

LATEST INNOVATIONS AND DEVELOPMENTS

How Geospatial Surveying Is Driving Land Administration

Five years ago, *GIM International* published an article titled ‘A New Era in Land Administration Emerges’. It outlined how innovative thinking coupled with quickly maturing, scalable technical approaches could transform land administration globally. To reach fruition, support from policymakers, world-leading private companies, modern geospatial technologies and a new professional mindset would be crucial. So what has happened since? Here, in close cooperation with the geospatial industry, *GIM International* provides a major update, paying special attention to standardization, technical approaches and land data acquisition in the context of global policies.

POLICY GUIDANCE AND UN-GGIM

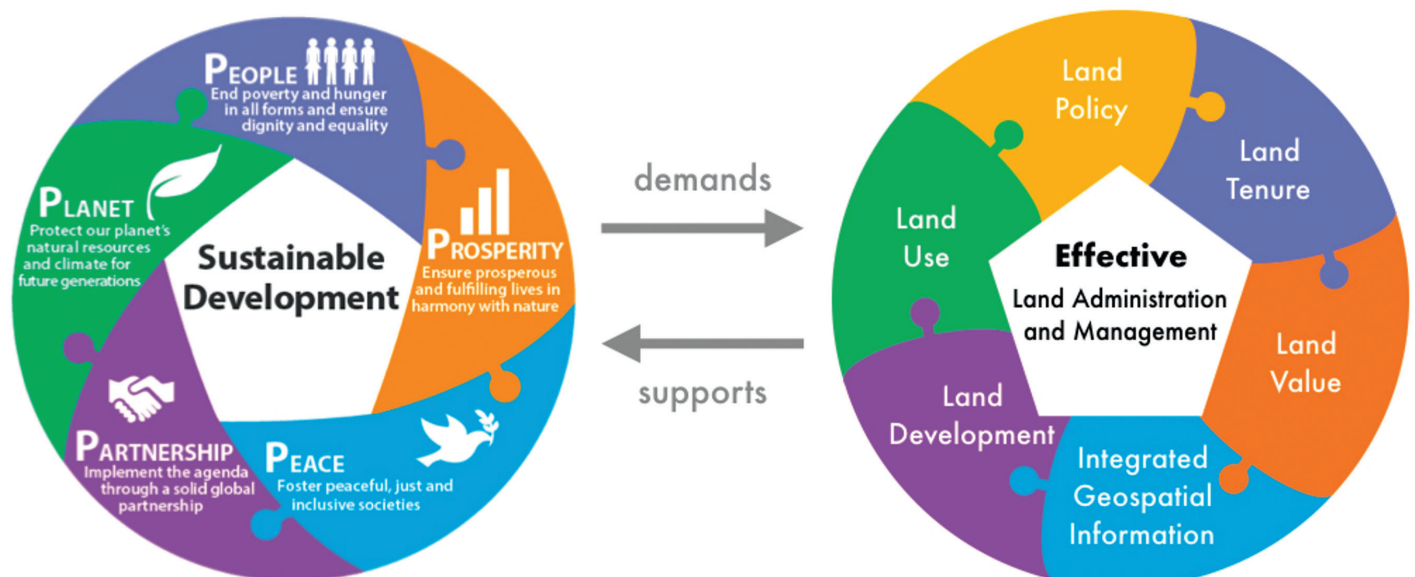
The national cadastral and topographic mapping agencies from UN member states are represented in the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM). The geospatial industry is involved as an observer. UN-GGIM’s Expert Group on Land Administration and Management has developed a reference document for developing, reforming, renewing, strengthening or modernizing land administration and management systems. It

is called the Framework for Effective Land Administration (FELA). Based on the Integrated Geospatial Information Framework (IGIF), it is currently under global consultation. The document calls for recognition of land tenure, land use, land value and land development data – including elements relating to gender, conflict and disaster – as fundamental geospatial data themes within any jurisdiction. Sustainable development demands effective land administration and management. Likewise, effective land administration

and management supports sustainable development, as defined in the Sustainable Development Goals (SDGs) (see Figure 1). FELA recognizes that an enabling environment through the development of policies, standards and regulations may lead towards a cooperative data-creation and data-sharing environment.

