Best Practice

Evaluating Satellite Land Cover Accuracy in a Suburban Environment Using Citizen Science: New Hyde Park, NY

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Abstract: Accurate land cover classification is essential for environmental monitoring, urban planning, and climate research; however, suburban landscapes remain difficult to characterize due to heterogeneous land cover. This case study evaluates the agreement between satellite-derived land cover tools and ground-based citizen science observations in New Hyde Park, New York. Using the Adopt-a-Pixel 3 km methodology, thirty-seven primary sampling units were established within a standardized area of interest. Field observations were collected using National Aeronautics and Space Administration (NASA)'s Global Learning and Observations to Benefit the Environment (GLOBE) Observer application and supplemented with high-resolution reference classifications generated through Collect Earth Online. These datasets were compared with satellite observation, specifically from European Space Agency (ESA) WorldCover, Dynamic World, ESRI Land Cover, Landsat time-series, and Meta/WRI Global Canopy Height datasets. Results indicate frequent over-generalization of developed land cover and underrepresentation of tree canopy, with the strongest agreement observed where surface water is present. Qualitative field documentation and community accounts revealed that storm damage, aging trees, and housing management practices contributed to long-term greenery loss, helping to explain some discrepancies between ground and satellite observations. Findings demonstrate that integrating citizen science, community knowledge, and reference data will continue to improve land cover assessment in suburban regions and support more inclusive and reliable environmental monitoring.

Keywords: citizen science, land cover comparison, suburban geography, remote sensing, participatory science

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1. Introduction

Satellite-derived land cover products are widely used to study environmental change, ecosystem health, and urban expansion. However, their accuracy is often constrained in suburban regions where residential development, tree canopy, and small green spaces are interwoven. Moderate-resolution imagery frequently generalizes these heterogeneous landscapes into dominant classes, particularly in areas containing a mix of developed and vegetated land cover types or where shadows are present.

Ground-based validation is therefore essential to assess and improve the reliability of these datasets. Citizen science provides a scalable mechanism for collecting such validation data by enabling public participation in environmental monitoring. National Aeronautics and Space Administration (NASA)'s Global Learning and Observations to Benefit the Environment (GLOBE) Observer program supports this effort by allowing participants to document land cover conditions using a mobile application. GLOBE is one of the world's most used citizen science platforms, and its use in increasing the availability and reliability of environmental data is used by scientists all over the world.

While citizen science expands spatial coverage, data quality is impacted by social, technical, and environmental constraints. This study presents a focused case analysis of New Hyde Park, New York, to evaluate satellite land cover accuracy in a suburban context and to examine how community characteristics and participant experience shape citizen-generated environmental data. We hypothesize that land cover may be overgeneralized and inaccurate at the granularity of satellite data accessible.

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2. Study Area and Methods

2.1. Study Area: New Hyde Park, New York and the Surrounding Region

New Hyde Park, formerly called Hyde Park, is located in Nassau County within the New York City metropolitan region. One of the earliest settlements in the United States, with Dutch settlers arriving in the 1620s and English settlers in the 1640s, the land was first used as a racecourse and later became farmland. The arrival of the Long Island Railroad in 1837 and later trolley and bus lines transformed the area into a commuter hub, spurring waves of immigration from German, Irish, Polish, Italian, and Jewish communities (Nowakowski, n.d.). The region underwent rapid suburbanization during the mid-twentieth century, resulting in dense residential development interspersed with mature street trees, private backyards, and small municipal parks. This pattern resulted in uneven tree cover, with mature canopy concentrated along residential streets and private properties and limited vegetation in commercial and high traffic corridors.

The region has experienced environmental disturbances, including major storms such as Superstorm Sandy in 2012, which contributed to canopy loss and infrastructure damage. Ongoing redevelopment and aging tree removal have further altered land cover patterns, presenting challenges for satellite-based classification. The 3 km × 3 km area of interest (AOI) encompasses portions of New Hyde Park, North New Hyde Park, Manhasset Hills, and Garden City Park.

2.2. Data Sources

This study employed a mixed-methods approach combining citizen science observations, manually assigned classifications, remotely sensed satellite data, and qualitative field documentation to evaluate land cover patterns in New Hyde Park.

