Public Disclosure Authorized
Public Disclosure Authorized

WORLD BANK GROUP
Urban, Disaster Risk Management, Resilience & Land

The Use of Technologies to Enhance Own Source Revenue Mobilization: Applications to the Property Tax

JUNE 2024

© 2023 International Bank for Reconstruction and Development / The World Bank
1818 H Street NW, Washington DC 20433
Telephone: 202-473-1000; Internet: www.worldbank.org

Some rights reserved

This work is a product of the staff of The World Bank with external contributions. The findings, interpretations, and conclusions expressed in this work do not necessarily reflect the views of The World Bank, its Board of Executive Directors, or the governments they represent. The World Bank does not guarantee the accuracy of the data included in this work. The boundaries, colors, denominations, and other information shown on any map in this work do not imply any judgment on the part of The World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

Nothing herein shall constitute or be considered to be a limitation upon or waiver of the privileges and immunities of The World Bank, all of which are specifically reserved.

Rights and Permissions

This work is available under the Creative Commons Attribution 3.0 IGO license (CC BY 3.0 IGO) http://creativecommons.org/licenses/by/3.0/igo. Under the Creative Commons Attribution license, you are free to copy, distribute, transmit, and adapt this work, including for commercial purposes, under the following conditions:

Attribution—Uri Raich and Dong Kyu Kwak. 2023. "The Use of Technologies to Enhance Own Source Revenue Mobilization: Applications to the Property Tax", World Bank, Washington, DC.

Translations—If you create a translation of this work, please add the following disclaimer along with the attribution: This translation was not created by The World Bank and should not be considered an official World Bank translation. The World Bank shall not be liable for any content or error in this translation.

Adaptations—If you create an adaptation of this work, please add the following disclaimer along with the attribution: This is an adaptation of an original work by The World Bank. Views and opinions expressed in the adaptation are the sole responsibility of the author or authors of the adaptation and are not endorsed by The World Bank.

Third-party content—The World Bank does not necessarily own each component of the content contained within the work. The World Bank therefore does not warrant that the use of any third-party owned individual component or part contained in the work will not infringe on the rights of those third parties. The risk of claims resulting from such infringement rests solely with you. If you wish to re-use a component of the work, it is your responsibility to determine whether permission is needed for that re-use and to obtain permission from the copyright owner. Examples of components can include, but are not limited to, tables, figures, or images.

All queries on rights and licenses should be addressed to World Bank Publications,
The World Bank Group, 1818 H Street NW, Washington, DC 20433, USA;
e-mail: pubrights@worldbank.org.

Contents

Figures

Boxes

Tables

List of Abbreviations and Acronyms

AI	Artificial Intelligence
AMC	Ahmedabad Municipal Council
API	Application Programming Interface
BPR	Business Process Re-engineering
CAMA	Computer-Assisted Mass Appraisal
CNN	Convolutional Neural Network
COTS	Commercial Off-the-shelf Solutions
dLRev	District Local Revenue Project
E&TD	Excise and Taxation Department
FCC	Freetown City Council
FOSS	Free Open-Source Software
GIS	Geographic Information System
GIZ	German Agency for International Cooperation
GSD	Ground Sample Distance
GVB	Geo-Valuation Block
IAAO	International Association of Assessing Officers
ICT	Information and Communication Technology
IPTI	International Property Tax Institute
LADM	Land Administration Domain Model
LGRCIS	Local Government Revenue Collection Information System
MIS	Management Information System
ML	Machine Learning
MLGDRD	Ministry for Local Government, Decentralization and Rural Development
MMDAs	Metropolitan Municipal District Assemblies
NCC	Nairobi City County
OSR	Own Source Revenue
OTC	Cadastral Technical Observatory
POC	Proof of Concept
PO-RALG	Prime Minister's Office- Regional Administration of Local Government
POS	Point of Sale
SDI	Spatial Data Infrastructure
SNG	Subnational Government
SVM	Support Vector Machine
UAV	Unmanned Aerial Vehicle
UIPT	Urban Immoveable Property Tax
VNG	International Cooperation Agency of the Association of Netherlands Municipalities

Acknowledgments

This report was prepared by Uri Raich (Senior Urban Specialist) and Dong Kyu Kwak (Senior Land Administration Specialist) under the guidance of Roland White (Global Lead for City Management, Governance and Finance). The authors benefitted from the original contribution of Aanchal Anand (Urban Economist), William McCluskey (Professor at African Tax Institute, University of Pretoria) and Peadar Davis (Consultant).

The report was peer-reviewed by Rajul Awasthi (Senior Public Sector Specialist), Sarah Antos (Senior Land Administration Specialist), Suhaib Rasheed (Senior Urban Development Specialist), and Roy Kelly (Professor of Practice of Public Policy at Duke Center for International Development).

The team is grateful to the following World Bank colleagues for sharing their operational experiences on own source revenue mobilization: Mika-Petteri Torhonen, Suhaib Rasheed, Shahnaz Arshad, Linus Pots, Edward Anderson, Andre Bald, Gyongshim An, Chyi-Yun Huang, Ivonne Moreno, Sarah Antos, Sheila Kamunyori, Beatriz Eraso Puig, and Davison Muchadenyika. External consultations were held with Benjamin Njenga, Isaac Nyoike, Paul Fish, Xaver Schenker, Alf Bremer, Jan Beck, William Amoah, Yulieth Rodriguez, Jose Luis Ariza, Eliecer Venegas, Gabriel Vallejo, Olga Lucia Lopez, and Sonia Alvarez.

The team would also like to acknowledge the close collaboration with the World Bank's Land Group and the Governance Global Practice for their active collaboration in this study.

Introduction

Own source revenue (OSR) refers to the revenue generated by subnational governments (SNGs) from local sources primarily in the form of taxes, charges, and fees (Slack, 2009). Adequate mobilization of OSR is key to SNGs to provide local public goods, services, and infrastructure (UN Habitat 2016). In the face of rising public debt and fiscal stress at the national level that could result in the reduction of transfers to SNGs, OSR mobilization gains relevance for bridging funding gaps at the local level. Moreover, strengthening OSR mobilization improves fiscal autonomy through more predictable access to revenue and greater ownership and control of expenditures at the local level. Despite their importance, OSRs in the developing world only account for 10 to 30 percent of total SNG revenue (OECD/UCLG 2019) and less than 1 percent of GDP.

Developing more effective OSRs at the sub-national level is essential for strengthening revenue flows, which facilitates development of sustainable towns and cities (Bahl and Linn 2014). SNGs (particularly in the developing world) often have a multiplicity of small revenue streams, which poses administrative challenges. In Kenya, for example, county governments have over 100 individual revenue streams, even though 9 revenue instruments generate 85 percent of total OSR collections (Adam Smith International 2014). Thus, from a pragmatic perspective, SNGs tend to focus on those OSRs that have a clear policy rationale and the greatest revenue-raising potential, as well as those that are most cost-effective to administer (National Treasury Kenya 2019).

The collection efficiency of OSRs is measured against realistic collection targets, which are usually missed because of administrative weaknesses. Common problems include (1) estimating the number of taxpayers missing from their local revenue rolls; (2) determining how many of those who are registered are inactive; (3) and understanding how much revenue is foregone through non-payment and ineffective billing systems (Fish 2015). Even when taxpayers are registered in the system, complete and reliable information on their tax liabilities, payments, and arrears are often missing. Furthermore, the recorded data for taxable objects (e.g., properties or businesses) and taxpayers may be inaccurate or incomplete, making billing, collection and enforcement challenging, if not impossible. Tax administrators and revenue managers can overcome some of these weaknesses by using appropriate management information systems (Fjeldstad and Heggstad 2012). These systems help upgrade several administrative and institutional capacities, such as identifying taxpayers and service users, assessing their payment obligations, and ensuring accurate and timely billing, payment, and enforcement.

Information and communication technology (ICT) have become increasingly powerful in facilitating the efficient identification of the tax/charge base, improving assessment, and making the collection of revenue more transparent, efficient, and easier (Prichard 2014). Appropriate ICT systems present advantages for governments and taxpayers like improvements in taxpayer services through a range of e-services and e-payment options. SNGs have increasingly seen the benefits of adopting ICT systems to improve administrative efficiency across the whole revenue chain, from identification, data collection and assessment, to payment and enforcement (Mascagni et al., 2014).

Some of the earliest technological interventions have been the application of relational databases that interconnect tables of relevant information within databases, enabling interaction between the datasets using reference numbers or spatial coordinates (Bird and Zolt, 2008). SNGs are data-rich organizations given the vast quantities of data they hold; this is particularly true in concern to revenue administration. The administration of the property tax, for example, involves holding data on several hundred thousand properties and their attributes. To put this into context, if an SNG has, for example, 200,000 properties liable to property tax, and for each property 10 data points are required (location, size, use, condition, amenities, etc.), then 2 million data entries must be stored and updated (McCluskey, Franzsen and Bahl 2017). As such, the integration of relational databases is transformative in managing data at the SNG level. Moving forward, the implementation of spatial and geographic databases within geographic information system (GIS[1]) now provides the baseline environment for the management of many OSRs.

Presently, SNG OSR mobilization operates in the context of an increasingly connected digital society, with heightened taxpayer expectations. The introduction of Big Data technology combined with advanced analytics and increased digital presence creates an opportunity to deliver significant improvements in the way SNG revenue systems operate and connect (OECD 2016b). In terms of tax base identification, aerial and satellite imagery have been game changers. The affordability of such imagery is now well within the means of SNGs. However, the extraction of useable data from the imagery generally requires the application of automated tools, which can be technically challenging and is an area where the SNGs will continue to require support.

SNGs in the developed world have long been using ICT to improve management efficiency and service delivery to citizens and businesses, and the developing world is now slowly making progress in this area. There is now emerging literature concerning technological applications to OSRs. This literature provides both theoretical and practical evidence on issues surrounding technological applications on revenue mobilization and illustrates international experiences, many of which have not been successful.[2] However, in general the introduction of information technology solutions is being regarded as a potentially transformative tool for strengthening local revenues and property taxes in particular (Kelly, White and Aanchal, 2020). Developing countries in Africa, Asia, and Latin America, are increasingly managing large volumes of data on taxable properties and taxpayers within the IT environment. The use of technologies has been playing a major role in improving outcomes, transparency and accountability through enhancements in property identification, data management, automation, billing, collection and enforcement (Prichard and Fish 2017). The rapid evolution of ICT with the advent of SMART technologies (smartphones, Internet of Things, big data, analytics, cloud platform, etc.) has provided renewed opportunities for optimizing subnational revenue management. Not only the technology has changed – the approach that SNGs take has also shifted, evolving from analogue to digital to e-government.

The objective of this study is to bring together various technological solutions in a structured way to present their key strengths and challenges for implementation in specific environments. In this way, the study seeks to provide World Bank task teams and their clients with basic tools and guidance regarding the use of technology applications to enhance OSR mobilization. To do so, the study documents existing and emerging technological applications to support OSR data capture, assessment, and administration. It draws on the experiences of World Bank projects and technical assistance in supporting the modernization of OSR systems in seven case studies.[3] Other international experiences are also referenced to complement the analysis and illustrate the available technological options. The analysis consisted of a secondary literature review and World Bank project documentation (see Annex 1) and was complemented by over 15 interviews with Bank teams, government clients and experts working on the topic.

The paper is structured in four sections: Section I covers the key literature review on the subject; Section II outlines the main technologies being applied to the OSR domain; Section III provides evidence of the use of the technological applications on a thematic basis within specific jurisdictions of the case studies; and Section IV presents the conclusions of the study.

Endnotes

1 GIS is an electronic software system that enables the creation of electronic maps that are geo-coded. It enables the management, analysis, and flexible presentation of textual data within a spatial context (Cusack, Bidanset and Fasteen 2018).

2 Examples include, "Technology and Taxation in Developing Countries: From Hand to Mouse" (Bird and Zolt, 2008); "Four innovations reshaping tax administration" (McKinsey, 2018); and "Technologies for Better Tax Administration: A Practical Guide for Revenue Bodies" (OECD, 2016) and "The Promise and Limitations of Information Technology for Tax Mobilisation" (Okunogbe and Santoro 2022)These papers provide a good analysis of technological applications in tax revenues and describe some of the challenges governments face with the application of technology to enhance local revenues.

3 The case studies are Punjab/Pakistan, Freetown/Sierra Leone, Zanzibar, Ghana, Kenya, Tanzania, and Colombia (See Annex 1).

Executive Summary

This study explores various technological solutions for enhancing own source revenues. It presents some of the most common options and outlines their key strengths and challenges for implementation in specific environments. The use of technologies has created opportunities for efficiency gains in several aspects of revenue management. These technological aspects can be categorized into three themes: (i) data capture and identification; (ii) assessment and processing; and (iii) integrated administration system. The study documents these three aspects, drawing on experiences from World Bank projects and technical assistance in supporting the modernization of OSR systems in seven case studies across Africa, Southeast Asia, and Latin America. The figure below presents an outline of the technological solutions covered in this study by theme.

Data Capture/Identification

- Remote sensing and high-resolution imagery (satellite/aerial/UAV/mobile mapping, and open-source imagery)
- Spatial data extraction
- Mobile surveying application

Assessment and Processing

- GIS-based data management
- AI/ML-based assessment
- Automated data processing (automated assessment and valuation)

Integrated Administration Systems

- Web-based OSR administration systems
- Integrated payment gateways
- Mobile/electronic payment solutions

Data Capture and Identification: The case studies show different starting points in terms of data collection, but despite this, the technological solutions used are standard. The common problem illustrated by the case studies is how to structure and update the existing databases to enhance OSR mobilization. Data collection has always been challenging for local governments in developing countries due to the lack of resources, inability to utilize mass data collection tools, and insufficient staff with skills to process and manage spatially-enabled datasets. The use of imagery and geospatial data along with the deployment of GIS has been central to all the case studies. They show that technology for data gathering and digital imagery combined with data processing is essential for establishing the base mapping, identifying the existence, and building footprints. Using mobile applications also improves the efficiency of data capture practices. This technology has been used extensively to provide the basic data building blocks and the spatial data infrastructure upon which all other data is built. To maximize the benefits of technology, clarity on the methodology for data collection is key. Once that is established, technology can make the data capture process more accurate and efficient and help to make the economic and political case for investing in the use of technological solutions. Establishing a robust data collection system is the first step for developing integrated assessment and administrative systems.

Assessment and Processing: OSRs require an assessment to determine the tax, charge, or levy to be collected. Technology can be applied in the assessment process by applying automated procedures. The level of automation for assessment can reduce complexity when dealing with a large amount of data. Technological solutions can automate value estimation using approaches such as a cost basis, comparative sales, and regression-based techniques, and utilizing emerging approaches such as AI/ML and spatial econometric mass appraisal techniques. In addition to these techniques, GIS has made the most important contribution to the valuation process through its ability to locate taxable objects and determine spatial characteristics. The major challenge identified in the case studies is how to embrace technology to automate the assessment process. One way to do so is by adopting simplified assessment procedures. In the case of the property tax, valuation methodologies can be difficult to apply if transaction evidence is limited and if under-declaration of prices is prevalent. In such cases where the property market cannot support a value-based property tax, an alternative such as the Unit Area method is a viable solution. The use of specific amounts or adjustment factors to reflect location, property use, age and condition can readily be built into an automated assessment system (Pakistan, Tanzania, and Sierra Leone). In this way, technology can automate simpler steps and combine them to generate tax assessments.

Administration Systems: Local revenue administration systems host the data collection and assessment activities discussed above. In a well-functioning system, data are collected straight into the administration system, and an automated assessment can take place either near real-time or on time-based processing as per needs. Furthermore, the system automatically generates demand notices, accepts payments through several electronic means, issues receipts, and supports enforcement and reporting. In addition, administrative systems are enabled to support reassessments and enhancements as legislation, software and technology evolve, thereby supporting change management processes and system updates. Administrative systems could also be spatially enabled to visualize geographic locations of a wide range of revenue sources. The rapid increase in the quantity of spatial and non-spatial data required to operate revenue administration systems provides a natural entry point for the use of technological solutions. The case studies show how administration systems, whether commercial off-the-shelf solutions (COTS) or custom-built solutions, have supported revenue administration effectively. A relational database that interlinks tables of non-spatial and/or spatial records is underpinning all the modern solutions. A common feature of the systems reviewed is the integration of a GIS component. The spatial dimension in revenue administration provides the capacity to locate taxable objects and visually display information.

Cross-cutting Themes: While this division of technologies by theme aids in mapping the suitability of the technologies for specific functions across the whole revenue stream, the technologies also cut across different themes, like GIS, which play a critical role in data capture, data processing and administration. Similarly, high-resolution imagery supports data identification and semi-automatic collection necessary to improve downstream processes, such as data analysis and revenue administration. As such, technological solutions should be assessed according to their complete functionalities. The two key elements that require close assessment in the selection of technologies include (i) training and capacity building in the use of specific technologies, and (ii) use of vendor-supplied proprietary software or the use of free open-source software (FOSS). In regard to the former, as technological innovations are rapidly advancing, SNGs have been struggling to keep up with these developments. Information and technology experts in the SNG public sector are scarce, and it is challenging to recruit and retain such staff. The latter involves FOSS, which has many advantages including a low dependency on proprietary technologies, no licensing costs and access to innovation and creativity from the open-source community. However, it requires a greater level of IT competence with higher-level skills, motivation, and commitment. Without the necessary skills and resources to utilize FOSS application, the cost of maintaining open-source technology or developing it to tailor fit the needs of SNG can be higher than commercial solutions. One key finding from the case studies is that the success of technological solutions for OSR enhancement also depend on non-technical considerations, such as commitment to revenue reforms, a full vision and plan for change management, and the political economy context in which the overall revenue reform is developed.

In terms of costs, decisions over the selection of specific technological solutions to enhance OSR must consider both the capital and operational expenses of each technology, as well as their expected benefits. The cost structure should detail the direct costs, such as hardware, software, licensing, system updates, acquisition of high-resolution imagery, and training, as well as indirect costs. These are primarily associated with field surveys for data collection/verification, which represent a high proportion of the total cost structure. Data on potential benefits (increased revenues) derived from specific technologies will then have to be compared with the costs to arrive at a technological solution that is economically suitable for a specific context. Contexts in which the expected benefits are high may opt for more costly solutions than those in which realized benefits, either because of a weak tax base or political economy considerations, will not cover the total costs.

While the initial infrastructure and system development may be funded by international assistance or central government support, the operational cost of the system and overall tax administration cost must be covered by the additional revenues deriving from the use of the system. Generally, in developed countries the benefits from the use of technological solutions are tens and sometimes hundreds of times higher than the costs (Holland, Korea, Canada, Australia, etc.). However, in developing countries with incipient tax bases, the cost of adopting certain technologies and administering an IT revenue system could be higher than the collected revenue. To avoid this situation, policy changes may be implemented to ensure that the potential revenue can cover these costs. Alternatively, it may be necessary to choose simple and cost-effective administration solutions with an appropriate package of technologies that are affordable and appropriate for that taxing jurisdiction at a specific point in time. However, these packages should have the potential to evolve over time as the revenue potential is captured and realized.

Literature Review on the Application of Information Communication Technology for OSR Enhancement

SECTION

I

The possibilities of information communication technology (ICT) seem limitless. It can provide governments, businesses, and citizens with access to relevant information, facilitating informed decisions through communication and enabling more efficient processes and services (Asian Development Bank, 2010). ICT is a transformative tool that can support SNGs in their efforts to more efficiently administer their OSRs. It is transforming the ways SNGs interact with citizens and deliver services (World Bank 2016). Technology is advancing exponentially and becoming increasingly affordable, providing a clear enabler for transformation in public service delivery. For revenue administration, technologies are challenging how SNGs think about their business and critically look at whether their services and business models are sufficiently aligned to support revenue administration in the twenty-first century (OECD 2016a).

Technologies such as the internet, portal solutions, social media, mobile platforms, cloud computing, aerial imagery, artificial intelligence, machine learning and Big Data are creating new opportunities for the way SNGs approach their revenue administration (OECD, 2016b).[4] Adapting to this new environment requires SNGs to embrace business processes that are strongly data-driven and that render them more agile in responding to the changing expectations of taxpayers. Digital and automation technologies can help maximize revenues of already-existing revenue streams and identify untapped revenue Technology can access this hidden revenue by providing more efficient discovery and faster revenue collection.

The use of ICT can facilitate more transparent and accountable revenue generation systems that benefit both government and taxpayers (Canares, 2016). Revenue systems, particularly in developing countries, are often characterized by frequent in-person interactions between revenue officials and taxpayers. Limited ICT applications and services create an environment that is more vulnerable to corruption, both in terms of collusion between revenue collectors and taxpayers to evade taxes, as well as extortion of taxpayers by revenue officials. Traditionally, local resource generation through taxation systems consisted of manual assessment, processing, collection, and reporting, making it susceptible to subjectivity, arbitrariness, and corruption. This adversely affects the capacity of local governments to raise funds and discourages local investment. These manual systems also typically incur in high costs, further discouraging compliance. In Kenya, for example, county governments lost millions of shillings through fraud and errors related to manual procedures, until the adoption of automated systems (Karimi et al., 2017).

1.1. ICT to Improve Tax Administration

Several studies have shown that weak SNG administration has been a core reason for poor revenue performance (Kelly, 2014; Kelly and Musunu, 2000; Fjeldstad, 2006; McCluskey and Franzsen, 2005). Revenue administration is often weak in several ways, including ineffective data collection and management, lack of data sharing, reliance on manual, paper-based systems, poor billing and collection practices, and weak enforcement (McCluskey et al., 2017a). The continued reliance on manual administrative systems supported by the use of paper-based demand notices, receipts, and handwritten ledgers leads to high collection costs, fraud and corruption, underpayment, revenue leakages, and inefficient data management (Prichard, 2014; Fjeldstad and Heggstad, 2012). SNGs that operate manual recording and inventory systems of properties and taxpayers struggle to maintain their data, given the large number of properties and taxpayers involved (McCluskey et al., 2018a). The manual operation neither enhances administrative transparency nor promotes taxpayer compliance. Creating a sustainable tax administration system that can administer OSRs efficiently and cost-effectively is a goal shared by many SNGs around the world.