INTEROPERABILITY AND OGC

In parallel, the Open Geospatial Consortium (OGC) published a white paper on land administration, providing an overview



▲ Figure 1: Sustainable development and land administration. (Courtesy: UN-GGIM)



▲ Figure 2: Overview of charter members of the OGC Land Administration Domain Working Group. (Courtesy: OGC)

of the land administration domain and proposing actions needed for the design and development of implementation standards. Close cooperation between OGC and the International Organization for Standardization's TC211 on Geographic Information is expected to accelerate these developments. The charter members (see Figure 2) of the OGC Land Administration Domain Working Group (DWG) seek to identify enabling standards and best practices to guide countries in a programmatic way to

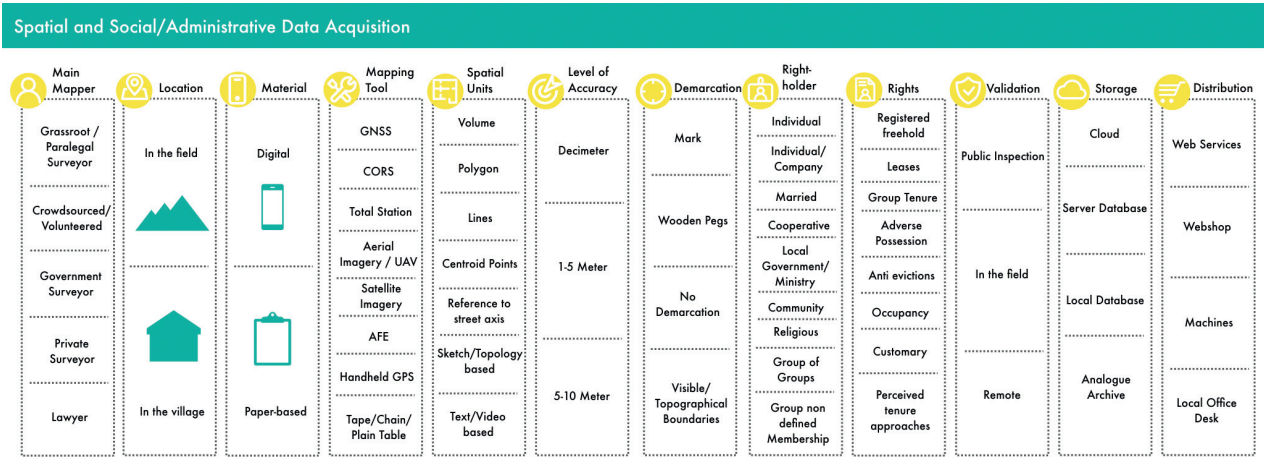
establish more cost-effective, efficient and interoperable land administration capabilities. The aim is to support the upgrading of current manual processes to semi-automated ones, and to suggest solutions that are more automated and open to new data sources and technologies. Interoperability is imperative in the field-to-cloud and field-to-office activities.

STANDARDIZATION AND LADM

The Land Administration Domain Model (LADM) has been an ISO standard for seven

years and is currently undergoing a review towards a second edition. A road map is under development. The scope of LADM will be extended to include valuation and fiscal representations, which will have an impact on data acquisition methods. Spatial planning and zoning inclusion, with legal implications, is another extension of the scope. Moreover, it is planned to include process models and workflows. Esri continues to invest in LADM for the ArcGIS platform. It has been configured to leverage LADM to meet land

