

Modeling Land-Use Transitions under Conflicting Conservation and Land Tax Policies in Bang Kachao, Thailand

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ABSTRACT

Bang Kachao Subdistrict faces a policy conflict between the 2019 conservation zoning regulation, which mandates at least 25% green cover, and the Land and Buildings Tax Act in 2019, which progressively increases idle land tax rates from 0.5% to 3% within three years. The rising tax burden has accelerated land conversion from vacant and forested plots to monoculture farms, threatening local ecosystem integrity. Using high-resolution drone imagery and high-resolution satellite imagery obtained from Google Earth Pro for the year 2005 and 2015, six land-use classes were mapped and projected to 2045. The model achieved an overall accuracy of 89.7% (Kappa = 0.86), forecasting a 14.1% decline in forest area (-0.144 km²), 15.9% agricultural net increase (+0.185 km²), and an increase in idle land from 0.031 km² to 0.094 km² over the 40-year period. Field surveys confirmed that landowners replaced nipa palm wetlands with eucalyptus plantations to qualify for tax exemptions. These results indicate that progressive taxation can undermine conservation policies. It is recommended that subdistrict governors establish Memoranda of Understanding (MOUs) with landowners to support nipa palm and native forest restoration through capped tax rates and integrated land-use zoning.

HIGHLIGHTS

- Modeled land-use in Bang Kachao under conflicting tax and conservation policies.
- High-resolution drone and satellite data projected a 14.1% forest decline by 2045.
- Progressive land taxes drive conversion of native wetlands to monoculture farms.
- Proposed MOUs and tax caps to align fiscal policy with ecological preservation.

1. INTRODUCTION

Land-use and land-cover (LULC) dynamics are central to understanding ecological balance, resource distribution, and human well-being, as changes in LULC significantly influence biodiversity, hydrological cycles, and greenhouse gas emissions (Liu et al., 2020; Khan et al., 2023). Land cover refers to the physical characteristics of the Earth's surface, such as forests, croplands, or urban areas, whereas land-use reflects the human activities that modify these features. Globally, rapid urbanization and agricultural expansion have intensified these transformations, raising concerns about the long-term resilience of peri-urban ecosystems. Bang Kachao, located in Phra

Pradaeng District, Samut Prakan Province, and widely recognized as the “green lung” of Bangkok, which it exemplifies these tensions between conservation and development (Yotapakdee et al., 2018). In 2019, the Thai government declared Bang Kachao an environmental protection area, mandating that at least 25% of the area remain as green space and restricting construction across six subdistricts (Saksornchai, 2019). However, the Land and Buildings Tax Act of 2019, enacted in 2020, imposes escalating taxes on idle land, rising from 0.5% in the first year to 3% after three years, incentivizing landowners to convert vacant plots into ecologically simplified monoculture plantations, such as banana, mango, or

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coconut, to reduce tax liability (Nanakorn, 2019). The interaction between conservation zoning and fiscal policy thus generates contradictory incentives, distinguishing Bang Kachao from other regional contexts. Whereas Jakarta's progressive land tax aims to reduce speculative land hoarding (Apriani and Inayati, 2020), in Bang Kachao economic pressure instead drives ecological change by encouraging the clearance of natural vegetation to qualify for lower tax rates. Consequently, the policy landscape serves as a laboratory for examining how overlapping legal and fiscal instruments shape land-use decisions.

This situation also exposes conceptual ambiguities in how "green space" is defined. In urban planning, agricultural areas are often counted toward green space quotas ($\geq 25\%$), yet ecologists argue this practice overestimates ecological health (Taylor and Hochuli, 2017). Agricultural monocultures, despite appearing "green," frequently rely on chemical inputs that degrade soil, water, and biodiversity (Raven and Wagner, 2021; Zhao et al., 2024; Jing et al., 2025). A function-based definition restricting "green space" to areas providing net positive ecosystem services such as native forests or low-impact agroforestry is therefore more appropriate for sustainability assessment. While the biophysical and spatial drivers of LULC change have been widely studied (Orina et al., 2024), socio-legal mechanisms, particularly taxation remain underexplored. Fiscal instruments can promote efficient land-use, but their environmental impact depends on governance capacity and policy design (Kalkuhl et al., 2017). This study addresses this research gap by examining how progressive taxation interacts with conservation policy to shape peri-urban land dynamics in Bang Kachao.

The central hypothesis is that progressive tax escalation under Thailand's land taxation framework may override conservation rules, thus accelerating the conversion of idle and wetland forests into low-diversity agricultural land and contributing to net forest loss. Accordingly, this study pursues three main objectives. First, it aims to assess and forecast land-use and land-cover (LULC) changes following the implementation of conservation zoning and the Land and Buildings Tax Act. To achieve this, an artificial neural network-based Multi-Layer Perceptron (ANN-MLP) modeling framework is employed to simulate land-use trajectories for the years 2035 and 2045. Second, the study seeks to verify the accuracy of the model by comparing simulated outcomes with observed data, ensuring the robustness and reliability

of the projections. Finally, the study aims to propose policy recommendations to support informed decision-making by local authorities and landowners navigating conflicting regulatory pressures between fiscal policies and conservation mandates. Through this analysis, Bang Kachao serves as a case study of how fiscal and ecological governance intersect, offering broader insights for rapidly urbanizing regions seeking to reconcile conservation objectives with economic and social imperatives.

2. METHODOLOGY

This study employed a mixed-method approach integrating quantitative LULC modeling with qualitative stakeholder insights. The Artificial Neural Network-Cellular Automata (ANN-CA) model quantified spatial change and forecasted future scenarios, while focus group discussions and on-site surveys provided contextual understanding of land management decisions and tax compliance behavior.