2.2.1. Citizen Science Data

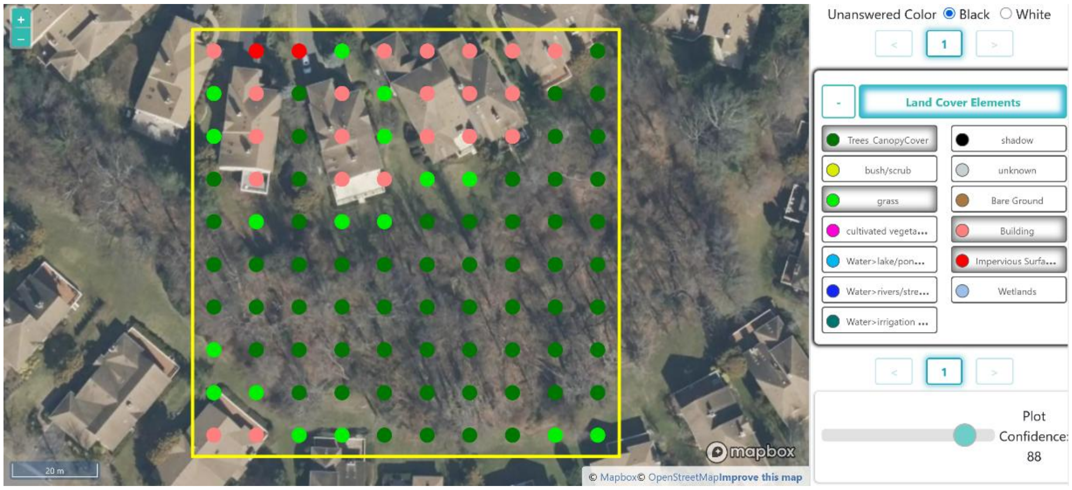
Ground-based observations were collected using NASA's GLOBE Observer mobile application. At each primary sampling unit (PSU), geotagged photographs were captured in six directions (north, south, east, west, upward, and downward) to document local land cover conditions. These images provided visual context for dominant surface types, vegetation structure, and built features. Associated metadata, including geographic coordinates and timestamps, were used to align field observations with satellite datasets using ArcGIS (ESRI, 2020).

Due to residential access restrictions and positional inaccuracies in geolocation data, some observations fell outside designated PSU boundaries and were excluded from quantitative analysis. Figures 1(a-c), below, show sample images of GLOBE observations in the New Hyde Park AOI.

Figure 1. Images taken by researcher, recorded in GLOBE Observer database/visualization tool.

2.2.2. Manually Assigned Classifications

Collect Earth Online (CEO) was used to generate reference classifications. Each 100 m x100 m PSU was subdivided into a 10 x 10 grid containing 100 evenly distributed points. Land cover at each point was manually classified using high-resolution satellite imagery. This process produced over 3,700 reference observations for the AOI, serving a benchmark for evaluating sorted satellite maps. The user interface to CEO is shown in Figure 2.


Unanswered Color ● Black ○ White

Plot Confidence: 88

Figure 2. Collect Earth Online classification user interface.

2.2.3. Satellite Data

Multiple satellite-based land cover products were analyzed to capture differences in spatial resolution, classification methodology, and temporal coverage:

- European Space Agency (ESA) WorldCover (10m, 2020/2021) (Zanaga et al., 2021)
- Dynamic World (10m) (Brown et al., 2022)
- ESRI Land Cover (2017/2024)
- Meta/ World Resources Institute(WRI) Global Canopy Height (1m)
- Landsat time-series imagery (1984–2025)

Satellite datasets were accessed through EarthMap, Google Earth Engine, and ArcGIS Online platforms. Image comparisons were conducted to align satellite classifications with PSU boundaries. To enable comparison across datasets with differing classification schemes, land cover categories were aggregated into broader functional classes, including developed surfaces, vegetation, and water. This aggregation was necessary because satellite products such as Dynamic World, ESRI, and WorldCover use differing classifications relative to each other and CEO, while Meta/WRI solely focuses on tree canopy height and presence. The analysis therefore focuses on general agreement patterns.

2.2.4. Qualitative Field Documentation and Community Accounts

In addition to quantitative datasets, qualitative documentation was collected by participant observation and Community Chronicles developed during the research process. These materials recorded resident perspectives on vegetation change, storm impacts, and household response in the long-term.