| WHAT IS YOUR VISION ON HOW TO SUPPORT LAND ADMINISTRATION (CADASTRE AND LAND REGISTRY) PROCESSES AND SERVICES IN THE FUTURE? | |
|--|---|
| Esri | Esri has pioneered the world's leading cadastral software. Services-based, the ArcGIS parcel fabric integrates with modern business systems and can ingest data of all types. |
| Topcon | Many of Topcon's technology solutions for mass data acquisition and processing are ideal for acquisition of cadastral mapping data. For example, since 2016 we have exclusively provided the National Land Survey of Finland (NLS) with its high-precision geomatics solutions, enabling the organization to maintain the highest possible standards of work and data production. |
| IGNFI/GEOFIT/INNOLA | IGNFI/GEOFIT/INNOLA's solutions are integrated LADM-compliant data management systems based on rule-driven workflows and open for integration and exchange with third-party systems/interfaces. These solutions provide integrated field approaches that offer an all-in-one cadastral mobile office, with survey capacities using any kind of differential global positioning system (DGPS), socio-technical land survey forms with embarked QC capacities, scanning facilities, as well as biometric options for signature and ID generation. |
| RIEGL | RIEGL fully supports the efforts of UN-GGIM and the EuroGeographics members to modernize and upgrade country information for environmental and economic resilience. |
| Racurs | In cooperation with our partners, we are working hard on affordable cloud and VR tools which make the process of obtaining cadastral data cheaper and accessible. This will speed up the process of cadastral work. |
| Meridia | Meridia enables community members to conduct high-quality data acquisition to boost participatory mapping approaches that reduce cost while maintaining quality and strengthening local engagement. |
| Trimble | Trimble looks at land administration holistically – not as islands of activities, but rather as an integrated ecosystem of actions and reactions. Successful land administration efforts address all aspects of land rights, roles and responsibilities, including stakeholders, workflows, data, sustainability, accessibility, transparency and security. |
| Cadasta | At Cadasta, the focus is on supporting the individuals and communities left out of formal tenure systems. Globally, and particularly in emerging economies, documented and recognized land tenure and resource rights are the exception, rather than the norm. |
| Leica Geosystems | Hexagon's vision supports land administration by continuously developing fit-for-purpose data collection sensors, software and autonomous solutions that shape urban and production ecosystems to become fully autonomous and connected. These developments increasingly improve the efficiency and effectiveness of land administration. |
| Netcad | There are some standards for data acquisition and topology controls in Turkey. These are done by using macros/add-ons. Netcad's mission is to control every process of data acquisition and to eliminate and prevent paper waste by using e-signature technologies. |



▲ Figure 3: Integrated acquisition of spatial and legal/administrative data. Many options and approaches should be available in a flexible way.

administration system needs across the globe. IGNFI/GEOFIT and Innola Solutions already provide proven national-scale, enterprise-level, LADM-compliant configurabilities, rule-driven systems, based on BPMN workflows. Those open solutions can integrate external services and sources using exposed web services/API (including GIS systems).

QUALITY AND FFPLA

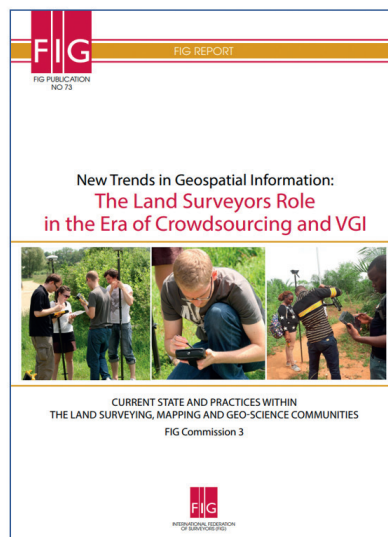
Data capture should fit the purpose of its intended use. In cases where value of land is higher or an intensive level of land use exists, conventional field surveys – using high-precision methods such as high-precision GNSS, total stations or terrestrial laser scanners – can be deployed. Trimble, Leica, Topcon and emerging players offer a wide range of such options. Areas with lower land values can use other approaches including use of aerial imagery, aerial Lidar and even radar. All these approaches are suggested in the Fit for Purpose Land Administration (FFPLA) approach. FFPLA urges cost-effective, time-efficient, transparent, inclusive, scalable and participatory data collection and management, including participatory surveying and volunteered and crowd-sourced land information. This means integrated acquisition of spatial and legal/administrative data. Many options and approaches should be available (see Figure 3). The user interface should be as simple as possible and the kind of measurement used should be recorded. In many situations, it is sufficient to identify visual boundaries in the field using easily understood imagery. By following FFPLA guidelines, land administration systems start from a simple basis and can be incrementally improved over time, whenever necessary or relevant. It is a dynamic process involving

