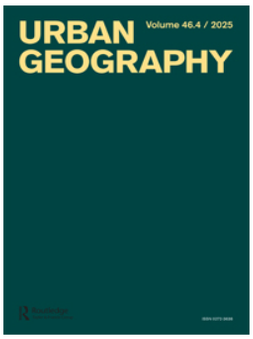

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Object-based change detection (OBCD): a case study for measuring retail led regeneration

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ABSTRACT

The Canadian retail landscape experienced a defining shift in the 1990s with the emergence of "big box" retailers and the proliferation of power centers nationwide. Within this context, the Ontario Stockyards neighborhood in Toronto, Canada, has undergone a remarkable transformation over the past three decades. It has evolved from a predominantly meat-packing industrial hub into a versatile urban environment featuring a mix of retail and residential spaces. This research seeks to elucidate the dynamics of commercial/industrial and residential area changes within this evolving landscape. The study spans a 23-year period, during which the distribution of land use categories undergoes notable fluctuations. This study sheds light on the intricate relationship between retail-driven urban regeneration, commercial/industrial transformations, and residential development. This paper uses the Stockyards neighborhood as a case study, to demonstrate the practical application of Object-Based Change Detection (OBCD) in real-world contexts. Through this case study, the potential and effectiveness of OBCD as a valuable tool for analyzing complex urban development is presented. The findings underscore the significance of integrated urban development strategies that leverage the transformative potential of retail-led initiatives.

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KEYWORDS
Power center; big-box retail; Object-Based Change Detection (OBCD); Toronto Stockyards; urban development

Introduction

Economic prosperity has long been identified as a key principle to sustainable development (Bansal, 2005). This component of sustainability covers the creation and distribution of goods and services, as they are essential elements in evaluating and contributing to increases in standards of living. Many economic development plans and growth management policies worldwide have placed significant emphasis on the importance of building complete communities (Ontario Ministry of Municipal Affairs, 2017; Lu et al., 2015). Many of these plans focus on density and intensification, the

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creation of urban growth centers, and strategic employment areas, in an effort to combat urban sprawl. Greenfield retail development, like low density housing development (sprawl), can burden communities and environments by effecting infrastructure, traffic congestion, and destroying important ecosystems (Greenberg et al., 2001). As a result, many planning initiatives attempt to cluster people and commercial activity by redeveloping deprived and underappreciated urban markets (Fuller, 2012). This study aims to investigate the multifaceted impacts of retail-led development, specifically the development of shopping centers, on urban environments. Despite the recognized influence of retail establishments on urban landscapes, there is a need for a comprehensive understanding of how these developments interact with and affect urban growth and transformation over time. This encompasses examining the economic, social, and architectural changes brought about by such developments, as well as assessing the transformation in land use and land cover patterns that accompany the evolution of urban areas.

Many urban planning approaches are using Integrated Urban Development (IUD) methods to create smart building solutions. These approaches often look to use spatially compact urban growth (i.e. Smart Cities), in an effort to achieve higher densities within urban markets. Canadian cities are looking at urban growth models, focusing on creating compact urban areas with a diverse combination of land-uses (Daniel, 2021). Urban planners often turn to retail-led urban regeneration as an approach to smart city development (Grimaldi et al., 2019). Using retail-led regeneration has been an important area of urban and retail-related research (Cummins et al., 2008; Emery, 2006; Lowe, 2005; Mitchell & Kirkup, 2003; Slach et al., 2020) as it has shaped many urban landscapes in North America. Retail development creates new markets, playing a vital role in the regeneration of deprived areas (Lowe, 2005). This research area has received significant attention due to the essential economic role that retail plays in creating new employment, as well as necessary access to goods and services for local communities (Guimarães, 2017; Mihaescu & Rudholm, 2020; Nappi-Choulet, 2006; Rao & Summers, 2016; Robertson & Fennell, 2007).

Integrating walkability into retail-led regeneration projects presents a holistic approach to urban redevelopment that prioritizes pedestrian-friendly environments alongside economic revitalization. Walkability, the degree to which an area supports walking as a primary mode of transport, is an essential component of sustainable urban design. It fosters environments where people can easily walk to shops, services, work, and leisure activities, thereby contributing to vibrant, active communities (Koschinsky et al., 2017). Incorporating walkability criteria into urban development plans can foster more sustainable, healthy, and economically vibrant cities (Pivo, 2014). It does so by reducing dependence on automobiles, lowering greenhouse gas emissions, and promoting physical activity among residents (Sulaiman & Tenney, 2023). Moreover, walkable urban spaces are likely to augment retail-led urban regeneration efforts by increasing foot traffic to businesses, thereby stimulating local economies. This synergy between walkability and retail development can catalyze the regeneration of deprived areas, further emphasizing the essential economic role of retail in providing employment and access to goods and services for local communities (Guimarães, 2017; Mihaescu & Rudholm, 2020; Nappi-Choulet, 2006; Rao & Summers, 2016; Robertson & Fennell, 2007).

