FIG PUBLICATION
NO 78

FIG REPORT

GEOSPATIAL DATA IN THE 2020s
Transformative Power and Pathways to Sustainability

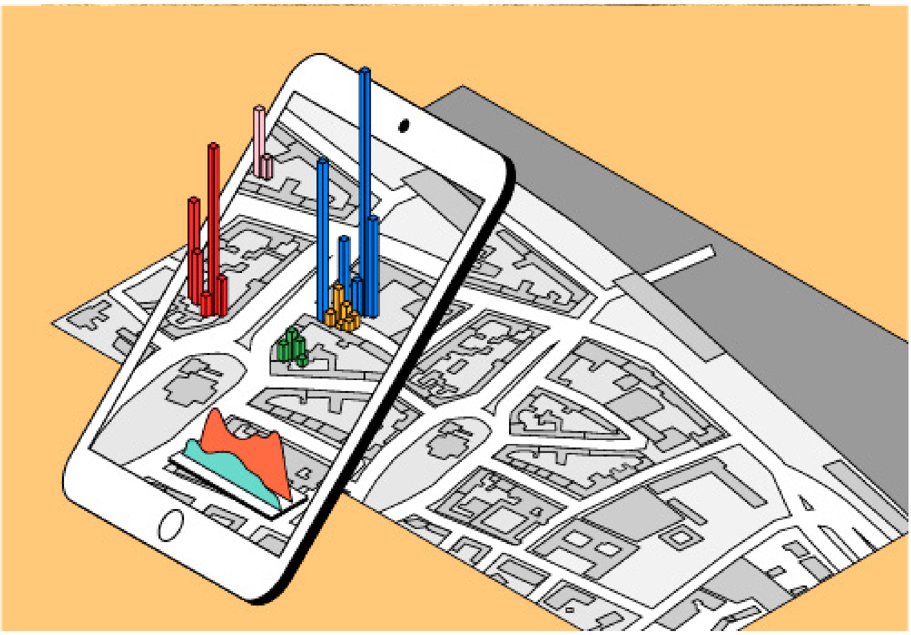


FIG Commission 3 – Spatial Information Management

INTERNATIONAL FEDERATION
OF SURVEYORS (FIG)

GEOSPATIAL DATA IN THE 2020s
Transformative Power and Pathways to Sustainability

FIG Commission 3 – Spatial Information Management

Editors:
Claire Buxton
Marije Louwsma
Hartmut Müller
Markus Schaffert

INTERNATIONAL FEDERATION OF SURVEYORS (FIG)

International Federation of Surveyors (FIG)
Kalvebod Brygge 31–33
DK-1780 Copenhagen V
DENMARK
Tel. + 45 38 86 10 81
E-mail: FIG@FIG.net
www.fig.net

Published in English

ISSN 2311-8423 (pdf)
ISBN 978-87-93914-01-8 (pdf)

Published by
International Federation of Surveyors (FIG)

Layout: Lagarto

CONTENTS

FOREWORD

Megatrends in the 2020s, such as climate change and resource scarcity, rapid advances in technology like artificial Intelligence and machine learning, changes in global demographics, in particular the ongoing growth of the world's population, the rapid ageing of populations in many countries, and global migration to megacities, are causing disruptions and will pose major challenges in the coming years.

Traditionally, land surveyors used to be viewed as 'measurers'. In recent years, the surveyor has evolved to a professional who measures, models and manages all kind of location related data. Surveyors use open standards, incorporate volunteered information, and ensure interoperability of systems to deliver knowledge derived from geospatial data of different scales and origin in the form of user-adapted geospatial information.

Today, geospatial information is widely recognized as an indispensable source for informed decision making in many fields, such as achieving the Sustainable Development Goals.

One technological advancement is Earth observation from space, which provides geospatial data at various spatial, spectral, radiometric and temporal resolutions and enables the use of the data for a variety of applications. The COVID-19 pandemic has demonstrated the importance to all stakeholders of having trusted geospatial health data readily available more or less in real time. Particularly in less developed regions of our world, where officially maintained geospatial data sets are a scarce resource, citizen input of volunteered geographic information can be very valuable. Digital land administration platforms can provide ready to use geospatial data to support emergency response, climate change response, disaster and conflict management, health management, spatial land use planning, real estate market stimulation, infrastructure provision, protection of women and vulnerable groups, and business activation and citizen action.

This FIG report sheds light on several areas where geospatial data can be particularly useful in supporting the path to sustainability in the 2020s, for spatial land use planning and health monitoring, with data collection through voluntary geographic information, with attention to diversity and inclusion, and by providing information on property, including property values.

This FIG-publication is the result of a very fruitful cooperation between the FIG Commissions 3 and 8 together with VCSP (Volunteer Community Surveyor Program) of the Young Surveyors Network over the last years.

Many people of these groups contributed to this publication. My congratulations and special thanks go to Hartmut Müller (Chair C3), Marije Louwsma (Chair C8), Markus Schaffert (Vice Chair C3), Claire Buxton, Roshni Sharma, and Tom Kitto (all VCSP) including all the working group chairs of C3 and C8.

Rudolf Staiger
President of International Federation of Surveyors

CHAPTER 1
GEOSPATIAL DATA AND SUSTAINABILITY– SETTING THE FRAME

CRISES, SUSTAINABILITY AND GEOSPATIAL INFORMATION – CROSSROADS IN A DECADE OF CHANGE

Markus Schaffert (Germany), Hartmut Müller (Germany)

1 *Introduction*

The young 21st century has been marked by several crises, which were partly of global reach. This applies, for example, to the US real estate crisis, the global banking crisis, and the debt crisis in European countries that took place in the years 2008 until 2010. These crises, which were primarily economic in nature, were followed by crises of a rather social or environmental character. Refugees and migrants arriving in Europe on an unprecedented scale in 2015, ravaging wildfires in California (2020) and Algeria (2021), and devastating floods on almost every continent (e.g. Central Europe 2021, Eastern Australia 2022, South Africa 2022) have contributed in bringing drivers and mega trends such as demographic and climate change to the forefront of public awareness.

In December 2019, the first known human cases of COVID-19 were reported, keeping the world on edge throughout the early 2020s. The pandemic has shown a complex, dynamic and disruptive character with recurring waves of virus mutations that have emerged at different times in different places. The pressures caused by the COVID-19 pandemic posed major challenges to people on all continents and required rapid and urgent responses. At the same time, and despite rising protectionism in the immediate times of the lockdowns, the need to secure international cooperation and to diversify supply chains was widely recognized. Forces and efforts against the pandemic were pooled and a wide range of joint measures was taken. In this context, the lockdowns and standstill provided "a timely occasion to change direction and to prevent future crises" (Bodenheimer & Leidenberger 2020: 61). Consequently, the "COVID-19 crisis may have opened a window of opportunity to 'rebuild better'" and drive transition to sustainability (Lehmann 2021: 2137). Opportunities for greater sustainability that the pandemic has opened up have arisen in the areas of mobility or consumer behaviour, for example. However, it remains to be seen whether reduced and more conscious consumer behaviour, increased use of home offices, and other measures taken in the face of the pandemic will have a lasting effect. The pandemic has at least proven that humanity is capable of changing living habits if necessary, it has triggered innovation and provided room for many creative thoughts.

In view of the crises of the 21st century and their underlying causes, sustainability is not an end in itself. Rather, it is an important factor in both preventing or overcoming crises and pursuing a more sustainable future. Sustainable development aligns the social and economic challenges facing humanity today, with the capacity of natural systems. In this sense, it is critical for today's generations to consider the needs of future generations and to take responsibility for regenerating, maintaining and improving planetary resources (Donovan 2009). This leads to calls for profound changes supporting "transformations to a good Anthropocene" (McPhearson et al. 2021: 1).

The Sustainable Development Goals (SDGs) serve as a global guide for countries and the international community on this journey. The SDGs were set up by the United Nations General Assembly in 2015 and are to be achieved by the year 2030. 232 indicators have been developed to measure progress on 17 SDGs and 169 associated targets. For calculating the indicators, we need data. Reliable data that could provide information even at small scales, however, is not available in many parts of the world. This is why the local monitoring of sustainability progress requires greater data availability, data innovation and, in essence, a "data revolution" (UN 2014).

While monitoring is paramount to tracking progress on the SDGs, proactively dealing with complex crises and creating sustainable pathways in a changing world requires more holistic approaches to leveraging data. Against this background, de Albuquerque et al. (2021) argue that *data usage* for monitoring, progress tracking and decision-making is one fundamental contribution for sustainable development. Beyond that, however, *data generation* and *data circulation* provide two additional functions of data that have not received the same attention in the debate about sustainable development and the corresponding UN goals. Data generation by stakeholders and the public allows for mutual learning that brings in new perspectives while challenging entrenched behaviours. In this way, the process of generating new data can provide "a new critical consciousness about the sustainability issues which are intended to be captured with data" (Albuquerque's et al. 2021: 159). Data circulation among actors and between different scales additionally allows for opening up new communication channels and for changing unsustainable governance arrangements.

Albuquerque's et al. (2021) reflections are based on a rather broad understanding of data, in which no distinction is made between data and information or between spatial and other data. In this book, we explicitly look at data with spatial reference and refer to both geospatial data as well as geospatial information. We believe that it is worthwhile to differentiate and take a closer look. In 1982, John Naisbitt wrote in his book *Megatrends*, "we are drowning in information but starved for knowledge". This sentence is more valid than ever if we modify it to bring it into line with the world today. Today, we are drowning in data and starving for information. The difference is that data has no meaning in itself because it comes with no context or interpretation, whereas information adds this value to the understanding of a subject (Baskarada, & Koronios 2013: 7). In our field of interest, Geographic Information Systems (GIS) have been used for many years to turn geospatial data into information. Features – that is, real-world spatial objects such as a tree or a road – have geometric, topological, semantic, and temporal properties, each of which can be considered in spatial analyses. Depending on the data model and the properties captured, software can be used to perform such varied analyses as (Euclidean) distance operations, shortest path calculations, change detection, spatial interpolation, spatio-temporal simulations, and so on. Since the spatial reference allows geospatial data from different domains and disciplines to be linked and jointly analyzed, an information source for interdisciplinary inquiries can be generated in this way. Often the characteristics of geospatial data are expressed with the phrase "spatial is special". This assessment is substantiated by the above-mentioned diverse and cross-sectoral capabilities of spatial analyses that transform geospatial data into rich and easily usable information (cf. Boxall & Anderson 2005).

The following examples show that geospatial data and information perform all three of the above functions that Albuquerque et al. (2021) identify for data for sustainable development. Moreover, they indicate that geospatial data and information can in fact play a fundamental, and at the same time, distinct role in the transition to sustainability.

Spatial data usage enables observation over space and time and allows the recognition of spatio-temporal patterns. This provides information to politicians, stakehold-

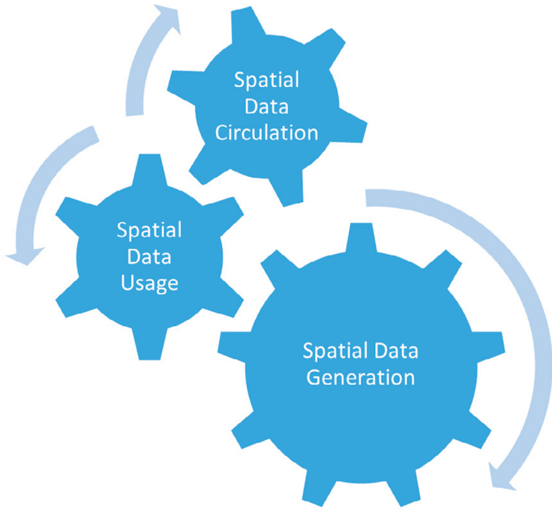


Figure 1: *The triad of spatial data functions for sustainable development.*

ers and the public that can show the progress of SDGs in a comparison of countries, regions or continents at the same or at different times (Kumar et al. 2019). Land cover changes, for example, can be classified from multispectral satellite imagery and statistically computed or further analyzed using GIS software. In this way, Giuliani et al. (2020), for instance, propose an approach to support monitoring desertification at different scales that provides information on the "proportion of total land area that is degraded" (SDG indicator 15.3.1) in line with the UN guidance. In recent years, the establishment of Spatial Data Infrastructures (SDI) all over the world and improved Earth observation systems, like the European Copernicus program and the Sentinel mission, have taken the capability to monitor the SDGs to a new level (cf. Scott, & Rajabifard 2019). This makes it possible to integrate data from various sources more efficiently and to access data with an increasingly higher spatial and temporal resolution. Kussel et al. (2019), for example, use such data to calculate indicator 2.4.1 on the "proportion of agricultural area under productive and sustainable agriculture". As the availability and accessibility of accurate geospatial data increases, the impact of this data is likely to grow. In the early 2020s, civilians in Russia and Ukraine – where the most recent and violent crisis of the young 2020s took place – demonstrated the potential by tracking military troop movements and challenging official reports by sharing this information. Today, high-resolution satellite imagery in combination with social media access and data allow almost anyone to perform tasks once reserved for government agencies. Other applications of geospatial "open source intelligence" can be broad in scope and support monitoring of additional sustainability concerns, such as tropical deforestation, or disaster mitigation (Tandarić 2015).

Spatial data generation is one of the key skills of surveying and mapping agencies worldwide, providing reliable data as a basis for topographic and statistical uses. A well-known non-governmental data source in this area is OpenStreetMap (OSM). OSM is a community-driven project to create an open, editable, and free map of the world. OSM and other Volunteered Geographic Information (VGI) can be integrated into the monitoring framework of the SDGs and help to fill data gaps at the local level (Fritz et al. 2019). The metadata for indicator 9.1.1 "Proportion of the rural population who live within 2 km of an all-season road", for instance, refers to OSM as an alternative data source for countries that do not have sufficient road data (Fraisl et al. 2020: 1743). OSM primarily aims at providing an open topographic map of the earth by voluntary data contributors. The underlying method of participatory mapping, however, is suitable for collecting a wide range of (non-topographic) data and information with spatial reference, such as neighbourhood-specific property information, suitability of green spaces for older people or citizens' flood memories. Furthermore, through participatory data generation, the aforementioned use of open source intelligence can be refined and applied to additional use cases. One example is the citizen science initiative Litter Intelligence, which contributes to the reporting of the indicator 14.1.1 "Index of coastal eutrophication and floating plastic debris density" (Fraisl et al. 2020: 1740).

However, there is more to be expected from spatial citizen science in the context of sustainable development than just filling SDGs' data gaps. Transdisciplinary research is regarded as one of the key principles of sustainability science (Osinski 2021: 2). It aims to resolve sustainability-related challenges by focusing on real world problems and integrate knowledge across different scientific disciplines, as well as from non-academic actors. The use of maps or aerial imagery by stakeholders and the public can contribute substantially to transdisciplinary projects, for instance by enhancing mutual learning in workshops and group discussions (Akbar et al. 2019). This strength of geospatial data results, among other things, from the generally understandable "language" of geovisualization within the transdisciplinary process which is otherwise often characterized by the clash of technical languages (Schaffert et al. 2020). Geovisualization provides a bridge to the third function (data circulation) attributed to data for sustainable development; it can, for example, greatly facilitate the exchange of data, information and ideas in workshops attended by experts from different disciplines.

Spatial data circulation has proven to be a valuable contribution in processes aiming at "grassroot sustainabilities" (Nicolosi et al. 2020) as well as for sustainable transition in cities and regions. Our cities are seen as a key for achieving a more sustainable planet. Geospatial data in turn is a core ingredient for implementing the ideal of a smart city (Xie et al. 2018). However, the evolution of smart cities into smart territories and regions requires improved spatial data circulation, for example the exchange of data between neighbouring cities and adjacent districts. SDIs are an important contribution to successful data transfer across administrative boundaries by bringing together geospatial data from different providers. For an SDI to work, its technical components are essential but not the only prerequisite. New organisational arrangements, such as SDI steering committees, have been established to complement the technical fabric of today's SDIs. In federal states such as Germany, these arrangements improve spatial data circulation between the state levels (municipalities, federal states, and the federal republic), leading to enhanced and even new forms of cooperation among the public authorities involved.

While these examples strongly suggest that geospatial data and information can contribute substantially to sustainable transition and transformation, it "is an overly optimistic assumption that increased data availability will automatically lead to improved decision-making and propel transformations to more sustainable futures" (Albuquerque's et al. 2021: 153, 154). There is an additional need to transform data into information and embed it with clarity into use cases so that (geospatial) data can unfold its potential. Against this background, this book presents best practice examples and use cases that show how spatial data innovations and technologies can contribute to a more sustainable future. The contributing authors try to answer questions on how this data and information promises benefit for certain application areas or when in an established technical process it can be integrated. This way, we hope that the readers ultimately turn geospatial information into knowledge supporting sustainability, since knowledge derives from information but is conveyed by instruction and answers to *how-to* questions (Ackoff 1989: 3). The 2020s with their challenging environments offer a particularly interesting field of experimentation to explore this potential.

2 Use cases and best practises: the structure of the book

In chapters 2 to 6 of this book, a wide range of use cases and best practice examples are presented to illustrate the significance of geospatial data and information for sustainable development. This collection highlights pressing issues such as the management of the COVID-19 pandemic, raises questions on empowerment, diversity, and participation in the geospatial context, discusses data integration in spatial planning and presents humanitarian mapping field work. These chapters are partly practically and partly academically oriented. Our focus is the integration of geospatial data, including established datasets and platforms, into pathways for sustainability. It is not so much about reflecting current technical developments such as artificial intelligence or block chain in the geospatial information realm. We believe that this focus will attract a broad readership, including but not limited to the spatial sciences.

- Chapter 2 takes a look at the nexus of **Spatial Planning and Geospatial Information**.

Marije Louwsma and Cemre Şahinkaya Özer explain that spatial planning is about generating location-based information on the development of a territory and its land use. Such information is essential for spatial policies, plans and decision-making, for instance for a smart city. Information on biodiversity, infrastructure, land use, population density, and soil quality, to name a few, can shed light on the possibilities or impediments for specific land uses and sustainable developments. Planning institutions profit from geospatial information, for instance, to analyse the current situation, develop and evaluate scenarios or plans, and monitor the impact of planning efforts. With further digitalization of services and online solutions, new possibilities have emerged to integrate geospatial information in spatial planning processes. Against this background, the authors introduce and explain the potential of geospatial information based on the spatial planning cycle. This cycle consists of (1) the development of spatial policies and plans, (2) the implementation of these policies and plans, and (3) monitoring and evaluation. The latter, in turn, provides input for updating or developing new spatial policies and plans.

- Chapter 3 refers to **The Spatial Dimension of Health** and specifically highlights the role of geospatial information in addressing the COVID-19 pandemic.

In a case study from Tel-Aviv, Israel, Avital Angel, Achituv Cohen, Pnina Plaut, and Sagi Dalyot aim to identify, quantify, and analyse changes in pedestrian traffic and walking patterns induced by COVID-19 policies in the 'first wave' of the pandemic. The study includes over 116 million pedestrian movement records documented by a network of 65 bluetooth sensors, between 1 Feb 2020 and 26 Jul 2020, with a comparison to the equivalent time in 2019 that signifies 'normal' pre-COVID-19 conditions. The results show a clear correlation between the various COVID-19 related policy restrictions and pedestrian count. For example, the shifts to work-from-home and closure of businesses were highly correlated with changes in walking patterns during weekdays. While the restrictions drastically affected pedestrian volumes and walking times, people's choice of where to walk did not change significantly, indicating the importance of attractive streets, parks and squares for city dwellers.

Marije Louwsma and Hartmut Müller follow up on this topic by looking at the geovisualisation of health information in the fight against the COVID-19 pandemic in Europe. For this purpose, they examined national dashboards from EU member states to find out what spatio-temporal information was used, how the information was visualised and whether this changed over the course of the pandemic. They conclude that further integration and alignment of public health data, statistical data and spatio-temporal data could provide even better information for governments and actors involved in managing the outbreak, both at national and supra-national level. The Infrastructure for Spatial Information in Europe (INSPIRE) initiative, using the European Nomenclature of Territorial Units for Statistics (NUTS) system, provides a framework to guide future integration and extension of existing systems.

- Chapter 4 **Geospatial Data and the Changing Society** takes a critical look at the societal context and its relevance to the way geospatial data is produced.

Roshni Sharma argues that diversity, inclusion, equality and belonging are fundamental issues that impact the surveying and geospatial industries around the world. In her article, she introduces the concepts behind the terms and translates them into practical applications. The discussion of these applications leads her to the conclusion that the ignorance or non-observance of these concepts can lead to gaps or at least to distortions in geospatial data products, for example due to the overrepresentation of certain social groups among the mappers or algorithm developers. With this wake-up call, the paper aims to help ensure that both industry and community-driven projects that produce geospatial data continue to benefit from diversity of thinking to drive innovation and to realise the inherent benefits.

- Chapter 5 **Participation and Spatial Empowerment** is dedicated to a closer inspection of the topic of participation and spatial empowerment. We thus remain in the interplay of social conventions and their impact on geospatial data production.

Claire Buxton, Cemal Özgür Kivilcim, Roshni Sharma, Tom Kitto, and Cemre Şahinkaya Özer take us to Australia and Tanzania and show how the Volunteer Community Surveyor Program (VCSP), a signature outreach program of the FIG Young Surveyors Network, contributes to humanitarian and environmental cases. They report on best practice events that took place in three instances during the pandemic (2020–2021), in collaboration with partner organisations. In these joint and volunteer events (so-called mapathons), geospatial data with direct societal relevance was collected. Static water infrastructures to support bushfire preparedness were mapped together with the Australian Surveying and Spatial Sciences Institute (SSSI). Building data was collected with the Humanitarian OpenStreetMap Team (HOT) and Crowd2Map (an initiative of the Tanzania Development Trust), to provide a more complete dataset to people on the ground working to protect young Tanzanian women from female genital mutilation. Their experiences lead them to conclude that surveyors have an important role to play in empowering people, but also in managing the data and ensuring its quality.

Their conclusions are supported by Ruba Jaljolie and Sagi Dalyot's contribution, which provides further evidence for the potential role of surveyors in terms of volunteer data collection for land management systems. Reflections on modern land management systems, which are "fit for purpose" suggest volunteered geographic information to be possible data sources to complement data from official bodies. However, this approach leads to challenges and ethical dilemmas in terms of data quality, data privacy, and data integrity. The results of this study demonstrate that surveyors in Israel show responsibility and professionalism when contributing data to land management systems. This also applies in the case that they would collect such data voluntarily. The findings are based on the subjects' self-assessment. Future studies will have to supplement the results with less subjective measures. Nevertheless, the study provides innovative evidence for a greater convergence of the voluntary and professional sectors in data collection.

- Chapter 6 **The Role of Land Administration Data in the Real Estate Sector** points to the relevance of the Cadastre and Property Market.

The cadastre and the real estate market can be seen as both an essential precondition for, and an integral part of, sustainable development. However, the prerequisites and approaches vary widely around the world and are not uniform even in distinct parts such as the UNECE region. The authors introduce the topic and identify differences that exist internationally. They explore the effectiveness of Western developed land administration management systems (LAMS), using the case of the Netherlands and Italy. Furthermore, they explain the "effectiveness divide" between the developed and less developed LAMS in the European region and the impact on property markets. Attention is thereby also drawn to the topic of informal settlements. The contribution reflects statements made in the previous chapters in that the voluntary collection of geospatial data collection is given increasing importance in surveying. Against this background, the authors conclude that a sustainable titling and registration system should be timely and low cost, not legally bound with planning requirements.

These use cases and best practice reports are summarized in a **Discussion and Conclusion** section presented by Markus Schaffert and Hartmut Müller (Chapter 7). The chapter reflects on the creative thinking behind the use cases and brings them together to further illustrate the contribution of geospatial data and information to sustainability. It also addresses the challenges that need to be overcome to realise this potential.

References

Ackoff, R. L. (1989). From data to wisdom. *Journal of applied systems analysis*, *16*(1), 3–9.

Baskarada, S., & Koronios, A. (2013). Data, information, knowledge, wisdom (DIKW): a semiotic theoretical and empirical exploration of the hierarchy and its quality dimension. Australasian Journal of Information Systems, 18(1).

Bodenheimer, M., & Leidenberger, J. (2020). COVID-19 as a window of opportunity for sustainability transitions? Narratives and communication strategies beyond the pandemic. Sustainability: Science, Practice and Policy, 16(1), 61–66.

Boxall, J., & Anderson, C. (2005). Geospatial Information Management: spatial is still special. In: Dalhousie Journal of Interdisciplinary Management, 1, 1–18.

de Albuquerque, J. P., Anderson, L., Calvillo, N., Coaffee, J., Cunha, M. A., Degrossi, L. C., … & Zipf, A. (2021). The role of data in transformations to sustainability: a critical research agenda. Current Opinion in Environmental Sustainability, 49, 153–163.

Fraisl, D., Campbell, J., See, L., Wehn, U., Wardlaw, J., Gold, M., … & Fritz, S. (2020). Mapping citizen science contributions to the UN sustainable development goals. *Sustainability Science*, *15*(6), 1735–1751.

Fritz, S., See, L., Carlson, T., Haklay, M. M., Oliver, J. L., Fraisl, D., … & West, S. (2019). Citizen science and the United Nations sustainable development goals. Nature Sustainability, 2(10), 922–930.

Giuliani, G., Mazzetti, P., Santoro, M., Nativi, S., Van Bemmelen, J., Colangeli, G., & Lehmann, A. (2020). Knowledge generation using satellite earth observations to support sustainable development goals (SDG): A use case on Land degradation. International Journal of Applied Earth Observation and Geoinformation, 88, 102068.

Hansen, H. S., & Schrøder, L. (2019). The societal benefits of open government data with particular emphasis on geospatial information. In International Conference on Electronic Government and the

Kumar, D., Singh, R. B., & Kaur, R. (2019). Conclusion: Spatial Information Technology for Sustainable Development Goals. In Spatial Information Technology for Sustainable Development Goals (pp. 219–224). Springer, Cham.

Kussul, N., Lavreniuk, M., Shumilo, L., & Kolotii, A. (2019, July). Nexus Approach for Calculating SDG Indicator 2.4. 1 Using Remote Sensing and Biophysical Modeling. In *IGARSS 2019-2019 IEEE International Geoscience and Remote Sensing Symposium* (pp. 6425–6428). IEEE.

Lehmann, P., de Brito, M. M., Gawel, E., Groß, M., Haase, A., Lepenies, R., … & Thrän, D. (2021). Making the COVID-19 crisis a real opportunity for environmental sustainability. Sustainability Science, 16(6), 2137–2145.

Levin-Keitel, M., Mölders, T., Othengrafen, F., Ibendorf, J., 2018. Sustainability Transitions and the Spatial Interface: Developing Conceptual Perspectives. Sustainability 10, 1880.

Rajabifard. (1982). Megatrends: Ten New Directions Transforming Our Lives. New York: Warner Books.

Nicolosi, E., French, J., & Medina, R. (2020). Add to the map! Evaluating digitally mediated participatory mapping for grassroots sustainabilities. *The Geographical Journal*, *186*(2), 142–155.

McPhearson, T., M Raymond, C., Gulsrud, N., Albert, C., Coles, N., Fagerholm, N., … & Vierikko, K. (2021). Radical changes are needed for transformations to a good Anthropocene. Npj Urban Sustainability, 1(1), 1–13.

Osinski, A. (2021). Towards a critical sustainability science? Participation of disadvantaged actors and power relations in transdisciplinary research. *Sustainability*, *13*(3), 1266: 1–21.

Scott, G., & Rajabifard, A. (2019). SDGs Roadmap. Sustainable Development Goals Connectivity Dilemma: Land and Geospatial Information for Urban and Rural Resilience, 13–44.

Tandarić, N. (2015). Geospatial Intelligence: A Review of the Discipline in the Global and Croatian Contexts. *Kartografija i geoinformacije (Cartography and Geoinformation)*, *14*(23), 38–49.

Topouzelis, K., Papakonstantinou, A., Batsaris, M., Moutzouris, I., Spondylidis, S., & Moustakas, A. (2021). Towards a coastal marine litter observatory with combination of drone imagery, artificial intelligence, and citizen science. In *EGU General Assembly Conference Abstracts*.

UN (2014): A World that Counts: Mobilising the Data Revolution for Sustainable Development. United Nations Data Revolution Task Force.

Xie, Y., Gupta, J., Li, Y., & Shekhar, S. (2018). Transforming smart cities with spatial computing. In 2018 IEEE international smart cities conference (ISC2) (pp. 1–9). IEEE.

CHAPTER 2
THE NEXUS OF SPATIAL PLANNING AND GEOSPATIAL INFORMATION

SPATIAL PLANNING AND GEOSPATIAL INFORMATION

Marije Louwsma (Netherlands), Cemre Şahinkaya Özer (Turkey)

1 The role of geospatial information in the spatial planning cycle

Spatial planning is all about making location-based decisions about the development of an area and its land use. Location-based information has always played a role in such decision-making and the development of spatial plans and policies. Geospatial data allows for the use, conversion of data, and production of information related to space (Chen &Liu, 2022) for both decision-makers and stakeholders. Information about soil quality, elevation, exposure, biodiversity, population density, infrastructure, or land cover for example, all provide information that can shed light on the possibilities or impediments for specific land uses or developments. Therefore, it is becoming more common to analyse the current situation, develop and evaluate scenarios or plans, and monitor the impact of planning efforts using geospatial information. With further digitalization of services and online solutions, new possibilities have emerged to integrate geospatial information in spatial planning processes.

In this chapter we would like to introduce the potential role of geospatial information based on the spatial planning cycle (Figure 1). This cycle consists of (1) the development of spatial policies and plans, (2) the implementation of these policies and plans, and (3) monitoring and evaluation. The latter provides input again for updating or developing new spatial policies and plans.

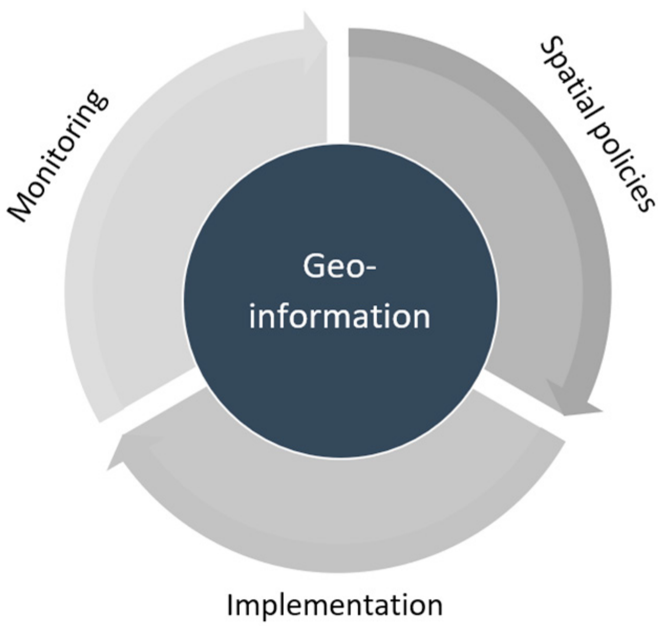


Figure 1: *The spatial planning cycle and the role of geospatial information.*

Due to the complexity in spatial processes and spatial planning systems, the use of geo-information comes along with some requirements. These requirements are very similar to those for a spatial data infrastructure. It must be technically and practically possible to combine information from different data sets to provide useful information as needed for the planning processes. Therefore, interoperability is a key requirement. The other two important aspects for geospatial information are scale and time in relation to the jurisdiction of authorities and institutions (legislation, formal and informal rules, and regulations) as demonstrated in Figure 2.

Spatial scale	**Temporal**	**Authority**	**Institutions**
Local	Short-term	Municipality	Informal rules
		Waterboard	Rules
Regional		Province	Regulations
	Intermediate	State	Decrees
National		Country	Laws
		EU	EU legislation
Global	Long-term	Global	International agreements

Figure 2: *Variations in spatial scale, time, responsible authority, and institutions that apply in spatial planning and the use of geospatial information.*

The spatial scale of the planning task determines the level of detail for required geospatial information. The planning context determines the time frame of the required data. Is the data about the current situation or short term sufficient or should information over a longer period be retrieved and analysed? The responsible authority or authorities determine how the data should be distributed between involved organisations and put together to retrieve the needed information. Similarly, data handling should comply with the institutional framework of formal and informal rules, regulations, and legislations. Privacy regulations are an example that may require data aggregation before it can be handled or published.

Moreover, the decision-making in planning has crucial importance and geospatial information also provides us useful opportunities to improve this process via decision support systems. A Decision Support System (DSS) is an integrated, interactive computer system, consisting of analytical tools and information management capabilities, designed to aid decision-makers in solving relatively large, unstructured problems (Watkins and McKinney 2000). Geospatial information in planning also enables complex decision making with the Spatial Decision Support Tools (SDSTs).

We will elaborate the role of geospatial information individually in the next three sections. For each phase, some examples will be given from practice about the possibilities and advantages of the usage of geospatial information. The last section will provide an outlook on the trends and the developments, and their potentials for spatial planning in collaboration with the geospatial information systems.

2 *Spatial policies*

The development of spatial policies is preceded by spatial analyses of the strengths, weaknesses, opportunities, and threats in the delimited area. In view of contemporary challenges such as the transformation from fossil-based to renewable energy, **suitability studies** can shed light on favourable and less favourable locations for solar power, wind farms, or hydroelectric power plants. These studies can also shed light on locations for affordable housing. Apart from finding suitable locations, it is also possible to conduct **a feasibility study** where the needed square meters for solar power can be compared with the available supply of suitable locations, e.g. rooftops or land. Various geodata sources and methodologies can be used for such analyses, such as LiDAR (Akbarian et al., 2021), aerial photography in combination with AI, building registries, topographical maps, big data (Kapoor et al., 2021) or other (Azzioui et al., 2021). Suitability and feasibility studies provide valuable input for the debate on spatial development and find the most sustainable pathway. Combining the results of individual analyses can contribute to integral considerations in spatial planning.

Developing spatial plans come with the need to make decisions. These decisions depend on many factors and actors. Geospatial information can be used to develop various alternatives or scenarios for spatial policies, to explore possible directions for spatial development and to assess the pros and cons of the alternatives. The pros can be seen as increased spatial cognition in planning applications and efficacy of the applied geospatial information methods. For instance, there are a number of European Commission projects that are based on geospatial information systems such as *natura2000* and *INSPIRE* that support the infrastructure policies. However, it is worth to note that the need for spatial data, hardware and software implementations are still the key issues for efficient geospatial information integration (Vullings et al., 2010).

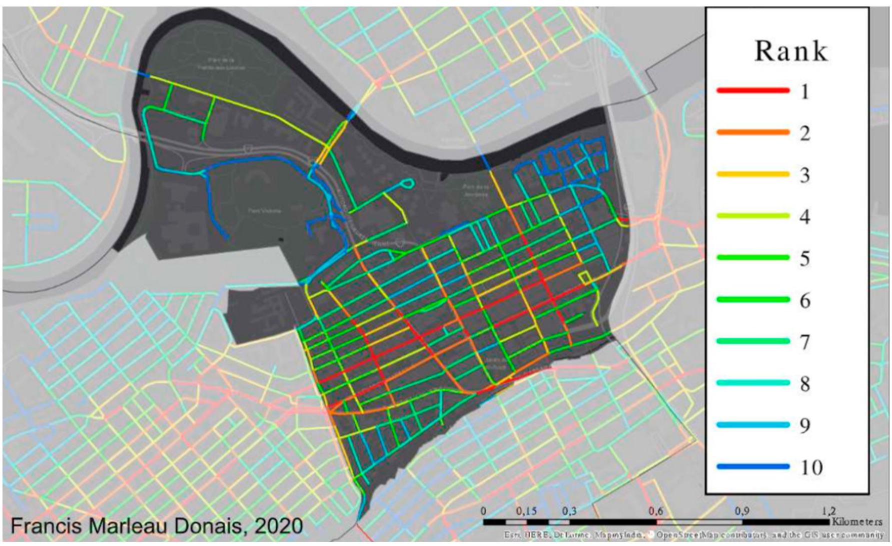


Figure 3: *A map that is created by the MC-SDSS tool for Quebec City, Canada that shows the priority of the streets for the participants (1 is the lowest, 10 is the highest priority).* (Source: Donais et. al., 2022).

Besides, **multi-criteria analyses** are particularly helpful to compare and weight the different alternatives or options. These techniques can also be applied in a participatory planning process where stakeholders with different interests can co-select and co-decide on the variables to include and their weight (te Boveldt et al., 2021). A project example that focusses on the multi criteria spatial decision support systems (MC-SDSS) has been applied in Quebec City, Canada, to improve the transportation facilities and provide a more sustainable planning. For this project, a MC-SDSS was created according to the work of group discussions and professionals in order to draft a common vision for the Quebec City and evaluate more than 20,000 streets of the city. The participants put the streets in order based on their priority to be revitalised. At the end of the project, participants' view about the suggested transportation plan was collected and evaluated in terms of sustainability. A map from the MC-SDSS tool is given in Figure 3 below (Donais et. al., 2022).

Furthermore, other analyses such as **environmental impact assessments** (Eggenberger et al., 2000), **water impact assessments** (Wiering et al., 2006; Swart et al., 2014), or **social cost-benefit analyses** (de Bruin et al., 2014), can shed light on the expected impact of the spatial plans on the environment, water system or society. The results from such assessments and analyses can be used to improve spatial plans to make them more sustainable. The quality of the provided geospatial information for the analyses is one of the variables – apart from the modelling – that determine the quality of the result. A good practice of environmental impact assessment was applied in São Paulo, Brazil, that analyses the Rodoanel highway planning case from the level of Strategic Environmental Assessment (SEA) to Environmental Impact Assessment (EIA) in the concept of Ecosystem Services (ES) as shown in Figure 4 below. A qualitative evaluation was conducted of this analysis through the SEA and EIA reports and it was found that the societal concerns were missing in both of the assessment levels.

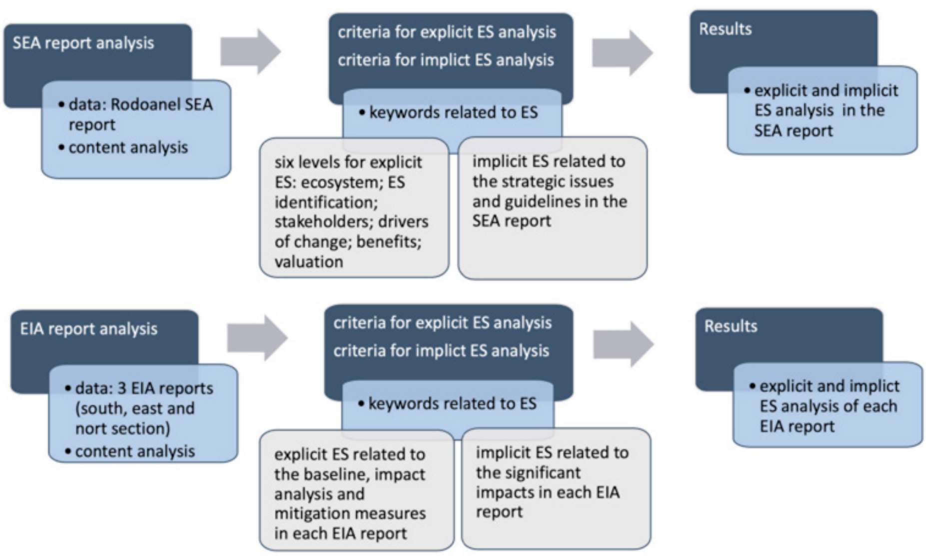


Figure 4: *Analysing the Ecosystem Services through the Strategical Environmental Assessment (SEA) and Environmental Impact Assessment (EIA) reports, in Rodoanel highway project in Sao Paulo, Brazil.* (Source: Gallardo et al., 2022)

This evaluation also mentioned that ES concepts are a complex system and the weak points of legal framework on making decisions are noted as the limitations of the project (Gallardo et al., 2022).

Sometimes the needed geospatial information is not available at the right level of detail and quality. Nevertheless, even simple but correct maps can provide important insights about the potential or expected effect of planning interventions by visual analysis without modelling.

For communication and decision-making with multiple actors and stakeholders, visualizations can help to get on the same page regarding the options on the table and are expected to enhance the debate. Here, various software solutions are available that use geospatial information to calculate and render the impact of possible options in a 2D, 2,5D or 3D map.

3 *Implementation*

Due to the planning legacy and variations in contexts, countries can use a different set of spatial plans to guide spatial developments for both the long and short term, and the local and national level. In this section some examples of spatial plans and their implementation will be discussed to exemplify the crucial role of geospatial information.