adaptation to different contexts, availability of technology and existing integrated/ multi-stakeholder approaches. In summary: less accurate measurements can serve the purpose for initial measurements. Higher precision can/should be used for incremental improvement (where needed).

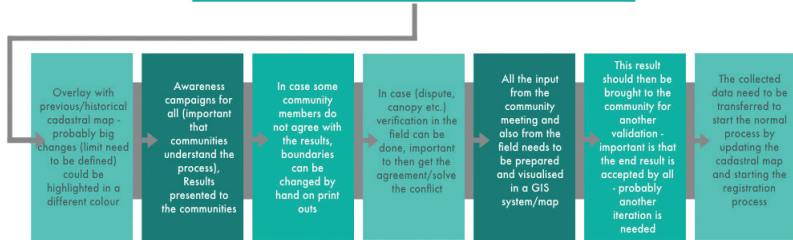
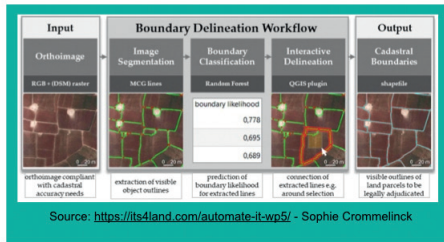
PRODUCTIVITY AND THE PRIVATE SECTOR

The International Federation of Surveyors (FIG) published a report on crowdsourcing (see Figure 4) recognizing that geographic data collection via authoritative professionals only – characterized as the ‘top-down’ scheme – has been challenged over the past few years. There is now a move towards more bottom-up approaches in which people generate data that is subsequently used as information in various land-related applications and services. This is in line with the FFPLA concept. Esri, IGNFI/GEOFIT

and Innola Solutions, Meridia, Trimble and Cadasta now all offer solutions in support of participation. Meridia states that the Meridia°Collect is designed to enable local community members to use advanced spatial and textual surveying features for initial land registration. It scales well (as proven in 50,000+ parcel projects) and is focused on usability and data consistency. Cadasta says that solutions must be adapted to the local context, but at the heart of their work they focus on ensuring data collection and management is done in concert, if not directly, by community members. Trimble states that, if input is required from non-professionals (via crowd-sourcing, for example), tools such as Trimble TerraFlex – a flexible and easy-to-use cloud-based solution for field data collection – also enable attribution. Leica’s FFPLA solution, Leica Zeno, provides a very easy-to-use GNSS field



▲ Figure 4: FIG has published reports on crowdsourcing and 3D land administration.



▲ Figure 5: Automated feature extraction (AFE) is under development in various domains. (Courtesy: Crommelinck, Unger, Bennett)

data collection tool offering scalable accuracy to meet all land administration requirements. Zeno can be used on consumer-grade

smartphones or tablets with the high accuracy and precision demanded in land administration.

INNOVATION AND 3D CADASTRES

Another relevant development is that of 3D cadastres. A comprehensive study recently published by FIG (see Figure 4) concluded that ongoing urbanization, increasing complexity of infrastructure and densely built-up areas require better recordation and registration of the legal status. This can only be provided to a limited extent by existing 2D cadastral systems. 3D, including indoor modelling, is required to capture the whole legal and spatial dimension, which further includes the marine environment. A dedicated 'vertical' land administration stream is without any doubt the trend which is requested and fully supported by suppliers. The support may range from assistance during initial registration and documentation of land rights, to deliverance of the full 'vertical' spectrum of land administration services – from field data acquisition, data conversion and data migration, to LADM-compliant data integration

