LEVERAGING TECHNOLOGY FOR PROPERTY TAX MANAGEMENT IN ASIA AND THE PACIFIC
GUIDANCE NOTE
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Abbreviations

ADB  Asian Development Bank
AI   artificial intelligence
AVM  automated valuation model
CMAS computerized mass appraisal system
CNN  convolutional neural network
DLNN deep learning neural network
DMC  developing member country
GDP  gross domestic product
GIS  geographic information system
GWR  geographically weighted regression
ICT  information and communication technology
ILIS integrated land information system
LIS  land information system
PT   property tax
Property taxation has long been recognized as a stable mechanism to support municipal finance, promoting economic growth and overall quality of life for the communities it serves. Various historical constraints, including legal, technical, and others, have resulted in a general lack of such benefits in Asian Development Bank developing member countries, particularly in comparison with more tenured property tax systems. This report aims to extend the foundation of the World Bank’s *Property Tax Diagnostic Manual* by introducing technical solutions that may be implemented by developing member countries to promote property tax reform that is both efficient and effective. It provides guidelines to help government practitioners set up computerized mass appraisal systems to facilitate mass valuation and other property tax administration functions. The solutions proposed are based on international best practices and standards, and are substantiated with examples, visual aids, and case studies.
The Asian Development Bank (ADB) has prioritized supporting the United Nations’ Sustainable Development Goals in Asia and the Pacific in its Strategy 2030 and this includes increasing domestic resource mobilization through fair and inclusive taxation. As developing economies in the region continue to address coronavirus disease (COVID-19) variants and ongoing challenges, governments are urgently looking for new ways to improve public finances through increased revenues to build a more inclusive and sustainable future.

The International Monetary Fund defines property tax (PT) as follows:

Although generally associated with the notion of recurrent (annual) taxes on immovable property, property taxes in practice encompass a variety of levies on the use, ownership, and transfer of property. Each of these taxes has very different objectives and varying yields. According to standard international tax classifications, property taxes encompass recurrent taxes on immovable property, measured gross of debt, and levied on proprietors or tenants; recurrent taxes on net (of debt) wealth; taxes on estates, inheritances, and gifts; financial and capital transaction taxes on the issue or transfer of securities and checks, or sale of immovable property; and other recurrent or non-recurrent taxes on property.

According to the World Bank’s Property Tax Diagnostic Manual, PT “has tremendous potential for increasing revenues, along with enhancing governance accountability, efficiency, and equity,” specifically for low- and middle-income countries. Property taxation has both fiscal and non-fiscal effects. Besides their primary purpose of generating revenue for government services and functions, PT can be an important instrument for capturing land value, promoting efficient land use management and infrastructure development, and stabilizing residential property prices. It can also support fiscal decentralization.

PT is considered by experts to be one of the best forms of taxation to contribute to social equity and economic efficiency, while providing a stable and predictable source of revenue for governments and communities. The PT function is important for several reasons:

1. Financing public expenditure: Funds raised through property taxation can be used to fund public programs and services, such as social services, education, and public safety.

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1 The main ones being the International Monetary Fund government finance statistics and the Organisation for Economic Co-operation and Development (OECD) revenue statistics.
2. Redistributing tax burdens: Taxing landownership can help reduce social and economic inequality by ensuring each taxpayer pays his “fair share” and preventing undue economic burdens on lower-income households and businesses.

3. Encouraging efficient land use: Higher taxation on undeveloped land holdings can encourage landowners to use their land more efficiently, for example, by converting properties into housing, businesses, or green space.

4. Promoting citizen participation: Citizens are often more inclined to engage in politics and pay taxes when they are aware of the importance of property taxation in their community.

The revenues from PT in Asia are significantly less than in European countries. From the report Revenue Statistics in Asia and the Pacific 2023: Strengthening Property Taxation in Asia we can read “A regional comparison of property taxes ... demonstrates that property tax revenues are less important in the Asian region than in the European Union (EU) and the Organisation for Economic Co-operation and Development (OECD).” In addition, we can see from this report that:

For many of the region’s low- and middle-income economies, the ratio of recurrent property taxes to gross domestic product (GDP) is quite low: the average ratio for the 20 economies remained close to 0.3% of GDP from 2014 to 2019 before increasing to 0.37% in 2020. Considering tax revenues in Asian economies average about 15% of GDP, revenues from recurrent property taxes are not a major contributor to overall revenue mobilization. For high-income countries in the region, the ratio of recurrent property taxes to GDP was about three times higher: the average for Japan, Korea and Singapore was 1.23% in 2020.4

Key lessons from previous ADB technical assistance projects on PT in developing members show that building effective systems hinges on overcoming common challenges shared in the region, such as (i) weak capacity of property registration institutions, (ii) inefficient property valuation methodology, and (iii) capacity constraints among local tax administrations. Also, PT is often linked to issues of power and cultural identity. Governments are therefore often under pressure to find a balance between public and private interests in PT. Overall, PT remains a key issue in Asia, and governments and civil society actors are constantly looking for innovative ways to improve access to property and address related issues.

ADB is assisting developing members to identify opportunities for modernization of land management using digital technologies, including the integration of fiscal cadastre and PT registry into wider e-government systems. Against this backdrop, this guidance note presents a step-by-step approach on how ADB developing members can leverage recent technologies in property tax management. It builds on the World Bank’s existing Property Tax Diagnostic Manual, which provides a comprehensive overview of the different components of PT and presents a step-by-step guide to diagnose and analyze PT systems and to develop a strategic plan to improve property tax performance under varying circumstances.

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Overview

ADB developing members with “poorly performing PT systems need to identify and implement the appropriate set of policy and administration reforms to improve tax base coverage, property valuations, billing, collection, enforcement, and taxpayer services. Doing so can help countries realize potential property tax revenues in a more equitable and efficient manner. Tax policy reforms typically focus on defining the tax base and its assessment basis and setting the tax rate structure, along with appropriate policy changes linked to abatement/tax relief, collection, and enforcement. Tax administration reforms typically focus on improving the tax base coverage, valuations, tax liability assessment, and collection, along with taxpayer service” (footnote 3).

The legislative process for tax reform may vary depending on the specific cases and circumstances. There is no universal political and legislative process for introducing PT reforms.

Main Challenges

Although most ADB developing members have some sort of land and/or building taxation system, the performance of PT revenues remains weak. Attempts to improve the system have been difficult because of vested interests, political and institutional constraints, and government inability to address these challenges. The main challenges faced by Asian governments are as follows:

1. Lack of qualified personnel: Government personnel responsible for PT administration may not be sufficiently qualified and/or trained.
2. Tax evasion by property owners: Properties may be hidden under fictitious names or by undervaluing their properties.
3. System complexity: The computerized mass appraisal system (CMAS) can be complicated and difficult for taxpayers to understand, which can lead to tax payment delays and even refusals.
4. Government corruption: PT may be associated with instances of favoritism, which can lead to loss of revenue.
5. Socioeconomic inequalities: Property taxation can disproportionately affect the most disadvantaged landowners who may not have the financial means to pay the taxes.
Proposed Generic Solutions

PT is seen as a relevant and fair tax for governments, primarily because of the link between the types of locally funded services and the benefit for property values. However, PT is underutilized because of its unpopularity, inelasticity, erosion of the tax base, and poor administration. Moreover, the implementation or reform of PT remains difficult because, as economically desirable as long-term benefits may be, short-run transitory effects may be politically undesirable.

PT is highly visible. Unlike the income tax, for example, PT is not withheld at source. Rather, taxpayers generally must pay it directly in periodic lump-sum payments. As a result, taxpayers tend to be aware of how much they pay. PT also finances services that are highly visible, such as roads, garbage collection, and neighborhood parks. Indeed, studies show that residents are more willing to pay for local services when they rate their government and service provision highly.

Visibility is clearly desirable from a decision-making perspective because it makes taxpayers aware of the costs of local public services. This enhances accountability, which is obviously a good thing from both economic (hard budget constraint) and political (democratic) perspectives. At the same time, visibility restricts the ability of local governments to raise or reform the tax.

Property taxes based on recurrent calculations of market value (i.e., ad valorem) are largely considered to be more equitable and specifically less regressive than those that are not:

“Value-based recurrent property taxes can improve the equity of the tax system. They are a wealth tax, and thus the burden tends to fall on the part of the population which possess assets. They can help produce a more progressive tax system by falling on those with wealth. By contrast, consumption taxes tend to fall particularly heavily on low-income groups, which tend to have a higher marginal propensity to consume. They can also enhance inter-generational equity between households by taxing older households, who have been able to accumulate property assets, more heavily, whilst reducing the tax burden on younger household with fewer assets beyond their ability to generate income through work.”

In such systems, governments estimate what a property would likely sell or rent for in an open market at the time of the valuation. Market value may be estimated using several methodologies and is typically stated as a property’s capital value or rental value. In capital value banding systems, rather than receiving a specific monetary taxable/assessed value, a property is assigned to a value range or “band” (e.g., ¥10 million–¥20 million).

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There are increasingly efficient information and communication technology (ICT) solutions capable of automatically calculating property values and thus establishing a rational, transparent, and, therefore, fair PT. A recent report suggests “while existing mass appraisal tools can be highly effective and produce excellent performance results, AI (artificial intelligence) offers another viable tool that, if used properly, can efficiently produce equally or, arguably, more accurate valuations for many jurisdictions.” These generic solutions could include the use of tax management software, the automation of PT calculation and declaration processes, the integration of geographic via dedicated geographic information systems (GIS) tools, as well as tax databases and staff training on new technologies, as presented in the next chapter.

If a country decides to improve the evaluation function, it should develop and implement a CMAS, which can be considered one of the critical PT administration reform initiatives that need immediate government attention. To be comprehensive, it should also develop a land information system (LIS) to address physical planning, cadastral surveying, title registration and valuation, and mass property assessment functionality through CMAS.

It is fundamental to seek an integrated property assessment information system that will

1. support all major property assessment valuation and associated administrative functions,
2. be flexible and easily modifiable, and
3. provide a consistent and user-friendly graphical interface and excellent tools for users to extract and analyze information and data for valuation and PT purposes.

The CMAS should present controllable cost of ownership for at least 10 years. The development of a CMAS will improve the delivery of local government valuations for rating and, consequently, the timely production of valuation rolls.