Embracing information technology is now well accepted and becoming more entrenched at the subnational level. The computerization and digitization of revenue departments contributes to good financial governance and improves the accountability and transparency of revenue departments (OECD, 2016a). Digitization of records using spreadsheets and databases is an initial step forward and away from the more traditional analogue procedures. The provision of digital services through, for example, electronic demand notices (via the internet and mobile phones) and payment platforms are revolutionizing the interface between taxpayers and service providers. The use of a range of e-services and e-payment options simplifies and expedites the payment of taxes and fees, thereby reducing compliance costs (Bird and Zolt 2008). Other benefits of the use of ICT include better management of tax base and taxpayer data, faster processing of information and data, fewer and reduced collection costs, and more accurate tax billing (McCluskey et al., 2017 and 2018b). In addition, more comprehensive and complete databases improve the ability of revenue authorities to undertake tax compliance analyses and enable more accurate revenue forecasting.

Thus, revenue administrations at the sub-national level are increasingly looking to ICT as a potential game-changer to enhance revenue performance. The deployment of digital technologies has spread quickly and now GISs have become an essential infrastructure component for revenue enhancement, used for property identification, verification, and assessment in many countries (Namangaya, 2018, Fosu and Ashiagbor, 2012). Research into the role and impact of ICT on revenue administration has revealed positive effects. Fosu and Ashiagbor (2012) provide evidence of this in Ghana with the introduction of the Local Government Revenue Mobilization System: an integrated GIS that provides information on revenue potential, revenue leakage, and automating revenue administrative processes. Similarly, Fish (2015) showcases how ICT created administrative efficiencies and improved revenue collection in Sierra Leone and Malawi. Kampala Capital City Authority (KCCA) in Uganda is also a good example of improving revenue administration (Kopanyi, 2015) through the implementation the e-City program for easy registry and payment systems and simplification of revenue processes (Kopanyi and Franzsen 2018). Research by Otieno et al. (2013) in Homa Bay, Kenya also found a strong correlation between the deployment of the revenue information system and improvements in OSR collection.

1.2. Data Collection, Management, and Privacy

The digital nature of modern data calls for digital infrastructure—a prerequisite for collecting, exchanging, storing, processing, and distributing data (World Bank, 2016). Revenue departments are data-rich organizations. At the most basic level, there are more potentially useable data in the revenue departments than SNGs have the capacity to handle. There are several noticeable trends in revenue-related data, including (i) the movement from analogue to digital, which has produced a massive amount of data—but often the data is not widely shared between institutions; (ii) mobile devices facilitate access to critical information in real-time, which can enhance problem-solving abilities; (iii) social media provides opportunities for community engagement in the coproduction of city services; (iv) the recent advances in artificial intelligence (AI) provide vital support in rapid data collection in 2D and 3D formats, semi-automated data updates on a large scale, and analysis of larger and deeper data; and (v) cloud computing and open-source systems allow workers in one city to benefit from applications developed in another city, provided that sharing protocols are in place.

The information available to SNGs is collected in various ways ranging from manual field surveys to satellite/aerial imagery interpretation and metering devices (see Box 1). A comprehensive and holistic approach to sourcing, producing, and managing data is central to better support revenue collection. Presently, the digital revolution generates exponential growth in data flows, creating a shift towards what is now known as Big Data. This refers to data collected from a large variety of sources, including the internet, social media, sensors, text messages, video, images and audio files, as well as other often unstructured sources (OECD, 2016b). SNGs are increasingly collecting big volume of data for their revenue management processes. However, these systems are often overwhelmed and face challenges in effectively managing its storage, processing, and data analysis.

BOX 1.

Options for Data Collection

Field Data Capture – The use of mobile technology to improve the effectiveness and efficiency of property (land and buildings) information captured in the field through direct measurements or GPS coordinates.

Desktop Data Collection – Deployment of tools and applications that facilitate a comprehensive approach to imagery interpretation (e.g., recognizing, identifying, locating, measuring, and extracting features) and digitization through desktop-based processing. Remote sensing data, such as high-resolution satellite imagery, aerial images and Light Detection and Ranging (or LiDAR), are popular sources of extracting OSR-related data remotely.

Data Analytics and Intelligence – Consideration of leveraging property information available from the government sources such as Ministry of Lands, Land Registration, national statistics agencies, and street address data, as well as sources of secondary data that can be evaluated, filtered, and connected to the primary data.

Hybrid Approach to Data Collection – A mix of data collection options (e.g., data analytics, desktop data collection and field data capture) to produce different types of data based on requirements and characteristics of the data obtained. For instance, desktop review or data intelligence solutions can inform the surveys, optimize and simplify the scope, and reduce workload in the field.

Treasury Management Systems as Point of Sale (POS) – Data collection through treasury management systems on payment amounts, payment type, timing of payments, arrears status and compliance. This data collection is called ‘passive data collection’ as the payers don’t have to take action on data gathering operations. Passive data can be utilized to better treasury management and analytics.

Data collection methods have been revolutionized and SNGs have opportunities to access information remotely from aerial and satellite imagery. This is particularly useful in the case of static objects, such as land and buildings, as processing such imagery provides rich data upon which several OSRs can be leveraged. Ayalew and Deininger (2016) demonstrated how remote sensing data can be used to extract or measure the height of buildings, which proved useful for the assessment of property taxes, estimation of floor area, and types of construction materials. Jain (2008) acquired socioeconomic attributes, roof material, shape and structure of buildings, and the age of construction from high-resolution imagery for property taxation. The various methodologies that comprise remote sensing can provide a solution to mass data collection for land and buildings (parcel size, built-up area, improvements, shape, and type/style of properties) and external factors (accessibility, neighborhood, land use, environment, and utilities). However, such remote sensing techniques can be expensive and require significant data processing and skilled technicians to extract the relevant information. Costs, the availability of experienced staff, and government commitment will be determining factors in its deployment.

The management of large quantities of data brings to SNGs the additional challenge of data privacy and cyber security (World Bank and United Nations, 2017). Digital information security is recognized as a critical risk, with a growing awareness that SNGs should ensure that the privacy and integrity of data and sensitive information is protected. The need to be alert to new vulnerabilities and the potential for external attacks on infrastructure and data is a recognition of the value of information. Cyber security incidents that impact confidentiality, integrity, or availability of information on assets present a serious threat to governments. As such, both sub-national and national governments are responsible for establishing trust in the data ecosystem for personal and nonpersonal data. This is done by ensuring the security of the network infrastructure and data flows through ramping up data protection. Information security and data protection require capacities that are often beyond those observed in SNGs in developing countries.

1.3. Limitations on the Role of ICT

Despite evidence on the benefits of adopting ICT solutions for revenue administration, there are also cases in which ICT administration projects become complex and expensive. For example, the start-up cost of implementing value-based property tax systems or a computer-assisted mass appraisal (CAMA) system could be high. They require collecting reliable data on properties (land and buildings) and sites (utilities), sales, and other pertinent market information that is often expensive or not available due to the lack of functioning and transparent real estate markets. It is therefore important for revenue departments to properly analyze available sources, data, capacity, legal frameworks, and forward-looking strategies, amongst others. The business case for introducing ICT to undertake mass appraisal or improve OSR collection should be based on sound analysis and a detailed appreciation of how and where the benefits will arise. Keen (2012) rightly concludes that there are no quick fixes. ICT solutions must be fit-for-purpose, and often, simple systems are more appropriate options (Prichard and Fish 2017).

The available literature suggests that the positive impacts of ICT systems on revenue administration require an enabling environment. This encompasses both an appropriate commitment to providing training and necessary facilities within the administration, and an external enabling environment such as a functioning judiciary and the general rule of law. It also requires functioning utilities, notably electricity and internet facilities. In addition, the effective management of OSR requires system integration among different departments (land management, urban planning, building permitting, etc.) that are often protective of their data. This leads to inefficient use of resources and can create administrative bottlenecks. Without these basic factors in place, the technology will fail to operate effectively. Furthermore, a considerable behavioral obstacle could be present, as many stakeholders may want to maintain the status quo. Meeting and overcoming these challenges requires commitment, perseverance, persuasive advocacy, and strong leadership, without which any process of change will be beset with delays and objections, derail and ultimately fail to achieve its potential (Okunogbe & Santoro, 2021).

Endnotes

[4] See also an upcoming Bank publication on this: "Junquera-Varela, Raul Felix; Lucas-Mas, Cristian Oliver; Krsul, Ivan; Calderon Yksic, Vladimir Omar; Arce Rodriguez, Paola. 2022. Digital Transformation of Tax and Customs Administrations. Equitable Growth, Finance & Institutions Insight; © Washington, DC: World Bank. Digital Transformation of Tax and Customs Administrations.

Technologies Used for Revenue Enhancement Activities

SECTION

II

2.1. Introduction

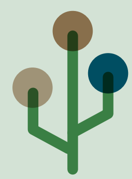
The use of technologies has created opportunities for efficiency gains in several aspects of revenue management. These technological aspects can be categorized into three themes: (i) data capture and identification; (ii) assessment and processing; and (iii) integrated administration systems (see Figure 1). This division of technologies by theme helps map out the suitability of the technologies for specific functions across the whole revenue stream; however, these technologies cut across different themes, too. GIS, for example, plays a critical role in data capture but also in data processing and administration. This section describes each identified technology, while Section III covers specific cases and technological applications for OSR enhancement by theme.

FIGURE 1.

Mapping of Technologies by Theme

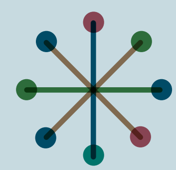
Data Capture/Identification

- Remote sensing and high-resolution imagery (satellite/aerial/UAV/mobile mapping, and open-source imagery)
- Spatial data extraction
- Mobile surveying application



Assessment and Processing

- GIS-based data management
- AI/ML-based assessment
- Automated data processing (automated assessment and valuation)



Integrated Administration Systems

- Web-based OSR administration systems
- Integrated payment gateways
- Mobile/electronic payment solutions

2.2. Data Capture and Identification

Remote Sensing and High-resolution Imagery. Remote sensing captures the physical properties of a geographic area/location without having to be there. This technology provides an "eyes in the sky" as opposed to a "feet on the ground" approach, although the latter is still important for ground truthing activities. It allows users to capture, visualize, and analyze objects and features (such as buildings, parcel boundaries and roads) on the surface of the earth. It provides a picture of a specific resolution, called raster data, captured at a specific point in time. Every day, millions of images are generated from space by an ever-growing number of satellites. Satellite imagery enables regular remote monitoring of the situation on the ground across many different aspects, such as changes in urban density and built-up areas. Earth observation data offers invaluable insight that informs policy decisions and ultimately solves problems.

Remote sensing uses sensors to capture an image. Satellites, airplanes, unmanned aerial vehicles (UAVs), and mobile mapping have specialized platforms that carry sensors. Each type of sensor has its own advantages and disadvantages. Several factors should be considered depending on the type of imagery to be captured, such as flight restrictions (for UAVs there may be restrictions on the height of the flightpath and no fly zones), image resolution, acquisition time and coverage. Each type of sensor is suitable for specific conditions. Satellites, for example, capture data on a global scale, while drones are a better solution for flying in small areas, and airplanes and helicopters fall somewhere in the middle. Other specific advantages and disadvantages of different applications are outlined in Table 1 below:

TABLE 1:

Advantages and Disadvantages of Various Remote Sensing Applications

TYPE	ADVANTAGES	DISADVANTAGES
UAV	Very high-resolution imagery, programmable flight paths, fast delivery, easy to capture locally, ideal for regular data updates	Small coverage, visible line of sight, short flying time, time-consuming image processing, operational risks (injury and collision)
Mobile mapping	'Street view' availability using LiDAR[5], fast data acquisition, very high resolution and accuracy, ideal for complex and dense areas	Complex post-processing to integrate with revenue system
Airplane	Pilot-flown flight paths, ideal for large cities	Coverage limited to pre-planned flight paths, complex technical requirements (flight permits, sufficient ground control points, area screening, etc.), requires clear weather for effective photography
Satellites	Large coverage, frequent image captures, ideal for remote and difficult places, wide availability due to various commercial providers	Coverage limited to orbital paths, cloud distortions, limited temporal resolution

By January 2021, there were around 6,542 satellites[6] in operation, of which 906 are used for observation of the Earth. Of the numerous available satellites, some of the most well-known include WorldView-1/2/3/4, Kompsat-2/3/3A, Landsat-7/8, Pleiades-1A/1B, Rapideye, and Sentinel. Satellite imagery has become more affordable given the level of competition between vendors. Data is priced per-square-kilometer based on the size of the area and the spatial resolution required.

When it comes to imagery, resolution is very important. High spatial resolution means increased detail and a smaller pixel size. Lower spatial resolution means less detail and larger pixel size. A pixel size is simply the pixel resolution (pixel = a single point in a raster image) that refers to the actual area covered on the ground. For example, a 30cm pixel resolution means each pixel in the image covers a square of 30cm x 30cm dimensions on the ground. Typically, UAVs can capture images at some of the highest resolution levels, around 10cm. Even though satellites are highest in the atmosphere, they are capable of 30cm to 50cm resolution.

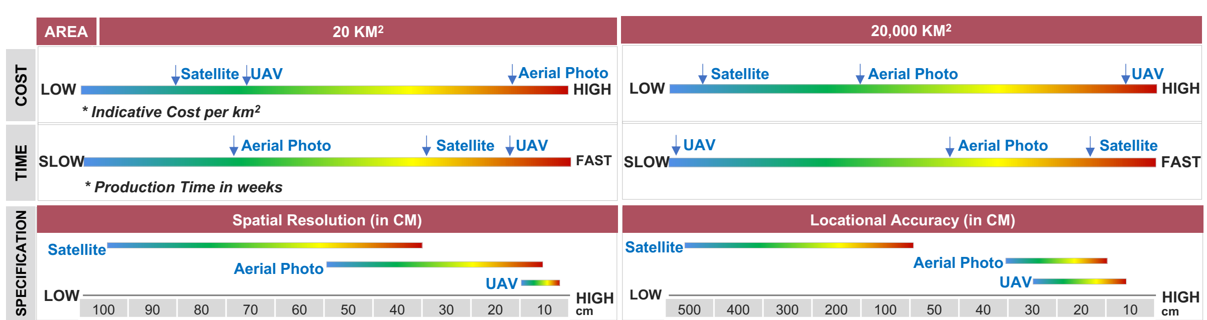
The choice of whether to use satellite, airplane, mobile mapping, or UAVs largely depends on the scale and objective of the project. Satellites are suitable when a large amount of data over a vast area must be quickly gathered. Drones are a reliable alternative when it comes to gathering information with high resolution for smaller areas. Research by Koeva et al., 2021 tested three different remote sensing technologies for valuation for taxation purposes (aerial images acquired with a digital camera, WorldView2 satellite images, and UAV images) and found that UAVs have the highest potential for collecting data to support property valuation for taxation. This is because of the need for accurate and up-to-date information.

BOX 2.

Technical Tips for Selecting Imagery Source and Indicative Cost Structure

Parameters for the pricing of imagery include source of imagery, geographical area, license options (subscription versus permanent use, number of authorized entities or projects), spatial resolution (ground sample distance (GSD) or size of a pixel), temporal resolution (previous data from an image archive versus a new collection image), spectral resolution (multispectral or panchromatic), and radiometric resolution (bits per pixel). The first four are the major parameters for pricing of such imagery. Calculating unit cost per km2 is a typical approach to decision-making, while the unit cost can vary significantly based on the volume of imagery acquisition orders. All discussions of cost are necessarily relative to the current capacity of staff, availability of equipment and pricing structures in place for different options, which vary according to location, product delivery time, and scale of operation.

AREA	20 KM^2	100 KM^2	1,000 KM^2	20,000 KM^2	80,000+ KM^2
Indicative Cost per km^2					
Satellite Imagery	$	$	$	$	$
Aerial Imagery	$$$$$	$$$$	$$$	$$	$
UAV/Drone Imagery	$	$$	$$$$	N/A	N/A
Production Time in Weeks					
Satellite Imagery (new collection)	4	4	4	8	24+
Aerial Imagery (including preparation)	10	10	10	20	40+
UAV/Drone Imagery (including post-processing, production time can be reduced by number of UAVs)	2	13	120+	N/A	N/A



** The figures may be varied based on the ground condition, available control points, and other technical elements.*

The below comparison table provides guidelines for selecting license options based on the purpose of the imagery, available budget, and maintenance period.

TYPE	ADVANTAGES	DISADVANTAGES
Subscription	• Acquires the latest images during the contract period (imagery is available for download 20 days from the collection date) • Affordable • Convenient image clipping • Multiple user access • Orthorectified imagery	• Requires effort to search for proper images from the imagery archive • Additional management work - human capacity and resources - image processing system (S/W, H/W) • Internet connection to download images - size of a snapshot image: a few MB - size of an entire scene: 100+ MB • No guarantee of clean cloud coverage
Permanent Use	• Ready for immediate use • No internet connection required • Shared by files • Guarantee clean cloud coverage (0-15%) • Permanent ownership • Available for geoportal base map • Orthorectified imagery • Easy to produce mosaic images	• Relatively high cost compared to the subscription license option • No imagery updates • Potential time gap between imagery acquisition and field usage

Open-source imagery. The open-source policy adopted by the European Space Agency, NASA, the U.S Geological Survey, and numerous new fleets of small commercial satellites have resulted in an exponential growth in the availability of Earth observation data. There are now many open sources of satellite data available. Providers of open data allow different levels of free access, including viewing and downloading options for data processing. However, most of the free satellite data available is either dated or of low resolution. In addition, open-source imagery may not fit mapping products that require precise georeferencing due to its positional shifting issues. There has been rapid development in providing free virtual mapping within a certain number of map views and service transactions through satellite imagery; these are available through many sources like Google Earth, Nokia's Here, Microsoft's Bing Maps, Flash Earth, Apple's iOS 3D Maps, Skyline Globe, and many more.

However, data for property tax administration that covers a large area often requires high-resolution satellite imagery that can be costly. It also often requires a high level of expertise. As such, sharing the imagery among different levels of government is a cost-effective solution. For example, if a government's land administration authority acquires aerial imagery on a regular basis, this could be shared with other departments and SNGs. As the market matures, efficiencies can also be garnered from utilizing volume pricing policies and memberships. Cost can be determined based on utilized map loads rather than predictive purchasing or subscriptions, which may not be justifiable particularly early in the technology development cycle.

Spatial data extraction and change detection. The potential of spatial data is growing rapidly, with innovations in data science, cloud computing and other methods for processing unstructured spatial data. Data analysis technologies through computer vision have accelerated large-scale mapping for real estate properties (e.g., buildings, land parcels and other structure objects) by automating parts of the process (Mayer, 2008). The effective tools and models for image segmentation include pixel-based clustering[7], object-based support vector machines (SVMs)[8], convolutional neural networks (CNNs) and U-Net architecture[9], and edge detection. Many parcel boundaries coincide with physical objects such as buildings, roads, fences, fields and rivers, and the boundary lining and corner points produced by these objects are detectable in modern high-resolution satellite images, aerial photography or point clouds. Computer vision approaches have been used to detect and extract these objects with high accuracy and efficiency in OSR contexts. Automated spatial data extraction technology requires minimal human intervention, reducing field surveying needs and costs for revenue-related data capture and identification.

SNGs are also investing in change detection, another critical remote sensing application. Image-to-image change detection is the comparison of multiple images, typically collected for one area at different times, to determine the type, magnitude, and location of change. For example, changes can occur because of new property developments within urban areas. Quickly urbanizing areas can be mapped efficiently using UAVs given the relatively small areas involved. With high resolution imagery and computer vision analysis, small changes to buildings, such as extensions and alterations, can be easily detected.

Mobile surveying application. Many SNGs are merging the use of imagery and mapping with mobile surveying applications. They are seeing the benefits of using mobile technology to enable more efficient information capture in the field. The use of smartphones and tablets has become prevalent for property tax purposes, like streamlining and improving field data collection. Tablets are typically provided with GIS mapping and data collection software linked to a central server for data exchange. The imagery can be viewed on the mobile device with the ability to confirm or deny the presence of a taxable object, add or confirm details such as type of use and construction, or identify or confirm boundaries. With the use of online questionnaires, key contact information can be entered directly on site, along with dimensions of the property and photographs. Where the imagery is lacking, mobile devices with a GPS module can be used to allocate spatial co-ordinates for structures on the ground, which can be collated into a fiscal cadaster and subsequently incorporated into a spatial database. This ability to survey on the ground using mobile device-based applications massively improves the efficiency of data collection in the field.

2.3. Assessment and Processing

GIS-based data management. GIS technology has emerged as a powerful set of tools for managing and analyzing spatial data (data tied to a specific location or building on the ground). In simple terms, a GIS can be described as an integrated framework that combines hardware, software, and spatial and non-spatial data for the purpose of capturing, managing, analyzing, and displaying all forms of geographically-referenced information. A GIS allows the user to view, understand, question, interpret, and visualize data in ways that reveal relationships, patterns, and trends in the form of maps, reports, and charts. The GIS answers questions and solves problems by presenting data in a way that can be visualized, quickly understood, and easily shared.

SNGs collect large volumes of spatial and non-spatial data as part of their function. GIS helps transform this raw data into a form that is useful for analysis and decision making and that provides an interactive interface for citizens. Geospatial data is essential when it comes to answering spatially-dependent questions that have an impact on revenue management. As open data usage becomes more widespread, SNGs can make their spatial data available to the public through web-based services. This allows the public to view parcel and building information such as property records and parcel and building boundaries. The deployment of GIS within SNGs is growing internationally as SNGs recognize the value of the geospatial data they hold. However, there are barriers to overcome, such as the lack of trained staff, restricted finances, limited capacity, absence of data and process interoperability within the institutions, and inadequate support for developing and maintaining GIS infrastructure. These issues, along with a lack of awareness of the potential of GIS, can make the integration of GIS into SNG administration extremely difficult (Namangaya, 2018).

AI/ML-based assessment. Artificial intelligence (AI) refers to “the science and engineering of making machines intelligent, especially intelligent computer programs”[10] with intelligence defined as “that quality that enables an entity to function appropriately and with foresight in its environment.”[11] More comprehensive definitions consider AI to mean all computer systems that can continuously scan their environment, learn from it, and take action in response to what they sense, as well as to human-defined objectives (World Bank, 2020). The last decade has shown significant technological advances in the AI domain, predominantly due to increases in computing power, communications networks, data storage, big data, and the Internet of Things, as well as in the remote sensing domain, such as the increased use of high-resolution imagery and street view imagery. Machine learning (ML) is the most common form of AI used in building footprint extraction. AI-enabled machines, computer vision, and algorithms recognize patterns in given data (training datasets) and then use these patterns to identify and detect the boundaries of buildings.

