committees: Africa, Asia-Pacific, Arab States, Americas and Europe. Statistical and mapping communities are strongly involved in these committees.

UNGGIM Europe identifies "geospatial priority data", considered as the most useful to analyze, achieve or monitor the SDGs within Europe (UN-GGIM WG1 2014). Fourteen types of core data (called themes) have been identified to compute the indicators in a harmonized way: administrative units, addresses, cadastral parcels, transport networks, hydrography, geographical names, ortho-image, land cover, elevation, statistical units, buildings, land use, regulated areas, and basic services. The definition of these core data is consistent with the different themes and data schemas proposed in the context of the European geographic information infrastructure for environmental policies, INSPIRE (European Parliament 2007). Yet, while the INSPIRE directive identified federated schemas to exchange and reuse existing data, UN GGIM Europe can recommend the production of core data when it does not exist in a country.

With respect to time, the priority and short-term objective is the provision of valid, current data and commitment to regular update frequency. The group also defines good practices, i.e. mid-term objectives more difficult to achieve. Members are encouraged to keep available for users the data already produced during past years. For vector data they are encouraged to adopt INSPIRE mechanisms of life-cycle attributes and incremental updates. For coverage data, they are encouraged to keep previous versions available. UNGGIM Europe also delivers considerations for the future: objectives considered as quite desirable but not yet mature enough where the committees aim to be an incentive for research and knowledge exchange. This is the case of producing historical data that has been identified for several themes, see figure 3. The committee mainly targets historical data not older than the middle of the twentieth century. Historical addresses may be required to check identity documents or to geocode business registers. Historical administrative data or statistical units are required to display time series of statistics. As hydrography, these data are needed to show the trends on a given topic through time. Historical regulated areas and land cover are useful to observe the evolution of land cover during a long period. Historical orthoimages are a good data source to observe different features.

3 Implementation of SDG Indicators in Spain: the role of High Resolution and Historical Land Use/Land Cover information together with Settlements reference data

Authors: Samuel Parada, Julián Delgado and Gonzalo Benayas
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Computing national indicators requires local data. However, in small municipalities and settlements both spatial and statistical information is usually scarce. Hence, Spain has engaged in the definition of a framework to secure the availability of homogeneous data describing local entities in detail, particularly those with limited funding for geospatial data. This framework will ease the production of national indicators, the documentation of these national indicators and also the comparison between local situations.

The main objective of this work is to explore the use of data from the Land Cover and Land Use Information System of Spain (SIOSE) and the Geographical Reference Information of Settlements (IGR-Poblaciones) in order to implement a set of SDG indicators in local entities in Spain. SIOSE offers land cover and land use data corresponding, respectively, to Annex II, theme number 2, and Annex III, theme number 4 of the INSPIRE Directive. Likewise, IGR-Poblaciones contains data related to Annex I, theme numbers 3 (Geographical Names) and 5 (Addresses), and Annex III, theme numbers 1 (Statistical Units) and 10 (Demography) of the same Directive. Moreover, Land Use/Land Cover and Settlements data are included in the 14 Global Fundamental Geospatial Data Themes established by the UN-GGIM and they are directly related to SDGs number 1 to 15.

From a technical perspective, SIOSE incorporates high resolution data from national and regional official authorities, e.g. cadaster data, Common Agricultural Policy data, the Spanish Forestry Map, among others, in a sole database. A historical version of this database dated at mid-20th century is being developed, which emerges as a fundamental tool for environmental, climate change and urban planning purposes in the SDG framework. SIOSE information is combined with IGRPoblaciones database, which provides the location, official name and geometric shape of population settlements while also offering different statistical parameters. A methodology to specifically compute SDG Indicators 11.3.1 "Ratio of land consumption rate to population growth" and 11.7.1 "Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities" for years 2014 and 2017 has been developed and applied to a collection of Spanish municipalities. The obtained level of details is greater than the municipal level, as illustrated in figure 3.

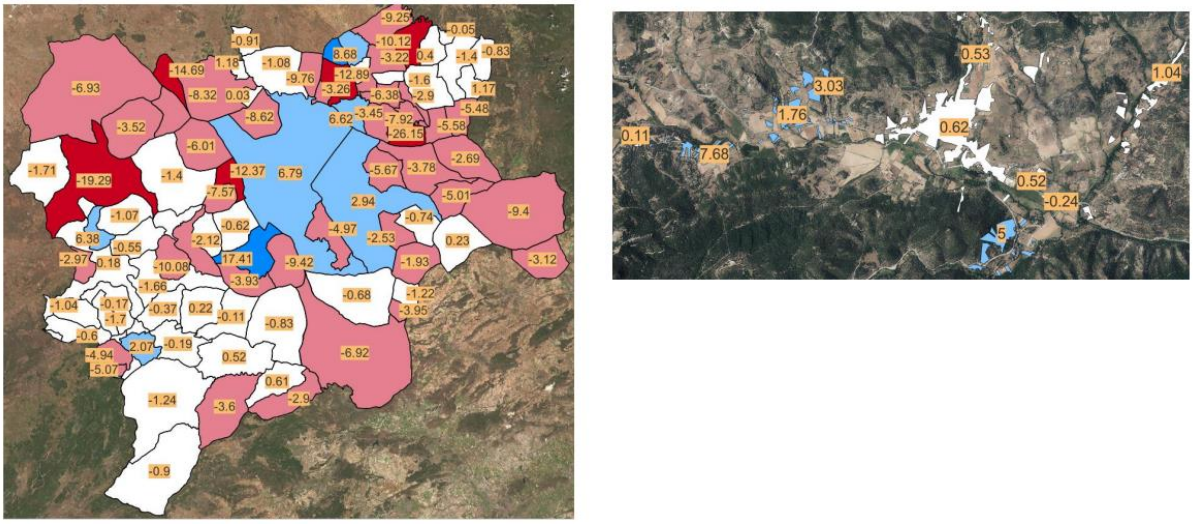

Figure 3: Visualisation of indicator 11.3.1 per municipality (left) and per settlement (right).