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Introduction

A CMAS is an asset management software that allows government employees to view, analyze, update, and value properties, as well as facilitate downstream tax collection. Data commonly include property images, features (parcel size, boundaries, building characteristics, etc.), tax history, deeds, ownership details, etc. Staff appraisers can develop and/or apply automated valuation models (AVMs) to yield market value estimates based on property characteristics for both single-property and mass appraisal purposes. Figure 1 demonstrates an example of CMAS software developed by Sinergise for Azerbaijan.

A CMAS may either be a single software or a group of operations across multiple packages. While governments with a successful CMAS will typically have a primary asset management software that handles most tasks (e.g., data input, valuation), specialized software is still commonly incorporated for others. For example, an office will still use GIS software to handle operations the asset management software is not capable of, such as parcel boundary editing. Additionally, some asset management software allows users to
build AVMs inside of it, while others incorporate values calculated externally using different software. In these offices, software programs are largely compatible and are based on common file formats. They are commonly referred to as computer-assisted mass appraisal systems. This term originated in the 1960s and 1970s when government offices first began to use computers in mass valuation and PT administration terms. The term has arguably become outdated as most (if not all) tasks are completed using a computer.

This tool kit suggests steps for the development of a CMAS that

1. establishes valuation or assessment rolls for different types of land use; and
2. facilitates PT collection through billing, and is considerate of global best practices and standards.

CMAS development should be led by a government valuation authority. This may be a stand-alone department or specific staff employed within a related department, such as the cadastre or land agency. If no such department or staff exists, a government implementation task force should be established, comprising stakeholders from various departments, such as the ministry of finance, urban planning, and GIS. This task force will lead the project until staff can be designated and functioning. The involvement of subject matter experts from various professional areas is critical for the success of a CMAS project.

Government experts in ICT should be included, as well as GIS technicians, legal policy experts, statisticians/data scientists, and valuers/appraisers. Subject matter experts should consider the needs of both internal and external stakeholders, including other government departments, taxpayers, and the broader community.

The government must define the objective of the CMAS and provide clear and explicit answers to the following questions:

- **What needs will the CMAS address?** These needs may be broad or specific, such as outdated and inequitable valuations, or insecure databases. The establishment of a national municipal finance administration is also an important need that the CMAS may meet.

- **What are the CMAS solutions to implement?** The government should specify the CMAS solution it intends to implement. The solution may vary based on the level of technological adoption within the government offices. For instance, some offices may want to update their existing system (GIS, new AVMs, etc.) in their current software, while others may need to set up a basic, first-time system.

- **What are the benefits of the CMAS?** It is crucial to outline the benefits that the CMAS will provide. These may be tangible or intangible, financial or nonfinancial, and may include reducing long-term costs, promoting efficiency and transparency, and updating outdated components. The identification of these benefits will also help to justify investments and budget requests for government and community approval.

According to the World Bank’s *Property Tax Diagnostic Manual*, “Close collaboration with the relevant stakeholders can help in developing buy-in, prioritizing reform interventions, and developing a plan for further action. It will only be through a problem-driven interactive approach that will make it possible to successfully identify, prioritize, and sequence the priority policy, administrative, and institutional reform intervention into a SIP for the taxing jurisdiction” (footnote 3). Doing so will promote efficient and transparent tax administration.
Cost Estimates for Computerized Mass Appraisal System Reform

It is important to stress that the costs of CMAS reform will vary significantly because of several factors, including the following:

- Stage of CMAS adoption (e.g., upgrading vs. first-time user)
- Size of jurisdiction (e.g., city vs. state vs. county)
- Number of properties to be appraised
- Types of properties to be appraised
- Supply and demand of local staff and firms
- Breadth of services offered by (e.g., software only vs. software and valuation services)
- Legal framework around valuation (e.g., public records vs. private records)
- Level of transparency and efficiency of real estate markets
- Availability of reliable data
- Timeline

Costs will vary further depending on employment of:

(i) Part-time staff vs. full-time staff
(ii) Internal staff vs. external consultants
(iii) Temporary staff vs. longer-term staff

Nationwide, multiyear CMAS software development, including land records setup, data collection, custom software design and setup, user licenses, valuation support, training, and more can cost upward of $100 million. Smaller countries or geographic areas within a country cost less than half that for the same. Some governments choose to build software in-house, while others will purchase from private companies. While this may be a cost-saving alternative, it may prove costly and unsuccessful in the long run due to staff turnover, lack of budget, learning curves, and other unforeseen problems that may otherwise be navigated by experienced firms. Free, open-source software, however, can be used to offset costs for functions of smaller scales (e.g., GIS, AVM creation, database management), though they do require expert personnel to implement, run, and maintain.
Computerized Mass Appraisal System Technology

As previously mentioned, CMAS can be a single, comprehensive software or can be composed of a suite of cross-functioning software platforms. Core components of these areas are introduced in Figure 2.

**Digital Land Administration Systems**

Digital land administration systems commonly provide the data foundation for CMAS software. Digital land registries house the information required to value and tax properties within a jurisdiction, including ownership, property features and descriptions, as well as market information. The availability and reliability of these registries is critical as they are used to create AVMs, value properties, distribute bills, and collect taxes. Records are typically compatible with software used for valuation and tax administration and based on common GIS software.

**Geographic Information Systems**

GISs include software used to store, view, manage, and analyze data based on geographic location. Government staff use GISs in all stages of valuation and PT administration, from data collection (e.g., remote sensing, mobile field apps), valuation modeling (e.g., data analysis, spatial AVMs, quality control), appeal management (inspection route planning, data visualization), and public interaction (web-based information and open data portals).
Statistical Software

Statistical software is used by analysts to reveal patterns in real estate markets to improve valuation accuracy and defensibility. Some software requires coding while others have more user-friendly interfaces. Some are open source while others are developed by private firms. This software is also used to create sophisticated AVMs, for example, using regression analysis or more complex machine learning algorithms. AVMs and/or final estimates of value should be compatible with CMAS software so values may be replicated or stored and accessed by staff users. Outputs of statistical software can be saved in a variety of formats typically compatible with CMAS software.

Appeal Management Software

Appeal management software allows staff to process appeals through information retrieval, scheduling, communication, and data sharing. Online appeal submission allows property owners to contest the assessed value of their PT. Typically, a form asks a set of questions, including reasons for challenge, the taxpayer’s opinion of value, an explanation, and supporting evidence. Data collected from the online form are fed into software that allows staff to interact with and process appeals through various stages. Appeal management may be a function of a CMAS system or separate software.

Billing Software

Billing software enables governments to issue tax bills and receive payments online. It allows for records to be immediately updated following the clearing of an online payment. Payment status may be reflected to all stakeholders on software and data-sharing applications. Billing software exists as a stand-alone software but may also be integrated into CMAS software or a government website.

Other Software

Many other software applications can improve CMAS. For example, public-facing web apps allow the public to look up property and market information, making staff more efficient while better serving the community.

Steps for Computerized Mass Appraisal System Development

Detailed steps for implementation are outlined below. Where appropriate, opportunities for application of artificial intelligence (AI) are noted. AI is a broad term that refers to any application of technology that performs a human-type job. Machine learning is a type of AI that uses advanced mathematical and statistical algorithms to “learn” data patterns and even make predictions. Applications of machine learning are largely present in modern-day CMAS across multiple areas, from data collection and parcel management, through valuation and tax administration. The success of machine learning is largely dependent on the availability of appropriate data that are relevant, accurate, timely, and complete.
Implementing a successful valuation module requires the following steps:

- **Step 1: Planning**: develop a comprehensive plan, outlining the goals, necessary resources, timelines, and division of responsibilities, both in the short and long term.

- **Step 2: Infrastructure Development**: establish the required technological infrastructure by acquiring suitable software and storage options (cloud-based or servers), while recruiting and training competent staff with clearly defined roles and responsibilities.

- **Step 3: Data Collection**: gather all essential data, including property and market information, ownership records, prices, and property characteristics, as well as any necessary maps or imagery. This will involve creating registries and cadastres as required.

- **Step 4: Automated Valuation Model Creation**: determine market values for taxable properties through the creation of AVMs.

- **Step 5: Assessment Calculation**: calculate property assessments and tax bills by declaring the assessed level (taxable value) based on market value, using applicable tax rates and exemptions to determine each property owner’s respective tax bill.

- **Step 6: Value Notification**: notify property owners of their assessed values, providing an opportunity for them to challenge and present counter information if needed.

- **Step 7: Appeal Management**: manage the appeals process, adjusting values as necessary using new data and market evidence.

- **Step 8: Bill Notification**: issue tax bills to property owners, accompanied by clear instructions and payment deadlines with comprehensive and user-friendly guidance to minimize reliance on government staff.

- **Step 9: System Maintenance**: sustain and monitor the CMAS by continually collecting relevant data, such as permits, new construction, and transactions. This should include regularly evaluating the performance of AVMs using ratio studies, and promptly updating them when they no longer yield reliable market estimates.

### Step 1: Planning

The development of such a system could be approached in two ways: either a pilot-project-type approach or a direct and global approach on the whole territory. A globalized approach would have the advantage of making it possible to send a message to all the stakeholders and, if it works, to go faster in setting up such a new system. A two-step approach, that is, first via a pilot project before its extension to the whole territory, would make it possible to answer a certain number of questions. According to good practices, it is recommended to opt for an iterative approach, that is, in at least two stages.

Indeed, careful project planning is essential to anticipate and address potential hurdles or obstacles that may emerge during the CMAS project without arousing suspicion. Early identification of these challenges allows for the development of alternative strategies to minimize their impact. These strategies may involve revising schedules, allocating
supplementary resources, or reevaluating specific aspects of the project blueprint. Efficient and discreet communication plays a vital role in ensuring that all relevant parties are informed about any modifications or adaptations to the project plan. By proactively considering and preparing for potential setbacks, project leaders can ensure that the project progresses smoothly, adheres to set timelines, and remains within the allocated budget.

Once current and required resources are understood, a gap analysis should be completed to understand what must be acquired. Identifying the necessary resources and financial requirements for the development of a CMAS is a critical step in ensuring a successful implementation. A comprehensive understanding of required resources is key to developing a realistic and feasible budget and plan for both implementation and ongoing maintenance. The plan should address the following:

- **Order of steps and specific tasks.** The plan should outline the sequence of tasks required to complete the project. The order of these tasks is critical, and each one must be completed before moving on to the next.