The Ontario Stockyards (previously Union Stockyards) neighborhood in the City of Toronto (Figure 1) has undergone a transformative period. Over the last three decades, the Stockyards area has transitioned from a predominantly industrial (i.e. meat-packing) to a multipurpose retail and residential environment. The Ontario Stockyards is located in the Junction neighborhood, at the corner of Keele Street and St. Clair Avenue. The area was initially known for the buying and selling of cattle, hogs and horses, which reinforced Toronto's "Hogtown" label (Old Time Trains, 2021). These Hogtown businesses acted as a catalyst for the emergence of meat-packing companies to the area that would buy, butcher and package the meat for distribution, predominately throughout Ontario. This contributed to a large source of employment within the area but acted as a deterrent for residential development, mainly due to the unpleasant odor emitted by the meat packing facilities (Old Time Trains, 2021). The Canadian Pacific Railway Company controlled the rail lines that serviced the area making the distribution of products relatively seamless (Old Time Trains, 2021). In the early 1990s, the stockyards area went through a significant redevelopment, resulting in the closure of almost all the meat packing facilities and replacing them with large format retail development. The retail development began in the southwest corner of Keele Street and St. Clair Avenue with the opening of Home Depot and Canadian Tire stores. In 2014, a large-scale shopping center was developed on the northwest corner of St. Clair Avenue and Weston Road, known as the Stock Yards Village. This shopping center is

Figure 1. Location of the Ontario Stockyards neighborhood (indicated by red square).

anchored by Nations Fresh Food (grocery retailer), SportChek (sporting goods), Winners (fashion), Homesense (home fashion) and a Michaels store (hobby store).

This once undervalued industrial neighborhood has now transitioned into a mixed-use area that has experienced significant commercial, transportation and housing development. It is known that retail development can act as a catalyst for community development (González & Waley, 2013; Padilla & Eastlick, 2009; Wilson & Hodges, 2022), however little is known about the details around how community change takes place. Therefore, through a case study of the Ontario Stockyards, this paper aims to identify the process and timeline of community revitalization through retail-led redevelopment using Object-Based Change Detection (OBCD). This approach utilizes image segmentation and classification techniques to group pixels into meaningful objects, allowing for a more comprehensive assessment of land use transformations over time (Chen et al., 2012). OBCD is known to enhance the accuracy and efficiency of land use change detection by considering not only individual pixels but also the contextual information and spatial relationships between them, ultimately providing valuable insights into evolving land use patterns (De Wit & Forsythe, 2023). With OBCD never really being applied to measure the effects of retail development, this paper highlights its benefits and identifies its potential to measure changes in other areas that have seen significant redevelopment. This paper addresses the following interconnected research objectives: (i) To contextualize the relationship between retail (specifically shopping center development) and urban development over time, (ii) To identify the categories of change (economic, social, and architectural) associated with retail-led development, and (iii) To evaluate and determine changes in land use/land cover over time.

This article is organized into four distinct sections, each contributing to a comprehensive understanding of the research. The first section provides the research context delving into several key aspects, including the discussion of retail development policy, and the importance of retail-led regeneration. The second section focuses on the methodology and provides an overview of the case study. It elucidates the methods used for data collection and outlines the chosen methodology, offering insights into how the research was conducted. The third section presents the results derived from the application of Object-Based Change Detection, illustrating the empirical findings. In the final section, the paper engages in a comprehensive discussion, draws conclusions based on the presented findings, and outlines the study's limitations. This section also suggests potential directions for future research in this academic field.

Research context

Planning policy

The importance of urban planning authorities in both urban regeneration and commercial development has long been recognized as critical. Success in both development types depends on the support of planners who create and implement the policy instruments that enable development, often under the policy guidance given by elected officials. Although planners do not directly develop shopping centers or urban regeneration projects themselves, they use the policy instruments at their disposal to create favorable conditions for those that do, often directing development towards the locations or areas that

urban planners deem desirable. Urban regeneration projects, such as retail-led developments, that are proposed close to existing residential neighborhoods often experience resistance from nearby residents who may oppose changes in the nature and structure of their neighborhoods. The need to consider neighborhood impacts means that the urban planning process for urban regeneration is more complicated and requires the use of additional planning policy instruments. Since both urban regeneration and commercial developments are notoriously difficult to implement in existing urban areas, projects that combine the two into retail-led urban regeneration projects have a greater magnitude in terms of neighborhood impacts and, therefore, require more integrated and creative use of policy instruments as well as political support from higher levels of government.

While the initial phase of automobile-based commercial development in the 1950s was primarily reactive to the existing spatial distribution of population in North American cities, most of the subsequent shopping center development that took place during the 1960s, 1970s, and 1980s, happened either in tandem with the expansion of suburban residential areas or was developed in advance on greenfield sites. Most commercial development from the 1990s to the mid-2000s was power center-oriented and focused on highway interchanges, either on former industrial or greenfield sites, that were at large enough distances from residential development that they were not typically seen as threats to the character or functioning of existing residential neighborhoods and faced little resistance from this perspective (Hernandez, 2003; Hernandez & Simmons, 2006). From the mid-2000s onwards commercial development focused on mixed-use style properties that combine elements such as residential, office, commercial, or other uses, typically involving much higher density than developments in previous decades (Rai et al., 2022; Zhong & Hui, 2021). Urban planners have guided these mixed-use developments to under utilized locations within existing urban areas under a combination of compact city, smart growth, and transit-oriented development philosophies that seek to limit urban sprawl, increase the efficiency of existing city infrastructure, and promote transit-oriented lifestyles respectively. By reorienting city development away from continued outward expansion and directing it back towards the existing built-up areas, this approach to urban planning, by its very definition, introduces urban regeneration style development and commercial uses towards existing residential areas. Resistance to such projects comes from multiple directions as residential occupants living in those neighborhoods or nearby are understandably concerned about effects on their existing way of life, while property developers understand these concerns and may prefer to develop in greenfield areas where development processes are magnitudes simpler (Atkinson, 2004; Newton, 2010).