The zoning plan, sometimes also referred to as land use plan or master plan, typically contains detailed information about the rules and regulations that apply regarding land use type, buildings, and related activities. The map contains large scaled geospatial information with planning information at the local level to show these details. Figure 5 shows an online platform (www.ruimtelijkeplannen.nl) which is used in the Netherlands to search for spatial plans based on the location. Responsible authorities are legally obliged to publish the spatial plans on this official platform, and therefore these digital plans have an official legal status (contrary to analogue versions of the same plan). Multiple plans can apply for a location. Figure 5 shows a zoning plan which

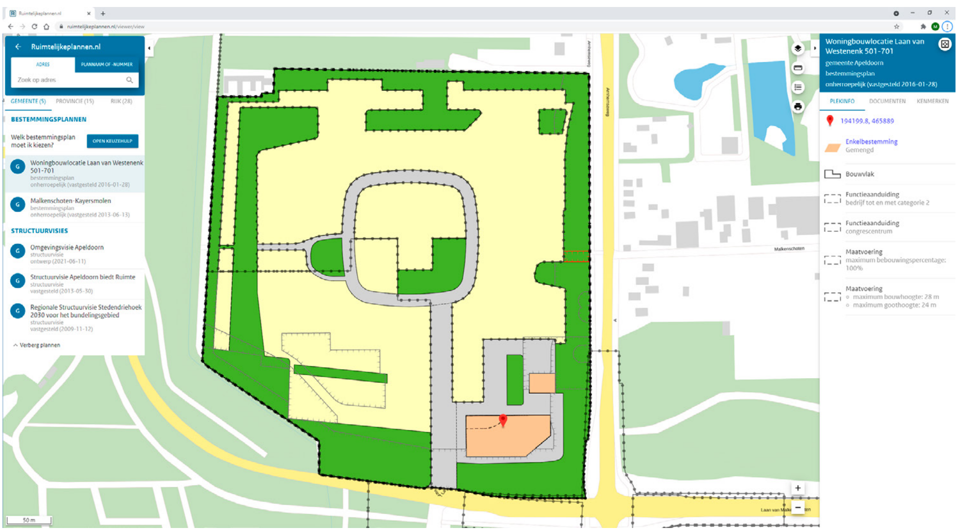


Figure 5: *Online platform in the Netherlands to search for spatial plans that apply.* (Source: www.ruimtelijkeplannen.nl)

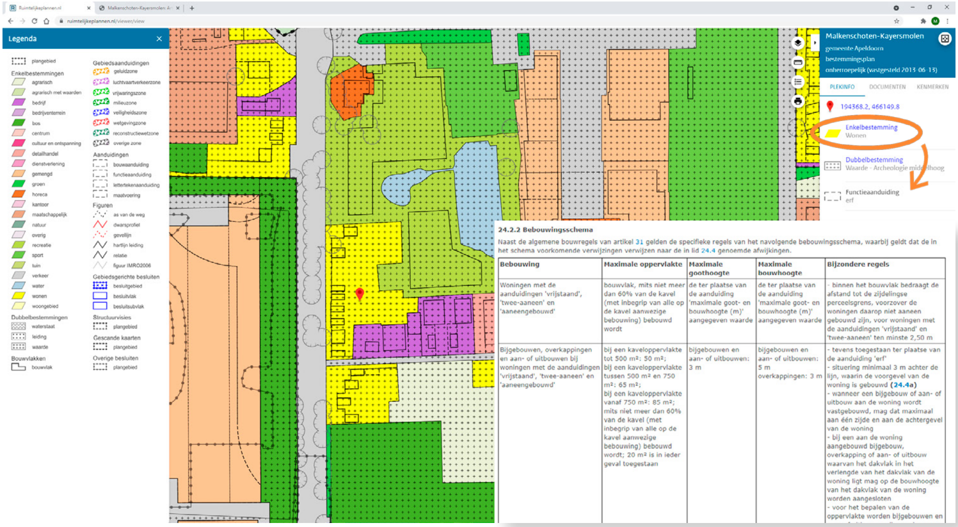


Figure 6: *Example zoning plan with legend left showing the land use types. The applicable location specific rules can be obtained by clicking on the map and then clicking on the related land use to the right, a separate document containing all the rules and regulations will be shown.*
(Source: www.ruimtelijkeplannen.nl)

is made for a new residential area. Figure 6 shows a zoning plan for an existing neighbourhood with mixed use (housing, catering, industry, greenspace). It is also possible to change the background layers. End users can choose between different topographical layers, including orthophotos, and switch on the layer with cadastral parcels. This enhances the interpretation of the location-based rules and regulations that apply.

There are also some other applications that announce upcoming planning decisions with the residents, and Turkey has useful examples in terms of geo-spatial applications in planning. Anyone with access to the internet can reach all the provinces database through the website (www.e-plan.gov.tr) and receive the information about the development plans in different scales, as can be seen in Figure 7 and Figure 8.

It is also common for users to create their own geospatial database for the province municipalities in Turkey. As it is shown in Figure 9 below, the Metropolitan Municipality of Istanbul has created the website (https://planaski.ibb.gov.tr/) for the residents to share and show where there will be a change on the development plans. Users can easily follow the updates about their neighbourhood and district from the website. An option is also given to send upcoming planning news via an SMS, particularly for elderly users.

Spatial plans hold information about land use, rules and regulations for activities in the spatial domain and these plans need to be transparent. Sometimes, the actual situation in the field is not in accordance with the planned land use and/or activities. For example, a new residential neighbourhood is planned to accommodate the growing population. Active or passive approaches can be followed, but in both cases houses and/or apartments need to be built, just like infrastructure, public spaces and services (e.g. sanitation, electricity, communication). In case of urban regeneration, it often

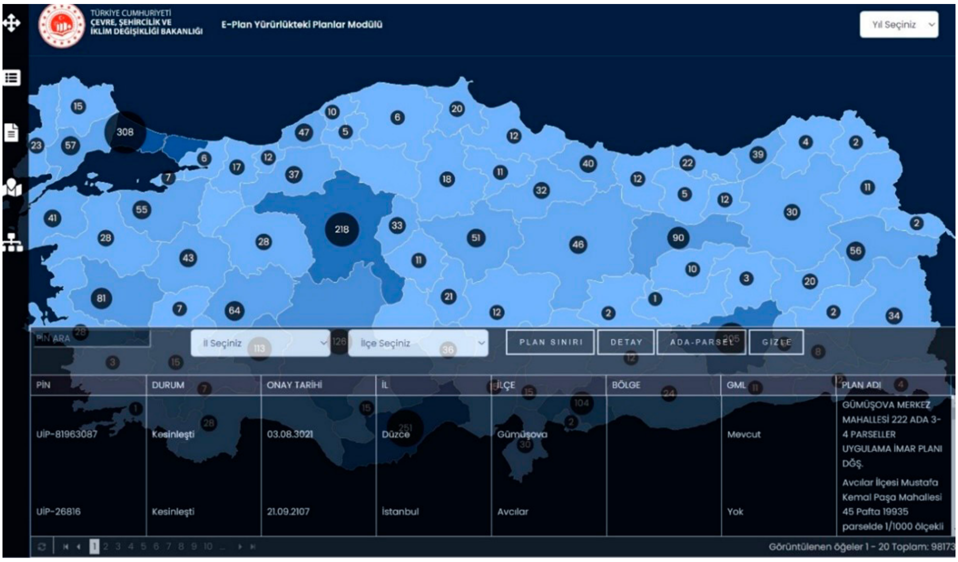


Figure 7: *It is possible to reach the development plans on all the cities in Turkey through the official website.* (Source: www.e-plan.gov.tr)

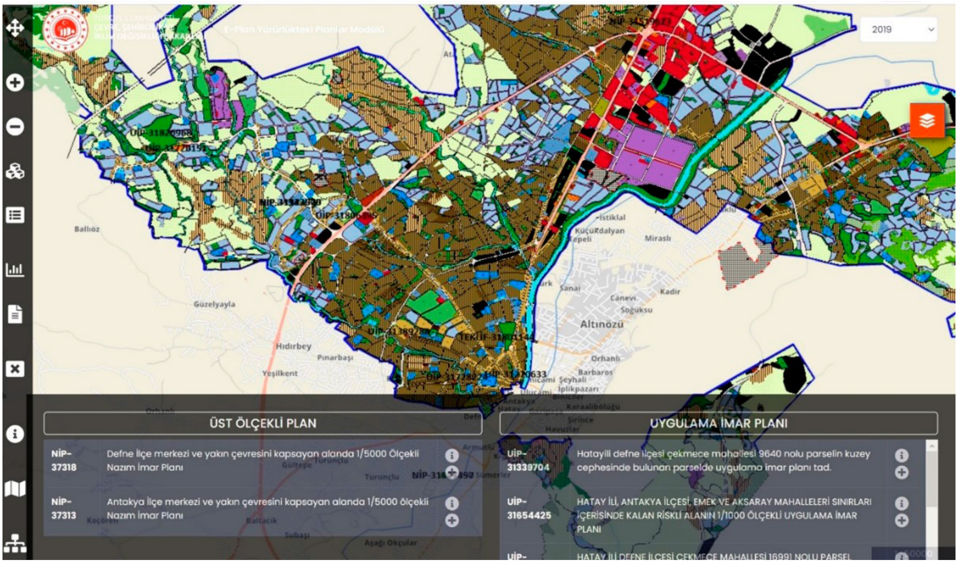


Figure 8: *Users can also see the existing development plans within the master plans and plan notes.*
(Source: www.e-plan.gov.tr)

starts with breaking down existing buildings and infrastructure (i.e. brownfield), which makes it more costly than extending the urban area at the outskirts by converting agricultural land into residential area (i.e. greenfield). In a mature spatial planning system, authorities have several instruments at their disposal to guide such projects and developments, e.g. with active land policy (expropriation, pre-emption rights, building

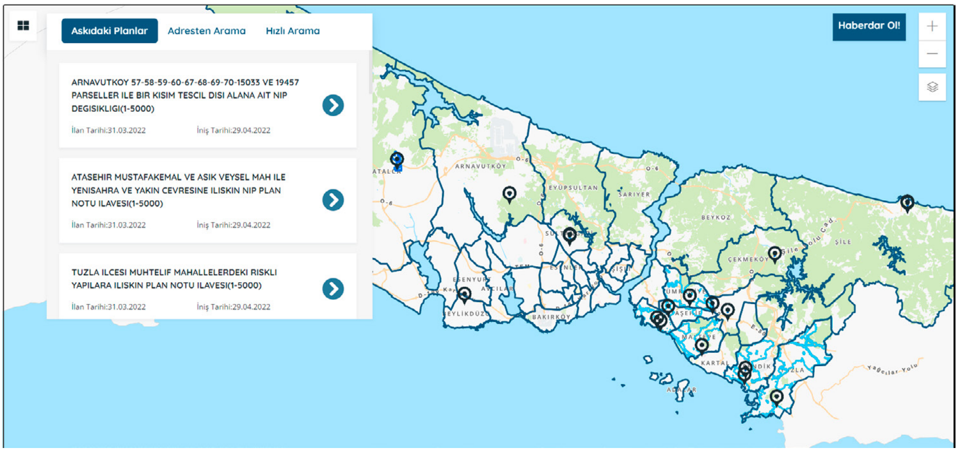


Figure 9: *A view from the Istanbul Metropolitan Municipality's website to announce the development plan changes.*
(Source: www.planaski.ibb.gov.tr)

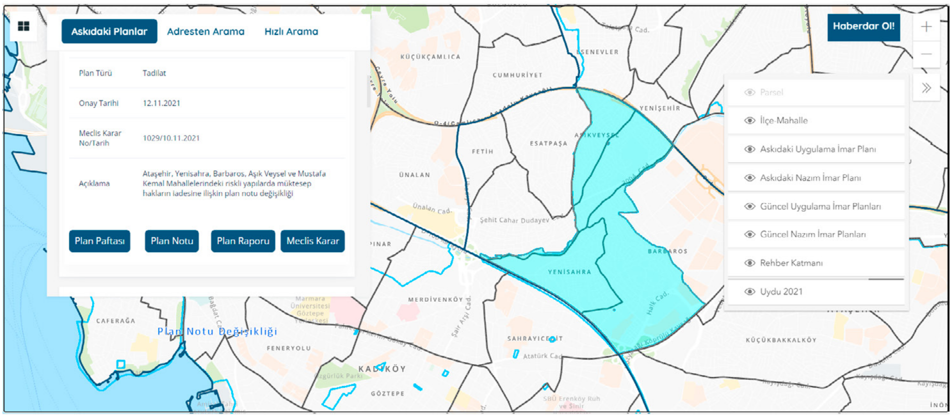


Figure 10: *The website also allows to receive the plan reports, detailed maps and the official decision letters for the users.*
(Source: www.planaski.ibb.gov.tr)

rights, land banking), permit system, financial arrangements, and the like. Having geospatial data and tools available can facilitate a transparent and participatory approach upon implementation of spatial plans.

4 Monitoring & evaluation

Monitoring and evaluation have two main functions: (1) to enforce the rules and regulations and (2) to assess the impact of spatial plans and planning interventions. Evaluation of planning interventions or spatial plans takes often place at one or two specified moments, whereas monitoring can also be applied at a more general level for monitoring any land use or land cover changes. Monitoring deforestation or afforestation with remote sensing and GIS techniques (Maw et al., 2021; van Stokkum et al., 2021) is such an example. The results of monitoring and evaluation activities provide inputs for new spatial plans or updates of spatial plans and interventions. Another important aspect is the enforcement of spatial plans. Monitoring provides essential information to authorities that support the possibility of enforcing land use, rules and regulations that apply.

Monitoring and evaluation techniques are very similar to the techniques applied for policy analyses as discussed in section 2.2. The main difference is that monitoring and evaluation is undertaken after planning interventions or on a continuous – at regular time intervals – basis, whereas for the development of spatial policies and plans it is undertaken to estimate ex-ante the potential effect in comparison with the set policy objectives.

For example, in the Netherlands demand for housing overrules the available supply. The impact of this mismatch on the housing market is severe: tremendous increase in housing prices, long waiting lists for social housing, people earning too little to buy a house, yet too much to qualify for social housing, etc. Efforts in housing policy aim to enlarge the housing stock and tailor the available housing types with the demographic and geographic demand. To monitor the effect of the housing policy, the province of Utrecht for example, developed a housing market monitor indicating the housing stock at a particular moment in time and changes compared to previous years or quarters (Figure 11).

Also at the EU level, monitoring and evaluation of policies takes place. For the environmental policy, the European Environment Agency (EEA) together with its partners,

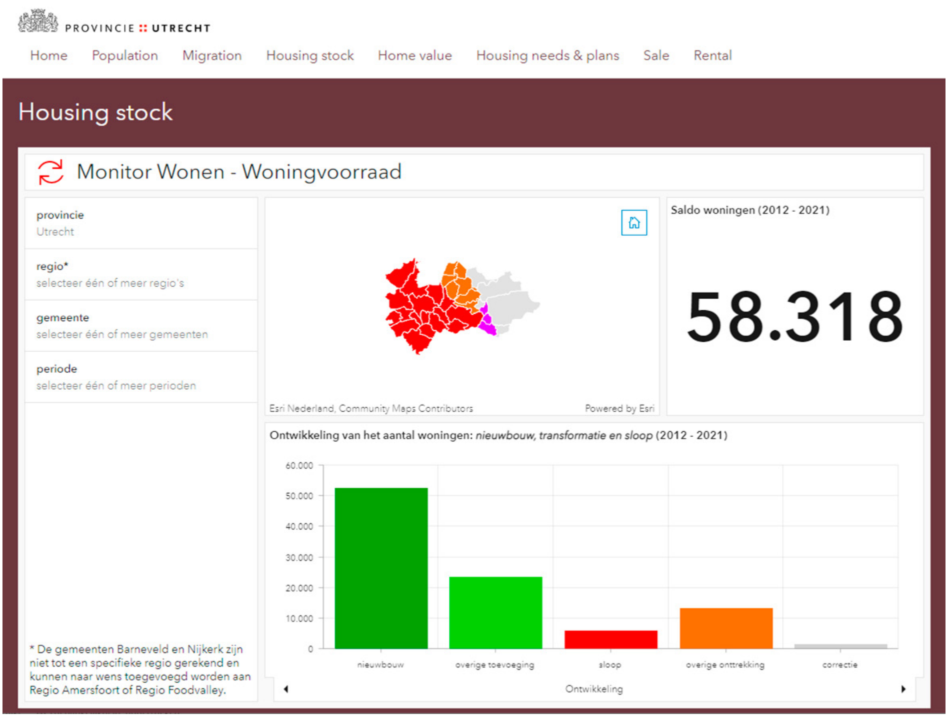
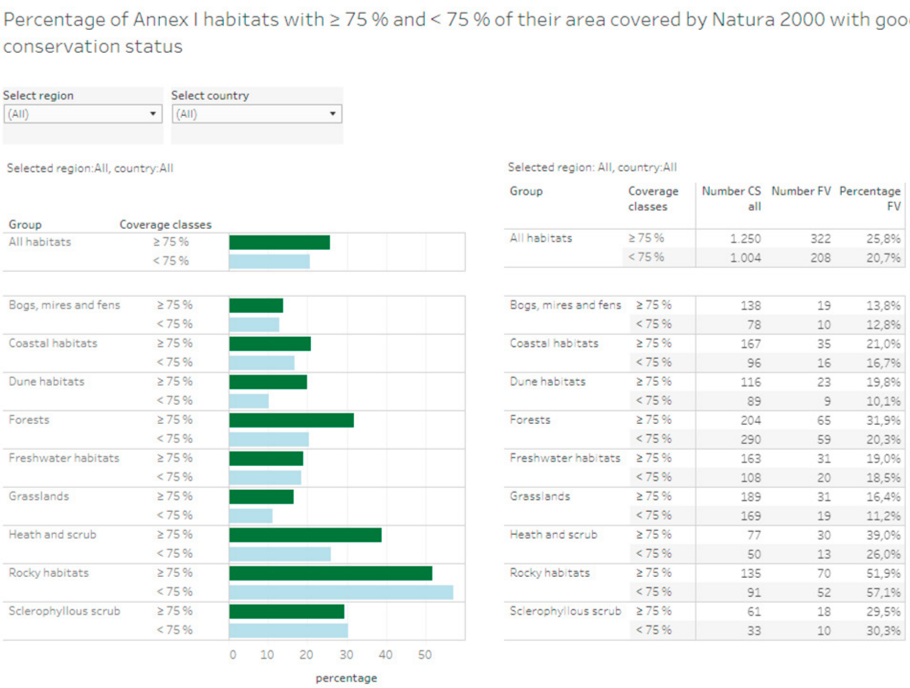


Figure 11: *Monitoring housing stock per municipality or region and per housing type – example from province of Utrecht, the Netherlands.*
(Source: https://monitorwonen.provincie-utrecht.nl/pages/woningvoorraad)



Group	Coverage classes	Number CS all	Number FV	Percentage FV
All habitats	≥ 75 %	1.250	322	25,8%
	< 75 %	1.004	208	20,7%
Bogs, mires and fens	≥ 75 %	138	19	13,8%
	< 75 %	78	10	12,8%
Coastal habitats	≥ 75 %	167	35	21,0%
	< 75 %	96	16	16,7%
Dune habitats	≥ 75 %	116	23	19,8%
	< 75 %	89	9	10,1%
Forests	≥ 75 %	204	65	31,9%
	< 75 %	290	59	20,3%
Freshwater habitats	≥ 75 %	163	31	19,0%
	< 75 %	108	20	18,5%
Grasslands	≥ 75 %	189	31	16,4%
	< 75 %	169	19	11,2%
Heath and scrub	≥ 75 %	77	30	39,0%
	< 75 %	50	13	26,0%
Rocky habitats	≥ 75 %	135	70	51,9%
	< 75 %	91	52	57,1%
Sclerophyllous scrub	≥ 75 %	61	18	29,5%
	< 75 %	33	10	30,3%

Figure 12: *Dashboard Natura 2000 network and its effectiveness.* (Source: European Environment Agency, https://tableau.discomap.eea.europa.eu/t/Natureonline/views/SONNatura2000effectiveness/Story1?:isGuestRedirectFromVizportal=y&:display_count=n&:showAppBanner=false&:origin=viz_share_link&:showVizHome=n&:embed=y)

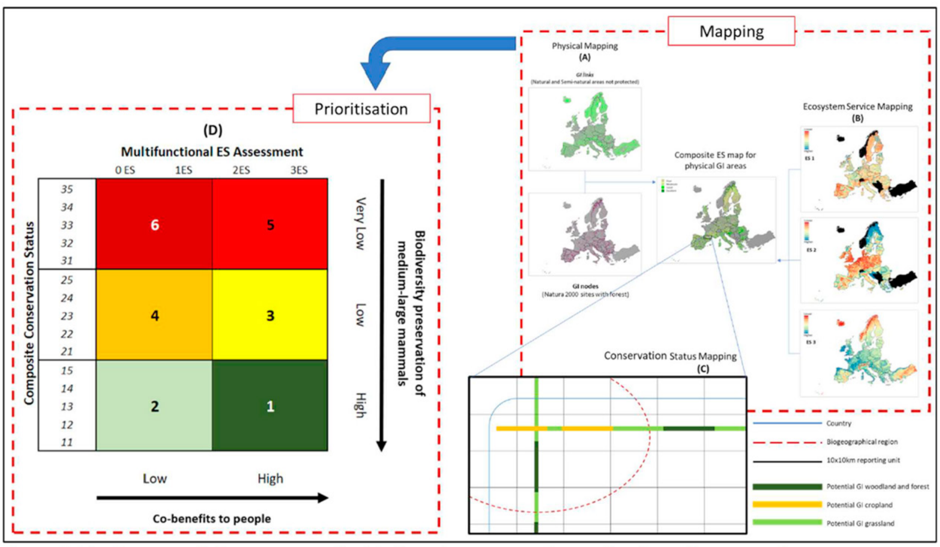


Figure 1. The integrated GI assessment for biodiversity preservation and co-benefits to people.

Figure 13: *Proposed integrated green infrastructure assessment for biodiversity preservation and co-benefits to people.* (Source: Carrao et al., 2020)

monitor the status of species and habitats at the EU level based on a 6-year time interval (European Environment Agency, 2020a). The results are published in a report and complemented by dashboards online. Figure 12 for example is one of the dashboards showing the status and effectiveness of the Natura 2000 network, based on the reports from the EU Member States.

Despite a strong policy framework and efforts by the European Member States to stop biodiversity loss and ecosystem degradation in Europe, the conservation status of protected species and habitats continues to decline along with the provision of ecosystem services. The new EU biodiversity strategy to 2030 aims to extend the Nature 2000 network towards '… a truly coherent Trans-European Nature Network' (European Environment Agency, 2020b). For this purpose, an assessment methodology has been developed (Carrao et al., 2020) which uses geodata to analyse several parameters of the assessment framework, for example the suitability to better connect protected areas (Figure 13).

5 Conclusions and outlook

This chapter described several examples on how geospatial data can play a role in spatial planning. It just scratches the surface of what is possible. Technological developments continue to improve data availability and quality. New software enables new applications, and with geodata becoming more commonly used outside the geospatial field, lay people also become more experienced with using geodata. This will all contribute to further integration of geospatial data and its applications in spatial planning processes, from ex-ante analyses to evaluation of policies, from participatory planning to informed decision-making, and so on.

Some developments were not mentioned but can also add to further use of geospatial data and applications in the field of spatial planning. The use of drones to collect data for example, 3D models and digital twins to visualize spatial plans and their impact, mobiles devices in participatory planning, or online public participation ('smartification'). Time will tell which innovations will be adopted by both the public and professionals in the field of spatial planning.

References

Informatiepunt leefomgeving, 2021. Hoofdlijnen omgevingswet. https://iplo.nl/regelgeving/omgevingswet/inhoud/. Accessed 27-7-2021.

Aan de slag met de omgevingswet, 2019. Omgevingswet in vogelvlucht. https://aandeslagmetdeomgevingswet.nl/ondersteuning/webinar-training/webcolleges-webinars/webcollege-omgevingswet-vogelvlucht/omgevingswet-vogelvlucht-blok-1/. Accessed 27-7-2021.

Akbarian, S., Jouybari, A. and N. Grondstein, 2021. Analysis of solar potential in an urban area using LiDAR data: A case study of Belgium. FIG e-Working Week 2021, *Smart Surveyors for Land and Water Management – Challenges in a New Reality*, virtually in the Netherlands, 21–25 June 2021.

Azzioui, A., Bouhamidi, M.H., Mouadine M., and M. Ettarid, 2021. Innovative Approach for a Reliable Mapping of the Morocco's Solar Resource. FIG e-Working Week

2021, *Smart Surveyors for Land and Water Management – Challenges in a New Reality*, virtually in the Netherlands, 21–25 June 2021.

Carrao, H., Kleeschulte, S., Naumann, S., McKenna D., and C. Schröder (2020). *Contributions to building a coherent Trans-European Nature Network*. European Environment Agency, European Topic Centre on Urban, Land and Soil Systems.

Chen, X., Liu, X. Quantitative Analysis of Urban Spatial Morphology Based on GIS Regionalization and Spatial Syntax. *J Indian Soc Remote Sens* (2022). https://doi.org/10.1007/s12524-021-01439-x.

de Bruin, K., Goosen, H., van Ierland, E. C., & Groeneveld, R. A. (2014). Costs and benefits of adapting spatial planning to climate change: lessons learned from a large-scale urban development project in the Netherlands. Regional Environmental Change, 14(3), 1009–1020.

Donais, F. M., Abi-Zeid, I., Waygood, E. O. D., & Lavoie, R. (2022). Municipal decision-making for sustainable transportation: Towards improving current practices for street rejuvenation in Canada. *Transportation Research Part A: Policy and Practice*, *156*, 152–170.

European Environment Agency (2020a). Explore nature reporting data. https://www.eea.europa.eu/themes/biodiversity/state-of-nature-in-the-eu/explore-nature-reporting-data, accessed 4 May 2022.

European Environment Agency. Dashboard Natura 2000 network and its effectiveness https://tableau.discomap.eea.europa.eu/t/Natureonline/views/SONNatura2000effectiveness/Story1?:isGuestRedirectFromVizportal=y&:display_count=n&:showAppBanner=false&:origin=viz_share_link&:showVizHome=n&:embed=y, accessed 4 May 2022.

European Environment Agency (2020b). Green Infrastructure – Building a coherent Trans-European Nature Network. Briefing no. 05/2020, https://doi.org.10.2800/960913.

Eggenberger, M., & Partidário, M. R. (2000). Development of a framework to assist the integration of environmental, social and economic issues in spatial planning. Impact assessment and project appraisal, 18(3), 201–207.

Francis Marleau Donais, Irène Abi-Zeid, E. Owen D. Waygood, Roxane Lavoie,Municipal decision-making for sustainable transportation: Towards improving current practices for street rejuven ation in Canada, Transportation Research Part A: Policy and Practice, Volume 156, 2022, pp. 152–170, ISSN 0965-8564, https://doi.org/10.1016/j.tra.2021.12.009.

Gallardo, A. L. C. F., Rosa, J. C. S., & Sánchez, L. E. (2022). Addressing ecosystem services from plan to project to further tiering in impact assessment: Lessons from highway planning in São Paulo, Brazil. *Environmental Impact Assessment Review*, *92*, 106694.

Kapoor, M., Dev Garg, R., Lakshmi, V., and D. Bassir, 2021. Solar Energy Planning Using Geospatial Techniques and Big-Data Analytics. FIG e-Working Week 2021, *Smart Surveyors for Land and Water Management – Challenges in a New Reality*, virtually in the Netherlands, 21–25 June 2021.

Louwsma, 2018. Towards a New Legislative Framework for Spatial Planning – the Environment and Planning Act. FIG Congress 2018. Embracing our smart world where the continents connect: the geospatial maturity of societies, Istanbul, Turkey, May 6–11, 2018. https://fig.net/resources/proceedings/fig_proceedings/fig2018/papers/ts04h/TS04H_louwsma_9321.pdf.

Maw, T.Z., Kanzaki, M. and C.H. Win, 2021. Forest Cover Change Analysis on a Protected Area in Southern Myanmar using Remote Sensing and GIS Technique: Applications to Forest Conservation. FIG e-Working Week 2021, *Smart Surveyors for Land and Water Management – Challenges in a New Reality*, virtually in the Netherlands, 21–25 June 2021.

Swart, R., Sedee, A. G. J., De Pater, F., Goosen, H., Pijnappels, M., & Vellinga, P. (2014). Climate-proofing spatial planning and water management projects: an analysis of 100 local and regional projects in the Netherlands. Journal of Environmental Policy & Planning, 16(1), 55–74.

te Boveldt, Geert, Imre Keseru, and Cathy Macharis, 2021. "How can multi-criteria analysis support deliberative spatial planning? A critical review of methods and participatory frameworks." Evaluation (2021): 13563890211020334.

Watkins D. J. & McKinney D. C. *Recent developments associated with decision support systems in water resources."*, Department of Civil Engineering, University of Texas at Austin, Austin, Texas (USA), 2000, U.S. National Report to IUGG.

Wiering, M., & Immink, I. (2006). When water management meets spatial planning: a policy-arrangements perspective. Environment and planning C: Government and policy, 24(3), 423–438.

van Stokkom, A., Dallinga, J., Debuyser, M., Hoekman, D., Kooij, B., Pacheco, P., Thau, D., Valkman, S., Beukeboom, H. and J. Ament, 2021. An Innovative Early Warning System to Tackle Illegal Deforestation. FIG e-Working Week 2021, *Smart Surveyors for Land and Water Management – Challenges in a New Reality, virtually in the Netherlands, 21–25 June 2021.*

Vullings, W., Bulens, J., Dessing, N., & Danes, M. (2012). Use of geo-Information in Policy: limitations and advantages. In *International Conference on Geographic Information Science, Avignon, April* (pp. 24–27).

CHAPTER 3
THE SPATIAL DIMENSION OF HEALTH

UBIQUITOUS BIG GEODATA FOR MEASURING THE CHANGE OF PEDESTRIAN MOBILITY PATTERNS DURING COVID-19

Avital Angel (Israel), Achituv Cohen (Israel), Pnina Plaut (Israel), Sagi Dalyot (Israel)[1]

1 Introduction and background

The COVID-19 pandemic is one of the most impactful events of the 21st century. In early stages, policy decisions were applied by governments around the world aimed at restricting citizens movement, including social distancing, lockdowns, closure of educational institutes and businesses – and more (Shakibaei et al., 2020), which had an unprecedented effect on people's mobility (Parady et al., 2020in the context of non-binding self-restriction requests. In particular, this study focuses on the effects of risk perception and social influence. A panel web-survey was conducted targeting residents of the Kanto Region, including the Tokyo Metropolis. In addition to describing the observed patterns in behavioral change, we modeled behavioral changes of four key, non-work-related activities: (i). Studies around the world mainly focused on how these policies changed motorized traffic (Shamshiripour et al., 2020but the pandemic has accelerated them remarkably. This research is an effort to investigate how and to what extent people's mobility-styles and habitual travel behaviors have changed during the COVID-19 pandemic and to explore whether these changes will persist afterward or will bounce back to the pre-pandemic situation. To do so, a stated preference-revealed preference (SP-RP), showing a decline of up to 80% in car traffic, and a 40%-60% decrease in public transportation usage (Jenelius & Cebecauer, 2020Västra Götaland and Skåne). Several studies showed an increase in cycling traffic of up to 20% (Bucsky, 2020). Very few studies explored the effect on walking activity (Dunton et al., 20202020. Participants reported minutes of vigorous, moderate, and walking physical activity for past 7 days (early-COVID-19), where Hunter et al. (2020), for example, showed a decline of around 30% in pedestrian traffic. Still, not much was done on a large scale and on measuring the physical and temporal aspects of these changes.

This paper aims to analyze the spatio-temporal effects on pedestrian mobility during the time of COVID-19 policy restrictions. Rather than relying on surveys (Dahlberg et al., 2020) or smartphone sensors (Dunton et al., 2020), which are limited in their extent to measure pedestrian mobility changes on larger scales, we aim to carry out the analysis using Bluetooth ubiquitous sensor data. This technology, which is commonly used for motorized-traffic monitoring (Mercader & Haddad, 2019), enables the collection of large quantities of real-time data, maintains privacy protection, and is relatively easy to install. However, it is only rarely used for pedestrian monitoring, mostly for small-scale systems that include only a small number of BT detectors (Malinovskiy et al., 2012). Using this technology, we aimed to analyze the spatial distribution of pedestrians for all COVID-19 policy phases in Israel, aspiring to assess the policies influence on how many, when and where people walk.

1 Original article: Angel, A., Cohen, A., Dalyot, S., & Plaut, P. (2022). Impact of COVID-19 policies on pedestrian traffic and walking patterns. Environment and Planning B: Urban Analytics and City Science, 23998083221113332.

2 Methodology

The study area is situated in Tel Aviv, Israel. The 10 sq km study area, depicted in Figure 1, is located in the northen part of the city. The BT system consists of 65 BT sensors placed at fixed locations near road intersections, creating 77 BT network links. The sensors record and monitor encrypted BT Media-Access-Control (MAC) addresses, depicted in Figure 2, which are sent from cars, mobile phones, headsets – and more. That way, as a pedestrian crosses two adjacent BT sensors, his/her movement is documented as traversing that link. As opposed to GPS observations that calculate position, the raw data recorded by the BT sensors contain travel time readings only.

Data was collected from the first of February to the 26th of July, 2020 (first COVID-19 pandemic wave), and for the equivalent time in 2019. The first pandemic wave was divided into eight phases, defined based on the beginning or ending enforcement time of policy restrictions directed by the Israeli government and the Israeli Ministry of Health. These include pre-COVID-19 (phase I), gradual restriction policies (phases II-III), quarantine (phases IV-VI), and exit-quarantine (phases VII-VIII). The timeline of the eight epochs is depicted in Figure 3.

Since the system collects BT readings from all moving (passing) objects, e.g., cars and bicycles, that use BT sensors, we first need to identify pedestrian readings only. To filter all other transportation modes, we developed a classification algorithm that relies on the statistical approximation of velocity values (Cohen et al., 2021). Experiments showed an accuracy rate of 89% in classifying pedestrian movement across the BT network. The algorithm considers the movement time along the link while minimizing wait (stop) time near intersections. We also consider the probability of traffic jams, which might introduce bias resulting from slow-moving vehicles that might be wrongly classified as pedestrians. Applying the classification process, we produce a log-file of pedestrian records only, allowing us to calculate pedestrian change values for all links for any given date and time, based on the pedestrians recorded by the BT system.

For the spatio-temporal analysis, we carried out the following calculations:

1. Evaluate traffic volumes by examining the daily average of pedestrian count (PC) on all links. We also compare these values to the equivalent period prior

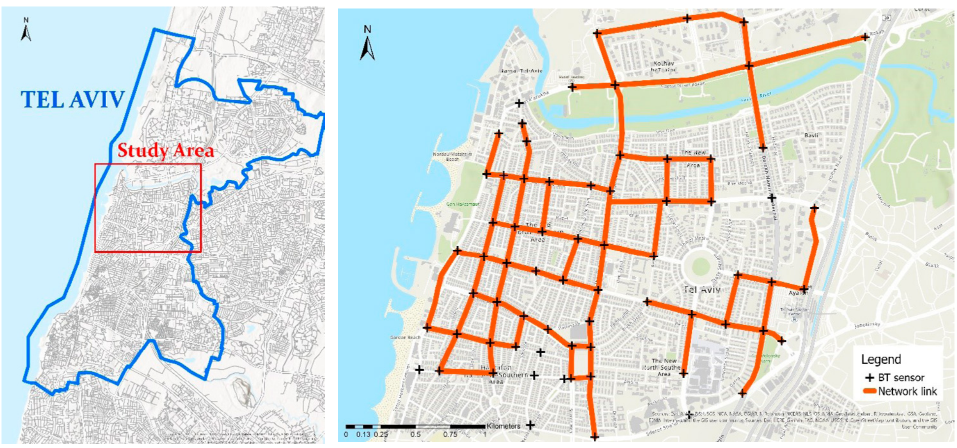


Figure 1: *Study area – left: general location of Tel-Aviv city center; right: the 65 BT sensors and 77 operating network links (street segments).*

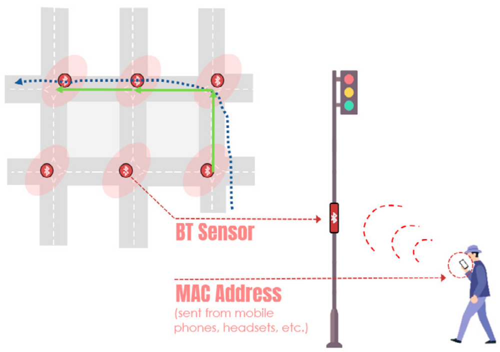


Figure 2: *Schematics of BT sensor technology documenting MAC addresses traversing its network.*

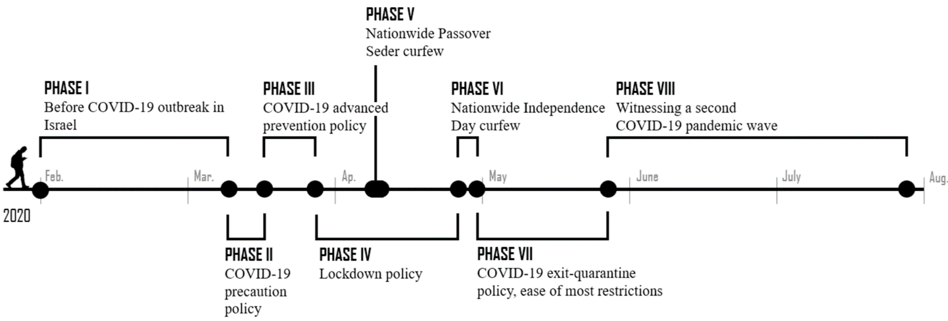


Figure 3: *Policy restrictions timeline.*

to the COVID-19 onset by defining five level(s) of change (LC) – from significant (smaller than 25%) to reverse (larger than 100%) – of PC.

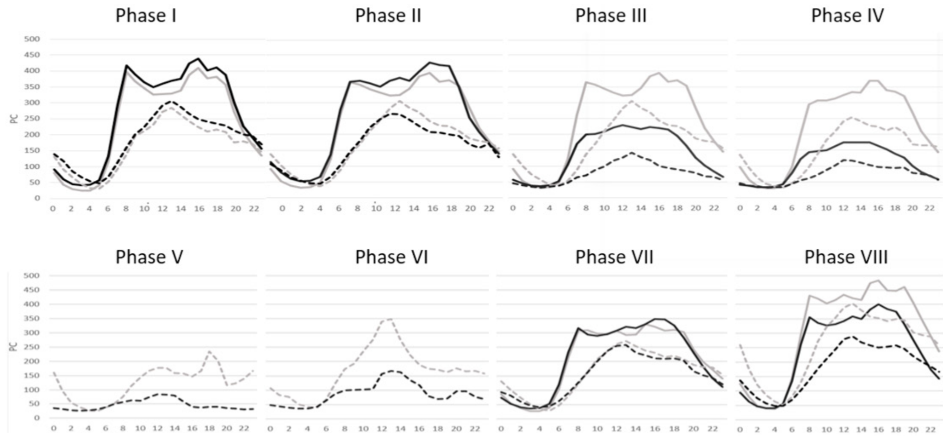
2. Highlight the different walking patterns on a temporal level. We also aim to identify pattern change in respect to where people prefer to walk. For example, are there preferences for residential links over commercial ones because shops are closed. We also aim to find specific locations that show large PC.

3 Results and discussion

A total of 116,107,592 pedestrian records were classified and analyzed in the study area. Figure 4 shows the calculated average PC values identified per network link in the study area according to the eight phases – 2020 compared to the equivalent time in 2019 – distinguishing between weekdays and weekends. LC values are given for each phase.

3.1 Pedestrian count

Phase I, *no restrictions*, shows a slight increase in PC value (~10%) during weekdays and weekends, which we assume is associated with the growing number of pedestrians who use BT-enabled devices over the course of the year. During Phase II, *first restrictions are enforced*, there is still no discernible change in PC values. In phase III, *advanced*



Phase	I	II	III	IV	V*	VI*	VII	VIII
LC (%), on weekdays	109%	107%	59%	48%	37%	52%	101%	79%
LC (%), on weekends	112%	92%	45%	48%			93%	69%

* *Phases V and VI do not include separation between weekdays and weekends as it is holidays.*

LEGEND:
2019 weekdays
2019 weekends\holiday
2020 weekdays
2020 weekends\holiday

Figure 4: *Daily average PC per network link in the study area, according to the eight analyzed policy phases in 2020, and 2019.*

prevention policy enforced, a significant decrease in PC values is evident: 41% over the weekdays and 55% over the weekends. PC continued to decrease during phase IV, as all citizens were prohibited from being more than 100m away from their homes. During the nationwide curfews, phases V and VI, a decrease of up to 63% in PC is observed. In phase VII, while restrictions were gradually removed, the results show a rapid increase in PC values to the ones in 2019, although still not as in phase I. As new restrictions are imposed in phase VIII, another decrease in PC is evident of close to 30%. This might indicate that despite the improved control over the virus spread at that time, the pandemic's societal impact was evident as people were more concerned, restricting their mobility and working from home due to the 'new reality' conditions. To conclude, the pedestrian traffic volumes in the study area were significantly affected by the various policies enforced during the COVID-19 pandemic. It is also evident that there exists a correlation of pedestrian volumes as policy restrictions tighten.

3.2 Walking patterns

Figure 5 depicts the weekdays and weekends PC average values of 2019 and 2020. Two noticeable changes in walking patterns are depicted: 1) In 2019, over the weekdays, walking patterns are characterized by a two-peak curve (morning and evening commute) that is transformed in 2020 to a single-peak at mid-day; 2) the walking patterns in 2020 for weekdays and weekends are almost identical. As the restrictions tightened, the walking pattern over weekdays gradually turned into a curve with a single-peak that characterizes the weekends. This is also the result of many education institutes being closed, and many workplaces shifting to work from home or sending employees to non-paid vacations. To conclude, analysis show that policy restrictions affected not only the number of pedestrians, but also the time-of-day they choose to walk. This can be interpreted that the purposes of people's journeys changed, where education and work are not the prominent ones.

Analyzing the streets with the highest PC values showed that most of them stay popular throughout the eight phases. These streets are mostly in the proximity of public open spaces (e.g., parks and squares) in the city. One example is Rabin Square, an urban plaza that constitutes a public space for leisure activities and gatherings, that continued to draw pedestrians from the connected streets. The analysis suggests that the important role of the plaza as an open public area was maintained even during strict policies regardless the closure of surrounding businesses. This plaza provided a social need while enabling for social distancing and adherence to the restrictions.