- **Responsibility allocation.** An effective plan should clearly outline the distribution of responsibilities and duties for every task. This encompasses the identification of project managers, task managers, and consultants. Additionally, it should define the necessary data; the required quantity of data; and the hardware, software, and data collection instruments to be utilized.

- **Timeline management.** The plan should incorporate a well-defined timeline. This enables project managers to monitor progress and ensure adherence to the predetermined schedule. It should include significant milestones, deadlines, and deliverables, ensuring that the project is consistently advancing in the intended direction.

- **Communication framework.** Consistent and timely communication is vital to maintain cohesion among team members and promptly address any arising issues. The plan should specify the frequency of meetings (e.g., weekly, monthly) and the obligatory participants for each session, fostering effective collaboration and coordination.

- **Post-implementation maintenance.** The plan should also consider what will be required to maintain the project after it is implemented. This includes identifying when check-ins will occur, what kind of progress will be measured, and what resources will be needed to support ongoing maintenance and support.

Planning should consider a pilot study to identify deficiencies, anticipate problems, and make necessary adjustments from lessons learned before implementing jurisdiction-wide PT rollouts.

**Step 2: Infrastructure Development**

**Software.** Once project plans have been approved and the needed resources are understood, hardware and software should be set up.

Cloud-based storage environments offer a safe, cost-efficient alternative to server-based storage physically located at a government office or third-party company. Data stored in a cloud may be viewed and managed by multiple users across multiple devices. The
cloud protects data from being lost due to environmental disaster or electricity blackouts. This type of storage relies on internet coverage so may potentially be slow or unavailable if connectivity is compromised. Cybersecurity should be prioritized to ensure private information is protected from unapproved access or manipulation. Cloud-based storage should be set up to house the underlying database tables of digital land registries.

**Hardware.** A cadastre is the central database that stores property records such as ownership, location, unique parcel identification number, parcel boundaries, property classifications, and property characteristics. A transaction registry stores the price and date of the transaction, as well as property attributes and characteristics.

Both a cadastre and a transaction registry are required for AVM creation, as well as the valuation and taxation of real estate, and typically form the basis of CMAS software (database tables used to digitally populate registry software may also be used to digitally populate CMAS software). In developing countries, nongovernmental entities at the local level (e.g., slum dweller associations, microfinance lenders) may offer reliable ownership and property records. If available, such supplemental data sources should be considered to acquire and/or validate records. Registries, CMAS software, and other data collection devices should be GIS-compatible so data may be viewed on maps, more easily accessed and edited, and yield more accurate valuations.

**Step 3: Data Collection**

Once the infrastructure to house and manage data is developed, they should be collected and populated therein. Many data points may already be collected by a government entity, although much data will likely need to be collected for the first time. Remote sensing collects physical characteristics without coming into direct contact. Examples include aerial and satellite imagery, street-level imagery, and orthogonal (looking down at an angle) imagery. Remote sensing allows governments to safely and efficiently collect key data across large geographic areas. The data can be used to supplement and update cadastres and improve AVM performance.

Deep learning neural networks (DLNNs) are machine learning algorithms that are trained to make decisions as a human would do through mathematically programmed criteria. Convolutional neural networks (CNNs) are a specific DLNN for image recognition and classification. CNNs are trained on a series of images to recognize patterns based on image pixels, edges, textures, and other visual components. This algorithm forms the basis of facial recognition and medical image analysis technology but has many applications for mass property valuation and PT administration. CNNs may be used in conjunction with remotely sensed data to offer efficiency benefits to governments.

CNNs may be trained to recognize building footprints in overhead imagery. This process trains models on aerial or satellite remote sensing imagery to recognize boundaries of parcels and structures. Boundaries are approximated and typically require human review, although this allows governments to capture data with reduced labor and other collection costs. Other types of feature extraction may help determine property characteristics and assign classifications. For example, when applied to street-level imagery, CNNs can be used to identify and store physical characteristics for large batches of properties, such as building

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type, number of levels, condition, view, and more. DLNNs may also be used to detect changes to a property, which oftentimes occur in absence of a government permit, such as pools, roads, landscaping, new construction, etc. When applied to geographic images, these algorithms can classify land use, crop types, and more. Such property feature data can promote accuracy and performance in mass appraisal market estimates, as well as increase taxable revenue.

For paper records that must be digitized, machine learning offers tools for automation. Text extraction is an automated deep learning process that recognizes letters in scanned documents that are either written by hand or typed. Algorithms can be trained to both recognize and store data.

Digitized transaction data should be stored in a registry database. If deeds are not collected by the government, alternative sources of market data to consider include notaries, multiple listing services, professional real estate and related associations, lending institutions, credit agencies, and private data firms. If laws permit the use of listing prices, web scraping may be an alternative to sale prices and other data that are available or unreliable (listing website terms of use should always be considered first to ensure scraping of data is not a violation). Supplemental sources may provide short-term solutions while the country develops a registry in the longer term.

Step 4: Automated Valuation Model Creation

Once acquired and stored, datasets are used to create AVMs for each class of real estate and sub-type. More sophisticated AVMs are based on the algorithm of multiple regression analysis. Regression-based AVMs were first proposed in 1922 by George Haas as a method for governments to more accurately and equitably value real estate. According to a recent study, AVMs are used today by leading governments to achieve consistent, accurate valuations in a cost-effective manner.11

AVMs analyze transaction data stored in a flat-file format, where each transaction is separate and complete transaction, and each column is a different property feature. Various mathematical modeling formats are typically tested to see which yields optimal valuation results. These formats may include regression and even more black-box machine learning algorithms. Spatial AVMs that incorporate GIS have demonstrated even greater accuracy and efficiencies.12

Ratio studies are a method of statistical quality control analyses used by governments to calibrate and optimize the valuations yielded by AVMs. The “ratio” is calculated for each transaction by dividing the model’s predicted value (the numerator of the ratio) by the actual sale price (the denominator of the ratio) and indicate whether a property is over- or undervalued (a ratio above 1 or below 1, respectively). Various statistics are then used to estimate valuation accuracy and consistency and help ensure valuation accuracy does not vary by stratum or across price bands.

Ratio studies also allow governments to promote defensibility of their valuations by demonstrating acceptable scores and overall valuation “fairness.”

A simple AVM example may be represented by the following formula:

**Market Value Estimate** = ($ = USD per square meter * building area) + (USD per year depreciation * building age) + (USD per acre * lot size)

With the following coefficients:

Rate per square meter = $1,000
Rate per year depreciation = –$1,500
Rate per acre = $40,000

Using these components, this AVM will value a quarter of an acre land plot with a 30-square-meter, 10-year-old building as:

**Market Value Estimate** = ($1,000*30) + (–$1,500*10) + ($40,000*.25)

reducing to:

= ($30,000) + (–$15,000) + ($10,000)

= $25,000

AVMs typically have many more factors based on property features and market conditions and exist for each of the approaches to value: income, cost, and comparable sales/market. Tables 1 and 2 show sample AVMs for residential and commercial properties. Each has additive factors on the left (value adjustments based on monetary amounts) and multiplicative factors on the right (value adjustments based on multipliers/percentage adjustments). Positive coefficients indicate positive value adjustments (e.g., +$14,770 per fireplace [Fireplace]), as do multiplicative adjustments above 1.0 (e.g., 1.2 multiplier for dwellings of very good grade [GradeVG] for a 20% increase from the baseline of average). Similarly, additive coefficients in parentheses indicate negative value adjustments (e.g., –$435 per year of dwelling age), as do multiplicative adjustments below 1.0 (e.g., .79 multipliers for dwellings of poor grade [Grade_PR] for a –21% reduction from the baseline of average grade).
### Table 1: Simple Residential Automated Valuation Model Example—Additive and Multiplicative Coefficients

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Dollar Adjustment</th>
<th>Variable Name</th>
<th>Multiplier Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>$51,190.00</td>
<td>Colonial</td>
<td>1.40</td>
</tr>
<tr>
<td>LandArea</td>
<td>$4.86</td>
<td>Grade PR</td>
<td>0.79</td>
</tr>
<tr>
<td>BuildArea</td>
<td>$72.32</td>
<td>Grade GD</td>
<td>1.10</td>
</tr>
<tr>
<td>Age</td>
<td>$(-435.00)</td>
<td>Grade GD</td>
<td>1.27</td>
</tr>
<tr>
<td>FirePlace</td>
<td>$14,770.00</td>
<td>Kitchen GD</td>
<td>1.08</td>
</tr>
<tr>
<td>RMoS</td>
<td>$(-1,184.00)</td>
<td>Neighborhood 200</td>
<td>1.28</td>
</tr>
<tr>
<td>AirArea</td>
<td>$16.39</td>
<td>Vinyl Siding</td>
<td>0.72</td>
</tr>
<tr>
<td>GradeA</td>
<td>$79,650.00</td>
<td>Brick Siding</td>
<td>0.82</td>
</tr>
<tr>
<td>GradeC</td>
<td>$(-33,260.00)</td>
<td></td>
<td>0.90</td>
</tr>
<tr>
<td>CondGD</td>
<td>$49,660.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CondVG</td>
<td>$101,100.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RMoS = Reverse Month of Sale.  
Source: Compiled by author.