Community accounts included estimates that "20–25%" of neighborhood canopy had been lost since the 1990s due to storm damage, aging trees, and redevelopment. Longitudinal field observations based on author documentation recorded the repeated trimming and removal of mature trees at residential properties following Superstorm Sandy and subsequent severe thunderstorms, including major canopy reduction within the AOI in 2013 and 2020, as shown in Figure 3(a-c).

Figure 3. Images of a fallen tree resulting from a 2020 thunderstorm (Image credit to Nandita Khaneja).

2.3. Methods

The Adopt-a-Pixel 3 km methodology was applied following Low et al. (2021). In this approach, researchers define a standardized AOI measuring 3 km by 3 km. Each AOI is divided into a 6 by 6 grid, creating 36 coordinate points evenly spaced 500 m apart. At each point, a 100 m by 100 m square, called a PSU, is centered. The 37th square, known as the centroid, is added at the exact center of the AOI, bringing the total number of sampling units to 37.

Once applied, the Adopt a Pixel 3 km methodology clearly delineates a study area and enables methodical, repeatable observations across defined spatial units. Its structured yet accessible format makes it well-suited for both researchers and citizen scientists. In addition to the ease of comparison between in-person observed data and remotely sensed data that the methodology offers, the proximity of sampling units facilitates local participation, expanding public accessibility and participation in environmental monitoring while fostering broader engagement in Earth sciences.

To analyze the level of agreement between reference and remotely sensed data in the context of each AOI, results from each data collection method are placed side by side in a comprehensive table. The table is organized so that moving from top to bottom, each column represents all of the collected data from one specific source or data set, and moving from right to left, each row contains all of the collected data from one specific sampling unit. This table was included as part of a larger poster on the topic of the same research. The poster also included additional representations of collected data, including the full AOI mapped onto each of the satellite data sets, as well as a side-by-side series of image chips pulled from the Landsat time-series data. To demonstrate the process behind evaluating the extent to which remotely sensed data and reference data agree with one another, data is pulled from rows, or primary sampling units, where the reference data and remotely sensed data agreed, partially agreed, and completely disagreed.

3. Results

3.1. Data Agreement Patterns

Comparison tables and imagery revealed limited full agreement among datasets for most PSUs. The only PSU (1 out of 37) exhibiting consistent agreement across all data sources corresponded to a local pond, which was accurately classified as surface water. Partial agreement occurred in the majority of PSUs (33 out of 37), in residential areas containing mixed impervious surfaces and vegetation. Disagreement occurred in few PSUs (3 out of 37), most commonly along tree-lined streets and backyard spaces where satellite products frequently classified areas as fully developed.

Meta/WRI canopy height data most consistently detected tree cover. ESA WorldCover demonstrated moderate agreement with reference data, while Dynamic World and ESRI products frequently over-generalized built surfaces. For example, in Figure 4, with data excerpted from Table 1, CEO and GLOBE data in PSU #15 shows the presence of tree canopy and developed land (road). Meta/WRI and WorldCover account for this heterogeneity, while Dynamic World and ESRI classify the area as fully developed, as shown by the solid red highlight. PSUs (#14, #15, and #24) also shows the Agreement, Partial Agreement, and Disagreement examples, respectively.

Table 1. Summary of estimated data agreement patterns across all listed PSUs investigated in the New Hyde Park AOI.

Data Source	Agreement	Disagreement
Meta/WRI	27	10
WorldCover	19	18
Dynamic World	2	35
ESRI	1	36
Total	**49**	**99**