Historically, the most potent instruments for regulating commercial development in greenfield areas have been a fusion of zoning regulations and long-range municipal plans (Adeniyi et al., 2020; Erkip & Ozuduru, 2015). Zoning regulations govern permissible land uses, height limits, density parameters, and property setbacks, while municipal plans harness population growth projections and traffic flow analyses to envision optimal locations for commercial development. These zoning tools are subsequently tailored to align with these predictions. In urban regeneration cases, more creativity is needed on the planners part due to the urban complexities of developing in pre-existing urban areas. Planners can encourage private investment in urban regeneration projects using various tools and incentives including tax breaks or streamlined planning processes to

make these projects more attractive and profitable for investors. In addition, planners are often able to make improvements to city services that would also increase the attractiveness of a given site, with improved community services and public transit improvements being the most common. In some cases, planning authorities actively advocate the feasibility and potential profitability of developing in urban regeneration areas partnering with public-private development agencies. Planners also play a critical intermediary role in facilitating public engagement between developers and the affected communities. Planners enable developers to understand their needs and aspirations and to incorporate these concerns into their designs in such a way as to reduce NIMBYISM, thereby developing greater trust between developers and local communities (Bouzguenda et al., 2019; Eduful, 2021; Zhuang, 2021).

Retail-led urban regeneration is often fraught with community pushback (Wyly, 2022). Most urban communities resist retail-led development due to local effects on property values, increased traffic and noise pollution, parking pressures, competition for small business, and environmental concerns around air and water quality (Hallsworth & Johnson, 2001). Almost no amount of public consultation is satisfactory to ease these NIMBY concerns, which are often quite valid, and developers are often incredibly wary of taking on such projects as a result, no matter what incentives might be offered by planners. In addition, since planners are beholden to elected public officials who are also beholden to the citizens that elect them, this makes such a concentration of community issues doubly important and would lead most planners and those holding public office to avoid such retail led urban regeneration projects altogether. The result is that such projects require additional intervention sometimes from the highest levels of city hall in large metropolitan areas, and sometimes from higher state or provincial levels (Instone & Roberts, 2006; Kim & Jang, 2017).

In the Toronto region, such intervention began in 2005 with the creation of the *Places to Grow Act* by the provincial government (Places to Grow Act, 2005), which gave the province the power to create regional growth plans that would override the plans made by individual municipalities within the regions covered. *Under Places to Grow*, municipalities are still required to create detailed growth plans, but the plans need to conform to regional growth plans created by the provincial government. Considering that planning for the growth of population and employment-related infrastructure was traditionally under municipal jurisdiction, this was a major change in how the two levels of government interacted and shared power and responsibility. The Ontario provincial election in 2003 was a landslide victory for the Liberal Party that was in -part won on a promise to find solutions to urban sprawl. The Liberal Party's commanding defeat of the Conservative Party paved the way for the passing of the The Places to Grow Act in 2005 and the associated Greater Golden Horseshoe Area (GGHA) Growth Plan – a regional growth plan covering municipalities around the Southern portion of Lake Ontario that extended as far as municipalities in Waterloo, Barrie, and Peterborough. In combination with the Greenbelt Plan also developed in 2005, the GGHA Growth Plan aimed to slow growth in the suburban municipalities at the urban fringe of the Toronto region and direct more growth to already built-up areas inside the greenbelt. The central focus of the plan was the establishment of 25 growth centers, primarily located in downtown areas of cities across the region, where many restrictions on construction height and density were to be significantly increased. At the center of the

GGHA Growth Plan region was the City of Toronto, which had four growth centers implemented within the municipal borders along with increased density and intensification targets for built-up areas outside of growth centers as well. In addition to increased densities within the existing built-up areas, the GGHA Growth Plan also required municipalities to support the development of mixed-use and transit-oriented urban environments in their municipal plans.

One place where the Toronto municipal plan aligns most noticeably with the GGHA Growth plan is in the City of Toronto Avenues policy, a framework found in the City's Official Municipal Plan that aims to create higher density growth within the city through urban regeneration by constructing mid-rise development along major transit corridors that are referred to as the "Avenues". The Avenues policy, adopted in 2006, aims to enhance the efficiency of transit-oriented development within the city and advocates for mixed-use development spaces. It actively promotes pedestrian-friendly design to improve the public realm. Additionally, it plays a pivotal role in accommodating the anticipated population density increases as outlined in the growth plan. It achieves this by strategically directing a substantial portion of the population growth to the transit corridors situated within the City's established urban areas, but outside of the designated growth centers. Although it is a city-level policy, the creation and implementation of the Avenues policy reflects the broader regional goals and purpose of the GGHA Growth Plan. Figure 2 shows the spatial distribution of the Avenues transit corridors that were identified by the City of Toronto at the time of the Avenues policy creation. St. Clair Avenue can be seen in this map as having an "Avenue" designation in this policy, stretching from Jane Street on the West to just past Bathurst on the East. St. Clair Avenue has been identified by the city as an urban regeneration target for many years which explains a great deal about the investments made to public transit and the permitted development of mid-rise housing and the brownfield/employment lands. The Avenues policy in place along St. Clair Avenue essentially streamlines the development process and provides a great deal of certainty for developers, making this an attractive area for redevelopment.