We also analyzed the PC values change in commercial and residential streets. While expecting commercial streets to show a more significant LC drop due to closure of shops, this was not evident in the data – both commercial and residential links experienced significant LC. PC values were found to be consistently higher in commercial links, compared with residential links, during all policy phases. This can be explained by the fact that the streets in the study area are highly mixed land-use, and that several commercial streets are artery links in the road network, also serving as boulevards, thus PC values were probably affected also from pedestrian navigation preferences.

4 *Summary and conclusions*

The spread of the COVID-19 pandemic provoked new policies and restrictions, which had an unprecedented impact on urban mobility and traffic on local and global scales. During the first wave of the virus spread in Israel, the Israeli government pursued new policies, which included limited gatherings, travel distance restrictions, closure of businesses and leisure venues, lockdown, curfews – and more. This study investigated the impact of these policies on pedestrian street traffic and walking patterns in Tel-Aviv, while using over 116 million records of pedestrian movement recorded by BT sensor technology. An algorithm was developed to classify pedestrian records from all other transportation modes, and several spatio-temporal processes were implemented to carry out the pedestrian mobility investigation and analysis.

The results showed that the COVID-19 restriction policies had a considerable impact on PC and walking patterns. PC values reduced between 41% to 63%, corresponding

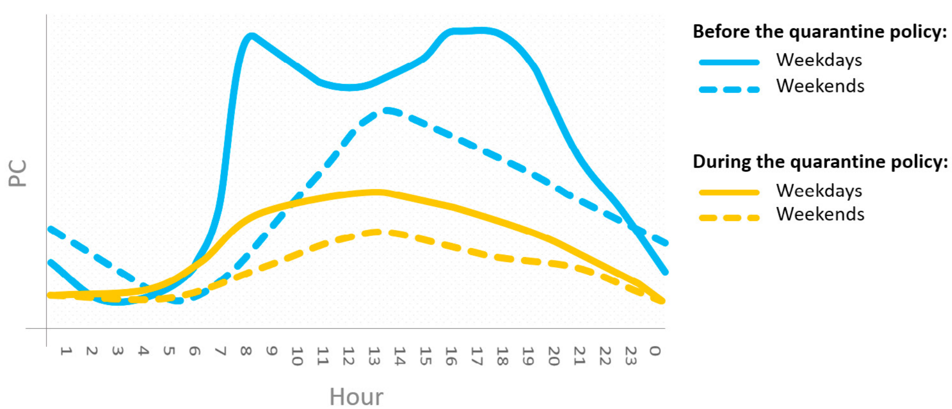


Figure 5: *Walking patterns during the day (on average): PC (pedestrian count) before and during the quarantine policy.*

to tightening and easing of policy restrictions. In general, it can be concluded that the public followed the restriction policies. A considerable change in the walking pattern was observed during the weekdays, which transformed to behave similarly to weekends, meaning that pedestrians changed their common daily activity due to a change in walking purpose. Interestingly, while the policy affected walking volumes and patterns, it did not change the locations pedestrians prefer to walk. Attractive streets, mainly around parks and squares, remained popular, proving their essentialness to citizens living in urban areas. This was also evident in commercial streets, where the fact that shops were mostly closed did not significantly influence corresponding PC values on those streets.

The methodology and data provided in this study prove the essentiality of timely geospatial data that are valuable for many stakeholders, such as urban planners and decisionmakers. In this study, the data was used to investigate the magnitude of COVID-19 policies' impact on pedestrian movement, as well as on the potential that automated PC technologies hold for monitoring walking behavior in real-time. Moreover, this study supports the initiatives of the Global Compact for Migration (GCM)[2] by promoting the collection and utilization of disaggregated data as a basis for evidence-based policies. It also supports the Sustainable Development Goals (SDG) 2030 agenda[3], by enhancing the concept of sustainable cities and communities through research that supports pedestrian-oriented planning.

References

Bucsky, P. (2020). Modal share changes due to COVID-19: The case of Budapest. *Transportation Research Interdisciplinary Perspectives*, *8*. https://doi.org/10.1016/j.trip.2020.100141.

Cohen, A., Dalyot, S., & Natapov, A. (2021). Machine Learning for Predicting Pedestrian Activity Levels in Cities. In 16th International Conference on Location Based Services (p. 124).

Dahlberg, M., Edin, P.-A., Grönqvist, E., Lyhagen, J., Östh, J., Siretskiy, A., & Toger, M. (2020). *Effects of the COVID-19 Pandemic on Population Mobility under Mild Policies: Causal Evidence from Sweden*. http://arxiv.org/abs/2004.09087.

Dunton, G. F., Wang, S. D., Do, B., & Courtney, J. (2020). Early effects of the COVID-19 pandemic on physical activity locations and behaviors in adults living in the United States. *Preventive Medicine Reports*, *20*, 101241. https://doi.org/10.1016/j.pmedr.2020.101241.

Hunter, R. F., Garcia, L., Sa, T. H. De, Zapata-diomedi, B., Millett, C., Woodcock, J., Pentland, A. S., & Moro, E. (2020). Effect of COVID-19 response policies on walking behavior in US cities. *Nature Communications*, *2021*, 1–9. https://doi.org/10.1038/s41467-021-23937-9.

Jenelius, E., & Cebecauer, M. (2020). Impacts of COVID-19 on public transport ridership in Sweden: Analysis of ticket validations, sales and passenger counts. *Trans-*

2 https://migrationdataportal.org/global-compact-for-migration.

3 https://worldtop20.org/global-movement?gclid=Cj0KCQiApsiBBhCKARIsAN8o_4gPWWI-Qo6t_Kxg8aqs2h31M6Up-O2g_9e3Wx6SqnOJjKt0JR_aTlEaAhy8EALw_wcB.

portation Research Interdisciplinary Perspectives, *8*(June), 100242. https://doi.org/10.1016/j.trip.2020.100242.

Malinovskiy, Y., Saunier, N., & Wang, Y. (2012). Analysis of Pedestrian Travel with Static Bluetooth Sensors. *Transportation Research Record: Journal of the Transportation Research Board*, *2299*(1), 137–149. https://doi.org/10.3141/2299-15.

Mercader, P., & Haddad, J. (2019). Automatic Incident Detection in Freeways by using Bluetooth Based Tracking. *7th Symposium of the European Association for Research in Transportation (HEART 2018)*, 1–4.

Parady, G., Taniguchi, A., & Takami, K. (2020). Travel behavior changes during the COVID-19 pandemic in Japan: Analyzing the effects of risk perception and social influence on going-out self-restriction. *Transportation Research Interdisciplinary Perspectives*, *7*, 100181. https://doi.org/10.1016/j.trip.2020.100181.

Shakibaei, S., de Jong, G. C., Alpkökin, P., & Rashidi, T. H. (2020). Impact of the COVID-19 pandemic on travel behavior in Istanbul: A panel data analysis. *Sustainable Cities and Society*, *65* (September 2020). https://doi.org/10.1016/j.scs.2020.102619.

Shamshiripour, A., Rahimi, E., Shabanpour, R., & Mohammadian, A. (Kouros). (2020). How is COVID-19 reshaping activity-travel behavior? Evidence from a comprehensive survey in Chicago. *Transportation Research Interdisciplinary Perspectives*, *7*, 100216. https://doi.org/10.1016/j.trip.2020.100216.

TOWARDS AN INTEGRATED GEOSPATIAL INFORMATION MANAGEMENT FOR PUBLIC SECTOR HEALTH DATA IN THE EU – THE COVID-19 PANDEMIC SEEN THROUGH THE LENS OF IGIF

Hartmut Müller (Germany), Marije Louwsma (Netherlands)

1 COVID-19 pandemic

In March 2020 WHO declared the COVID-19 outbreak a pandemic (WHO, 2020). The pandemic put an unprecedented burden on society and almost void of information, governments initially struggled to respond effectively to minimize the impact of the outbreak. It is key for governments and their agencies to have the appropriate and reliable information at hand to make informed decisions. The need for information is apparent at all governance levels, even though nations hold the authority to decide on interventions and measures taken for their own territory.

From a geospatial perspective, the COVID-19 pandemic once again underpins the need for reliable geospatial data to support governing prevention of the spread of the pandemic and to minimize the risk to people (UN-GGIM, 2020). What can geospatial information and technologies do to assist stakeholders in a global pandemic? How can insights be communicated? How can geospatial technologies help in understanding the COVID-19 situation? How is adequate collaboration, coordination, engagement, and communication possible? What patterns are emerging? The availability of suitable geospatial information, and of aggregated and geographically disaggregated public health and related data was key for all countries to address the pandemic, across all population stakeholders. Due to tight economic relations between countries in the European Union, and consequently the cross-border movement of goods and people, cooperation between member states is needed. In times of a pandemic such as COVID-19 a supranational view is needed, next to the national governance level, to take appropriate and coordinated action at all governance levels; supranational, national, regional, and local. Trends in outbreaks over time and space, hotspots of infection, applicable rules and regulations, and available resources for medical treatment can be identified and geospatially enabled information disseminated to responsible authorities and to the public in general.

This chapter will analyse the use of geospatial data by national governments in the first phase of the COVID-19 pandemic in Europe in 2020 and 2021. From the lens of the Integrated Geospatial Information Framework (IGIF), the role of geospatial data in governing the pandemic has been analysed. How were the challenges posed by the COVID-19 pandemic managed by Member States in the European Union (EU) regarding the use of geospatial data and tools? The next section describes the IGIF and how it is used for the analysis. The third section encompasses the European standards for data and statistics. The fourth section shows the empirical findings from the national COVID-19 dashboards that were established to monitor the outbreak. The fifth section reflects on the data used and the last two sections provide some conclusions and recommendations.

2 The Integrated Geospatial Information Framework IGIF

2.1 IGIF introduced

National Mapping Agencies and other public institutions have long been custodians of their nation's geospatial data. Since 2016, the global 'integration of spatial, statistical

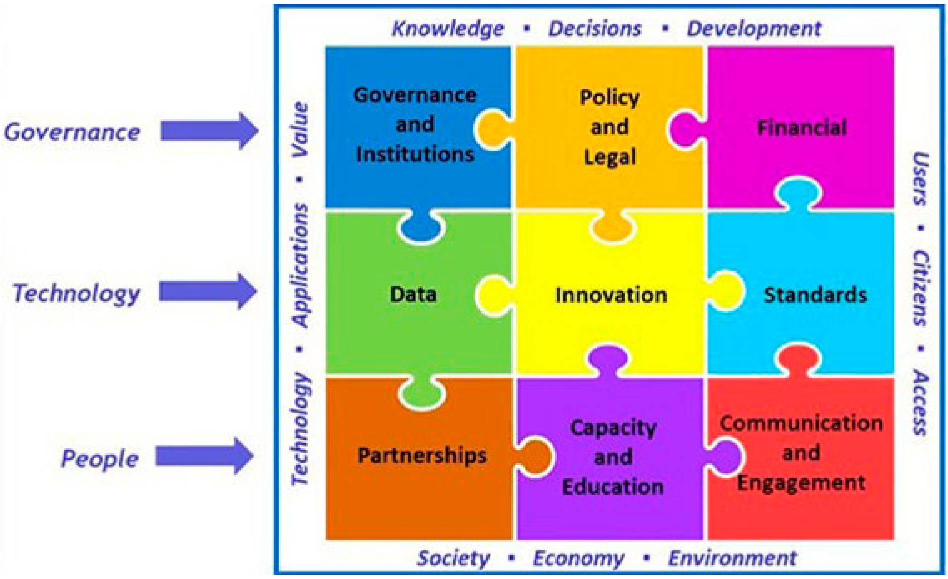


Figure 1: *Nine strategic pathways of the Integrated Geospatial Information Framework.* (Source: UN, 2018, p. 21)

and other related information' has been explicitly on the agenda of the UN Committee of Experts on Global Spatial Data Management (UN-GGIM, 2016). The COVID-19 epidemic demonstrates — in a perhaps unparalleled way —the need to provide globally integrated spatial, statistical, and health-related information, adapted to the needs of diverse user groups. The pandemic has shown the need to deal with the highly dynamic nature of health-related information in this context. A globally well-defined, integrated statistical and geospatial framework could serve as an excellent basis for managing not only relatively low-dynamic statistical data, but also highly dynamic health data, such as those generated in the event of a global epidemic.

In August 2018, the UN-GGIM adopted the Integrated Geospatial Information Framework (IGIF) (UN, 2018) which was developed by experts in the geospatial field from collective global lessons. Based on nine strategic pathways, the framework aims to provide guidance for countries to strengthen national geospatial information management arrangements within and across UN Member States at the institutional level. The strategic framework can guide countries through implementation by developing Country-level Action Plans. The nine distinguished strategic pathways are: (1) governance and institutions, (2) policy and legal, (3) financial, (4) data, (5) innovation, (6) standards, (7) partnerships, (8) capacity and education, and (9) communication and engagement (1). The first three pathways (1–3) relate to governance, the second three (4–6) relate to technology, and the last three (7–9) relate to people.

Governance and institutions – *pathway 1* – refers to the leadership, governance model, institutional arrangements and a clear value proposition as a means to strengthen multi-disciplinary and multi-sectoral participation and a commitment to achieving an Integrated Geospatial Information Framework. *Pathway 2* – policy and legal – refers to the legal and policy framework that enables the availability, accessibility, exchange, application, and management of geospatial information. *Pathway 3* – financial – refers to establishing the business model, developing financial partnerships, and identifying the investment needs and funding sources for delivering integrated geospatial information management, as well as recognizing the benefits.

Pathway 4 – data – aims to establish a geospatial data framework and custodianship guidelines for best practice collection and management of integrated geospatial information that is appropriate to cross sector and multidisciplinary collaboration. The UN-GGIM adopted a *minimum list of fourteen global fundamental geospatial data themes* to be addressed: (1) global geodetic reference framework, (2) addresses, (3) buildings and settlements, (4) elevation and depth, (5) functional areas, (6) geographical names, (7) geology and soils, (8) land cover and land use, (9) land parcels, (10) ortho-imagery, (11) physical infrastructure, (12) population distribution, (13) transport network and (14) water. Health data was not distinguished as a separate theme in this list.

Pathway 5 – innovation – stands at the crossroads of all nine pathways. This pathway has the potential to stimulate, trigger and respond to rapid change, leapfrog outdated technologies and processes, and bridge the geospatial digital divide. It intends to serve as a transition guide for leveraging the latest cost-effective technologies, innovations and process improvements. As such, it distinguishes five levels in a Technology Maturity Index (see Appendix) for the geospatial landscape (UN, 2020). The five maturity levels are in respective order from low to highly mature:

- Level 1: Analogue Mapping
- Level 2: Digital Cartography
- Level 3: Geographic Information Systems (GIS)
- Level 4: Spatial Data Infrastructures (SDI)
- Level 5: Integrated Geospatial Information Management

Pathway 6 – standards – refers to ensuring the adoption of best practice standards and compliance mechanisms that enable legal, data, semantic and technical interoperability, which are fundamental to delivering integrated geospatial information and knowledge creation. Standards enable different information systems to communicate and exchange data and provide users with lawful access to, and reuse of, geospatial information.

Pathway 7 – partnerships – aims to establish effective cross-sector and interdisciplinary cooperation, industry and private sector partnerships, and international cooperation. *Pathway 8* – capacity and education – ensures that geospatial information management and entrepreneurship can be sustained in the longer term by capacity building and education. *Pathway 9* – communication and engagement – recognizes that stakeholders (including the general community) are integral to the implementation of integrated geospatial information management systems and that their buy-in and commitment is critical to success.

2.2 IGIF lens on the pandemic

Various IGIF pathways are relevant for the analysis of the role of geospatial data during the COVID-19 pandemic, especially in those dynamic early days of the outbreak. In this chapter we focus on the *three strategic pathways related to technology, namely data (SP 4), innovation (SP 5), and standards (SP 6)*. The implementation guides for these three pathways are – at moment of writing – not all yet finalised, but drafts have been published for consultation.

The European Union has put efforts in developing and implementing standards for geo-information to enable data sharing between Member States. Since the INSPIRE directive, establishing an INfrastructure for SPatial InfoRmation in Europe, has been endorsed (European Union, 2007). EU Member States have implemented the directive to a large extent. So, there was already a standard for geospatial data developed and operationalised in many spatial data infrastructures within the EU, before the COVID-19 pandemic outbreak. Member States are familiar with these standards. However, data standards mostly have been applied within the geodata sector, but not specifically for the data theme 'health'. The outbreak of the pandemic provides a good case to evaluate the application of standards in other domains than the geo sector.

Regarding the analysis of the pathways data and innovation, empirical data about available COVID-19 dashboards was collected for each Member State in the first months of 2021. The national dashboards were analysed on how information about the COVID-19 outbreak was disseminated and presented. The analysis focused mainly on the data including how the data was presented (map type, statistics, graphs), available metadata, and access to the underlying data set. Section 4 describes the results and compares the Member States' dashboards based on a set of parameters applied in a multi-criteria evaluation. The collected empirical data stems from another research (Müller and Louwsma, 2021), and has been reused for the purpose of this analysis looking at the COVID-19 pandemic through the lens of IGIF.

The IGIF Technology Maturity Index (see Appendix) is used as basis for the evaluation of the maturity of the COVID-19 dashboards within the European Union's Member States. According to the index, the maturity of the geospatial landscape is determined based on several criteria such as the operational level, data supply patterns, accessibility, used data formats, user services, analytics, and applied standards.

3 The Nomenclature of Territorial Units for Statistics (NUTS) in Europe

The Nomenclature of Territorial Units for Statistics (NUTS) for Europe is an implementation of strategic pathway 4 – data – and relates to the distinguished geospatial data theme '5. Functional Areas'. The NUTS system is based on the Universal Transverse Mercator coordinate system (UTM) which is an implementation of the UN-GGIM global fundamental geospatial data theme '1. Global Geodetic Reference Framework'.

From the beginning in the 1970s, the Nomenclature of Territorial Units for Statistics (NUTS) has provided a classification of the economic territory of the European Union into territorial units (EUROSTAT, 2018). The three-level hierarchical classification scheme enables spatial aggregation and disaggregation according to the governance level. The system facilitates combining national statistical data from Member States in a standardized, consistent, and interoperable format at the European level. Each Member State is divided into NUTS 1 regions, each NUTS 1 region is subdivided into NUTS 2 regions, which in turn are subdivided into NUTS 3 regions. As such, it provides a good consistent basis across Europe for showing the spatial distribution of COVID-19 related information.

In May 2003, NUTS was formally adopted by Commission Regulation (EC) No 1059/2003. On a regular basis, the classification can be adjusted. So far, six different NUTS versions have been published (years 2003, 2006, 2010, 2013, 2016, and 2021). This fact highlights the need to track changes in administrative units, even for European countries that can be considered stable in terms of administration. Nonetheless, the changes can be significant. NUTS 2021 lists 92 NUTS 1 regions, 242 NUTS 2 regions, and 1166 NUTS 3 regions for the European Union 27 plus the United Kingdom.

The NUTS Regulation defines the population size in minimum and maximum thresholds for the population rather than size of an area as key indicator (Table 1). This enhances comparability between units at the same level. Due to the three distinguished hierarchical levels, it also allows for scaling up or down.

Table 1: *Population size of the European Union's administrative units (EUROSTAT, 2018).*

Level	Minimum number of inhabitants	Maximum number of inhabitants
NUTS 1	3 million	7 million
NUTS 2	800,000	3 million
NUTS 3	150,000	800,000

Following the heterogeneous population density across the EU territory the NUTS classification results in a wide span of both area size and population number: the largest NUTS 1 region covers 336,859 km^2, the smallest region only 161 km^2, depending on the population density in an area. At NUTS 2 level, the largest region covers 227,150 km^2, the smallest 13 km^2. At NUTS 3 level the figures are 105,205 km^2 for the largest region and again 13 km^2 for the smallest. The population varies between 17.9 million and 29,200 inhabitants at the NUTS 1 level, between 12.2 million and 29,200 at the NUTS 2 level, and between 6.5 million and 10,900 inhabitants at the NUTS 3 level. These variations among statistical units in terms of area, population and population density are suboptimal for reporting about COVID-19. However, the NUTS system is the only standardized system currently known to be applied in Europe.

4 Member States COVID-19 dashboards

The national dashboards, as developed to inform the public about the spread and status of the COVID-19 pandemic in their country, have been evaluated by the authors of this chapter. The evaluation is based on a set of criteria to compare the dashboards of individual Member States in a standardized way. Most criteria relate to the topics mentioned in the IGIF maturity index, although not all aspects from the index are covered.

Table 2: *Evaluation matrix for evaluation of dashboards (adapted from Müller and Louwsma, 2021).*

Criterion	Classification
COVID-19 parameters	number of cases, deaths, hospitalized people, positive test results, reproduction number, other parameters
Map type	choropleth map, size map, heat map, dot map, multivariate map
Graph type	bar graph, line chart, pie chart, histogram
Metadata	frequency of updates, data source, data collection method, definition of indicators
Access to data	pre-defined tables, downloadable data sets, feature and mapping services

The following criteria were selected for the evaluation of the dashboards: (1) COVID-19 parameters, (2) map type, (3) graph type, (4) available metadata, and (5) access to the data. The evaluation matrix (Table 2) shows selected evaluation criteria, and their respective classification. The last two criteria focus on the available metadata, and to what extent access to the data sets is possible from the dashboard. The latter criteria (metadata and accessibility of data sets) are particularly important since they are critical success factors for integrated geospatial information management. A multicriteria evaluation has been used to standardize the criterion scores to enable meaningful comparisons of the various types of criteria and to weight the criteria according to their level of importance (Carver, 1991).

Based on the results of the multicriteria evaluation, Figure 2 maps the rating of dashboards per Member State (see Appendix). Looking at the dashboards from the IGIF maturity index, it shows that most dashboards provide and present information in a decent way but do not reach the most innovative end (level 5). Most dashboards would rank at maturity level 3 or 4, including maps, graphs, statistics, and metadata. However, these figures were mostly non-dynamic, meaning that the information was presented for a given date, in a given way. Some dashboards were limited to providing basic information, whereas others presented the information in numerous, extensive ways. Overall, for the end-user it was not possible to perform analyses or queries within the dashboard.

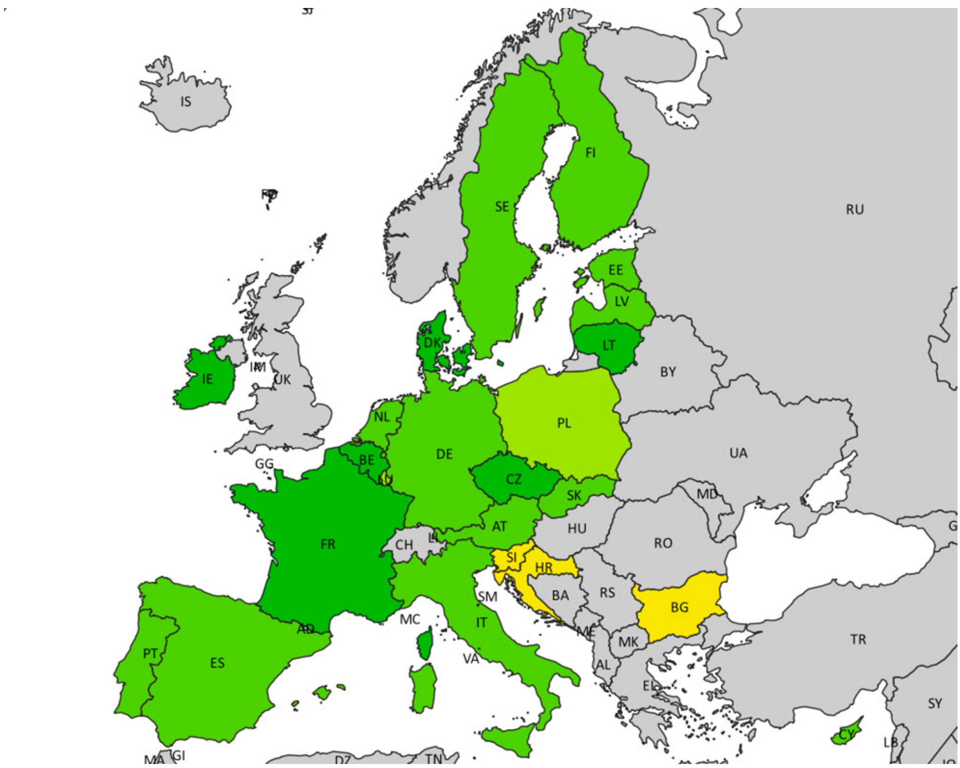


Figure 2: *Rating of the evaluated dashboards from 27 EU Member States, dashboards for Member States Greece, Hungary, Romania were not found.* (Own elaboration)

Two Member States are exemplified, the Netherlands and Germany, to provide some more in-depth information on how geospatial information was governed over the course of the early days of the pandemic.

The government in the Netherlands chose to publish most Covid-19 related information initially in traditional graphs instead of mapping it. Only the relative number of Covid-19 cases and hospitalized people per 100,000 inhabitants per municipality were visualized geographically (Figure 3a,b). Compared to absolute numbers, this relative number allows for comparison between municipalities with varying population densities. Over the course of the pandemic the national government developed a dashboard to inform the public. The NUTS 2 level (provinces) is used as a basis, but geographically larger NUTS 2 units have been further subdivided according to administratively defined safety regions. The dashboard provides information at the national level, at safety region level (slightly smaller areas than the regional government) and at municipal level. Each is presented on a different dashboard tab.

In Germany policy makers agreed to respond to regional dynamics of new infections on a local basis, using the NUTS 3 level administrative units as the spatial reference. The Robert Koch Institute, Germany's public health institute, collects data on infectious diseases, among others. The Institute communicates information through a COVID-19 specific dashboard and offers the updated underlying data to the public on a daily basis. The data can be downloaded in different formats. Retrieving the data via an ESRI ArcGIS Feature Service is a very versatile way to get direct access to the attributes and geometry of the layers. Geospatial data retrieved via a Web Feature Server make it possible to use the complete set of GIS tools for comprehensive spatiotemporal analyses. For example, the period of time and further spread of local outbreaks can be tracked. At the same time, using such spatially aggregated data preserves data protection and data privacy.

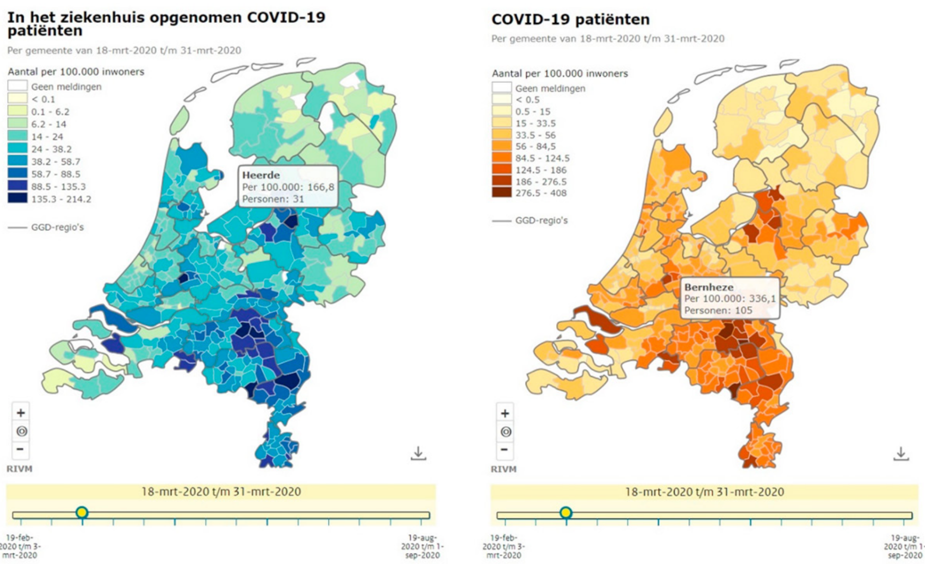


Figure 3: *Number of hospitalized people (a) and COVID-19 cases (b) for the period 18–31 March 2020 per 100,000 inhabitants per municipality.*

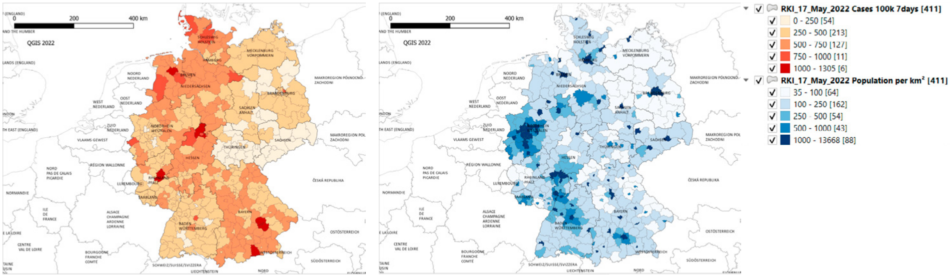


Figure 4: *Number of confirmed COVID-19 cases per 7 days and 100,000 inhabitants as of 17 May 2022 (a) and number of inhabitants per km² (b).* (Own elaboration)

Figure 4 shows visualisations of COVID-19 cases (left) and population density (right) in Quantum GIS. Population density is used here as an example of available official statistical data. Many other statistical data can be linked to COVID-19 figures through the same mechanism, using the standardized IDs of all official functional units. Population data by age group, for example, can be used to identify areas with a high percentage of vulnerable groups, such as the elderly, at the click of a button in the GIS.

Apart from national dashboards, international agencies were also providing information at the global level. WHO operates its own dashboard on COVID-19 cases, including the WHO European Region COVID-19 Subnational Explorer (Figure 5). It provides COVID 19 cases by incidence (cases per 100,000 population) over the last 7 days, 14 days, or the entire pandemic.

It is possible to access the pan-European data through an ESRI ArcGIS Web Feature Server (Figure 6), similar to how national COVID-19 data in Germany can be accessed and downloaded through the national Web Portal. This opens up the possibility of analyzing COVID-19 information together with other relevant spatial data, provided that all information is available in an equally standardized form.

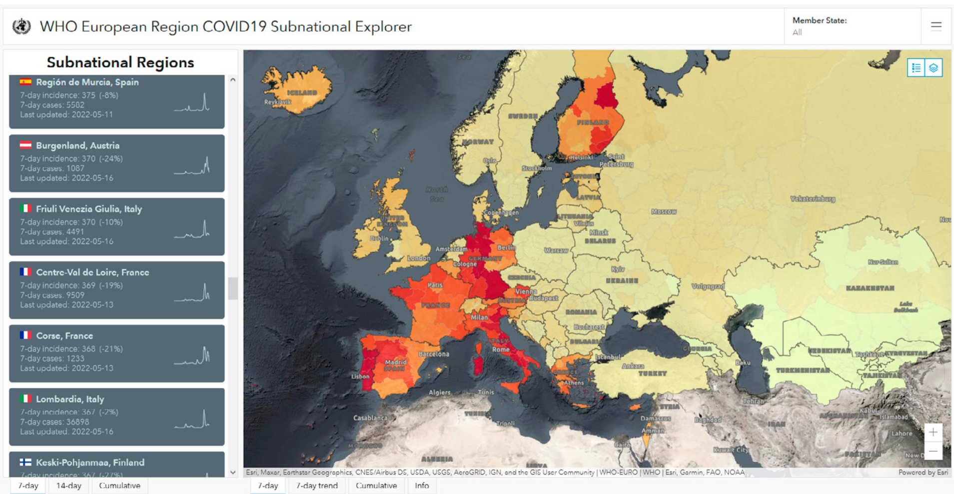


Figure 5: *WHO European Region COVID-19 Dashboard*
https://experience.arcgis.com/experience/3a056fc8839d47969ef59949e9984a71.

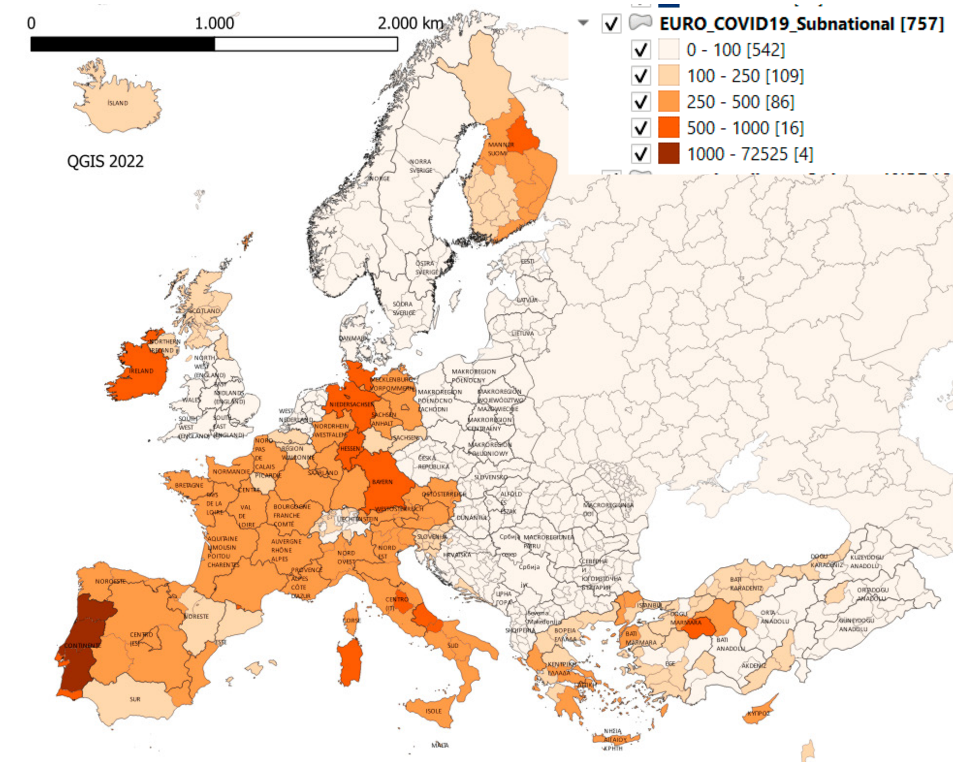


Figure 6: *Number of confirmed COVID-19 cases per 7 days and 100,000 inhabitants, imported via ArcGIS Web Feature Server into QGIS.* (Own elaboration)

The provision of international data faces special challenges and often has its own specific limitations. The information in the dashboard's disclaimer provides insight into the many challenges of collecting reliable data on COVID-19 cases:

> *'Caution must be taken when interpreting all data presented, and differences between information products published by WHO, public health authorities, and other sources using different inclusion criteria and different data cut-off times are to be expected. While steps are taken to ensure accuracy and reliability, all data are subject to continuous verification and change. All counts are subject to variations in case detection, definitions, laboratory testing, and reporting strategies.'*

The argument for such official caveats is found in the data collection process, as data are collected from dozens of publicly available sources from international, national, and regional authorities, all of which follow their own standards and are often not coordinated with each other.

5 Data shortcuts and challenges of COVID-19 data provision

A comprehensive review of the existing data problems is beyond the scope of this report but further research would be warranted here to implement lessons for future pandemics. For illustration purposes, some relevant exemplary problems that have appeared from the analysis and examples can be listed as follows:

5.1 The quest for reliable data

The number of confirmed cases depends largely on the number of conducted diagnostic tests: the more laboratory tests are conducted; the more positive cases are discovered. A lack of test material or testing capacity hampered some countries to produce reliable data regarding the number of positive tested persons. As an alternative other data were used to monitor the progress of the disease, such as the number of hospitalized people.

5.2 The timeliness of reporting

There is no obvious reason why both the number of confirmed cases of disease and the number of disease-induced deaths should be lower on weekends than on working days. However, this is exactly what most country statistics display. It seems to be much more likely that a smaller number of cases are registered at weekends because fewer diagnostic tests are conducted at weekends, or because there are delays in reporting due to staff at health offices not being on the job, or for other reasons. The timeliness of the data therefore fluctuates without this being precisely documented in many cases.

5.3 The need for unambiguous definitions

Differences in the definition of diagnosed and reported cases even changes. Two examples shall be given to illustrate this statement.

In Russia, official national COVID-19 mortality figures throughout 2020 were generated by reporting only deaths in which novel coronavirus infection was detected at autopsy. On 28 December 2020 Rosstat, Russia's statistics agency, reported that "the number of deaths from all cases recorded between January and November was 229,700 higher than in 2019". After further investigation, the country's deputy minister concluded that the number of deaths in Russia from the novel coronavirus is not 57,000, as the official figures claim, but more than 180,000 (Rosstat, 2020).

In France the methodology of counting changed. In early April, France reported 17,827 additional cases and 532, then884 additional deaths from nursing homes, that had not previously been included in the official counts. Similarly, the daily figures for COVID-19 deaths in one country might, for example, only include those dying in hospitals, while other countries include deaths in nursing homes in their figures (Worldometer, 2020).

6 Discussion

The COVID-19 pandemic created an urgent need for timely public health information in a very short period of time. Many countries quickly provided spatially disaggregated cartographic information dashboards on their web portals. This paper focuses on the analysis of these dashboards and relates them to IGIF in general and the IGIF Technology Maturity Index in particular. Since the results were generated via Internet research, analogue maps (Level 1: Analogue Mapping) are excluded a priori; all dashboards automatically reach Level 2 (Digital Mapping). The highest Level (Level 5: Integrated Geospatial Information Management) was not achieved by any dashboard. In particular, the integration of provided data via a Global Web of Data and Linked Data was not found anywhere. The differences in maturity between Level 2 (Digital Cartography), Level 3 (Geographic Information Systems), and Level 4 (Spatial Data Infrastructure) were not so distinct. However, differences can be found in data accessibility. Isolated systems provide little in the area of data access. Advanced systems provide their data in an international standard format as download services or web map services, making them accessible for analysis in GIS and other systems. An in-depth analysis of COVID-19 data provision in relation to the IGIF Technology Maturity Index must be reserved for future work.

7 Conclusions

The COVID-19 pandemic shed light on the need for easily accessible, up to date, and reliable geospatial information from different sectors, public health, official statistics, and many others. The pandemic caused urgent calls for an integrated geospatial management that supports synoptic views of all needed information. A globally well-defined integrated statistical and geospatial framework could serve as an excellent basis for managing not only relatively low-dynamic statistical data, but also highly dynamic health data, such as those generated in the event of a global epidemic. Based upon well-defined cross-sector data integration, automated data flows performed in common reference frames, such a framework could provide knowledge on demand, and real-time query responses adapted to the needs of diverse user groups. The Integrated Geospatial Information Framework (IGIF) provides guidelines and tools to support the implementation of such a system, or system of systems.

References

Carver, S.J. (1991). Integrating multi-criteria evaluation with geographical information systems. International Journal of Geographical Information System, 5(3), 321–339.

European Union (2007): Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE) https://eur-lex.europa.eu/eli/dir/2007/2/oj (accessed on 21 June 2022).

EUROSTAT (2018). Regions in the European Union, edition 2018, Nomenclature of territorial units for statistics – NUTS2016/EU-28, Publications Office of the European Union, Luxembourg 2018, doi: 10.2785/475524.

Müller, H., & Louwsma, M. (2021). The role of spatio-temporal information to govern the COVID-19 pandemic: A European perspective. ISPRS International Journal of Geo-Information, 10(3), 166.

Rosstat (2020). COVID-19: Russia admits to understating deaths by more than two thirds BMJ 2020; 371 doi: https://doi.org/10.1136/bmj.m4975 (Published 31 December 2020, accessed on 21 June 2022).

UN (2018). Integrated Geospatial Information Framework – a strategic guide to develop and strengthen national geospatial information management. Part 1: overarching strategic framework.

https://ggim.un.org/meetings/GGIM-committee/8th-Session/documents/Part%20 1-IGIF-Overarching-Strategic-Framework-24July2018.pdf (accessed on 21 June 2022).

UN (2020). Appendices – Strategic Pathway 5: Innovation. https://ggim.un.org/IGIF/documents/SP5-Appendices%204Jul2020-GLOBAL-CONSULTATION.pdf (accessed on 21 June 2022).

UN-GGIM (2020). COVID-19: Ready to respond. The Role of the Geospatial Community in Responding to COVID-19. White paper. Available online: https://ggim.un.org/meetings/GGIM-committee/10th-Session/documents/COVID-19_Ready-to-Respond.pdf (accessed on 21 June 2022).

UN-GGIM (2016). UN Committee of Experts on Global Spatial Data Management, sixth session New York, 2016. Available online: http://ggim.un.org/knowledgebase/Attachment1651.aspx?AttachmentType=1 (accessed on 21 June 2022).

WHO World Health Organization (2020). Coronavirus Disease (COVID-19) Situation Reports. Available online: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports (accessed 21 June 2022).

Worldometer (2020). COVID-19 coronavirus pandemic. Available online: https://www.worldometers.info/coronavirus/ (accessed on 21 June 2022).