2.1 Study area

Bang Kachao is a conserved green area covering approximately 16 km² across six subdistricts in Phra Pradaeng District, Samut Prakan Province, Thailand (approximately 13.6°N, 100.6°E). This study focuses on Bang Kachao Subdistrict, which forms part of the larger Bang Kachao Area and covers approximately 3.14 km² (Figure 1).

2.2 Data sources and LULC modeling

Historical satellite imagery from Google Earth Pro in 2005 and 2015 was used to assess long-term land-use and land-cover (LULC) transitions in Bang Kachao Subdistrict before and after major policy interventions of the 2019 conservation zoning and the 2020 Land and Buildings Tax Act. All images were visually interpreted and cross-validated against the 2025 UAV orthomosaic and local land records to ensure temporal consistency. Concurrent field surveys of ten purposively selected landowner properties provided additional ground verification through GPS-referenced photos and site observations. Although Google Earth Pro offers high-resolution visualization, its lack of standardized spectral data and acquisition metadata introduces minor uncertainties (Bol and Randhir, 2024). Consequently, the analysis emphasizes relative temporal trends such as forest reduction and urban expansion rather than exact area estimates, ensuring robustness and reproducibility.

2.2.1 UAV data acquisition and orthophoto processing

High-resolution aerial imagery of Bang Kachao Subdistrict was captured using an MX1000 Multirotor drone with an RTK Station Emlid RS2 between 21 and 22 January 2025 under clear weather conditions (Torres et al., 2024). The survey produced

overlapping photographs processed through Agisoft Metashape (Agisoft LLC, 2022) and ArcMap 10.8 (Esri, 2020) to generate a georeferenced orthomosaic with ≈ 3 cm spatial resolution (Tripathi et al., 2024). Accuracy was validated with 107 ground control points following established photogrammetric procedures (Kögel et al., 2025).

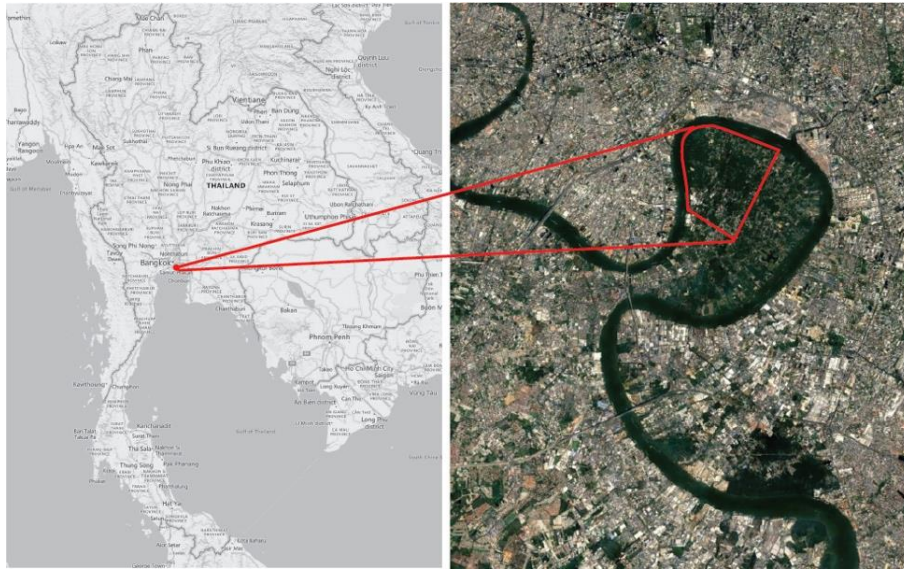


Figure 1. Satellite image of Bang Kachao Subdistrict, Samut Prakan Province, Thailand (source: Google Earth Pro).

2.2.2 Land-use and land-cover classification

LULC classification was designed to represent both ecological and socio-economic characteristics of the peri-urban landscape. Six categories were delineated from field observations, UAV orthophotos, and historical imagery: (i) agricultural land, (ii) forest land, (iii) urban and built-up land, (iv) idle land, (v) water body, and (vi) canals in agricultural areas. The canal category was distinguished separately because canal siltation often signals farmland abandonment. This classification framework supports spatial analysis of environmental change and quantification of land-use transitions, clarifying how policy pressures and hydrological factors shape Bang Kachao's landscape transformation.

2.2.3 LULC modeling and forecasting

The workflow comprised three main stages: data acquisition, processing and digitization, and change detection with calibration and forecasting (Figure 2). All imagery was imported into QGIS, georeferenced to the 2025 UAV orthophotos, and digitized through heads-up interpretation to delineate six LULC classes agricultural land, forest land,

urban/built-up land, idle land, water bodies, and canals in agricultural areas (Zhang et al., 2022). Vector polygons were assigned class codes and converted into classified raster layers with consistent spatial resolution and coordinate projection. These standardized raster datasets were then used for calibration and simulation within the Modules for Land-Use Change Evaluation (MOLUSCE) environment implemented in QGIS (NextGIS, 2019; Albut, 2024).

To enable modeling, digitized vector polygons were rasterized at a uniform 3 m spatial resolution (3 meter $\times$ 3 meter area on the ground) using Universal Transverse Mercator-UTM Zone 47N projection. This process preserved boundary precision while standardizing inputs for transition analysis. Rasterized LULC maps for 2005, 2015, and 2025 were paired with explanatory variables representing proximity to roads, canals, and water bodies, as well as spatial neighborhood effects within a 3×3 cell window. These driving factors were derived from validated UAV and satellite data to capture both physical and policy-driven forces influencing land-use transitions.