With vast amounts of data becoming available, AI is likely to disrupt the traditional way of property data assessment and processing. These technological advances have led to an exponential increase of revenue-related data that bring more cost-efficient solutions and provide up-to-date information on property taxes, fees, and charges. Organizations such as the International Property Tax Institute (IPTI) and the International Association of Assessing Officers (IAAO) are at the fore in critically evaluating AI solutions and developing standards and codes of practice. IPTI’s 2021 white paper on the “Potential of Artificial Intelligence in Property Assessment” provides a framework to produce a standard on the use of AI in property assessment administration (IPTI, 2020). The IAAO (2022) paper “A Review of the Methods, Applications, and Challenges of Adopting Artificial Intelligence in the Property Assessment Office” delivers an introduction and overview of AI through several cases and pilot studies and a review of relevant analytic methodologies. The paper looks at the changing role of valuers and assessment administrators and the evolution of valuation offices where AI will be used to improve operations, value estimates, and administration.

Automated assessment technologies. The use of automated assessments is becoming more widespread, particularly for OSRs. The nature of automation is that traditional manual processes are replaced by digital processes that automatically analyze and/or standardize calculations from stored data. Both revenue streams require an assessment to reflect the specific circumstances. The property tax could include the type of property and its size, and for the business license, this could be the type of business, location and number of employees. Simplified assessment models are developed based on objective criteria such as the area of land and/or buildings. Other criteria can be added into the assessment model such as location, age, presence of amenities, etc. The strength of this approach is that the underpinning model has a fixed structure. This makes the automation of the model relatively simple and with such automation, the assessment of large numbers of subject objects can be done quickly. The principal advantage of this technology is that the characteristics on which the model is built are transparent and straightforward to verify. The model structure, as previously mentioned, is fixed and is in a format that can be easily explained to the taxpayer.

2.4. Integrated Administration Systems

Web-based OSR administration systems. Single administration platforms that integrate previously siloed information from multiple departments and automate records and management processes, increase the SNGs internal efficiency. Key to the success of such systems is the move from paper-based administration to digital solutions. Technology has dramatically impacted the way in which organizations handle documents and data. Several SNGs around the world have moved to web-based OSR administration systems, which provide a convenient and efficient way to improve revenue collection, increase transparency, and manage their multiple revenue streams (Fish, 2015).

The integration of aerial/satellite imagery within the administration system is fast becoming a standard component of revenue systems. The imagery does not only ease the identification of the tax bases but adds greater visual and analytical power by using either proprietary or open-source GIS software (Knebelmann, 2022). In terms of revenue administration, GIS provides the revenue department with spatial tools to visually display textual data such as payments received, arrears by individual property/taxpayer, type of property (residential, commercial, and industrial) and supporting revenue budgeting. Integrating GIS with the conventional revenue management system or management information system (MIS) leverages the significance of geospatial data for OSR administration to record, view, and analyze data.[12]

Technically, GIS-based MIS could be designed to handle all types of revenue streams, dealing with registration, assessment, collection, accounting, debt management, auditing, tax monitoring, and reporting. A great strength of integrated revenue management systems is the ability of the system to cover different revenue processes, including automatically generating tax bills to be mailed manually or electronically. In this way, payment can be automatically chased via reminders using mobile messaging, payment can be automatically received, reconciled, and receipted, and enforcement notifications can be automatically generated when payment is in default (Sausi et al., 2021). In addition, reports can be generated automatically to provide business management information at different levels. This provides rapid business intelligence to the revenue function, allowing key performance indicators to be established and performance to be monitored. The system can also incorporate an internal audit functionality with controls and records to changes made to the accounts. Functions such as these provide accountability, minimize fraud, and facilitate revenue forecasting.

In terms of costs for developing OSR administration systems, it would not be easy to estimate a price as many variables are involved and web application technologies evolve rapidly. In general, a GIS-based MIS on a COTS basis designed to deal with all the administrative tasks (enterprise software) related to own source revenues can be several million US dollars or more, plus annual maintenance and periodic upgrades. Development costs for a bespoke GIS-based MIS would be two times more than a COTS based on the size of software functionality. Investment in hardware and IT equipment can cost more than the application development. The costs for system maintenance are not easy to estimate, but they are a key element when designing the initial investment and considering options for any rollout/scaling up. As a ballpark figure, the costs of maintenance and updating usually range from 5 to 10 percent of the initial system investment cost. See Annex 2 for more details on sequencing the development of OSR administration systems and Annex 3 for guidelines on calculating the total cost of ICT ownership.

Integrated payment gateways. A direct linkage between the banking sector and OSR administration systems is a noticeable trend in the OSR technology domain. This allows taxpayers to make payments through specific banks either in person or online, using integrated payment gateways and cross platform services. Integrated payment gateways have become widespread with the advances in e-commerce and offer a variety of hosted and self-hosted application programming interface (API) based solutions. API-based self-hosting allows a revenue department freedom to tailor the customer experience and facilitates a range of payment types. An alternative approach is a cross platform link, usually to the payment gateway of an approved bank. While this ensures that the responsibility for handling the money remains with the bank, the transaction is not seamless and integrated, as this requires the taxpayers to leave the departmental website to complete the transaction.

Launching the payment gateway solution depends largely on the capacity of the SNG and ICT departments to operate secure payment systems and on the overall central regulatory framework, including payment guidelines, accounting procedures, banking regulations, etc. Regardless of the option selected, these systems are crucial to facilitate online payments. Money flows from citizens and businesses to the SNG that typically includes transactions such as taxes (property taxes, sales' taxes, etc.) and fees (parking fees, business licenses, building permits, fines, etc.). An integrated payment gateway platform is an important target for modernization, as payments for services are at the heart of SNG economic activity. By digitalizing the administration and collection, SNGs can both increase revenue collection and generate savings due to increased operational efficiency.

Mobile and e-payment solutions. Mobile and e-payment services have exponentially increased over recent years due to the increase in smartphone penetration and mobile access to the internet from a technical perspective. Mobile subscriptions with broadband capability (3G or better) reached 83 subscriptions per 100 people globally in 2021 (74 subscriptions per 100 people in developing countries) (International Telecommunication Union, 2021). Electronic payments have enabled countless innovations that advanced financial access and inclusion for people, businesses and governments through improved transparency, efficient transfers, and reduced fraud and risk. For the OSR domain, SNGs benefit from expanding the tax base through formalizing collection, shifting payment behaviour to mobile and electronic methods, and reducing leakage.

Notably, the evolution of mobile money contributes to the enhancement of OSR performance, along with the matured technologies related to mobile networks, banking and billing systems, and point of sale (POS) devices, among others. Mobile money is an electronic wallet service that allows users to store, send and receive, cash-in and cash-out money, and make small payments using their mobile phones. An increasing number of countries and cities, mainly in Africa and Asia, are enabling citizens to pay their taxes and fees through mobile money; examples include Kenya, Mauritius, Rwanda, Tanzania, Uganda, and Philippines. In these countries, tax payment via mobile money is not marginal; in Tanzania, for example, 7.2 percent of total tax revenue was paid via mobile money (equating to TZS 890.1 billion or US$ 407 million) in 2015/16 (GSMA, 2021). Mobile money in low-income cities brings several benefits both to citizens and SNGs. It offers increased convenience to citizens by reducing distances traveled and loss of time in queues at tax offices and banks. As such, mobile money services remove barriers to compliance and reduce tax avoidance. A unique transaction code is generated through the mobile money service provider whereby both government and taxpayers can trace the payment history through the mobile money platform. This enables expansion of the taxpayer base by reaching citizens that live in informal settlements (people do not need to have an address or smartphone to have a mobile money account), thereby bringing citizens without a history of paying taxes into the payment regime and moving people and businesses from the informal to the formal sector. In addition, by eliminating cash payment and intermediary agents, this system increases transparency, traceability, and real-time control, meaning that mobile money helps SNGs fight fraud and corruption. All of this contributes to significant increases in municipal revenue and strengthens SNGs' financial capacity to provide quality services.

Endnotes

5 LiDAR (light detection and ranging) is an optical remote-sensing technique that uses laser light to densely sample the surface of the earth, producing highly accurate 3-dimensional measurements. LiDAR produces mass point clouds that can be managed, visualized, analyzed, and shared using a GIS application.

6 Union of Concerned Scientists, https://www.geospatialworld.net/blogs/how-many-satellites-are-orbiting-the-earth-in-2021/

7 Pixel-based clustering is a traditional approach that decides what class each pixel belongs in on an individual basis. It does not take into account any of the information from neighbouring pixels.

8 SVMs are supervised machine learning methods used for classification, regression analysis and outlier detection.

9 As a type of CNNs, U-NET performs semantic segmentation of images by predicting the image pixel by pixel through an encoder network followed by a decoder network. U-NET has the ability to learn in environments of low to medium quantities of training data, it is widely used recently at fast and precise segmentation of satellite imagery.

10 Definition attributed to Professor John McCarthy in 1956. Quoted in Moor, James. 2006. "The Dartmouth College Artificial Intelligence Conference: The Next Fifty Years." AI Magazine, Volume 27 Number 4, pp 87–91. https://pdfs.semanticscholar.org/d486/9863b5da0fa4ff5707fa972c6e1dc92474f6.pdf.

11 One Hundred Year Study on Artificial Intelligence (AI100). "Defining AI." Stanford University. ttps://ai100.stanford.edu/2016-report/section-i-what-artificial-intelligence/defining-ai.

12 GIS is a georeferencing tool that can be integrated into the broader Management Information Systems (GIS) for spatial visualization and analysis. However, due to the technical advances in database and system architecture where textual and spatial datasets are converged and interact as one source, the boundary between MIS and GIS has become vague.

Thematic Case Studies

SECTION

III

3.1 Thematic Case Study 1: Data Capture and Identification

Key Challenges

Manual approaches to building local revenue bases are no longer a sustainable solution. A primary element of OSR mobilization relates to the establishment of the base against which the revenue is to be raised, either for the first time or for the expansion and updating of an existing base. This identification of the revenue base applies to all OSRs, such as taxes, fees, levies, and charges. In the case of property taxes, the overriding issue regarding the completeness and accuracy of the revenue base is the time and cost involved in conducting land and building surveys, especially if this is done manually. Traditional manual approaches to establishing a tax base are costly both in terms of time and resources, often requiring many thousands of individual surveys. The Bangkok Metropolitan Area, for example, estimated in 2020 that it would take four years to complete the property surveys if they were undertaken manually without modern IT approaches.[13] Inefficient data capture overwhelms both financial capacity and political capital against an unrealized tax gain that may take years to materialize. The challenge then is how to gather and maintain data in a timely and cost-effective way to provide a sufficient return on the initial investment. Existing databases, particularly for large urban areas, become increasingly outdated due to urban sprawl, demographic change, and overall economic trends. In this context, technological advances offer the opportunity to capture information at scale and speed and also to automate processes for data collection, management, and quality control.

Data capture includes both objective and subjective elements. Data capture to establish the tax base involves identification on the ground of taxable objects, activities, and events. The data requirements vary considerably and involve the collection of both basic, objective information and of more complex information that requires a degree of judgement and professional opinion. Objective data covers an object or occurrence, such as the existence of a building, an advertising panel, a telecom mast or a business. The collection of objective data is straightforward and can often be automated and grouped in a binary structure of yes or no answers (e.g., is there a parcel of land, is it idle or does it have fixtures, etc.). The second type of data capture is more nuanced and involves an element of discrimination regarding the nature of the subject; for example, in a situation where there are multiple owners, who is the legal taxpayer? How is the use of a building defined? What is the quality of the construction? Some of these aspects are discoverable while others involve a judgment or creation of ordinal categories (e.g., condition – good, average, poor). In some cases, certain data characteristics require informed opinions, such as property value that could require reference to third-party information and professional judgement.

Technology enables efficient generation and maintenance of OSR data. Technology offers numerous opportunities for the identification and categorization of taxable objects, such as the estimation of land or building area, through image-based solutions. In the case of property taxes, for example, the following sequential steps outline the extent to which technologies can identify and capture data:

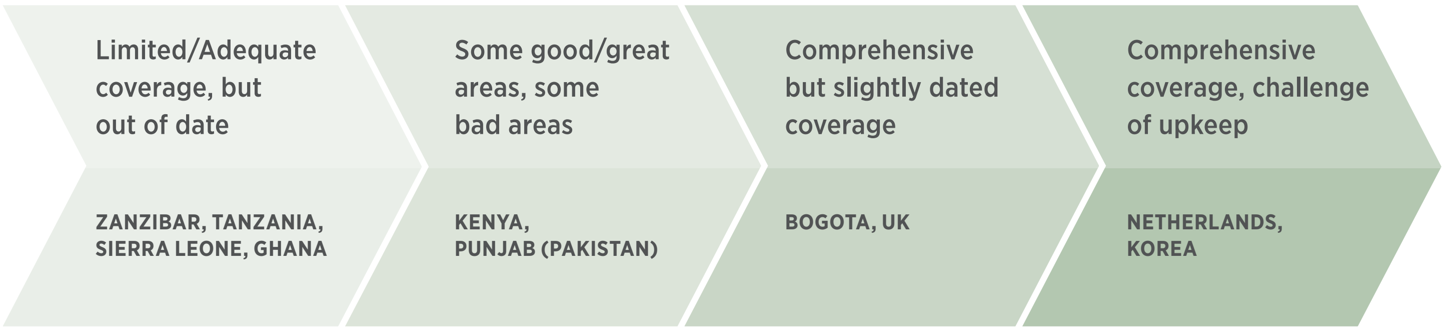
- Identifying the geographic extent of the jurisdiction through the existing data and resources
- Identifying the mapping options, such as open-source mapping and high-resolution imagery
- Subdividing the geographic extent into administrative areas through high-resolution imagery
- Further subdividing the areas into value zones within the geographic boundaries, with land allocated into specific categories through high-resolution imagery
- Identifying the existence of buildings or other structures through high-resolution imagery
- Recording these parcels and structures accurately according to their spatial location within the jurisdiction, by processing the images and geocoding the parcels and buildings
- Identifying the nature of the structures and deciding whether to include or exclude them from the tax base using high-resolution imagery, LiDAR, and integration with other datasets
- Capturing key attributes such as construction materials through high-resolution imagery, LiDAR, integration with other datasets, and machine learning

While technologies offer great potential for data capture, building an up-to-date database requires a combination of both technological solutions and traditional in-field inspections for ground-truthing, as illustrated by the mass valuation systems in Nairobi, Freetown and Punjab.

Data capture challenges depend on the initial condition of each SNG. There is a significant range in possible scenarios: situations with no current or recent tax revenue base expansion, situations where there is a comprehensive tax revenue base coverage, and a variety of situations in between (Figure 2). Towards the lower end of base coverage, there are typical examples where there is good coverage of the oldest established urban areas but no or minimal coverage of the most recent expansion areas, often informal or unplanned. In the middle of the continuum there are situations with generally good yet dated coverage. Karachi, Pakistan, for example, has not conducted a citywide survey of land and buildings since 1980; with little updating during the intervening years, this has resulted in a situation where there are only 900,000 properties on the valuation roll against an estimated 2.5 million properties. The same situation is observed in other cities, where rapid urban expansion is not included in the tax base in a timely manner. In other cases, the current property tax coverage can be considered legally comprehensive even though large areas are not included in the tax base. This is observed in several African countries (e.g., Botswana, Lesotho, and Zambia), where property tax cannot be levied on properties outside the formally declared rating areas. (McCluskey et al 2017b).

FIGURE 2.

Continuum Framework Model of Tax-base Data Capture/Identification



Understanding where an SNG falls on this continuum helps in identifying the type of technological solution that could be selected. Figure 2 shows the starting point of several jurisdictions prior to reforming their OSR systems. Due to a lack of resources and dated administrative systems, SNGs could not keep the data current. In the case of Sierra Leone (Freetown City Council, FCC), for example, the tax base systems that supported property tax and other OSRs were weak on account of a very fragmented tax base, outdated software, and poor maintenance. Addressing these weaknesses has been characterized by an initial process of data capture and incrementally migrating to a digital data system, largely for the first time. It took FCC one year to move from the far left of Figure 2 towards the middle. On the other end of the spectrum, there are much more advanced cases like Bogotá, Colombia, where legacy systems were built from well-established pre-existing manual and paper-based systems and commercial software (e.g., Oracle and ESRI). Zanzibar, mainland Tanzania, Kenya and Punjab (Pakistan) lie between these extremes with some progress due to recent or prior support to the local revenue systems.

Time and external risks are also key challenges at the data capturing stage. Time plays a significant role, as even good databases can deteriorate without systematic efforts and procedures to update the data. Similarly, episodes of political instability and/or administrative failure can also rapidly undermine the status of the tax base, particularly where the system is based on physical maps and on locally held physical infrastructure such as in-house servers (as opposed to cloud platform). Hazards like storms, floods, fires, earthquakes, and civil unrest can also result in data damage or loss. For these reasons, data security, business continuity plans, and alternatives such as cloud backup and Disaster Recovery-as-a-Service (DRaaS) are becoming increasingly important to maintain and restore the data and technology infrastructure.

Thematic Case Studies

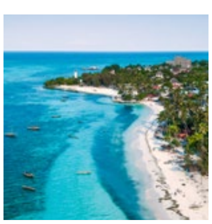
Case in point – Sierra Leone. Freetown City Council (FCC) has made considerable progress in capturing building data sets through a tailored approach that combines high-resolution imagery and manual data collection practices.[14] Less than 30 percent of urban properties were recorded in the FCC's property tax system due to the following impediments: (i) no transparency in transactions within the property market; (ii) the absence of a national system of land registration and ownership; (iii) informal deals conducted with no formal recording of transactions; (iv) unregulated real estate agents working in the market; and (vi) the lack of open and transparent information on real estate property. To enhance OSR mobilization, FCC was first confronted with the challenge of collecting data for OSR generation. Two prime sources of OSR, the property tax and business licenses, were the main targets. They began by mobilizing resources to plan and manage a mass data collection exercise. The solution chosen by FCC was to build a common database with fields for both property tax and business license fees. A reform project was established to procure high-resolution satellite imagery (captured by Maxar Technologies) to create the base map. A locally procured ICT solution was utilized for object detection algorithms to digitize the roof profile of buildings that automatically capture a spatial reference and collate these into a GIS database (Fish, 2018). The original intent was that these objects would be collated into a spatially referenced street addressing system based on Plus Code[15] from Google, but this was not completed due to a competing street addressing project at the national level. Moreover, the FCC approach was hampered by the unsatisfactory performance of the locally sourced data analysts. The process of geo-referencing the buildings largely fell to data collectors using a hybrid approach, whereby aerial photography and mobile devices were used to identify buildings in the field and allocate geocodes. Data collectors equipped with electronic data capture devices could record details such as construction type, number of floors, use and other observable characteristics, as well as owner and occupier contact details of 35 properties per day per person. The data collection project began in 2018 and by 2021 it had registered 97,413 new properties (compared to the 30,134 property records present in the old valuation roll at the beginning of the project).

FCC faced initial difficulties that were not solely related to technological challenges but rather to the unwillingness of some municipal staff to engage with the reform process and political limitations. Implementation of the property tax reform was suspended by the Ministry of Local Government and Rural Development, who mandated that national guidelines for property rates in 2021 needed to be provided by the central government before the new property rates could be introduced. There was also a political dimension given that FCC was led by the opposition to the national government. Together, these obstacles stalled the project for over a year. Despite these challenges, however, the project's results were remarkable, with a registration of almost 100,000 new properties. In addition, the National Revenue Authority in Sierra Leone has benefitted from the work done by FCC as one of the attributes of the field surveys covered data on rental properties, which allowed FCC to impose a levy on rental income of the property owners. The FCC's sound methodological approach could now be rolled out to secondary cities in country where OSR data sets are still incomplete.

Case in point – Ghana. Use of a mobile application has increased the efficiency of OSR data acquisition, allowing a sixfold increase in collection speed and facilitating the creation of parcel-base databases in 90 districts. In Ghana, there was no effective property tax database or street addressing system. In 2011, the Metropolitan Municipal District Assemblies (MMDAs) were mandated to develop policies for street addressing; however, they were not entirely successful due to the lack of large-scale digital imagery. The data collection process to identify businesses and property taxpayers was done manually and there was no opportunity to use GIS due to the lack of geospatial data and property addressing.

The District Local Revenue Project (dLRev) developed by the German Agency for International Cooperation (GIZ) supported the integration of high-resolution imagery, including imagery from drone footage, to build a parcel-based database. In 2020, dLRev provided drones and IT workstations to capture and orthorectify aerial images in all 16 regions. Unique addresses were allocated to each of the parcels and the work was complemented with field surveys to collect data on the details of the properties. The field inspection process was improved by using technology in the form of 'drop down' menus via an online data collection app version of the system. The app can capture several OSR-related data points, including property rates, business licenses and service fees. The app processes data temporarily offline and syncs once it is re-connected to the internet. The mobile application effectively turns any smartphone into a data collection device, avoiding the requirement to procure and manage specific devices. In addition, the extensive spatial database in Ghana has prompted sharing of the database with government departments responsible for land registration and property taxation. For example, the National Land Use and Planning Management Information System took advantage of integrating the elements from the dLRev system to streamline data processing.

The dLRev project was successful in using high-resolution imagery and a GIS-based fiscal cadaster. The field app enhanced the data capture performance by reducing manual labor from 120 to 20 days to complete 10,000 parcels. The data collectors used tablets to upload new information to the server that reflected the changes to the mapping in real-time. Institutional support from the Land Commission contributed to the success of the dLRev model. The system was scaled out to 40 districts in 2014, 60 in 2016, and 90 in 2019, and it aims to cover the majority of MMDAs. As of 2021, MMDAs have collected and registered data on over 400,000 businesses and properties through the dLRev data collection app and platform.



Case in point – Zanzibar/Tanzania. Drone images provide building data in dense urban settings, but such technical solutions should be harmonized with the regulatory framework and decision-making processes. In Zanzibar, the critical challenge was the poor property tax-related information, which was only levied on an ad-hoc basis in the Stone town area. The valuation roll only contained 1,370 properties, while the estimated population of the Zanzibar Municipal Council is over 300,000. The lack of data was a fundamental barrier to realizing the potential inclusion of additional properties. Under the auspices of the Zanzibar Mapping Initiative, a large-scale data collection campaign was implemented to capture data on buildings (land was excluded from the tax base, like Tanzania) using drone imagery. The imagery was produced via an arrangement with a higher education establishment, with students trained to operate the drones. As a result, more than 500,000 buildings were captured under the project. 13,232 building in pilot areas in Stone Town and Matemwe-Kiwengwa were selected for physical property inspection, utilizing digital tablets to collect data on use, condition, construction materials, and amenities of the buildings.