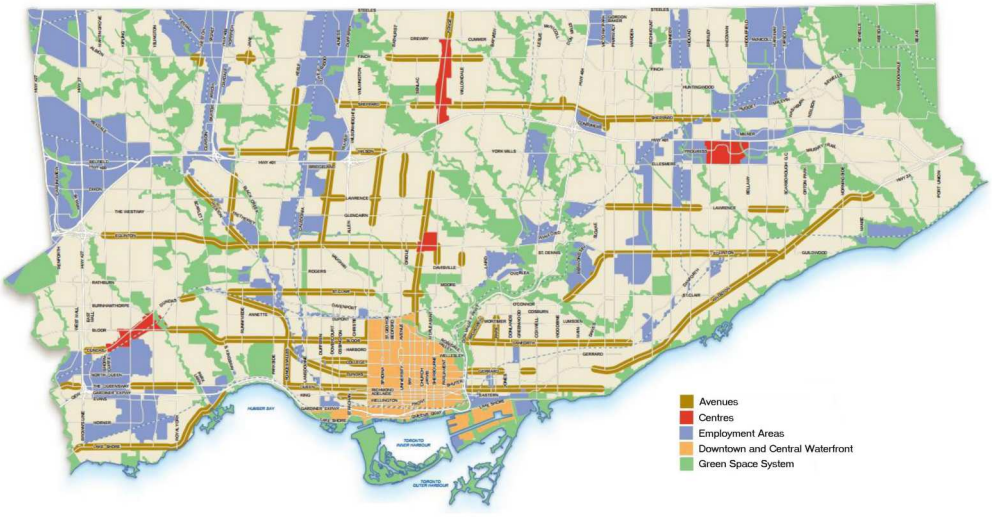

Figure 2. Avenues policy map. Source: City of Toronto (2017).

Shopping center development phases

There have been four distinctive phases of commercial development within Canada: (i) Downtown Department Stores and Commercial Strips (1900 to 1950), (ii) Planned Shopping Centres (1960–1990), (iii) Power Centres (1990–2010), and (iv) Mixed use and E-commerce (2010-present day) (Table 1).

The development of retail spaces in North America showcases a phased evolution between the US and Canada. The US pioneered the modern enclosed shopping mall in 1956, heralding a new retail epoch, with Canada embracing this innovation slightly later in the late 1950s to early 1960s (Rice et al., 2022). This sequence underlines a northward migration of retail innovations, with Canada tailoring the American concept to its unique landscape, reflecting a parallel yet distinctly timed development in retail architecture.

Before World War II, North American retail was characterized by limited consumer mobility and low car ownership, with shoppers frequenting local corner stores and downtown department stores like Eatons and Simpsons for higher-value purchases, due to better public transit access. This era highlighted the department store's role as a key urban retail hub. From 1950 to 1990, the retail landscape underwent significant change, driven by the rise of the automobile, the development of shopping centers, and a move towards suburban retailing. Early shopping centers were small, unenclosed, and car-focused, built to meet local convenience needs after residential areas were established. However, the lack of retail planning controls led to widespread retail sprawl. The 1960s saw shopping centers institutionalized, with specialized fields emerging to address various concerns, including design and marketing. By the 1970s, these centers were not only seen as commercial hubs but also entertainment destinations, incorporating restaurants and theaters. The 1990s marked the entry of big box retailers and the expansion of power centers,

Table 1. Phases of commercial development.

Phase	Approximate Time Period	Transportation and Accessibility	Shopping Characteristics
Downtown Department Stores and Commercial Strips	Early 1900s to late 1950s	• Railway/Street Car/Bus transportation • Linear spatial organization along transit routes	• Locally small family-run stores with a focus on convenience • Downtown department stores – focus on high-order goods
Planned Shopping Centres	1960s to late 1980s	• Automobile and Subway	• Large "Anchor" tenants meant to draw customers to smaller in-line tenants • Smaller centers provided convenience, while larger centers provided comparison shopping • Movement of Downtown department stores out to larger regional shopping centers
Power Centres	1990 to 2010	• Automobile Oriented • Typically located close to highway interchanges	• Clusters of big-box stores around a central parking lot, offeringone-stop shopping • Powerful economies of scale
Mixed Use	2010s – present	• Transit-oriented development	• Integration of E-commerce fulfillment services (pick-up locations) • Return to smaller stores and local shopping • Reliance on convenience shopping

Adopted from Daniel, 2021

defined by multiple large stores sharing a parking lot, a model that emerged to consolidate retail spaces and reduce costs. These centers, often located on greenfield or industrial sites near major highways, were characterized by their lack of interior walkways and focus on value-oriented retail. Since the late 2000s, the focus has shifted towards mixed-use developments, integrating residential, commercial, and recreational spaces to serve local communities better and counteract urban sprawl. This approach, created by the growth of e-commerce, aims to create denser urban environments by offering a mix of services, including e-commerce fulfillment, and less traditional retail, reflecting changes in consumer behavior and the retail industry's adaptation to new challenges.

Retail-led regeneration and the economic contribution of shopping centers

Retail-led regeneration refers to the rejuvenation of land and structures, which often previously served industrial or commercial purposes but have become vacant or underutilized. Since the 1990s, it has emerged as a crucial element of urban planning, especially aimed at revitalizing deprived areas (Fernandes & Chamusca, 2014). This strategy is essential for community revitalization, as it fosters job creation, economic growth, and enhances the area's appeal (Instone & Roberts, 2006). Shopping centers, as a component of retail-led regeneration, play a significant role in boosting the economy at both regional and local levels (Slach et al., 2020). Their impact extends beyond simple economic transactions, leading to benefits such as increased employment (Robertson & Fennell, 2007), community stabilization (Rao & Summers, 2016), support for hospitality and tourism (Mihaescu & Rudholm, 2020; Sullivan et al., 2012), and contributions to construction, housing, infrastructure development (Lee, 2013), and tax revenues (Musil, 2011; Yu et al., 2012). Historically, shopping centers have been pivotal in transforming neighborhoods by attracting residents, employees, visitors, developers, and investors (Howard, 2007; Musil, 2011). The shift towards retail-led regeneration reflects broader municipal trends of transitioning from production-based to consumption-based areas, encompassing commercial and residential uses. City planners aim to enhance an area's image and desirability through consumption-focused development, alongside complementary initiatives in transit and recreation, thereby boosting community attractiveness and vitality (Daniel, 2021). Many research studies have highlighted the community benefits from the existence of shopping centers as they are seen as vehicles for economic stimulation (direct employment, indirect employment and capital investment) (See Table 2) (Cloete, 2020). While the direct employment opportunities presented by the presence of a shopping center are obvious (store staff, security professionals, cleaning personnel, maintenance personnel), there are other substantial employment benefits that are created. The economic multiplier effect created by shopping center sales, the removal of less desirable land uses, community stabilization, construction-related expenditures and increased tax revenues have also been well documented (Cloete, 2020; Musil, 2011).