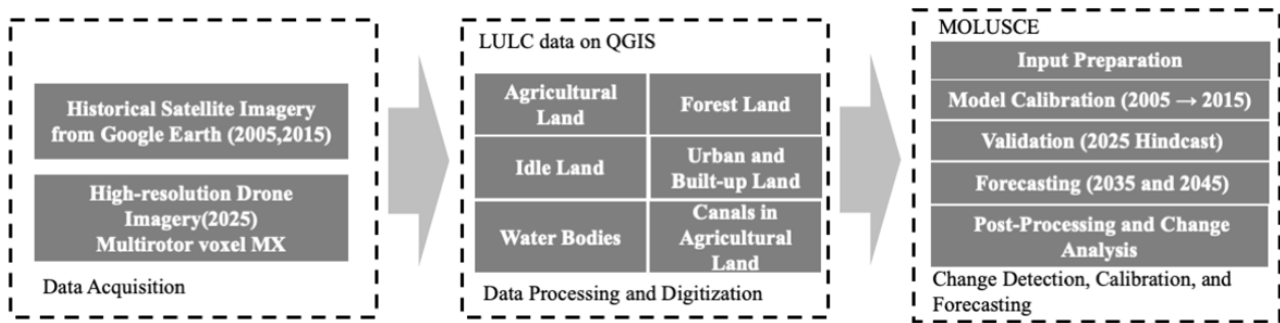


Figure 2. Workflow of data acquisition, processing, and forecasting of LULC changes.

2.2 Focus group

The focus group activities were conducted in Bang Kachao Subdistrict, involving local farmers, homestay operators, municipal officials, and community leaders. Two sessions were organized to gather stakeholder perspectives on future land-use scenarios. During the first focus group, participants were presented with drone-derived maps and field survey data to facilitate discussion on current land-use patterns and their perceived changes. They were asked to reflect on possible future scenarios for Bang Kachao considering ongoing environmental and policy pressures. The second focus group was structured as a participatory workshop focused on land-use design under the Land and Buildings Tax Act in 2019. Participants were tasked with developing land-use models that balance economic returns, environmental sustainability, and community well-being. This exercise encouraged local stakeholders to envision adaptive management strategies aligned with both fiscal and ecological objectives. Additionally, participants conducted an exercise to calculate the break-even point between investment in land development and tax exemption.

3. RESULTS AND DISCUSSION

3.1 Land-use and land-cover

Figure 3 illustrates the land-use and land cover (LULC) patterns of Bang Kachao Subdistrict in 2025, derived from UAV-based orthophotos. Agricultural land occupies the largest proportion of the area (Figure 3(a)), reflecting the persistence of fruit orchards and small-scale household cultivation. Forest land is the second most extensive category and can be divided into two main types: wetland forest dominated by nipa palm (*Nypa fruticans* Wurmb) along the western riverbank adjacent to the Chao Phraya River, and mixed dry forest located in the interior (Figure 3(b)). Urban and built-up areas are concentrated in the

central part of the subdistrict, corresponding to the main road network and settlement clusters (Figure 3(c)). Idle land represents the smallest category and is typically found along road corridors, indicating plots awaiting future development (Figure 3(d)). The subdistrict contains twelve main canals connecting inland areas to the Chao Phraya River (Figure 3(e)), along with numerous smaller canals dispersed throughout agricultural zones (Figure 3(f)). As can be seen, the forest in the northern part has a smaller extent than that in the east due to road accessibility. Where roads are present, the area has the potential to become urban, leading to a reduction in forest area. Additionally, agricultural areas have interspersed with forest land, which may have implications for biodiversity. This aspect warrants further investigation.

3.2 Class-by-class change

The transition probability matrix (Table 1) was calibrated using observed LULC changes from 2015 (pre-tax) to 2025 (post-tax), reflecting land-use dynamics during the first decade following the implementation of the Land and Buildings Tax Act in 2019 (effective from 2020).

The analysis revealed high stability across most land-use types in Bang Kachao Subdistrict. Water bodies and idle land remained completely stable (probability of persistence for each land-use type, $p=1.000$), indicating that during the first decade following the implementation of the 2019 Land and Buildings Tax (effective in 2020), the tax had little to no observable impact on reducing idle land. Urban and built-up land ($p=0.993$) and agricultural land ($p=0.996$) also showed high persistence, indicating relative stability of both developed and agricultural areas during the first decade, which may be influenced by policy mechanisms such as the Land and Buildings Tax Act. Forest land exhibited moderate stability

($p=0.959$), with minor losses primarily to agricultural land ($p=0.024$) and idle land ($p=0.012$). In contrast, canals in agricultural areas were the least stable ($p=0.749$), with 21.0% converting to agricultural land and 1.7% to urban and built-up land. This loss was not

directly driven by tax policy but rather by farmer abandonment associated with soil salinity, a common biophysical stressor in deltaic environments that intensifies as productivity declines.