A production of historical land cover / land use data, illustrated in figure 4, is also being proposed by automatic analysis of the 1:50 000 historical national topographic maps, with the integration of national crop maps and historical orthophotos.

Future work considers the possibilities of applying this methodology with geospatial data to other SGD Indicators like 2.4.1, 11.2.1, 15.4.2.

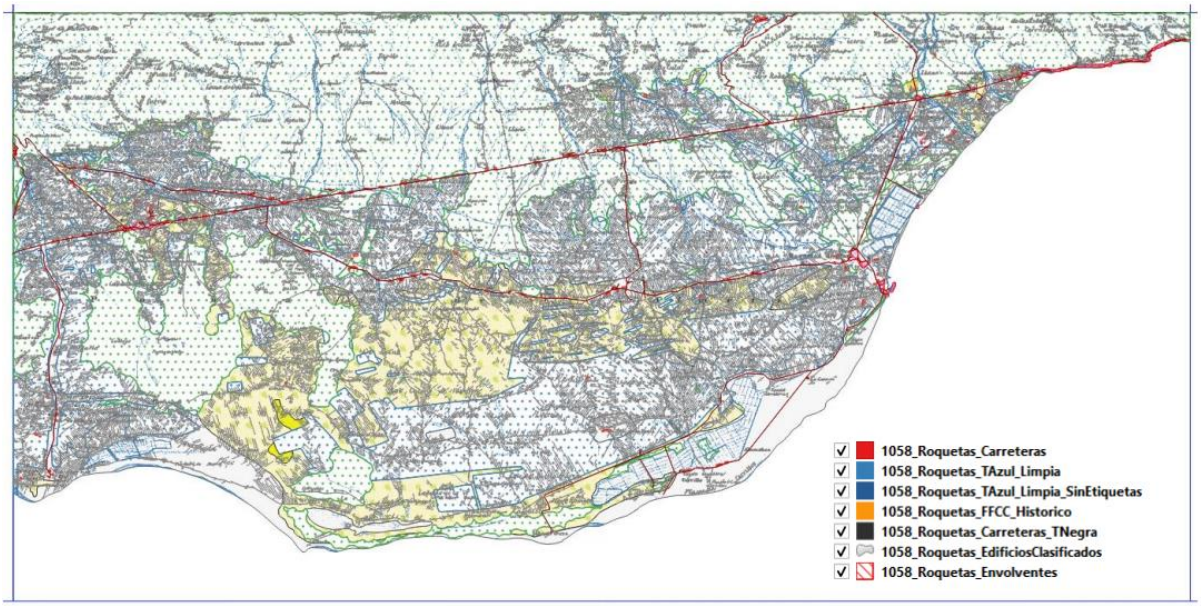

Figure 4: Historical LC/LU data ready for analysis.

4 Gauss Centre "The Temporal Change of Geospatial Data": Research agenda in the context of SDGs

Authors: Mareike Dorozynski [1)], Tobias Werner [2)], Mireille Fangueng [1)], Frank Thiemann [1)], Franz Rottensteiner [1)], Thomas Brinkhoff [2)], Philipp Otto [1), 3)], Monika Sester [1)], Torsten Dahms [4)], Michael Hovenbitzer [4)]
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The identification of land cover changes is of great interest for studies of various spatial processes, for example in the context of questions related to the development of populated areas or environmental protection. Such analyses require information about land cover and its changes for recent and past epochs, where time-stamped geodata such as remote sensing imagery and topographic maps can serve as sources of information. Against this background, the Federal Agency for Cartography and Geodesy (BKG, Germany) has established the Gauss Center[1]. In cooperation with the Leibniz University of Hanover (LUH) and the Jade University of Applied Sciences Oldenburg (IAPG), methods are being developed for the automated classification, organisation and analysis of geospatial data of varying age and quality (see Figure 5). The aim is to derive land cover information for different points in time and to enable computer-aided analysis of land cover time series. This enables one to receive specific knowledge about historical and current land cover and its changes by employing appropriate spatiotemporal database queries. It allows us to analyse the evolution of land cover, plan and monitor actions to achieve individual development goals and learn about potential interdependencies between social developments, economic activities and environmental changes. For instance, determining the land

[1] https://www.gausszentrum.uni-hannover.de/en/

cover in urban regions allows to do so for sustainable development of cities and communities (Goal 11), e.g. by classifying both sealed areas and vegetation to monitor the growth of a city, on the one hand, and on the other hand, to evaluate the need for green areas in a city.

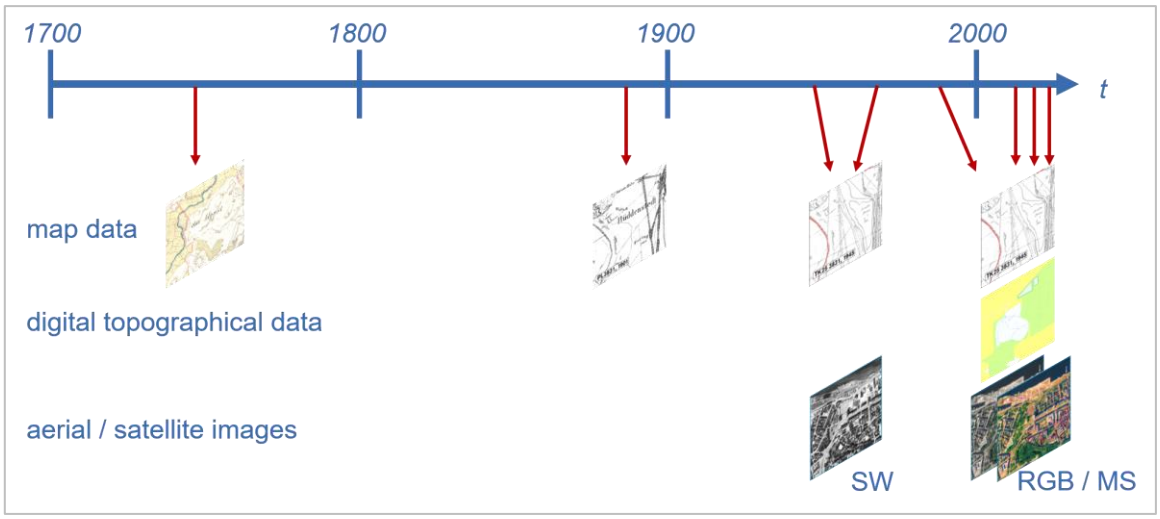

Figure 5: Exemplary presentation of the input data considered in the Gauss Centre as a function of time.