### Table 2: Simple Commercial (Rent) Automated Valuation Model Examples—Additive and Multiplicative Coefficients

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Dollar Adjustment</th>
<th>Variable Name</th>
<th>Multiplier Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>$(-19,960.00)</td>
<td>Office Warehouse</td>
<td>0.59</td>
</tr>
<tr>
<td>Area</td>
<td>$14.39</td>
<td>Nhood100</td>
<td>0.81</td>
</tr>
<tr>
<td>Nhood100</td>
<td>$(-170,600.00)</td>
<td>Warehouse 1St</td>
<td>0.58</td>
</tr>
<tr>
<td>Nhood200</td>
<td>$(-19,450.00)</td>
<td>Office</td>
<td>1.28</td>
</tr>
<tr>
<td>Warehouse1St</td>
<td>$(-60,270.00)</td>
<td>RMoS</td>
<td>1.00</td>
</tr>
<tr>
<td>OfficeA</td>
<td>$109,300.00</td>
<td>Nhood300</td>
<td>0.69</td>
</tr>
<tr>
<td>OfficeB</td>
<td>$20,140.00</td>
<td>Nhood400</td>
<td>0.74</td>
</tr>
<tr>
<td>CondPoor</td>
<td>$(-23,390.00)</td>
<td>Nhood500</td>
<td>0.74</td>
</tr>
<tr>
<td>CondVG</td>
<td>$39,700.00</td>
<td>Nhood500</td>
<td>1.35</td>
</tr>
<tr>
<td>CondEx</td>
<td>$61,120.00</td>
<td>CondFR</td>
<td>0.82</td>
</tr>
<tr>
<td>CondGD</td>
<td></td>
<td>CondPR</td>
<td>0.74</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OfficeC</td>
<td>0.76</td>
</tr>
</tbody>
</table>

RMoS = Reverse Month of Sale.  
Source: Compiled by author.
Figure 3 provides a list of minimum requirements for a valuation modeling tool.

AVMs are used to some degree in the following Asian economies:

- People’s Republic of China (AVMs are created at some local municipalities, though not implemented for PT)
- Philippines (some local governments)
- Hong Kong, China
- Japan
- Republic of Korea
- Pakistan
- Singapore
- Thailand

Regression is specifically used in Singapore and Hong Kong, China.\(^{13}\)

Step 5: Assessment Calculation

After AVMs have undergone strict quality control and are validated, they can be used to value all properties in the jurisdiction. Once these model estimates are deemed reliable by the government, they should be put into production. CMAS software should be able to apply models to a universe of properties and then store them, as well as allow them to be viewed and analyzed. Property assessments and tax bills should be calculated by declaring the assessed level (taxable value) based on market value, using applicable tax rates and exemptions to determine each property owner’s respective tax bill.

Step 6: Value Notification

Once models are live and applied to the role, the software should allow for sending valuation notices and bills to taxpayers, either directly or through being integrated with bill collection software. Property owners should be notified of their assessed values, providing an opportunity for them to challenge and present counter information if needed. Notifications of changes typically lead to inquiries and protests, especially if the assessed values and tax bills increase. In such cases, the project should manage these inquiries and appeals, and update the assessed values as additional market evidence is presented by taxpayers. Any changes and notes should be maintained within the database to ensure accurate and up-to-date property values. Valuation notifications are often handled by an external department or consulting firm, using export of property records from the CMAS software.

Step 7: Appeal Management

In case of taxpayer disagreement on the value notification, this last step can proceed to appeal. After appeals are filed, staff reviews each case and discusses directly with the taxpayer. The CMAS can employ an historical point of view. Some appeals are settled after an explanation is offered and the taxpayer agrees. Others reach a hearing led by government workers or a review board of impartial parties including real estate, legal, and other educated professionals, where each party presents their opinion of value. Rejected appeals may even escalate to courtrooms. Values overridden by appeal decisions, as well as new data discovered through the review process (e.g., rooms, bathrooms, or upgrades that were previously unregistered), are used to adjust final assessments.

Step 8: Bill Notification

Once values are finalized (sometimes still before or during ongoing appeals from value notifications), tax bills should be calculated and sent to property owners. Bills should be accompanied by clear instructions, payment deadlines, frequently asked questions, and contact information.
Step 9: System Maintenance

After the valuation cycle is complete, the CMAS should be sustained and updated by continually collecting relevant data, such as permits, new construction, and transactions. This should include regularly evaluating the performance of AVMs using ratio studies, and promptly updating them when they no longer yield reliable market estimates. Markets should be monitored while data are continually updated. Eventually, CMAS will require technological updates to include new GIS layers, updated AVMs, etc. It will also require new considerations to remain compliant with external applications and updates in other departments that share or use the same data. CMAS should remain flexible so government functions are not interrupted and/or made less efficient.
Introduction

As noted in Chapter 3, CMAS can either be a stand-alone software or a suite of software used to complete tasks required for PT. The technical examples highlighted in this chapter may help promote efficiencies regardless of whether they are part of the same software or broken up across various ones that are compatible with one another. For example, it is not essential that an office’s primary asset management software be able to create AVMs, so long as it is able to incorporate the output of software that can.

Advanced Technology Highlights

Image Interpretation by Artificial Intelligence

PT is a tax item that can implement “evidence-based taxation”; at the same time, it is necessary to develop a large area of evidence with limited human resources. The area may be country-wide, state-wide, or city-wide. For this reason, aerial photography, satellite imagery, and, in recent years, drones are also used for PT management in many countries.

These images that show the current situations are used for the following purposes:

- Land valuation
  - Creation of land database
  - Survey of land use
  - Survey of usage situation (e.g., integrated use of multiple parcels)
  - Building valuation
    - Creation of building database
    - Change detection (newly build, demolished, rebuild)

14 This section presents a list of advanced technologies that are being used to help facilitate or enhance CMAS functions discussed in Chapter 3. The list highlights useful examples and is by no means intended to be exhaustive. The tools introduced are examples that can help governments promote robust performance in accordance with global best practices to produce and maintain valuation rolls and facilitate taxation, for agricultural, residential, industrial, and commercial properties.
• Others
  ✓ Zoning of valuation unit (commercial, residential)
  ✓ Survey of facing street (width, paved, unpaved, etc.)
  ✓ Alternative use of maps (survey for transportation, environment, other information that affects price of property).

Acquired images are processed manually and used for the various purposes described above, but AI-based image interpretation technology can automate this.

Although there are differences in the tax system of each country, taxation on land often adopts individual valuation methods and tax rates depending on the purpose of use. Therefore, land use information is important for PT management, and it is also necessary to develop a database. On the other hand, land use often changes with the transfer of rights or changes in the form of land, so the amount of work is extremely large even when images are used. By applying AI, it is possible to automate land use surveys. Figure 4 shows a case in Japan using aerial photographs taken in 2019 and 2021 to classify land use as interpreted by AI in a 5-meter mesh.

**Figure 4: Output of Artificial Intelligence Interpretation**

There are 361 possible outcomes when detecting land use change in 19 categories. A matrix was created to organize this information so that it can be used for property tax management, and priority was given to changes in land use that have a large impact on the land value (Figure 5). This result has the potential to save labor for the land use survey, which is currently being conducted manually. However, accuracy issues remain as described later, so full application to property tax management has not yet been realized in Japan; further, many companies are still in the research and development stage.
In building valuation, remote sensing technology is used to create a database and a change detection survey. The building database is generally created by creating a building footprint from image data such as aerial photographs and by matching this footprint with the tax ledger. The building database prepared in this way matches the location and shape of the building with various taxation information. Such a database can optimize taxation by visualizing buildings that are subject to it but are not taxed, or, conversely, cases where the buildings do not exist but are taxed. Figure 6 shows some of the output of a project using satellite images and AI technology implemented in Nepal by ADB. Using a model that is as accurate as this, building footprints for the database can use AI interpretation.

Output of the TA-9061 REG: Enhancing Governance and Capacity Development as Driver of Change (49156-001).
Figure 7: Comparison of Artificial Intelligence Interpretation and Manual Interpretation

AI Interpretation

Manual Interpretation

AI = artificial intelligence.
Source: PASCO Corporation.

Figure 8: Combination of Automatic Interpretation by Artificial Intelligence and Manual Interpretation

Source: PASCO Corporation.
Since the buildings are newly constructed or destroyed, it is necessary to update the
building database according to changes. Building change detection is the task of comparing
old and new aerial photographs, extracting buildings that have changed, and reflecting them
in the tax ledger. AI interpretation is used in this work process in Japan.

So far, it has been reported that automatic interpretation by AI may save labor in surveys
for PT management. However, surveys based on remote sensing such as aerial photographs
and satellite images are not effective for objects that cannot be seen from the sky.
Naturally, the accuracy decreases compared to on-site surveys. In addition, since AI image
interpretation technology is still in the developing stage, it is not possible to obtain results
with the same level of accuracy as images that are interpreted manually.

Therefore, to apply image interpretation by AI to property tax management, some ingenuity
is currently required. In the case of Japan, AI is used to update the building database, but
the process has been partially automated to save labor in manual surveys. In other words,
it is devised to combine automatic interpretation by AI and manual interpretation. As for
other measures, it may be possible to adopt mitigation measures on the system side. In this
case, it must be verified that the results of remote sensing and AI are scientifically correct.

**Geospatial Machine Learning for Automated Valuation Models**

Sophisticated algorithms that combine property and market data with location can detect
and reveal complex patterns within real estate markets, helping governments improve
land and building valuations, as well as other CMAS functions. Figure 9 shows results of

---

**Figure 9: Example of Geographically Weighted Regression Value Adjustment
for Bedroom Count (BedCount)
(Thai baht)**

Source: Created by author.
a special kind of machine learning algorithm called geographically weighted regression (GWR). This map shows the results of a GWR model used to identify the determinants of condominium prices in Bangkok, Thailand. The varying colors suggest that, on average, each bedroom in a building is associated with an increase in price between approximately B10,000 in areas with purple dots and approximately B90,000 in areas with yellow dots. GWR allows governments to inspect how price drivers vary by location and better understand market patterns when creating AVMs, ultimately promoting transparency, accuracy, and defensibility of valuations.

Figures 10 and 11 demonstrate how spatial clustering algorithms may be used to group similar neighborhoods or zones into larger market areas. These algorithms can be useful for governments to more accurately model patterns and behaviors in markets that drive property values. Visualization of these groupings allow all government employees to more efficiently analyze and process data in mass workflows, ranging from data collection, to valuation, quality control, and appeal management.
Data Visualization

Data visualization helps governments become more efficient in PT by providing a better understanding of databases and real estate markets. Patterns in data are often difficult to learn when presented in tabular format alone, and data visualization can more easily identify and learn patterns for better decision making. Figure 12 demonstrates a free, web-based app that allows governments to conduct ratio studies. By simply uploading a spreadsheet of sales data, governments may acquire detailed diagnostics of the quality of their valuations used for PT. Metrics used are those proposed by international best practices, including the International Association of Assessing Officers Standard on Ratio Studies, as well as other metrics proposed by leading industry research. The metric above is an example of a statistical test called the price-related bias that estimates whether valuations are consistently accurate across low-, middle-, and high-priced properties. This simplified dashboard does not require the user to be able to perform statistical coding or execute other analytical software. Governments can download a final PDF report with summary diagnostics of ratio studies to guide internal valuation strategies that improve valuation accuracy and ensure certain groups of taxpayers are not receiving favorable effective tax rates.