Appendices

Appendix A: *COVID19 dashboards of EU Member States in February 2021.*

Member State	Dashboard
Austria	https://covid19-dashboard.ages.at/
Belgium	https://epistat.wiv-isp.be/covid/covid-19.html
Bulgaria	https://www.nsi.bg/en/node/18163/
Croatia	https://www.koronavirus.hr/en
Cyprus	https://covid19.ucy.ac.cy/
Czech Republic	https://onemocneni-aktualne.mzcr.cz/covid-19?utm_source=general&utm_medium=widget&utm_campaign=covid-19
Denmark	https://experience.arcgis.com/experience/aa41b-29149f24e20a4007a0c4e13db1d
Estonia	https://www.terviseamet.ee/en/coronavirus-dataset
Finland	https://experience.arcgis.com/experience/92e9bb33fac744c9a084381fc35aa3c7
France	https://dashboard.covid19.data.gouv.fr/vue-d-ensemble?location=FRA
Germany	https://experience.arcgis.com/experience/478220a4c454480e823b17327b2bf1d4
Greece	Not found
Hungary	Not found
Ireland	https://covid19ireland-geohive.hub.arcgis.com/
Italy	https://opendatadpc.maps.arcgis.com/apps/opsdashboard/index.html#/b0c68bce2cce478eaac82fe38d4138b1
Latvia	https://spkc.maps.arcgis.com/apps/opsdashboard/index.html#/4469c1fb01ed43cea6f20743ee7d5939
Lithuania	https://osp.maps.arcgis.com/apps/MapSeries/index.html?appid=c6bc9659a00449239eb3bde062d23caa
Luxembourg	https://covid19.public.lu/fr/graph.html
Malta	https://deputyprimeminister.gov.mt/en/health-promotion/covid-19/Pages/covid-19-infographics.aspx
Netherlands	https://coronadashboard.rijksoverheid.nl
Poland	https://rcb-info.maps.arcgis.com/apps/opsdashboard/index.html#/6cb3eecfc7be41069556e85509d6edd6
Portugal	https://covid19.min-saude.pt/ponto-de-situacao-atual-em-portugal/
Romania	Not found
Slovakia	https://korona.gov.sk/koronavirus-na-slovensku-v-cislach/
Slovenia	https://www.gov.si/teme/koronavirus-sars-cov-2/
Spain	https://cnecovid.isciii.es/covid19/
Sweden	https://experience.arcgis.com/experience/09f821667ce64bf7be6f9f87457ed9aa

Appendix B: *IGIF Technology Maturity Index.* (Source: UN,2020)

Levels of Maturity / Generational Bracket	Level 1: Analogue Mapping	Level 2: Digital Cartography	Level 3: Geographic Information Systems	Level 4: Spatial Data Infrastructure	Level 5: Integrated Geospatial Information Management
Focus	Map Production	Product-Based	Process-Based	User Centric	Knowledge On-Demand
Operational Level	National, Subnational, Private Sector	National	National, Subnational, Private Sector	Cross-Sector Integration	Global Network
Data Supply Patterns	Siloed Production	Siloed Production and Delivery	Informal Individualised Supply Chains	Formalised Hierarchical Supply Chains	Published Direct to the Web
Storage	Plan Press	Computer Hard Drives, Portable Hard Disk	Optical Disk/ Mainframe Computing	Cloud Storage	Cloud/Edge Computing
Acquisition	Photogrammetry	Digitisation/ Scanning	Digitisation/ Image Interpretation	Automated Image Interpretation, Social Media, Crowdsourcing	IoT sensors, Machine-learning, Artificial Intelligence
Access	Counter sales	FTP Sites	Web Portal (multiple agency portals)	Centralised National Web Portals	Global Web of Data
Data Formats	Paper Maps	CAD (2D)	GIS (2D)	GIS (Discontinuous, 2D, 3D, 4D)	Linked Data (Seamless 2D, 3D, 4D)
Users Services	NA	NA	NA	Data Catalogue/ Security Services	Brokering Services
Standards	Ad-hoc Technical Specifications	Organisation-Wide	National/ISO	ISO	OGC/W3C
Knowledge Representation	Map Legend and Production Notes	Analogue Metadata	Digital Metadata	Digital Metadata and Provenance	Metadata, Provenance, Domain and Process Ontologies
User Domain	Government	Government	Government, Private Sector, Academia	Government, Private Sector, Academia, Community, Citizens	Everyone
Analytics	NIL	Predominantly Analogue Analysis	Digital Analysis, Manually Executed Algorithms	Automated Algorithms	Real-time Query Responses
Reference Frame	Map Projection	Various Map Projections/ Datums	National Geodetic Datums	Global Reference Frame (Static)	Global Reference Frame (Dynamic)

CHAPTER 4

GEOSPATIAL DATA AND THE CHANGING SOCIETY

HOW AND WHY DIVERSITY AND INCLUSION ARE VITAL FOR THE FUTURE OF GEOSPATIAL DATA MANAGEMENT AND THE SURVEYING PROFESSION

Roshni Sharma (Australia)

1 Foundations

1.1 What are diversity and inclusion?

Tobler's first law (TFL) of geography states that "everything is related to everything else, but near things are more related than distant things." As surveyors and geospatial professionals, we tend to interpret this in a geographical sense, however it applies just as much to the way in which we work too. When the groups we work in or peers we surround ourselves with are the same, or similar to ourselves in many ways, we get used to thinking alike or in the same patterns over time. We are subconsciously more inclined to miss other perspectives, ideas or potential ways of doing things.

Especially within the context of the fourth industrial revolution rapidly promoting innovation, new ways of doing things and automation, we need now more than ever to capitalise off diverse thought. For a small industry such as ours, we can facilitate innovation to access the business benefits diverse thought brings. With technological advances rapidly escalating, other industries are also increasing in their ability to replicate our processes and methods but without the deep understanding of data quality that we possess, making it even more pressing for us to retain our niche within the global context with pride and excellence. Not only for our profession but also for public good.

Diversity, *inclusion*, *equity* and *belonging* are fundamental issues that impact the surveying and geospatial industry across the world, in both the global north and south, across country borders and at all scales, from small sole traders to multinational organisations. Bear with me – while this section explores some foundational concepts, we will translate these concepts into their practical applications and how these create important gaps in how we map and what we miss in following sections.

Diversity describes the amount of 'sameness' in the composition of a group – sometimes there are many people who are quite similar to each other in terms of appearance, or even going deeper in terms of values and worldview and even down to interests and habits. Sometimes there is a variety of people who are not so similar in these ways. Often there are eight facets of diversity that help define the different identities that people can hold – gender, age, sexual orientation, (dis)ability, cultural background, socio-economic status, religion/spirituality and race. These are both visible and invisible, and are by no means the only aspects of diversity that come into play with how we work. Thereare also factors that relate less to our identities but are still very impactful, such as whether we live and work in a rural or urban environment, what career stage we are at, the different types of and levels of experience we have with various soft and hard skills, our preferences in learning and communication style, etc. Often again, we hold all of these 'identity-creators' at once in one way or another – this is known as '*intersectionality*' because these, and the implications of each in terms of power or marginalisation, can't be separated.

Inclusion refers to how the mixture of composition in a group works together – sometimes this is functional within a psychological safety context where innovation can flourish, and sometimes this is a perfunctory and functional, and sometime dysfunctional. While diversity can often be measured quantitatively, inclusion is a subjective individual experience that can be measured qualitatively.

These concepts may feel abstract as we consider them here, however we'll bring them to life in terms of both the people, organisations and systems in mapping and surveying, and the impact that these factors have on the data that we create and the hidden but significant implications of this, very soon.

1.2 Power and privilege at systemic, organisational and individual levels

When we think of power within the workplace, many of us revert to models such as French and Raven's (1959) bases of power (legitimate, reward, expert, referent, coercive and informational power), among other models within organisational behaviour and design. However, more important than this within the concept of surveying and geospatial data is power as it pertains to how individuals that form organisations (and indeed national and global systems as well) function at an interpersonal level.

Power is important – it is the basis for agency, influence and negotiation. It is also vital in that those with power are able to get their voices heard, thereby in a surveying context they are able to shape what data is created, how it is used, who has access to it, where it is stored and what gets left out (overtly or inadvertently). *Privilege* is a related concept – it is the accumulation of power or access to power as a result of identity factors (both visible and invisible). Privilege does not arise as a result of hard work and applied effort. While it can and often is related to this, there are also people who work just as hard if not harder, and still do not have access to privilege as a result of not having the 'right' identity factors – such as being the 'wrong' gender, of the 'wrong' socio-economic status, the 'wrong' religion.

The human brain is an efficient machine which filters incredible amounts of data about the world around us from all of our senses in every second. For our brains to cope with this overload of information, we – from the moment we are born – create assumptions and 'rules' to help us to operate in the society around us. Often in our daily lives, we are exposed to people who tend to be reasonably similar to us. However, in workplaces, we get exposed to a wide variety of people who are both similar and different to us in many ways. Over time, the types of assumptions we make get cemented based on the thoughts, emotions and behaviours of those around us. This influence comes from our immediate family members, our friends and extended family members, what we see on television and the internet, the news channels we are exposed to, and so on. We form certain views, beliefs and assumptions about the people in the world – around age, gender identity, physical and intellectual abilities, sexual orientation, weight, race, and many other things. These are the legacy of generations of thinking and behaving in social hierarchies where parts of society are treated as 'other', distrusted, disliked or excluded. Sometimes we are conscious of the assumptions we hold towards certain groups of people, but often we are unaware of our own prejudices – they are unconscious, and therefore more insidious. These unconscious ways of thinking and behaving that come from society at large will continue to create social divisions unless they are challenged – and that challenging starts on an individual level with us working to recognise and change our own unconscious biases.

When we have diversity present in a group, there are likely to be different levels of inclusion – some people will be more included than others. When we strive to balance this out, there are two approaches that tend to be taken to promote fairness – *equality* treats everyone the same regardless of need, while *equity* treats different people or groups differently depending on need. This concept is subtle and links in with power – specifically in that there tend to be power dynamics created over the course of human history that act on individual, organisational and systemic (national and global) scales. This means that opportunity does not provide equal access to all people or groups just because they have ability and work hard towards something. Equality factors do not take this into account – they treat everyone as though if they apply effort, the meritocracy will ensure that they will be rewarded with the fruits of their labour. This rings true for those who have access to power and privilege – however, for those who do not, i.e. marginalised groups**.** No matter how much talent they have or how hard they work, the system is stacked against their accessing power or privilege as a result of their efforts. Equity takes this into account, and uses solutions that recognise these systemic power imbalances and works to allow reward for effort and talent that accounts for the specific power contexts within a specific situation. This creates *belonging* – the activation of inclusion in a way that retains talent, decreases staff turnover, and leverages psychological safety. These allow constructive team conversations which unlock new ideas and ways of thinking. This is the essence of unlocking business performance, growing profits, retaining and broadening client bases, and unlocking new ways forward for providing products services that the world is demanding of our surveying technologies (Bain & Company 2022; SSS-DLN 2019, 2022).

Within geospatial and surveying, the creation and management of quality location-based data is our bread and butter. There is no denying, however, that the way we work is changing, as are technological advances. Geospatial is ubiquitous – the layperson knows what Google maps is, however generally won't be aware of the elements related to data accuracy, data quality, data reliability, metadata elements and other factors which we as an industry understand to be vital for good data management.

1.3 Business benefits for belonging within surveying

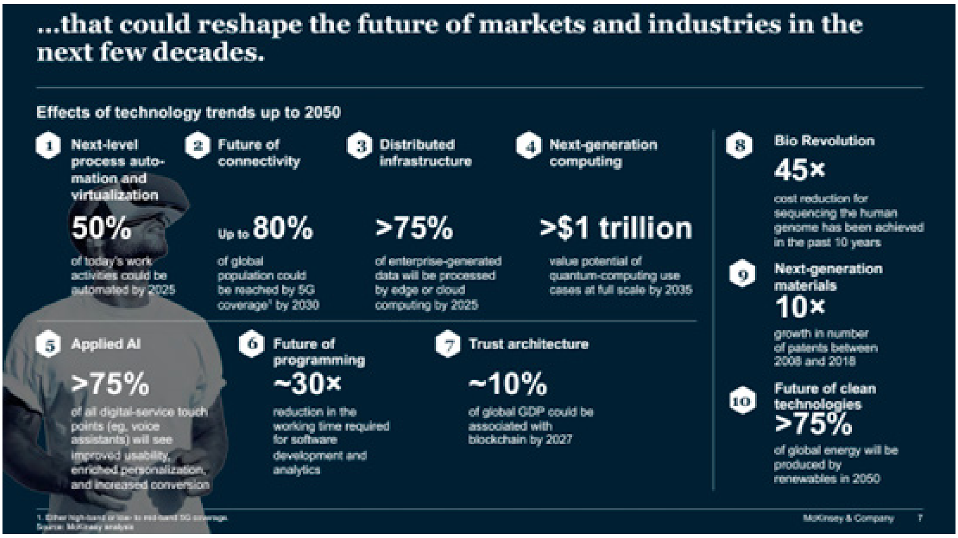
Drucker's famous statement, "Culture eats strategy for breakfast" highlights that the quality of your workplace culture can elevate your business outcomes much more powerfully than your strategic planning.

Ultimately, surveying and geospatial exist to serve societies to coexist as harmoniously and productively as possible with flourishing economies and sustainable use of natural resources and a protected, thriving environment. Whether your work as a surveyor is in land administration, engineering and mine surveying, hydrography, photogrammetry and remote sensing, cartography and spatial information, quantity surveying or any other of the many facets of our industry, these are the end-goals we are all working towards. We must keep in mind, however, that the world around us is in constant flux – and there are global megatrends which are always at play to shift the way that the future – indeed, the near future not just the distant future – will look. A recent report by PWC (2022) pins down five key megatrends, which are reshaping the world we live in, with implications for organisations, industries and wider society, right now and in the future:

1. Rapid urbanisation
2. Climate change and resource scarcity

3. Shifts in global economic power
4. Demographic and social change
5. Technological breakthroughs

We are all touched by each and every one of these already – over the 2020s we have already seen shifts in the ways that cities are growing, the escalation of 1-in-100 year floods and megafires happening year on year across almost every continent, the war in Ukraine, the global COVID-19 pandemic, and many technology trends. For us as surveyors, technology trends are set to significantly influence the ways in which the future of the work we do exidsts – we need to stay relevant, while retaining the core legacy and history that allows us to be true specialists in the creation and maintenance of quality,



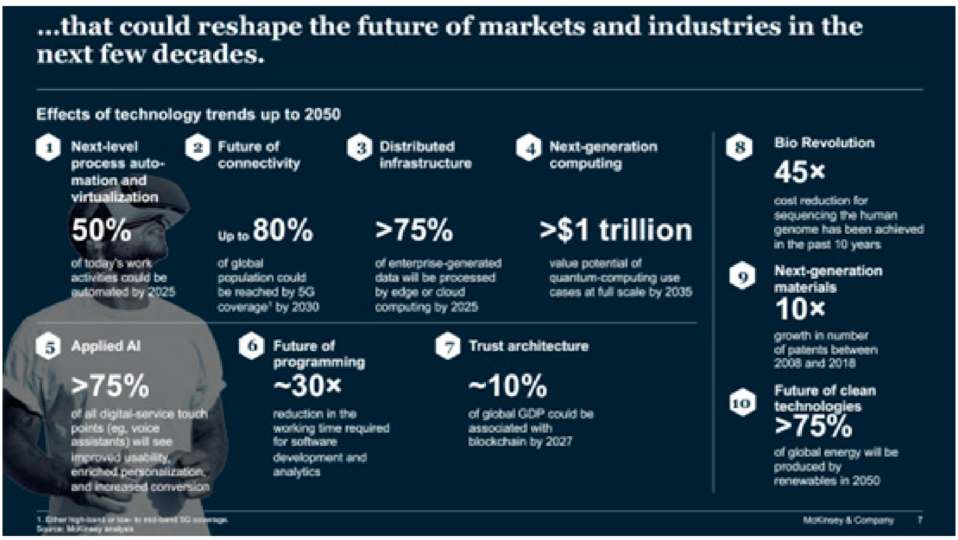


Figure 1: *Extract from McKinsey & Company top trends in tech snapshot Executive Summary.* (Source: McKinsey Digital 2022)

precise and accurate geospatial data that no other experts can do. The McKinsey tech trends index shows that there are a suite of technological breakthroughs which are set to reshape the ways in which the world works in the near future – the majority of which rely on accurate, precise, quality geospatial data (Figure 1). In light of this, the need for geospatial and surveying organisations to attract and retain talent and grow as an industry has never been more urgent. Talent comes from all walks of life, and surveying and geospatial businesses can leverage this now more than ever.

Having diversity within your workforce or team does not automatically bring benefits. Sometimes, it just creates more friction or greater staff turnover. For diversity to translate into business benefits, it requires the culture of your team or workplace to embrace inclusion to create a sense of belonging. As Verna Myers is often quoted as explaining, "Diversity is being invited to the party, inclusion is being asked to dance, and belonging is dancing like no one is watching."

Signs of a diverse, inclusive workplace culture include:

- Better decision making through a variety of perspectives giving rise to robust, respectful discussions
- Greater ideation and debate, leading to thought leadership
- A culture of belonging leading to higher employee engagement and greater retention of talent
- Greater levels of innovation as a result of psychological safety allowing for failing fast, making mistakes and learning from them, and the ability to trying new things together
- Making better decisions, faster, leading to increased profits and business results
- Increased organisational brand due to healthier and safer culture, attracting top talent more effectively
- Stronger ability to respond well to disruptions

This may seem, on the surface, to be broadly unrelated to spatial data creation and management – however, data does not get created in a vacuum – it is created by organisations who are composed of people. Having an awareness of *who* is creating geospatial data, *how*, and for *what purpose* is vital for us to consider so that we can explore the implications of what gets missed in the process.

2 Context and purpose

2.1 Who is creating the data, and why does that matter?

As we move through life, we each get different messages about how we and those around us, whether similar or different, can expect to be treated. An example provided by Emma Cox from the University of Wisconsin-Madinson's Centre for Religion and Global Citizenry showcases this:

> *"For example, I, as a white person, often feel entitled to be recognized when I enter a room, because society constantly reinforces the idea that I am welcome and deserving of attention in any space, and that my needs are top priority. This is how I benefit*

> *from racism. However, I also identify and am perceived as a cisgender[4] woman, and being a woman has taught me to be quiet and meek when I enter a room, which transforms into internalized oppression."* (Cox 2018)

Power, i.e. the configuration of structural privileges and structural oppression that arises from various systems having been designed by people like them to work for people like them (and missing partially or entirely people who are not like them) is an inherent part of our society. While change is happening, in the face of systems that have existed for tens, hundreds or in some cases thousands of years, it can be a slow and extremely complex process. If we focus for a moment on gender specifically, in light of the following case study on OpenStreetMap, books such as Caroline Criado Perez's 'Invisible Women' showcase that the world we live in has been in many cases designed by and for men:

> *"What's odd about women's invisibility is that women aren't a minority". Still, they have to live in a society which is centred on men. "From a lack of streetlights to allow us to feel safe, to an absence of workplace childcare facilities, almost everything seems to have been designed for the average white working man and the average stay-at-home white woman. Her answer is to think again, to collect more data, study that data, and ask women what they want. It's that simple."* (Saini 2019, reviewing 'Invisible Women' for The Guardian)

As modern cartography is now digital, and maps are used not only by specialists but also laypeople all around the world for numerous uses – those they were originally intended to be used for as well as many uses that their creators may not have dreamed of. The data that goes into them is important. The limitations and weaknesses of these datasets are also incredibly important to understand. We can begin to see how this plays out in the following OpenStreetMap case study.

CASE STUDY 1: OPEN STREET MAP

It has been known for several years that crowdsourced or VGI (volunteered geographic information) is likely to contain biases (Bittner 2017). Gardner et al (2020) took this concept further with their seminal exploration of the globally used OpenStreetMap, which they begin by saying:

> *"Our engagement with maps has changed. Nowadays, if you order a taxi, a pizza, or use an app to navigate your way through an unknown urban district, the data that these location based services use to provide you with that service will not be that collected by a qualified surveyor tasked by a government appointed agency <…>. It is now more likely that this data originates from an online volunteered mapping platform, populated with 'crowdsourced' geospatial data. <…> Empirical evidence also suggests that overwhelmingly, the creators of this data <…> are young men with an interest in technology and the computer skills and knowledge to match"* (Gardner et al. 2020: 1604–1605)

OpenStreetMap (OSM) was founded in 2004 based on the same peer production model as Wikipedia, with the mission of creating "a free, editable map of the world", and the movement of people anywhere in the world with an internet connection being able to contribute to mapping the world around them, OSM has been gaining popularity

4 Cisgender: denoting or relating to a person whose sense of personal identity and gender corresponds with their birth sex. (Oxford English Dictionary).

ever since. This democratisation of the creation of maps for use by and for laypeople has been part of the movement to bring geospatial as an industry to the awareness of the world. However, this has been a double-edged sword when we dig deeper into *who* has been doing the majority of this VGI. Numerous studies over a series of different years have shown that a staggering 95–98% of all contributions to OSM data are being produced by men (Schmidt and Klettner 2013; Schmidt et al. 2013; Steinmann et al. 2013; Stephens 2013; Stephens and Rondinone 2012) who are predominantly young and technologically enabled (Budhathoki and Haythornthwaite 2013; Schmidt and Klettner 2013).

Let's look at that again – 95–98% of OSM data are being produced by men who are predominantly young and technologically enabled. On the surface, this might seem like an 'average' statistic for who is creating maps, especially given that our industry (and STEM more broadly) has tended to historically be dominated by white males from the times of the scientific revolution and before. However, greater insights emerge from this when we consider that *users* of OSM data generally don't understand the limitations or metadata of the data they are using – they consider the data to be an objective, relatively complete view of reality that has been made digitally available for their use. They rarely, if ever, are likely to stop and consider how the data came to be, or who mapped it.

We have the theoretical knowledge, as geospatial professionals, that "as it is inherently imbued with the intent and context of the subjects that produce it, knowledge cannot be separated from its creators" (Haraway 1991). Further to this, as geospatial professionals, we have an understanding that it is not only the nature of the data itself that we consider but also the way that data is stored, accessed and used – "when the epistemologies, vocabularies, and categories of data structures do not or cannot encompass the experiences, knowledge claims, and identities of some social groups or places, this produces their under-representation in digital data" (Elwood:2008: 178).

> *Men are the main participants in processes that determine the way geospatial data is modelled.*
>
> *This results in "gendered representations of user-generated geospatial content. Given the widespread use of location based service provision on crowdsourced geospatial data, <…> these subjective versions of the world are endlessly reproduced"* (Gardner et al. 2020: 1608, referring to Mülligann et al. 2011 and Stephens 2013)

Johnson (2014) observes three dimensions through which socio-cultural privileges are embedded and perpetuated when it comes to data: (1) the embedding of social privilege in datasets as the data is constructed; (2) the differential in capabilities of data users; and (3) the norms that data systems impose through their function as disciplinary systems.

When geospatial data is created by a group who are uniform in their identities, ways of thinking and ways of doing, we run the risk that they will simply miss out on including things into the data that they feel are not relevant or important to them as a demographic group. The credibility and scope of the data is undermined, and its use constrained. This unconscious bias is not a value judgement on other people or groups – it is a function of the way that the human brain functions. It does however have the undesirable and potentially highly damaging result that particular demographics, people or places will become hidden, invisible or lost as a result. And it is these implications which have consequences that add up over time. Gardner's research revealing that statistically, men made significantly more contributions (87%) to digitising and tagging features compared to women. In effect, we see in OSM that when points of interest within a particular locale are examined, it is significantly likely that strip clubs will be digitised significantly more often than childcare centres or aged care facilities (Stephens 2013). There are many and varied implications of this, other than the obvious and banal, such as individual safety, impacts of planning approvals favouring or missing certain types of development to cater for what mapping shows a community might need, economics and profit margins for businesses that are mapped versus those which are not mapped, among others. The ways in which our cities are planned and used are based upon the data that is created here by a highly skewed demographic who, through their unconscious biases, power and privilege, impact so much more than they likely thought was possible through a few mouse clicks to digitise and tag a building.

In this example, we might notice that there are several groups who are not included within the general OSM mapper. Women are an obvious one, as are the elderly and the socio-economically disadvantaged. Less obvious are people with disabilities, First Nations people, people of colour or from diverse cultural and religious backgrounds, people from various socio-economic backgrounds who may not have access to technology, and the list goes on. Gardner et al (2020) focused their research on exploring gender differences in editing and tagging preferences. They found established research showing that women of all ages tend to disproportionately bear the responsibility for childrearing and household care, leaving less time for education or work, let alone volunteer geographic information (Liff et al 2004; Gilbert et al 2008 among others). Add to this that there is still an existing global stigma for girls undertaking STEM activities which, while shifting especially in the global north, is still a point of stigma in the ways in which many girls are able to spend their time. Within technology, there tend to be many less women than men at all levels. A 2016 McKinsey report revealed that women made up 37% of entry-level roles, only 25% of senior management roles – 52 women being promoted to manager for every 100 men (McKinsey 2022).

It's important to note that the situation with OpenStreetMap has shifted since these papers were written, however this case study makes a notable point that many of us, by way of our unconscious biases, come up against in the geospatial work and data that we engage with and create on a daily basis. As they say, 'there but for the grace of God go I'.

Overall, this case study highlights several factors of relevance:

- The need for us to protect, as an industry, the role we play as creators and custodians of accurate, precise, and high-quality geospatial data
- The implications of unconscious biases (which we all have). When data is created by a group that is not fully representative of the environment or context the data needs to represent, how robust and complete is it? What implications of this arise as it gets reproduced and as other datasets get created from it?
- The power and privileges which we, as data creators and custodians, often take for granted. How often do we take the time to think about what we have captured within a dataset and what we have missed? Or reflect in hindsight about about implications can have down the line in ways that we didn't conceptualise when we created a dataset?

What can I do about this?

It starts with awareness, with you. If you are curious about what sorts of biases you personally hold, the Implicit Association Test (IAT), carried out by Harvard University (https://implicit.harvard.edu/implicit/takeatest.html) might be a useful place to start. You can also read about various types of unconscious bias that we come across in our daily lives and at work in this article (https://asana.com/resources/unconscious-bias-examples). This HBR article "How to measure inclusion in the workplace" (May 2021, https://hbr.org/2021/05/how-to-measure-inclusion-in-the-workplace) is a great place to read about the Gartner Inclusion Index, which you could administer anonymously within your organisation to measure levels of inclusion. This resource also provides four tangible, practical steps that managers and employees can take to generate greater diversity and inclusion within a workplace.

2.2 How systems of power in society translate into the data we create

When people from privileged, dominant groups create most of our data products, the result is not only that we end up with datasets that are biased or unrepresentative that get used as 'truth' and reproduced time and time again. An even more catastrophic and dangerous outcome is that some data does not get collected at all (D'Ignazio & Klein 2020).

Mimi Onuoha (2016) says that "*That which we ignore reveals more than what we give our attention to. It's in these things that we find cultural and colloquial hints of what is deemed important. Spots that we've left blank reveal our hidden social biases and indifferences*." She is custodian of the Library of Missing Datasets, which is an archive of datasets which are reasonably expected to exist but don't – the problems that call for these datasets exist and are acknowledged, but the datasets which would help to conceptualise, analyse and resolve them have been missed – and this list is growing today. On Github (https://github.com/MimiOnuoha/missing-datasets) Onuoha explores some of the key reasons related to data collection for this, summarised as:

1. Those who have the resources to collect data lack the incentive to (corollary: often those who have access to a dataset are the same ones who have the ability to remove, hide, or obscure it).
2. The data to be collected resist simple quantification (corollary: we prioritize collecting things that fit our modes of collection).
3. The act of collection involves more work than the benefit the presence of the data is perceived to give.
4. There are advantages to nonexistence.

CASE STUDY 2: WHERE COMMUTERS RUN OVER BLACK CHILDREN ON THE POINTES-DOWNTOWN TRACK

This case study appears in Chapter 2 (pages 49–52) of the book 'Data Feminism' by D'Ignazio & Klein (2020). The following lines draw heavily on this source and the quotations refer to it.

The Detroit Geographic Expedition and Institute (DGEI) published a provocative map in 1971 entitled *Where Commuters Run Over Black Children on the Pointes-Downtown Track*. This map (Figure 2) uses black dots to visualize the locations where the accidents hap-

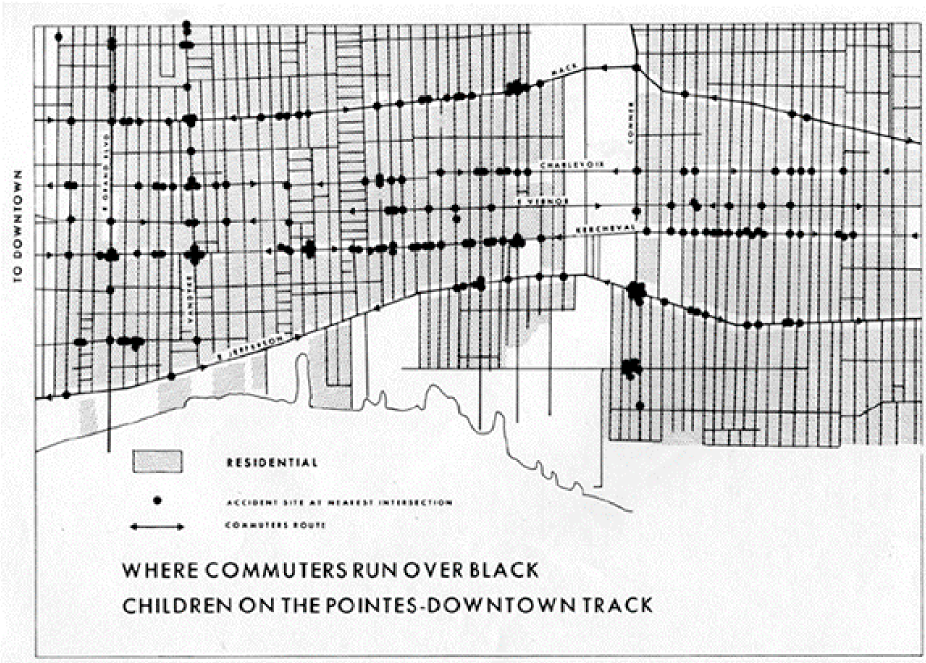


Figure 2: *The Detroit Geographic Expedition and Institute (DGEI) map from 1971, Where Commuters Run Over Black Children on the Pointes-Downtown Track.* (Figure taken from D'Ignazio & Klein 2020)

pened. *"On one single street corner, there were six Black children killed by white drivers over the course of six months. On the map, the dots blot out that entire block."*

While the extent of the problem had long been known to the people living in this neighborhood, collecting data to substantiate these facts proved to be a challenge. This is because no one kept detailed records of the deaths and no significant information about what happened was made public. *"We couldn't get that information," explains Gwendolyn Warren, the Detroit-based organizer who headed the unlikely collaboration: an alliance between Black young adults from the surrounding neighborhoods and a group led by white male academic geographers from nearby universities."* By working collaboratively, the youth learned how to map and use their local knowledge to produce reports on issues such as the economic and social inequalities among children in the community.

If one compares the DGEI map with a map of Detroit created some thirty years earlier, the Residential Security Map (Figure 3), there are clear differences in design and message. *"The maps differ in terms of visual style, of course. But more profound is how they diverge in terms of the worldviews of their makers and the communities they seek to support. The latter map was made by the Detroit Board of Commerce, which consisted of only white men, in collaboration with the Federal Home Loan Bank Board, which consisted mostly of white men. Far from emancipatory, this map was one of the earliest instances of the practice of redlining, a term used to describe how banks rated the risk of granting loans to potential homeowners on the basis of neighborhood demographics (specifically race and ethnicity), rather than individual creditworthiness."* D'Ignazio & Klein (2020) conclude that all of Detroit's Black neighborhoods are located in red areas on the Residential

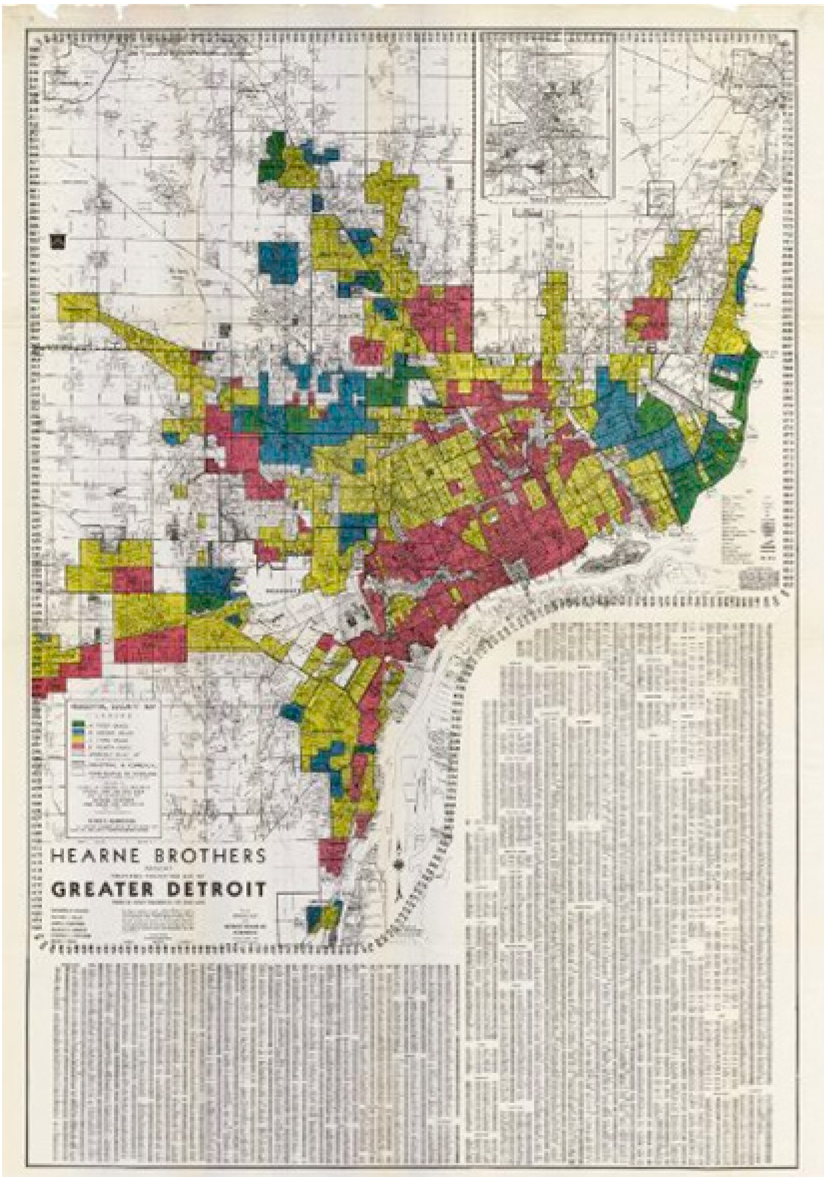


Figure 3: *Residential Security Map created by the Detroit Board of Commerce.*
(Figure taken from D'Ignazio & Klein 2020)

Security Map *"because housing discrimination and other forms of structural oppression predated the practice".*

The above case study highlights systemic oppression based on race and socio-economic status, and the degree to which power and privilege impact these systems both within the way they are perpetuated in society but also the ways in which they are brought to life in the data we create, manage and map as geospatial professionals. While this example might seem to be stark, there are no doubt instances in each of our careers as professionals where we have either created or represented data in a particular way to provide a specific message – indeed, this is part and parcel of the art of cartography. If we have ever created a thematic map, we have used data to tell a story that reveals – to some extent minor or major – an unconscious bias and a reflection of the power and privileges that we as custodians and creators of data hold, which both captures and misses elements of the world around us.

What can we do about this?

By its very nature, the data profession is also equipped to be an agent of incredibly powerful change. Through the way we create, collect and manage data, we have the unique ability to be able to challenge power structures and work towards more inclusive, just and equitable data, mapping and interpretation. Four places to start recommended by D'Ignazio & Klein (2020) are:

1. *Collect*: be aware of missing data and work to collect it.
2. *Analyse*: explore datasets you create or come across to consider how they capture inequity or inequitable outcomes across individuals and groups to facilitate accountability through data.
3. *Imagine*: aim higher in the standards you set for who collects data, why, how the data is stored and accessed, and what else could be done with the data. Consider your data as a tool for liberation.
4. *Teach*: Tell your story, and inspire a love of geospatial and surveying to people of all types to encourage them to come into the profession and stay in the profession. Ultimately, we need to inspire as much diversity and inclusion in our industry as possible to shift the harmful legacies of a historical lack of diversity, without losing our previous and valuable heritage. Our industry is valuable, beautiful, powerful and filled to the brim with potential – let's get people of all types from everywhere excited to be part of it. For example, visit local school and speak to students about what your career involves.

2.3 AI/ML and ethics in spatial data management

> *"In an essay about his science fiction, Isaac Asimov reflected that "it became very common…to picture robots as dangerous devices that invariably destroyed their creators." He rejected this view and formulated the "laws of robotics," aimed at ensuring the safety and benevolence of robotic systems. Asimov's stories about the relationship between people and robots were only a few years old when the phrase "artificial intelligence" (AI) was used for the first time in a 1955 proposal for a study on using computers to "…solve kinds of problems now reserved for humans." Over the half-century since that study, AI has matured into subdisciplines that have yielded a constellation of methods that enable perception, learning, reasoning, and natural language understanding."* (Horvitz 2017, Editorial for special issue of Science (Vol 357, Issue 6346) devoted to AI)

CASE STUDY 3: IS BARACK OBAMA A WHITE MAN ACCORDING TO MACHINES?

Face Depixliser is an AI algorithm tool which uses the PULSE algorithm to create a high-resolution image from a pixelated low-resolution image through machine learning generative models. In June 2020, it sent social media platforms into a frenzy when a blurred (but still recognisable) photo of Barrack Obama was used by the tool, it output-

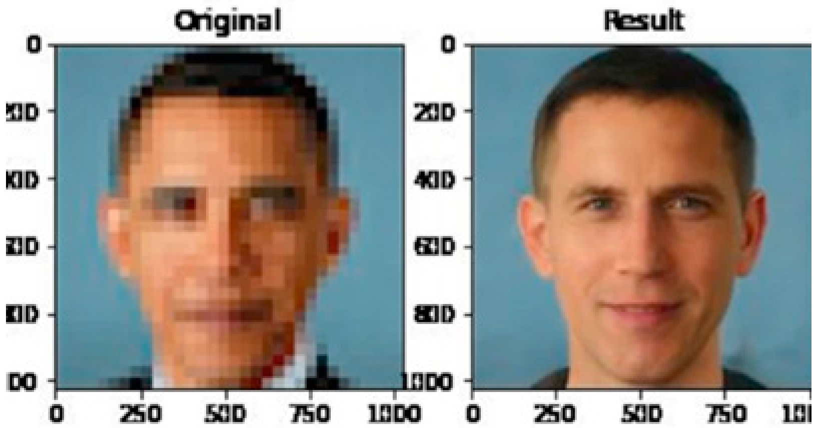


Figure 4: *Face Depixeliser unpixelates blurred but recognisable image of Barrack Obama as a white male.*

ted an image of an unblurred white male (Figure 4). Barrack wasn't the only face subject to creating this outcome – other faces of people of colour created the same outcome (Truong 2020). This problem of racial bias within AI – isn't new. Indeed, it is known that algorithms perpetuate the bias of their creators and the data they're working with – in this case by turning people of color, white.

The authors of PULSE recognise that the algorithm wasn't trained on a dataset, but searches through a model called StyleGAN (trained on a dataset of faces taken from Flickr) for realistic faces of imaginary people that correspond to each low-resolution input image. StyleGAN has known biases that are documented (here), however the issue of racial bias still remains.

> *"…bias inherently comes from the researcher themselves which is why we need more diversity. If an all-white set of male researchers work on project, it's likely that they will not think about the bias of their dataset or methodology."* (Alexia Jolicoeur-Martineau in Truong 2020)

The University of New York recently published a report titled "Discriminating Systems – Gender, Race, and Power in AI", which reports, among other things, that in the United States of America:

- More than 80% of AI teachers are men,
- Only 15% of AI researchers on Facebook and 10% of AI researchers at Google are women, and
- Men currently represent around 71% of the group of candidates for IA US jobs, as shown in the 2018 AI Index report.

We can see from Case study 3 continuation of the trends expressed in Case Studies 1 and 2 – that as geospatial professionals, the datasets we create include the unconscious biases that we hold as individuals. The power and privileges that we hold as individuals and groups creating data will become embedded into the data that we create – the things we notice, the things we deem important to make a note of, the things we deem unimportant in designing information systems, the language we use. What we include and what we miss is a direct result of the power and privileges that we hold, which shape our unconscious biases. As artificial intelligence becomes more and more a part of our lives as geospatial professionals, these influences must be kept in mind.

3 Missing less in how we map

Hope is not lost – there is so much that we can do. The nature of the surveying profession is evolving rapidly. We are merging traditional disciplines such as cadastral surveying with data management tools and techniques such as paperless mapping, spatial digital twins, and the like. We are being called to leverage earth observation science to support hydrographic surveying, and the need for FAIR (findable, accessible, interoperable and reusable) principles are more relevant for spatial data management for surveyors than ever before. The future of geospatial data management and the surveying profession is evolving in response to many megatrends, perhaps with the most significant influence coming from rapid technological advances changing the ways in which we create, store, share and manipulate data. Perhaps now more than ever before in history, geospatial data is capable of, and available to drive data-driven decision-making within almost every facet of society.

As surveyors, our workplaces are more than has ever been possible before, open to people of diverse backgrounds and identities. We are no longer a profession stereotyped by caucasian men (as the legacy of the industrial revolution – though the experience and wisdom of our white male forefathers and peers definitely hold much wisdom and value to learn from). Workplaces for many of us these days include people who come together as teams of diverse individuals to bring many perspectives, many different backgrounds and types of life experience, and importantly, many different ways of thinking. While these factors tend to be removed from our everyday work and technical tasks, they nevertheless play a vital role in influencing the ways we create and manage geospatial data. It is clear that diversity, inclusion, equity and belonging are no longer the domain of human resources and just about culture – they reach into the core of our technical roles too.