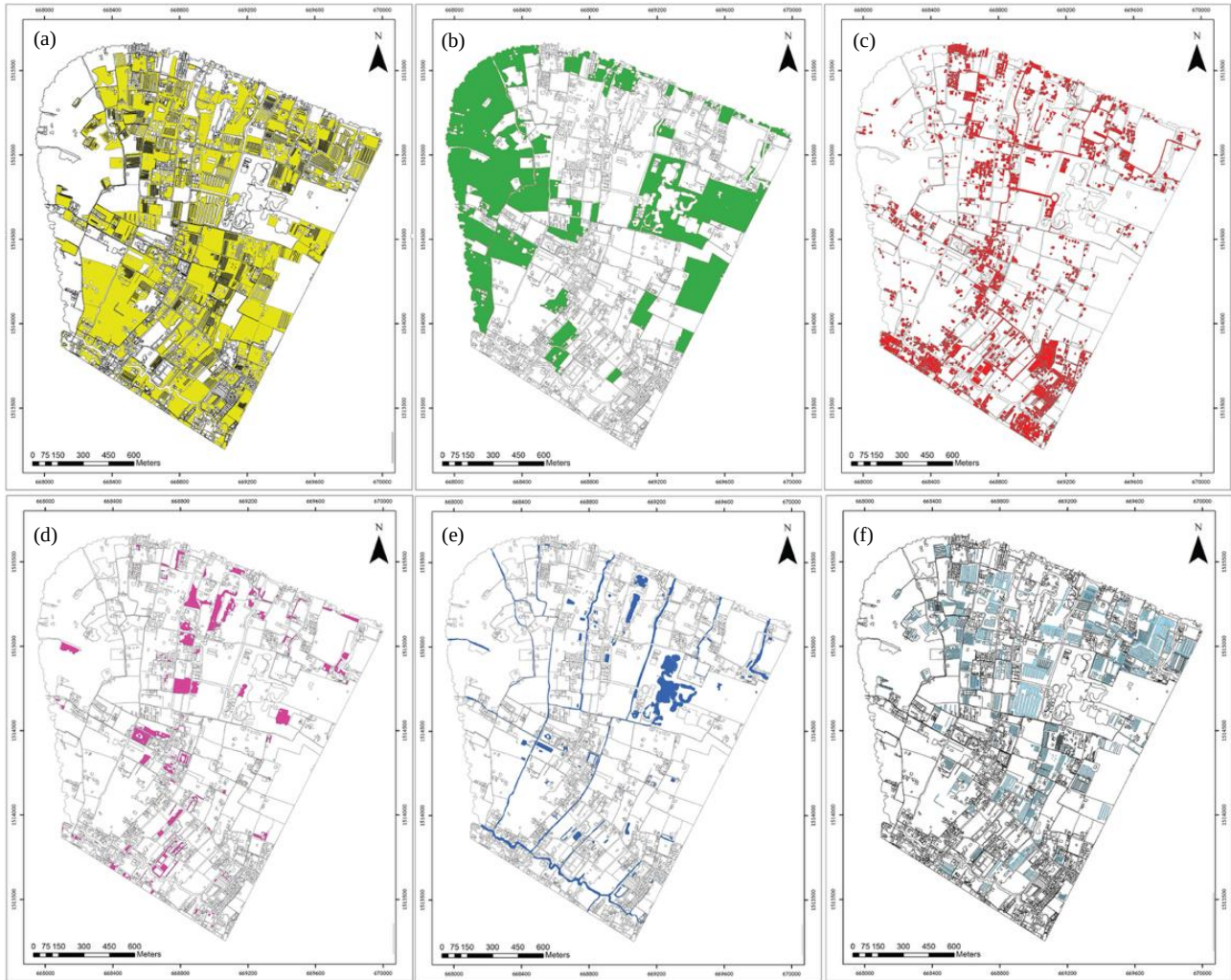


Figure 3. Land-use classification on (a) Agricultural Land, (b) Forest Land, (c) Urban/Built-up Land, (d) Idle Land, (e) Water Body, (f) Canals in Agricultural Areas in year 2025

Table 1. Land-use and land-cover transition probability matrix LULC from 2015 to 2025

LULC	Water body	Idle land	Forest land	Urban and built-up Land	Agricultural land	Canals in agricultural area
Water body	1.000	0.000	0.000	0.000	0.000	0.000
Idle land	0.000	1.000	0.000	0.000	0.000	0.000
Forest land	0.001	0.012	0.959	0.003	0.024	0.001
Urban and built-up land	0.000	0.002	0.004	0.993	0.003	0.002
Agricultural land	0.009	0.003	0.000	0.000	0.996	0.000
Canals in agricultural area	0.007	0.014	0.003	0.017	0.210	0.749

Table 2 presents temporal changes in land-use and land cover (LULC) in Bang Kachao Subdistrict from 2005 to 2045. Agricultural Land remains the dominant category, showing a net increase from 1.23 km² to 1.36 km² ($\pm 4.13\%$). Forest Land shows a steady decline (-0.198 km², or -6.31%), while Canals in Agricultural Areas decrease (-0.093 km², or -6.31%), indicating the degradation of the ditch network due to the abandonment of agricultural land. Urban and Built-up Land expands ($+0.085$ km², or $+2.71\%$) and stabilizes after 2025. Idle

Land increases ($+0.060$ km²) due to abandonment of marginal plots. Water Body area remains stable, reflecting relative hydrological resilience. The model's intermediate projection for 2035 aligns closely with the 2025 UAV observations, confirming temporal robustness for the 2045 forecast. Overall, the results illustrate a gradual transition from forest and canal-based landscapes toward more intensively cultivated and urbanized forms, driven by fiscal pressure and environmental challenges.

Table 2. Land-use and land-cover (LULC) change in Bang Kachao subdistrict, 2005-2045

LULC category	2005 (km ²)	2015 (km ²)	2025 (km ²)	2035 (km ²)	2045 (km ²)	Δ Area (km ² , 2005-2045)	Δ (%)
Water body	0.131	0.124	0.149	0.148	0.148	+0.017	+0.54
Idle land	0.034	0.050	0.113	0.096	0.094	+0.060	+1.91
Forest land	1.082	0.971	0.886	0.844	0.884	-0.198	-6.31
Urban and built-up land	0.373	0.339	0.461	0.459	0.458	+0.085	+2.71
Agricultural land	1.230	1.407	1.329	1.354	1.360	+0.130	+4.13
Canals in agricultural area	0.292	0.261	0.204	0.201	0.199	-0.093	-2.96
Total area	3.142	3.142	3.142	3.142	3.142	-	-

Figure 4 illustrates the temporal evolution of land-use and land-cover (LULC) from 2005 to 2035. In 2005 (**Figure 4(a)**), the landscape was primarily composed of agricultural and forest land, with scattered idle and limited urban areas. By 2015 (**Figure 4(b)**), forest areas declined and urban land slightly expanded, particularly along the northern and western boundaries, while agricultural land remained dominant but increasingly fragmented. The 2025 UAV orthomosaic (**Figure 4(c)**) reveals further agricultural encroachment into former forest zones, accompanied by reduced idle land and gradual urban growth. The 2035 ANN-CA simulation (**Figure 4(d)**) projects forest decline, agricultural expansion, and a sharp decrease in idle land, reflecting the influence of the 2019 Land and Buildings Tax Act, which discourages land underutilization. Overall, the sequence depicts a shift from forested to cultivated and developed land, emphasizing taxation and urbanization as key drivers of LULC transformation.