The project uses existing historical and current aerial photographs and map data as a data basis, where digital topographical data and satellite images are also taken into account for more recent points in time (see Figure 5). The information on the respective land cover is only implicitly contained in the majority of the data (image data or scanned map data). In order to enable the desired automated analysis, the original raster data must first be segmented according to a predefined object type catalogue and thus be digitised. All data, i.e. both the original raw data and the results of the segmentation, are stored in a database. This representation forms the basis for the automatic spatiotemporal analysis, which will be carried out in the project based on statistical investigations.

To make this workflow possible, various open research questions need to be pursued, such as: How can historical and current data be stored together? What structures can be used to harmonise data from different sources in a database? How can changes over time be analysed automatically? Which object types can be derived reliably, and with what accuracy from historical geodata? Which factors have a (statistically) significant influence on the city's growth and to what extent? Into which areas are cities expanding, and at what rate? For the automatic derivation of land cover from historical and current data, deep learning methods are primarily to be used. This raises the question of the type of network architectures and, in particular, their transferability. Finally, can significant influencing factors for selected spatial processes, such as urbanisation, be identified from the results of a statistical time series analysis? As part of the project, these open questions are to be answered using several suitable test areas in Germany.

A spatial database system (Alam et al., 2022) is used as the basis for organising spatiotemporal data, which enables interoperable data exchange in conjunction with standardised and project-specific interfaces. Besides vector data and grid coverages, data cubes will be supported to represent time series. Basically, the aim of the classification is to predict a land use class for land cover data (Sandmann et al., 2022). This class structure contains different types of vegetation, sealed areas, and water bodies, allowing for various spatiotemporal analyses related to issues in the contexts of the SDGs.

In a first experimental series for multi-modal land cover classification from aerial orthophotos and topographic maps (Dorozynski et al., 2024), a multi-modal classifier is compared to its two uni-modal counterparts, i.e. an aerial orthophoto classifier and a uni-modal topographic map classifier. The

classifiers are based on a UPerNet (Xiao et al., 2018) with a tiny Swin Transformer (Liu et al., 2022) with a patch size of 4 and a window size of 16 as an encoder that extracts features at four downsampling stages. For multi-modal classification, early fusion of the features is realised by stacking the features of both modalities (orthophoto and map) at all four downsampling stages. These combined features are presented to the decoder to achieve multi-modal land cover predictions; in the case of uni-modal classification, only the features of the respective single input modality are considered in the decoder. Experiments are conducted on two datasets in the region of Hamelin (Germany), each consisting of topographic maps 1:25,000 (TK25) from 2011, aerial orthophotos (DOP) from 2010, and a manually created reference based on the visual inspection of the DOP. One dataset (urban dataset) allows for the differentiation between "Building" and "No Building", while the other one (rural dataset) differentiates "Coniferous trees", Deciduous trees", "Crop", and a background class "Other". The results on the rural dataset show that an aerial DOP classification (mF1: 84.4%, OA: 92.4%) is currently to be preferred over a multi-modal classification (mF1: 83.7%, OA: 92.1%) and the map classification (mF1: 62.2%, OA: 65.1%). Similarly, the achieved quality metrics are the highest for the DOP classifier on the urban dataset (mF1: 89.2%, OA: 81.1%); the results of the TK25 classifier (mF1: 81.2%, OA: 86.9%) and those of the multi-modal classifier (mF1: 62.2%, OA: 65.1%) indicate that a later fusion scheme is likely to improve the multi-modal classification. This becomes particularly clear in the qualitative results achieved on the urban dataset (see Figure 6).

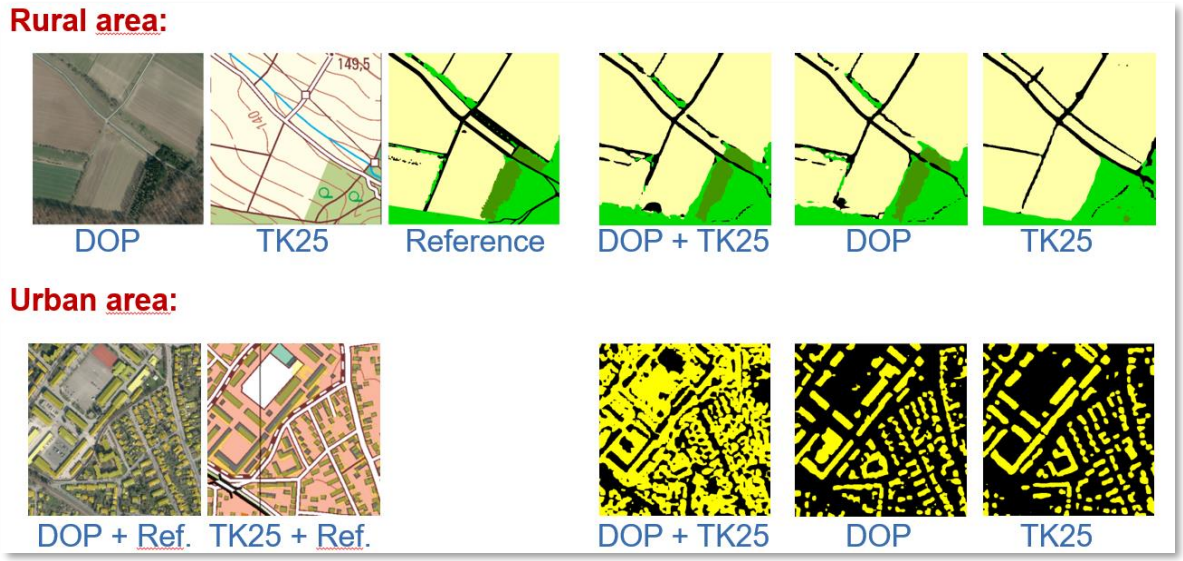

Figure 6: Qualitative results of uni-modal (DOP, TK25) and multi-modal (DOP+TK25) land cover classification.