Figure 13 is an example of how to visualize the respective impact each property feature (e.g., land area, building area, location) has on the AVM ability to accurately estimate prices. This analysis allows governments to better understand the influence of particular features on property values, ultimately making models more accurate, efficient, and defensible to other stakeholders, including taxpayers. Such visualizations can be particularly useful for governments when explaining which features were ultimately used to estimate a property’s value, and why certain features were omitted, ideally fostering trust in and acceptance of models.
Figure 12: Free Interactive Web App for Valuation Quality Control

The median ASR can also be used to evaluate vertical equity when calculated for each sale price decile as provided in this following chart. The chart displays how the ASR changes as the sales price increases. The range between median ASR for the lowest priced decile (1.009) and highest (0.992) decile is 0.017. This suggests a trend toward lower ratios as sales price increase, a regressive trend.

First Decile AS Ratio | Median AS Ratio | Tenth Decile AS Ratio
1.009 | 0.999 | 0.992

Median ASR by Sale Decile

Source: Institute of Land Policy and Center for Appraisal Research and Technology.

Figure 13: Example of Line Chart of Variable Impact on Automated Valuation Model Performance

Source: Created by author.
Figure 14 is an example of how AVMs may be used to calculate and visualize how buildings tend to depreciate with age. Appropriately including depreciation in mass valuation is essential for accurate property valuation. It helps ensure older properties, especially those requiring maintenance such as new roofs or siding, are not overvalued and therefore overtaxed. Figure 14 shows how older properties (moving right on the horizontal axis) receive larger decreases in value (vertical axis).

Figure 15 shows how valuations may be inspected for variations in accuracy across dwellings of different sizes during valuation quality control (ratio studies). The chart suggests that, as properties increase comparatively in size (horizontal axis), they tend to be appraised at higher percentages of market value (vertical axis). Governments may use such data visualizations to inspect and make necessary calibrations to improve overall performance.

Figure 16 demonstrates how various data may be plotted for visual analysis, for example, when comparing prices of residential improved vs. residential vacant land. Such analysis can better inform governments of trends in the market and allows valuation models to more appropriately consider patterns of different property types or classifications.
Figure 15: Scatter Diagram and Trendline of Ratios against Dwelling Size (square meters)

Source: Created by author.

Figure 16: Example of Line Chart of Median Price of Improved vs. Vacant Land over Time

Source: Created by author.
Figure 17 shows how plots may be used to inspect whether valuation performance (vertical axes) varies by construction condition of the dwelling (horizontal axis). Such visualization provides governments with a lens to ensure valuation accuracy is consistent across different property classifications.

Free and open-source software provides governments with an ability to implement technical solutions listed in this chapter for mass valuation and property taxation administration that do not require software licenses or payments for use. The following are several types of such software broken down by technology:

- **Web scraping**: Scrapy (Python), MechanicalSoup (Python), Heritrix (Java)
- **Data visualization**: Apache Superset, Shiny, Leaflet, RStudio (R), Jupyter Notebooks (Python)
- **Deep learning neural networks**: TensorFlow, PyTorch, Keras, Python, RStudio (R)
- **Geographic information systems**: Quantum Geographic Information System, Shiny, Leaflet, RStudio (R), Jupyter Notebook (Python)
- **Automated valuation models**: RStudio (R), Jupyter Notebook (Python)
- **Online bill payments**: Mojaloop
Vision Proposed

The vision of this tool kit is to show how to implement a system in support of valuation for rating purposes that will enhance analytical capabilities, productivity, and operational efficiency toward improvement of land administration.

To achieve this vision, the technology architecture should have the following characteristics:

**Technology.** The system design and platform should take advantage of recent developments in ICT as described above. A web-based application approach using open-source technologies is preferable.

**Integrated.** There should be one authoritative source for each data element, and all modules using a given data element should retrieve from the authoritative source. As much as possible, all functional areas of the AVMs and CMAS shall be concentrated and accessible from one application/graphical user interface, expected to have seamless connection with the integrated land information system (ILIS) for retrieval/upload of valuation and other relevant data.

**Flexible.** In the event that property rating practices and statutes change, the system should be flexible. The use of a business rules engine in the system architecture is encouraged to allow this flexibility. The system could include provisions for updating of inflation coefficients, cost catalogs, ground rate, and other reference data. The system should include flexible report production module, which should allow adding of additional reports without programming.

**Interoperable.** The CMAS must permit easy import/export of information from/to a wide variety of other applications, including desktop applications, the internet, e-mail, other relational database management system-based systems, executive information systems, and administrative system products from other suppliers. In addition, the system should permit direct access to information by other applications and be capable of direct access to information stored in other applications (i.e., the system must use data standards). The solution shall present a total business workflow use case, including all the internal modules, and external applications and explanations of how data can move through the process.

**Modular.** The design of the system should facilitate rapid and correct response to changing needs of property valuation in the specific country. The CMAS shall map the property assessment business process that will guide the development of the system components in line with the statutory provisions under the local laws. The system must allow for expansion, upgrade, or even replacement in a modular manner, with minimal disruption or addition of functionality, taking into account the additional cost to the responsible ministry or agency that this upgrade could generate.

**Stable, extensible, maintainable, and scalable.** The AVM solution should be technically stable and relatively bug-free, and appropriate fixes should be readily available from the CMAS developer. The system design must allow its future modifications to allow for added functionality, data loading, increase in users, etc.
Efficient. The system should simplify the maintenance of information by the given ministry or agency in charge’s existing staff. This system must not encumber the ministry/agency with a requirement for expensive specialized staff, maintenance overheads, and rigid data and reporting structures. It will be fundamental to provide appropriate training to all the profiles described in Table 3: “Example Overview of Computerized Mass Appraisal System User Profiles,” specifically the data and system administrators and external stakeholders, and to produce detailed system and user documentation.

Easy to use. The system must have an easy-to-navigate user interface and user manuals must be developed. A specific, efficient, competitive maintenance and support strategy for the first year after system commissioning must be foreseen as well, with a minimum qualified remote management team that provides automation services during working hours on a 5 days out of 7 basis, with resolution of critical bugs within 48 hours.

Secure. The system must provide various levels of security extending to individual data elements, as well as auditing of essential functions. User restrictions would be provided by the specific ministry or agency in accordance with existing ICT policies of the country. The security system should comply with International Organization for Standardization standard 27000.

About the Integrated Land Information System. In terms of ILIS, development prerequisites include functionality to support individual valuation by capturing transactional data.

The ILIS solution should support the land valuation officers, including with computer-aided property valuation. In addition, it should have the functionality to view, download, integrate, analyze, and use the registration, cadastral data, and market transactional data. It should also have the GIS functionalities necessary for land valuation. Moreover, it would be fundamental to provide the integration and seamless exchange of the data with ILIS at least at database level.

Practical Guidance

A successful CMAS solution should support the following areas:

- Data management
- Market analysis
- AVM creation and value reconciliation
- Objection/appeal management

A good system will perform the functions described in detail below, in an effective, easy-to-use manner.

The data management function involves efficient collection/upload of property and other relevant data, data entry, editing, data organization, and storage. The data management functionality should enable control of the quality of data on assessable property descriptions and characteristics collected and captured into the system.

The data management function should enable users to define which variables to collect and maintain in response to the rating system and statutory requirements. The capturing of data needs an audit trail that will keep track of the last several changes to entries, including
what was changed and by whom. Historical data should be available in the system for reuse in the analysis. The solution must require developing a mobile collection tool that will be used by property inspection teams to gather relevant data for upload to the CMAS. It is also important that a mobile property collection tool be provided to external stakeholders, which will be encouraged to collect and supply data to the relevant ministry in exchange for access to some of the data from the CMAS (the data exchange policy with external stakeholders shall be defined in the valuation methodology document).

The **market sales** function involves data screening and processing, ratio studies, and reporting. The ability to link transaction information to associated improvement physical characteristics, store and edit the linked data, and produce extracts of transactions data in an editable electronic format is an essential requirement of the CMAS. The solution shall comply with data formats that are used in the current LIS in the study country. This should integrate with the data management functionality, valuation management functionality, and GIS interface. The market sales analysis module shall facilitate and guide the user to select comparables for their further use in the reporting and production of the valuation roll.

The **AVM creation and value reconciliation** function should consist of applications of the determination of annual value based on rental evidence. It should also be compliant with existing regulatory documentation in the study country at the moment of project design phase completion. The solution should also provide standard functionality for a capital value–based rating system. This will provide opportunities for future changes in the rating law in the study country to resolve the bottleneck caused by the discovery of rental evidence. The CMAS shall store the property characteristics associated with rentals, land, and improvements to support valuation management. The solution should satisfy the statutory requirement to determine annual rental value. This functionality should seamlessly integrate with the data management and market analysis functionalities. A statistical package should be included into the CMAS software; absent this, a package from a third party that allows standardized and easy data exchange with the CMAS software must be provided. This package shall contain at least multivariable regression functions to allow production of various valuation models and their application to the existing data.

**Objection/appeals management** is the function of preparing and storing responses to objections to value submissions, defending the values, and scheduling the hearings before an adjudicator. The solution shall provide a CMAS that interfaces with a word processing software to educate objectors on valuation court procedures and for mass mailing of notices.

**Rating administration support function involves valuation roll production and administration and report generation.** The development should consider PT appraisal software that supports the valuation roll administration process, including the ability to extract and send valuation roll data to a system that enables a tax billing, reconciliation, and enforcement system. Historical official valuation rolls and results of valuation simulations shall be managed in the system.

**Workflow management involves the assignment, tracking, and monitoring of tasks and documents within the rating process.** The PT appraisal solution should allow integrating the workflows developed within the current LIS in the study country.