The graph illustrates the temporal evolution of land-use and land-cover (LULC) categories from 2005 to 2045, with areas measured in square kilometers ranging from approximately 0.12 km² to 1.40 km² (**Figure 5**). Six LULC classes Water Body, Idle Land, Forest, Urban and Built-up Area, Agricultural Land,

and Canals in Agricultural Area are represented by distinct lines with overlaid linear trend lines to indicate general temporal tendencies. Agricultural land increases from 1.162561 km² in 2005 to 1.347852 km² in 2045; however, the low coefficient of determination ($R^2=0.13$) indicates considerable temporal variability and suggests that this change is not well captured by a simple linear trend, likely reflecting non-linear and policy-driven land-use decisions associated with the Land and Buildings Tax Act. Forest land decreases consistently from 1.022286 km² to 0.878241 km², exhibiting a strong linear decline ($R^2=0.78$) that highlights ongoing conservation challenges.

Idle land increases to a peak of 0.112510 km² in 2025 before declining to 0.093646 km² in 2045, indicating a temporary rise followed by tax-induced land conversion ($R^2=0.62$). Urban and built-up areas remain relatively stable, reaching 0.458218 km² in 2025 and slightly decreasing to 0.455786 km² by 2045, with a moderate linear trend ($R^2=0.71$). Canals in agricultural areas show a strong and consistent decline from 0.276754 km² to 0.198273 km² ($R^2=0.80$), while water bodies remain largely stable, varying from 0.124632 km² in 2005 to 0.146900 km² in 2045 ($R^2=0.76$).

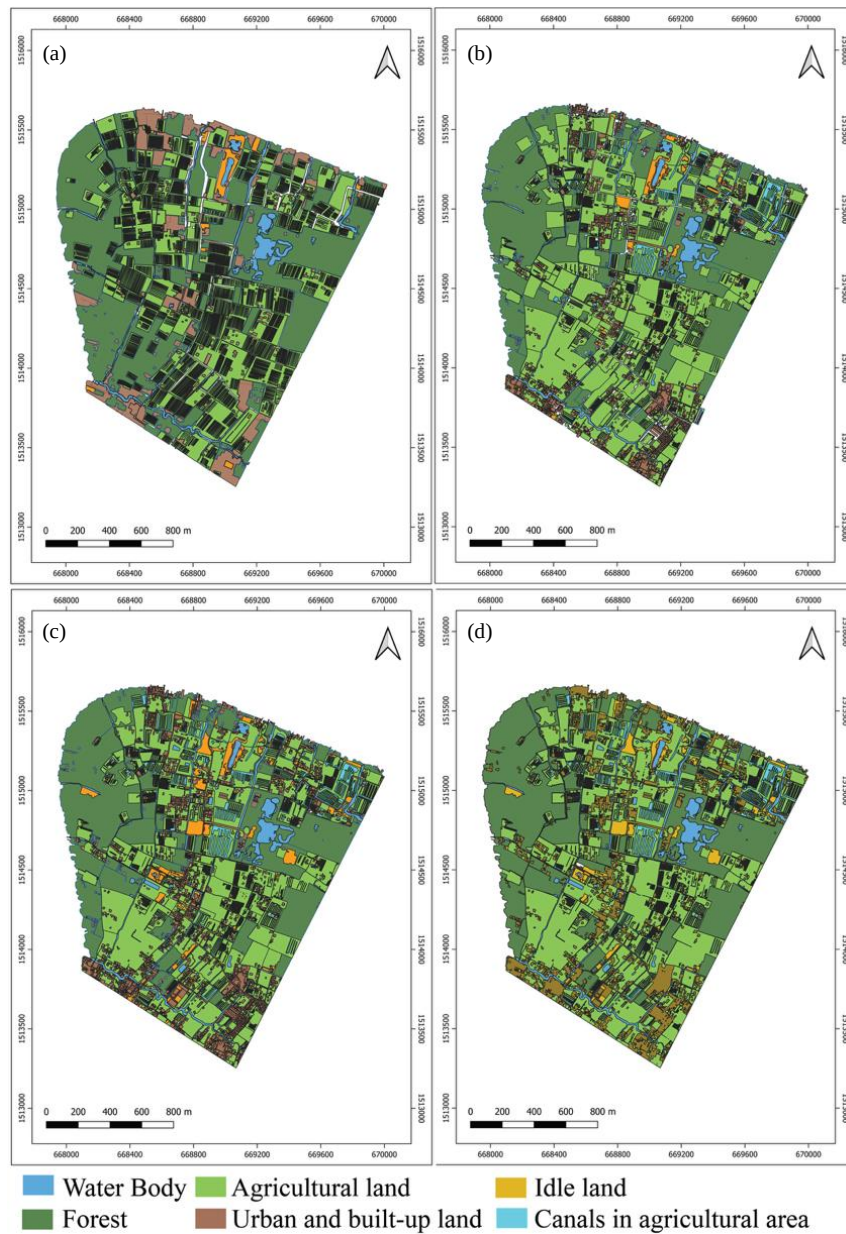


Figure 4. Simulated LULC change from 2005-2035: (a) 2005 baseline, (b) 2015, (c) 2025 UAV, (d) 2035 projection