As part of another joint project between the BKG and the Leibniz Institute of Ecological Urban and Regional Development (IOER, https://www.ioer.de/), the methods developed by the Gauss Centre are being used, and the results data produced across the board are being published in the IOER Monitor. The present work focuses on processes in urban areas and, in contrast, the IOER works on landscape modelling, such as in the contribution "Automated Detection of Landscape Features in Historical Maps to Support Climate Protection and Modelling".

5 Using historical aerial photogrammetric campaigns to retrieve the evolution of territories, HIATUS project

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In most European countries, aerial photogrammetric surveys have been carried out regularly since the Second World War. These historic images now form important archival collections. In France, they have been digitized and are now available online from a web service, enabling their use by the geomatics community. Archival aerial photogrammetric surveys appear as being a powerful remote sensing data source to study long-term land use/cover evolutions of territories over the last century. Indeed, these surveys form relatively dense time series, while exhibiting a very high spatial resolution data. Besides, they are generally stereoscopic surveys, making it possible to derive 3D information (Digital Surface Models). More specifically, the following use cases have been identified through empirical analysis of the image potential: study of artificialization and urban sprawl, study of forest extension, study of agricultural practices, coastline erosion, glacier evolution and archeology. This relates mainly to the following SDGs: SDG 11 about sustainable cities, SDG 13 about climate action, SDG 15 about Life on land.

However, several difficulties have to be faced to be able to use archived aerial photogrammetric surveys in automatic remote sensing analysis processes.

First, their fine georeferencing has generally been lost and only coarse information is still available. Retrieving a fine georeferencing of archival images is mandatory to obtain remote sensing products (ortho-images and digital surface models) suitable for a comparison between epochs [Giordano et al., 2018]. Another pre-processing issue states in the radiometric equalization of images, in order to obtain a homogeneous mosaic suitable with automatic classification processes. [Lelégard et al., 2020, 2021]

Second, the automatic analysis of historical data has to face other difficulties caused by their great heterogeneity (survey pattern, spatial resolution, spectral configuration, image quality) and the lack of ground truth data from the past.

The HIATUS project funded by the French research agency has established an automated pipeline to handle these heterogeneities, using automatic ground control points (GCPs) computation and a non-parametric model for the radiometry.

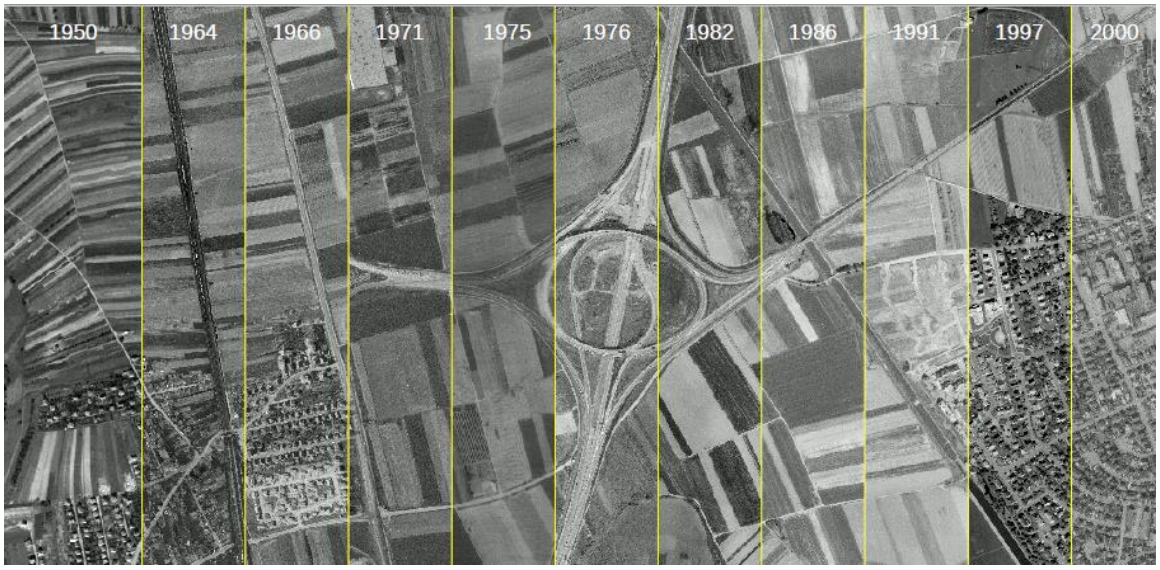

Figure 7: "Timeline" mosaic: ortho-images generated from several archival aerial campaigns.

Different use cases have been investigated [Fernandez-Garcia et al., 2023]; [Derminon et al., 2024]; [Barbosa-Ferreira et al., 2024].

6 Automated Detection of Landscape Features in Historical Maps to Support Climate Protection and Modelling

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[1)] Leibniz Institute of Ecological Urban and Regional Development (IÖR), Dresden, Germany
[2)] Federal Agency for Cartography and Geodesy (BKG), Frankfurt auf Main, Germany

Peatland and woodland areas play a crucial role in the global carbon cycle. The restoration of these areas contributes to substantial carbon dioxide sequestration. To inform and support active climate protection (SDG 13) such as e.g. restoration measures, the project investigates the potentials of automated detecting and extraction of former woodland and peatland areas. The work is promoted by the German Federal Agency for Cartography and Geodesy (BGK), which supports the efforts of digitization of historical geodata by another initiative (Gauss Center) that also includes newer time series data such as aerial images[2].