**Data archiving should provide for the secure storage and retrieval of historical transactions.** The development should consider providing an archiving plan for the various types of data and reports generated by the system.
Computerized Mass Appraisal System  
Main Technical and Functional Areas

The development of a property valuation system for tax purposes should present the priorities to be considered in terms of technical and functional requirements through a CMAS solution. This must be able to respond to any change in the bases for determining the taxable value. Therefore, the three approaches to value (comparison of costs, revenues, and sales) must be adequately developed to respond to any future reform of property valuation policies and legislation. The CMAS solution must therefore be able to maintain assessment rolls on a multi-jurisdictional basis, taking into account the need to maintain data from all local governments.

The CMAS solution must fulfill the functionalities described in Appendix 1.

Main Valuation Tasks

Figure 18 shows the main valuation tasks and their distribution among the actors. User management and workflow modules are used by the ICT system (such as CMAS). An administrator creates users and their profiles. Each user is assigned to perform tasks according to his profile(s). An example overview of profiles is given (Table 3) with main proposed tasks.

---

**Figure 18: Business Appraisal Processes Overview**

![Diagram showing the main valuation tasks and their distribution among the actors.](image)

- **CMAS Profiles**
  - Supervisor
  - Field Inspector
  - Data manager
  - Analyst
  - Accessor

- **Main Tasks**
  - Decision and Task Distribution
  - Workflow Management
  - Workflow Data
  - Field Inspection
  - Physical Parameters of the Properties
  - Data preparation (GIS, Replacement, Sales, Income)
  - Results of modeling.xml
  - Ministry in charge of Valuation/PT database (current and historical data)

- **Administration**
  - DB Administrator
  - CMAS Administrator
  - Users
    - Profile and CMAS management
    - RDBMS management
  - Users
    - Valuation report.doc
    - Value zones.shp
    - Valuation rolls.xls
    - Workflow reporting.doc

**Legend**
- CMAS = computerized mass appraisal system
- DB = database
- GIS = geographic information system
- PT = property tax
- RDMS = relational database management system

Source: Created by author.
### Table 3: Example Overview of Computerized Mass Appraisal System User Profiles

<table>
<thead>
<tr>
<th>No.</th>
<th>Users Profile</th>
<th>Rights and Functions</th>
<th>Users</th>
</tr>
</thead>
</table>
| 1   | **Database Administrator**     | User management:  
• Create new accounts  
• Disable account (for tracking reasons, an account is never deleted from the database)  
Database management:  
• Backup and recovery procedures  
• Imports and exports | System Administrator |
| 2   | ICT Valuation System Administrator | • Define CMAS profiles and assign users to profiles  
• Update data catalogs and tables | System Administrator |
| 3   | **Supervisor**                 | • Define tasks  
• Manage required resources  
• Follow up on tasks | Ministry in Charge of Valuation/PT:  
Valuer General  
Valuer General/Rating and Taxation |
| 4   | **Analyst**                    | • Statistical analyses  
• AVM creation for mass appraisal  
• Valuation quality control (ratio study analysis)  
• Value reconciliation analysis | Valuer  
Regional Valuation Expert |
| 5   | **Data Manager**               | • Data acquisition  
• Data formatting for modeling purposes | Valuer  
Regional Valuation Expert |
| 6   | **Valuer**                     | • Individual appraisals (on selected parcels)  
• Applying adjustments, exemption on individual basis or group basis farm  
• Reporting and mapping capabilities (rolls, appraisal documentation)  
• Manage appeals | Valuer Technicians |
| 7   | **Data/ Field Inspectors**     | • Entry of the field inspections data  
• Receive batches of transaction data with completed and missing fields as described above (integrate the information into the .xls file until Deeds system is operational)  
• Assign apparent validity codes to the obviously invalid sales based on information inherent in the data received or readily obtainable by reading a copy of the deed | Valuer Technicians |
| 8   | **Viewer**                     | • Consultation of the data through the standard interfaces and all the outputs of the CMAS  
• Display of the valuation roll only | Ministry in Charge of Land Registration Cadastre – staff members  
Ministry of Finance  
Other relevant Ministries |

AVM = automated valuation model, CMAS = computerized mass appraisal system, ICT = information and communication technology, PT = property tax.

Source: Compiled by author.
Many advanced technologies are helping governments around the world administer market-based property taxes more efficiently, all while promoting tax equity, community service, and government transparency. Advancements continue to allow governments to become more accurate and cost-effective, for example, by relying on AI to scan and collect data from overhead property imagery instead of sending individuals out into the field. Technologies improve functions at all stages of a mass valuation—from data collection to appeal management—and across all CMAS software.

The level of PT technology adoption in Asia and the Pacific varies greatly. These disparities are likely due to the range of economic, legal, and other constraints. Some economies have highly sophisticated technology and approaches (e.g., Hong Kong, China; Singapore), while others have no CMAS to speak of (e.g., Viet Nam).

Regardless of constraints or hesitancy, governments can improve CMAS and overall property taxation over the long term. Seemingly small contributions to improve efficiencies in software, policies, and procedures add up quickly. Long-term planning should consider cost–benefit analysis of implementation and ongoing maintenance. Benefits should not be reflected in monetary terms (i.e., increased tax revenue), but also for society and the economy, including more equitable redistribution of the tax burdens. The following has particular relevance to the discussion at hand:

There are some clear technical obstacles to be overcome including the need for a comprehensive register of properties, having good data sources about achieved property transaction prices, a valuation infrastructure, and an efficient system of tax collection. Putting these in place can be expensive and requires significant investment up front, before there is a benefit in the form of increased tax yields. Some of these costs can be offset by bilateral donors, assistance from FAO (Food and Agriculture Organization of the United Nations), and loans from the World Bank. Usually, such projects show a significant return on the capital employed.¹⁶

Technology is always advancing, and government offices should remain agile. As CMAS technologies are upgraded, it is important for management to stay aware of new technological applications. This does not necessarily require new and ever-changing software, but ensuring existing resources are being used to their full potential, especially before considering making a potentially costly addition. Professional events (conferences, workshops, etc.), membership associations, research publications, and industry standards should be explored for leadership, development, and support in the successful long-run implementation of and benefits from PT technology.

The governments or agencies in charge of the property tax (PT) administration and management must consider several priorities in terms of technical and functional requirements in a proposed automated valuation model (AVM) solution.

It should be able to cater for any future changes in bases for determination of ratable value. Therefore, all the three approaches to value (cost, income, and sales comparison) should be adequately developed to cater for any future reforms in property rating policies and legislation. The computerized mass appraisal system (CMAS) solution must be able to maintain valuation rolls on a multi-jurisdictional basis, taking into consideration the need to maintain the data from all local governments in the country.

The table describes how the CMAS system ideally should meet business requirements, that is, the minimum modules and functionalities plus the technical requirements needed for developing a comprehensive CMAS. Indeed, a minimum solution must provide robust performance in accordance with the International Association of Assessing Officers AVM performance standards and produce and maintain valuation rolls for all central or local governments for different types of land use (agricultural, residential, industrial, commercial).

The vision of this tool kit is to show how a system can be implemented in support of property valuation for rating purposes that will provide an enhancement in analytical capabilities, productivity, and operational efficiency toward improvement of land administration and specifically PT administration.

Therefore, the CMAS solution shall be required to provide more information on how the solution will fulfill the following functionalities described and summarized in the table.

<table>
<thead>
<tr>
<th>System Integration</th>
</tr>
</thead>
<tbody>
<tr>
<td>The solution should be capable of integration with the land information system (LIS) to enable the valuation process to seamlessly access geospatial data and ownership information required for sales analysis. The valuation information and communication technology (ICT) software should be able to provide results of mass valuation to LIS and other software (e.g., tax).</td>
</tr>
<tr>
<td>The solution should have an integrated statistical package or provide for integration with third-party statistical software. Describe what statistical package comes as a bundle with the solution or what statistical software can be integrated with the product.</td>
</tr>
<tr>
<td>The solution should be integrated with a relational database management system.</td>
</tr>
<tr>
<td>The solution should be capable of integration with word processor, spreadsheet, and e-mail client to accomplish tasks. Indicate office suites and e-mail clients that come with the solution or can be integrated with the product. FLOSS will be a preferred option.</td>
</tr>
</tbody>
</table>
The solution should integrate with digital image management software that can be used to handle scanned documents and digital photographs.

The solution should be able to integrate with a workflow management package that maintains work assignment, scheduling, and messaging. The workflow module should allow tasks to be managed at all levels.

The system solution should allow for remote access to the client-side interface via a standard web browser to enter and edit data. Please explain how this access is achieved.

**Hardware/Architecture**

The system should be able to connect and provide information to all regional offices; web technologies are preferred.

The system developer/provider should indicate the client-side workstation requirements including but not limited to central processing units, ready access memory, and hard-drive size.

The solution provider should indicate the server requirements including but not limited to central processing units, ready access memory, and hard-drive size.

The system provider should indicate the programming languages that can be used to extend the proposed system should there be a need for future improvements.

The database should support the standard American National Standards Institute Structured Query Language and procedural language.

The database should support multiple concurrent sessions.

The database should support “locking” fields, records, pages, and tables while in use.

**Usability**

The solution should have a user-friendly interface.

The solution should allow access of all critical information from one screen.

The solution should be able to move seamlessly from one screen to another.

The solution should contain online context-sensitive help at field and screen levels.

The screens should be readable and easy to navigate.

The solution should have browsing capabilities with good response time (browse data in database).

The solution should have search and sort capability with good response time.

The system provider should supply response figures for various networks, number of client users, and operating system configurations.

The solution should support edit checks and validation on required fields.

The solution should support use of a mouse on the client side.

The solution should support export/import of data. Indicate what format(s) is/are supported.

**Data Management**

The solution should easily store and retrieve properties and their attributes.

The solution should support properties with unique keys that cannot be changed.

A user should be able to find a property by valuation roll number, plot number, owner’s name and/or owner’s ID number combination, any other attribute of the property legal description.

The solution should allow adding user-defined property characteristics.

The solution should have the ability to add and maintain cost or market data on all property improvements necessary to support the application of the cost, sales comparison, or rental-income-based approaches to value.

The solution should store and retrieve valuation results for an individual property or a group of properties.

The solution should add and maintain new properties, exemptions, classes, characteristics, types and attributes, neighborhoods, etc.

The solution should provide for temporal storage and processing of data.

The system should allow the user to change the system’s effective date and enable use of valuation procedures for different effective dates.