| WHAT ARE THE LATEST LAND ADMINISTRATION INNOVATIONS THAT YOU WOULD LIKE TO SHARE? | |
|---|---|
| Esri | The parcel fabric is the most modern, purpose-built and configurable land administration capability in the market in 15 years. It leverages all the capabilities of the ArcGIS platform supporting distributed, federated, fit-for-purpose and enterprise land systems. Combined with the Esri Geospatial Cloud leveraging the largest global geographic database and extensive services, configurable apps and capabilities, this delivers a complete land administration system. |
| Topcon | Topcon invests in providing solutions that improve the whole land acquisition workflow, including initial data acquisition, management, provision and maintenance. From Topcon hardware solutions such as the Sirius Pro UAV to Topcon's in-house software such as MAGNET Collage, as well as partnerships with Bentley ContextCapture, Topcon's cutting-edge technology provides invaluable support to those in the land administration community. |
| IGNFI/GEOFIT/INNOLA | We are working on the integration of blockchain technology to improve the overall security of our systems. |
| RIEGL | The introduction of the RIEGL VQ-1560 II dual-channel waveform processing airborne Lidar scanning system for high point density mapping and ultra-wide area mapping is an excellent example of innovation to meet the requirements for efficient and precise data capture for authoritative data needed by the mapping community. |
| Racurs | At last year's Intergeo, we released the StereoClient: a tool for stereo processing of images from cloud storage. This tool allows stereo measurement with a smartphone, needing only a VR adapter, a keyboard, a mouse and a special app. |
| Meridia | Meridia provides online and offline-ready sync between multiple data collectors, and traceable field snapping to avoid overlaps and slivers. |
| Trimble | Recent algorithmic and positioning infrastructure advances allow high-accuracy cadastral boundary surveys with the use of consumer-level hardware. Trimble Catalyst delivers professional-grade positioning to the masses as an on-demand, user-based service. This can enable a scalable and affordable solution for large-scale parcel survey. |
| Cadasta | At Cadasta, we are working on providing tools for data acquisition, management and maintenance in addition to providing relevant datasets for our partners so that they might maximize their ability to analyse land holdings and make informed land management decisions. |
| Leica Geosystems | Airborne imaging sensors are ideal for remote sensing projects in land use, agriculture, forestry and the environment. Launched at Intergeo 2019, the Leica CityMapper-2 is specifically designed for airborne urban mapping and offers twice the data collection performance to address this urgent need for 3D data. The world's only hybrid oblique imaging and Lidar airborne sensor captures two nadir (RGB/NIR) and four oblique 150MP images every 0.8 seconds, offering the highest resolution to visualize every corner of a city. Together with a new-generation 2MHz pulse rate Lidar, this sensor breaks all conventional barriers of urban mapping. The release of Leica Zeno also supports professionals collecting data for land administration purposes at the low end. |
| MGGP Aero | MGGP Aero provides geospatial information based on aerial imagery and Lidar data. Land administration can rely on its use on the resolution, overlaps and precise accuracy provided. For cadastral purposes we only use wide-format photogrammetric cameras and at least 7cm GSD resolution or better. MGGP Aero solutions focus on the use of aerial imagery for land administration (cadastral purposes, stereophotography, 3D mesh models, oblique imagery and regular time sequenced aerial imagery). |
| Netcad | Netcad solutions include online signature and topology control processes and support in fair property exchanges by using AI technologies. This is of specific complexity in Turkey. Nationwide integrated services are available. Netcad is working on opening CAD data on web browsers and Linux. |

and transactional workflow-driven data management and dissemination.

AUTOMATED FEATURE EXTRACTION

Automated feature extraction (AFE) is under development in various domains, including the land administration domain (see Figure 5). The most notable developments are in infrastructure management in urban areas (e.g. transport, buildings) and agriculture (land use). The application to land administration is more recent and should be considered at R&D and pilot level. It is argued that a large number of cadastral boundaries are visible and coincide with natural or human-made physical object boundaries. Imagery-based approaches have been proved as usable for land titling and recordation of all people-to-land relationships in countries such as Ethiopia and Rwanda.