Shopping centers significantly impact communities and consumers, shaping community vibrancy and sustainability through retail interactions (Bailey, 2020; Musil, 2011; Robertson & Fennell, 2007). They not only foster socio-cultural and economic purposes but also contribute to the cultural identity of the communities they serve. Shopping centers' evolution into mixed-use developments brings diverse public spaces, employment opportunities, educational facilities, entertainment, and commercial offerings.

Table 2. Economic benefits of shopping centers.

Economic Benefits	Description
Direct Employment	Shopping centers create direct employment such as, store staff, security professionals, cleaning personnel, maintenance personnel as well as the jobs during construction of the center (developers, planners, construction workers). These are considered direct employment because without the presence of the center these jobs would not otherwise exist.
Indirect Employment	Shopping centers also create indirect employment through the multiplier effect, which takes place when the employees working at the center spend their wages on goods and services. Also, it creates employment in the transportation field (public transportation, taxis and ride sharing, gas stations).
Capital Investment	Shopping centers also generate private capital investment to areas that previously had little, namely, new buildings as well as significant improvements to the surrounding infrastructure. These investments are continual as centers are frequently updated (refurbishments, expansion, refascias).

Cloete, 2020

This diversification leads to the creation of complete communities, capable of fulfilling all basic needs (Pivo, 2005). Research indicates shopping centers provide personal and societal benefits, such as reducing loneliness and stress (Kim et al., 2005; Rosenbaum et al., 2016), and enhance area livability by improving safety, convenience, and aesthetics. They also offer a broad range of goods and services, addressing local needs. The relationship between retail, particularly shopping center development, and urban development is crucial, as it reveals the ongoing transformations in urban landscapes driven by retail-led change, through changes in land use and patterns over time.

Data and methodology

Data

Aerial orthophotos were obtained from the City of Toronto archives via Land Information Ontario (Land Information Ontario, 2022) and the Scholars GeoPortal (Scholars GeoPortal, 2022). They varied in terms of their date of acquisition, number of tiles and spatial resolution. Table 3 summarizes the datasets that were utilized. For each year of data, mosaic images were created using Catalyst Professional image processing software (PCI Geomatics, 2022). All of the image datasets were clipped to a common area based on the footprint of the two tiles that comprise the 1995 dataset (Figure 3). The footprint was determined visually as being the area where changes had occurred in the vicinity of the Stockyards power center development. The resulting datasets resulted in a database of ~3.9 gigabytes which created some data processing challenges due to the shear volume (size) of the files that were created. Other years of data were available; however, they were not selected for analysis due to issues such as incomplete georeferencing, missing

Table 3. Orthophoto dataset characteristics.

Imagery Acquired	Layers Available	Number of Tiles/Size	Spatial Resolution
September 15, 28, 29, 1995	RGB	2 (82.5 mB)	1 m
Spring, 2002	RGB	9 (677.9 mB)	20 cm
April to May 9, 2011	RGB (NIR)	15 (3.01 gB)	10 cm
March 20 to 26, 2018	RGB (NIR)	15 (198.1 mB)	8 cm

Metadata for the 1995 datasets – https://geohub.lio.gov.on.ca/documents/05abf73ee4c84b8088e953c2a3cbc93f/about
Metadata for the 2002 datasets – https://geohub.lio.gov.on.ca/documents/208a7f9efefa419f9d9b7fdc6bd78176/about
Metadata for the 2011 and 2018 datasets – https://www.toronto.ca/city-government/data-research-maps/maps/purchase-maps-data/orthoimagery-specifications/

Figure 3. The 1995 Orthophoto Mosaic (red oval indicates the approximate location of the Stockyards Power Centre).

data areas and incomplete coverage. The Red, Green and Blue (RGB) bands were analyzed as they were available for the entire (1995-2018) analysis period.

All years were resampled to a common spatial resolution of 0.15 meters.

Four classes were chosen for comparison. These were:

a) Pavement: This includes all areas that are either asphalt or concrete.
b) Rooftops: all roofs made of various materials including asphalt shingles, metal roofing, gravel and tar.
c) Mixed: This includes Soil/Railyards/Barren Land (bare soil and/or excavated land)
d) Vegetation: This includes all areas of grass, trees, and other types of vegetation.