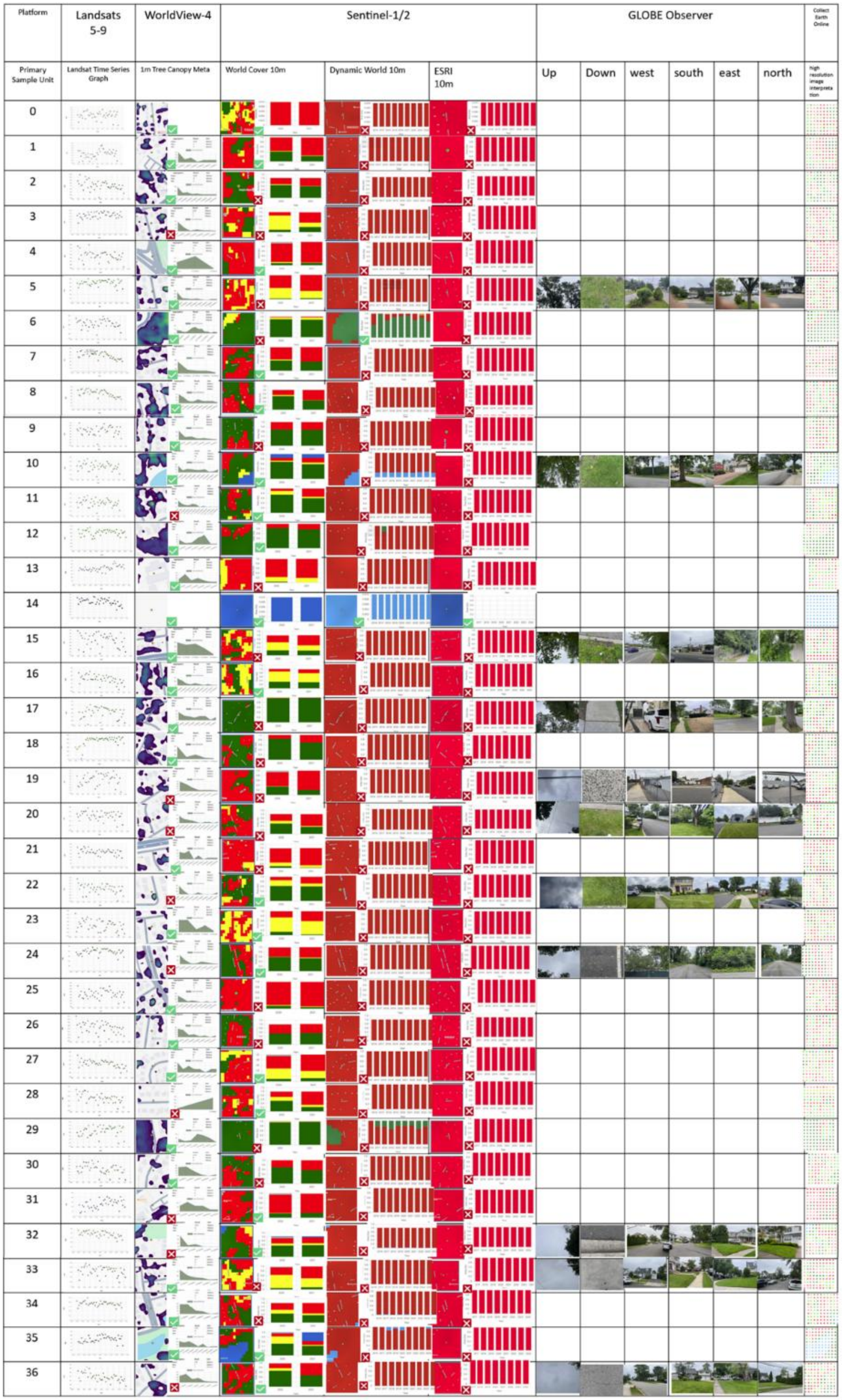


Figure 4. Adopt-a-Pixel comparison table.

Confusion matrices (Table 2) illustrate classification agreement patterns for WorldCover, Dynamic World, and ESRI, showing that vegetated areas are frequently misclassified as developed surfaces in Dynamic World and ESRI datasets. This analysis is based on the dominant land cover type in each PSU, and comparison is performed to a CEO dataset.

Table 2. Confusion matrices for the WorldCover, Dynamic World, and ESRI (Predicted) relative to CEO and GLOBE (Reference).

(a) WorldCover (Reference \ Predicted)	Developed	Vegetation	Water
Developed	12	6	0
Vegetation	5	12	0
Water	0	0	2

(b) Dynamic World (Reference \ Predicted)	Developed	Vegetation	Water
Developed	21	0	0
Vegetation	14	1	0
Water	0	0	1

(c) ESRI (Reference \ Predicted)	Developed	Vegetation	Water
Developed	21	0	0
Vegetation	15	0	0
Water	0	0	1

3.2. Effects of Data Collection Constraints

Due to GPS misalignment and access limitations in residential areas, several GLOBE observations fell outside designated PSU boundaries and were excluded from quantitative comparison. Participant concerns regarding private property and neighborhood interactions further restricted data collection in some locations. These constraints reduced the number of usable ground observations and contributed to gaps in validation coverage.

3.3. Temporal Trends

Landsat time-series analysis indicated gradual decreases in canopy cover over time, consistent with aging tree removal, storm impacts, and redevelopment. These trends aligned with local observations reported by community members and municipal records.