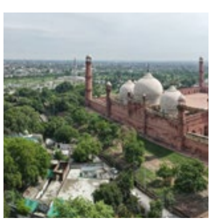
Despite all the efforts, the collected data has not been used to develop the property tax as initially planned and there is no associated operational plan to use the captured data to deploy a property tax. Full utilization of the spatial data has been constrained by competition over dataset ownership among several entities,[16] as well as a lack of agreement on how the data should be used. This demonstrates that technical solutions are only as good as the regulatory framework and decision-making processes they are embedded within. In any event, the data has proved valuable in the rollout and development of other uses in Zanzibar, like e-commerce, environmental impact assessments, and coastal erosion and housing surveys, demonstrating the broad value of capturing high-resolution imagery.

The drone project in Zanzibar successfully identified and generated around 500,000 building features between 2016 and 2018. However, Zanzibar experienced a hiatus in data collection activity, with no concrete plans to continue the data capture exercise. The Zanzibar case can be perceived as a partial success as the spatial data collected from 2018 grows increasingly obsolete as time passes.

In mainland Tanzania, the 189 local governments have a wide range of OSRs under their administration. Historically, data collection has been manually driven with a paper-based recording system. To improve the system, the national government (with support from several donor agencies) introduced a national system based on a GIS-enabled spatial data collection platform. In 2014, the Local Government Revenue Collection Information System (LGRCIS) was introduced as a pilot project to eight local authorities. In terms of data, all OSR-related information was manually input into the LGRCIS, a process that was facilitated by the digitization of manual records and maps. Since its inception, the spatial GIS component of LGRCIS was more of an add-on rather than a fully integrated component; however, since 2019, there have been efforts to integrate the GIS spatial element. While the LGRCIS has been a notable success in revenue administration (covered in Thematic Case Study 3), the data collection process was not particularly innovative. Nowadays, very high-resolution satellite imagery (e.g., up to 15cm GSD) and advanced analysis on remote sensing data (e.g., image classification, edge detection, semi-automated polygon generation, etc.) are widely used to capture data quickly and update records regularly. It is also important to design and build a system architecture to properly collect, store, integrate, share, and publish GIS data. Learning from this case, SNGs need to consider developing a sustainable and efficient data collection platform that accommodates both spatial and textual data.

Case in point – Kenya. Comprehensive coverage of up-to-date OSR data can be achieved in a relatively short time by utilizing GIS-based solutions and process automation. Nairobi City County (NCC) in Kenya has a long history of attempts to modernize its land value-based property tax system. In 2017, NCC's valuation roll had around 126,000 land parcels that had not been updated since 1980. A World Bank project[17] included a component to establish a mass valuation GIS-based property rates system. The objectives of the component were to (1) provide a GIS parcel database based on data held by the survey of Kenya; (2) produce digital base maps; (3) collect core valuation data of properties in the county; (4) revalue all parcels in NCC; and (5) automate the production of rates demand notices. To do so, NCC hired a local GIS consulting firm to collect data for all parcels and to build a mass valuation system. The consulting firm developed the GeoManager Valuation System designed to support all the valuation processes in an automated, secure, and user-friendly platform with a relational database management system.[18] Upon completion of the project, 225,180 parcels were digitized out of an estimated total of over 300,000. The difference was made up of cadastral records held by the Ministry of Lands that had significant issues, such as lack of information on ownership. This meant that the land parcels would not be entered into the valuation roll and hence would not pay property taxes.

The experience in NCC presents mixed results. On the one hand, the number and values of land parcels were successfully upgraded and a mass valuation component integrated to the new system. On the other hand, however, the process for updating land parcel records for revaluation had been ongoing for over ten years, delayed by a series of issues like limited access to spatial and land ownership data from other ministries. Delays were also caused by the development of a proprietary GIS system, as the consulting firm has ownership of the system source code and NCC staff need to be continuously trained. While mass valuation of land parcels was completed in 2018, it has taken four years for the new values to be approved by the NCC Assembly and the process is still not fully completed. There is also no clear roadmap of when the new values would be used for the new tax bills.



Case in point – Pakistan. Complementary technical collaboration among government authorities had a significant impact on tax base expansion, increasing 19 percent of the urban immovable property records through digital data capture and mass field surveys. The case of the Punjab province in Pakistan follows a similar path to others presented in this thematic area, defined by out-of-date land and building records, an old legacy database, heavy reliance on manual interventions, predominant paper-based records and no use of digital mapping or GIS. No mass survey of land parcels and buildings was conducted in the province for decades. In 2012, a World Bank project[19] began to address these challenges by developing a GIS-based administrative system for the Urban Immoveable Property Tax (GIS-UIPT). The GIS-UIPT required the development of technological solutions to allow automated management functions based on orthorectified satellite imagery and aerial photos. The Excise & Taxation Department (E&TD) had insufficient resources to conduct a mass property survey and no GIS capacity. To fill the gaps in the technical capacity, the Urban Unit (a provincially owned research entity) undertook a mass survey based on orthorectified high-resolution images and developed the GIS-UIPT system for use by the E&TD. There was a paradigm shift from manual to computerized systems for data collection. Original paper-based records for the UIPT, including maps and ledgers, were scanned and compared with the satellite imagery for record validation. The digital records were complemented with ground inspection using digital survey sheets to produce UIPT maps presenting administrative and property boundaries for tax purposes.

The GIS-Integrated UIPT system was a major step forward in modernizing and streamlining the administration of the UIPT. A pilot testing of the GIS-UIPT system was originally carried out in the city of Sialkot in 2014. The system was then scaled up in 2017 to the five largest cities in Punjab, resulting in about 90 percent coverage of the urban properties. By 2016 the UIPT records had increased to 3.2 million properties, from 2.7 million in 2008. The system has been distributed province-wide and connected through the government's network to ensure that information security is protected. The database and application systems reside on the Urban Unit's premise, while the E&TD is responsible for the actual administration of the UIPT. There are plans to hand over full responsibility for the system to the E&TD, which will have to significantly scale up its technical skills to maintain the GIS-UIPT system.

The Punjab project created spatially-enabled UIPT data sets based on orthorectified high-resolution imagery and scanned and digitized paper records of the E&TD. The GIS-UIPT system facilitated an update of the data held by E&TD into a modern GIS-enabled database. While the E&TD has overall responsibility for the UIPT (e.g., field data collection and entry of new and upgraded buildings), the GIS-UIPT system and geospatial data are maintained by the Urban Unit. Sharing responsibilities between the E&TD and the Urban Unit has worked well for the continued scale-up of the UIPT.

Case in point – Colombia. Bogotá gained significant returns on investment by leveraging the use of spatial data infrastructure, building change detection and third-party data sources for comprehensive coverage of property data. Unlike other cases, Bogotá had a very different starting point with a relatively well-established cadaster—albeit in need of modernization. In 2004, the cadastral coverage encompassed 42 percent of Bogotá's land area, and the cadaster wasn't fully connected to fiscal records. The need to improve the cadastral coverage was directly related to raising capital to fund the Bogotá Rapid Transport infrastructure, cementing the pivotal role of the cadaster as being primarily a fiscal instrument. At that time, the government decided to build a spatially-enabled fiscal cadaster based upon a new base map and common address system. Initial efforts encountered difficulty in linking the legal cadaster (digitized from the old parcel folio) with the fiscal records, due to outdated maps and differences between the unique identifiers that would interlink the different data sets.

The Bogotá Spatial Data Infrastructure (SDI) was launched in 2004 to integrate, exchange and analyze geo-referenced information based on cadastral data. A new base map was created using satellite and later drone imagery, with cadaster and properties geocoded (becoming spatially-enabled) and address matched. The SDI has served as the core of geospatial data collection, encompassing roads, planning zones, building permits and construction activity. After several initiatives, by 2018, it had consolidated and integrated information from various public entities, including agriculture, rural development, commerce, industry, tourism, economy, and finance. Furthermore, upgrading GIS-enabled data enabled the connection between the legal cadaster and fiscal records. The comprehensive geospatial data created an extensive linking to other government databases, allowing rapid capture of built environment changes and integrating characteristics from building permits and transactional evidence from mortgage valuations. This level of integration would be impossible without the effort put into the regulatory arrangements and the technical solutions – building blocks for good integration that required extensive planning and negotiated agreements within government agencies and other stakeholders.

Building information was captured from drones and other existing imagery, providing key details such as building footprint, roof type, and use type, which are allocated using a machine learning algorithm. Such data must be cleaned, validated and linked to ownership/personal records before being used for tax purposes. The Cadastral Technical Observatory played an integral role in facilitating, gathering and analyzing information on real estate market prices through various sources, including commercial appraisals carried out by financial entities, specialized real estate marketing portals, transaction prices, and specialized publications on building construction costs. These upgraded data facilitated a better understanding of the real estate market and allowed for the application of statistically-based valuation models. Furthermore, Bogotá has made a quantum shift to data verification, becoming much more reliant on third-party declarations as opposed to in-the-field inspections. This advancement involves obtaining information from various sources, including building change detection from remote sensing imagery, transaction prices via notaries, databases developed by entities providing public services, and self-declared information.

Bogotá's approach to data capture and identification showcases the notable success of its OSR operations. The coverage of cadaster reached 100 percent in 2020. Strategic improvements to expand the coverage and to build the tax base have shown significant returns on investment, with revenue from the property tax amounting to $ 9.04 billion (Colombian Peso, millions) in 2021, as compared with $ 1.73 billion (Colombian Peso, millions) in 2004. Now several cities in Colombia are attempting to follow the same path.

A number of factors contributed to the success of the cadastral management initiatives undertaken by Bogotá including: (1) the establishment of SDI for access and interoperability; (2) support from the technical directors who recognized the importance of cadastral information; (3) the allocation of the necessary resources to guarantee the annual updating of property values in the cadaster; (4) support for the integration and use of information for decision-making purposes; and (5) the legitimacy of the institutions and the quality of processes involved.

Concluding Remarks

Despite the different starting points for data collection observed in the SNG case studies, the technological solutions used are standard. The common problem amongst them is how to update the existing databases to enhance OSR mobilization. The use of imagery, geospatial data and the deployment of GIS have been central in all the examples showcased here.

Data Collection and Management. SNGs must manage large databases for OSR administration. Collecting data has always been challenging for local governments due to the lack of resources, inability to utilize mass data collection tools, and insufficient staff with the skills to process and manage spatially-enabled datasets. All the cases covered included technical assistance programs to support data collection and systems development. Sustained data updates and improvement are also important, as data collection is not a start-stop activity but one that requires continuous revisions. As such, support systems and new business processes should constantly be updated throughout training and capacity-building activities to ensure their sustainability.

Data Sharing and Interoperability. Data sharing amongst tiers and government units is key to producing comprehensive local revenue bases. Challenges in data sharing arise because of limited interoperability, absence of technical standards, and the lack of government willingness to share data across departments. It is not rare for national governments to procure the latest high-resolution imagery but to be reluctant to share it with local governments. The Bogotá experience illustrates the best practice of extensive data sharing by using cadastral data as the core data. It is apparent from the cases examined that data integration and interoperability are essential. Different levels of government often need the same kind of data. Once collected, data can be used in multiple applications; a good example is FCC collection of data on rental properties, which was used by the National Revenue Authority to levy the income tax on rental income. Harnessing existing data from diverse government datasets and other sources has obvious cost-saving and efficiency advantages. Data, particularly land and property-related information, is becoming a multi-purpose resource beyond OSR generation. There are substantial opportunities for other government entities to benefit from it. To the extent possible, each data point should be collected only once and shared with multiple users.

Adoption of Technology. The adoption of technology can be seen as both an opportunity and a threat. In Bogotá, there was resistance on the part of public officials, who initially failed to see the merit in implementing new technologies and automation methodologies. Nevertheless, the adoption of technology is now widely accepted internationally as essential to improving the efficiency of data collection. The case studies demonstrated that technology for data gathering and digital imagery combined with data processing is essential for establishing the base mapping and building footprints. Using mobile applications also improves the efficiency of data capture practices. This technology has been used extensively to provide the basic building block data, or the SDI upon which all other data is built. However, the use of technology for populating datasets with more qualitative data is not yet mature. For example, while LiDAR and ML approaches can add considerable insight into the material used in the construction of buildings, it has been used far less frequently than the data collected by humans.

To maximize the benefits of technology, clarity on the methodology for data collection is key. Once that is established, technology can make the data capture process more accurate and efficient and can help make the economic and political case for investing in the use of technological solutions. Establishing a robust data collection system is the first step in developing integrated assessment and administrative systems, as explored in the following two thematic cases.

Innovative Developments in Data Capture and Identification. For the future, there are innovative developments that can become game changers in data capture and identification, namely automatic feature extraction and change detection techniques. Automatic feature extraction for OSR purposes uses AI and ML to produce indicative land parcel boundaries. The process involves leveraging aerial photography or satellite imagery for parcel feature extraction and segmentation. The indicative parcel maps generated can then be further refined if a higher level of boundary accuracy is required. It is common for most parcel boundaries to coincide with physical objects such as buildings, roads, fences, fields and rivers, and the boundary lining and corner points produced by these objects are detectable in modern high-resolution images. New technologies for AI-based automation, mapping and geospatial data capture have the potential to make land rights registration faster, more affordable, and more accessible (World Bank, 2020b).

The Korea Real Estate Board has been developing innovative methodologies to automate the identification of land characteristics. The system uses geospatial technology and AI to analyze data such as land shape, distance to major roads, land use type, slope and elevation (Chae and Kwon, 2018). Prior to this development, land characteristics were surveyed and determined by the intuition and subjective judgments of individual surveyors. Technology is rapidly advancing, and there are now field-based mobile GIS property mapping applications to help local authorities overcome challenges of property identification and capture using mobile cloud computing mapping services (Neene and Kabemba, 2017).

Change detection based on remote sensing technology is also used to discover and identify differences in ground objects using two or more images in the same geographical location (Singh, 1989). Change detection now plays an important role in the field of remote sensing analysis and has been widely used across many areas, such as urban planning, tax base (buildings) management, and disaster assessment (Xiangyun and Lizhi, 2013). In recent years, this has created widespread interest due to the possibility to detect more delicate changes (such as the alteration of small buildings) with the help of huge amounts of remote sensing data, especially high-resolution data (Jiang et al., 2022).

These technological advances are likely to provide benefits to the initial data collection and data maintenance. Aspects of these more advanced technologies have been deployed in some of the case studies; for example, in Tanzania, 18 million building footprints were created in three weeks in 2018 through automated feature extraction. Similarly, FCC has utilized automated feature extraction for building footprints. While these cutting-edge techniques are gaining momentum, their successful application requires advanced technical skills and uptake depends largely on an appropriate enabling environment in terms of political support, available resources, and capacity to update imagery.

BOX 3.

Data Capture and Identification: Lessons Learned

1. Assess the Baseline and Develop Strategy

- Data capture often begins without a clear OSR mobilization strategy or a fair assessment of SNG capacities to collect and maintain data; this compromises the potential results to mobilize OSR effectively.
- While short-term solutions can be effective initially, lack of consideration to mid- and long-term solutions and investments can end up costing more time and money.

2. Leverage Geospatial Data and Technologies

- High-resolution imagery is more widely used by SNGs due to the efficiency for capturing the existence of taxable objects and rapidly establishing base maps.
- Open-source geospatial data provides affordability, where SNGs can benefit from data already available to explore the potential of utilizing GIS before moving to investments in mass data collection.

3. Explore Mobile/Matured Technology Options

- Having a data capture mobile application with feature lists in pull-down menus for ground-level data capture is practical and increases the efficiency of mobile surveying teams, making initial data capture and data maintenance quick and affordable.
- In low technical capacity settings, the use of street addressing could be a good starting point for developing a spatially enabled fiscal cadaster for OSR mobilization.
- At the early stage, utilizing commercial mobile apps based on open-source base maps (e.g., Geo Open Data Kit) can be a practical option for quickly capturing OSR data and developing mid- and long-term strategies. In addition, AI-powered Optical Character Recognition (AI OCR) technology has recently been widely used for digitizing OSR documents without the need for time-consuming manual data entry.

4. Build Capacity and Maintain Data

- SNGs have started to increase their capacity for utilizing geospatial technology. Sustainable OSR data maintenance demands a greater focus on technical training and upskilling.
- However, retaining skill sets in rarely used technology such as LiDAR is not cost-effective or efficient. This type of activity should be contracted out to specialized providers.

5. Ensure Data Sharing and Interoperability

- Efforts to share, interlink and integrate data structures and information between national and municipal cadasters and databases (e.g., property registries, building permits, property tax, etc.) tend to generate economies of scale and improved efficiency.
- Establishing data standards and a unique identifier for interoperability among relating datasets is a critical success factor.

6. Hold Ownership and Manage Risks

- When third-party vendors are involved, ownership of the data and the system by the SNG is key. Vendor operation should transition to SNG independent operation. This requires SNG resources and capacity to operate the technology-enabled system.
- SNG taking ownership of tech-based solutions without proper capacity building and support tends not to be successful nor sustainable.

3.2 Thematic Case Study 2: Assessment and Processing

Key Challenges

Technology-driven automated processes facilitate the assessment of OSR-related information. OSRs require an assessment to determine the tax, charge, or levy to be collected. The objective is to utilize the available information to arrive at acceptably accurate chargeable amounts that are in line with the legal framework where the assessments take place. The assessment process can be subjective, but the subjectivity can be minimized if the assessment process is built with clear rules that can be automated through computer systems or applications. The key question of this thematic case is how technology can be applied in the assessment process and specifically how it can be simplified and automated in each assessment function. Assessment rules are usually included in the SNGs fiscal codes (like in central and eastern European countries) or in the annual finance acts (like in Kenya and Tanzania). These rules prescribe specific charges or levies for each OSR instrument including business licenses, advertising panels, service levies, etc. Technology and software are then applied to automate and operationalize the assessment that must be sufficiently robust to deal with the thousands and sometimes millions of taxpayers.

OSR assessment and processing may require spatial data and an integrated assessment application to streamline business processes. For some OSRs, assessment and processing are relatively straightforward, requiring the identification of an event and indication of a specified charge; for example, the case for various forms of licensing, where a rate per category (parking, births, marriages, etc.) is established in the regulation. For other OSRs that have a location base, spatial data capacity is vital for efficient OSR assessment, like property taxes, and building and planning permissions. These activities require location factors such as the physical characteristics, number of dwellings, size of a retail complex, proximity, zoning, etc. Once these have been determined, the data is complemented with non-spatial characteristics, such as the corresponding fee structure, to complete the assessment process. There are other cases of spatially-located recurrent activities provided to locations in services such as solid waste collection and unmetered utility provision. In these cases, the assessment is relatively straightforward, according to a determined charge or fee. Some information can be identified via GIS.

As data increases in its complexity and detail, more comprehensive and accurate assessments are required. The large revenue-generating OSRs, typically property taxes and service levies, require complex assessments, including estimations of more quantity and quality attributes than those in a single transaction. Furthermore, assessing property values requires a more complex technical process that captures the physical characteristics of the structures. For this, more dynamic capture of the built environment can be involved, through for example, the use of change detection software capable of comparing imagery from different time periods. This also requires inter-departmental data sharing, as alterations and additions to the structures are declared at different points in time and to different departments (e.g., building control department and urban planning department). Automated systems can integrate these data so that the property taxes or fees for building permits and planning permissions are accurate.

The assessment and processing challenges depend on the jurisdiction's capacity and the data context. In general, the assessment process, especially of recurrent property taxes, is complex especially if based on value estimates. There is a choice between a prescribed, rules-based assessment model or the use of individual estimates of property value. The latter can be cost and time prohibitive on a property-specific level. Removing the value estimation and reducing subjectivity by adopting prescribed rules can be transformative in terms of building an effective tax base. Manual assessment has been the traditional approach and is still widespread in many countries. Like the data capture and identification continuum discussed in Thematic Case Study 1, the context for assessment and processing can be viewed as a continuum. At one extreme, there is a challenging context for assessment, characterized by a low-capacity level within the jurisdiction and limited data availability on construction costs or market prices from transaction evidence. This is the starting context observed in Freetown City Council, Sierra Leone and Ghana, where it is reasonable and appropriate to use simple assessment processes such as prescribed flat rates and charges. To operationalize these simplified systems, technology, including satellite imagery, can be deployed to achieve object identification, which will then be subject to a charge. On the other extreme, there are jurisdictions with high capacity, comprehensive data and transparent market information, where more complex and accurate assessments can be undertaken.

The level of automation for assessment can reduce complexity when dealing with a large amount of data. The valuation challenge is faced in all jurisdictions operating a recurrent property tax. Technological solutions can automate value estimation using approaches such as a cost basis, comparative sales, and regression-based techniques, and utilizing emerging approaches such as AI/ML and spatial econometric mass appraisal techniques (McCluskey et al 2012, 2013). In addition to these techniques, the most important contribution of GIS to the valuation process is the ability to locate taxable objects and determine spatial characteristics. However, a major restriction is that this process is highly data-intensive and hence only applicable when the required data, systems and capacity are available. Several developmental 'stages' can be defined, according to technical capacity, tax base attribute data and market data availability, forming an assessment and processing continuum from least developed to most developed context. These stages contain the starting points of the jurisdictions in Tanzania, Kenya, Pakistan, and Colombia. The stages allow us to chart the progress achieved by these jurisdictions due to their IT-supported reform programs. The Assessment and Processing Context Continuum is presented in Figure 3.

FIGURE 3.