As surveyors, we are gatekeepers to local knowledge of people and the environment. The work we do creates datasets which represent boundaries and locations – we tells stories of the world on many different scales. This brings with it great power, but also great weight – for our datasets will be reproduced and transformed as a reflection of truth of the world and its systems. In order to maintain credibility, both our data creation and our spatial data management must remain vigilant within ourselves about how our own personal, team and organisation's unconscious biases flow into the work we do. Some simple tools at the centre of our ability to be empowered in these aspects are:

1. Curiosity
2. Non-judgement
3. Awareness
4. Reflection, and
5. Challenging.

While we are all busy people with a lot of work to do, cultivating curiosity is part of having a growth mindset, an oft-encouraged attitude in many workplaces today. Paired with non-judgement – as every single person on this planet has unconscious biases at no fault of their own as a result of simply being human – curiosity can be a powerful way to notice what we have favoured or missed in our surveying practice. These converge to create awareness, which is enhanced by reflection, and together these empower us to challenge unconscious biases within ourselves and the way we work in our teams and organisations. The power and privileges that we hold as individuals and groups creating data will become embedded into the data that we create – the things we notice, the things we deem important to make a note of, the things we deem unimportant in designing information systems, the language we use. What we include and what we miss is a direct result of the power and privileges that we hold – either unconsciously or consciously. The power is yours.

References

Bain & Company (2022). '*Take It from the Top: Accelerating Women's Representation in Executive Leadership*' Online report accessible at https://cew.org.au/wp-content/uploads/2022/07/2022-Accelerating-Womens-Representation-in-Executive-Leadership.pdf.

Bittner, C. (2017). Diversity in volunteered geographic information: comparing OpenStreetMap and Wikimapia in Jerusalem. *GeoJournal 82*, 887–906. https://doi.org/10.1007/s10708-016-9721-3.

Budhathoki, N. R., & Haythornthwaite, C. (2013). Motivation for open collaboration: Crowd and community models and the case of OpenStreetMap. *American Behavioural Scientist, 57*, 548–575.

Cox, E. (2018). '*Power, privilege and marginalisation: The larger impact of stereotypes*'. Online article, 17 December 2018. https://religion.wisc.edu/2018/12/17/power-privilege-and-marginalization-the-larger-impact-of-stereotypes-emma-cox/.

D'Ignazio, C. & Klein, L. (2020). *Data Feminism*, Massachusetts Institute of Technology Press, Cambridge.

Elwood, S. (2008). Volunteered geographic information: Future research directions motivated by critical, participatory and feminist GIS. *GeoJournal, 72*(3), 173–183.

Gardner, Z., Mooney, P., De Sabbata, S. et al. (2020). Quantifying gendered participation in OpenStreetMap: responding to theories of female (under) representation in crowdsourced mapping. *GeoJournal 85*, 1603–1620. https://doi.org/10.1007/s10708-019-10035-z.

Gilbert, M. R., Masucci, M. M., Homoko, C., & Bove, A. A. (2008). Theorizing the digital divide: Information and communication technology use frameworks among poor women using a telemedicine system. *Geoforum, 39*(2), 912–925.

Haraway, D. (1991). *Simians, cyborgs and women: The reinvention of nature*. New York: Routledge.

Horvitz, E. (2017). '*Editorial: AI, people, and society*'. Online article, 7 July 2017. https://www.science.org/doi/full/10.1126/science.aao2466.

Johnson, J. A. (2014). From open data to information justice. *Ethics and Information Technology, 16*(4), 263–274.

Liff, S., Shepherd, A., Wajcman, J., Rice, R., & Hargittai, E. (2004). An evolving gender digital divide? *OII Internal Issue Brief*. https://doi.org/10.2139/ssrn.1308492.

McKinsey (2022). *Repairing the broken rung on the career ladder for women in technical roles.* Online article, March 1 2022. https://www.mckinsey.com/industries/_technology-media-and-telecommunications/our-insights/repairing-the-broken-rung-on-the-career-ladder-for-women-in-technical-roles.

McKinsey Digital (2022). '*The top trends in tech*' Online article. https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/the-top-trends-in-tech.

Onuoha, M. (2016). '*The Library of Missing Datasets*'. Online article, 2016. https://mimionuoha.com/the-library-of-missing-datasets.

PWC UK (2022). '*Megatrends*'. Online article, https://www.pwc.co.uk/issues/megatrends.html.

Saini, A. (2019). '*Invisible Women by Caroline Criado Perez – review*'. Online article, 11 March 2019. https://www.theguardian.com/books/2019/mar/11/invisible-women-exposing-data-bias-by-caroline-criado-perez-review.

Schmidt, M., & Klettner, S. (2013). *Gender and Experience-Related Motivators for Contributing to OpenStreetMap*. In Paper presented at the AGILE, Leuven, Belgium.

Schmidt, M., Klettner, S., & Steinmann, R. (2013). *Barriers for contributing to VGI projects*. In Paper presented at the proceedings of the 26th international cartographic conference, Dresden, Germany.

SSS-DLN (2019). '*Thinking differently about difference*' Online report accessible at https://sssdln.org/what_we_do/.

SSS-DLN (2022). '*Inclusion@Work Report*' Online report accessible at https://sssdln.org/inclusionwork-report/.

Steinmann, R., Hausler, E., Klettner, S., Schmidt, M., & Lin, Y. (2013). Gender dimensions in UGC and VGI: A desk-based study. In T. Jekel, A. Car, J. Strobl, & G. Griesebner (Eds.), *GIS forum 2013: Creating the GISociety* (pp. 354–355). Berlin/Offenbach: Herbert Wichmann Verlag.

Stephens, M. (2013). Gender and the GeoWeb: Division in the production of user-generated cartographic information. *GeoJournal, 78*(6), 981–996.

Stephens, M., & Rondinone, A. (2012). *Gendering the GeoWeb*. New York. https://www.slideshare.net/geographiliac/gendering-the-geoweb.

Truong, K. (2020). *This Image of a White Barack Obama Is AI's Racial Bias Problem In a Nutshell.* Online article, 24 June 2020. https://www.vice.com/en/article/7kpxyy/this-image-of-a-white-barack-obama-is-ais-racial-bias-problem-in-a-nutshell.

CHAPTER 5

PARTICIPATION AND SPATIAL EMPOWERMENT

EVOLUNTEERING AND ENGAGING YOUNG SURVEYORS IN THE 2020s

Claire Buxton (Canada), Cemal Özgür Kivilcim (Turkey),
Roshni Sharma (Australia), Tom Kitto (Canada), Cemre Şahinkaya Özer (Turkey)

1 Introduction

Open Science initiatives such as those from the European Commission and the USA have worked to democratise and integrate knowledge and science across society, providing a collaborative solution for society in the digital era. Public participation innovations in citizen science have empowered anyone with an internet connection, anywhere in the world, to explore the globe from their fingertips: using tools such as Google Earth to produce, edit and affiliate user-generated content with location without specialist training. These innovations have launched new dimensions in accessing and producing geospatial information.

Mapping has played a key role in governing land, its assets and human activity and has largely been completed by specialist individuals, organisations, and institutions rather than lay individuals. In more recent times, geospatial data collection and mapping has continued to be important for authoritative agencies and relevant professionals globally. Technological developments over the past decade in particular, such as GNSS-enabled smartphones, have bridged the gap between the role of professional surveyors and the role of lay individuals to contribute geospatial data. Volunteer Geographic Information (VGI) has been around since 2007 when Goodchild coined the term. The growing strength of crowd-based projects such as OpenStreetMap since 2004 and Zooniverse among many others (Franzoni et al., 2021, 252) have presented an effective method of global contribution.

To begin with, the shift to geospatial data production by individuals without formal geospatial training brought many questions such as inconsistency, lack of accuracy, and data quality (Sarah et al., 2011, 571–590). As more geospatial data is recorded and various citizen science / VGI projects have continued, their benefits have opened a new field of research, enabled by rapid data production and the consensus of multiple data collectors. Today, VGI's beneficial role as part of citizen science is demonstrated in various examples from observing animals with eBird (Zhang, 2020) to rapidly defining disaster affected areas (Yalcin et.al, 2020), through to contributing to the UN Spatial Development Goals (SDG) (Fraisl et al., 2020). In the land administration sector, many

Figure 1: *The progression of the surveying industry advancement.*

tools have been developed that leverage mobile technology for participatory mapping of land rights with underserved and vulnerable communities. For example, the Global Land Tool Network's STDM, FAO's Open Tenure, the Cadasta Platform, and more recently SmartLandMaps coming out of the success of the Its4Land initiative from ITC (Degbelo et al., 2021, 3). These tools are making use of citizen science in their own way.

FIG Commission 3 released a detailed publication with various examples of VGI, guiding how nations and organisations should position the role of the land surveyor in this changing paradigm (FIG, 2019). Around the same time as that publication, the VCSP was revived after a pilot in 2017 and includes a response to VGI, e-Volunteering. After its first meeting in 2018, Working Group 3.6 (WG3.6) was built on the idea of creating a response to the changing roles of the surveyors and skill sets needed to counterbalance the emerging new technological needs. This chapter is a collaboration between these groups and an update to that 2019 publication with case studies to demonstrate how to take a proactive role, using VGI. The case studies presented were covered in a paper written by members of these two groups for the FIG working week, 2021 titled e-Volunteering in Unprecedented Times: New Synergies to Address Environmental Challenges (Sharma et al., 2021).

2 Drivers of humanitarian disasters

In review of a prominent humanitarian publication's top 10 list since 2020, the most frequently mentioned drivers of humanitarian disasters are conflict, COVID-19, and climate change (International Rescue Committee, 2021). There are many more crises spinning off from these and many causes of stress in our world today. Some countries are so wrought with conflict that combating climate change and COVID-19 has become a low priority. "These are also the places where the Sustainable Development Goals (SDGs) are most off track and where foreign direct investment and other financial flows remain limited." The below are some ways in which geospatial data management and analysis is being used in these three disaster settings.

2.1 Conflict

Spatial representation of conflict news using AI web crawlers is just one way in which geospatial data is used in an humanitarian conflict setting. Liveuamap does just that as they draw on their journalism and software engineering backgrounds. This low cost, high frequency data acquisition provides richer and higher resolution data that is used across various disciplines and at all levels of governing bodies. Citizen science has a high impact in times of disaster and crises. Information can be vitally important, take this map from the Ukraine conflict taken from Liveuamap in Figure 2 as an example.

2.2 Climate change

There are many, but to choose a great example from recent times where geospatial data is being used for climate action, the Global Carbon Atlas team have produced an interactive map representation of CO_2 emissions from human activity over time. With contributions from scientists all over the world, this platform has huge potential for the global fight against global warming by putting big data into easily digestible formats for the general public and offering accessible data downloads for scientists.

One of the major outcomes of COP26 in Glasgow was the Paris Rulebook which includes agreements from all Paris signatories on how they plan to report on their country's

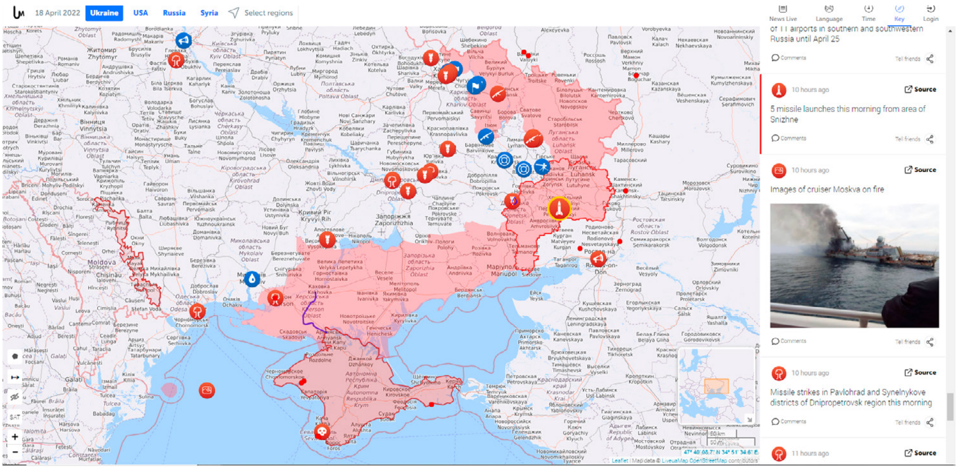


Figure 2: *An online map showing up-to-date war news in Ukraine, Liveuamap LLC, 2022.*

nationally determined contributions to reduce emissions. One of these agreements is an enhanced transparency framework for reporting emissions (Carver, 2022). Perhaps this is another area of application where the volunteer contribution of surveyors to the planet in danger will count, keeping government organisations accountable through supplying transparent, quality geospatial data on emissions.

Another practical way that geospatial data analysis is being used to contribute to the reduction of greenhouse gas emissions is through site selection using Geographic Information Systems (GIS) that combines semantic information with spatial information for the site selection of electric vehicle charging stations (Lebrun & Korem, 2022).

Figure 3: *An online map showing the contributors to greenhouse gas emissions by country over time. The screenshot is reproduced from the Global Carbon Atlas, www.globalcarbonatlas.org.* (Source: Friedlingstein et al., 2021)

2.3 Pandemics (COVID-19)

With the struggle of the COVID19 pandemic being shared globally in the early 2020s, the benefit of geospatial data has become even more apparent in the public-eye. Various spatial tools were developed to improve contract tracing, distribution, and information availability. From a world-wide scale with the Johns Hopkins COVID-19 Map built by Dr. Lauren Gardner and her team (CSSE at Johns Hopkins University & Gardner, 2022) to the country-level in Zimbabwe (Figure 4), GIS tools and big data from ESRI, FAO, MOAA, and HERE are being used in the fight against COVID19. This demonstrates the adaptability of the geospatial world to provide big data as geoinformation to the media and to the public to quickly absorb in a map form.

At the time of writing this, the pandemic is not over and scientists predict more will follow with an increasing occurrence. A link can be found between anthropogenic changes and zoonotic diseases (Lawler et al., 2021). This means that, as human activity like urbanisation continues, the risk of further pandemics increases. Linked with this are two aspects that VGI can aid with. These are:

1. Mapping on land use and urbanisation in order to provide open data to aid decision making and education; and
2. Mapping of those future pandemics to provide the similar outputs as described above on a country-level to make impactful decisions and reduce the spread.

3 *Solutions*

Above, we have laid out the impact geospatial data is having during the three greatest crises facing society in the 2020s, now allow us to describe some voluntary solutions to these issues below.

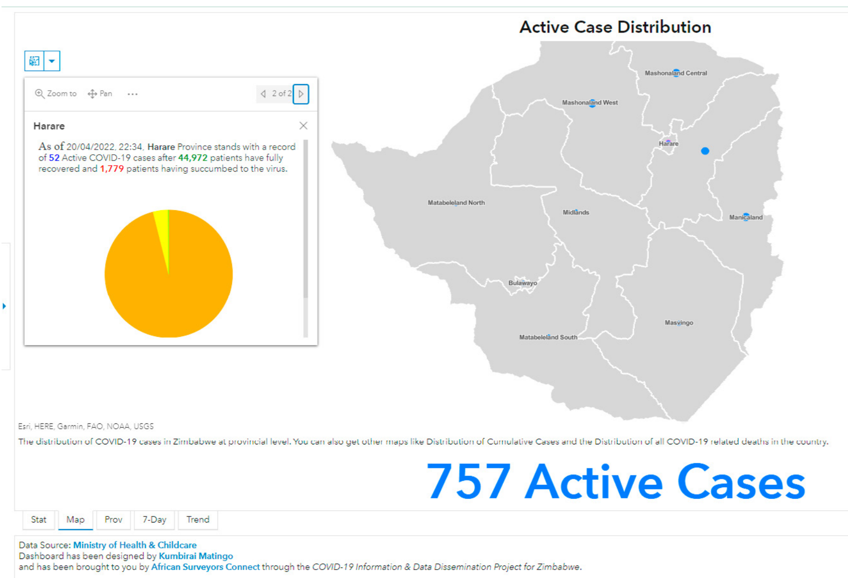


Figure 4: *A map from the Coronavirus (COVID-19) Dashboard used to inform residents and decision makers for evidence-based decision-making.*
(Source: Matingo & African Surveyors Connect, 2022)

3.1 Volunteer Community Surveyor Program

The VCSP leverages on the skills, experience, talents, and education of young surveyors, and matches this competence with the needs of its partners. This program brings together a community of surveyors willing to give their time to combat challenges that threaten our climate and stunt the potential for securing equal land rights. Similar to VGI but involving more skilled mappers and/or guidelines, the VCSP has introduced the term 'e-Volunteering.' This VCSP path leverages the FIG Young Surveyors Network to contribute to existing and new programs online and therefore encourage young surveyors to contribute their skills in a way that works more flexibly with their schedules, commitments, and abilities.

With the availability of a platform such as Humanitarian OpenStreetMap (HOT OSM), there are ample opportunities for volunteers to be involved in projects that work to aid in environmental disaster preparedness. One such example is the use of HOT OSM for mapping static water infrastructure demonstrated in the work of the VCSP with SSSI on the Firewater Mapathon. This example is discussed below.

While a lack of technical capacity exists in the parts of the world that need it most, technical capacity can be volunteered online and is available. With e-Volunteering, the VCSP can support humanitarian projects through providing the data and verification required to enable these countries and communities to enhance their technological position and boost innovation. There is potential for the VCSP to also support analysis efforts of the many land-related targets and indicators for the SDGs that are established but currently have no regular data to start from.

3.2 Collaboration of VCSP and WG3.6 (Geospatial Next)

Validator training is high on the priority list of both the VCSP and WG3.6 volunteers. In recognising the concerns many scientists and practitioners express around VGI having low levels of data quality, the introduction of guidelines and training is important to ensure contributions through e-Volunteering are representing the surveying profession well.

3.3 Case studies of national impact

From 20 years ago to now, the progression for the surveying industry and volunteering has been extensive. When it comes to disaster preparedness in the 2020s, for example, there are tools in place in the 2020s that allow for immediate access to static-water infrastructure location information for bushfire responses in Australia. Flash back to 20 years ago, even five years ago, and firefighters were using local knowledge alone, adding to an already critical timeline for emergency response. Our case studies below present the ability for volunteer solutions to support decision making at various levels.

CASE 1: FIREWATER MAPATHON

Engaging ordinary citizens into scientific and technical data provides various benefits. In late 2019 and early 2020, Australia experienced a swathe of significant bushfires of unprecedented ferocity. The Surveying & Spatial Sciences Institute (SSSI), the peak national body for the Australian geospatial industry, responded to the industry's desire to contribute in a positive way by organising a national-scale map-a-thon in early February 2020, pulling together over 600 volunteers (both surveyors and citizens). While many participants were from Australia, promotion of the event by the FIG Young Surveyors Network allowed participation from people across over 25 countries. The February 2020 Mapathon was targeted towards supporting bushfire recovery efforts through participants digitising buildings damaged by the bushfires, with a total of 2,793,879 hectares mapped. This included 15,731 edits, mapping of 13,891 overall buildings, 1,091 damaged features and 945 damaged buildings.

The FireWater Mapathon was the second mapathon initiative of SSSI, held on 31 October 2020 and focused on bushfire preparedness efforts. Again, the FIG Young Surveyors Network was involved as supporters of this mapathon through the newly revived VCSP program, providing international connection and round-the-clock support. Participants collected data on static water infrastructures (such as dams, water tanks and swimming pools) to support firefighting efforts by providing information on where these vital sources of water could be found for emergency management personnel. This crowdsourced data is being validated and used to update the accuracy and completeness of foundation geospatial data used by emergency management groups. These groups include the Australian Static Water Supply System, through the efforts of Geoscience Australia (GA) and the Intergovernmental Committee on Surveying & Mapping (ICSM).

The OpenStreetMap (OSM) Platform and Hot Task Manager were used to coordinate the mapping effort, set up by NGIS Australia. High-quality aerial imagery was donated to the mapathon event by Nearmap and the Department of Environment, Land, Water and Planning (DELWP Victoria), providing the detail required to detect these relatively small on-the-ground features accurately. Additionally, the Growing Data Foundation is currently seeking investment to create a web application called FireWater, which will use the data collected in the mapathon alongside existing data to more accurately direct fire crews to nearest available water sources during bushfire events (Growing Data Foundation, 2022).

In total, 140 e-volunteers representing 45 countries came together to participate in this 24-hour Map-athon, contributing over 800 hours of crowdsourced, citizen science time. They mapped water resources over an area of 294,000 hectares, with over 37,000 edits and they digitised 37,000 new infrastructure features over the course of the mapathon. As pointed out by Zaxarias and Perperidou back in 2016 (Perperidou & Zaxarias, 2016, 9), it is essential for volunteers to have access to simple guidelines and rules to control the data quality so SSSI developed these resources for mappers to use prior to, and during the mapathon.

CASE 2: MAPPING FEMALE GENITAL MUTILATION OUT OF TANZANIA

During the FIG Working Week 2021, a mapathon was held by VCSP and WG3.6 helped with a workshop prior to this event. This time, Crowd2Map and Humanitarian OpenStreetMap (HOT) were the partners providing the project opportunity and knowledge to the organisers and attendees. Crowd2Map provided a project for the volunteers to help on and feel connected to, mapping female genital mutilation out of Tanzania. Sadly, this is an ongoing practise in Tanzania which has cultural or religious origins but is now illegal in Tanzania, see Figure 6. Thankfully, the prevalence of FGM is decreasing in more recent years but cuttings are still happening.

This project involved digitising buildings from satellite imagery in rural Tanzania with the goal of providing that information to local activists and volunteers for the Tanzania Development Trust. Ground teams used this geospatial information for unmapped or limited areas to help find safe houses for women and girls who are at risk of being cut.

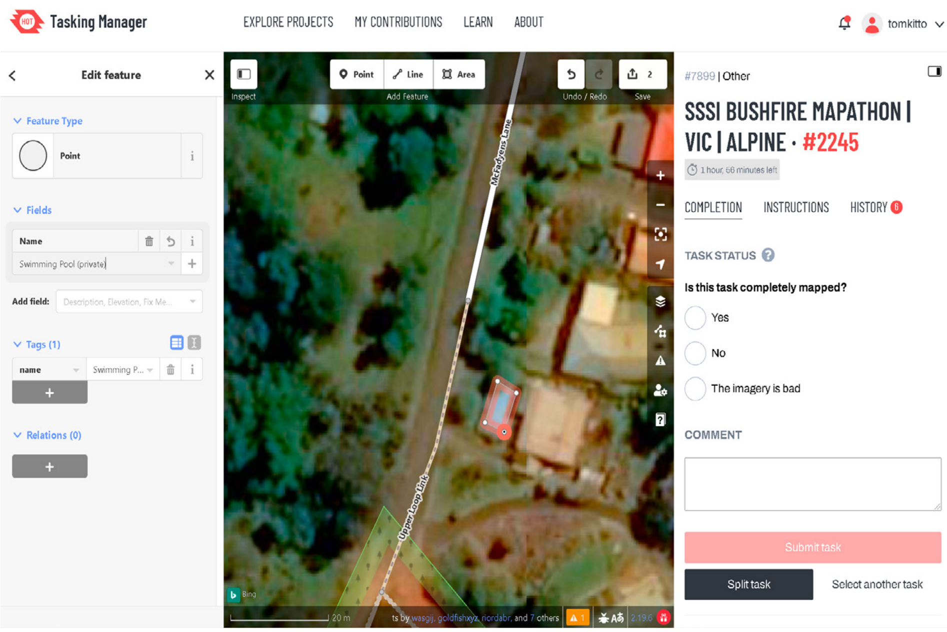


Figure 5: *Screenshot example of a typical mapped water resource during the FireWater Mapathon.* (Source: https://tasks.hotosm.org/projects/7899)

A valuable training resource was provided by Crowd2Map for those who signed up for the mapathon to complete before-hand. Crowd2Map have many online mapping projects that surveyors can contribute to and these are listed on the Crowd2Map website.

A total of 51 mappers joined the 24-hour mapathon with 118 buildings and 3km of roads being mapped in the first hour. The project is now complete thanks to contributors from this group but also the wider global volunteers to HOT. The HOT tasker keeps the full statistical breakdown of projects and what was mapped. For this particular area in Tanzania, from Kagera to Geita, 13,811 buildings and 17km of road were mapped.

Given the position of surveyors as data quality professionals, the value-add from the perspective of the VCSP is to provide validators because there are hundreds of thousands of mappers, but only hundreds of validators (Aytoun et al., 2021). However, it takes time to get that validator status as a mapper must make many change-sets (contributions) and gain experience before applying for, and obtaining, their validator badge. Because most surveyors have already got deep knowledge of geospatial data, the VCSP wanted to introduce young surveyors to the possibility of bringing that expertise to the HOT platform. To do this, Sam Colchester from HOT kindly ran a validator session online prior to the mapathon as part of the workshop (Colchester et al., 2021). A total of 18 young surveyors elected to attend that session or stayed behind and learned some beginner mapping tips from Tom Kitto, the VCSP eVolunteering lead.

It is a joint goal of the VCSP and WG3.6 to have more young surveyors in FIG meeting that validator status so that they can contribute through e-Volunteering in a more meaningful and engaging way than beginner mapping.

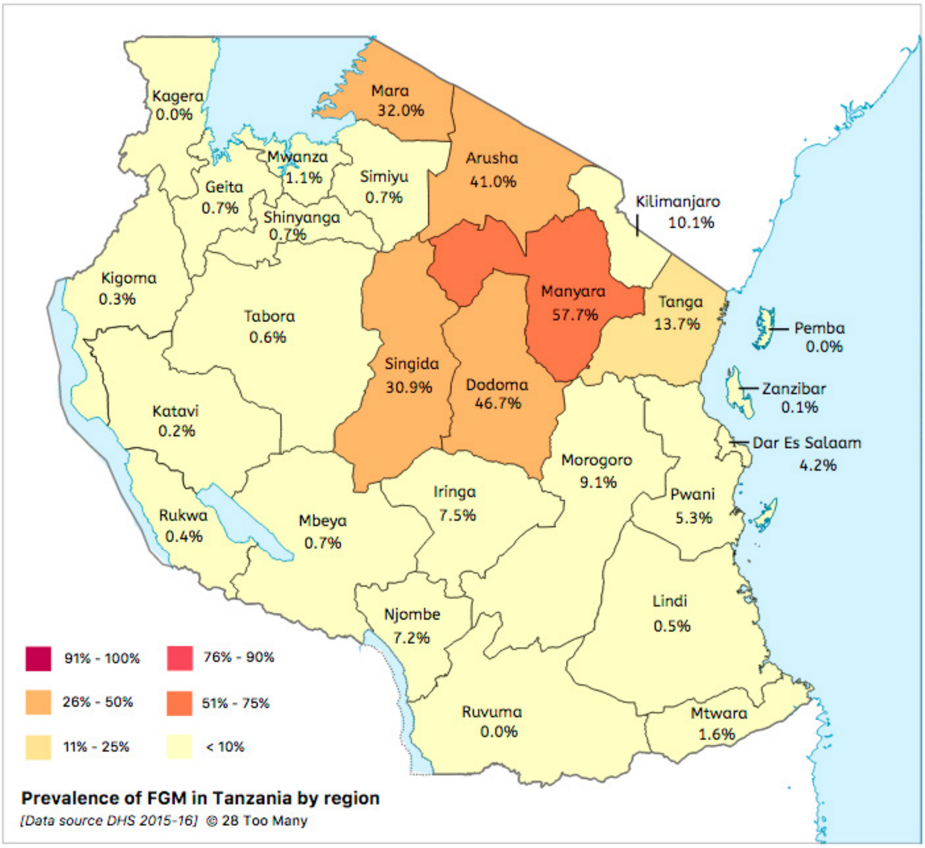


Figure 6: *Map showing the Prevalence of FGM in Tanzania by region.* (Source: 28 Too Many, 2015)

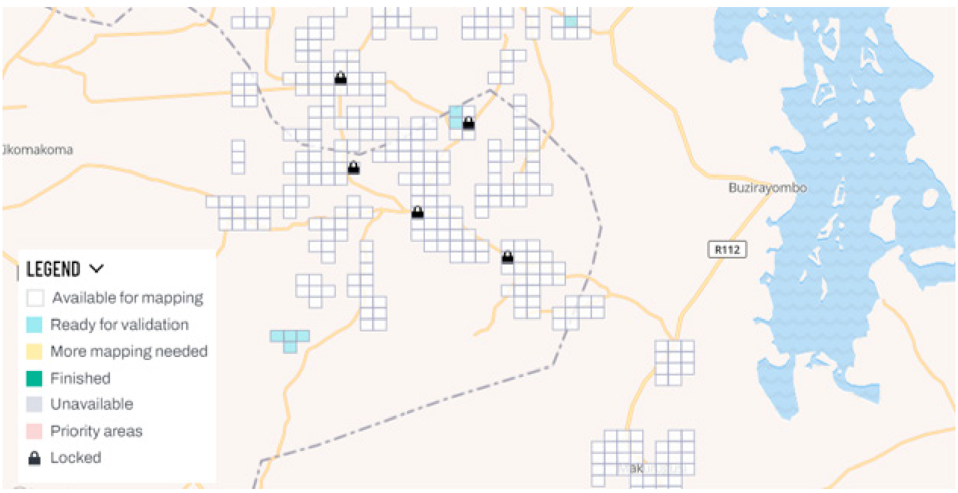


Figure 7: *Screenshot of project area when the mapathon was being held, the project is now finished.*

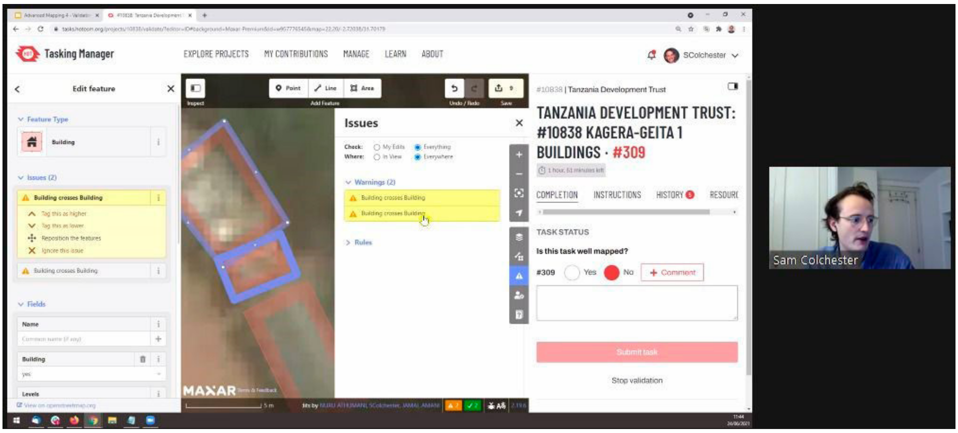


Figure 8: *Sam Colchester of HOT team shown as he trains young surveyors on data validation.*

4 *Recommendations and future of e-Volunteering*

4.1 Future VCSP e-Volunteering Events and WG3.6 Collaborations

Together, the two groups of VCSP and WG3.6 can collaborate to increase the value the VCSP can bring to projects by up-skilling young surveyors with particular skills required for e-Volunteering (including OSM validation and data and gap analysis), providing online support to in-Country volunteers (VCSs), and connecting skilled young surveyors through networking and training. These two groups also see potential in collaborating in some more innovative ways. Brief discussions have been had around developing basic algorithms to support machine learning, creating a podcast, and creating a package for future e-Volunteering events. Already though, the VCSP have begun collaborating in a more definitive manner: with this chapter.

By extending and increasing the outreach of VCSP events, with the help of WG3.6, young surveyors can gain new skills to help solve environmental and social challenges by contributing their existing skills. Vice versa, with the help of the VCSP, WG3.6 can connect with a greater number of young surveyors and create more visibility to encourage them to participate in Commission 3 and its activities. In turn, this will attract more young surveyors to join FIG activities and contribute to the continuum of the profession and the FIG.

4.2 Possible roles and responsibilities of new generation surveyors

Individuals, organisations, and academia all have a role to play in defining how the surveying profession contributes and takes ownership of spatial data quality through both e-Volunteering and through enabling citizens through VGI. Some suggestions for private companies is to run day-off e-Volunteering events as a corporate social responsibility initiative. Private companies need to look beyond investment, toward making active contributions (Ravn-Christensen & Norre, 2020). Academia can contribute through enabling the design and use of geospatial tools for collection of data for local clean-up projects, for example. Alongside academics, individuals and organisations can provide training on new skill sets: from data collection through to analysis and collaborative approaches for computing algorithms.

5 Closing reflections

e-Volunteering is not only bringing people together from the industry with a common purpose but is also strengthening a global network to encourage young surveyors to get involved in the industry through a higher purpose than themselves. e-Volunteering as a technically-charged version of VGI, is a chance for surveyors of various levels and backgrounds to volunteer their time and skills in a way that not only helps them grow, but also can provide vital online support toward projects geared toward sustainable resource use and environmental protection.

It is particularly important for young surveyors to get involved in VGI, as can be seen with the impact VCSP e-Volunteering has had. Through the use of data captured and verified by FIG young surveyors, effective decision making for an array of problems facing our globe can be made. With transparent, truthful geospatial data and maps, solutions can be reached to combat the three drivers of humanitarian disasters (conflict, climate change, and pandemics), among other drivers.

References

Aytoun, R., Chandiru, R., Colchester, S., Deffner, R., & Kateregga, G. (2021, May 24). *Validators: Experienced Mappers Making an Outsized Contribution*. Humanitarian OpenStreetMap Team. Retrieved April 22, 2022, from https://www.hotosm.org/updates/validators-experienced-mappers-making-an-outsized-difference/.

Carver, D. (2022, January 27). *What were the outcomes of COP26?* Commons Library. Retrieved April 20, 2022, from https://commonslibrary.parliament.uk/what-were-the-outcomes-of-cop26/.

CSSE (Center for Systems Science and Engineering) at Johns Hopkins University & Gardner, D. L. (2022, April 21). *COVID-19 Map – Johns Hopkins Coronavirus Resource Center*. Johns Hopkins Coronavirus Resource Center. Retrieved April 21, 2022, from https://coronavirus.jhu.edu/map.html.

Colchester, S., FIG Young Surveyors, & VCSP. (2021, July 5). *HOT OSM Validator training – "Map FGM out of Tanzania" workshop as part of FIG eWorking Week*. Retrieved April 22, 2022, from https://www.youtube.com/watch?v=1NUpjnr3GUE&t=583s.

Degbelo, A., STÖCKER, C., Kundert, K., & Chipofya, M. (2021, June 21). SmartLandMaps – From Customary Tenure to Land Information Systems. *FIG Proceedings*, *2021*(1), 1–12. https://fig.net/resources/proceedings/fig_proceedings/fig2021/papers/ts07.5/TS07.5_degbelo_stocker_et_al_11155.pdf.

Fraisl, D., Campbell, J., See, L., Wehn, U., Wardlaw, J., Gold, M., Moorthy, I., 2020. Mapping citizen science contributions to the UN sustainable development goals. Sustain. Sci. 15, 1735–1751. https://doi.org/10.1007/s11625-020-00833-7.

Franzoni, C., Poetz, M., & Sauermann, H. (2021, September 20). Crowds, citizens, and science: a multi-dimensional framework and agenda for future research. *Taylor & Francis Online*, *29*(2), 251–284. https:///doi.org/10.1080/13662716.2021.1976627.

Friedlingstein, Andrew, & Peters. (2021). *CO2 Emissions*. Global Carbon Atlas. Retrieved April 20, 2022, from http://www.globalcarbonatlas.org/en/CO2-emissions.

Growing Data Foundation. (2022, 1 1). *Firewater*. Growing Data Foundation. Retrieved April 21, 2022, from https://gdf.org.au/firewater/14/06/2021/.

Humanitarian OpenStreetMap. (2021, November 19). *#10838 TANZANIA DEVELOPMENT TRUST: #10838 KAGERA-GEITA 1 BUILDINGS*. Tasks HOTOSM. Retrieved April 22, 2022, from https://tasks.hotosm.org/projects/10838/stats.

International Rescue Committee. (2021, December 15). *The top 10 crises the world can't ignore in 2022*. Rescue.org. Retrieved April 18, 2022, from https://www.rescue.org/article/top-10-crises-world-cant-ignore-2022.

Lawler, O. K., Allan, H. L., Baxter, P. W., Castagnino, R., Tor, M. C., & Dann, L. E. (2021, November 1). The COVID-19 pandemic is intricately linked to biodiversity loss and ecosystem health. *The Lancet Planetary Health*, *5*(11), 840–850. The Lancet – Open Access. https://doi.org/10.1016/S2542-5196(21)00258-8.

Lebrun, G., & Korem. (2022, April 4). *Geospatial Helps Site Selection for EV Charging Stations*. Korem. Retrieved April 18, 2022, from https://www.korem.com/geo-spatial-technology-help-choose-optimal-locations-electric-vehicle-charging-stations/.

Liveuamap LLC. (2022, April 18). *5 missile launches this morning from area of Snizhne Snizhne – Ukraine Interactive map – Ukraine Latest news on live map*. Liveuamap. Retrieved April 18, 2022, from https://liveuamap.com/en/2022/18-april-5-missile-launches-this-morning-from-area-of-snizhne.

Matingo, K. N., & African Surveyors Connect. (2022, April 20). *COVID-19 Information & Data Dissemination Project for Zimbabwe*. COVID-19 Dashboard-Mobile. Retrieved April 21, 2022, from https://www.arcgis.com/apps/dashboards/34d90727cc5548dab0bd6cce8db04595.

Perperidou, D. D.-G., & Zaxarias, N. (2016, May). *Volunteer Geographic Information: How to guide volunteers to produce accurate road network data*. FIG Proceedings 2016. Retrieved April 21, 2022, from https://www.fig.net/resources/proceedings/fig_proceedings/fig2016/ppt/ts01c/TS01C_perperidou_8340_ppt.pdf.

Ravn-Christensen, C., & Norre, K. (2020, May 10). Private Sector Responsibility in Supporting Sustainable Development – The interconnection between business approaches, the youth, CSR and the SDGs in creating sustainability. *FIG Proceedings 2020*, *2020*(1), 1–14. https://www.fig.net/resources/proceedings/fig_proceedings/fig2021/techprog.htm. 9309.

Sarah, E., Goodchild, M. F., & Sui, D. Z. (2011, August 9). Researching Volunteered Geographic Information: Spatial Data, Geographic Research, and New Social Practice. *Taylor and Francis Online*, *102*(3), 571–590. https://doi.org/10.1080/00045608.2011.595657.

Sharma, R., Kitto, T., Sahinkaya, C., Kivilcim, C. Ö., & Buxton, C. (2021, May 5). e-Volunteering in Unprecedented Times: New Synergies to Address Environmental Challenges. *FIG Proceedings*, *2021*(1), 1–17. https://fig.net/resources/proceedings/fig_proceedings/fig2021/papers/ts03.5/TS03.5_sharma_kitto_et_al_11128.pdf.

28 Too Many. (2015, January 1). *Tanzania28*. 28 Too Many. Retrieved April 22, 2022, from https://www.28toomany.org/country/tanzania/.

Yalcin, I., Kocaman, S., Gokceoglu, C., 2020. A CitSci approach for rapid earthquake intensity mapping: A case study from Istanbul (Turkey). ISPRS Int. J. Geo-Information 9. https://doi.org/10.3390/ijgi9040266.

Zhang, G., 2020. Spatial and temporal patterns in volunteer data contribution activities: A case study of eBird. ISPRS Int. J. Geo-Information 9. https://doi.org/10.3390/ijgi9100597.

ATTRIBUTES AND ETHICAL PREFERENCES OF LAND SURVEYORS TOWARDS DATA CONTRIBUTION TO LAND MANAGEMENT SYSTEMS

Ruba Jaljolie (Isarel), Sagi Dalyot (Israel)

1 *Introduction*

When discussing data accessibility and data sources for Land Management Systems (LMS), different approaches are considered, mostly relying on photogrammetry (Shokri & Sadeghian, 2021) and aerial images (Nacar et al., 2018). Determining appropriate data sources for LMS should take into account cultural and legal gaps between different states, the required data accuracy in LMS, and affecting urban trends (Jaljolie & Dalyot, 2020). Prospective LMS require massive volumes of data as preliminary input, as well as continuous updates of the database. However, an optimal method for gathering, inputting, and updating data has yet to be identified. As such, it is necessary to provide effective – yet affordable – strategies for achieving this goal. Among the suggested data sources is Volunteered Geographic Information (VGI) and crowdsourcing (Mourafetis, & Potsiou, 2020; Naghavi et al., 2022). VGI for LMS involves ethical dilemmas, and a significant gap still exists in the measuring and analyzing of stakeholders' perceived values in the specific context of ethical issues and conflicts. Therefore, methodological research should be conducted for ensuring the preservation of reliability, ethical values (e.g., transparency), and users' privacy.

This research analyzes the results of a questionnaire disseminated to land surveyors in Israel, one of the most important groups of stakeholders of LMS, that aims at investigating and analyzing the ethical preferences and common characteristics of those who desire to contribute data to LMS. Understanding these attributes and characteristics results in guidelines for integrating ethical conducts in LMS that are compatible with users' preferences, inputting data in an ethical manner, and administrating land surveyors who wish to take part in such endeavours. This in turn has an economic and social value that benefit governments, industries, and the public.

2 *Methodology*

2.1 Questionnaire objectives and assumptions

A questionnaire was disseminated among 25 professional land surveyors in Israel that presented with the necessary background on the local ethical code of land surveyors, as well knowledge regarding the national Cadastral specifications. 48% of the participants are independent contractors that own private land surveying offices, while the rest are land surveying employees. The questionnaire was designed to allow the investigation of integrating ethics into the design process of LMS, while considering the diverse stakeholder groups (e.g., land surveyors as data contributors). Another objective is to identify the common attributes and characteristics among professionals who will be willing to contribute data to LMS. The motivation is that in the future, stakeholders that will present these desired attributes and characteristics may be invited to contribute data to LMS.