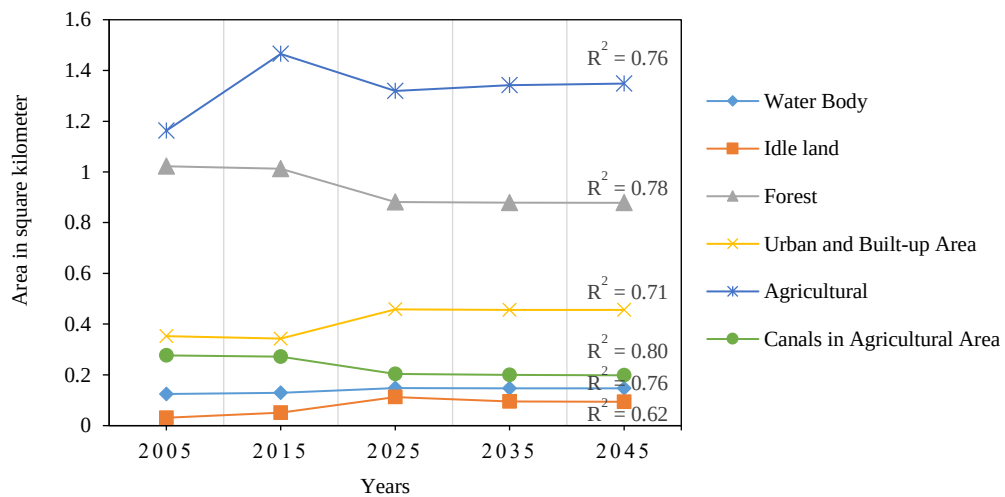


Figure 5. Temporal trends of land-use categories from 2005 to 2045

3.4 Validation

Figure 6 presents the multiple-resolution budget validation comparing observed and predicted 2025 LULC maps. The results indicate high overall agreement, with the medium location-medium quantity information curve consistently above 0.8 across resolutions, approaching the theoretical upper bound of perfect agreement. This demonstrates that the model performs well in balancing spatial allocation and land quantity predictions. By contrast, accuracy is lower when only quantity information is considered (approximately 0.35-0.4) and lowest under the no location-no quantity assumption (<0.25), underscoring the model's skill relative to chance. Performance improves modestly at coarser resolutions, suggesting that the model captures broader landscape patterns more effectively than fine-grained spatial details.

3.5 Site survey

Site surveys were conducted in April 2025 to qualitatively validate selected land-use and land-cover (LULC) transitions identified by the modeled LULC change analysis between 2023 and 2025. Ten land parcels were purposively selected from areas classified by the model as undergoing notable land-use change following the enforcement of the Land and

Buildings Tax Act. Among the surveyed parcels, eight were converted to coconut and mango farms, one to a garden house, and one to a learning center. One formerly residential parcel was converted to eucalyptus cultivation, and riverbank modifications, including the replacement of nipa palm with a stone barrier, were observed (Figure 7(a)). Another parcel originally classified as wetland dominated by nipa palm was completely cleared (Figure 7(b)). These site observations correspond to modeled transitions from residential or wetland categories to agricultural or developed land-uses. Although limited in number ($n=10$) and not statistically representative, the surveyed parcels provide illustrative case evidence that helps interpret policy-related LULC changes at the parcel level and complements the spatial modeling results.

These observations provide empirical evidence of land-use dynamics at the parcel level, demonstrating how policy-induced incentives translate into concrete transitions among residential, wetland, and agricultural land-uses. Analytically, these parcel-level responses suggest that land tax enforcement functions less as a deterrent to idle landholding and more as a catalyst for rapid, low-diversity land-use conversion, particularly in contexts where ecological land-uses lack clear fiscal recognition.