Continuum Framework Model of OSR Assessment and Processing

Increasing capacity, enabled via technology, process improvement, regulatory reform and market maturity

Limited attribute data, opaque market data	**Basic attribute data, thin market data**	**Good attribute data, some market data**	**Excellent attribute data, transparent market data**
Floor area-based systems with limited discrimination based on few variables	Cost-based systems, calibrated by locational adjustments	Robust market value related systems, using a variety of value significant attributes	Full ad valorem appraisal to market value, rebased frequently
Imagery and algorithms can identify extent and basic 'counting' based in tax base coverage	Drone footage, digital cost schedules and broad locational identification from imagery	Integrated database and spatial imagery embedded in a GIS-based MIS	AI/ML and spatial econometric mass appraisal
ZANZIBAR, TANZANIA, SIERRA LEONE, GHANA	**KENYA, PUNJAB (PAKISTAN)**	**BOGOTA, UK**	**NETHERLANDS, KOREA**

Thematic Case Studies

Case in point – Kenya. NCC was able to revalue the tax base in 2017 for the first time since 1980 by utilizing simple assessment systems. Assessing property taxes on a market value base is challenging due to the technical and administrative complexities and the scale of the valuation exercise. Due to these challenges, the use of specified assessment rules is gaining traction in many countries. In these systems, properties are allocated several categorical attributes, such as land use, location, size, condition of property, proximity to roads and facilities, etc., which are subjected to a rules-based assessment formula. Customized software can then be applied to automate the assessment based on property-specific data and assessment rules. This approach allows simplified mass appraisal functions without analyzing market transactions, and it is illustrated by the NCC experience where the estimation of the land tax on a specific parcel relies on estimating the market value of the parcel. The reliance on individual assessments, the complexity of the assessment process, and the use of manual valuation approaches resulted in the NCC not being able to revalue their tax base for close to four decades. NCC then decided to adopt a country-specific assessment approach aided by modern technological solutions. The Geo-Valuation Block (GVB) was introduced for simplified property appraisal that keeps the consistency of values in nearby properties. The GVB is used on the basis of spatial proximity analysis and geoprocessing to reconcile property values within or neighboring properties of the GVB. GVB is a "block-based" not "unit-based" approach where no individual site value takes place; on the contrary, the values within a GVB are automatically assigned. The valuation roll under the GVB comprises seven essential attributes, including unique number, location, area, name and address, site value, type of property, and remarks. The recent revaluation was completed in 2017 using an automated and simplified mass valuation approach. NCC now has an automated assessment system that provides the basis for a more regular assessment of the land tax base. However, the new values have not yet been used for the calculation of the tax liability.

According to NCC, the valued properties increased from 32,000 in 1980 to 142,000 in 2019, increasing their revenues to 21 billion Kenyan Shilling through GIS-based mass valuation. NCC developed a data model to build a spatial, integrated database for use in the assessment process. Their GIS (Geo-Manager) supports dynamic and comprehensive data for valuation. NCC benefited from technologies to automate processes, deliver quality services, enhance revenue collection, and facilitate interactive data exchanges between the valuation, land rates calculation and billing modules.

Case in point – Pakistan. Punjab province adopted the automation system for simplified mass assessment to improve the UIPT processes. Property tax, business licenses, rents, advertising sites and fees and charges can lend themselves to simple, automated assessment models. These models are based on easily identifiable criteria and objective measurement. A good example is the use of Valuation Tables for residential properties in the Punjab province of Pakistan. In this case residential properties are located within a specific zone with prescribed rates per square yard for land and per square foot for buildings. The property has differential rates depending on whether it is rented or owner-occupied. The assessment rules for the UIPT are embedded into the administrative system, which facilitates a fully automated tax assessment. The valuation tables are predefined, fixed for a period of years, and coded into the software of the assessment system. Once the property data is loaded into the system, the GIS-enabled software provides a fully automated assessment of the property tax liability based on simplified criteria; this can include the residential zone, whether rented or owner-occupied and the size of the land parcel and buildings. The system can also automatically re-calculate the liability for every property upon changes in the attributes of the valuation tables. This model is a form of simplified mass assessment. Table 2 provides the prescribed assessment levels for residential property in Punjab. The reference table for valuation assessment is provided by the Board of Revenue, but the values are not updated nor they at par with market values. However, the calculation of the tax liability is a simple process which is provided by the existing system.

TABLE 2.

Punjab's Residential Property Valuation Assessment for Urban Immoveable Property Tax (July 2021)

Residential Zone	RENTED				OWNER OCCUPIED			
	Rate (PKR) on Land (Sq. Yd.)		**Rate (PKR) on Covered Area (Sq. Ft.)**		**Rate (PKR) on Land (Sq. Yd.)**		**Rate (PKR) on Covered Area (Sq. Ft.)**	
	Up to 500	Exceeding 500	Up to 3,000	Exceeding 3,000	Up to 500	Exceeding 500	Up to 3,000	Exceeding 3,000
A	23.00	18.40	23.00	18.40	4.60	3.68	4.60	3.68
B	17.00	13.60	17.00	13.60	3.40	2.72	3.40	2.72
C	14.00	11.20	14.00	11.20	2.80	2.24	2.80	2.24
D	11.00	8.80	11.00	8.80	2.20	1.76	2.20	1.76
E	8.20	6.56	8.20	6.56	1.64	1.31	1.64	1.31
F	6.50	5.20	6.50	5.20	1.30	1.04	1.30	1.04
G	4.00	3.20	4.00	3.20	0.80	0.64	0.80	0.64

Source: Punjab Excise, Taxation & Narcotics Control Department

Case in point – India. The methodological simplification combined with the online self-assessment interfaces in Ahmedabad allows for an efficient assessment of properties. Other examples of simplified assessment approaches that facilitate the application of technology can be found in several large Indian cities. Ahmedabad Municipal Council (AMC) in the State of Gujarat replaced the annual rental value assessment approach historically used for the property tax with a prescribed unit area methodology (see Box 4). The property tax in Ahmedabad is fully automated, with over 2.2 million properties levied annually through the automated assessment system. An online application allows property owners to input the floor area of the building and select the appropriate adjustments from several options. Based on that data, the property tax departments estimate the final tax liability. The assessment system allows the taxpayer to measure and input the floor area of the building and select the appropriate adjustments from options within the online system, which then automatically calculates the tax bill. This model is one of the interactive technologies in the OSR domain that provides technology-facilitated self-assessment with built-in controls. The self-service interface can be extended to include additional solutions, like creating a one-stop-shop, to make the tax transactions more convenient.

BOX 4.

Example of the Unit Area Assessment Method

The Unit Area method determines the rate of tax per square metre based on the internal floor area of the building. Different rates can be determined for residential and non-residential buildings subject to minimum and maximum rates prescribed in the legislation. The current rates (as of 2022) are 16Rp/m^2 for residential and 28Rp/m^2 for commercial properties. The tax assessment is formula driven:

Tax = {Area x Rate/m^2}x {LOCATION x AGE x USE x OCCUPANCY}

The location factor is a proxy for capturing the land value of a specific area for residential and non-residential uses. AMC has been divided into four areas/locations. The age factor is designed to reflect depreciation in the value of buildings. Adjustments are made to reflect the different types of residential and commercial uses. The occupancy factor reflects if the building is owned or rented. The tax payable on a tenanted non-residential property is twice that of an owner-occupied building. The formulaic approach adopted by AMC has the benefit of simplicity as there are few variables within the assessment model. This approach is widely used to permit online self-assessment.

Case in point – Sierra Leone. FCC made significant progress on property tax assessment and business licensing despite starting from a highly manual-based approach. FCC recognized the need to abandon the previous property tax assessment model (based on Annual Rental Value) for a more simplified model. One of the objectives of their reform was to assess property values in a fairer and more transparent way. The new approach developed in 2017 was based on several attributes associated with the building, along with georeferencing technology to locate each property. The assessment begins with the capture of the property's floor area and the identification of pre-defined attributes of the property and its location. A relative point weighting is applied to the attributes, informed by an analysis of rental value information derived from value-generated appraisal in the area. This new assessment model automates the assessment and tax liability. Manual data entry into the system is still required, but once that is completed the processes are fully automated, including the printing of demand notices. The FCC appraisal exercise increased the total appraised value by over five times and improved the progressivity of the property valuation roll (FCC, 2021). Overall, the project resulted in a 110 percent increase in the number of taxable properties.[20]

Case in point – Tanzania. Integrated revenue systems can entertain assessment systems with different levels of complexity. The property tax administration has been unstable in Tanzania in recent years, moving from the local government to the national government (Tanzania Revenue Authority) and then back again to the local government. Under the administration of local government, there were two assessment systems in place: a flat rate option and a well-established cost-based approach, with schedules and tables to differentiate by location and property type. The LGRCIS was designed to accommodate both the cost-based assessment and the much simpler flat rate approach. The LGRCIS fully automated the assessment approach for property tax. In the same way, a simplified assessment based on tables was applied to the hotel levy, advertising panels, and telecom towers. Under the national government administration, the property tax assessment was further simplified by replacing the cost-based approach with a flat charge based on the use of the property. The experience demonstrates that IT systems can be effectively developed and operated by SNG's, however they can also be undermined by central government policy changes.

Case in point – Ghana. A flexible approach combined with traditional and automated assessments allowed the government to adopt the new, simplified model to raise revenue quickly. Two systems in use (dLRev[21] and TaxMan[22]) have built upon their data gathering successes and utilized locational and property characteristics via the revenue management systems (described in Thematic Case Study 3) to undertake an assessment. In the dLRev system, a web GIS-based module allows the Lands Valuation Division to provide and maintain the value for each property. The dLRev system automatically applies a tax rate based on the property value to generate the tax bill. In the TaxMan system, unvalued properties (those not valued by the Lands Valuation Division) are subject to a simplified model using indicative values for key features and locations. The TaxMan system automatically executes an assessment of the unvalued property when system users enter the physical characteristics and location into the system. During the development of the TaxMan system, there were concerns regarding the prevalence of two systems and the impact on valuation practitioners in regards to job and valuable skill losses. These concerns were addressed by accepting any existing or new valuations provided by the national government, while the system generates the assessment for other unvalued properties. While the mixed method could raise uniformity issues, it removed a major challenge to the wider system adoption and contributed to raising revenue.

Case in point – Colombia. Bogotá is at the forefront of adopting data integration, processing, and management technologies to undertake property tax assessments. The Cadastral Technical Observatory (OTC) of Bogotá utilizes comprehensive data sets from 3 primary sources and 22 secondary sources, populated by the banking sector, websites (property agents), special reports (such as building construction costs) and cadastral data (transaction sales) for the assessment of property values.[23] The OTC led the process of developing a data exchange standard for integration and interoperability among the various data sources. This technical approach didn't seek to construct a single, giant IT system but rather one that could facilitate smooth information exchange. Significant advancements were made to automated processing and assessment by exercising data mining and analysis. An ML algorithm is applied to drone footage, which provides details of the extent of the building, typology, and construction method. This information is automatically analyzed using cost tables for the assessment. These detailed data inform property assessment, where the land value is based on transactional evidence and the building value is based on construction costs.

In Bogotá, the driving factors for the modernization of OSR assessment involved efficient data integration with primary and secondary data sources for regular property appraisal, rather than visiting each property every year.

Concluding Remarks

The assessment function is a critical part of OSR generation. The major challenge SNGs face is how to embrace technology to automate the assessment process.

Simplified Approaches and Automation. A key aim is to simplify the assessment process. In the case of the property tax, valuation methodologies can be difficult to apply if transaction evidence is limited and if under-declaration of prices is prevalent. In such cases where the property market cannot support a value-based property tax, an alternative such as the unit area method presents a viable solution. The use of specific amounts or adjustment factors to reflect location, property use, age and condition can readily be built into an automated assessment system (Pakistan, Tanzania, and Sierra Leone). In this way, technology can automate and combine steps to generate tax assessments.

Scope of Assessment Automation with the Use of Technology. Other main OSRs, such as business licenses, hotel levies, advertising panels and building permits, are also suitable for developing applications to automate the assessment process. Redesigning business workflow would be the first step in streamlining the existing business process, creating operating models, and transitioning to automation with the use of core technologies; these include computer-aided mass appraisal, data mining, advanced analytics, smart workflow, remote sensing, and geospatial analysis, among others. Several jurisdictions have focused on the large revenue generators within the assessment system, such as business licenses and property tax (Ghana, Punjab, and FCC, Sierra Leone), as opposed to trying to include all or most of their revenue streams (Tanzania). Accurate assessments are made possible by collecting the basic attribute data as discussed in Thematic Case Study 1, and processing the data according to a set of simple arithmetic rules and algorithms, as discussed in the following Thematic Case Study 3.

BOX 5.

Assessment and Processing: Lessons Learned

1. Prioritize Targets

- From a fiscal point of view, an initial focus on the large revenue generators is more cost effective than attempting to cover all properties at the same time.
- Revenue streams such as business licenses, property taxes, and advertising panels can apply a table or schedule-based assessment that can be easily automated, thereby increasing revenue collection.

2. Recognize Feasible Methodologies

- Weighted-point assessment approaches such as those used in FCC, as well as adjusted area methodologies used in several Indian cities can be deployed effectively in markets with little to no transactional data.
- While the use of market value-based approaches for property tax offers many advantages, it tends to be difficult to implement in environments with low administrative capacity.
- Attempts to introduce cutting edge approaches like ML are not appropriate when data and capacity are limited.

3. Embrace Geospatial Technologies and Transit to Digital

- Moving away from manual assessments based on ledgers and spreadsheets has built confidence in data processing by removing subjectivity on the calculation of property values and taxes. Modern OSR administration is transitioning to 'digital by default.'
- GIS has become an integral part of the assessment systems (Ghana, Punjab, and FCC). The geospatial analysis process helps in intersecting, extracting, and joining taxable objects. It also builds data relationships with non-spatial data sets (existing database or even Excel sheets) on a large scale to quickly generate assessment outputs.

4. Develop Automation Workflow

- The introduction of automation in the assessment of property valuation has significantly removed problems associated with subjectivity and value contestation by taxpayers. This is due to the built-in checks and archiving routines of the automated systems, which provide quality control on data entry and processing.

5. Implement Batch Processing

- Individual data processing only increases manual workloads. Automation of OSR data assessment requires batch processing (e.g., data input, load, sort, process, and complete) that handles bulk data, minimizes human intervention, reduces repetitive tasks and costs, and increases speed and accuracy.

6. Monitor and Make it Sustainable

- Development of simple and data driven "dashboards" to monitor the performance of OSR on a regular basis has proven a useful management tool for local government officials.

3.3 Thematic Case Study 3: Administration Systems

Key Challenges

Lack of integrated administration systems is not conducive to OSR enhancements. Local revenue administration systems host the data collection activity discussed in Thematic Case Study 1, and the assessment and processing tools discussed in Thematic Case Study 2. In a well-functioning system, data are collected straight into the administration system and an automated assessment takes place "in real time." Furthermore, the system automatically generates demand notices, accepts payments through several electronic means, issues receipts, and supports enforcement and reporting. In addition, administrative systems are enabled to support reassessments and enhancements as legislation, software and technology evolve to support change management processes and system updates. Administrative systems can also be spatially enabled to visualize the geographic locations of a wide range of revenue sources. Box 6 illustrates the main administrative tasks of a revenue management system.

BOX 6.

The Main Components and Processes of Revenue Administration

Registration:	to properly identify and register all (legal) taxpayers and objects
Assessment:	to verify taxpayer data and cross-check and assess liabilities
Collection:	to collect revenue due and receive payments
Payment:	to enter payments into the taxpayer account and balance payments with debits
Enforcement:	to identify defaulters and impose sanctions, enforcement, and collection processes
Auditing:	to verify and control payments based on a fair and sound selection system
Reporting:	to provide analytical reports regarding revenue assessed and collected

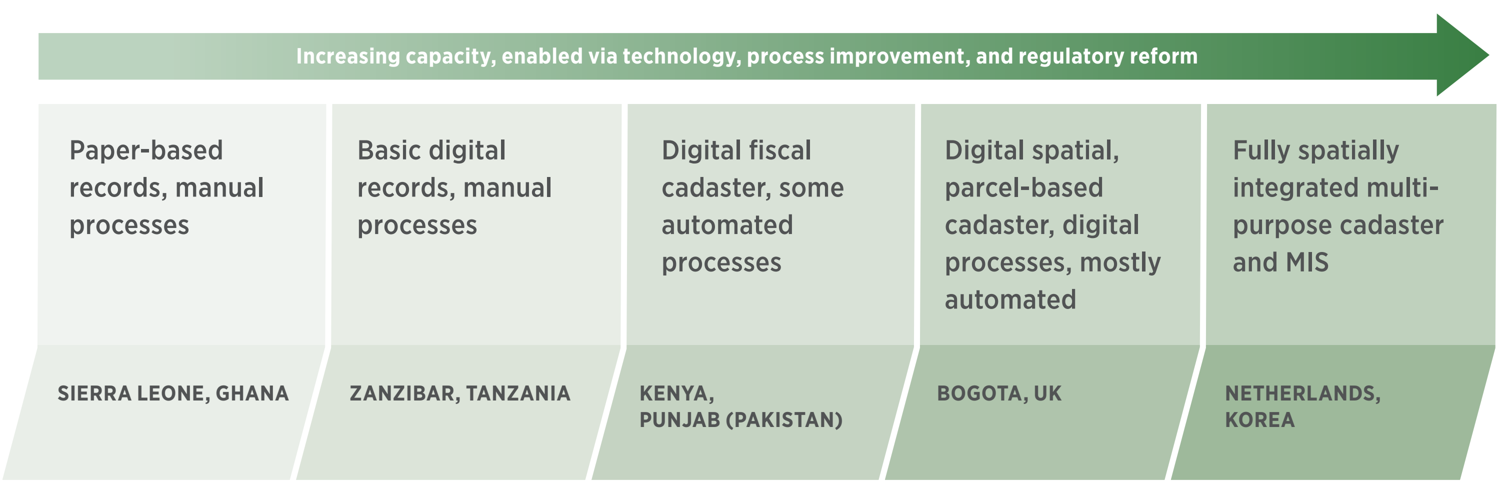
The increased use of technologies has facilitated the development of integrated revenue administration systems. From a technology perspective, the capacity of both SNGs and the taxpayer community to understand and interact with digital platforms has increased. For instance, there has been a massive growth in mobile device subscriptions, which facilitates online revenue payments via mobile phone money transfer networks such as M-Pesa (Kenya, Tanzania, Ghana), Tigo Pesa (Tanzania), Airtel Money (India) and Max Malipo (Tanzania), among others. Technologies have facilitated a synergy between revenue administrations and the banking sector. While such systems were initially developed for small rural agricultural producers to make payments, local governments in various countries (Kenya and Tanzania, for example) have developed mobile money solutions and integrated them into their revenue management systems at both the national and subnational levels (Mas and Radcliffe, 2010). Mobile money payment systems have been initiated by private telecommunications companies in Asian and African countries but have now been included with the SNG revenue administration systems. The rapid development and use of these mobile and online payment systems are driven by the significant growth of mobile phone connections. In sub-Saharan Africa, for example, 495 million people have mobile services, a number which is estimated to grow to 615 million by 2025 (GSMA, 2021).

A key problem in many local revenue administrations is that they operate with fragmented and partially manual administrative systems. The challenges arising from weak revenue administration systems are plentiful, including revenue leakage, incomplete tax rolls, evasion, and ineffective billing systems, amongst others. Transitioning to better-integrated administration systems allows for a more efficient and equitable revenue system. To do so, the revenue administration system must be informed by the data gathering, assessment and processing activities. In this way, the administration system can access the necessary information to support billing, collection, and enforcement activities. Encouraging transparency throughout this process removes uncertainty over liabilities and payments, thereby increasing tax compliance and reducing evasion and corruption.

Developing a fully integrated administration system takes time. At one extreme of a continuum, there are jurisdictions with incomplete systems that heavily rely on manual procedures. This was the case in FCC and Ghana, both of which required a complete overhaul of the entire system and a business process reengineering exercise. A similar situation was observed in Tanzania but the issue was incrementally addressed through a series of externally-aided projects. Nairobi City Council and Punjab operate slightly advanced systems because they started developing revenue administration systems relatively early. On the other end, Bogotá began to transition to a digital system earlier and through a more comprehensive approach, albeit with several challenges in updating the system to expand the coverage for the rapidly expanding urban areas and informal settlements. A conceptualization of this continuum is presented in Figure 4 below.

FIGURE 4.

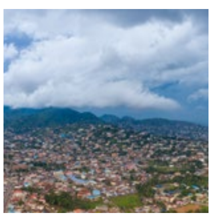
Continuum Framework Model of OSR Administration Systems



Revenue administration systems facilitate efficiency but can also be complex and expensive. Rapid developments in technological systems are creating opportunities to resolve administrative problems and enhance local revenues, so local governments are eagerly adopting them. However, all the case studies analyzed point to several challenges when it comes to decisions to procure revenue administration systems. Operating COTS has been hindered by the frequent need to access other systems or technology support that is unavailable in the local jurisdictions. COTS may require operating conditions such as uninterrupted power supply, access to high-speed and/or dedicated internet, and the purchase of expensive licenses. Furthermore, COTS may also be inflexible to changing features and functions based on specific work processes. In addition, their operation also requires capacity and technical abilities that may not be present. In these cases, the incremental development of simpler systems could be a better option.

Fragmentation of systems at the SNG level. Another key challenge is deciding whether to provide a unified national system of revenue administration or to allow each jurisdiction to choose or develop its own. For example, in Romania there are over 3,000 municipalities with their own revenue management system. Similarly, since 2020 Thailand has given more than 6,000 SNGs the task of administering the property tax, requiring each of them to develop or procure their own system. At times, however, there are misalignments and even conflicts between central and local revenue administration systems. In FCC, for example, political interference between national and local governments resulted in delays in the implementation of the revenue administration systems at the local level. While there are potential economies of scale from adopting common approaches with other SNG's that are aligned with central government systems, centrally made decisions may be affected by complex political dynamics. On the other hand, when systems are locally developed, SNGs are confronted with technical and financial challenges that can compromise the operation of the systems. Examination of the case studies illustrates some of these challenges and how technology can help to address them.

Thematic Case Studies



Case in point – Sierra Leone. Prompted by an OSR reform and with external support, FCC developed its own revenue administration system by leveraging existing technologies. Starting in 2019, FCC reformed the city's property taxation and business licensing procedures, by investing in a revenue management system. The system was developed on an open-source platform with embedded imagery overlaying the digitized rooftops of buildings. The system is managed by the developers and is therefore subject to an annual management fee, but FCC plans to take ownership of the system once they build sufficient in-house technical skills. Between 2019 and 2020, the revenue management system was upgraded to manage the property tax and business license fees. Once the data on both revenue streams is entered into the system, it automatically prints all property tax demand notices, which are then delivered manually. The system offers a full suite of services including the assessment of tax liabilities, printing of demand notices, dashboards showing daily revenue collections, maintenance of data, arrears management and several payment options via bank, mobile phones and point-of-sale machines.[24]

FCC has taken the lead in developing its own revenue management system since waiting for national government assistance was not a feasible option. FCC has demonstrated that technology supported OSR reform can be achievable and generate significant additional revenue. FCC had the resources and opportunity to raise finance (as the capital city), something that many of the smaller SNGs do not have. The revenue management system has been tested and successfully implemented and is now waiting to be scaled up to other secondary cities in Sierra Leone. This would require a combination of proactive effort from SNG's and the donor community, as well as support from the central government.