Methods

The traditional approach for image classification involves pixel-based analysis (De Wit, 2022). The advent and implementation of object-based change detection (OBCD) change detection/classification approaches has been a more recent development (Chen et al., 2012; De Wit & Forsythe, 2023; Gao & Mas, 2008; Hossain & Chen, 2019; Hussain et al., 2013; Kutz et al., 2022; Walter, 2004). Singh (1989) identifies the object-based approach

as a process of identifying differences in the state of an object by observing it at different times. Chen et al. (2012) state that object-based methods identify differences in geographic objects at different moments. Hussain et al. (2013) identify three techniques: direct object change detection, classified objects change detection and multitemporal/multidate-object change detection. Direct object change detection refers to comparing objects' boundaries and/or the attribute values within the object's boundary, while classified objects change detection is the practice of classifying objects into classes for from-to comparison. Finally, multitemporal/multidate-object change detection method incorporates stacks of images. When analyzing urban objects, Chen et al. (2012) state that OBCD techniques are appropriate as the urban context is comprised of manmade objects with discrete boundaries. The following analysis falls into the classified objects change detection category. Figure 4 illustrates the three main stages of the analysis through which the changes were detected.

When analyzing urban objects, Chen et al. (2012) state that OBCD techniques are appropriate due to discrete boundaries that can be identified within urban areas. Therefore, classification of each image was performed using the Object Analyst in Catalyst Professional software (PCI Geomatics, 2022). Area extent in each of these classes and changes between classes were determined using the area analysis functionality within ArcGIS Pro (ESRI, 2022). In the following study, features were selected through an experimental approach and the best performing accuracy was selected for the training model, including statistical values of mean Red, Green, Blue, Near Infrared, and NDVI in combination with the geometrical attributes of Elongation and Compactness.

The first stage comprises data preparation, the extent of identification of the Area of Interest, and the division of the Area of Interest into six tiles. In 2011, imagery was captured containing a rich array of channels, including visible and near-infrared wavelengths. This imagery underwent processes of image classification and object identification. The reason for selecting this particular year was the abundance of channels available, allowing for a comprehensive analysis. To address limitations in computational capacity, a strategic approach was adopted. The region of interest was deliberately reduced in size and divided into six equally sized sections. Within this framework, image segmentation and object classification were later carried out in a batch format. Successfully overcoming the issue of computational capacity was outlined in previous research by De Wit and Forsythe (2023). To cover a wide representation of rooftops, pavement, vegetation, and other mixed surfaces, a total of 255 objects were selected for training. A single training model was employed to execute these tasks efficiently. The lower left corner of the study area, referred to as tile four, was identified as the focal point for developing the training model. This choice was motivated by various factors. The chosen area exhibited a diverse range of rooftop surface materials, encompassing structures from industrial, commercial, and residential categories. Additionally, the presence of vegetation and other prototypical objects from the Pavement and Mixed classes further influenced the decision to concentrate efforts here. These classes were chosen as they covered the range of different landuse/landcover in the imagery. In addition, they encompassed the set of features that this study was interested in identifying.

The second stage of the analysis includes the classification of the 2011 imagery set, the application of a batch approach, and post-processing of the results. Object-based segmentation allows for relationships between features to be identified in the detection process. Image segmentation was performed through object-based methods by incorporating a