Table continued on next page
The solution should maintain valuation information for multiple years and allow easy access to any historic data.

The solution must support process rollback if a decision made in a step of a process is reversed.

The solution should allow an easy cancel or edit of saved transactions.

The solution should support suspending transactions. For example, changes are not updated until certain conditions are met or a specific role approves the updates.

The solution should allow for cancellation of a process once after it has been submitted or suspend a transaction pending approval.

The system developer should give a typical system configuration indicating the limit of transactions, concurrent workflow incidents, and users who can be supported.

### Security

The solution should be developed in line with the Open Web Application Security Project best practices in case of web application and other relevant security standards otherwise.

The database should fully support authorized, password-protected access to its resources.

The solution should allow the administrator to notify and compel users to change passwords as part of standard security policy.

The solution should allow the administrator to reset user password and cannot access the user’s current password.

The solution should maintain a log of all failed attempts to access its resources.

The system should maintain a log of unauthorized attempts to access its resources.

The solution should support multiple security levels (privileges and roles) according to predefined use profiles.

The solution should be able to restrict some users to “read only” access. Such users should be prevented from altering any database content.

The solution must maintain a secure log of all user activity.

The solution should take advantage of advancement in sign-in technology by allowing alternative sign-in such as thumb and optical recognition.

### Database

The database should be scalable relational database. To ensure compliance with LIS, use of PostGres/PostGIS is preferred.

The database should fully support authorized, password-protected access to its resources.

The provider’s solution should support multiple security levels (privileges and roles) according to Administrator predefined user role profiles.

The solution should have the ability to recover in the event of hardware or power failure.

The database should roll back incomplete transactions in the event of the hardware or power failure.

The database should have full backup/recovery, archiving, and mirroring capabilities while the system is in use.

The solution should provide a list of the suspended transactions for review and approval.

The solution should store and/or retrieve building sketches and images, etc.

The system shall allow users to import, export, and manage digital photos and images.

The solution must keep an audit trail (including who, when, and why) of all database transactions affecting property, sales, valuation results, etc.

The solution should, depending on user security role, be able to define groups of properties and perform mass updates of values and certain characteristics.

The solution should have the ability to search cost manuals through a local area network.

The solution should have the ability to keep permanent records of the information (correspondence, phone calls) exchanged with the property owners or their representatives and that relates to property status, characteristics, values, appeals, exemptions, etc.

The solution should have the ability to support different exempt statuses.

The solution should have the capability to support adjustments granted to taxpayer groups.

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*continued on next page*
The solution should simultaneously maintain both the market and assessed property values.
The solution should be easily adjusted to respond to changes in local government rating legislation.
The solution should support mixed-property classes and changes property classification.
The solution should allow multiple users work on the same task or file simultaneously.
The solution should support valuation of different types of neighborhoods: commercial, industrial, residential, peri-urban, agricultural.
The solution should have capability to perform batch processing of a group of properties based on a user-defined criterion such as geographical location, type of property, zoning, etc.

**Building Permits and Field Inspection**

The solution should support interfacing with planning department to capture building permits with description and status.
The solution should have capabilities for searching permits by roll number, address, owner’s name, contact name, any part of the legal description, permit date, and field inspection date.
The solution should be able to track permit processing statuses.
The solution should maintain permit status, inspection date, inspector’s identification, reason for inspection, type of inspection, detected changes and action taken.
The solution should capture subdivision permits.
The solution should allow identification of permit data by tax year and neighborhood.
The solution should allow checking of electronic permit data.
The solution should be able to schedule a field permit inspection and track its status, inspection date, and inspector’s identification.
The solution should seamlessly integrate and interact with a geographic information system.
The solution should be able to utilize electronic tablet/handheld data collection devices as a primary source of data collection and entry. Google Android devices will be preferred because of cost.
The solution should allow users to enter building sketches directly on the handheld devices and upload to the server through the global positioning system.
The solution should allow users to edit or modify building sketches before approval for commitment to the system.
The solution should provide capabilities to label areas, display dimensions on building sketches, check and correct closure of building sketches, calculate areas, plus display, store and copy sketches from a library of predefined standard plans.
The solution’s sketching functionality should be able to accommodate angles and curves and automatically close the sketches.
The solution should allow the user to maintain stages of construction by completion percentage, by building segments, or whole structure by applying the rates from the partial completion matrix.
The solution should be able to import/export sketches using standard format and print sketches.
The solution should have the capabilities to convert existing paper-based sketches into the standard electronic format and migrate them into the system.
The sketching functionality should be easy to learn and use by users with different levels of computer literacy.
The solution should, once saved, enable the sketch to automatically populate appropriate characteristic elements of the property in the database.

**Income Approach**

The solution should have the capability of valuing property using the income approach based on gross rent multiplier and direct capitalization.
The solution should allow the user to enter, store, and track income and expenses received from property owners.
The solution should have the capacity to determine income for properties in respect of which no income statements are available.

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Table continued

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<tr>
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Sales Comparison Approach

Table continued

<table>
<thead>
<tr>
<th>Description</th>
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<tbody>
<tr>
<td>The solution should allow the user to maintain user specific tables for market factor, historic trends, reasonable anticipated outcomes, and other adjustment indexed by building types, use, zoning, and neighborhood.</td>
</tr>
<tr>
<td>The solution should allow user-specific tables merging income information and property characteristics to provide value indications.</td>
</tr>
<tr>
<td>The solution should support storage and analysis of lease information as it pertains to commercial agricultural land.</td>
</tr>
<tr>
<td><strong>Sales Comparison Approach</strong></td>
</tr>
<tr>
<td>The solution should have the ability to capture and maintain sales information.</td>
</tr>
<tr>
<td>The solution should have the ability to code sales to describe their validity.</td>
</tr>
<tr>
<td>The solution should have the ability to maintain historic sales information, introducing the capability to capture, edit, and maintain the physical property and other valuation characteristics, as they existed on the date of sale.</td>
</tr>
<tr>
<td>The solution should provide users the ability to perform edit checks on sales data including presence of required data, correct data type, value ranges for numeric data, and consistency with data already stored in the system.</td>
</tr>
<tr>
<td>The solution should have the ability to derive and maintain benchmark per unit values for residential, multi-residential, commercial, industrial properties.</td>
</tr>
<tr>
<td>The solution should have the capability of valuing condominiums using the sales comparison approach.</td>
</tr>
<tr>
<td>The solution should feature tables of per-unit values per condo development based on individual units’ percent of ownership and allow for adjustments for features that may vary among units in the same complex.</td>
</tr>
<tr>
<td>The solution should have the ability to build and maintain tables of rents for different property types.</td>
</tr>
<tr>
<td>The solution should have the ability to calibrate appraisal models using techniques such as multiple linear regression and nonlinear regression, among others.</td>
</tr>
<tr>
<td>The solution should have the ability to compare the characteristics of the property to the individual sales and select the most comparable based upon user-defined criteria.</td>
</tr>
<tr>
<td>The solution should have the ability to compare characteristics of the property to characteristics of other properties within a predefined geographical neighborhood.</td>
</tr>
<tr>
<td>The solution should be able to use neighborhood, date of sale, quality, condition, proximity as the criteria for search.</td>
</tr>
<tr>
<td>The solution should have the ability to print a comparable property report.</td>
</tr>
<tr>
<td>The solution should allow for selecting user-defined comparable for a particular property overriding the default system selection for the comparable property report.</td>
</tr>
<tr>
<td>The solution should provide a report that shows a market adjustment grid including property characteristics sales information and unit price adjustments.</td>
</tr>
<tr>
<td>The solution should be able to produce any required sales comparison approach detailed and summary valuation reports.</td>
</tr>
<tr>
<td><strong>Cost Approach</strong></td>
</tr>
<tr>
<td>The solution should have the ability to value all improvements based on their characteristics and include all base areas and subareas.</td>
</tr>
<tr>
<td>The solution should have the ability to handle all taxable residential, commercial, industrial structures typically found within the jurisdiction of local governments.</td>
</tr>
<tr>
<td>The solution should have a user-definable, percentage adjustment format for depreciation.</td>
</tr>
<tr>
<td>The solution should have the ability to apply functional and economic obsolescence separately from physical depreciation.</td>
</tr>
<tr>
<td>The solution should allow maintaining user-defined cost and depreciation tables.</td>
</tr>
<tr>
<td>The solution should allow update of the cost and depreciation tables by authorized users.</td>
</tr>
<tr>
<td>The solution should allow using the cost-based value as the supporting information for other appraisal approaches.</td>
</tr>
<tr>
<td>The solution should allow for storage of both actual age and condition ratings for each building with option for appraiser to select either method for determining depreciation.</td>
</tr>
<tr>
<td>The solution should allow user to adjust cost data for local variations and changes over time.</td>
</tr>
<tr>
<td>The solution should allow the application of sales-based market adjustment factors and automated application of them by neighborhood, building type, class, age, and another user-defined factor.</td>
</tr>
</tbody>
</table>
### Value Reconciliation

The solution should have the ability to calculate values from each of the appropriate approaches to value and automatically produce a weighted recommended value based on user-defined criteria.

The solution should have functionality to produce and save user-defined detailed valuation reports listing all physical data and rating information relevant to the property in a comprehensive and user-friendly format.

The solution should allow the user to have the ability to select an individual value deemed to be most appropriate or set the system to select a value indication from a specified approach.

The solution should provide separate fields for the values computed from each different approach.

The solution should allow the user the ability to override calculated values on the system and provide codes indicating the reason for the override.

The solution should have a comment or notes field for use in supplying additional information.

The solution should provide for user-defined extracts of valuation data for use in ratio study statistical analysis software.

The solution should allow authorized user profiles to manually override values of individual properties selected by the property value, property class, use, geographical location, etc.

The solution should provide tabular (tables) and graphical documentation to substantiate the valuation results.

The solution should have the ability to compute statistics including the price-related differential, mean, median, weighted mean, coefficient of variation, and coefficient of dispersion statistics.

The solution should have the ability to list parcels with extreme, unusual, or inconsistent data.

The solution should allow the users to update and define the criteria used to trigger error and warning messages as validation rules.

### Ratio Studies

The solution should have the ability to calculate sales ratios using assessed value and sale price or adjusted sale price.