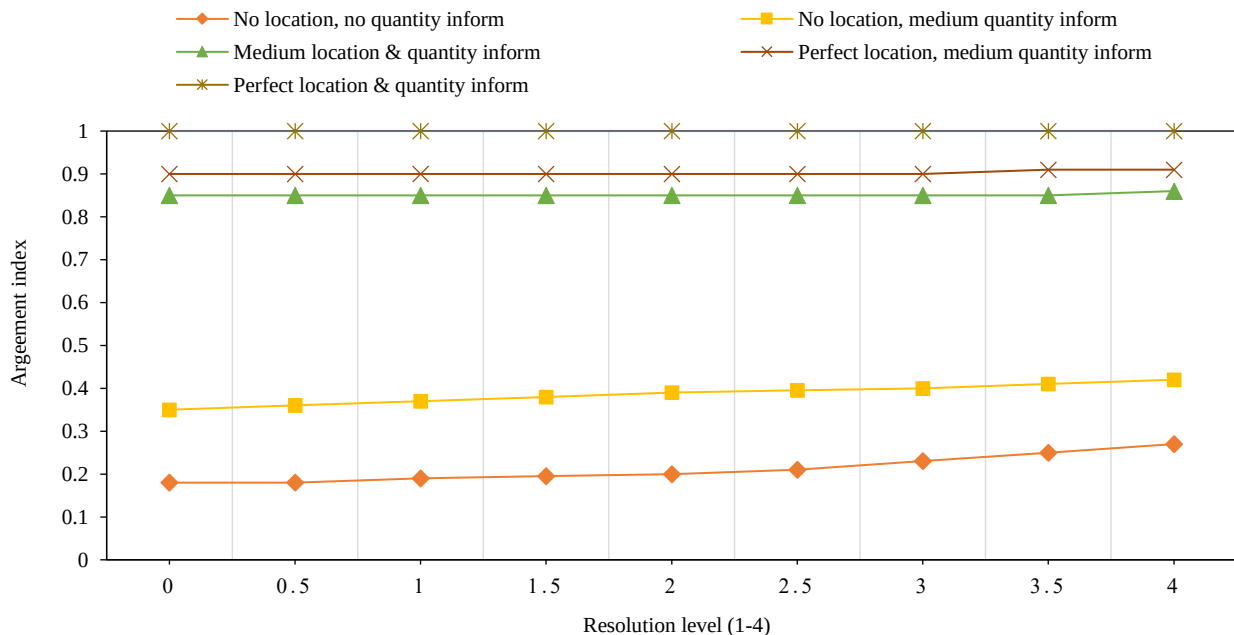


Figure 6. Multiscale validation of the 2025 LULC simulation using the Multiple-Resolution Budget (MRB) framework. Model agreement is decomposed into quantity agreement (correct total area per LULC class) and location agreement (correct spatial allocation). No location-no quantity represents a null baseline; no location-medium quantity indicates correct class proportions without spatial accuracy; medium location-medium quantity reflects partial agreement in both class amounts and spatial placement; perfect location-medium quantity represents ideal spatial allocation constrained by quantity errors; and perfect location-perfect quantity denotes the theoretical upper bound (Agreement Index=1.0), where simulated and observed maps are identical.



Figure 7. Land-use responses after implementation of the Land and Buildings Tax Act. (a) Landowners planting eucalyptus trees on previously idle land to avoid taxation; (b) Removal of nipa palm in wetland areas to convert land for taxable uses

Findings from a stakeholder workshop on tax-compliant, eco-friendly land design indicate that all landowners faced upfront compliance costs, contributing to six out of ten listing their land for sale by mid-2025. This suggests that conservation requirements, when paired with uncertain fiscal benefits, may unintentionally encourage land divestment. Focus group discussions further revealed legal ambiguity over whether nipa palm qualifies for tax exemption under the Mangrove Forest Conservation Act (2015). Although the Thai Cabinet has approved a land tax exemption for privately owned mangroves ([Department of Marine and Coastal Resources, 2024](#)), unclear implementation particularly for wetlands not formally classified as mangroves, creates policy misalignment. In line with SDG 15.a, this study recommends formal MOUs and tiered land tax relief (capped at 0.5%) for ecologically verified plots to reduce uncertainty, prevent land abandonment, and sustain ecosystem services. Together, these findings help explain the modeled land-use dynamics by showing how regulatory ambiguity and compliance costs translate into land divestment and subsequent land-use conversion.

According to the community leader, Bang Kachao frequently experiences soil salinity and farmland degradation, consistent with regional estuarine conditions reported by [Pokavanich and Guo \(2024\)](#). Since 2015, many agricultural plots have been abandoned or sold due to declining productivity and rising maintenance costs. Previous studies suggest that sustainable practices such as agroforestry and community-based forest management can improve soil health, biodiversity, and local livelihoods ([Mukul and Saha, 2017](#); [Alfonso-Bécares et al., 2024](#)). Encouraging these land-uses could restore ecological

balance and strengthen long-term economic resilience for landowners.

The expansion of non-native crops may be associated with reduced habitat suitability for native species, as simplified agricultural systems typically support lower biodiversity than natural or semi-natural vegetation ([BIOFIN, 2024](#)). However, this study does not directly measure biodiversity outcomes, and any ecological implications are inferred from observed land-use changes and existing policy assessments. Although forest loss in Bang Kachao remains limited, the observed trends highlight the importance of clear zoning that differentiates wetlands, agricultural areas, and settlements. Future research will incorporate field-based biodiversity surveys to test whether agricultural expansion and forest fragmentation are associated with measurable declines in species richness and ecological integrity.

4. CONCLUSION

Land-use forecasting in Bang Kachao Subdistrict indicates that progressive taxation under the Land and Buildings Tax Act (2019) has gradually overridden conservation zoning introduced the same year, contributing to continued forest decline and agricultural expansion projected through 2045. Although urban growth remains constrained, saline intrusion, unclear nipa palm classification, and high pond excavation costs have increased land divestment among local owners. These findings identify fiscal and regulatory uncertainty as key mechanisms limiting the mobilization of financial incentives required under SDG 15.a (Life on Land). In the short term, subdistrict authorities could clarify nipa palm classification and cap tax rates for ecologically verified forest and agroforestry areas to reduce immediate divestment

pressures. Over the longer term, structural reforms should align land-use taxation with conservation zoning and reinvest tax revenues in shared drainage and access infrastructure. Together, these measures would operationalize SDG 15.a by reducing land abandonment, strengthening wetland resilience, and promoting sustainable land management in Bang Kachao.

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AUTHOR CONTRIBUTIONS

Conceptualization, Phatworaruthai J, Teeravarunyou S; Methodology, Teeravarunyou S; Software, Kitirojpan P; Validation, Yao S; Formal Analysis, Torabi F; Investigation, Teeravarunyou S; Resources, Phatworaruthai J; Data Curation, Kitirojpan P; Writing-Original Draft Preparation, Teeravarunyou S; Writing-Review and Editing, Teeravarunyou S; Visualization, Yao S; Supervision, Pattanachan P; Project Administration, Kamolwit K; Funding Acquisition, Teeravarunyou S.

DECLARATION OF CONFLICT OF INTEREST

The authors have no conflict of interest to declare.