In your previous contribution, the job you have done was excellent, and you have showed special abilities in operating the system and developing creative processes for inputting data. Consequently, you are kindly asked to contribute additional data and to share your experience with other land surveyors. How would you behave?

- ○ I would be happy to share my experience and to give guidance to surveyors. In addition, I would contribute more information to the system when I have time for it.
- ○ I would be happy to share my experience and to give guidance to surveyors. However, I would not contribute any more information. Each participant should make his duty and contribute information equally.
- ○ I would refuse to share my experience with other surveyors, I would rather keep my skills only for my own use.

A close friend of you has a high chance to win a tender for construction project if you reveal to him private information that you can access as a result of your contribution to the local LMS. Your friend asked you to reveal that information and claimed that winning the tender is crucial so that she/he can pay tuition for his/her son. Would you divulge that information?

- ○ I would definitely reveal that information because I am a good and loyal friend.
- ○ I would never reveal that information since I have to maintain privacy and confidentiality.
- ○ I would only reveal that information for money.
- ○ By no means! This conflicts justice and equity.
- ○ I would refuse to participate in the contribution process from the beginning in order to avoid an ethical dilemma.

Figure 1: *Example of two questions asked in Section 2 (translated from Hebrew).*

Accordingly, four assumptions are made in the questionnaire design:

- **Assumption 1:** privacy is the utmost concern of data contributors, and they would never compromise it. This is since land surveys serve private citizens, and as such should maintain confidentiality.
- **Assumption 2:** Contributors expect some sort of compensation for their efforts, even if it is minimal. Since efforts are made by the contributor, some sort of compensation, even if it is not payment, is custom.
- **Assumption 3:** It is more likely for individuals to contribute data if they are young and employed, while it is less likely if they are older or independent contractors. Research shows that age is correlated with the use of technology. Moreover, employees worry less when it comes to business income.
- **Assumption 4:** Individuals are more likely to contribute data relevant for their hometown than for other locations. This is due to several reasons, for example: access to the property, local knowledge – and more.

2.2 Questionnaire organization

Participants were asked to provide basic demographic and professional information, such as age and years of experience. The questionnaire was kept anonymous to encourage truthful responses. The contextual purposes and motivation of the questionnaire were introduced to the participants, including providing the definition of LMS, as well as its functions, contribution to the management of land resources, its merits, and its means of operation. This context was used to stimulate them to take part in the questionnaire while being aware of the value of their participation. Next, the participants were informed that they will be required to contribute and enter 3D coordinates of spatial parcels into the LMS due to a shortage of human power and resources. In addition, they were informed of professional benefits and rewards that they will receive for their contribution, as well as an estimation of working hours they will need to put for this effort. Under these conditions, they were asked to answer the other sections.

Section 1 of the questionnaire included questions designed to test ***assumption 3*** and provide a general overview on the participants' usage patterns of location-based mobile applications that involve user-generated data and information, such as WAZE and BOOKING. Section 2 of the questionnaire is designed to test their willingness to contribute data, specifically in the context of LMS, and to identify the ethical values and principles that are important for them. This is achieved through multi-choice questions based on value scenarios. Each question describes conditions of a virtual situation and asks participants how they would behave in such a situation. Figure 1 depicts two examples of questions. Several questions were rephrased in another form to reflect a slightly different scenario aimed to examine how this change might influence the participants' decisions. The goal of this section is to gain an understanding of what ethical values are preferred by participants in different situations, and to test ***assumptions 1, 2*** and ***4***. In section 4 of the questionnaire, participants are required to distinctly determine the importance of ethical values and to rank moral principles based on their importance, which tests ***assumption 1***. The questionnaire included three more sections that are out of the scope of this study.

3 Results

3.1 Value preferences and ethical patterns

Responses to Q_2, Q_4–Q_7[5]

Question 2: The participants were informed about the excellent job they had previously done by inputting cadastral data into the LMS, and that they showed excellent skills of working with the LMS. In light of this information, they were asked if they were opened to sharing their knowledge (on the methods they used for inputting data into LMS) with their peers to improve the services of the LMS and to contribute more cadastral data into the LMS, other than the data that they had already contributed. **Response:** 76% of the respondents said they will share their knowledge with their peers and make additional contribution into LMS by inputting additional cadastral data if they have enough time. 20% said they will only share their knowledge and experience without contributing additional cadastral data, while one participant stated she/he would rather keep the knowledge for her/his exclusive use.

Question 4: Participants were put in another situation where they have observed a malfunction in the LMS, and they can contribute for the good of the public by informing relevant agencies about that malfunction. **Response:** 64% of the participants expressed responsibility and care by informing the problem for the common good. 32% of respondents would take steps not only to inform about the malfunction but also to correct it in their spare time. One respondent presented irresponsibility and carelessness.

Question 5: Among the ethical dilemmas that participants were required to resolve is to choose whether to act ethically, justly, and with dignity when contributing data to a project that concerns their relatives' property, or to be biased for the favour of their relatives. **Response:** 32% of participants preferred to decline participating in this project due to conflicts of interest, most of them would explain their reasons for declining. 68% would be willing to take part in this project, stating that they will act honestly.

Question 6: In response to a question regarding a friend who desperately needs money for tuition for his son, many respondents indicated that they would not act honestly if they knew that they could help their friend to win a tender for a building by divulging to him information they had obtained from their involvement in the LMS (see Figure 1, bottom). **Response:** 40% will reveal the information to their friend, while 16% will reject to contribute and explain why. 44% of respondents would contribute without disclosing their information to the friend, either for reasons of justice and equity or for reasons of reliability and privacy.

Question 7: The land surveyors were asked whether their responses to the previous questions would differ if they were contributing to another city rather than their hometown. This question was designed to assess their willingness to contribute to projects far from home, thereby minimizing conflict of interest concerns. **Response:** 77.3% of the participants would not change their answers, stated that they would act the same and practice similar ethical preferences, in case that they are required to contribute data to another city; 22.7% would make less efforts in such cases. The participants who expressed their refusal to contribute data in the previous question were excluded before calculating these percentages.

5 Q_i denotes Question number #i.

3.2 Analysis of conflicts of interests

Table 1: *Conclusion and desired actions in terms of LMS and policy (Q2, Q4–Q7).*

	Conclusion	Interpretation	Desired action
Q_2	The answers indicate high appreciation of sharing knowledge for the public good.		Establishing a communication platform, in which the land surveyors can share knowledge and experience on LMS; this is expected to advance the data contribution process.
Q_4	High responsibility was reflected by the land surveyors' community.		Contributors should be ranked according to the steps they make to enhance LMS. Contributors who demonstrate consistent initiatives will be identified and given further responsibilities and/or rights within the LMS.
Q_5	In general, the land surveyors' community maintains honesty and dignity.		Land surveyors can contribute data to LMS.
Q_6	By contributing to LMS, land surveyors might be exposed to data and information they are affiliated with. Many land surveyors would divulge this data for the benefit of their acquaintances in intractable cases, where the loyalty level is reduced (less significant).	In intractable cases, this behaviour is expected among other stakeholders.	To avoid conflicts of interest, steps should be taken to eliminate the chance of a land surveyor to be exposed to data that relates to close friends or relatives. For example, by allowing contribution only to distant areas from the hometown and offices of the land surveyors (contributors).
Q_7	Contribution slightly decreases when projects are far from their hometown (compatible with ***Assumption 4***).		Allowing contribution to areas that are not the hometown of the data contributors can still be considered.

3.3 Comparison of specific values

Privacy importance (Q_9)

Privacy in land-related applications is the focus of many scientific publications (e.g., Adhikari & Panda (2018); Smith et al. (2011); Mooney et al., 2017). Q_9 was formed to check privacy superiority in comparison with the importance of academic research. Participants were asked whether they would keep using the LMS if they knew that documentation of their LMS usage is being made (anonymously and without revealing their identities) for the purpose of academic research. **Response** shows that privacy is not necessarily superior. Only 44% thinks that privacy is more important than academic research, while 56% think that both are equally important. 96% of the participants would keep working with LMS in this case. Table 2 details the interpretation and resulting desired actions.

Table 2: *Conclusion and desired actions in terms of LMS and policy (Q9).*

	Conclusion	Interpretation	Desired action
Q_9	Privacy is not always superior. ***Assumption 1*** is not correct.	This might be interpreted by the fact that people got used to contemporary technological developments that regularly violate their privacy.	Data contributors should state their privacy concerns before contributing to LMS. Privacy contracts should be made according to users' preferences.

Data quality vs. public good and data accessibility (Q_{11}–Q_{14})

Q_{11} asked participants whether they would like to join a LMS data contribution group. They had to choose one of four options: 1) No, I would not like to contribute data, 2) Yes, in condition that intimacy within the group members is ensured, 3) Yes, for the public good and human wellbeing, 4) I would join only if professionalism were ensured and if the group makes significant contributions. Q_{12} told participants that by their contribution to the LMS, they would be highly valued by their employers and customers; still, this would consume considerable time and efforts. Having this in mind, they were asked to choose whether to 1) not contribute data at all and use their time for advancing their private benefits, 2) contribute low quality data only for being appreciated by employers and customers, 3) contribute data even if their contribution would not be appreciated by others, for the sake of the public good, 4) invest time and efforts and contribute high quality data. In Q_{13}, they were told that after joining the LMS data contribution group, they were offered to carry out a new project with high income; however, accepting that project conflicts their responsibility towards the data contribution group. In this situation, they had to choose how to act: 1) to give up their commitment to the data contribution group, so that they can carry out the profitable project, 2) to give up carrying out the new project since they desire to contribute for the public good in order to be appreciated by employers and costumers, 3) to give up carrying out the new project so that they can keep their commitment to the data contribution group, 4) to give up carrying out the new project so that they can benefit the public, even if they would not be appreciated for that. Q_{14} asked participants to check the integrity and correctness of data that was inserted to the LMS by other contributors. Three options were suggested: 1) to refuse to check the data, since this is needless, 2) to check the data, but without making arduous efforts, 3) to check the data thoroughly. Figures 2 and 3 show the value preferences that were reflected from the response to each question. It is visible that data contributors appreciate professionalism, completeness, loyalty, and precision of data more than usability and accessibility for everyone. This implies that the data they contribute would be reliable, and they would prefer not to contribute data at all rather than contributing data that is not qualitative. Figure 2 shows that the public's good and human well-being were valued above personal interest and intimacy. However, a land surveyor is more likely to reject to contribute data, despite the common good, to accept a revenue from a project (see Figure 3). Further conclusions and desired actions derived from Q_{11}–Q_{14} are depicted in Table 3.

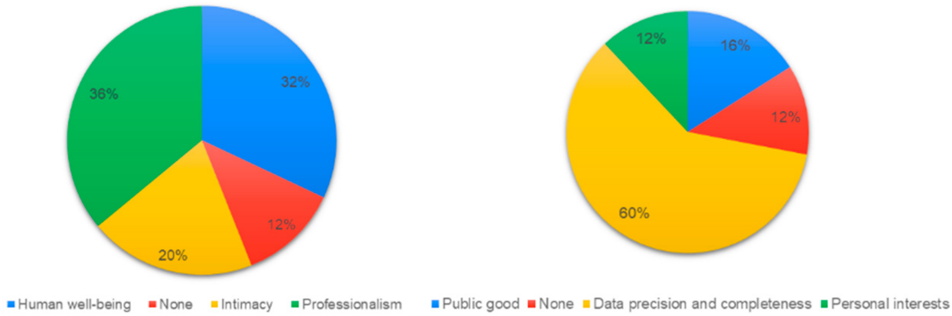


Figure 2: *Value preferences as analyzed from questions Q11–Q14.*

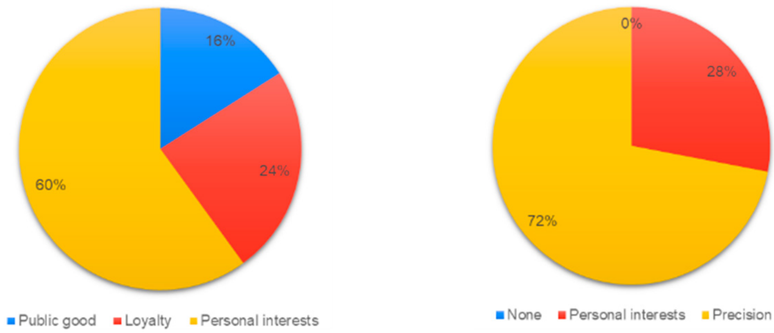


Figure 3: *Value preferences as analyzed from questions Q_{11}–Q_{14}.*
(Figures do not include participants who selected they do not wish to contribute data at all, with or without being compensated.)

Table 3: *Conclusion and desired actions in terms of LMS and policy (Q_{11}–Q_{14}).*

	Conclusion	**Interpretation**	**Required action**
Q_{11}–Q_{14}	Data reliability and professionalism are superior principles.	If reliability is not ensured, LMS might be useless and untrusted. Land surveyors would decline to be involved in LMS unless professionalism is ensured.	Data quality algorithms should be implemented in LMS (e.g., D'Antonio et al. (2014) and Fogliaroni et al. (2018)).
	Most land surveyors aspire to provide reliable data. Still, some expect to provide data less than thoroughly, just for being appreciated for their contribution.	Land surveyors are aware of the importance of maintaining data precision and correctness, as the data they provide is associated with land tenure and affect land planning and pricing.	Land surveyors can be trusted as data contributors to LMS.
	Personal profit is preferable above the common good (compatible with ***Assumption 2***).	Individuals in any occupation expect to receive revenue for their work.	Motivating land surveyors to volunteer data is effective. This can be done by explaining the importance of their contribution for the public good, or by giving them special preferences and discounts.

Ranking of values

The average ranking of all values is sorted in ascending order in Figure 4. Accountability and reliability received the highest rankings, and hence are the most important values. Privacy value is less important, and the common good and data availability values are insignificant values. Based on these values, ***Assumption 1*** is not correct. Privacy is not necessarily the utmost concern of both data users and contributors, and they might compromise it.

3.5 Relation of age and occupancy with the willingness to contribute data

Table 4 shows the participants' age average and variance who expressed their willingness to contribute data (conditionally or unconditionally) compared to the participants who would not contribute data. In addition, the percentages of participants willing to contribute data were calculated for independent contractors and employed workers.

Table 4: *Age distribution and job distribution in contributing data.*

	Age distribution (years)		Job distribution (percentage)	
	Mean age	Variance	Independent contractor	Employed
1. Will not contribute	55.7	3.7	8.3%	15.4%
2. Will contribute	33.0	3.9	91.7%	84.6%
2a) Will contribute anyway	34.0	5.0	16.7%	38.5%
2b) Will conditionally contribute	44.9	4.3	75.0%	46.1%

Figure 4: *Value rankings given by the participants.*

Based on these values, ***Assumption 3*** is correct. It is more likely for individuals to contribute data if they are young and employed, while it is less likely if they are older or independent contractors. This can be explained since younger ages are more open to innovation and emerging technologies, their awareness of the importance of contribution to the society, their familiarity with mobile applications and smart devices. In addition, employees that do not have their own business show a tendency and willingness to contribute data in their free time, perhaps since their income is secured (earn salaries) and they are not concerned with increasing revenues. Young and employed surveyors should be addressed and recruited for contributing data to prospective LMS.

4 Discussion and conclusions

This research presents preliminarily analysis of a questionnaire disseminated among land surveyors from Israel that investigated and analyzed the perceived ethical values of data contribution to LMS. The findings can serve as guidelines on adopting a code-of-conduct that does not conflict the ethical preferences of land surveyors, as well as identifying certain groups within this community that show the highest potential of contributing to LMS. The results show that, in general, the land surveyors' community can be trusted since they reflected responsibility and integrity. Besides, motivating land surveyors to contribute data is necessary and is expected to enhance their performance.

Main conclusions are that land surveyors would contribute data while protecting certain ethical values; meaning that if other values are not ensured, land surveyors might not contribute data. Among the most important values found are reliability, accountability, and integrity, meaning that land surveyors see themselves as professionals that are held accountable for what they contribute, specifically to LMS that serve their core of occupation. Although privacy is usually emphasized in academic publications as a superior right that nobody would compromise, assumption 1 was shown to be not true: respondents did not rank it as a superior ethical value, while appreciating, for example, that providing data to academic research is more important than privacy. To sum, land surveyors were found to be well-suit to contributing data to LMS since they showed awareness of ethical values, data reliability, and the common good. Besides, their expertise in land surveying makes them trusted by data users. This encourages integrating VGI perspectives in LMS, since ethical contribution is highly guaranteed when made by specific contributing groups, such as the land surveyors who were analyzed here.

Following the above, further research and actions are still required. The authors suggest disseminating this survey again and collecting responses from more participants and from other countries, analyzing whether ethical values are global, or show some national differentiation due to, e.g., certain principals and working practices. Also, drafting a code of ethics for land surveyors that takes into account their preferences and consider the ethical aspects of contributing data into LMS is required. Ethics is a very important aspect, mainly since technological advancements continue, such that certain defined guidelines should be made on a wider holistic manner that will include all stakeholders. This study focused on detecting ethical preferences of land surveyors as data contributors within LMS. Similar studies should be conducted for assessing the ethical patterns of other stakeholder groups and relate to the different aspects of LMS. We believe that the results presented here provide a preliminary perspective that should be adopted and extended as contemporary LMS using VGI are materialized.

References

Adhikari, K., & Panda, R. K. (2018). Users' information privacy concerns and privacy protection behaviors in social networks. Journal of Global Marketing, 31(2), 96–110.

D'Antonio, F., Fogliaroni, P., & Kauppinen, T. (2014). VGI edit history reveals data trust-worthiness and user reputation. In 17th AGILE Conference on Geographic Information Science, Connecting a Digital Europe through Location and Place, Castellon, Spain, June 2014.

Fogliaroni, P., D'Antonio, F., & Clementini, E. (2018). Data trustworthiness and user reputation as indicators of VGI quality. Geo-Spatial Information Science, 21(3), 213–233.

Jaljolie, R., & Dalyot, S. (2020). Multi-Dimensional Land Management Systems: A Delphi Study of the Expert Community. FIG Work. Week.

Mooney, P., Olteanu-Raimond, A. M., Touya, G., Juul, N., Alvanides, S., & Kerle, N. Considerations of Privacy, Ethics and Legal Issues in Volunteered Geographic Information. Citizen Sensor, 119.

Shokri, A. H., & Sadeghian, S. (2021). 3D Cadastre Implementation using Uav-Based Photogrammetry Methodwithout Ground Control Points (Gcps).

Smith, H. J., Dinev, T., & Xu, H. (2011). Information privacy research: an interdisciplinary review. MIS quarterly, 989–1015.

Naghavi, M., Alesheikh, A. A., Hakimpour, F., Vahidnia, M. H., & Vafaeinejad, A. (2022). VGI-based spatial data infrastructure for land administration. Land Use Policy, 114, 105969.

Nacar, F., Karabörk, H., & Çay, T. (2020). Study of usability of aerial images and high-resolution satellite images in cadastre renewal works in Turkey. Survey Review, 52(372), 191–204.

CHAPTER 6

THE ROLE OF LAND ADMINISTRATION DATA IN THE REAL ESTATE SECTOR

CADASTRE AND PROPERTY MARKETS

**Chryssy Potsiou (Greece), Marije Louwsma (Netherlands),
Enrico Rispoli, Maria G. Scorza (Italy)**

1 *Land administration, real estate and property*

1.1 The emergence of cadastre and land registries

Within large parts of Western Europe, the introduction of property taxation by Napoleon around the beginning of the 19th century (Grab, 2003) led to a systematic registration of land. Cadastres were developed, which were inventories of lands created to support land registration with the necessary graphical and textual information. Traditionally, cadastres and land registries, the so-called dual systems, were under the responsibility of different ministries. Until the end of the 1970s, cadastral information included 2d paper maps showing the size and location of all land parcels together with text records that described the attributes of the land.

Land registration provided information about the evidence of ownership of rights in land which in some countries was also guaranteed; land registration was usually under the responsibility of the ministries of justice. This has created security for titles and has supported the real estate and mortgage markets. Cadastral information varied depending on the land policy they served in the various countries; they supported either records of property ownership and other legal rights and/or the taxation of land, or the recording of land use. Through the years cadastres and land registers provided a framework for sustainable development and economic growth.

In the beginning of the 1980s, the era of automation emerged and since then automation has significantly changed government agencies including cadastres and land registries. They gradually started digitization of their various records of information and of their services. Soon it was realized that major benefits could be derived through "integration" of those digital records. However, digital systems were developed at different speeds and usually on different technical platforms. This together with a lack of standards for formalized data exchange caused some inefficiency in service provision and a certain extent of duplication of work. This has initiated organizational reforms. In the effort to minimize challenges and improve effectiveness in some countries, cadastres and land registries were merged and usually moved to the responsibility of the national mapping and cadastral agencies (NMCA's). Then followed rapid ICT and GIS developments enabled them to evolve towards multipurpose systems that supported the administration of land. An example of an early definition (National Research Council US, 1983) describes a multipurpose cadastre as "a system that basically consists of four components: 1. A geodetic reference framework, 2. A series of accurate large-scale base maps, 3. A cadastral map that delineates individual parcels, and 4. A series of registers or files that record the land rights related to the parcels."

Since the launch of the internet and the creation of the online world in the 1990s, a new branch of economics called the digital economy, internet economy, or web economy gradually emerged and has been defined as the branch of economics studying zero marginal cost of intangible goods over the internet. Digital networking and communication infrastructures have provided a global platform over which people and organizations devise strategies, interact, communicate, participate, collaborate and search for information. Thus, new terminology has appeared in the everyday life such as e-government, e-business, e-commerce, e-democracy, e-participation. These have also influenced the land administration systems. New terminology was developed such as e-cadastre, e-registration and finally, by 2005, even e-conveyancing (electronic land transaction) was possible in some advanced systems. Electronic services have been developed which have enabled easy access to cadastral and land registration products and services to certain professionals (e.g., lawyers, surveyors, real estate agents as well as banks) that were involved in the operation of real estate markets. New developments had also enabled interaction and cooperation among various government agencies that were interested in using location-based data, as well as integration of major nation-wide geospatial records kept in cadastres, land registries or in the newly merged NMCA's. Among other things, the extent of digitization, integration of information, and electronic services of such systems have already become crucial factors for the support of property markets and the sustainable management of land. This has led to the emergence of initiatives for the establishment of national spatial data infrastructures (NSDIs), regional spatial data infrastructures and a global spatial data infrastructure; in parallel, discussion was focused on both technical and non-technical issues such as standards and interoperability of data as well as policies for data sharing and pricing. Land administration systems were then considered to be the backbone of such infrastructures that will support sustainable development and good governance.

1.2 Transitions and land reform

While this was happening in the West, in Eastern Europe major land reforms took place since the beginning of the 90s. The major economic change from centrally driven systems into free market economies took place in a large number of countries with economies in transition,. Maybe these were collectively the largest land reform in human history. Such reforms focused on several parallel projects for denationalization of land and real estate, such as restitution of old property rights and provision of property titles, privatization of land and buildings, as well as land registration aiming to establish modern land administration systems that would support the efficient operation of real estate markets.

Accumulated experience in the Western developed land administration and management systems (LAMSs) was then provided to all countries in transition on how to improve effectiveness of their land administration systems. UNECE Working Party on Land Administration prepared the publication "Land administration in the UNECE Region – Development Trends and Main Principles" and defined the term as "a good land administration system (LAS) is a system that will guarantee ownership and security of tenure; support land and property taxation; provide security for credit; develop and monitor land markets; protect land resources and support environmental monitoring; facilitate the management of state-owned land; reduce land disputes; facilitate rural land reform; improve urban planning and infrastructure development; and provide statistical data in support of good governance. It should be affordable and open to everyone, meeting the needs of all its users, and must be sustainable" (UNECE, 2005). Based on this publication, and its earlier version, the land management model was published (Enemark et al., 2005; Enemark, 2006).

1.3 Multipurpose cadastres

Thus, in the 21st century the term multipurpose cadastre is usually replaced by the term LAS and is recognized as the tool to support sustainable real estate markets and the good management of land that includes various domains such as land ownership and tenure, land use and development, and land valuation and taxation (Enemark, 2006; Williamson et al., 2010). Such data sets can be either within the responsibility of one and single agency or they can be under the responsibility of various agencies but are digitally linked to each other (UNECE, 2005). In parallel, the UN Millennium Development Goals emphasized among other challenges the need for addressing extreme poverty and improving living conditions of those living in slums, the need for environmental stability, and for good management of land. Since then, most governments aimed at addressing these global challenges. The geospatial professional community within FIG, UN and the World Bank, as well as the various NMCAs started seeking relevance in those challenges. As there is no unified model of an LAS, it was early emphasized that the design of an LAS should be tailored to the needs of people and their relationship to land, to support tenure security for all, and to sustainably manage land use and natural resources (Enemark et al., 2014; 2016) This approach is often called Fit-For-Purpose Land Administration (FFPLA).

The social, economic and environmental value of modern LASs that can serve multiple purposes in society was broadly recognized and in 2015, the "UN Sustainable Development Agenda 2030" was published based on this concept. In this document, all UN member states agreed that in order to end poverty in all its forms everywhere (SDG1) by 2030 we need, among other things, to "ensure that all men and women, particularly the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, *ownership*, *and control over land and other forms of property, inheritance, natural resources,* appropriate new technology, and financial services including microfinance" (SDG 1.4). The year 2015 and Agenda 2030 is a landmark in land management history as for the first time all UN member states agreed that "ownership of land" should be included into the document. As it was roughly estimated that almost 70% of the land on earth remained unregistered, the global need for land and property registration was emphasized, too.

While countries in transition were focusing on establishing modern LAMSs in a joint FIG/UNECE conference in 2007, it was broadly realized that since the major economic change of the beginning of the 1990s, for several reasons a major informal development had taken place in most of these countries (Tsenkova et al., 2009; Potsiou, 2010). That resulted in a large number of unregistered properties representing "dead capital" in the countries with economies in transition, threatening the effectiveness of the LAM systems and leading to informal real estate markets. Since then, new research initiated in this field aimed to address this "effectiveness issue" and formalize informal properties, bringing them back into the economic cycle (Potsiou, 2015).

1.4 Tenure security

Securing land rights is perhaps the most obvious reason to record land rights. Legal recognition of tenure and rights on land, natural resources and constructions as well as registration of such rights into LASs, empowers owners against poverty (SDG1), land grabbing and evictions which is a frequent phenomenon in informal settlements (FAO, 2012). Registration of rights in LASs creates marketable and bankable property units thus enabling formal transactions including sales, renting as well as mortgaging of the property unit. It therefore enables easy access to credit for the funding of the various needs of the occupants, including all necessary improvements of both the properties and the neighbourhoods. At the same time, it tends to support the national economy and the general well-being of the people. Having access to updated and reliable information about the relationship between people, land, and rights enhances transparency in the market, minimizes fraud and eases transactions on the land and real estate. Legal recognition and registration of property rights minimizes social unrest, increases the public trust in government and, most importantly, provides legal certainty for all parties involved. The purchase of land only to learn later that the seller lacked full rights to the land is disruptive for the new owner.

Apart from legal certainty, LAMSs also support land and property valuation, which is vital for formulating sustainable real estate markets, land policies, land reforms, planning and land use regulations, as well as for the levying of fair property taxation.

Following the global financial crisis of 2008, it was concluded by many experts that "the crisis was the result of inadequate regulation of real estate and financial markets. Real estate bubbles were allowed to inflate, mortgage lending was inadequately supervised, the financial markets were allowed to develop complex financial instruments that few understood, credit risk was inadequately modelled and credit rating agencies failed to carry out their fundamental role. Investors also failed to properly understand the instruments they were buying. Consumers failed to evaluate the risks they were undertaking when buying property with inflated value. As a consequence, recessionary effects spread to the real economy worldwide". Therefore, it was agreed to develop a framework for promoting sound real estate markets as well as improved financing for the sector. Enhancing effectiveness of LAMSs operations and services for transparent land and property management was highly recognized as one of the major principles of the "UNECE Policy Framework for Sustainable Real Estate Markets" published, and updated recently, for this purpose (UNECE, 2010; 2019).

It also is widely recognized that land administration information combined with demographic, statistical and other geospatial information can support the implementation of several SDGs. Figure 1 shows the geospatial information linkages to the Sustainable Development Goals, Targets and Indicators.The quality and completeness of initial registration, and the continuous maintenance of LAMSs are key to keeping information up to date and maximising its value for property markets and society in general.

Thus, there is an increasing pressure in many UN member states for improving LAM infrastructure with nation-wide coverage as soon as possible, latest by 2030. How land administration and management systems are designed, such as their maturity, determine the types of information they will provide and how this information should be recorded, structured and distributed. Consequently, the current role of the various LAMSs differs as well.

In this effort, several NMCAs investigate new ways to improve effectiveness and create fast, reliable and affordable procedures, as well as to increase their products and services to meet societal needs, by enhancing citizen engagement. Cadastral surveys can also be enhanced through validation and integration of information derived from the public through VGI and crowdsourcing techniques into authoritative records (Cetl et al., 2019; Potsiou, C., et al., 2020; Apostolopoulos and Potsiou, 2021; Gkeli, M., et al., 2019; 2020) The Greek cadastral agency, by example, has officially introduced e-participation and VGI techniques that enable rightholders to successfully self-record the land parcel on an orthophoto and submit a declaration of their property rights on the property, thus reducing errors and speeding up official cadastral surveys without reducing accuracies (Mourafetis and Potsiou, 2020). In parallel, during the past decade, there is some

Target Contribute to progress on the Target, not necessarily the Indicator									Goal	Indicator Direct measure or indirect support to the Indicator					
							1.4	1.5	1 No poverty	1.4.2					
						2.3	2.4	2.c	2 Zero hunger	2.4.1					
					3.3	3.4	3.9	3.d	3 Good health and well-being	3.9.1					
									4 Quality education						
								5.a	5 Gender equality	5.a.1					
		6.1	6.3	6.4	6.5	6.6	6.a	6.b	6 Clean water and sanitation	6.3.1	6.3.2	6.4.2	6.5.1	6.6.1	
					7.2	7.3	7.a	7.b	7 Affordable and clean energy	7.1.1					
								8.4	8 Decent work and economic growth						
					9.1	9.4	9.5	9.a	9 Industry, innovation and infrastructure	9.1.1	9.4.1				
						10.6	10.7	10.a	10 Reduced inequalities						
	11.1	11.3	11.4	11.5	11.6	11.7	11.b	11.c	11 Sustainable cities and communities	11.1.1	11.2.1	11.3.1	11.6.2	11.7.1	
				12.2	12.4	12.8	12.a	12.b	12 Responsible consumption and production	12.a.1					
					13.1	13.2	13.3	13.b	13 Climate action	13.1.1					
		14.1	14.2	14.3	14.4	14.6	14.7	14.a	14 Life below water	14.3.1	14.4.1	14.5.1			
	15.1	15.2	15.3	15.4	15.5	15.7	15.8	15.9	15 Life on land	15.1.1	15.2.1	15.3.1	15.4.1	15.4.2	
								16.8	16 Peace, justice and strong institutions						
17.2	17.3	17.6	17.7	17.8	17.9	17.16	17.17	17.18	17 Partnerships for the goals	17.6.1	17.18.1				

Figure 1: *Geospatial information linkages to SDGs, targets and indicators.*
(Source: Group on Earth Observations, Geospatial linkages to SDGs
https://earthobservations.org/documents/publications/201704_geo_unggim_4pager.pdf)

Figure 2: *Sample of current FFPLA projects.* (Source: Enemark et al., 2021)

progress recorded in FFPLA initiatives in providing secure land rights at scale (Enemark et al., 2021). Fig 2 shows a sample of FFPLA projects that have been recently assessed that give us promising results.

In the meantime, international researchers are continuously seeking new methods to improve the value of land administration and management infrastructures by introducing 3d cadastres especially for the visualization and management of complex rights, restrictions and responsibilities within densely built urban areas (van Oosterom, 2018). Building Information modelling (BIM) has opened an additional source of valuable location-based data about the complex-built environment, with particular focus on the architecture, structural and engineering detail of both buildings and infrastructure projects, mainly aiming to facilitate efficient collaboration in construction design and efficient management of complex buildings. The potential and challenges of integrating BIM into modern urban land administration is being investigated (Rajabifard et al., 2019) and is anticipated to further improve services in the real estate markets. The increasing use of BIM and the interoperability challenges of its integration with GIS and its potential to support a large number of development activities in the real estate sector, has recently initiated new discussion and research among NMCAs, the Eurosdr Geobim project (Ellul et al., 2020).

1.5 Digital transformation in land administration and real estate

The world's "digital transformation" is growing rapidly and is further accelerated due to the Covid 19 pandemic. With the parallel evolution of BIM, 3d city models and the internet of things (IoT), a growing interest has developed for a digital representation of the physical environment including its dynamic processes. Such digital representation should enable real time monitoring and interaction between physical and digital worlds. Thus, new terms such as the "cadastre 4.0" and the "digital twin" , that both originate from industry, come into use today when people try to identify the coming new version of land administration systems and the future geospatial information infrastructures. People are talking about "digital twins of urban areas,[being] actually a System of Systems" that will be able to support good governance of complex smart cities.

In fact, a common definition of a digital twin in the geospatial domain is still lacking; however, it is clear that it includes 3D city models, BIM and objects with geometric and semantic information, real-time sensor data, procedures and simulations that allow the continuous updating, monitoring and real time representation of the real world, as well as interaction and the important real-time intervention between the real world and its digital twin.

Today it is well understood that the digital twin in the geospatial domain offers important potential especially in building smart cities and in satisfying current societal needs as described, for example, in SDG 11 (sustainable cities and communities). By now, NMCAs in the developed markets are already well equipped to address DT challenges and have realized that the digital twin is the logical next development for the task of national mapping that can satisfy a whole new range of user needs. Still decision makers in the field of land administration need a broad understanding of emerging issues and developments that are expected to shape the future of the sector. To this end UNECE recently shared scenarios for future land administration and land management solutions, based on the relative importance and anticipated impacts of global megatrends and drivers specifically related to the sector (UNECE, 2021).

In the next sections the current state of the art of the use of digital cadastral information is further explored by providing examples from (a) developed property markets with examples from the Netherlands and Italy, and (b) informal markets.

2 Geospatial information in property markets – use cases in the Netherlands

As mentioned earlier, a mature and well-developed LAM system enables applications beyond the traditional role of cadastres (tax, tenure security etc.). The land administration domain model (LADM) (Van Oosterom et al., 2013) provides a strong basis to map the people – land relationships and capture these into a digital 2D or 3D cadastral sys-

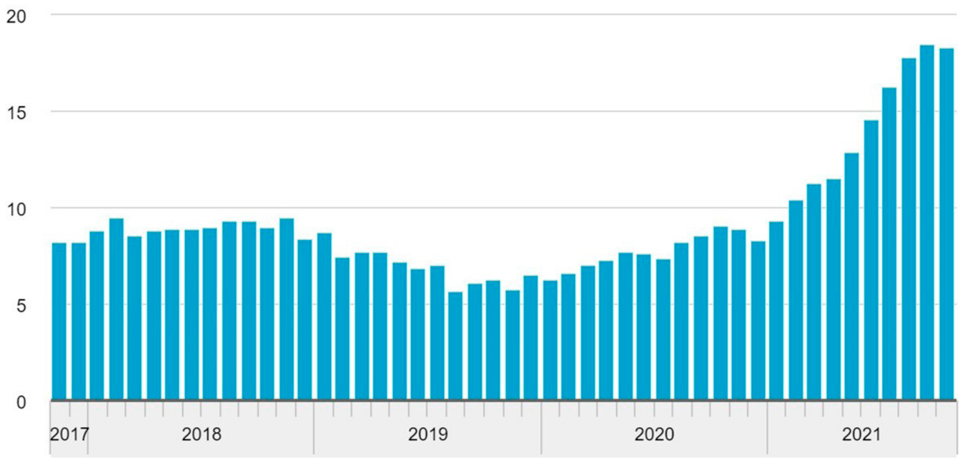


Figure 3: *Price increases (in %) compared to a year earlier of owner-occupied houses in the Netherlands.*
(Source: CBS, Kadaster, https://www.cbs.nl/nl-nl/nieuws/2021/47/prijsstijging-koopwoningen-ruim-18-procent-in-oktober)

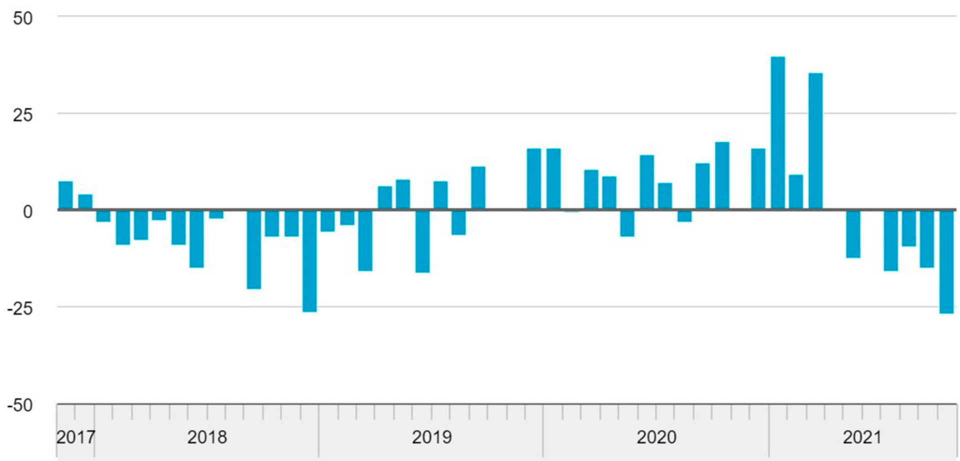


Figure 4: *Change in the number of transactions (in %) compared to a year earlier of owner-occupied houses in the Netherlands.*
(Source: CBS, Kadaster, https://www.cbs.nl/nl-nl/nieuws/2021/47/prijsstijging-koopwoningen-ruim-18-procent-in-oktober)

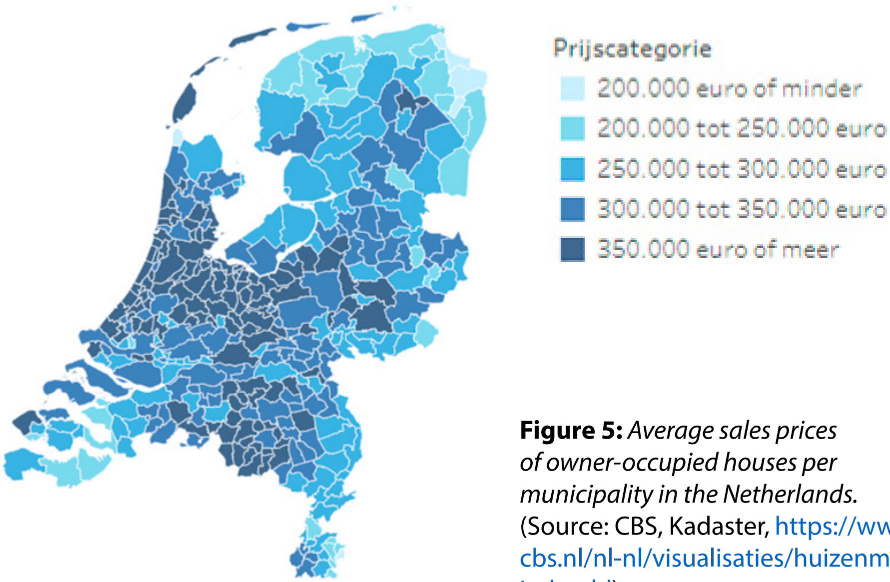


Figure 5: *Average sales prices of owner-occupied houses per municipality in the Netherlands.* (Source: CBS, Kadaster, https://www.cbs.nl/nl-nl/visualisaties/huizenmarkt-in-beeld)

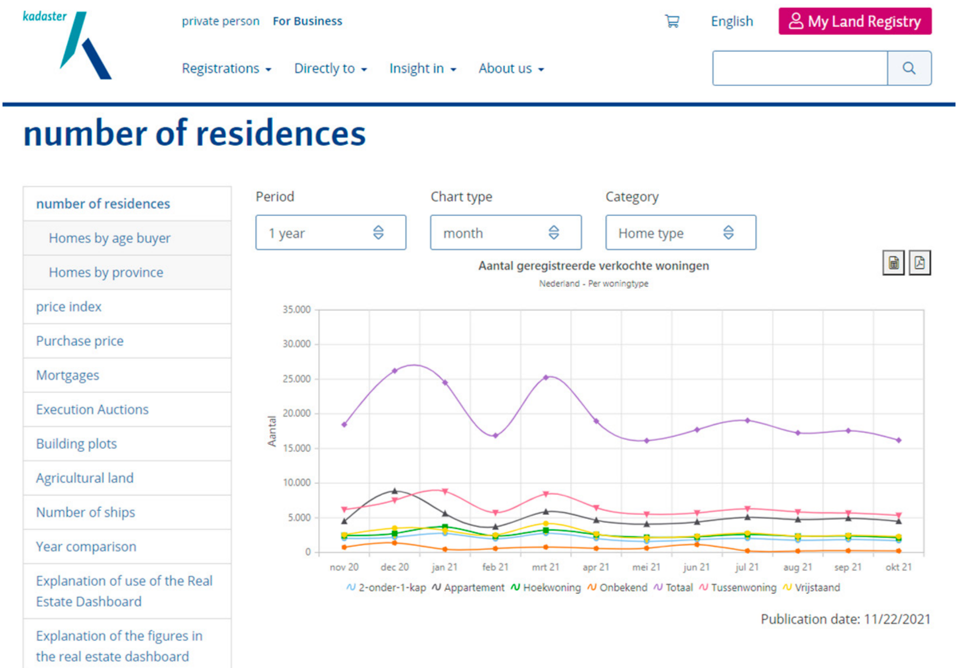


Figure 6: *Dashboard of the Dutch cadastre, land registry and mapping agency with access to various bits of information about the real estate and land market, such as the number of transactions per housing type.*
(Source: https://www.kadaster.nl/zakelijk/vastgoedinformatie/vastgoedcijfers/vastgoeddashboard/aantal-woningen)

tem. Having information digitally available enhances possibilities for both monitoring and making in-depth analyses of property markets. Combining geospatial and legal information enables advanced geographical analyses by creating maps to visualize the information both geographically and/or statistically (see Figures 3, 4, 5, and 6).