Case in point – Kenya. Kenya's experience illustrates a situation in which county governments have full autonomy in procuring optimized COTS solutions for revenue management systems. With decentralization, SNGs are increasingly confronted with the challenge of investing and managing their OSRs. As part of the national government's re-organization of local government and devolution of revenue powers in 2014, Kenya's 47 county governments were given significant autonomy. County governments administer a wide range of OSRs, which represent an important share of total revenue; however, counties have traditionally suffered from weak OSR collection performance. The adopted approach involves each county modernizing its revenue administration by procuring its own system. However, this has created system fragmentation, as most counties procured COTS from several vendors (Commission for Revenue Allocation, 2018). There have also been interoperability problems with the National Treasury fiscal system, as the revenue collection and management system adopted by the counties has not been fully compatible with the National Integrated Financial Management Information System (NIFMIS).

Several county governments, including Kiambu, Taita Taveta, and Busia, have procured COTS in lieu of a tailor-made county-specific system, since the former is designed to provide generic solutions for Kenyan counties. Kiambu County, for example, procured a software solution for county revenue management (CountyPro) in 2014 developed by Strathmore University. The CountyPro system was ready for use by counties and was compliant with relevant Kenyan laws and regulations. The system was a web-based solution that allowed for the administration of fees and charges, including land tax, business license, building permits, advertising signs, market stalls, and parking, among others. Furthermore, the system package included an online facility for citizens to pay their fees and charges, along with automation, decreased paperwork, and greater accuracy and transparency.

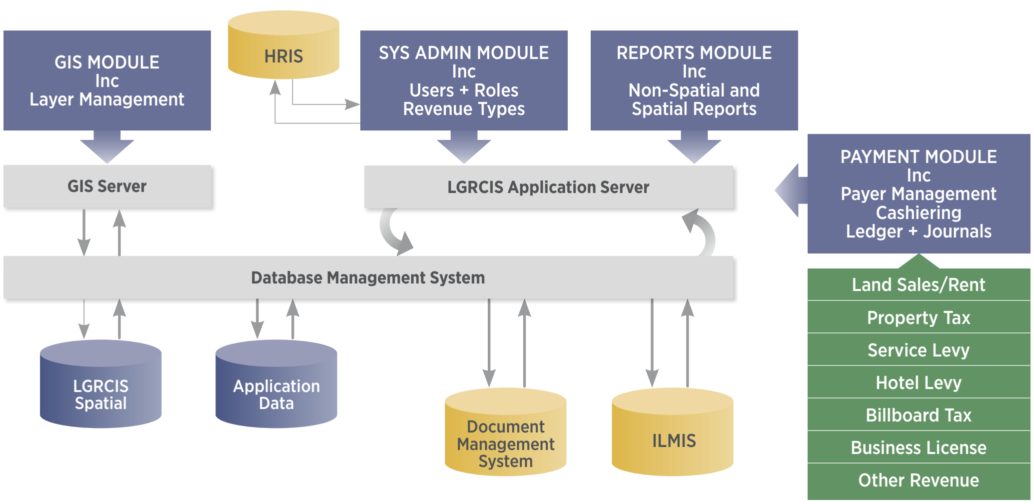
However, the cost of maintaining the on-site server has been high: the data center needs continuous power supplies, networking and equipment for upgrades, cooling systems, fire suppression and security. These challenges are common to on-premises servers and IT equipment, which may be addressed by adopting cloud-based systems. Other problems relate to inadequate internet connection and downtime due to frequent power shortages. The power supply and internet availability issues would remain and continue to affect all digital activity in similar jurisdictions across Kenya. Solving these challenges via wider IT infrastructure improvements and specific resilience planning for SNG operations will be important for business continuity and effective SNG OSR operation.

Optimization of revenue productivity against administration costs is necessary and is ultimately the benchmark for measuring the success of technology deployment. While the benefits of technological solutions cannot be disputed, several challenges in system implementation prevail. Kenyan counties have acquired various stand-alone COTS systems from multiple vendors, all with varying degrees of success when measured against system costs and improved revenue collection. The counties need to work with their SNG peers, the national government, and other stakeholders to ensure that any county revenue management system is effective and sustainable over time.

Case in point – Tanzania. With the help of LGRCIS, Tanzania's medium-sized cities shifted from inefficient paper-based revenue collection systems to a modern GIS-enabled platform that would support the entire SNG revenue chain. In Tanzania, the World Bank supported the development of an innovative revenue management system (LGRCIS) in eight pilot municipal councils.[25] LGRCIS is a software platform designed to administer multiple revenue streams for municipal councils, including property tax, billboard tax, service levy, hotel levy and business licenses. LGRCIS was developed by modular programming to enhance local revenue collection through taxpayer identification, invoicing, receipting, demand notice generation, defaulter identification and facilitation of electronic payment via a single gateway. The system enabled easier payment options for citizens via mobile phone money transfers. LGRCIS is also integrated into the National Micro Finance Bank to reduce physical cash collection and increase electronic payments. It has subsequently been rolled out to all 189 SNGs. Figure 5 below illustrates the key components of LGRCIS.

FIGURE 5.

Schematic of LGRCIS



Source: PO-RALG, Government of Tanzania

Table 3 shows the selected pilot municipalities that implemented LGRCIS in FY15 and the subsequent change in their collected OSRs.

TABLE 3.

Own Source Revenue Collected

MUNICIPALITY	FY2015/16 (BN TZS)	FY2019/20 (BN TZS)	INCREASE IN OSR (%)
Arusha	13,649	18,050	32
Dodoma	3,336	35,588	960
Ilemela	6,012	10,296	71
Mbeya	8,067	11,454	42

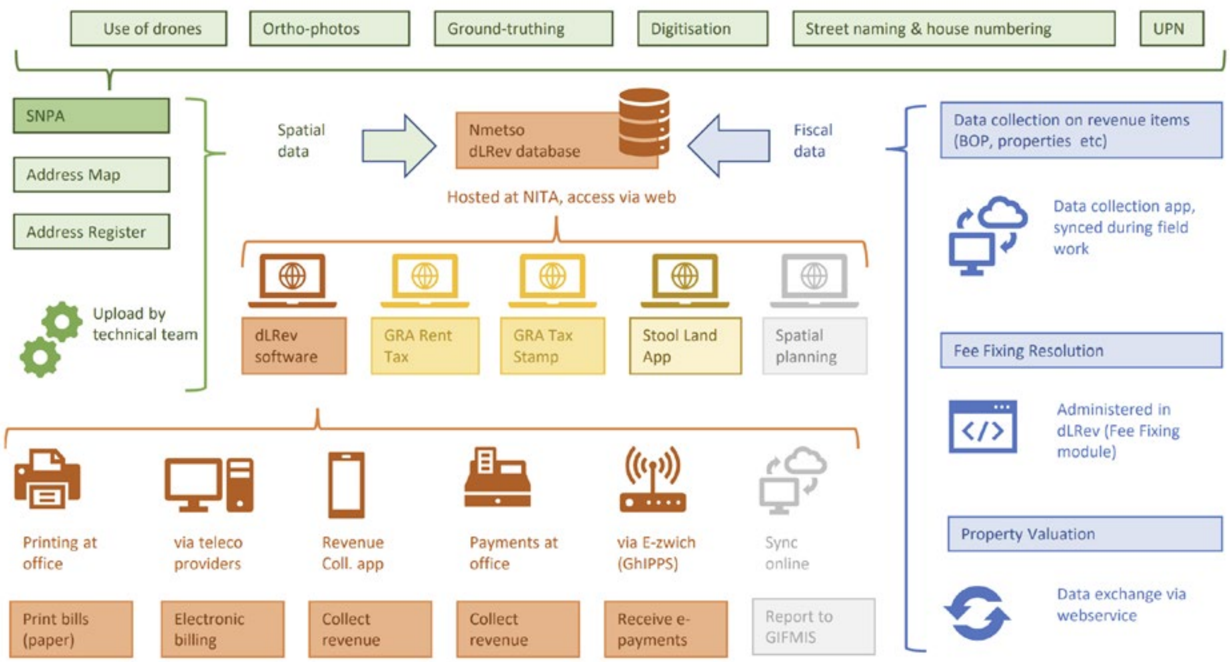
Source: World Bank, 2021a

A key aspect of the LGRCIS was its incremental approach from a series of pilots to cover all 189 local governments in Tanzania. The piloting helped identify system weaknesses and permit the developer to address specific issues through system upgrades and corrective maintenance. Another particularity of the Tanzania case is that the source code for LGRCIS is owned by the national government. The management of the system, including the maintenance of the data servers, is under the control of the Prime Minister's Office- Regional Administration of Local Government (PO-RALG), which also supports system trainings and capacity building programs for local government staff. Additionally, PO-RALG owns the system source code and local governments are not charged by PO-RALG to use LGRCIS. The assumption is that once the World Bank support ends, PO-RALG will cover the full capital and running costs of the system.

Case in point – Ghana. In collaboration with international partners, the Government of Ghana has transformed the revenue mobilization landscape by deploying tailored revenue management systems to the SNGs. Ghana followed a path like Tanzania's, where the national government took the lead in improving the revenue system for the SNGs. The SNGs did not have revenue maps, resulting in a limited overview of their building stock. SNGs rarely used spatial data due to the absence of house numbers and street names (except in some large cities like Accra and Kumasi). Revenue collection of OSRs was paper-based and manual, making it difficult for finance departments to locate the taxable properties and taxpayers and resulting in several inefficiencies. To address these challenges, the Ministry for Local Government, Decentralization and Rural Development (MLGDRD) with the support of GIZ launched the Street Naming and Property Addressing Project and developed the dLRev system. The dLRev is a tailor-made, open-source, and web GIS-based solution for Ghana's MMDAs. The dLRev allows revenue officers to easily print bills and register payments for business licenses, property rates and other revenue sources. The dLRev application, database and operating infrastructure are hosted by the national government, and all data is safely stored on the servers of the National Information Technology Agency. Mobile payment options are processed securely through Ghana Interbank Payment and Settlement Systems, a subsidiary of the Bank of Ghana. The interface of the Ghana Integrated Financial Management Information System (IFMIS) embeds dLRev into the Ministry of Finance's data infrastructure. The dLRev is in line with Ghana's Street Naming and Property Addressing Project and is fully compatible with Ghana's Land Use and Planning Management Information System (see Figure 6 below).

FIGURE 6.

dLREV System Schematic



Source: GIZ, 2020

The initial dLRev software was piloted in five MMDAs in 2013 and by 2019, 90 MMDAs had already installed the system. At the outset, there was little technical knowledge at district levels and poor IT infrastructure. To address this, the project delivered intensive system and GIS training to local governments across the country. In 2017, the MLGDRD published a nationwide harmonized catalogue of revenue streams for local governments, which was critical for automating the local revenues given that the software could be modified to include the standard set of revenue sources. The dLRev is now freely available to all MMDAs since the system resources were handed over to the MLGRD for domestic revenue collection (including complete documentation, user manuals and an administrator's guide).

A further initiative aimed at district revenue management in 31 MMDAs in Ghana has been ongoing since 2019 with the support of the International Cooperation Agency of the Association of Netherlands Municipalities (VNG). This project has run alongside dLRev in a different set of trial districts. VNG developed "TaxMan," which is designed to support all revenue streams within an MMDA. The system has been built using free open-source software with functionality for GIS integration, as there are plans for a future version of an open-source GIS platform (e.g., QuantumGIS). TaxMan provides the full suite of administrative services necessary to manage a wide range of local revenue sources, including bulk printing of demand notices for distribution. The TaxMan App is used to record field data, geo-location, and photographs of the properties. Collected data is held in cloud servers partitioned between the various MMDAs. The TaxMan App can also locate the property to deliver the demand notices regardless of the absence of street addresses and postal numbers in the 31 MMDAs involved. VNG has provided the participating MMDAs with the system for free. The districts will be able to continue using the system under a particular licensing arrangement until the project finishes. An alternative option is for the National Information Technology Agency of Ghana to take over the system and provide the necessary technical support to MMDAs.

According to a 2020 implementation review of dLRev by GIZ, the number of days to print and distribute demand notices has come down from 25 to 2 days, and the average growth rate of revenue collected in the year after implementing dLRev was 54 percent. In 2022, the MLGDRD instructed all 261 MMDAs in Ghana to implement the dLRev software for revenue management.

Case in point – Pakistan. By creating a web-based interface that enables electronic payments through the banking sector, the World Bank project helped automate the billing and collection system to improve taxpayer compliance. The UIPT in Pakistan's Punjab Province was administered by the provincial E&TD, reliant on a largely paper-based system and manual interventions. The system had a high cost of compliance as the traditional methods of payment were time-consuming and primarily cash-based. The billing and collection systems were archaic, necessitating a reform of the administrative processes. A World Bank project between 2012 and 2018 supported the reform of the UIPT to address the inefficiency of the existing OSR system. After introducing the modernized collection and billing system, the UIPT administration was fully automated with the development of GIS-enabled UIPT. E&TD staff were trained to fully administer the UIPT within the new system. Significant improvements were made to the collection process through the GIS component. Tax bills were produced through the system and then manually delivered. The system was able to track the delivery of bills and monitor payments in real time. Changes to the assessed values were made within the system, which allowed for electronic checks and several levels of management approvals. As the E&TD has other revenue streams, a future objective is to integrate all OSR administration within the system.

The GIS-UIPT system was rolled out across the five largest cities in the province in 2014 and was later extended across the entire province. The new administration system increased annual revenue collection from 3.5 percent in 2010 to 9.2 percent in 2020, with and a compound annual growth Rate (CAGR) of 13.7 percent for that period.

Concluding Remarks

The rapid increase in the quantity of spatial and non-spatial data that SNGs must collect and administer provides a natural entry point for using technological solutions. Revenue administration systems improve the efficiency and quality of fiscal management, fostering transparency and contributing to better use of public resources. The case studies presented illustrate how administration systems, whether COTS-based or custom-built solutions, have supported revenue administration effectively. A relational database that interlinks tables of non-spatial and/or spatial records underpins all modern solutions. A common feature of the systems reviewed here is the integration of a GIS component. The spatial dimension in revenue administration provides the capacity to locate taxable objects and visually display information such as ownership, occupancy, assessments, payments, arrears, fines, etc.

Phased-system development. Most cases begin with piloting projects to test their proposed revenue management systems. Extensive piloting projects were part of the operationalization of revenue systems in Ghana and Tanzania. They implemented a phased-system development approach combined with a modular system architecture[26] to measure and incrementally improve the development process. Prototyping the revenue administration system is important, as this process provides feedback on fine-tuning functionalities, identifying technical problems, fixing errors, and continuing integration.

Choice of the right software. There are an array of administration system options. One option is the custom-developed (bespoke) solution tailored to the specific needs of the concerned jurisdiction and designed and developed using internal or external expertise. This software type was the preferred solution in Punjab Province and Tanzania. Another option is to procure a COTS, which was done in several Kenyan counties and Ghana. The benefits of the COTS solution include the time taken for developing applications in-house and the investment needs for developing and retaining in-house IT resources.

BOX 7.

Administration Systems: Lessons Learned

1. Determine How the Fragmented Administration Systems Interact

- The OSR administration system should support billing, collection, enforcement, and reporting activities in a holistic approach, while driving greater productivity and efficiency. SNGs can start from basic system integration by mapping out existing applications and procedures, such as data flow, types of software, functionalities, user connections, specific requirements and restrictions, among others.
- Evidence suggests that in general, when SNGs adopt different technological solutions for the basic system integration, including digital solutions to address previous manual, paper-based approaches, there are noticeable improvements in their revenue management.

2. Adopt Agile and Affordable System Design

- Modular system design allowed SNGs to upgrade their administration systems incrementally. The module-based architecture (e.g., document management, assessment, administration, reporting, collection, and GIS modules) leads to practical and powerful benefits in a challenging situation where the ICT skills of local staff are relatively weak but growing.

3. Build a Centralized Database

- A centralized database is key for an efficient OSR administration system. This requires SNGs data migration of the historical records and existing data sets to a new database. Extract, transform, and load (ETL) technology is useful to quickly undertake data migration.
- A cloud database that is built and accessed in a cloud environment can address the challenges of on-premises IT equipment. Selection of a cloud platform (private, public or hybrid) can be determined based on various SNGs situations.

4. Explore Options for Utilizing the National Systems

- Though challenging, when SNG revenue administration systems are interoperable with national financial systems (like in the case of Colombia), it results in substantive economies of scale and efficiency gains.
- In certain context, the development of a national government revenue administration system is a practical approach as long as capacity and autonomy are provided at the SNG level for its operation.

5. Undertake Incrementally and Make it Sustainable

- Rigorous testing and piloting of the system before scaling up for widespread deployment has proven a beneficial practice.
- To foster sustainability, it is key that developers are able to remain in business while upgrading the system and dealing with technical problems. Additionally, SNG lack of ownership of the software/system source code has proven problematic.
- Proactive advice from national government and/or municipal associations on the procurement of IT systems in terms of capital and operational costs, licensing, and capacity building programs is proven to positively affect SNG decisions on the adoption of specific technological solutions.

Endnotes

[13] Information provided during meeting with Bangkok Metropolitan Municipality, May 2020.

[14] Transform Freetown (which was launched in 2019) was the vision of Mayor Yvonne Aki-Sawyer and Freetown City Council. An objective of the vision was to undertake a geo-mapping of the city to support property tax collections. https://fcc.gov.sl/transform-freetown-one-year-report/

[15] https://maps.google.com/pluscodes/

[16] There are several competing entities including: the Commission for Lands, responsible for land surveys, valuation and GIS; Zanzibar Municipalities responsible for issuing demand notices for various fees and charges; and potentially the property tax and the Zanzibar Revenue Board, also involved in valuation

[17] Nairobi Metropolitan Services Improvement Project (NaMSIP, P107314, 2012-2020)

[18] GeoManager had the following GIS modules: (1) property data management; (2) sales data analysis; (3) property valuation; (4) value reconciliation; (5) objection and appeal management; (6) production of the Valuation Roll; and (7) property rate calculation for each parcel.

[19] Pakistan Punjab Cities Governance Improvement Project (P112901), https://projects.worldbank.org/en/projects-operations/project-detail/P112901

[20] https://www.ataftax.org/property-tax-reform-lessons-from-freetown

[21] The district local revenue system developed by the German Agency for International Cooperation (GIZ)

[22] The local revenue management system developed by the International Cooperation Agency of the Association of Netherlands Municipalities (VNG International)

[23] INFORME DE GESTION 2020 of Special Administrative Unit of Cadastre in Bogotá, https://www.gobiernoBogotá.gov.co/transparencia/planeacion/planes/informe-gestion-2020

[24] https://www.ids.ac.uk/opinions/collaborating-to-reform-freetowns-property-tax-system/

[25] Tanga, Arusha, Mwanza, Ilemela, Kigoma, Mbeya, Mtwara and Dodoma. Tanzania Strategic City Program (TSCP)

[26] Modular programming is a software design technique that emphasizes separating the functionality of a program into independent, interchangeable modules, such that each contains everything necessary to execute only one aspect of the desired functionality.

Cross-cutting Themes and Conclusions

SECTION

IV

This section brings together the three thematic cases to present an overview of the conditions that led to the successful adoption of technologies for the enhancement of OSRs. The three thematic cases described specific uses of technologies in each case, but there are various commonalities across the value chain of OSR enhancement. A case in point is GIS, which offers efficiency gains in data collection, processing, and administration. Similarly, high-resolution imagery supports the data identification and semi-automatic collection necessary to improve downstream processes, such as data analysis and revenue administration.

Contextual Continuum Reform Framework. Figure 7 combines the three thematic cases (Data Capture/Identification, Assessment/Processing, and Administration Systems) with the different developmental stages to produce a Contextual Continuum Reform Framework. This framework maps the specific context in which a SNG is in relation to the use of technologies to enhance OSR. Viewed vertically, the framework illustrates the series of linked contexts of jurisdictions at various stages of OSR technological reform. While these are not mutually exclusive, they can be used as a base typology to characterize the starting context prior to undertaking any reforms. Viewed horizontally, the framework shows the potential developmental trajectory that a jurisdiction may take – ideally from left to right in each thematic area – in their use of technologies for OSR enhancement.

FIGURE 7.

Contextual Continuum Framework of SNG OSR Reform

STATUS	**Limited/Adequate coverage, but out of date**	**Some good/great areas, some bad areas**	**Comprehensive, but slightly dated coverage**	**Comprehensive coverage, challenge of upkeep**
DATA AND ASSESSMENT	**Limited attribute data, opaque market data** Floor area-based systems with limited discrimination based on few variables Imagery and algorithms can identify extent and basic 'counting' based in tax base coverage	**Basic attribute data, thin market data** Cost-based systems, calibrated by locational adjustments Drone footage, digital cost schedules and broad locational identification from imagery	**Good attribute data, some market data** Robust market value related systems, using a variety of value significant attributes Integrated database and spatial imagery embedded in a GIS-based MIS	**Excellent attribute data, transparent market data** Full ad valorem appraisal to market value, rebased frequently AI/ML and spatial econometric mass appraisal
ADMINISTRATION	**Basic digital records, manual processes**	**Digital fiscal cadaster, some automated process**	**Digital spatial fiscal cadaster, digital processes mostly automated**	**Fully spatially integrated multi-purpose cadastre and MIS**

ENABLERS

- **Increasing capacity enabled via technology**
- **facilitated by a benign political context**
- **sustained via continued investment in system development**
- **process improvement**
- **delivered via effective procurement and deployment**
- **training and public acceptance**
- **regulatory reform**

Accessing the Technology – Capacity and Software Selection

Training and capacity building for technology use. SNGs have been struggling to keep up with the rapid advancements in technological innovation. Information and technology experts in the SNG public sector are scarce, and it is challenging to recruit and retain such staff. The lack of skilled staff in the initial stages of the use of technologies was identified as a key challenge in the case studies. Often SNGs rely on private sector and international consultants, however this model of support is not sustainable in the mid- to long-term. In cases where national governments directly engage with SNG in the mobilization of OSRs, one advantage is that they support training and capacity building programs around the use of the specific technologies. Other cases include donor-driven interventions that provided capacity building programs to support the new technologies, such as those in Ghana and FCC. Where such training is insufficient, there is a high risk that the sustainability of the technology will be an issue.

Standardization of ICT solutions. Standardized SNG's revenue administration systems developed by a national government are the preferred solution in several countries. Benefits include (i) cost-effectiveness of providing technical support for one system with standard technical specification, as opposed to several; (ii) regular upgrades and system improvements; (iii) consistency and standardization of training and capacity building programs; and (iv) across-the-board performance monitoring for all local governments. A helpful illustration is the case of LGRCIS in Tanzania, which provided all 189 municipalities with a common technological solution. This brough familiarity to the use of the system, meaning that incoming staff from different locations could operate the system and continue the revenue administration tasks without interruption or need for additional training. The operation of LGRCIS also simplified reporting to the central government department, as the information was received in standard form. However, one drawback is that such an IT solution could restrict the pace of system updates with new features and functions, meaning that innovations and upgrades that are viable in a large cities and metro areas may be delayed as they are not cost-effective for the whole system.