REFERENCES

- Agisoft LLC. Agisoft Metashape Professional, version 2.0 [Internet]. 2022 [cited 2025 Nov 11]. Available from: <https://www.agisoft.com/>.
- Albut S. Land use land change utilizing the QGIS MOLUSCE plugin. In: Gundogu S, editor. Mimarlıkta İleri Araştırmalar. Ankara, Turkey: YAZ Yayınları; 2024. p. 172-88.
- Alfonso-Bécares D, Giampietro M, Corbera E, Serrano-Tovar T. Advancing the understanding of forest conservation dynamics through livelihood and landscape change scenarios: A case study in Chiapas, Mexico. *Environment Development and Sustainability* 2024;26(12):29957-79.
- Apriani RN, Inayati I. Alternative policy on progressive tax rate on Idle Land in the Special Capital Territory of Jakarta. *Public Administration Journal* 2020;10(2):127-37.
- BIOFIN. The impacts of harmful subsidies on biodiversity and ecosystems in Thailand [Internet]. 2024 [cited 2025 Nov 11]. Available from: <https://www.biofin.org/knowledge-product/impacts-harmful-subsidies-biodiversity-and-ecosystems-thailand>.
- Bol TT, Randhir TO. Predicting land use and land cover changes in the Chindwin River Watershed of Myanmar using multilayer perceptron-artificial neural networks. *Land* 2024;13(8):Article No. 1160.
- Department of Marine and Coastal Resources (DMCR). Thailand's mangrove forests to be land-tax exempt [Internet]. 2024 [cited 2025 Nov 11]. Available from: <https://www.bangkokpost.com/thailand/general/2924855/thai-lands-mangrove-forests-to-be-land-tax-exempt>.
- Esri. ArcGIS Desktop: ArcMap, version 10.8 [Internet]. 2020 [cited 2025 Nov 11]. Available from: <https://desktop.arcgis.com/>.
- Jing H, Liu Y, Hou J. Impacts of agricultural intensification on biodiversity: habitat loss, agrochemical use, water depletion, and soil degradation. *Journal of Environmental Management* 2025;395:Article No. 128036.
- Kalkuhl M, Fernandez Milan B, Schwerhoff G, Jakob M, Hahnen M, Creutzig F. Fiscal Instruments for Sustainable Development: The Case of Land Taxes. Berlin, Germany: Mercator Research Institute on Global Commons and Climate Change (MCC); 2017.
- Khan N, Raza M, Shakoor MSA, Biswas F, Rahaman M. Dynamic of population growth and its effect on land use/land cover of bahraich district in Uttar Pradesh. *Journal of Environmental Studies and Sciences* 2023;13(1):124-40.
- Kögel M, Feile L, Möldner F, Carstensen D. SSegRef2Surf—Near Real-time photogrammetric flood monitoring and refinement of classified water surfaces. *Remote Sensing* 2025;17(8): Article No. 1351.
- Liu S, Li X, Chen D, Duan Y, Ji H, Zhang L, et al. Understanding land use/land cover dynamics and impacts of human activities in the Mekong Delta over the last 40 years. *Global Ecology and Conservation* 2020;22:e00991.
- Torres AL, Olivera MV, Almeida Del Savio A, Bambarén GG. Effect of Climatological factors on the horizontal accuracy of photogrammetric products obtained with UAV. *Sensors* 2024;24(22):Article No. 7236.
- Mukul SA, Saha N. Conservation benefits of tropical multifunctional land-uses in and around a forest protected area of Bangladesh. *Land* 2017;6(1):Article No. 2.
- Nanakorn P. Land and Buildings Tax Act, B.E 2562 (2019). Bangkok, Thailand: Office of the Council of State; 2019.
- NextGIS. MOLUSCE: Modules for Land Use Change Evaluation [Internet]. 2019 [cited 2025 Nov 11]. Available from: <https://plugins.qgis.org/plugins/molusce/>.
- Orina JA, Tontisirin N, Anantsuksomsri S. Reviews on the land use and land cover changes in Bangkok. *International Journal of Building, Urban, Interior and Landscape Technology* 2024;22(2):Article No. 252537.
- Pokavanich T, Guo X. Saltwater intrusion in Chao Phraya Estuary: A long, narrow and meandering partially mixed estuary influenced by water regulation and abstraction. *Journal of Hydrology: Regional Studies* 2024;52:Article No. 101686.
- Raven PH, Wagner DL. Agricultural intensification and climate change are rapidly decreasing insect biodiversity. *Proceedings of the National Academy of Sciences of the United States of America* 2021;118(2):e2002548117.
- Saksornchai J. Govt moves to protect Bangkok's famed "green lung" [Internet]. 2019 [cited 2025 Nov 11]. Available from: <https://www.khaosodenglish.com/news/bangkok/2019/03/28/govt-moves-to-protect-bangkoks-famed-green-lung/>.
- Taylor L, Hochuli DF. Defining greenspace: Multiple uses across multiple disciplines. *Landscape and Urban Planning* 2017;158:25-38.
- Tripathi RN, Ramachandran A, Tripathi V, Badola R, Hussain SA. Optimizing riparian habitat conservation: A spatial approach

- using aerial and space technologies. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing* 2024;17:16932-43.
- Yotapakdee T, Asanok L, Kamyao T, Norsangsri M, Karnasuta N, Navakam S, et al. Benefits and value of big trees in urban area: A study in Bang Kachao Green Space, Thailand. *Environment and Natural Resources Journal* 2018;17(1):33-43.
- Zhang S, Barrett HA, Baros SV, Neville PRH, Talasila S, Sinclair LL. Georeferencing accuracy assessment of historical aerial photos using a custom-built online georeferencing tool. *ISPRS International Journal of Geo-Information* 2022;11(12):Article No. 582.
- Zhao R, Luo X, Yang Y, Syahid LN, Chen C, Lee JSH. Cropland expansion drives vegetation greenness decline in Southeast Asia. *Biogeosciences* 2024;21(23):5393-406.