It becomes possible to perform extensive analyses – whether administrative or spatial – and to combine it with other data through capturing cadastral information in advanced digital GIS or Land Administration Systems (LAS). How these analyses can be conducted depends on the property market itself, on how the data are unlocked and on which tools are used.

In property markets, information about the characteristics of either buildings or land is relevant. Information about the characteristics of buildings, for example, relate to available floor space (m^2), volume (m^3), allowed use, height restrictions, state of repair. Similarly, information about parcels such as location, access, size, and soil type are required. Some of this information may be part of the cadastres whereas in other locations some information is captured in other data sets such as the census or trade register, topographical map, soil map, land use map etc. Deciding on what information is relevant to capture also depends on the land and real estate markets. For example, a social housing rental policy aims to provide housing to the less well-off. This part of the housing stock is often not for sale on the property market. It pays off to register such information to make it possible for users to select meaningful indicators and the right data. In this example perhaps leave the social housing stock out of the figures to interpret developments on the housing market.

Web Map Service (WMS), Web Map Tile Service (WMTS), and Web Feature Service (WFS) services cater to different use cases than download services do. In countries that have developed a national spatial data infrastructure (NSDI), the cadastral data set is often part of this infrastructure. Publishing this information on a public platform allows third parties to include these data in their own products, which creates added value. Figure 7 shows the viewer of the Dutch national geodata platform (see www.pdok.nl/viewer) with the cadastral map, building and address information, and some basic topography.

Figure 7: *The viewer of the Dutch national geodata platform.*

The platform (see www.pdok.nl/datasets) also holds an overview of available data sets and services for dissemination (download, WMS, WCS, WMTS, WFS etc.).

However technical tools alone do not determine the role of cadastre in property markets; the legal framework determines which data and how these data can be used. In Germany for example, people must demonstrate a relevant interest, such as property purchase, before they are granted access to the cadastral information. Important legal issues are the right to access information and the right to privacy. Legal rules and regulations between the two are sometimes contradictory. Balancing both aspects of privacy and access can be difficult, especially in the case of spatial information.

Advanced digital cadastres provide information on land and property transactions. Cadastres can have multiple roles in developed land and property markets; its information can support:

- Registration of transactions and/or titles
- Securing land rights
- Monitoring land and real estate markets (statistics and spatial differences)

Development of the cadastre in the Netherlands

The Dutch cadastre, land registry and mapping agency (www.kadaster.nl) has developed over time towards a multipurpose cadastre. Introduced by Napoleon in 1832 to levy property tax, the cadastre nowadays has taken a central role in real estate and land markets by providing related information and securing land rights. Apart from this role, the cadastre is responsible for producing and updating the national topographical map (scale 1:10.000 up to 1:100.000), cadastral map, and the national geodetic reference framework. Both the cadastral and topographical data sets are part of the national geodata infrastructure (system of key registers). The cadastral data set can be subdivided into the cadastral map and information about the land and property rights. Additionally, the cadastre also plays a central role in the spatial data infrastructure as service provider by delivering services to distribute datasets from other governmental agencies. The national data platform for geodata (www.pdok.nl) is maintained by the Dutch Kadaster, commissioned by a consortium of (governmental) geo-partners. Specific services, e.g., WMS and WFS, also have been developed to open up other geodata sets that are part of the national spatial infrastructure. Other governmental agencies are then responsible for the data itself.

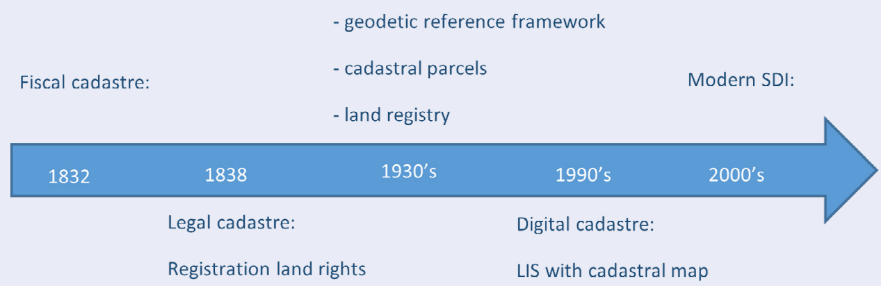


Figure 8: *Overview of historical development of Dutch cadastre.*

– Provide in-depth spatial and statistical analyses about functioning of land and real estate markets

– Policies, e.g., land policy and its implementation, land use planning etc.

It is possible to monitor the land and real estate market by combining data about sales prices with information about the sold/bought properties, and about the buyers and sellers.

3 The effectiveness of developed land administration and management systems and geospatial information in property markets – the case in Italy

In addition to the census data relating to land and buildings, a considerable amount of information concerning the territory is connected to the computerized systems of the advanced digital cadastres.

In fact, through the Cadastre it will be possible to consult the distinct territorial information existing in the various sectoral platforms and concerning the whole country. This can occur in countries with a high degree of digitized and, in particular in Europe, also due to the advanced state of implementation of the so-called INSPIRE Directive (acronym for Infrastructure for Spatial Information in Europe).

This infrastructure contains effective information for implementing, monitoring and evaluating community policies at various levels and for providing information to citizens. As can be seen in Figure 9 below, GIS allows to stratify the territorial information and to overlap them for comparison.

The methodology of INSPIRE allows direct interconnection and makes available a greater amount of higher quality data. Although the directive focuses in particular on environmental policies, it is already extended to other sectors such as agriculture, transport

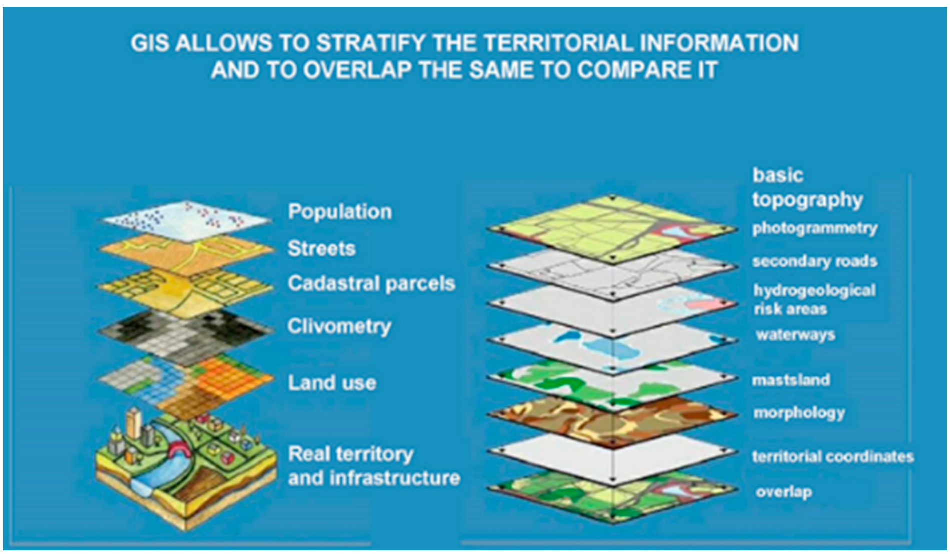


Figure 9: *Sample of GIS.*

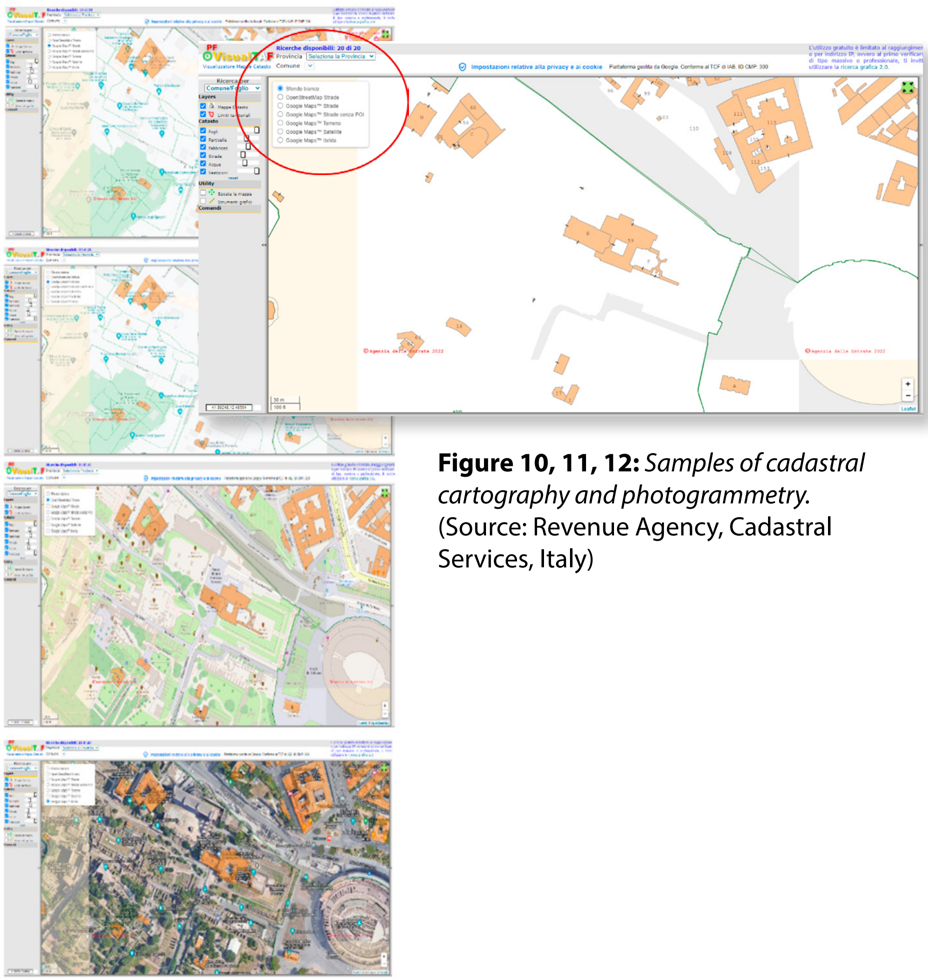


Figure 10, 11, 12: *Samples of cadastral cartography and photogrammetry.* (Source: Revenue Agency, Cadastral Services, Italy) and energy. This extension makes the global values of protection in the environmental sphere more concrete. The territory as a landscape and a place of social life, has shaped the cultural identity of the people to consider themselves no longer as individuals but as whole communities with the right to a good quality of life. From these considerations arises the need and the duty of each country to safeguard not only the harmony of the landscape forms, in relation to things and places with conspicuous characters of beauty, but the whole territory through general regulation and its use.

Therefore, the infrastructure, in order to be connected to the territory at this level of detail, cannot ignore the cadastral references. Consequently, through cadastral references, geographic data, metadata and services are made available: coordinate systems, geographic grid systems, geographic names (toponyms), administrative units, addresses, real estate properties, transport networks, hydrography, plano-altimetric plan, land use, thematic maps of geological risk, architectural or landscape constraints, etc.

In this way we benefit from a truly substantial information database linked to cadastral information. In Italy this database is mainly managed by the Revenue Agency and it contains information for over 74 million urban properties and 60 million rural properties.[6]

This great resource, named the Territorial Information System (SIT) ensures that with a few clicks, it is possible for anyone in Italy to access various databases: land registry, aerial images of the area and silhouettes of real estate units registered and not registered. Furthermore, it is possible to select, for example, the units with a certain number of rooms, with a higher yield or to make comparisons between average soil classifications and cadastral classifications of a single building and prevalent general classification in a certain area.

The system operates through "layers" that can activate or deactivate and that allow viewing the most relevant information in the most functional way for the user. An example of some of the layers that are available are:

- Census data;
- Information from the Real Estate Market Observatory;
- Cadastral cartography;
- Road markings;
- Water courses;
- High resolution ortho- photos, etc.

The information that is managed in Italy with GIS concerns territorial and geographic data, demography, the average level of citizen education, housing densification, income statistics, propensity to spend and orientation towards consumption, the income-producing company, the quality and diffusion of infrastructures, etc. This information can be integrated and be comparable to all that available from public administration to support the good governance of the territory. The data contained within the platform, in fact, can be found and used not only by public administrations but also by anyone with a legitimate interest. This will not only allow for carrying out institutional tasks, but also for integration of the data with further information to support territorial and en-

6 Data, images and description taken from documents published by the Revenue Agency, Cadastral Services, Italy.

vironmental policies. The practical advantages offered by such a sophisticated system respond to a wide range of interests. This integrated geo-information is strategic for economic, political and geographical purposes.

Over the last thirty years, market globalization and free enterprise have had a stimulating role for economic growth in industrialized and almost all developing countries. In this period, in fact, the commercial distribution system was able to expand and evolve in ways that are often not easily controllable.

As was discussed at the beginning of this chapter, the general economic crisis, which currently still affects Europe and much of the Western world, is reflected in all economic and productive sectors and in particular in that of financial investment, which has recently become inconsistent.

As a result of the sometimes uncontrollable commercial distribution and economic crises, real estate has once again become a solid safe haven for investors. In Italy, as in many countries, the availability of certain rights and the free circulation of goods is based on the possibility of transactions through acts of private negotiation. Contracts that transfer the ownership of a specific thing or transfer a real right or other right come into effect with the simple consent of the parties, legitimately expressed and therefore regardless of the transfer of possession. This circumstance could give rise to an apparent situation that does not correspond to the actual legal situation. The dynamics of the sale (supply and demand) is based on forecasts of concrete and reliable information on the potential market, obtained through the use of GIS. The public registers ensure a control system suitable for guaranteeing the certainty of the transfer of ownership from one subject to another and the protection of the rights of the parties through the formal maintenance, in chronological order, of the signed documents (contracts, information on contractors and data description of the goods)

Cadastral data and real estate advertising data constitute the integrated real estate registry (which is included in the GIS layers) that can allow for checking of the consistency of the GIS data. By "real estate advertising" we mean the certified conservation of contracts and the possibility of knowing the information regarding the transfer of real estate properties.

The SIT can also be connected to the Register of Owners (ADT), the database containing the archive of the holders of real rights on the properties that allow the correct identification of the owners of properties through the deedscsearch option. From these deeds, the headings in land registry originate, allowing comparison with the relevant registers: real estate advertising; business Register; register of the identity of persons. These are all linked through the SIT.

The union of SIT and ADT represents an evolution in the current land administration system which aims to become the new National Property Catalog in Italy. Properties will then have a unique, up-to-date and fully digitized identity card.

In this context, knowledge of land and property transactions in relation to cadastral data may have multiple roles in developed land markets as well as real estate markets recently characterized by a situation of severe financial instability and chaos.

In fact, in the last two years, first the Covid-19 pandemic and more recently the armed conflict in Ukraine and the sanctions on Russia have upset the people of Italy's way of life and will have heavy economic consequences for Europe and for the whole world.

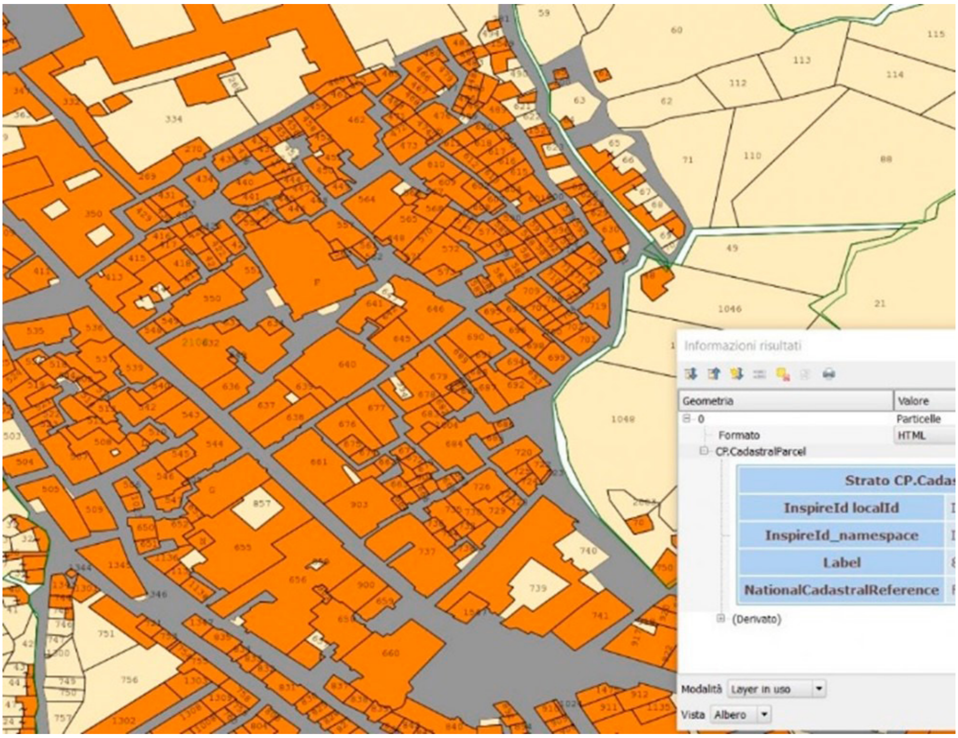


Figure 13: *Sample of Cadastral Cartography.*
(Source: Revenue Agency, Cadastral Services, Italy)

To date, no references are available to assess what are the short-term and long-term scenarios that may have repercussions on the real estate market as a consequence of this difficult time. Because Real Estate responds to market logics based on medium-long term cycles, it is therefore difficult to see an impact in the short term. On the real estate market, the consequences of what is happening are presumed to be lower than in many other sectors that will probably go through a period of immediate crisis, such as the energy-intensive one but also that of food supply or tourism.

In this context though, it is appropriate to ask specifically what the consequences will be for the real estate market and whether the "brick" can still be a safe investment in such an uncertain scenario due to the discontinuity and uncertainty of stable reference property values. When the market is characterized by widespread disorientation, serious limitations of the algorithms that produce automatic evaluations emerge. The reliability of the reference data collapses and data quickly become obsolete. Particularly in these situations, in order to be suitable for obtaining the consistent result with the definition of its meaning, valuation consists in seeking the value starting from concrete evidence and at the same time identifying the market phenomena that can have a lasting impact on this value. The real-time availability of data concerning the transfer of real estate rights, linked to the possibility of using updated and efficient information systems, allows for an instant interpretation of the market trend and of all the factors that affect the market value of the properties.

With these prerogatives, it is possible to optimize the tools available, making the real estate market very similar to that of capital which is subject to rapid changes. There-

Figure 14: *Data and images elaborated from documents published by the company Comparabilitalia.it® produced by: Italian Institute of Resources for Economic Development Srl.*

fore, change in the propensity to invest, which could exist from one day to the next, can be promptly considered.

These aforementioned strategic-operational tools, including the real estate database, support professionals and in particular real estate valuers in their professional research, facilitating the retrieval of data and market information necessary for the preparation of a valuation report. In fact, the real estate valuer needs to consult the actual prices of the sales and market information associated with characteristics (comparative data) that can be found quickly and with objective relevance.

SISTER (Sistema InterScambio Territorio) is the Italian web portal with which the Revenue Agency (formerly the Territorial Agency) provides telematic services to citizens, professionals, companies. The "Sister Platform" is an electronic service that aims to simplify the searches, allowing the user to view the data relating to trades registered in a given period, divided by cadastral category and geo located in a specific place. The system allows one to quickly view and easily cross-reference real estate data, based on the cadastral category sought, with those already present in the registry.

With only one reference to the province, municipality, sheet, parcel and subordinate being required for a search in order to obtain all the needed details.

With the Real Estate Price Exchange, the real estate valuer can quickly calculate the average prices of a specific property and instantly generate an editable document in RTF format.

By integrating different tools located in a single graphic interface, it is possible, easily and quickly, to search for the prices of real estate on the market.

With the Real Estate Price Exchange it is possible to quickly identify geo-referenced sales prices and other information connected to it, such as: municipality, address, year of sale, month of sale, transferred share, consistency, cadastral category and Real Estate Market Observatory area.

Figure 15: *Data and images elaborated from documents published by the company Comparabilitalia.it® produced by: Italian Institute of Resources for Economic Development Srl.*

SCHEDA DATI COMPRAVENDITA
[020181/2021]

Latitudine: 45.480781584 N	Longitudine: 9.173104997 E	
Indirizzo: VIA PAOLO LOMAZZO 5	Anno: 2021	Mese: 4
Comune: Milano	Foglio: 309	Mappale: 547
Numero di registro particolare: 020181/2021		
Superficie Commerciale*: 107,47 m²	Prezzo: 440.000 €	
Prezzo medio: 4.094 €/m²		

Consistenza: 9 mq	Categoria: C02	
Settore: PER	Zona OMI: C16	Quota: 100.00%
Superficie stimata: 9,90 m²		

Consistenza: 105 mq	Categoria: A03	
Settore: RES	Zona OMI: C16	Quota: 100.00%
Superficie stimata: 105,00 m²		

Using the territorial information available on the SIT, it is possible to access the documents containing the maps and urban data, the land use, the existence of territorial or landscape constraints, etc. Furthermore, by integrating with the "cadastral map" level, it is possible to simply obtain some fundamental elements such as the number of the parcel and the cadastral sheet of a specific property. Using the results obtained, the real estate valuator uses all the valuation, comparison and calculation data integrating any further useful data into it.

In regard to the economic context, it is certain that those responsible for local administration increasingly assume a leading role in the prevention of negative consequences and the mitigation of market distortions. In fact, through the management of data and activities aimed at fiscal control, in the last fifteen years a beneficial result was bringing out and identifying undeclared or informal buildings that are invisible to the tax authorities. The operation was conducted by the Territory Agency. The goal was to be able to identify, one by one, the so-called "ghost" properties not declared to the tax authorities. The mechanism was apparently simple, even if it required sophisticated technologies. The Italian territory was entirely photographed from above and the digital aerial images, with a very high degree of resolution (capable of recognizing an object on the ground with a margin of error of just 50 centimeters), were superimposed on the cadastral maps. Through an ad hoc software, the "shapes emerging from the ground" not present on the maps were detected using automatic image recognition (a form of machine learning). Those other than buildings (trees, poles, mounds of earth and more) were therefore discarded, and those "buildings" not included on the cadastral maps were identified. At that point, the owners of parcels of land on which the presence

Figure 16: *Sample of so-called "ghost" properties.*
(Source: Revenue Agency, Cadastral Services, Italy)

of a building was detected were identified. The parcels of land on which the informal properties are located were collected in a list, municipality by municipality, and were then used to obtain the cadastral and fiscal regularity.

With this goal, the government used the economic maneuver to accelerate the formalization process of the so-called "ghost" properties, assigning a deadline for spontaneous registration. The formalization provided for the payment of technical expenses to professionals and the formalization of the taxes due for the previous five yea

At the moment over 90% of the buildings have been formalized. The "ghost houses" operation revealed over 1.2 million real estate units not known to the Land Registry, 2/3 of those units were declared by the owners within the deadline. The tax authorities have attributed a presumed cadastral value to the others.

Socio-economic considerations deriving from the analysis of the real estate market

Observing the aggregate data obtainable from the SIT system, it is highlighted that the concentration of purchases in certain geographical areas and the large overlapping of offers of similar properties constitutes a competitive factor that does not always guarantee a profitable investment for companies. Above all, it does not represent the prerequisite of quality and convenience for consumers[7].

Furthermore, the economic flows deriving from unweighted initiatives, in the absence of regulated and sustainable market spaces, have consequences for the social situation both regionaly and globaly. For example migratory movements, possible increases or losses in the functionality of existing social structures, new behavioral models, changes in social use of places, etc… There are also socio-economic impacts, for example changes in communication and transport flows, high costs of services, changes in the values of commercial areas, infrastructural costs and costs of their modifications, etc.

The coordination and aggregation of information, monitored through GIS, makes it possible to outline a study on investment propensities and to draw useful considerations for testing support interventions. These interventions are to be implemented through government action, in order to direct development and prevent the marginalization of the less interesting territories from a speculative point of view. In this context, those who govern the territory can refer to symptomatic indicators to evaluate the negative consequences of interventions and the remedies for mitigation of market distortions.

The socio-economic study of which the summary is presented consists of a research platform on the orientation of commercial and real estate investment choices. The information-gathering phase, based on the processing of concretely available and reliable data compared with each other, was obtained through the use of GIS.

Outlining an appropriately precise picture might have seemed difficult and perhaps of little use considering the rapid transformation process to which some basic information is subject.

The result of the research, however, provides a fairly accurate picture (Fig. 17). The research highlights the parts of the territory that present, respectively, potential for sustainable development and non-convenient investment to understand the advantages and disadvantages of each productive investment in relation to the coexistence of dif-

7 Graphs and considerations taken from the text "Abruzzo 2020" – Department of Architecture – University "G. d'Annunzio" Chieti – Pescara – Prof. Roberto Mascarucci (coordinator).

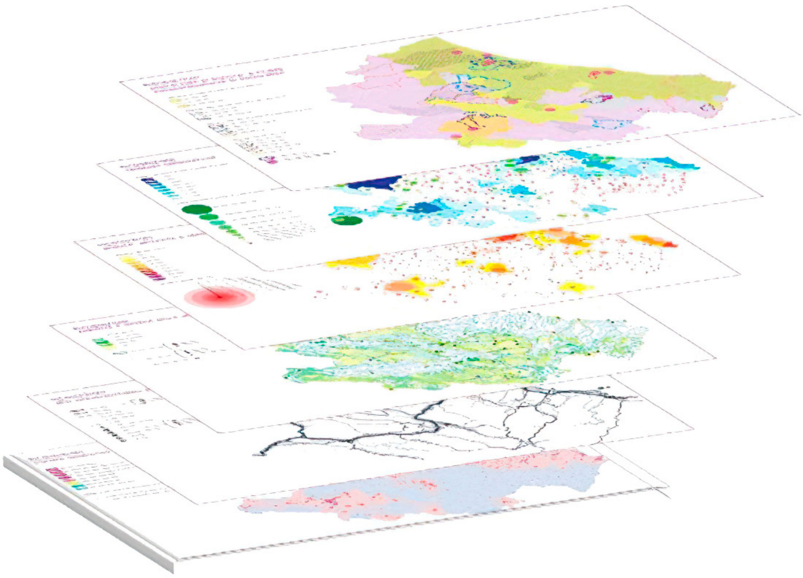


Figure 17.
(Source: "Abruzzo 2020" – Department o f Architecture – University "G. d'Annunzio" Chieti – Pescara)

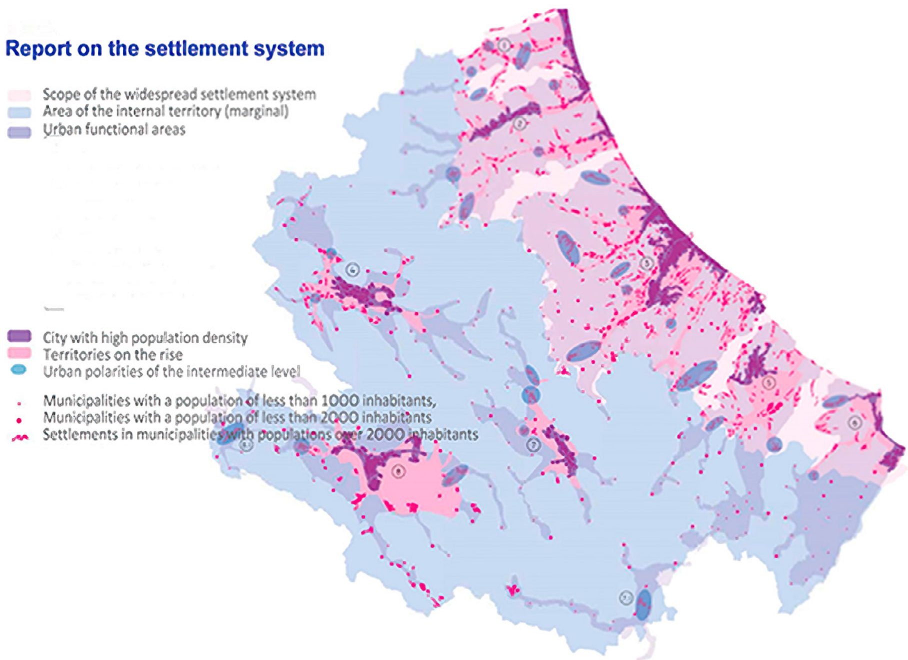


Figure 18.
(Source: "Abruzzo 2020" – Department of Architecture – University "G. d'Annunzio" Chieti – Pescara)

ferent market levels. The different levels being in the center and in the suburbs of the cities and the large concentration towards increasingly expanding areas to the detriment of others that become increasingly marginal.

The management of GIS is also a tool for the design and implementation of policies to balance territorial development, taking into account the interests of consumers as a necessary component of the economic well-being of the territory and a primary factor in the profitability of investments.

The research produced the following reflections:

- Investment planning based on consumer concentration is not always convenient, even in relation to the subsequent concentration of competition and high market supply;
- The demographic shift towards the "islands" of economic ease creates imbalances between metropolitan areas (with an ever-higher concentration of inhabitants) and suburban areas which become increasingly marginal and sparsely populated;
- The loss of importance of the historical centers to the advantage of the economic centers constitutes a danger to cultural heritage and for loss of economic well-being;
- Available and comparative spatial information:
  - are very useful for determining the market value of properties;
  - are an important indicator of the socio-economic factors of the area;
  - should be used in the best possible way, as a reference point to trigger the appropriate development or rebalancing mechanisms in favor of economically marginal areas.

4 *The "effectiveness divide" between the developed and less developed LAMs in the European region and the impact on property markets*

As mentioned earlier developed LAM systems have managed to increase the value of information for all people, especially the urban population, in order to get more growth and efficiency in governance. As the UNECE countries are home to the wealthiest part of the global population, one would expect that tenure insecurity would not be an issue in this region. However, recent research proves this is not the case (Nyzalov et al, 2022). Over 13 per cent of the UNECE adult population feel insecure about their land and housing property — more than 130 million people. This recent research shows that average rates of perceived tenure security vary among the UNECE sub-regions, with people in the EU and North America feeling more secure about their property rights than people in the Commonwealth of Independent States (CIS) or other ECE countries; the highest share of secure tenure positive reports are from Austria, Denmark, Finland and Sweden.

International research compiled since 2007 uncovered that the weak effectiveness of land administration and management systems – along with several other reasons such as population migration and rapid urbanization, disasters, conflicts, poverty, inefficient land policy & resistance to change, weaknesses of the private sector, overregulation and the lack of affordable or social housing policy – have led to a significant amount of informal development and consequently to informal markets. It was estimated that the phenomenon affected about 70–90% of new construction in many economies in transition (Potsiou, 2010; 2015) and about 50 million people, or more, within UNECE countries (Tsenkova et al., 2009).

Such constructions included squatting on private and state land with both legal and technical informality such as unclear or no titles, excess of construction and/or planning permits or a lack of permits for construction and occupancy. They included a great variety of constructions from single dwellings to multi-floor apartment buildings, retail, industrial, office or special purpose buildings; the majority were permanent constructions of fair quality but were considered illegal and therefore were not registered into the LAMs. Most were not taxed, could not be transferred, inherited, rented or mortgaged, and represented "unproductive", "dead" capital and "missing geospatial information". Such settlements had multiple social, economic and environmental impacts, including high risks to natural disasters floodings, earthquakes, air, soil and water pollution, no waste management, etc. Ineffective policies and high costs usually give significant incentives to build and work "under the radar". Informality in the real estate sector is directly related to a general informal sector, where both real estate properties and residents may lack legal documentation and remain unregistered, living and working informally, depending on a daily income, while enabling the economy to operate for the rest of the urban citizenry. This is a prominent characteristic of the so-called frontier markets; it may also exist in developed economies but its extent and consequently its impacts are less significant. Informal labour usually is not well paid and workers lack the privileges of the formal labour systems.

To improve effectiveness of LAMs and thus support national economies and property markets, countries that faced this phenomenon were encouraged to initiate formalization projects to legalize and register as many as possible informal constructions into the LAMs for integration into the economic cycle.

By 2015 it was assessed that several LAM projects, including formalization, were slow, expensive and not sustainable. Many of the denationalization projects – the restitution of property rights, the privatization of lands and the property registration – faced serious challenges that included overlapping of projects and redundant responsibilities of the authorities who run the projects, especially in the contact zones (e.g., between rural and urban areas several parcels were repeatedly privatized). Long delays were experienced and large areas of land were exempted from these projects. The poor effectiveness of the newly established LAM systems also included delays in land registration; confusion among cooperative, state, public, municipal and private rights; incomplete records as well as poor coverage; high fees and charges, very slow bureaucratic planning and construction permitting; poor valuation and inefficient taxation; lack of housing policy; congested courts; limited access to information; fragmentation of both land and buildings as well as of ownership on land or building (e.g., small parcels or constructions belonged to large numbers of owners-heirs which made the management of land and/or construction a complex and difficult task); and serious constitutional development restrictions on certain types of land. There was also significant weakness detected in the private sector e.g., those professionals involved in real estate markets (local developers, planners, valuers, etc.). Informality issues caused problems in rural areas, as well, where farmers had no access to World Bank loans, for instance, due to unregistered, informal rights. In many areas, transactions, too, were challenged as conveyancing had to be done by courts. All the above led to poor or frontier property markets where personal relations matter more than rules and regulations.

Formalization policies adopted often lacked concrete strategy; formalization was a long lasting, bureaucratic and expensive procedure that required compliance with existing laws and regulations prior to registration, or may have started with the best of intentions but became bogged down due to administrative bottlenecks or change of government. Governments often understood the problem but did not fully realize the size of its impacts or were not willing to understand (Potsiou, 2015). The need for UNECE Guidelines for Formalization was then obvious. In 2019 such guidelines were compiled and published (Potsiou et al., 2019) and provided information on how to structure a fit-for-purpose formalization project; how to create a strategy and achieve political support; how to decide what can be formalized, to classify informalities, determine the level of inspections, fees and charges; how to develop the legal framework to create individual marketable and bankable property units while registering them into the LAMs; how to monitor progress and be ready to act for necessary amendments; and finally how to improve the land management system in order to eliminate the phenomenon of informality in the future while building sustainable property markets (Fig 19).

The overall guide for formalization of informal constructions is based on the concept that such constructions may become commodities once formalized and registered, meaning that they may be mortgaged allowing access to credit which can provide funds for construction improvements and a large number of other activities e.g., for disaster recovery works, education, health, and business.

Titling and registration should be timely and low cost, not legally bound with planning requirements.

Post-formalization or parallel improvements and service-provision may be needed depending on the settlement. However, there is no "one size fits all" general rule for improvement provision; improvements can be initiated and funded by inhabitants in partnership with national and/or local authorities, private sector and donors. Therefore, it is important to build awareness of how to establish such partnerships.

Future reforms may also include consolidation of parcels, reconstruction and land readjustment projects to include density in the self-made, horizontally-spread cities; requiring broad public awareness, acceptance and trust in government. To achieve this, governments must invest time and effort in building community engagement and must be willing to act to secure ownership rights prior to future reforms. Security of ownership rights is a social issue, fundamental to the well-being of occupants. A country without an inclusive formal system for registering property rights limits its own economic development and prevents its citizens from realizing their full economic potential.

By the time the UNECE guidelines were published in 2019, few countries had reported significant progress within the 4 years of implementation of the SDGs globally. In the following years, many projects, including formalization and property registration, faced significant additional delays due to the Covid-19 situation. The "effectiveness divide" became larger. A "new poor" class of people was created, including mainly the self-employed. COVID-19 had a higher, "localized" concentration among informal settlement residents where people are not prepared, basic infrastructures are poor, and where there is a significant lack of reliable geo-referenced data. In addition, residents of informal settlements provide much of the unskilled service support to nearby urban economies and the virus was spread in both directions. The need for UNECE to take ac-

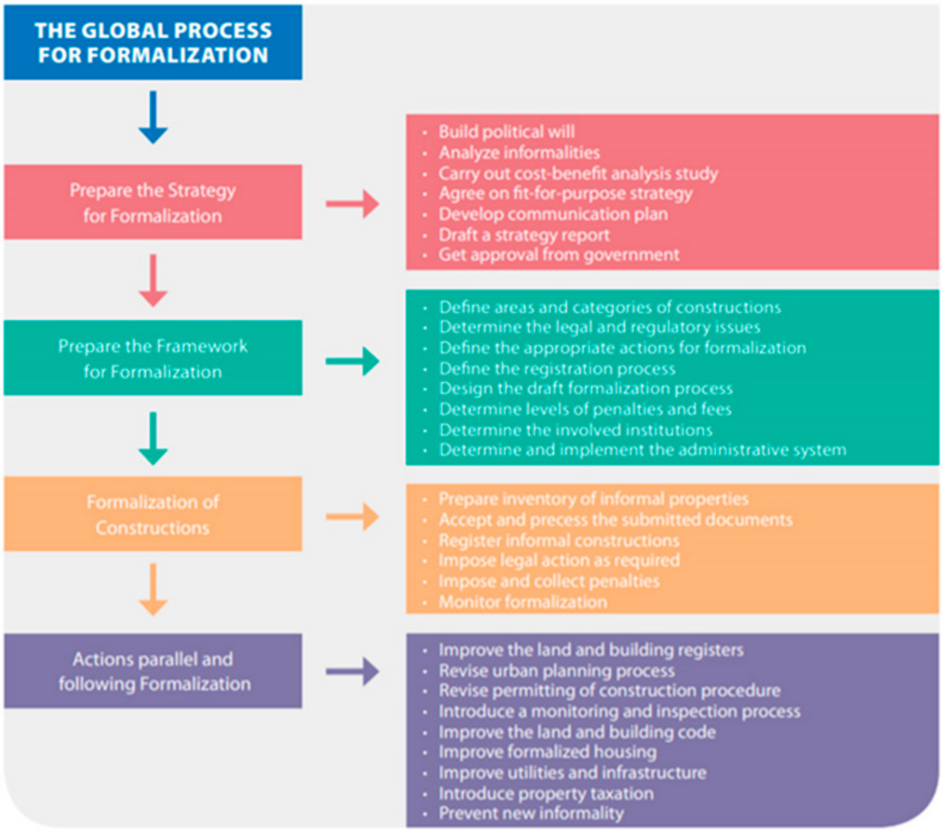


Figure 19: *The structure of UNECE Guidelines for Formalization of Informal Constructions.* (Source: Potsiou et al, 2019)

tion was obvious again. Advanced LAM systems were successful in assisting the economy during the Covid-19 pandemic. They supported the world's rapid "digital transformation" in 2020–21. It was then that the Hellenic Cadastral Agency was transferred into the responsibility of the Ministry of Digital Governance. The agencies provided reliable and affordable geospatial and demographic data in a timely manner in management of the pandemic. But in the countries with a large percentage of informal and unregistered constructions and rights, with less effective LAM systems, there is a significant lack of geospatial data that inhibits good decision-making.

How countries prepare for future disasters is vital. Therefore, UNECE has compiled and published in May 2022, the Post Covid-19 Recovery Action Plan for Informal Settlements in the UNECE region (Nystrom et al, 2022). This publication summarizes the experience gained during the Covid-19 pandemic and is structured in nine policy areas including geospatial data, formalization of rights and constructions and property registration; community engagement; telecommunication and information technology; physical infrastructure improvement; social services; pandemic measures and cultural issues; food and basic consumption and distribution during a pandemic; environmental concerns, green areas, recreation; and building, construction and planning. Each policy area has one main goal, under each goal are targets and under each target are actions to be taken.

There is a global growing need for real-time maps, and location information to track and share location data. A geospatial-enabled platform, along with data analytics tools and solutions play critical role in assisting the risk reduction management of dense urban areas. Internationally, in less well-organized urban areas over a billion people lack security of property rights for land and housing, and fear losing the right to use their land or property. It is anticipated that experience built within UNECE both in formalization of informal constructions and in building back better informal settlements in the post Covid-19 era will be of value for other regions, too, as it has happened in the past.

Unfortunately, as the world is recovering from the pandemic a tragic war has exploded in the UNECE region involving two countries with large populations. The question still remains relevant: will the "effectiveness divide" among LAM systems within the UNECE region increase? And what will be the war impact on the global economy, property markets and the SDGs? It is broadly recognized that we must continue strengthening the capacity of national and local governments to address the needs of the most vulnerable population groups living in informal settlements. This would enhance the socio-economic recovery following the pandemic and the war and will contribute to urban resilience in our cities and countries.

References

Apostolopoulos, K., Potsiou, C. (2021) "Consideration on how to introduce Gamification tools to enhance Citizen Engagement in Crowdsourced Cadastral Surveys" Survey Review, https://doi.org/10.1080/00396265.2021.1888027.