Software selection. Another element regarding technology adoption for SNG OSR is the proper selection of technological products and solutions. The most common challenge is making the choice between an in-house custom-developed system or acquiring a COTS. Arguments in favor of a tailor-made solution include (i) customization according to specific jurisdiction requirements; (ii) transferability of specialized domain knowledge already built into any existing legacy system; (iii) incorporation of best practices from different technologies; and (iv) lack of reliance on timely updates of a generic system, which could prove operationally difficult. On the other hand, COTS have several advantages including (i) time savings in the development of the system; (ii) proven technologies previously used in a diversity of contexts; and (iii) robust, field-tested systems. Table 4 provides additional comments on the differences between a COTS and tailor-made revenue systems.

TABLE 4.

Comparison of COTS and Bespoke Systems

	COTS	TAILOR-MADE (BESPOKE)
Ownership	COTS is essentially rented, so there are license fees for a period of time	System is owned. Payment is for the development of the system
Number of users	There can be a limit placed on the number of users related to the number of licenses	There is no limit on users
System design	COTS software is built for the mass market designed to meet common business challenges with a feature-set as broad as possible to encompass the needs of the users; the solution offered may be a perfect fit for the desired purpose	Custom-designed system is built for specific purposes and can be intuitive and scalable
Source code	Source codes are owned by the system vendor	The system owner owns the source codes, which allows for easier future customization
Implementation	A COTS solution is likely to be quicker to implement, though configuration and integration work may still be required	The time taken to develop needs to be factored in as lengthy development, and testing may come at a cost
Cost	Likely to be cheaper due to low upfront cost and only paying for the license to use; however, license costs can rise over time with the increase in users	Higher upfront cost: development costs depend on the number of functionalities and system architecture, requiring long-term investment
Flexibility	It can be inflexible when customization is required	Changes in the design can be made more quickly
Market use	There are examples of the COTS product working successfully in other organizations	With custom development, there is no absolute certainty that the system will be scalable, workable, or affordable
Technical support	There is usually a large ecosystem with a community of user forums, verified reviews, and training programs	In-house support can be efficient but also costly in terms of retaining skilled staff

As SNGs are confronted with the decision of which technology to adopt, an important factor to consider is the ability of revenue and IT departments to handle the technology. Another important decision is the selection of local or international providers: international vendors usually display good technical capacity but often push for the adoption of existing systems, which may not be well suited to the local conditions. International service providers are also typically risk-averse and prefer to work with national, provincial, or big city governments rather than with smaller jurisdictions that carry greater risks. On the other hand, local vendors are likely to be aware of the local circumstances but may lack the necessary capacity to guarantee the required service standards and timelines.

Another important choice is the use of vendor-supplied proprietary software versus free open-source software (FOSS).[27] The use of FOSS: (i) reduces the dependency on expensive proprietary technologies; (ii) enables knowledge sharing and local capacity development; (iii) avoids the payment of license fees; and (iv) benefits from the flexibility of customization that comes from the innovation and creativity of the open-source community. These were perceived benefits in the Bogotá case during the transition away from legacy proprietary solutions. However, it requires a greater level of IT competence as compared to proprietary systems due to its maintenance for critical features. The FOSS has a huge community of developers and is quickly evolving, but their use requires staff with higher-level skills, motivation, and commitment.

A final consideration on software selection concerns the approach to the use of GIS. GIS is now widely accepted as a key component within all aspects of SNG IT deployment. Licensed GIS software comes with support packages, training opportunities and frequent upgrades. Open-source GIS also gains significant ground within this environment. It requires specific skills to customize the software for specific applications, but it also has the advantage of being free.

Political Economy in Technological Decision

One key consideration in the decision to adopt technological solutions is the political economy at play between different departments in the central government and their relationship with SNG. This dimension appeared in various of the case studies.

Reluctance of Data Sharing. Central government ministries such as the Ministry of Land often hold important satellite and/or aerial imagery for the entire country. Sharing of this imagery could support data collection at the SNG level. However, such sharing is often problematic and driven not by technological issues but by other considerations. The consequence is that SNGs procure their own imagery despite the existing imagery at the central level, resulting in duplicated investments in many respects. This was witnessed in the Kenya and Ghana cases.

Political Economy and Decentralization. In the case of FCC, Sierra Leone, for example, the city and the national parliament were dominated by different political parties, which undermined the results brought about by FCC's reform plan. The political relationship delayed the introduction of the reform considerably. In Bogotá, Colombia, there was considerable friction between the Ministry of Justice and the city regarding the status and use of the legal cadaster. The Ministry of Justice had their own plans to modernize the legal cadaster, but the focus of such plan was not primarily for the optimization of OSRs.

When considering the relationship between the central government and SNG, there is a risk that SNG revenue-raising can become a victim of its own success. Fiscal decentralization is predicated on the concept of assigning a common set of revenue sources, which typically are neither the most lucrative nor easiest to collect. Despite this, when the assigned revenue becomes a realized revenue stream via the successful deployment of technological solutions, the management of the revenue sources can be subject to reallocation by the central government, often with the argument of increasing administrative efficiency by using national-level revenue systems. While this decentralization can be justified in cases where SNG has no capacity, it is less justifiable when the SNG capacity has been established. Tanzania is an example where this has occurred. After SNG was empowered through the =provision of the LGRCIS, key revenues from the property tax and advertising panel fees increased sharply. The administration of these revenues was subsequently reassigned to the central government, with little evidence of them being rerouted to SNGs (Fjeldstad, 2014). While this decision has since been reversed, it comes with considerable frictions. The LGRCIS solution delivered strong revenue performance and continued to do so with smaller revenues during the period in which larger revenues were collected by the national government.

System Sustainability

System Ownership. The procurement of technological solutions should be subject to rigorous selection criteria from the start, including a comprehensive capacity building program and project management to produce a high-quality solution. This allows SNGs to take full ownership of the technological solution, including clear arrangements within any license to cover both increased users and geographical expansion. In the absence of a full takeover, there should be a robust supplier agreement in place, which facilitates use and development. This can be established in return for an acceptable fee structure and the ability to retender in an open competition capable of sustaining an acceptable number of competitive bids. This approach was adopted in FCC and Ghana, where donor-funded support programs were designed from the start to ensure that the SNG retained ownership of operational data and received software transfers after the initial proving period.

System Maintenance. Continuous maintenance is a key component for sustaining a revenue administration system and ensuring its operation and reliability. However, SNGs experience technical difficulties in commissioning the revenue administration systems to manage, maintain and update through time. Challenges arise when software and data are subject to propriety ownership rights or contractual restrictions from the service provider. This can limit the ability to handle continuous operations and upgrade the software. It is not rare for technical documentation to be withheld from end-users, resulting in potentially expensive additional costs. In terms of updating the system, third-party ownership of the software source code can be problematic for the SNG, as they may be prevented from making appropriate changes. In these circumstances, SNG may have to abandon the use of the adopted technology and start again.

Interaction with Existing Systems

Linkage between Cadaster and OSR Data. Often, the initial consolidation of data for OSR purposes starts with the existing cadaster. However, in many instances the cadaster is also subject to a process of modernization, generally linked to the introduction of a modern land registry. For example, where taxation is levied on ownership of land and buildings, it is useful to link it to official proof of ownership; otherwise efforts to enforce payment can be undermined (e.g. Kenya). Property transactions are an important source of information for taxes (e.g., recurrent property tax, property transfer tax, capital gains tax and inheritance tax), but such data is part of the land registration workflow often housed in separate ministries, meaning it can take considerable time to access. In other contexts, land registration and formalization of titling is also at an early stage, which can delay the use of such data for OSR generation purposes. Moreover, establishing a comprehensive cadaster is a time consuming and cumbersome process and even where digitized legacy systems are in place, challenges can remain that require technical solutions, inter-agency agreement, and pragmatic solutions. In Bogotá, for example, earlier digitization had followed a path common to many jurisdictions since the system was based on folio numbers and not on spatial basis. The Colombian cadaster has seen several attempts to move towards a more spatially-enabled Land Administration Domain Model (LADM).[28] This would include digital maps and a functioning system to maximize the efficiency and legitimacy of the tax base by interlinking the cadaster and OSR databases for simultaneous updates. From a pragmatic perspective, however, having a full and operation legal cadaster that can be used for taxation purposes often takes a long time, so in the short- to medium-term, it is often necessary to develop a fiscal cadaster based on a spatially-enabled address system; this enables revenue mobilization while working to reach compatibility with the legal cadaster.

Address Systems. In other cases, street addressing systems can also serve as the initial data point for property taxes. In recent times, property addressing has been aided by the introduction of digitized grid-based solutions such as “what3words” and “Plus Codes”, which cover the entire globe with a map-based reference system at a scale suitable for identifying the location of residential and commercial premises. These solutions offer a valuable starting point but they do not provide a full solution or even a viable alternative to an officially-sanctioned addressing system. Issues arise because individual properties may have multiple addresses, or such addresses may encompass two or more separate properties. While representing a specific property’s perimeter can be dealt with via a process of ‘geofencing,’[29] some challenges remain that render the adoption of an addressing system complicated.

Even in cases such as Bogotá where addresses have evolved organically over time and become part of the system, the challenge was formalizing all the different ways of representing these addresses within a common address file. Bogotá overcame this hindrance by linking official datasets, which massively sped up revenue data processing. In more informal settings such as Sierra Leone and Ghana where no real addressing systems are in use, it is difficult to capture and formalize loose, unconsolidated, and opaque data on addressing. However, places like Uganda, the Kampala Capital City Corporation (KCCA) achieved considerable success in developing an addressing system that has underpinned OSR mobilization (Kopanyi and Franzsen, 2018; Kopanyi, 2015).

Where Next?

Transition to Modern OSR Management and Decision on Investment. When deciding on investment in OSR reform and modernization, SNGs need to conduct a technical assessment to examine capacity, available data sets, related IT systems and potential interlinks and interoperability of the existing IT resources. A pilot or proof of concept (POC) will follow to test technological options and select the most suitable solution according to the local conditions. A site selection for the POC should consider a relatively easy area where test data can be quickly captured and collected to achieve a quick win. Investment should involve all three technology categories – data capture/identification, assessment/processing, and integrated administration system – because they are systematically correlated as a complete procedure of the data flow cycle.

An investment in high-resolution imagery should be calculated based on the area to be covered. In general, UAV imagery is a practical solution for areas of less than 100km^2 considering its quick mobilization and fast output delivery. Acquisition of aerial imagery can be done through local service providers. If aerial imagery is not readily available, satellite imagery is the best option due to its wide availability in the market. Data capture can be semi-automated by using either commercial or open-source tools. Field data collection through mobile apps (either free or paid apps) is a common practice nowadays. SNGs should test the commercially available applications and determine whether they need to develop a customized mobile application.

A business process re-engineering (BPR) with the participation of government officers and external experts, is a practical option for SNGs to test if the proposed processes to improve OSR function as expected, before investing in the system. During the BPR practice, successful examples of OSR enhancement through technology from other countries should be considered to identify the most cost-effective investment path. The pre-trained models for AI/ML and pre-defined assessment/processing functions of the existing applications help SNGs explore the possibility of assessment automation. A major restriction on adoption of AI/ML should be carefully considered since this is highly data-intensive and only applicable when the required data, systems and capacity are available. As OSR data processing and assessment involve various datasets, SNGs may consider costs for data cleaning, data exchange, and reference key creation to connect a primary dataset to the other relevant datasets.

Developing an integrated administration system is one of the significant components of investment. A phased-system development approach that prioritizes core functions and applies modular programming enables SNGs to invest wisely in the administration system and incrementally improve it. A modular approach to software architecture can easily accommodate the needs for evolving solutions and upgrades, as well as the increase in system users. Other essential technical elements that should be considered for investment include data structure for interoperability, available communication infrastructure, backup, data protection, network security, service volume (number of concurrent users) in the short and medium terms, and deployment planning. A cloud platform is a practical option for SNGs that doesn't require dedicated in-house IT equipment. With careful technical design and piloting, the initial investment is expected to pay-off.

Technological Advances. There has been increased interest in the development of advanced technologies such as AI and ML with respect to data analysis and management. SNGs have traditionally used computers to store, analyze, and organize their work, particularly when managing revenue streams. However, a combination of factors has accelerated the deployment of technology, including the potential of the internet, widespread use of smartphones and mobile computing, scalable cloud computing, data science using AI and ML, and the integration of sensors and devices into the 'Internet of Things'. The massive growth of information, digitization, almost unlimited computing power, and AI provides a platform with new ways of working with and analyzing information and data (IAAO, 2022).

By leveraging the latest advancements in deep learning, it is now possible to convert billions of images of the Earth into high-definition maps. This evolution has enabled the AI system to detect, extract (map), and update features from geospatial imagery with an increased level of detail, offering a highly scalable mapping solution that maintains the accuracy of manual digitization. Revenue administrations with experience in using digital tools and spatial technologies are starting to integrate AI and ML into their administrative systems.

Challenges ahead. This analysis found strong evidence that the use of technological solutions can greatly improve data identification, collection, assessment, processing, and revenue administration at the SNG level. The use of technological solutions is now a key element of any tax reform process. In essence, the 'business as usual' option is no longer an option. Technology can simultaneously address the administrative challenges facing SNGs while also producing the much-needed revenue to address SNG funding gaps. While technological advances offer great potential for OSR enhancement, this analysis reveals that many challenges remain. Everyone interviewed for this analysis – many of them directly involved in the local revenue reform process for decades – agreed that success is not contingent upon the use or selection of a specific technological solution. Technologies are becoming more prevalent and affordable, which has helped the process and allowed SNGs to reach targets that were impossible to imagine even a few years ago. However, the extent to which technologies can deliver on their full potential depends on overall financial constraints and political, regulatory, organizational, and institutional determinants, which are beyond the current and future technical solutions.

Endnotes

27 FOSS is distributed under a free licence that permits the users to copy, alter and redistribute the software without restrictions. The source code – the set of instructions that make up a computer programme – is made publicly available.

28 LADM is an international standard (ISO 19152:2012) for the land administration domain that provides a formal mechanism for describing land administration data, such as cadastral and deeds data.

29 A geofence is a virtual perimeter for a real-world geographic area. A geofence could be dynamically generated (as in a radius around a point location) or match a predefined set of boundaries. The use of a geofence is called geofencing. (https://en.wikipedia.org/wiki/Geo-fence)

References

Adam Smith International, 2014. *Own Source Revenue Potential and Tax Gap Study of Kenya's County Governments.* London, UK

Ayalew, A.D. and Deininger, K. 2016. *Property Tax in Kigali: Using Satellite Imagery to Assess Collection Potential.* In Proceedings of the 2016 World Bank Conference on Land and Poverty, Washington, DC, USA, 20–24 March 2016.

Bahl, R. and Linn, J.F. 2014. *Governing and Financing Cities in the Developing World.* Policy Focus Report. Cambridge, MA: Lincoln Institute of Land Policy.

Bird, R.M. and Zolt, E.M. 2008. Technology and Taxation in Developing Countries: From Hand to Mouse. *National Tax Journal* 61(4:2): 791-821.

Chae, M.O. and Kwon, I. 2018. *Korea's Mass Assessment System of Land Pricing for Taxation, Utilizing ICT*. Paper presented at the World Bank Conference on Land and Poverty. World Bank, Washington DC, March 19-23.

Fish, P. 2015. Practical Aspects of Mobilising Property Tax: Experience in Sierra Leone and Malawi. *Commonwealth Journal of Local Governance*, June: 242-262.

Fish, P. 2018. *Practical Guidance Note: Training Manual for Implementing Property Tax Reform with a Points-Based Valuation*. ICTD African Tax Administration Paper 2. The International Centre for Tax and Development, UK.

Fjeldstad, O-H. 2006. *Local Revenue Mobilization in Urban Settings in Africa.* Bergen: Chr. Michelsen Institute.

Fjeldstad, O-H. and Heggstad, E.R. 2012. *New Challenges for Local Government Revenue Enhancement*. Bergen: Chr. Michelsen Institute.

Fjeldstad, O-H. 2014. *Policy implementation without institutional cooperation: Central-local government relations in property tax collection in Tanzania*. Paper presented at the annual conference of the International Center for Tax and Development, Arusha, Tanzania, December 7-9.

Fosu, C. and Ashiagbor, G. 2012. *GIS Application for Local Government Revenue Mobilization*. Paper presented at Global Geospatial Conference, Québec City, Canada, 14-17 May 2012.

FCC, 2021. *Transform Freetown: Second Year Report, January 2020 – January 2021*. Freetown City Council, Sierra Leone.

GIZ, 2020. *The operationalization of the dLRev software for improved revenue mobilization at local government level: a cost-benefit analysis.* Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH under Ghana Priorities project. Accra, Ghana.

GSMA, 2021. *The Mobile Economy: Sub-Saharan Africa*. GMSA, London, UK.

IAAO, 2022. *A Review of the Methods, Applications, and Challenges of Adopting Artificial Intelligence in the Property Assessment Office*. International Association of Assessing Officers, Kansas, United States.

IPTI, 2021. *The Potential of Artificial Intelligence in Property Assessment*. The International Property Tax Institute, Toronto, Canada.

Jain, S. 2008. Remote sensing application for property tax evaluation. *Int. J. Appl. Earth Obs. Geoinf.* 10: 109–121.

Jiang, H., Peng, M., Zhong, Y., Xie, H., Hao, Z., Lin, J., Ma, X. and Hu, X. 2022. A Survey on Deep Learning-Based Change Detection from High-Resolution Remote Sensing Images. *Remote Sens.* 14, 1552.

Junquera-Varela, Raul Felix; Lucas-Mas, Cristian Oliver; Krsul, Ivan; Calderon Yksic, Vladimir Omar; Arce Rodriguez, Paola. 2022. Digital Transformation of Tax and Customs Administrations. Equitable Growth, Finance & Institutions Insight;. © Washington, DC: World Bank.

Karimi, H., Kimani, E.M. and Kinyua, J.M. (2017). Effect of technology and information systems on revenue collection by the county government of Embu, Kenya. *International Academic Journal of Information Systems and Technology*, 2(1), 19-35.

Keen, M. 2012. *Taxation and Development – Again*. IMF Working Paper WP/12/220, Washington DC: IMF.

Kelly, R. and Musunu, Z. 2000. *Implementing Property Tax Reform in Tanzania*. Working Paper WP00RK1, Cambridge MA: Lincoln Institute of Land Policy.

Kelly, R. 2014. Implementing Sustainable Property Tax Reform in Developing Countries, in R.M. Bird and J. Martinez-Vazquez (eds), *Taxation and Development: The Weakest Link? Essays in Honor of Roy Bahl*, Cheltenham, UK: Edward Elgar: 326–363.

Kelly, Roy, White, Roland, Anand, Aanchal 2020. *Property Tax Diagnostic Manual,* Washington DC, World Bank Group

Knebelmann, J. 2022. *Digitalisation of property taxation in developing countries: recent advances and remaining challenges*. ODI Report. London: ODI (www.odi.org/publications/ digitalisation-of-property-taxation-in-developing-countries-recent-advances-and-remainingchallenges)

Koeva, M.; Gasuku, O.; Lengoiboni, M.; Asiama, K.; Bennett, R.M.; Potel, J.; Zevenbergen, J. 2021. Remote Sensing for Property Valuation: A Data Source Comparison in Support of Fair Land Taxation in Rwanda. *Remote Sens.* 13, 1-25.

Kopanyi, M. 2015. *Local Revenue Reform of Kampala Capital City Authority*. International Growth Centre Working Paper, London: London School of Economics, with University of Oxford

Kopanyi, M. and Franzsen, R. 2018. *Property Taxation in Kampala, Uganda: An Analytic Case Study on a Successful Reform.* Working Paper 18-03, African Tax Institute, University of Pretoria, South Africa.

Mas, I. and Radcliffe, D. 2010. Mobile Payments go Viral: M-PESA in Kenya. *Journal of Financial Transformation*. March: 169-182.

Mascagni, G., Moore, M. and McCluskey, R. 2014. *Tax Revenue Mobilisation in Developing Countries: Issues and Challenges.* Brussels: EU-Policy Department.

Mayer, H., 2008. Object extraction in photogrammetric computer vision. *ISPRS J. Photogrammetry & Remote Sensing*. 63(2):213-222.

McCluskey, W, Davis, P, Haran, M, McCord, M & McIlhatton, D. 2012. The Potential of Artificial Neural Networks in Mass Appraisal: The Case Revisited, *Journal of Financial Management of Property and Construction*, vol. 17, no. 3, pp. 274-292.

McCluskey, W.J. and Franzsen, R.C.D. 2005. An Evaluation of the Property Tax in Tanzania: An Untapped Fiscal Resource or Administrative Headache? *Property Management* 23(1): 43-69.

McCluskey, W., Huang, C-Y., Doherty, P., Franzsen, R. and Fish, P. 2018a. *Using information and communication technology to enhance local government revenue collection in Tanzania*. African Tax Institute Working Paper 18/08. University of Pretoria, South Africa.

McCluskey, W.J., Franzsen, R.C.D. and Bahl, R.W. 2017b. Policy and Practice, in R.C.D. Franzsen and W.J. McCluskey (eds), *Property Tax in Africa – Status, Challenges and Prospects*, Cambridge MA: Lincoln Institute of Land Policy: 29-104.

McCluskey, W., Franzsen, R., Kabinga, M. and Kasese, C. 2018b. *The Role of Information Communication Technology to Enhance Property Tax Revenue in Africa: A Tale of Four Cities in Three Countries.* ICTD Working paper 88. International Centre for Tax and Development, Brighton, UK.

McCluskey, WJ, McCord, M, Davis, PT, Haran, M & McIlhatton, D. 2013. Prediction accuracy in mass appraisal: a comparison of modern approaches, *Journal of Property Research*, vol. 30, no. 4, pp. 239-265.

Namangaya, A. 2018. Practices in Institutionalizing GIS for Revenue Mobilization: The Case of Secondary Cities in Tanzania. *Current Urban Studies*, 2018, 6, 559-57.

National Treasury, 2019. *Enhancement of County Government's Own Source Revenue*. National Treasury and Planning, Nairobi, Kenya.

Neene, V. and Kabemba, M. 2017. Development of a Mobile GIS Property Mapping Application Using Mobile Cloud Computing. *Journal of Advanced Computer Science and Applications*. 8(10): 57-68.