The system should provide standard reports to include assessment measurements based on International Association of Assessing Officers statistics such as sales ratio analysis, minimum, maximum, variance, mean, median, standard deviation, price related differential, confidence interval, and coefficient of dispersion. These reports should be run by user-defined subcategories (i.e., property type and characteristics, neighborhood, classification, etc.).

The solution should have the ability to allow users to exclude certain properties from sales ratio analysis and report.

The solution should have reporting capabilities that include the ability to create sales listings in ratio calculations.

The solution should have the ability to export relevant valuation data to a statistical package for detailed statistical analysis.

The solution should have the ability to flag properties falling outside accepted sales ratio parameters according to business rules.

The solution should allow user to execute sales ratio analysis over multiple years to illustrate market value for land parcels changes over time.

The solution should have the ability to graphically depict sales ratio statistics.

### Statistical Analysis and Report Writing

The solution should provide functionality for basic tabulations and descriptive statistical calculations, such as frequency distributions, medians, means, standard deviations, etc.

The solution should have functionality to define report templates, produce and save user-defined reports.

The solution should allow the ability to produce graphical output of data, including scatter plots, bar charts, histograms, and other basic charts.

The solution should allow for output of reports and screen captures, at the user option, to printers and files.

The solution should allow the user to apply the “what if” scenario value and class changes to the parcel record.

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Table continued

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>The solution</td>
<td>should allow the user to create “what if” scenarios in the solution environment to test the impacts of changing depreciation schedules, building extra features, building rates, etc.</td>
</tr>
<tr>
<td>The solution</td>
<td>should allow the user to apply the results of the “what if” scenario or retain the original state.</td>
</tr>
<tr>
<td>The system</td>
<td>should allow the user to archive a “what if” scenario for future reference or access.</td>
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<tr>
<td><strong>Appeals</strong></td>
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<tr>
<td>The solution</td>
<td>should allow the user to maintain recommended appeal adjustments to the property that requires approval by an authorized user.</td>
</tr>
<tr>
<td>The solution</td>
<td>should have the ability to associate multiple parcels per value objection.</td>
</tr>
<tr>
<td>The solution</td>
<td>should have the ability to duplicate common objection data across multiple parcels. (e.g., owner name, values, plot numbers, etc.).</td>
</tr>
<tr>
<td>The solution</td>
<td>should be able to support appeals with unique objection number linked to the property ID, hearing date and location, assigned valuer, assigned lawyer in the case of an appeal to the High Court, details of the objection, objection status, issues objected upon and decisions of the Valuation or High Court.</td>
</tr>
<tr>
<td>The solution</td>
<td>should support objection search by property ID, owner’s postal address, owner’s name, objection date, land title number, plot number, unit number (in case of condominium developments), and the ability to track objection processing status through the workflow.</td>
</tr>
<tr>
<td>The solution</td>
<td>should produce supporting documentation that can be used to present and/or defend valuation objections.</td>
</tr>
<tr>
<td><strong>Data Archival</strong></td>
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<tr>
<td>The solution</td>
<td>should support user-defined aging cycles for historic data and provide easy access to archived historic data.</td>
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<tr>
<td><strong>Setup, Support, and Training</strong></td>
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<tr>
<td>The automated valuation model (AVM) solution</td>
<td>should provide detailed responses to the following:</td>
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<tr>
<td>Terms and types of support and support agreements available including the price</td>
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<tr>
<td>Availability of onsite training, internet training, or CD-ROM training, and the cost</td>
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<tr>
<td>Available services and rates for customized programming of the system</td>
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<tr>
<td>Availability of additional integrated modules. Ability to provide additional functionality in a modular fashion (e.g., adding a new valuation approach as legislation changes are effected)</td>
<td></td>
</tr>
<tr>
<td>Access to source code and/or deposit of source code with an escrow agent</td>
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<tr>
<td>Access to software upgrades and licenses and price, if any</td>
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<tr>
<td>Availability of direct and remote technical support when required (e.g., 24 hours/7 days a week/365 days)</td>
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<tr>
<td>Access to user and technical documentation</td>
<td></td>
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<tr>
<td>Training program for ICT staff on support, maintenance, or enhancement of the system throughout the development phases of the CMAS</td>
<td></td>
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<tr>
<td><strong>Workflow</strong></td>
<td></td>
</tr>
<tr>
<td>The solution</td>
<td>should integrate workflows to support all ICT valuation system solution functionalities.</td>
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Computerized Mass Appraisal System in Hong Kong, China

Hong Kong, China currently maintains a sophisticated computerized mass appraisal system (CMAS) system of cross-functioning software and digital databases to facilitate the mass rental valuation for more than 2 million properties. Mass appraisal efforts first began in 1986, with an initiative for the comprehensive digitalization of all property data. A geographic information system (GIS) was introduced for further functionality and efficiencies in 2014.

All data used for valuations are kept in a central, digital database that is compatible across all CMAS software. Rental data are collected from compulsory questionnaires sent to taxpayers or acquired from landlords. The government tracks and updates property characteristics to create regression-based automated valuation models (AVMs). Models are created, reviewed, and calibrated by government staff. International Association of Assessing Officers ratio studies are implemented to perform quality control after revaluations.

Hong Kong, China allows for e-payments using auto payment from a bank account, payment over the phone, payment over the internet, or payment with an ATM. The number of e-payments increased by 36% from 2017 to 2018 and by 63% from 2019 to 2020.

Hong Kong, China implements many advanced technologies that help maintain a CMAS that is complex, yet efficient and effective.


Regression-Based Automated Valuation Models in Moldova

The Republic of Moldova implemented a value-based property tax in 2000 and has been creating mass appraisal models since 2004. In 2015, these changes, in addition to a shift from a split tax on land and buildings to a single tax, helped increase tax revenues by 35%, with an 84% increase in taxable values of income-producing commercial and industrial properties.
In recent years, Moldova has been working toward implementing regression-based AVMs and even had their first nationwide AVM for apartments approved in 2023. The Public Services Agency is responsible for AVM creation that is supported by the World Bank. The agency has invested significantly in the overhaul of all database systems to promote the performance and overall success of AVM implementation.

The agency collects approximately 120,000 deeds per year through administrative territorial units at the local level and prepares the data to create AVMs. Data are verified for accuracy and updated accordingly. Sales that are unable to be verified as accurate or reflective of a typical open market transaction (e.g., family sale or bank sale) are not used for AVM creation. Finally, the agency standardizes the data with formatting and objective coding systems (e.g., building materials, presence of water).

Separate AVMs are currently being created and tested for additional classes of properties, including detached urban houses, summer cottages, storage garages, rural houses, commercial properties, and agricultural properties. Models are created and calibrated using a combination of Microsoft Excel and RStudio. The full CMAS of Moldova is a fit-for-purposes system that crosses across multiple software platforms including Quantum Geographic Information System for free, open-source GIS software. Models are being tested using ratio studies and are demonstrating great enhancements over previous mass appraisal models.


Web-Scraping of Listing Data for Nationwide Automated Valuation Model in the People’s Republic of China

Many countries are faced with a lack of available or trustworthy data with which to create reliable AVMs for property taxation. This may be due to constraints of governments resources (collection staff, budgets, etc.) or reporting customs of the market (e.g., underreporting of sale prices by buyers and sellers to evade transaction stamp duties). One common suggestion in the industry in the absence of aggregate data for confirmed sales is similar data using listing data may be instead used to create AVMs. In such an instance the primary difference is that instead of a price that was paid, it is the asking/listing price at the time of data collection that is used to train AVMs. Governments considering web-scraping listing or property data should first verify such practice permissible by law and website terms of use (if it is not, the government may consider seeking special permission through a use license agreed in a contract).

In a study funded by the Lincoln Institute of Land Policy, the authors evaluated the feasibility of regression-based AVMs in the People’s Republic of China. The authors created various types of regression models using scraped data and run detailed ratio
study tests according to International Association of Assessing Officers standards to estimate the accuracy and overall performance of the models. They concluded that a baseline benchmark AVM may be created for the entirety of the country (assuming reliable listing website data). They suggested that models can likely be improved with further analysis, additional data, and additional modeling considerations common to mass valuation workflows.

The research is very relevant for countries that have no transaction registries and limited or nonexistent resources for developing one: it demonstrates that in the absence of reliable and aggregated transaction data, governments may be able to gather cost-effective data that may be used for AVM. Listing data are typically comprehensive with regard to property characteristic coverage (size, constriction year, bathrooms, etc.) and geographic location—desirable features of a dataset when looking to identify all possible determinants of value. Data should still undergo quality control testing to determine overall quality with respect to accuracy, completeness, recurrence, and representativeness of true properties location within the jurisdiction.


**Artificial Intelligence for Image Recognition of Unregistered Pools in France**

Swimming pools are taxed in France. From 2021 to 2022, France was able to raise over €10 million in collections in test areas using artificial intelligence (AI) machine learning algorithms to discover over 20,000 private swimming pools that were not registered with the government. Neural networks are used to recognize pools based on shape and color. Once AI recognition models are reviewed, calibrated, and optimized, government staff compare results against existing databases. Property records are updated accordingly to adjust future valuations to reflect the positive increase from the pool.

The government’s deputy director general of public finances estimates the software used to perform the analysis will help the government increase taxes by almost €40 million from 2022 through 2023. The software is open source but was developed for the government by a private firm. The aerial imagery used to train these models is publicly available data.


Leveraging Technology for Property Tax Management in Asia and the Pacific

Guidance Note

This guidance note explains why countries in Asia and the Pacific should use technology, including remote sensing and artificial intelligence, to reform property tax management and help strengthen public finances. Outlining why property tax is a stable revenue source, it shows how technology can be used to roll out computerized mass appraisal systems, automated value modeling, and integrated land information systems. It assesses the complex hurdles and financial constraints facing countries and shows how the Asian Development Bank is helping better integrate land management into wider e-government systems.

About the Asian Development Bank

ADB is committed to achieving a prosperous, inclusive, resilient, and sustainable Asia and the Pacific, while sustaining its efforts to eradicate extreme poverty. Established in 1966, it is owned by 68 members —49 from the region. Its main instruments for helping its developing member countries are policy dialogue, loans, equity investments, guarantees, grants, and technical assistance.