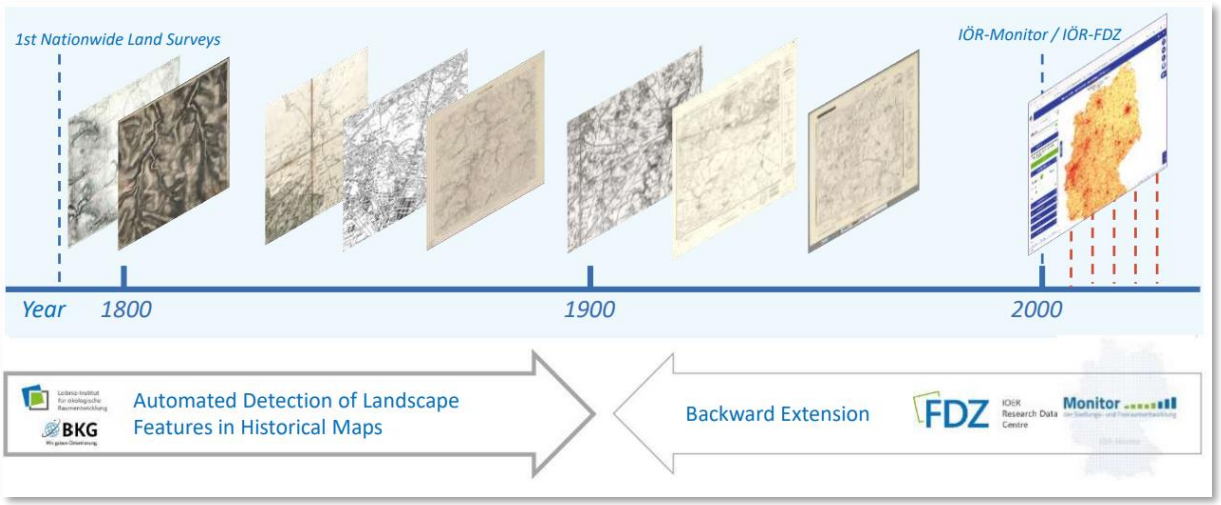

Figure 8: A two-end approach to generate land data that can support land change monitoring on the past 200 years.

This work relies on different methodological components to automate the analysis of old maps and generation of metadata. It is implemented in a QGIS Toolbox. Among perspectives is the promotion of the tools to apply them to other countries.

[2] Home - IOER FDZ (https://ioer-fdz.de/)

7 Mapping buildings changes over the past decade on city region areas to support research and public action on densification, the SUBDENSE project

Authors: Bénédicte Bucher [1), 2)], Mouhamadou Ndim [1), 2)]
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[2)] University Gustave Eiffel, Champs sur Marne, France

Can building change data help our societies make the right decisions to achieve resilient and inclusive cities as targeted in UN Agenda SDG 11? They can be used as shared evidence to ground theories and express perceptions about the dynamics of territories. Evidence-based discussion and open debates is particularly needed in the domain of densification. This word refers to the increase of inhabitants' density in already dense areas and also to public action targeting the development of housing units to allow more inhabitants to live in pre-existing built up areas. Today, there is an urgent need to understand what densification can be successful and lead to sustainable cities. Considering the number of stakeholders and the plurality of interests, improved discussions are needed among data scientists, policy makers, developers, land owners, and citizens to understand what is desirable densification, and how to achieve it. Unlike density maps, and existing land use land cover products, topographic change provides a higher level of spatial disaggregation which is needed to observe local variations in the contrasting benefits and disbenefits of denser urban environments (Bucher et al. 2025).

The SUBDENSE project (2023-2025) investigates the production and usage of building change data from building data produced by mandated authorities over the past decades in three European countries, France, Germany and UK. Building data is not natively adapted for diachronic analysis. The provision of stable indicators has been adopted lately as well as the documentation of reasons for changing building data, in specific properties. But these are not systematically available when going back in 2011 for example. Besides, biases can be introduced by evolution of the products: the feature changes but the entity does not. Last but not least, in order to propose a new data product there is a need to agree on its specification and define concepts and properties to represent real world building changes.

The approach adopted in our project is illustrated in Figure 9. It consists in detecting changes in building data, through a semi-automated workflow, producing maps of building changes with these detected changes and using these maps with different experts -densification experts and data experts- to further refine the specification of a building change product. The approach is elaborated on three city regions, Liverpool, Strasbourg, Dortmund, with the corresponding national building data from the ATKIS, OSMasterMap and BDTopo. An example of a map is illustrated in Figure 10.

It relies on a collaborative platform called Subdense dashboard and a semi-automated and collaborative production workflow to process topographic sources in their original format, together with their documentation. A dedicated matching algorithm compares footprints of buildings features in 2011 and in 2021 vintages to match homologous features. The documentation of the source product is retrieved and analysed manually and the reader shares on the dashboard quotes that can impact diachronic analysis in order for developers to apply post-processing rules. The dashboard also supports the documentation of metadata fragments at every step of the process to document the quality of the resulting data.

The approach has been implemented on a git+QGIS architecture. First results evidence the potential of these maps and platform to ground more concrete discussions between local administrations and scientists on a complex phenomenon that is densification.

More specific changes to be investigated are the change of housing units attached to building evolutions, in particular to roof-stacking as well as the status of vacant plots.

We also investigate the reproducibility of the approach to Romania, which presents different challenges in terms of data.