OECD, 2016a, *Advanced Analytics for Tax Administration: Putting data to work*. OECD Publishing, Paris.

OECD, 2016b. *Technologies for Better Tax Administration: A Practical Guide for Revenue Bodies.* OECD Publishing, Paris.

OECD/UCLG, 2019. *2019 Report of the World Observatory on Subnational Government Finance and Investment – Key Findings.* OECD, Paris, France.

Okunogbe, Oyebola; Santoro, Fabrizio. 2021. The Promise and Limitations of Information Technology for Tax Mobilization. Policy Research Working Paper; No. 9848. World Bank, Washington, DC.

Otieno, O.C., Oginda, M., Obura, J.M., Aila, F.O., Ojera, P.B. and Siringi, E.M. 2013. Effect of Information Systems on Revenue Collection by Local Authorities in Homa Bay County, Kenya. *Universal Journal of Accounting and Finance* 1(1): 29-33.

Prichard, W. 2014. *Using Local IT Solutions to Improve Local Government Tax Reforms.* IDS Policy Briefing 58, Brighton, UK: Institute of Development Studies.

Prichard, W. and Fish, P. 2017. *Strengthening IT Systems for Property Tax Reform.* ICTD Summary Brief Number 11, Brighton, UK: Institute of Development Studies.

Sausi, J., Kitali, E.J. and Mtebe, J. 2021. Evaluation of local government revenue collection information system success in Tanzania. *Digital Policy Regulation and Governance*, 23(5): 437-455.

Singh, A. Digital change detection techniques using remotely-sensed data. *Int. J. Remote Sens*. 10, 989–1003.

Slack, E. 2009. *Guide to Municipal Finance*. UN-Habitat, Nairobi, Kenya.

World Bank, 2016. *World Development Report 2016: Digital Dividends*. Washington, DC: World Bank.

World Bank, 2020. *Artificial Intelligence in Emerging Markets*. Washington, DC: World Bank.

World Bank, 2020. *Use Case Viability Report: AI for Parcel Mapping.* World Bank Group, Washington, DC.

World Bank, 2021. *Promise and Limitations of Information Technology for Tax Mobilization (Policy Paper 9484).* Washington, DC: World Bank

World Bank, 2021a. *Tanzania Cities Transforming Infrastructure and Competitiveness Project.* PAD4444. Washington DC.

World Bank and United Nations. 2017. *Combatting Cybercrime: Tools and Capacity Building for Emerging Economies.* Washington, DC: World Bank.

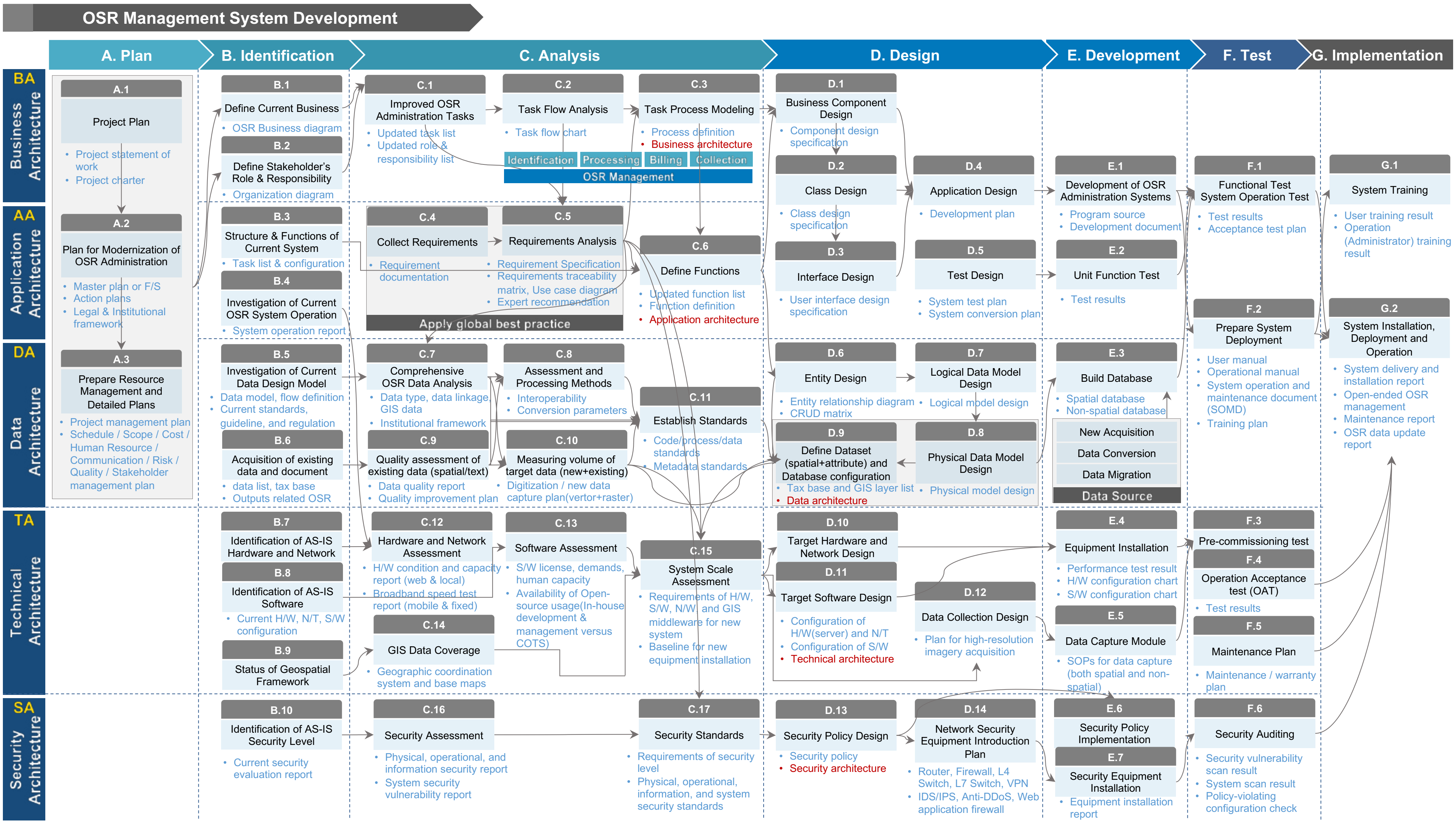
Xiangyun, H. and Lizhi. Y. 2013. A Fast and Simple Method of Building Detection from Lidar Data Based on Scan Line Analysis. *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, Volume II-3/W1, 2013 VCM 2013. The ISPRS Workshop on 3D Virtual City Modeling, 28 May 2013, Regina, Canada.

Annexes

Annex 1: Case studies and associated Bank Projects

COUNTRY/ CITY	PROJECT ID
Punjab, Pakistan	P112901- Pakistan Punjab Cities Governance Improvement Project
Freetown	P175302- Land Sector Dialogue
Zanzibar	P111155- TZ-Zanzibar Urban Services Project P155392- TZ-Zanzibar Urban Services Project Additional Financing P165128- Boosting Inclusive Growth for Zanzibar: Integrated Development Project
Colombia	P112852- Bogotá Urban Services P172535- Resilient And Inclusive Housing Project
Ghana	P120636- Land Administration Project - 2
Kenya	P107314 Nairobi Metropolitan Services Improvement Project (NAMSIP)
Tanzania	P111153- Tanzania Strategic Cities Project P148974- Tanzania Strategic Cities Project - Additional Financing P123134- Dar Es Salaam Metropolitan Development Project P118152- Urban Local Government Strengthening Program

Annex 2: Sequencing the Development of OSR Administration Systems and the Adoption of OSR-related Technologies



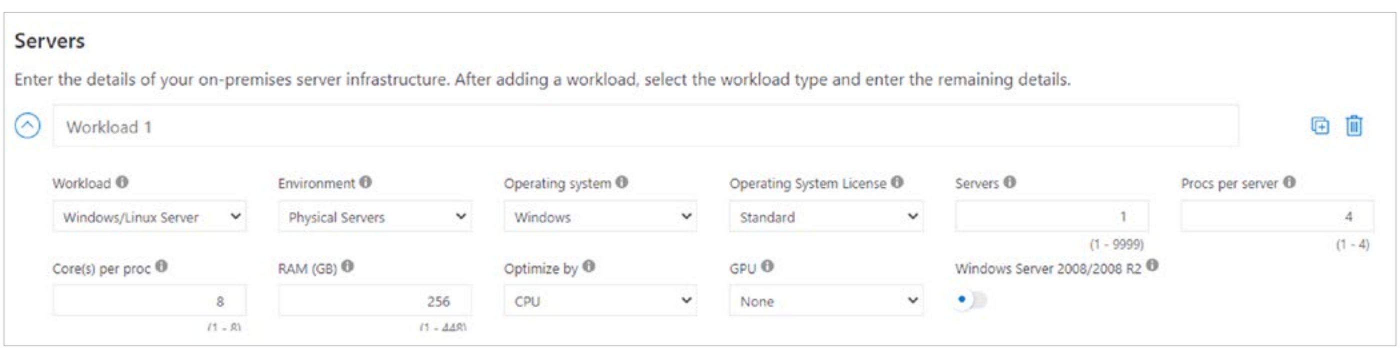
Annex 3: Total Cost of Ownership (TCO) Calculator

1. **What is TCO Calculator?** The TCO Calculator helps ICT experts/ICT project designers understand the cost areas that affect IT applications, such as server hardware, database, software licenses, electricity, networking and IT labor. TCO Calculator is a simple tool but provides the latest costings of various ICT elements. It also estimates the potential cost difference by migrating IT resources to cloud-based storage/servers compared to on-premises environments, and finally generates a report.
2. **Who provides TCO Calculator, and how to access it?** Microsoft provides the IT resource costing service, and the web address is https://azure.microsoft.com/en-us/pricing/tco/calculator/
3. **What are the procedures for estimating the ICT investment costs?** Details of the on-premises workload need to be entered, including: (i) servers; (ii) databases; (iii) storage; (iv) networking geographical region; (v) electricity costs; (vi) storage costs; and (vii) IT labor costs.
4. **Example:** The below example show the ICT investment estimation of one of the countries in the South Asian Region where the land mass is around 200,000 km^2 with over 110 million population. The volume of storage is set for 500 TB, which can sufficiently cover the whole territory and store other new data sets (e.g., photos, MIS data, land records, etc.)

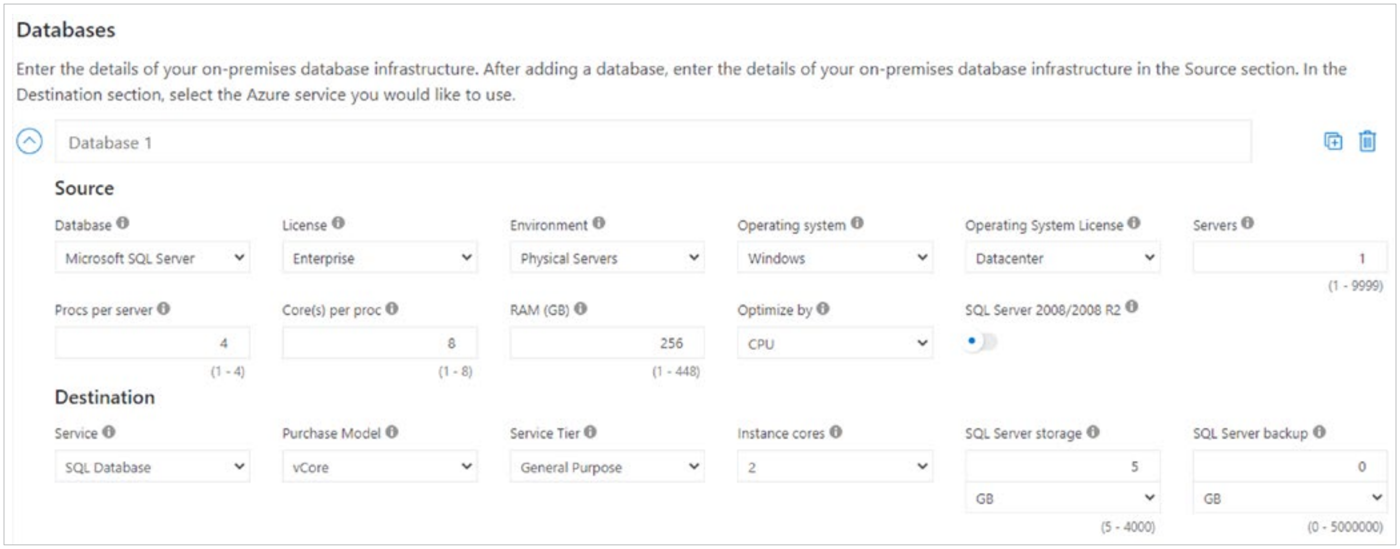
- **How to calculate the file size of high-resolution imagery?** In this case, the example includes 30cm spatial resolution (GSD) imagery. The average file size for the imagery is 36 MB per km^2; however, please note that the average size is varied by ground conditions (e.g., forest, built-up area, agricultural land, road, waterbody, etc.) and spatial resolution.

- The formula is: 200,000 km^2 x 36 MB x 1.4 (40 % for building tile images) x 2 (redundancy in database) = **20,160,000 MB or 20.16 TB**.

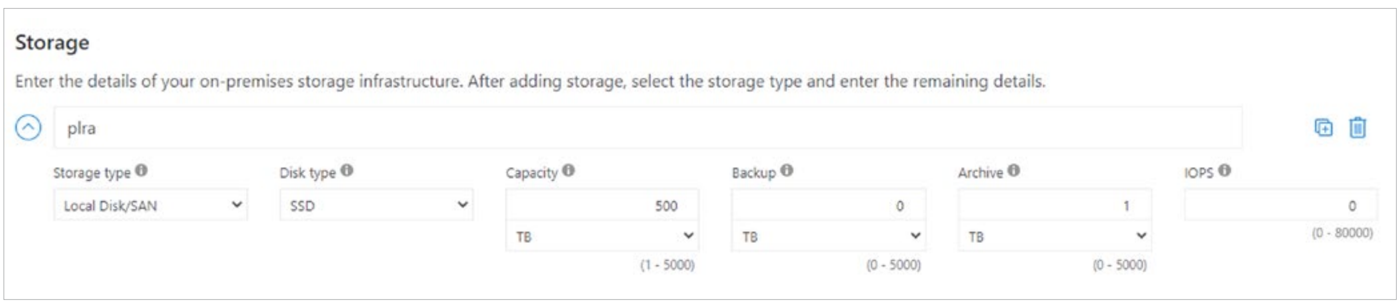
Step 1. Servers



Step 2. Databases

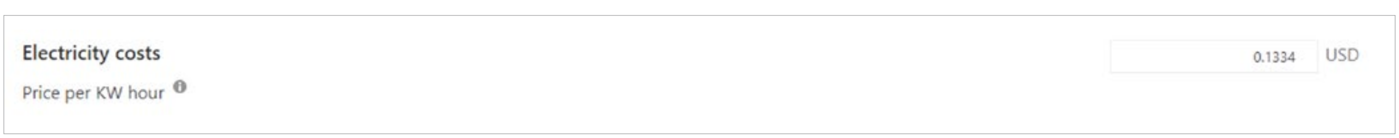


Step 3. Storage (512 TB (usable 238 TB, SSD, RAID 10 configurations)



Step 4. Networking (Destination Region: Southeast Asia)

Step 5. Electricity costs



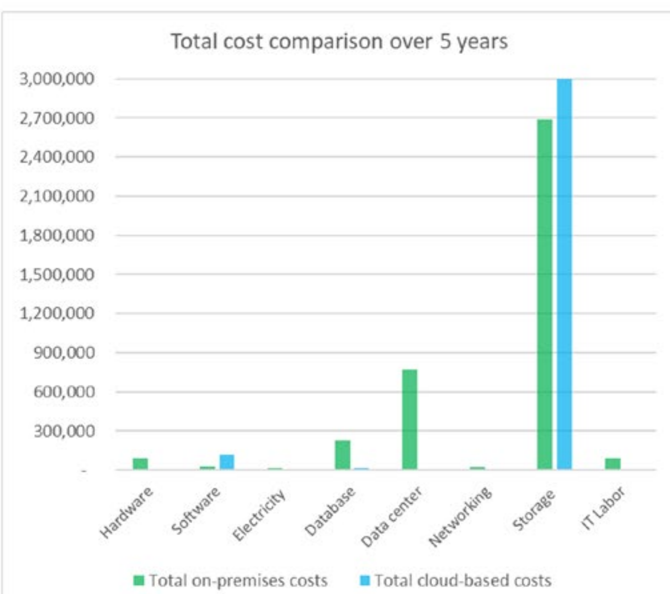
Step 6. Storage costs

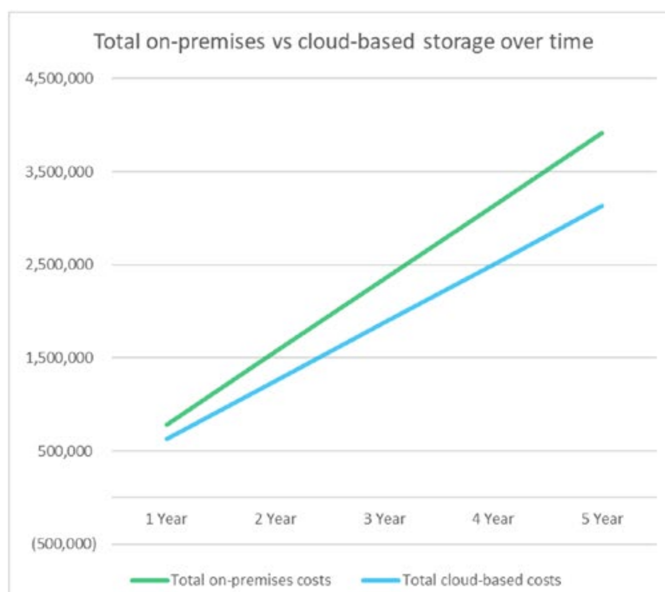
Storage costs		
Storage procurement cost/GB for local disk/SAN-SSD	3.5	USD
Storage procurement cost/GB for local disk/SAN-HDD	0.2	USD
Storage procurement cost/GB for NAS/file storage	0.2	USD
Storage procurement cost/GB for Blob storage	0.2	USD
Annual enterprise storage software support cost	10	%
Cost per tape drive	160	USD

Step 7. IT labor costs

IT labor costs		
Number of physical servers that can be managed by a full time administrator	5	
Number of virtual machines that can be managed by a full time administrator	20	
Hourly rate for IT administrator	23	USD

Final report. The total cost of ownership for a data storage of 512 TB (usable 238 TB, SSD, RAID 10 configurations) is estimated to compare cloud-based storage and on-premises installation for five years. Based on the analysis, the cloud-based storage would cost US$3.14 million over five years, while the on-premises storage would cost US$3.92 million. The cost savings, if using cloud-based storage, would be 24.7% (US$777,200) compared to the total cost of on-premises data storage option.





On-premises cost (US$)		Cloud-based storage cost (US$)	
Hardware		**Hardware**	
Total cost for physical server(two)	43,528	-	
Cost of maintaining physical server(s) - 20% of cost of physical server x 5 years	43,528	-	
Total hardware cost over five years	87,056	Total hardware cost over five years	0
Software		**Software**	
Total software license cost (Cost of data center operation S/W license)	24,620	Total Virtual Machines software cost	116,144
Electricity		Electricity	
Price of electricity per kWh (for businesses)	0.1334	-	
Power rating of 16 core, 256 GB RAM server (1,002 Watts) x 2 per month	195.22	-	
Total electricity cost over five years	11,713	Total electricity cost over five years	0
Database		**Database**	
Database license cost	228,0969	Database cost (general purpose single gen)	17,164
Data Center		Data Center	
Data center compute cost x 5 years	12,091	-	
Rack mounting/installation cost x 5 years	755,675	-	
Total data center cost over five years	767,766	Total data center cost over five years	0
Networking		**Networking**	
Network hardware and software cost assumed to be 15% of hardware and software cost over five years	16,751	-	
Network maintenance cost assumed to be 15% of network hardware and software cost over five year(s)	2,521	-	
Total networking cost over five years	19,273	Total networking cost over five years	0
Storage		**Storage**	
Cost per GB (Local Disk/SAN-SSD)	3.5	Usable storage volume in GB	(256,000)
Storage (RAID 10 Mirror & Stripe configuration) volume in GB	512,000	Total IOPS (input/output operations per second)	(7,680,120)
		Number of premium disks	(64,001)
		Disk price per month	49,920
Total storage procurement cost	1,792,000	Total Locally redundant storage (LRS) premium disk maintenance cost over five year(s)	2,992,508
Backup and archive cost	160	**SQL Database Server storage**	
Storage maintenance cost over five year(s)	896,000	Usable storage volume in GB (500)	
		Annual storage cost per usable volume (12,000)	
		SQL Database Server Storage cost over five year(s)	690
		SQL Database Backup Storage Cost over five year(s)	3,450
Total storage cost over five years	2,688,160	Total storage cost over five years	2,996,648
IT Labor		**IT Labor**	
Total IT labor cost over five years	92,000	Total cloud-based storage IT over five years	11,500
Total storage cost over five years	**$3,918,684**	**Total cloud-based storage cost over five years**	**$3,141,458**

Image Credits

PAGE 32
Shutterstock / Michael Duf

PAGE 33, TOP
Shutterstock / Delali Adogla-Bessa

PAGE 33, BOTTOM
Shutterstock / Rachmo

PAGE 35, TOP
Shutterstock / mbrand85

PAGE 35, BOTTOM
Shutterstock / Vasiq Eqbal

PAGE 36
Shutterstock / Santi Andrade

PAGE 43
Shutterstock / Sopotnicki

PAGE 44
Shutterstock / Vasiq Eqbal

PAGE 45
Shutterstock / tantrik71

PAGE 46, TOP
Shutterstock / robertonencini

PAGE 46, BOTTOM
Shutterstock / MOIZ HUSEIN STORYTELLER

PAGE 47, TOP
Shutterstock / Wirestock Creators

PAGE 47, BOTTOM
Shutterstock / Santi Andrade

PAGE 52
Shutterstock / Michael Duf

PAGE 53
Shutterstock / Vlad Karavaev

PAGE 54
Shutterstock / MOIZ HUSEIN STORYTELLER

PAGE 55
Shutterstock / Truba7113

PAGE 57
Shutterstock / Vasiq Eqbal

WORLD BANK GROUP
Urban, Disaster Risk Management, Resilience & Land