Cetl, V., Ioannidis, C., Dalyot, S., Doytsher, Y., Felus, Y., Haklay, M., Mueller, H., Potsiou, C., Rispoli, E. & Siriba, D. (2019). New Trends in Geospatial Information: The Land Surveyors Role in the Era of Crowdsourcing and VGI. FIG Publication No 73. ISBN 978-87-92853-86-8. https://www.fig.net/resources/publications/figpub/pub73/figpub73.asp.

Ellul, C., Noardo, F., Harrie, L. & Stoter, J. (2020). The EuroSDR GeoBIM Project-Developing Case Studies for the Use of GeoBIM in Practice, The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, 44, 33–40. https://doi.org/10.5194/isprs-archives-XLIV-4-W1-2020-33-2020.

Enemark, S. (2006). Understanding the Land Management Paradigm. FIG Commission 7 Symposium on Innovative Technologies for Landadministration, Madison, Wisconsin, USA.

Enemark, S., Williamson, I. & Wallace, J. (2005). Building modern land administration systems in developed economies. Journal of Spatial Science, 50(2), 51–68.

Enemark, S., Bell, K. C., Lemmen, C. & McLaren, R. (2014). Fit-for-purpose land administration. Joint FIG / WORLD BANK publication, 39 p. https://www.fig.net/resources/publications/figpub/pub60/Figpub60.pdf.

Enemark, S., McLaren, R. & Lemmen, C. (2016). Fit-for-purpose land administration: Guiding principles for country implementation. UN-Habitat, HS/033/16E, Nairobi 00100, Kenya.

Enemark, S., McLaren, R. & Lemmen, C. (2021). Fit-for-Purpose Land Administration—Providing Secure Land Rights at Scale, Land 10, no. 9: 972. https://doi.org/10.3390/land10090972.

FAO (2012). Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security (VGGT). Publication of the Food and Agriculture Organization of the United Nations, ISBN 978-92-5-107277-6, 48 p. http://www.fao.org/nr/tenure/voluntary-guidelines/en/.

Gkeli, M., Potsiou, C. & Ioannidis, C., (2019). Crowdsourced 3D cadastral surveys: looking towards the next 10 years. Journal of Geographical Systems, 21(1), pp. 61–87.

Gkeli, M., Potsiou, C. & Ioannidis, C. (2020). A technical solution for 3D crowdsourced cadastral surveys. Land Use Policy, 2020, 98, 104419.

Grab, A. (2003). Napoleon and the Transformation of Europe. Macmillan International Higher Education.

Mourafetis, G. & Potsiou, C. (2020). IT services and crowdsourcing in support of the Hellenic Cadastre: advanced citizen participation and crowdsourcing in the official property registration process. ISPRS International journal of geo-information 9 (4), 190.

National Research Council (US)- Panel on a Multipurpose Cadastre. (1983). Procedures and standards for a multipurpose cadastre. National Academies Press.

Nystrom, S., Potsiou, C. & Wouters, R. (2022). COVID-19 Recovery Action Plan for Informal Settlements in the ECE Region. United Nations Publications, ECE/HBP/214, eISBN 978-92-1-001356-7, 47 p., https://unece.org/sites/default/files/2022-05/COVID-19%20RAP_E.pdf.

Nizalov, D., Tan, E., Potsiou, C., Langdown, I., Childress, M. & Locke, A. (2022). Sustainable Development and Security of Property Rights in the UNECE Region. UNECE publication, 44 p. https://unece.org/sites/default/files/2022-05/Prindex%20ECE%20web%20E.pdf.

Potsiou, C. (2010). Informal Urban Development in Europe – Experiences from Albania and Greece. Summary version, UN-Habitat publication, ISBN 978-92-1-132266-8.

Potsiou, C. (2015). Formalizing the informal: Challenges and opportunities of informal settlements in South-East Europe. United Nations & FIG publication, ISBN 978-87-92853-31-8. https://www.unece.org/fileadmin/DAM/hlm/documents/Publications.

Potsiou, C., Nystrom, S., Wouters, R. & Figueiredo, A. (2019). Guidelines for the formalization of informal constructions. United Nations Economic Commission for Europe, UN Geneva, 55 p., ISBN 978-92-1-117234-8. https://unece.org/DAM/hlm/documents/Publications/Technical_guidelines_informal_settlements.EN.pdf.

Potsiou, C.; Paunescu, C.; Ioannidis, C.; Apostolopoulos, K.; Nache, F. (2020). Reliable 2D Crowdsourced Cadastral Surveys: Case Studies from Greece and Romania. ISPRS Int. J. Geo-Inf. 2020, 9, 89. https://doi.org/10.3390/ijgi9020089.

Rajabifard, A., Atazadeh, B. & Kalantari, M. (2019). BIM and Urban Land Administration. CRC Press, 235 p.

Tsenkova, S., Potsiou, C. & Badyina, A. (2009). Self-made Cities: In Search of Sustainable Solutions for Informal Settlements in the United Nations Economic Commission for Europe Region. United Nations Publications, ISBN 978-92-1-117005-4, 139 p.

UNECE (2005). Land Administration in the UNECE Region Development Trends and main principles. United Nations publications, 112 p. http://www.unece.org/fileadmin/DAM/env/documents/2005/wpla/ECE-HBP-140-e.pdf.

UNECE (2010). Policy framework for sustainable real estate markets. UN publications, 34 p. https://unece.org/DAM/hlm/documents/Publications/policy.framework.e.pdf.

UNECE (2019). Policy Framework for Sustainable Real Estate Markets. UN publications, 42 p. https://unece.org/DAM/hlm/documents/Publications/2019_Policy_Framework_for_Sustainable_Real_Estate_Markets.pdf.

UNECE (2021). Scenario Study on Future Land Administration in the UNECE Region. United Nations publication, ECE/HBP/209, eISBN 978-92-1-001120-4, 24 p. https://unece.org/sites/default/files/2021-12/Scenario%20Study_E_0.pdf.

van Oosterom, P., Lemmen, C. & Uitermark, H. (2013). ISO 19152: 2012, land administration domain model published by ISO. *FIG Working Week 2013 in Nigeria–Environment for Sustainability, Abuja, Nigeria, 6–10 May 2013*.

van Oosterom, P. (2018). Best Practices 3D Cadastres. 3D Cadastre Joint Working Group Commission 3 and Commission 7, FIG Publication No 72, ISBN 978-87-92853-84-4, 71 p. https://www.fig.net/resources/publications/figpub/pub72/Figpub72.pdf.

Williamson, I., Enemark, S., Wallace, J., & Rajabifard, A. (2010). Land administration for sustainable development (p. 487). Redlands, CA: ESRI Press Academic.

CHAPTER 7
DISCUSSION AND CONCLUSIONS

GEOSPATIAL INFORMATION IN THE 2020s – PAVING THE WAY TO SUSTAINABILITY?

Markus Schaffert (Germany), Hartmut Müller (Germany)

In recent decades, the idea and concepts of sustainable development have entered into the agendas of governments and companies, and corresponding goals "have become central to the mission of research laboratories and universities worldwide" (Bettencourt & Kaur 2011: 19540). Accordingly, many scientific disciplines today address the topic of "sustainability" from their own perspective while increasingly pursuing inter- and trans-disciplinary approaches. At the same time, studies that come under the umbrella of *sustainability science* (cf. Clark & Harley 2020) and *research on sustainability transitions* or *transformation* (cf. Loorbach et al. 2017) have proliferated. Studies from these sciences are often broad in scope; still, they have their distinct nucleus committed to research on sustainability.

On the one hand, this research has brought forth insights and knowledge that can complement and theoretically underpin the findings from the case studies outlined earlier in this book. On the other hand, sustainability transitions research has been calling for greater attention to spatial realities in recent years. This call for a spatial turn points to ways in which geospatial information can contribute to the development of these sciences. In this context, Levin-Keitel et al. (2018: 1) argue that while the transitions to sustainability are inherently related to space, transition research mainly takes domain-specific approaches (e.g. climate or water), giving space a subordinate role. The more explicit consideration of spatial concepts and realities, however, offers several advantages for research on sustainability transitions. These benefits derive from three conceptual perspectives through which space serves as a *normative concept,* offers *approaches to action* and forms a *semantic bridge* (Levin-Keitel et al. 2018). The gap in research identified by Levin-Keitel et al. has so far been theoretically addressed, without a focus on the implications of data. However, the applications of geospatial data and information presented in this book suggest that this type of data is set to play

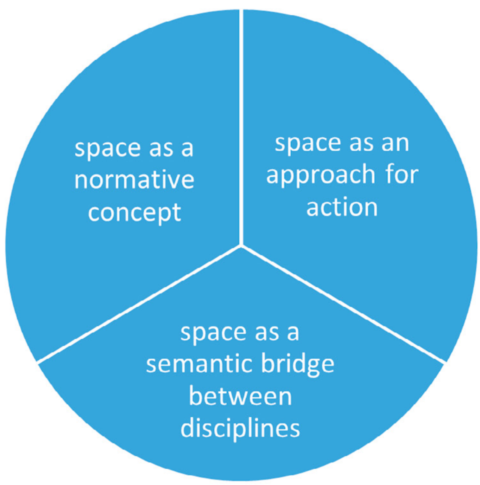


Figure 1: *The three conceptual perspectives of space.*

a central role in the future. We explain this capability in the following sections with regard to the three conceptual perspectives of space.

Space as a *normative concept* specifies how a desired transition to sustainability is proposed to look in a spatial context, for example a city or region. Spatial planning is the discipline in which this concept comes to particular fruition. Here, land use plans or urban simulations are used as instruments that provide a spatially explicit orientation for a desired development. These instruments rely on geospatial data today and might be even more data-driven in the future (cf. Bibri 2021: 33). Louwsma and Şahinkaya Özer (Chapter 2) have shown us earlier in this book how planners can make greater and systematic use of this kind of data. By starting from processes that are established in the application areas, in this case the planning cycle, the intensified use of data by domain experts becomes realistic. This is even more true if relevant data sources can be identified and expected benefits of the intended data usage are explained to the planners and other people involved. Structured data management plans that outline the handling of data and include agreements on roles are one of the tools to support this process effectively (cf. Henzen et. al 2021: 1). Data management plans and collaborative data handling are likely to become even more important in the future to bridge the multifaceted gap between smart buildings and smart spatial planning and make a holistic and scalable digital twin of a city a reality (cf. Herle 2020).

While the benefits of the normative concept of space are particularly evident in spatial planning, normative assessments in a spatial context are not limited to this discipline. A moral notion on how a future development should look like is also evident in other use cases described in this book. Efforts to support those affected by illegal female genital mutilation, for example (Buxton et al., Chapter 5), go hand in hand with the (normative) conviction to end this practice and replace it with new conventions and norms. The same applies to Sharma´s call for greater diversity, inclusivity, and power equality in the geospatial industry (Chapter 4), which presupposes an ideal of society and a will to change societal conventions accordingly. As a data specialist, you may not be involved in decisions about what strategy to pursue for a desirable future, and you probably cannot determine what is considered sustainable in a particular scenario. But when it comes to implementation, it is important to point decision-makers and others to what datasets are needed (and what is missing) to successfully navigate the path to a better future, and how this data has to be processed to extract information from it that can be drawn upon by end-users. In this context, direct dialogue between (geospatial) data scientists and decision makers, planners and the public is advisable and meaningful. For this to happen, however, data scientists must be willing to leave laboratory environments and actively participate in debates relevant to practice and the wider public. This requires a willingness to respect the data criticism and concerns that laypersons might have and to harness them as constructive feedback to improve collaborative learning and mutual research. Such criticism can arise, for example, if the public is familiarized at an early stage with geospatial data innovations that are not yet fully mature – especially in controversial projects, such as the siting of wind farms (cf. Kindsvater & Schaffert 2022).

There are probably as many *approaches to action* as there are disciplines that would benefit from adopting a more explicit spatial perspective. Research on sustainable mobility, to take just one example, could benefit from spatial data by taking the methodology of Angel et al. (Chapter 3) as a starting point for action. This use case have shown how mass data from sensors in urban public spaces reveal dynamic spatial patterns. These were applied here to COVID-related mobility changes of pedestrians. The transferability to other mobility issues, e.g. with regard to carbon-dioxide emissions from different transport vehicles or usage of cycles and alternate transport-means, is obvious. From this, approaches to action for sustainable traffic management could be derived, which a city administration can adopt as part of a smart-city transformation or a transport network operator could improve efficiencies with.

In order to promote the use of spatial data in the sustainability sciences, the data must support the inter- and transdisciplinary work that is standard in these fields. This is where the bridging effect of space comes into play. Space offers a *semantic bridge*, since spatial visualisations such as maps use a language that is universally comprehensible. It helps to establish a common understanding of experts from different disciplines, each with their own technical vocabulary. The same is true when scientists work with stakeholders or the public in the field (Schaffert et al. 2020). Spatial language facilitates, for example, the development of land use plans, where balancing the individual interests of sectoral authorities is essential and public participation may be mandatory. This language can even assist firefighting in Australia, where geospatial information can help firefighters locate usable water sources and aid residents to navigate roads that are still passable for evacuations. It also supports mutual learning in the fight against female genital mutilation in East Africa by reporting the location of aid facilities for those affected and those helping (Buxton et al., Chapter 5). The beneficial interplay of space, data and sustainability becomes particularly evident in the smart city context, where smart concepts for urban challenges are rapidly gaining traction (Köhler et al. 2019: 15). Much of the (big) data used in smart city applications is spatially referenced (Grün 2013: 3) and multiple tools have been developed to extract information from them (e.g. Angel et al., Chapter 3). Technological innovations, however, are a means to a smart city, not an end (Nam & Pardo 2011: 3). Cities and towns are faced with the need to effectively govern their development and overcome challenges with a strong impact on their economy as well as on the health and quality of life of their citizens. In the context of rapid and complex changes, decision makers need smart tools such as ICT-based foresight (Szpilko 2020) or scenario planning approaches (Chakraborty & McMillan 2017) to address such challenges. Rather than being purely technical tools, these are sociotechnical instruments with a strong participatory aspect. Increasing spatial data availability and the capability to process, analyse and visualize this data, makes such instruments more and more efficient. In addition, geovisualization provides "spatial dialogue platforms and opportunities to contextualize and present primary data in an understandable way" (Degbelo 2016: 19). In this way, geospatial information helps bridge the gap between technology, vision, and strategic planning, thereby contributing to inclusive and participatory smart cities, villages, or regions, all of which require more than just technical solutions.

Calls like 'data revolution for sustainability', 'data innovations for the SDGs', 'space for the transition to sustainability' make the inclusion of data, with or without a spatial reference in research on sustainability, seem self-evident. However, there are significant *challenges to overcome* in order to boost the use of data on our journey towards sustainability. The use cases described in this book reveal several issues that should be given full attention, addressing them both scientifically and with knowledge from practice: The *lack of available data* is a key challenge that hinders monitoring the SDGs at the local level (cf. Chen et al. 2020). We have learned from Buxton et al., (Chapter 5) that participatory mapping can fill this data gap to some extent and add local knowledge.

While comprehensive, consistent, reliable, and timely data are critical for measuring progress towards sustainability objectives, data collected by volunteers can easily have quality deficiencies (Medeiros & Holanda 2019).

The integration of more and more datasets, whose quality may be unknown to the end user, adds to this challenge. At the same time, more holistic approaches of information provision are necessary in the face of complex crises and the desire to join pathways towards sustainability. Consequently, Louwsma and Müller (Chapter 2), have pointed out that further (spatial) data, e.g. statistical datasets, should be integrated for monitoring COVID-19 and future pandemics. In this way, for instance, population data could be used to analyse where elderly citizen, as a particularly vulnerable group, reside. In the case of Germany, to give an example, demographic data on municipalities can be taken from the municipal population registers while alternatively census-based data from the state offices can be used. The values of these datasets can differ significantly though (cf. Schaffert & Höcht 2018: 267f.). Against this backdrop, *data quality* can be seen as second key challenge for the use of geospatial data in sustainability sciences. Jaljolie and Dalyot (Chapter 5) show that surveyors are willing to use and share their knowledge to bring data quality into real-world applications and that they draw on ethical standards to do so. When heterogeneous data from different sources are increasingly formalised, as we know it today from land administration and management systems (Potsiou et al., Chapter 6), the threshold to use them on the road to sustainability will lower. Surveyors and spatial data scientists, with their century-long experience in cadastral development and land management, are ready to support this task.

A third key challenge that needs to be addressed in order for geospatial data to contribute to sustainability transformation is *data privacy*. Critical issues, such as privacy "have not been fully addressed in the sustainability discourse, in which the role of digital technologies, and data innovations in particular, have received scant attention so far in analyses of sustainability transformations" (de Albuquerque et al. 2021: 154). By using a big data approach, Angel et al. (Chapter 3) were able to show that the COVID-19 control restrictions had a significant impact on footfall and walking time. Working with many sensors and at the same time combining different sensor types, provides information that can advocate efforts for sustainable transitions. However, the use of big (spatial) data brings the issue of privacy and data protection to the fore. The proper balance between information needs for sustainable development and privacy protection has not yet been found and may need to be determined for each use case individually. Tying in with critical data issues, it also must be discussed who benefits from data circulation. Our ways of sharing data can lead to an unequal distribution of information that disadvantages specific social groups (de Albuquerque et al. 2021: 160). Unbalanced data circulation can also happen in the world of geo-ICT, as Sharma (Chapter 4) noted with regard to map-creators being of a particular small-section of society. This shows that debates that were once initiated by critical GIS scientists (cf. Pavlovskaya 2018) are still relevant in the 2020s, where power inequalities need to be re-addressed in the context of sustainability.

Tayleur and Phalan (2018: 1) believe that "spatial data are key to sustainability", yet this potential "remains largely unrecognized and underdeveloped". However, we believe that addressing and solving the aforementioned challenges is key to realizing the promises of geospatial data and information. To develop ideas on how to overcome these challenges, it will again be important to point out solutions in the context of real-world use cases. Use cases are needed to provide guidance and orientation, for instance with regard to data quality, since a spatial dataset´s quality always has to be assessed in the context of the respective application purpose (ISO 19157). Before indicators for monitoring can be defined and the datasets needed to calculate them, use cases and a clear idea of what is to be measured are needed. After it is clear what is to be analysed and measured, it can then be decided which data (from which period, from where and with which attributes…) are truly required. In this way, one can limit oneself to the necessary information and not hoard unnecessary data, which is preferable from a data privacy perspective.

Against this background, this book presented best practise examples on how to use geospatial data and information in cases relevant for sustainable transition. We hope that it helps and stimulates using, generating and circulating (spatial) data for pathways leading to a more sustainable future.

References

Bettencourt, L. M., & Kaur, J. (2011). Evolution and structure of sustainability science. Proceedings of the National Academy of Sciences, 108(49), 19540–19545.

Bibri, S. E. (2021). A novel model for data-driven smart sustainable cities of the future: the institutional transformations required for balancing and advancing the three goals of sustainability. *Energy Informatics*, 4(1), 1–37.

Herle, S., Becker, R., Wollenberg, R., & Blankenbach, J. (2020). GIM and BIM. PFG–Journal of *Photogrammetry, Remote Sensing and Geoinformation Science*, 88(1), 33–42.

Chakraborty, A., & McMillan, A. (2017). GIS and Scenario Analysis: Tools for Better Urban Planning. In Comprehensive Geographic Information Systems (pp. 371–380). Elsevier.

Chen, J., Peng, S., Chen, H., Zhao, X., Ge, Y., & Li, Z. (2020). A comprehensive measurement of progress toward local SDGs with geospatial information: methodology and lessons learned. *ISPRS International Journal of Geo-Information*, *9*(9), 522.

Clark, W. C., & Harley, A. G. (2020). Sustainability science: Toward a synthesis. *Annual Review of Environment and Resources*, *45*, 331–386.

Degbelo, A., Granell, C., Trilles, S., Bhattacharya, D., Casteleyn, S., & Kray, C. (2016). Opening up smart cities: citizen-centric challenges and opportunities from GIScience. *ISPRS International Journal of Geo-Information*, 5(2), 16.

Grün, A. (2013). SMART Cities: The need for spatial intelligence. *Geo-Spatial Information Science*, *16*(1), 3–6.

Henzen, C., Della Chiesa, S., & Bernard, L. (2021). Recommendations for Future Data Management Plans in Earth System Sciences. *AGILE: GIScience Series*, *2*, 1–7.

International Organization for Standardization. (2013). ISO 19157: 2013 Geographic information-Data quality.

Kindsvater, M.; Schaffert, M. (2022). Mapping tranquil landscapes with social media data. A case study in the context of sustainable transformation, FIG – International Federation of Surveyors, Working Week, Warschau.

Köhler, J., Geels, F. W., Kern, F., Markard, J., Onsongo, E., Wieczorek, A., … & Wells, P. (2019). An agenda for sustainability transitions research: State of the art and future directions. *Environmental innovation and societal transitions*, *31*, 1–32.

Levin-Keitel, M., Mölders, T., Othengrafen, F., Ibendorf, J. (2018). Sustainability Transitions and the Spatial Interface: Developing Conceptual Perspectives. Sustainability 10, 1880.

Loorbach, D., Frantzeskaki, N., & Avelino, F. (2017). Sustainability transitions research: transforming science and practice for societal change. *Annual Review of Environment and Resources*, *42*, 599–626.

Medeiros, G., & Holanda, M. (2019). Solutions for data quality in GIS and VGI: a systematic literature review. In *World Conference on Information Systems and Technologies* (pp. 645–654). Springer, Cham.

Nam, T., Pardo, T.A. (2011). Conceptualizing smart city with dimensions of technology, people, and institutions. In Proceedings of the 12th Annual International Digital Government Research Conference: Digital Government Innovation in Challenging Times, College Park, MD, USA: 282–291.

Pavlovskaya, M. (2018). Critical GIS as a tool for social transformation. The Canadian Geographer/Le Géographe Canadien, 62(1), 40–54.

Schaffert, M., & Höcht, V. (2018). Municipal Population Data for Rural Development in Germany. Opportunities and Constraints of Land Management in Local and Regional Development, 259.

Schaffert, M. Becker, T., Steensen, T. Wenger, F.C. (2020). Qualitative GIS to Support Sustainable Regional Branding and Transition in Northern Germany, in: Hepperle, E., Paulsson, J., Maliene, V., Mansberger, R., Auzins, A., Valciukiene, J. (eds). Methods and Concepts of Land Management: Diversity, Changes and New Approaches. Zürich: vdf Hochschulverlag 2020, 149–168.

Szpilko, D. (2020). Foresight as a tool for the planning and implementation of visions for smart city development. Energies, 13(7), 1782.

Tayleur, C., & Phalan, B. T. (2018). Spatial Data Are Key to Sustainability Standards Increasing and Demonstrating Their Impact. Tropical Conservation Science, 11, 1940082918797856.

Taylor, L., Richter, C., Jameson, S., & Perez de Pulgar, C. (2016). Customers, users or citizens? Inclusion, spatial data and governance in the smart city. Inclusion, Spatial Data and Governance in the Smart City.

KEY TAKE AWAYS AND RECOMMENDATIONS

- Identify and close data gaps

Data is central to monitoring processes, such as the progress of sustainability goals. However, sufficient data is often not available. For instance, data for monitoring the UN Sustainable Development Goals is often not available at the local level. To close these data gaps, innovative approaches for data collection and production are needed. Advanced sensors – e.g. high-precision remote sensing and the increasing use of low-cost sensors –, but also Volunteered Geographic Information and other user-generated content, can and increasingly do complement traditional spatial data collection (such as terrestrial and air-borne surveying, often carried out under the responsibility of official agencies).

- Strengthen public-private-partnerships for data capture

Best practices from this book show that local non-experts can be enthusiastic about data collection if they are aware of its purpose, and barriers to participation are reduced to a minimum. At the same time, professional surveyors are willing to make voluntary contributions for improving data in land management systems. Stronger networking between data experts and laypersons could help to improve data quality in voluntary data collection projects. If not only experts but many citizens participate, a much larger volume of data can be collected. This could help to fill data gaps for monitoring spatial developments, such as achieving the UN Sustainable Development Goals at the local level.

- Make authoritative datasets easily available and accessible

With the widespread establishment of Spatial Data Infrastructures (SDIs), an important stage has now been reached in many countries. In most countries, however, many datasets continue to reside in "data silos". This is especially true for the data of public authorities that are not legally obliged to provide it. For example, the mandatory provision of data in the European SDI refers to datasets that are critical for environmental monitoring and reporting. Government datasets that could make an important contribution in other application areas continue to form a heterogeneous, inconsistent and disconnected data landscape. However, such data can also be important for other areas of sustainable development. Data sets on real estate transactions, to name just one example, contribute to the transparency of housing markets. In the current low interest phase, such data make it possible to determine the impact on renting and social housing, and thus to monitor the social aspect of sustainability.

- Generate innovative data products by data fusion

Monitoring progress on sustainability goals requires data. Such data need not only come from new data collection with better sensors or additional volunteer data collectors; it can also be generated by combining existing datasets from various sources with data analytics methods. As spatial datasets become increasingly available, there is growing potential for such spatial data innovations. However, end-users need fit-for-purpose information for the use cases they are engaged in. A growing number of individual datasets alone will not automatically meet their needs. What is needed is the conversion and fusion of existing data into ready-to-use information.

- Integrate geospatial information into user-specific business processes

Innovations in geospatial data and information must enable professionals from different disciplines to easily integrate them into their disciplinary context. Such users are regularly not (geo-)data specialists. To find starting points fXXXXXXXXXXor integration, it is therefore critical to start from established business processes in such disciplines. This requires guidance and best practice solutions on how to use the data and how to integrate it into user-specific processes.

- Integrate geospatial information into pathways to sustainability

Geospatial data usage in research on transformation and transitions to sustainability is promising. Here, too, geospatial information must be integrated into specific processes. An additional initial step might be necessary to explain the importance of the spatial perspective for domain-specific transformation processes. Once this benefit has been recognised, domain experts are likely to understand how geospatial data and information can support them on their way to sustainability. Even stronger collaboration between spatial data researchers and other disciplines seems to be an appropriate next step.

- Address multi-dimensional quality issues

When data from different sources are merged to create innovative new data products, data quality issues become increasingly challenging. Data schemas reduce the complexity of the real world and are created with specific application purposes in mind. They often do not sufficiently consider the usability of the data captured in these data schemas for other applications. Against this background, how can we assess the completeness, accuracy, consistency, precision and timeliness of a spatial data product that uses five, twelve or twenty different spatial datasets from different providers? So far, there is no universal answer to this question. However, when creating a new data product, information on data quality should be a mandatory part of the meta-information that is provided with the product.

- Find the balance between data protection and knowledge generation

Geospatial (mass) data and the increasing ability to link it to other datasets raise legitimate privacy concerns. However, part of the debate threatens to torpedo the enormous positive possibilities of taking human knowledge to a new level by analysing this data scientifically and making it available to a broad user community. There are wide regional differences in this debate and there is no universal formula to find a balance accepted by all stakeholders. In some countries, there is still little sensitivity to data protection, sometimes associated with weak implementation of security technologies to protect data. In other countries, however, fears within society hamper data-based cooperation. As a result, sustainability-relevant data are not released from their silos and fed into the scientific debate, even if security structures have been established to protect the data. To resolve the trade-off between data protection and knowledge generation, joint societal, legislative and technical efforts are needed.

- Find the balance between data-related empowerment and establishment

Official data and voluntarily collected data complement each other. The knowledge of established experts can increasingly be supplemented and strengthened by the voice and expertise of those who are more marginalised. This finding is scalable and applies both at the level of individual organisations and to whole groups that may have been less included in data generation. As the importance and availability of data and information increases, power gaps in data collection and algorithmic design become more present and solutions more urgent. However, it does not seem to be purposeful to consistently link the need to close power gaps with the abolition of established processes and knowledge systems.

- Improve (geospatial) data literacy

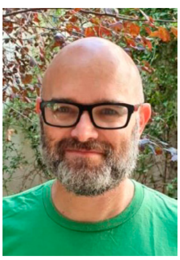
The valuable knowledge building that has been taking place for years to raise people's awareness of sustainable development worldwide should increasingly be complemented by data literacy building. Innovations in geospatial data, privacy and ICT security technologies are critical for sustainable development and sustainable data use. Therefore, technology development must go hand in hand with human capital development for sustainability. Capacity building is key to find the right balance between data protection and data sharing to support the transformation to sustainability.

CONTRIBUTING AUTHORS

Avital Angel is a PhD Candidate at the department of City and Regional Planning, Faculty of Architecture and Town Planning, the Technion. She is a member of EIT Urban Mobility Doctoral Training Network (DTN) and her research fields of interest are pedestrian mobility and big data, urban/regional structure and the environment, health promoting environments and smart cities. Her PhD research focuses on the relationship between attributes of the built environment and walking behaviour, using bigdata technologies. Avital is a landscape architect and urban planner with practical experience in environmental planning and urban design.

Claire Louise Buxton. Since completing her Bachelor's Degree in Surveying (BSURV) from the University of Otago in New Zealand, Claire's expertise has developed in post-earthquake geodetic surveying, cadastral surveying, infrastructure rebuild, residential and industrial land development, and engineering surveying. With Underhill Geomatics, Claire is a project manager and has developed a skill base in rail surveys, high-precision monitoring, and complex logistical surveying projects. Claire has continually improved her knowledge in land tenure through post-graduate studies and holds a certificate of proficiency in Advanced Land Tenure from the University of Otago. Claire has 10 years' professional experience in private surveying across New Zealand and Canada and has continually volunteered for the industry. Over the past three years, Claire has lead the scale-up of the FIG Volunteer Community Surveyor Program into new sustainable paths with a team of volunteers. Claire hopes that young surveyors like herself can get a foot in the door of humanitarian and environmental surveying through the VCSP.

Achituv Cohen, PhD, is a postdoctoral fellow in the SPAR lab, Department of Geography at the University of California, Santa Barbara. He holds B.E., M.Sc., and Ph.D. from the Technion, Israel in Mapping and Geoinformation Engineering. Dr. Cohen's research lies in the fields of urban planning, accessibility, and inclusion, crowdsourced geodata and spatial data mining. He provides a thorough and independent understanding of spatial analysis and computation and combines it with a keen approach of collaboration and learning towards behavioural and cognitive sciences, observation, and systematic analysis of urban phenomena.



Sagi Dalyot is an Asst. Prof. at the Department of Mapping and Geoinformation Engineering, the Technion. He is a geodata scientist, developing methods of interpretation, mining, and integration of crowdsourced user-generated content to augment and develop location-based services and smart mapping infrastructures, focusing on routing and navigation solutions for people with mobility disabilities. He is the chair elect of the International Federation of Surveyors (FIG) Commission III on Spatial Information Management, and he serves as secretary of ISPRS WG IV/5 on Indoor/Outdoor Seamless Modelling, LBS, and Mobility.

Ruba Jaljolie is a Ph.D. candidate at the Department of Geo-information and Mapping Engineering, the Technion. She has published several papers in journals and conferences. Her research aims to investigate and develop algorithms, models, and processes required for Multi-Dimensional and Multi-Purpose Land Management systems (MMLMSs). She investigates theoretical and conceptual aspects of MMLMSs, including ethical aspects, sustainability, and stakeholders' perspective.

Tom Kitto is a Registered Land Surveyor with 14 years' experience in practices throughout New Zealand, Australia, and Canada. He has an interest in all things surveying and aviation with a desire to improve our environment and society through innovative use of spatial technology and data. As a member of the VCSP team Tom worked to establish partnerships with leading NGO's and interest groups to create in-Country and e-Volunteering opportunities for young surveyors worldwide. Tom currently works for Candrone, a drone manufacturer and service provider based in Vancouver, Canada, and is a registered surveying consultant in New South Wales, Australia.

Cemal Özgür Kıvılcım, PhD is a Chief Engineer at Istanbul Metropolitan Municipality. He is the chair of the FIG Commission 3 Working Group 6 „Geospatial Next". His work includes collaborating in multidisciplinary projects and across departments of public works including heritage preservation, public infrastructure, superstructure. surveying, and geospatial data/information management. He holds a BSc. from Yildiz Technical University, MSc. and PhD from Istanbul Technical University. He contributed to the ISPRS and FIG youth initiatives of ISPRS and FIG as a founding member, and led the ISPRS Student Consortium and FIG Young Surveyors Network in various roles. He is a member of Turkish Chamber of Survey and Cadastre Engineers (HKMO), and ISPRS.

Marije Louwsma is senior advisor at the international department of the Cadastre, Land Registry and Mapping Agency in the Netherlands. For FIG she chaired commission 8 Spatial Planning and Development for the term 2019–2022. With MSc degrees in spatial planning and geo-information management and applications, her professional interest focuses on an interdisciplinary approach in the field of land administration, land use planning and geo-information. She has published several articles, papers, and book chapters among others.

Hartmut Müller teaches Geoinformatics at the University of Applied Sciences Mainz, Germany; he holds a diploma and a doctorate degree in Geodesy, publishes regularly in international scientific journals and gives invited lectures at national and international congresses; he serves as a reviewer for the accreditation of higher education programs, as a reviewer of proposals for research and development programs, and of scientific articles in international journals; he is Chair of FIG Commission 3 Spatial Information Management (2019–2022) and represents the Commission Officers in the FIG Council (2021–2022).

Pnina Plaut is an Assoc. Prof. at the Faculty of Architecture and Town Planning, the Technion, and the Head of the Center for City and Regional Studies – CCRS. She holds a BSc in Civil Engineering, MSc in Urban and Regional Planning from the Technion, and a PhD in City and Regional Planning from the University of California, Berkeley. Her fields of interests are transportation and land use planning and policy, urban mobility and new technologies, social networks, travel behaviour and urban structure. She leads a research group at the CCRS investigating health promoting environments, focusing on the impact of the built environment on health, including active transport and active living by design.

Professor **Chryssy Potsiou** is teaching Cadastre, Land Management and Property Valuation at the School of Rural, Surveying & Geoinformatics Engineering of NTUA, Greece. Honorary FIG President. Past positions: FIG President (2015–2018); Vice President (2011–2014); Commission 3 Chair (2007–2010). UNECE Working Party on Land Administration (WPLA) bureau member (2001–2018). WPLA Vice Chair (2019–2020). Member of the boards of the Hellenic Mapping and Cartographic Organization, KTIMATOLOGIO S.A., Hellenic Association of Rural and Surveying Engineers (HARSE), Hellenic Society for Photogrammetry and Remote Sensing, and Hellenic Society for Geographic Information Systems. She has published 130 peer reviewed papers.

Dr. Enrico Rispoli is Board Member of the National Council of Italian Surveyors; diploma in Surveying and Bachelor's degree in law. He is a freelance professional in the field of construction, land registry and legal assistance in urban planning and administrative matters. He is an Expert in the disciplines of sustainable governance and land monitoring. He has been Chair of FIG Commission 3 (2015 – 2018). Currently he is a Director of FIG Foundation and Vice President of the European Council of Geodetic Surveyors (CLGE). He is co-author of several publications as *FIG Publication n. 73; Marine Cadastre in Europe – a preliminary study; European Valuation Standards 2020 – Italian edition.*

Cemre Şahinkaya Özer is a PhD candidate at the Department of Urban Renewal and Planning Theory at the University of Kassel, Germany. She holds a double major degree on urban & regional planning and geomatics engineering, and completed her Technical University of Munich on land management. Her field of interests are urban transformation processes, housing, urban liveability and spatial data in urban areas. Cemre has practical experience in urban regeneration and urban planning applications.

Markus Schaffert is a teacher and senior researcher at Hochschule Mainz: University of Applied Sciences in Germany. He graduated in geography at the University of Heidelberg and completed his doctorate at the Technical University of Darmstadt. In 2019, he was appointed full professor in geospatial informatics in Mainz. His research focuses on the use of geospatial information to support sustainable spatial transformation, e.g. in the areas of "Demographic Change", "Rural Digitalisation" and "Transdisciplinary Research".

Maria Grazia Scorza is the Head of the International Department of the National Council of Italian Surveyors; university degree in Languages and Modern Literatures. She has been Chair of Public Relation and Communication during FIG Working Week 2012; Vice Chair of FIG Commission 3 (2015–2018). Currently she is Adviser of the European Council of Geodetic Surveyors (CLGE). She has contributed to the Italian edition of the European Valuation Standards 2020.

Roshni Sharma. Having traversed environmental science and management, human geography, palaeoclimatology and business, Roshni is a thought leader, a compassionate disruptor, a connector and someone who gets things done. She is one of Geospatial World's 50 Rising Stars of 2022, and founder of the SSSI Young Professionals Mentoring Program which has served over 700 participants globally. Roshni hosts the Locate and Discomfort Zone podcasts, is Convenor of Australia's Space, Spatial and Surveying Diversity Leaders Network, and sits on the NSW Government's Board of Surveying and Spatial Information. At FrontierSI, Roshni works to harness location intelligence to create tangible positive change for society by creating traction around sustainability and tech for good.

ACKNOWLEDGEMENTS

This publication brought together the expertise of leading professionals from different countries to share their experiences and approaches, in particular to highlight the role of geospatial data in different related fields in the current decade. The support of numerous delegates from FIG Commissions 3 and 8 who participated in two annual workshops and produced coordinated research papers is gratefully acknowledged.

We would like to acknowledge and thank all chapter and subchapter authors and other contributors. We are grateful to the FIG office and the publishing team for their support and arrangement to publish this work.

For hosting the annual joint workshops of Commission 3 and 8 in 2019 and 2021, thanks go to the Romanian Surveyors Union and the Consiglio Nazionale Geometri e Geometri Laureati, Italy. Thanks go to the DVW German Association for Geodesy, Geoinformation and Land Management for their continuous support of FIG Commission 3 activities during the 2019–2022 and previous periods.

FIG PUBLICATIONS

The FIG publications are divided into four categories. This should assist members and other users to identify the profile and purpose of the various publications.

FIG Policy Statements

FIG Policy Statements include political declarations and recommendations endorsed by the FIG General Assembly. They are prepared to explain FIG policies on important topics to politicians, government agencies and other decision makers, as well as surveyors and other professionals.

FIG Guides

FIG Guides are technical or managerial guidelines endorsed by the Council and recorded by the General Assembly. They are prepared to deal with topical professional issues and provide guidance for the surveying profession and relevant partners.

FIG Reports

FIG Reports are technical reports representing the outcomes from scientific meetings and Commission working groups. The reports are approved by the Council and include valuable information on specific topics of relevance to the profession, members and individual surveyors.

FIG Regulations

FIG Regulations include statutes, internal rules and work plans adopted by the FIG organisation.

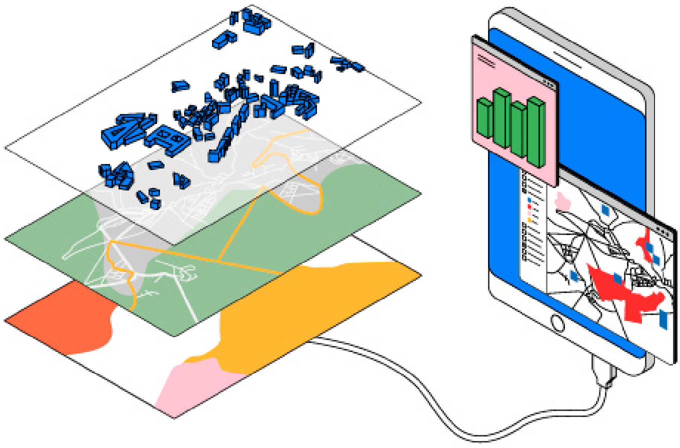
List of FIG Publications

For an up-to-date list of publications, please visit
www.fig.net/pub/figpub

ABOUT FIG

International Federation of Surveyors is the premier international organization representing the interests of surveyors worldwide. It is a federation of the national member associations and covers the whole range of professional fields within the global surveying community. It provides an international forum for discussion and development aiming to promote professional practice and standards.

FIG was founded in 1878 in Paris and was first known as the Fédération Internationale des Géomètres (FIG). This has become anglicized to the International Federation of Surveyors (FIG). It is a United Nations and World Bank Group recognized non-government organization (NGO), representing a membership from 120 plus countries throughout the world, and its aim is to ensure that the disciplines of surveying and all who practise them meet the needs of the markets and communities that they serve.



Commission 3 has the practice of presenting the results of its work in publications that address topical issues. This new publication on 'Geospatial Data in the 2020s – transformative power and pathways to sustainability' looks at the role of geospatial data in the current decade. A diverse community of 16 authors (9 female, 7 male) from 9 different countries (Australia, Canada, Germany, Greece, Israel, Italy, Netherlands, New Zealand, Turkey), covering a wide range of ages and stages of their professional careers, representing FIG Commission 3 Spatial Information Management, FIG Commission 8 Spatial Planning and Development, and the Volunteer Community Surveyor Program (VCSP) of the FIG Young Surveyors Network, have come together to prepare this joint publication.

The publication presents a wide range of use cases and best practice examples to illustrate the significance of geospatial data and information for sustainable development. The collection highlights pressing issues such as the management of the COVID-19 pandemic, raises questions on empowerment, diversity, and participation in the geospatial context, discusses data integration in spatial planning and presents humanitarian mapping case studies. The articles are partly practically and partly academically oriented. Our focus is on integrating geospatial data, including established datasets and platforms, to find pathways to sustainability. The authors aim to provide answers to the question of what benefits geodata and geospatial information promise for different application areas and how they can be integrated into established technical processes of selected domains.

In this way, we, the editors and authors of this publication, hope to support readers in transforming geospatial data into geospatial information and then geospatial information into knowledge to promote sustainability, as knowledge is created from information and information from data. We are convinced that the challenging environment of the 2020s, with its many disruptions that we have already experienced so far, offers a particularly interesting experimental field for exploring and leveraging geospatial information's potential.

ISBN 978-87-93914-01-8 (pdf)