Nevertheless, even in ideal cases, not all visible cadastral boundaries can be automatically detected; certain boundaries require a semi-

built to operate in relatively stable environments. Disaster risk management (DRM) generally assumes a dynamic, if not chaotic, environment. After a disaster occurs, the aim is to quickly assess and triage damage, injury and loss of life, and respond with medicine, food, water, housing and basic infrastructure. New conceptual thinking has established a link between the key LAS constructs of land, people and rights, and the core DRM concepts of hazard, vulnerability and exposure. This theoretical link has been converted into a practical data model by embedding new attributes into the ISO 19152 LADM standard (see Figure 6).

CONCLUDING REMARKS

New-era land administration is being embraced by surveyors, the private sector, policymakers, governments and communities alike. Underpinned by emerging policies such as UN-GGIM's FELA and principles of interoperability (OGC), standardization (LADM) and pragmatism (FFPLA), a range of sustainable and scalable private-sector

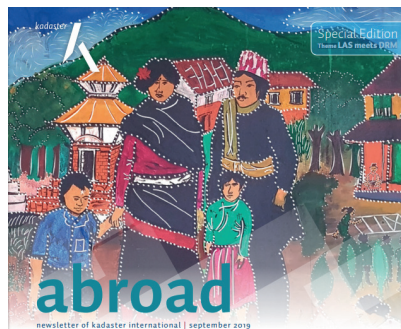
POLICIES AND PRINCIPLES OF INTEROPERABILITY, STANDARDIZATION AND PRAGMATISM ARE ENABLING INNOVATIONS AND AUTOMATION IN NATIONAL LAND ADMINISTRATION

automated approach, especially in urban areas where the morphology of cadastral boundaries is complex. AFE cannot deliver complete matching; some tenure boundaries are also defined socially or are covered by thick canopy and thus are not visible in imagery. AFE can be a good method for updating a cadastral map or for initial working-draft land recordation. AFE is perhaps on the cusp of going beyond R&D, as all the big vendors are working on it. Linking with those providers for pilots will reveal many lessons, including the viability of the approach in different parts of the landscape. AFE will not be suitable everywhere, but – like UAVs – it will have a niche role to play in both initial capture and updating/maintenance.

DISASTER READINESS

There has been increasing focus on ensuring land administration systems are better able to adapt and respond to both natural disasters and conflicts. It is crucial to gain an overview of areas where conflicts have an impact on land rights. Land administration systems (LASs) are typically

products and services are being developed. These are enabling innovations and automation in national land administration sectors. Importantly, these technical developments are supplemented – if not enabled – by simple legal procedures and streamlining institutional processes. ◀



▲ Figure 6: What happens when disaster risk management meets land administration? Special edition of the newsletter Kadaster Abroad.

The tables show answers from a survey on geospatial innovations and developments relevant for land administration systems. The survey was conducted in close cooperation with *GIM International*. For further results, see: www.gim-international.com.

FURTHER READING

- FIG, 2019, *New Trends in Geospatial Information: The Land Surveyors Role in the Era of Crowdsourcing and VGI*, International Federation of Surveyors, FIG Publication No 73
- FIG, 2018, *FIG publication on Best Practices 3D Cadastres - Extended version*, International Federation of Surveyors, November 2018
- Kadaster, 2019, *Kadaster Abroad*, Special Edition – Theme: LAS meets DRM, Kadaster, September 2019
- OGC, 2018, *Open Geospatial Consortium White Paper on Land Administration*, OGC, February 2019
- UN GGIM, 2019, *Framework for Effective Land Administration*. Expert Group on Land Administration and Management United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM), July 2019 – Under Consultation
- UN-GGIM, 2018, *Integrated Geospatial Information Framework*

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