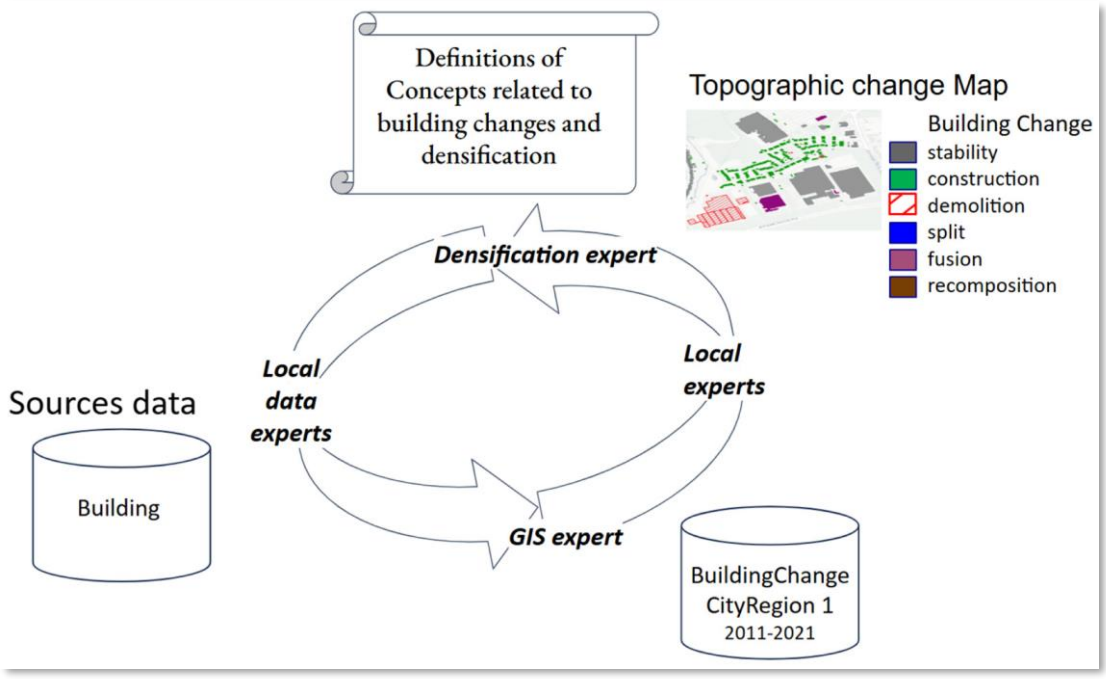

Figure 9: Proposed iterative and collaborative process: detection of building changes in surveyed data for city regions in France, the UK and Germany, that are visualised and used to further specify data products focused on real building changes, after (Bucher et al. 2025).

Figure 10: Extract of a BuildingChange map showing the visual pattern: overlay in the same area of red hashes, which are demolitions, and of green shapes which are constructions of buildings.

8 Use of historical data for buildings legalization process

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State Geodetic Administration, Zagreb, Republic of Croatia

In the territory of today's Republic of Croatia during the 20th century, due to specific historical and socio-economic circumstances, two periods are significant in terms of illegal construction. The first period is from the end of World War II to the mid-1960s, when mass reconstruction was carried out (construction was often done without permits especially outside urban areas). The second period began at the end of the 1970s and lasted until the mid1990s. This led to the situation that a significant number of constructed buildings were not legal. The Government of the Republic of Croatia made a decision to implement the legalization of illegally constructed buildings in order to regulate the situation related to the illegally constructed buildings as much as possible. This is online with the necessity to achieve strong institutions, SDG 16. In 2013 "law on Construction", 1968 was adopted as the cut-off date for general legalization. Everything that was built on the territory of the Republic of Croatia by February 15, 1968 is considered to be legal. For such buildings, a permit is issued based primarily on historical materials of the State Geodetic Administrations (SGA) or, if necessary, other appropriate evidence that it was built before the cut-off date. In addition, for buildings built or reconstructed after that date, if it is visible on the digital aerial photogrammetric images or on the orthophoto made on the basis of aerial survey started on June 21, 2011, it can be legalized.

On the territory of the Republic of Croatia, systematic aerial photogrammetric surveys were started in the 1950s. From 1947 to 1967, a topographic survey was also carried out. The making of the Croatian Base Map (HOK) on a scale of 1:5000 began in 1948. For its production, topographic survey data, existing topographic and cadastral plans in larger scales (1:500 to 1:2500) were used, and from 1960 on, aerial photogrammetry data were also used. After gaining its independence, the Republic of Croatia began to systematically carry out aerial photogrammetric surveys from 1996 for the production of official state maps. In 1998, the production of digital orthophoto maps at a scale of 1:5000 (DOF5) started. The owner has to fill in a request for legalization and describe its building using SGA data.

9 Creation and Geo-referencing of 3D data of destroyed monuments: the example of the Schaffhausen Bridge

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Historical and Time Stamped Geographical Data are usually 2D maps. However, small-scale models of buildings, monuments and even cities could be found in museums collections. Such models typically provide valuable insights, particularly in cases where these buildings have undergone alterations or faced destruction. We propose a procedure to digitalize such artefacts, and attach to them 3D geo-references. It has been applied to the Schaffhausen Bridge, built in 1757 by the architect-carpenter Hans Ulrich Grubenmann, and burnt in 1799.

This bridge was known throughout Europe for its innovative structure. There are today few known remaining models of this bridge. One such model dating back in 1757, measuring 1.2m long, is at the museum of the Ecole des Ponts in France. Another model can be seen in the Teufen museum that

measures 2.5m long. The scale of these models is represented in Figure 11. There also remain engravings and paintings that add more information of the context surrounding this bridge.