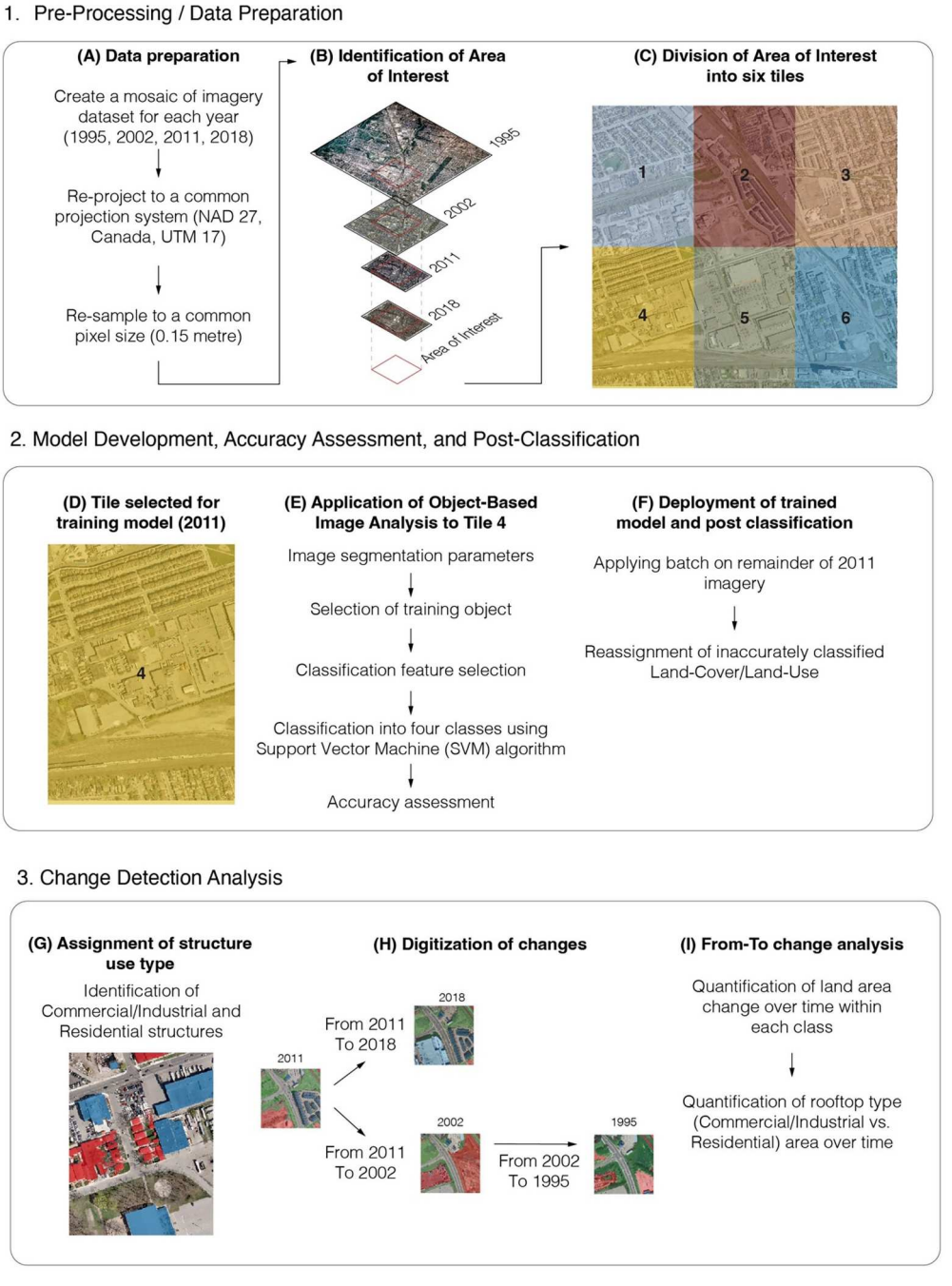

Figure 4. Method workflow.

multiresolution segmentation. A series of exploratory endeavurs in segmentation and classification were conducted, with the goal of achieving optimal results. The most accurate outcomes from these trials were selected to facilitate batch classification for the remaining study area. The final parameters for image segmentation were selected to be a scale of 250, a

shape of 0.1 and a compactness of 0.9. The bands which weighed the image segmentation were Red, Green, Blue, Near Infrared, and a Normalized Difference Vegetation Index (NDVI). The subsequent assessment of accuracy was conducted exclusively for the classification of image objects found within the lower left corner (tile four) of the study area.

The third stage focused on change detection analysis where rooftops were assigned one of two types: Commercial/Industrial or Residential. This was achieved by visual interpretation. Changes to the four classes were subsequently digitized. The generated 2011 imagery results were used as the basis of the digitization of past and future imagery. Lastly, from-to totals of land area use and rooftop type were quantified.

Despite the meticulous procedures, some challenges arose during the classification process. Certain rooftops were incorrectly classified as either Mixed or Pavement classes. Similarly, a number of pavement areas and vehicles were inaccurately identified as rooftops. These errors stemmed from the diverse range of materials and surfaces associated with these objects. For instance, the resemblance between corrugated metal rooftops and vehicles, as well as the presence of gravel on large flat industrial rooftops, contributed to the misclassification. Given these challenges, a post-classification phase was initiated to ensure an accurate representation of the study area. This phase involved corrective measures, such as reassigning misclassified objects to their appropriate classes. In some instances, adjustments were made to the boundaries generated during the image segmentation step. This comprehensive approach aimed to refine the analysis and provide a true depiction of the studied area.

Results

The classification results for 1995, 2002, 2011 and 2018 are presented in Figure 5. The results for each year are highly visual and substantial changes can be identified throughout the analysis period (Tables 4–6).

For interpretation of the changes that occurred (From-To) between the dates of image acquisition, the following categories were utilized:

a. Pavement to Rooftops
b. Pavement to Mixed
c. Pavement to Vegetation
d. Remained Pavement
e. Rooftops to Pavement
f. Rooftops to Mixed
g. Rooftops to Vegetation
h. Remained Rooftops
i. Mixed to Pavement
j. Mixed to Rooftops
k. Mixed to Vegetation
l. Remained Mixed
m. Vegetation to Pavement
n. Vegetation to Rooftops
o. Vegetation to Mixed
p. Remained Vegetation