4. Discussion

4.1. Suburban Classification Challenges and Limitations

Results demonstrate that suburban landscapes pose persistent challenges for moderate-resolution satellite classification. Fragmented canopy, narrow vegetation corridors, and small private green spaces are systematically underrepresented in most products. Mixed pixels and spectral confusion contribute to these inaccuracies. Spectral confusion refers to the inability of satellite sensors to distinguish between land cover types with similar reflectance signatures.

Higher-resolution datasets, particularly WorldCover and Meta/WRI, performed better in capturing fine-scale features, though discrepancies remained.

A key limitation of this study is the use of aggregated land cover categories for cross-dataset comparison. Differences in classification systems across satellite products required grouping into broader functional classes, which may obscure finer distinctions between land cover types. As a result, agreement metrics should be interpreted as indicative of general classification trends rather than precise accuracy measurements. Due to differences in classification schemes, the confusion matrix reflects agreement at the aggregated category level rather than original dataset classifications.

4.2. Community Context and Citizen Sciences

Community history, land-use patterns, and participant experience played central roles in shaping both land cover structure and data collection practices in New Hyde Park. Postwar suburban development produced dense residential neighborhoods characterized by narrow vegetation corridors, mature street trees, and privately managed backyard canopy. This landscape configuration complicates satellite-based classification and limits public access for field validation.

Participant observations and community engagement revealed that private property boundaries, resident concerns, and social interactions influenced where and how GLOBE observations could be collected. These constraints resulted in uneven spatial coverage and reduced sample density in some PSUs. Rather than representing methodological weaknesses, these limitations reflect the realities of conducting environmental research in lived residential environments. Community Chronicles provided additional insight into long-term vegetation change. Resident estimates indicating approximately 25% canopy loss were consistent with Landsat-derived trends and CEO reference data. The lead author's longitudinal observations of storm-related tree trimming and removal following Hurricane Sandy further illustrated how household-level safety decisions contribute to cumulative canopy decline.

These household and community-level management practices are rarely captured in remote sensing products but represent important mechanisms driving land cover change. While satellite imagery documents net vegetation loss, qualitative data explain how extreme weather events, infrastructure vulnerability, and homeowner responses shape observed patterns.

4.3. Implications for Platform Design: Development Toward EarthLens

Findings revealed recurring technical and operational barriers that limited the scientific utility of citizen-generated data, including image compression, inconsistent metadata retention, and restricted visualization workflows.

In response, the EarthLens platform is being developed as a research-oriented extension of existing citizen science frameworks. EarthLens integrates low-altitude drone imagery, high-resolution ground photography, and satellite data within a unified analytical environment. The system incorporates visible and near-infrared cameras, compact spectrometers, and precision geotagging hardware to preserve spatial and spectral fidelity.

EarthLens supports automated land cover classification through machine-learning models trained on validated reference datasets. Native visualization tools enable multi-scale comparison between drone, satellite, and ground-based data. By grounding system design in empirical findings and participant feedback, EarthLens represents a research-informed approach to improving citizen science infrastructure.

5. Conclusions

This case study demonstrates that structured citizen science observations, when combined with the Adopt-a-Pixel methodology, provide valuable validation for satellite land cover products in suburban environments. In New Hyde Park, satellite datasets frequently over-generalize developed land cover and underestimate fragmented tree canopy. Community history, land-use patterns, and participant access constraints significantly influenced data quality and interpretation. These contextual factors are essential for understanding discrepancies between ground and satellite observations.

Limitations identified in the GLOBE Observer platform highlight the need for improved tools that support high-resolution, analysis-ready citizen-generated data. The development of EarthLens illustrates how mixed-methods research can inform the design of next-generation observation platforms grounded in community experience and empirical validation.

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Data Availability Statement: Data are available in Zenodo (doi:10.5281/zenodo.18702869). Maps throughout this study were created using ArcGIS® software by Esri. ArcGIS® and ArcMap™ are the intellectual property of Esri and are used herein under license. Copyright © Esri. All rights reserved. For more information about Esri® software, please visit https://www.esri.com. All GLOBE images were sourced from the GLOBE Date Visualization System, but generated by the researchers. This dataset is produced for the Dynamic World Project by Google in partnership with National Geographic Society and the World Resources Institute.

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