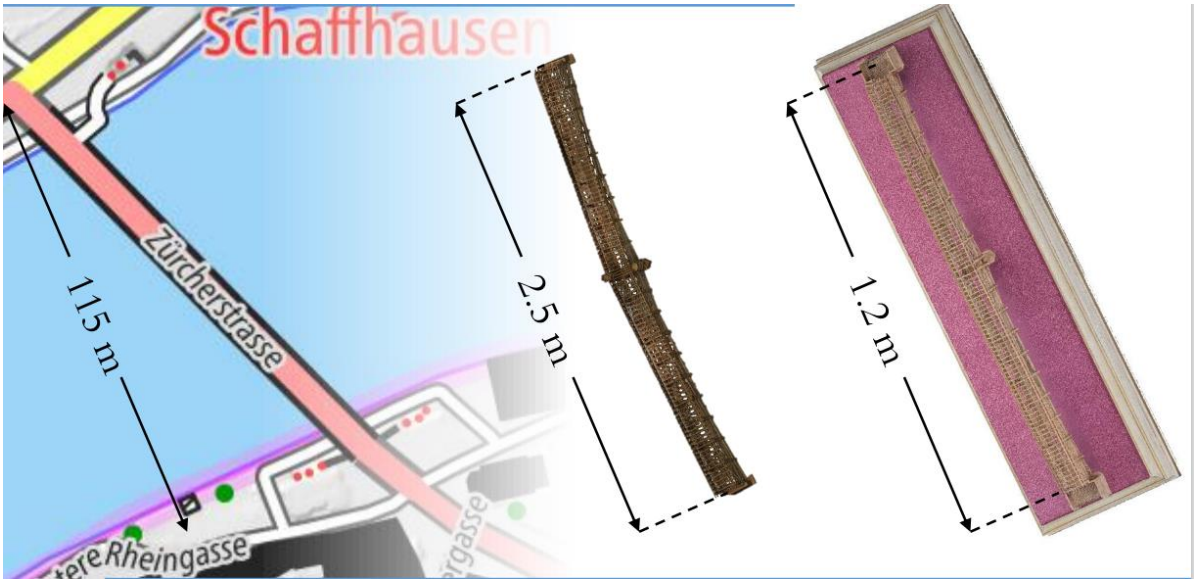

Figure 11: Relative size of remaining models of the former Schaffhausen Bridge that was burnt in 1799.

We developed an acquisition method by photogrammetry of these models. This method addresses the specific difficulties of macroscopic imagery of thin complex structures: the small size and high complexity of such structures is not adapted to the state of the art photogrammetric processes. The bridge is georeferenced with modern 3D data from aerial LIDAR. This process uses historical engravings where the bridge is visible and historical maps as illustrated in Figure 12.

Figure 12: Referencing the Shaffhausen bridge using old engravings where it is visible together with other landmarks that still exist.

These methods could be transferable to other models in order to study the 3D evolution of a city or the territory with potential applications in the domain of SDG 11.

10 The EC eArchiving Initiative: A way to ensure interoperable and sustainable access to geospatial records

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In the era of rapid digital transformation, the importance of preserving and accessing historical geospatial data becomes increasingly paramount, especially in the context of Sustainable Development Goals (SDGs). A comprehensive approach has been developed under the European Commission's eArchiving initiative to this purpose. It aims to enhance the interoperability, openness and transparency, and accessibility of geospatial records, which are crucial for historical analyses and future policy-making aligned with SDGs.

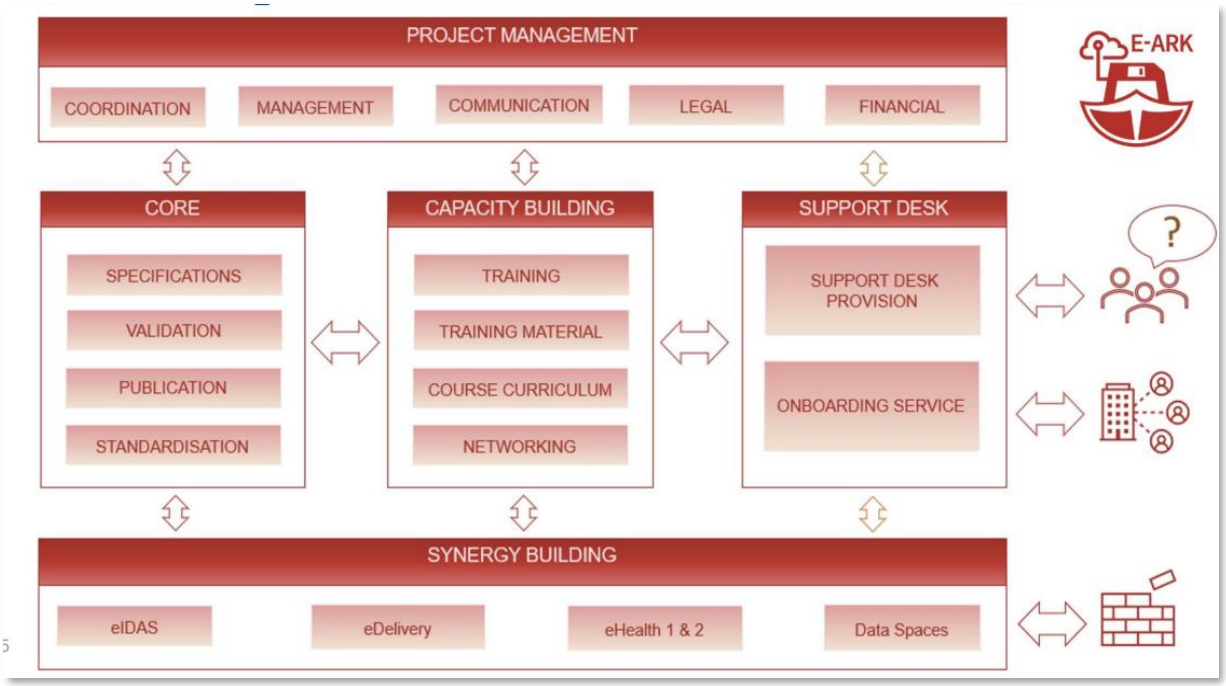

Figure 13: Activities of the eArchiving project,
copyright: DILCIS, Digital Information Life Cycle Interoperability Standards, http://dilcis.eu.

There is a need to further specify "Content Information Type Specification (CITS) Geospatial" within the eArchiving framework and its Guidelines and its adaptation in different EU archives. Besides, data science formats are becoming increasingly important in the geospatial domain. The eArchiving framework targets different stakeholders (archives, geospatial data producers and managers, users) who can contribute to the development of the specification.

11 Missing link between spatiotemporal (historical) data and AI (machine learning) usage

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Semantic geospatial data fitness for specific sustainable development goals, like performing spatio-temporal queries in a semantic sense, is not well discovered at NMCAs. We aim to develop a methodology for assessing the state of the art of semantics of existing metadata in the domain of geospatial data at the Slovenian geoportal, which might be helpful for other NMCAs in the region. We perform bottom-up analyses and a top-down synthesis approach to the target datasets. Different categories of knowledge need to be considered: representation of geographic space independent of any technology and models specific to different technologies as illustrated in Figure 14.

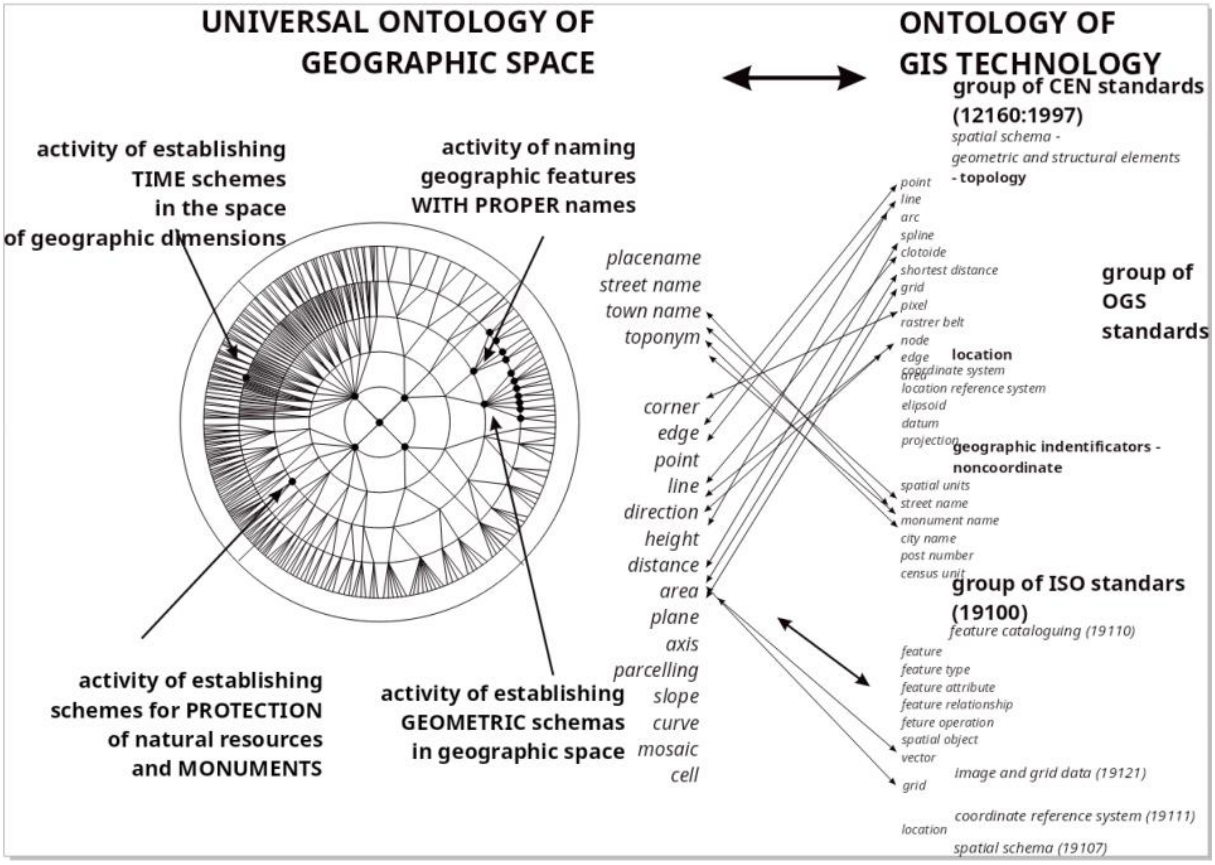

Figure 14: A universal ontology of geographic space, independent of technologies is needed.

The current project will deliver guidelines for managing semantic linkage among the NMCA's internal datasets and selected external datasets as a particular aim of the Framework for Effective Land Administration (FELA). This approach can also greatly benefit the sustainable accessibility of existing historical data in the new demands of the digital economy.

12 CONCLUSIONS AND PERSPECTIVES

The outcome of the workshop can be summarized as follows.

Historical and time-stamped geodata are an important asset to achieve a sustainable future as they can be used to provide temporal depth to the observation of important dynamics identified in the UN 2030 Agenda. They allow us to observe how forests evolved over centuries as well as more generally land cover and coastline, to observe the evolution of built up areas and how people's access to public space evolved with the densification of cities in the past decades.

Replicable methods and reusable tools have been developed to valorise these assets. Artificial intelligence is an important assistant for these processes, particularly deep learning models and ontologies. User interfaces have been developed to make resulting data or the very methods and tools widely accessible from potential users. Issues remain. Discovering relevant sources is still challenging. It implies matching SDG requirements with available archives. Attaching time to the data is all the more complex with heterogeneous timestamps, like old maps or vector databases. More generally there is a need to document the uncertainties in derived data. Besides scientific communities, data providers and publishers are also renewing their data product to better manage time, through attribute or through versioning compatible with the delivery of snapshots or of differentials. This raises more globally the question of how to survey changes: detecting changes and modelling them in a new product.

Recommendations and perspectives for the future emerge from this workshop.

A first recommendation is to make these solutions, either the derived data or the tools to produce them as well as the historical sources, more visible from potential users: EuroSDR members, statistical communities, education communities and scientific communities who study the corresponding dynamics. Key communities that we need to work with on such a topic are the archiving communities as well as the statistical communities, as well as targeted users.

A second recommendation is to explore the notion of change: what is change in the real world, what is change in data, how to better organize data to represent a changing world with less uncertainties.

Last, there are probably other perspectives and joint collaborations that could emerge from communities accustomed to managing archives like librarians or biologists.

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