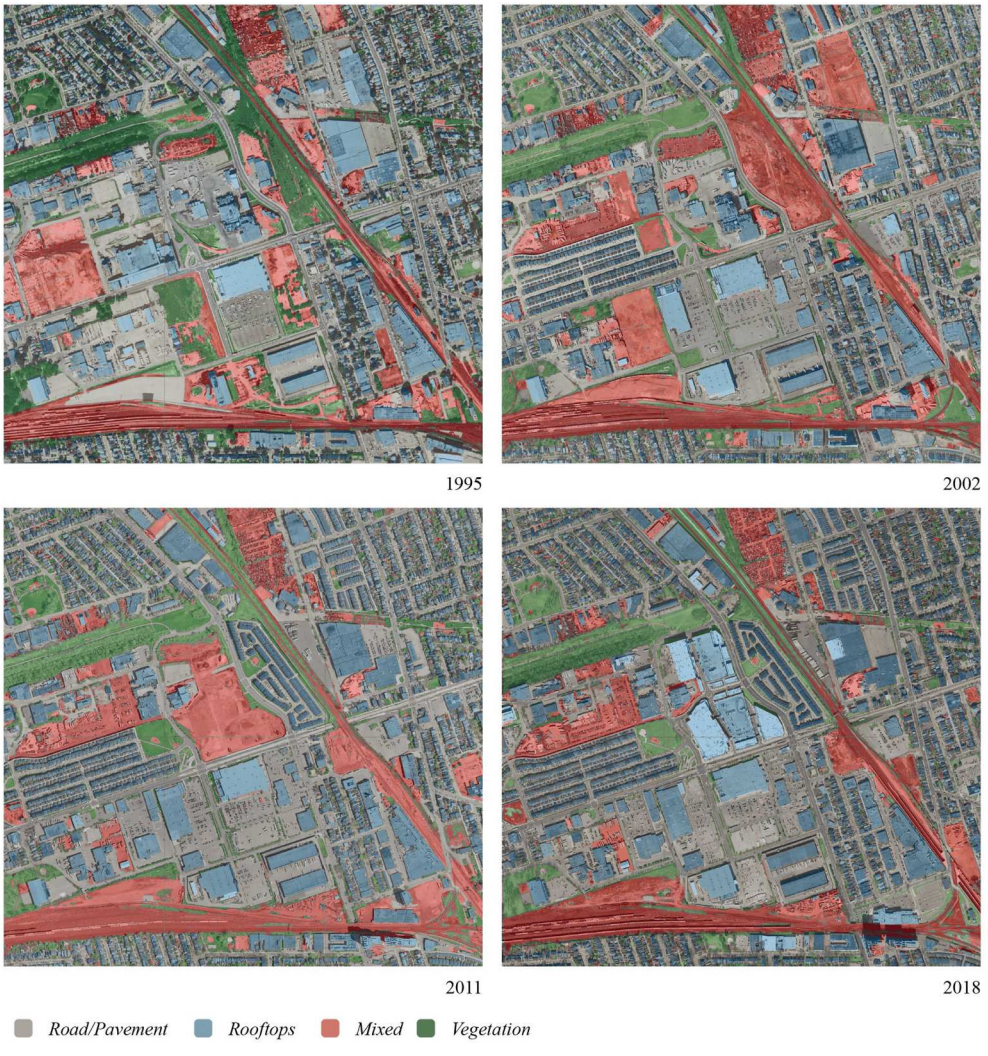

Figure 5. Landuse/Landcover.

Table 4. From 1995 to 2002 change matrix.

		2002							
	Total 1995	Pavement		Rooftops		Mixed		Vegetation	
1995	m^2	m^2	%	m^2	%	m^2	%	m^2	%
Pavement	713,514	$571{,}334_{d}$	80.1_{d}	$12{,}235_{a}$	1.7_{a}	$116{,}235_{b}$	16.3_{b}	$13{,}710_{c}$	1.9_{c}
Rooftops	495,389	$15{,}287_{e}$	3.1_{e}	$444{,}478_{h}$	89.7_{h}	$31{,}365_{f}$	6.3_{f}	$4{,}258_{g}$	0.9_{g}
Mixed	466,508	$57{,}000_{i}$	12.2_{i}	$41{,}523_{j}$	8.9_{j}	$347{,}807_{l}$	74.6_{l}	$20{,}178_{k}$	4.3_{k}
Vegetation	405,142	$31{,}019_{m}$	7.7_{m}	$13{,}930_{n}$	3.4_{n}	$57{,}395_{o}$	14.2_{o}	$302{,}798_{p}$	74.7_{p}
Total 2002	2,080,554	674,640	103	512,165	104	552,803	111	340,945	82

The area changes in each of the categories from 1995 through to 2018 are presented in Tables 4–6. The analysis of land cover transformations in the Ontario Stockyards spanning from 1995 to 2018 reveals significant changes in land use patterns. During the first

Table 5. From 2002 to 2011 change matrix.

		2011							
	Total 2002	Pavement		Rooftops		Mixed		Vegetation	
2002	m^2	m^2	%	m^2	%	m^2	%	m^2	%
Pavement	674,607	$624{,}381_{d}$	92.6_{d}	$7{,}420_{a}$	1.1_{a}	$41{,}404_{b}$	6.1_{b}	$1{,}402_{c}$	0.2_{c}
Rooftops	512,140	$4{,}955_{e}$	1.0_{e}	$478{,}605_{h}$	93.5_{h}	$26{,}838_{f}$	5.2_{f}	$1{,}743_{g}$	0.3_{g}
Mixed	552,785	$62{,}550_{i}$	11.3_{i}	$45{,}036_{j}$	8.1_{j}	$407{,}960_{l}$	73.8_{l}	$37{,}239_{k}$	6.7_{k}
Vegetation	340,946	$5{,}829_{m}$	1.7_{m}	$4{,}589_{n}$	1.3_{n}	$28{,}235_{o}$	8.3_{o}	$302{,}294_{p}$	88.7_{p}
Total 2011	2,080,478	697,715	106.5	535,650	104.0	504,436	93.5	342,677	95.7

Table 6. From 2011 to 2018 change matrix.

		2018							
	Total 2011	Pavement		Rooftops		Mixed		Vegetation	
2011	m^2	m^2	%	m^2	%	m^2	%	m^2	%
Pavement	697,689	$688{,}679_{d}$	98.7_{d}	$3{,}814_{a}$	$0.\ 5_{a}$	$3{,}444_{b}$	0.4_{b}	$1{,}751_{c}$	0.2_{c}
Rooftops	535,622	$2{,}423_{e}$	0.4_{e}	$528{,}192_{h}$	98.6_{h}	$4{,}812_{f}$	0.8_{f}	194_{g}	0.0_{g}
Mixed	504,436	$42{,}623_{i}$	8.4_{i}	$51{,}895_{j}$	10.2_{j}	$398{,}820_{l}$	79.0_{l}	$11{,}096_{k}$	2.1_{k}
Vegetation	342,677	$4{,}697_{m}$	1.3_{m}	$4{,}707_{n}$	1.3_{n}	$5{,}033_{o}$	$1.4\ _{o}$	$328{,}239_{p}$	95.7_{p}
Total 2018	2,080,825	738,424	108.9	588,609	110.8	412,110	81.9	341,281	98.0

phase, from 1995 to 2002, the most substantial transformation observed was the transition from Pavement to Mixed surfaces, accounting for a total area of 116,235 square meters. This change was particularly concentrated in the western and northeastern sections of the study area. The majority of the former Pavement surface served as infrastructure to support Industrial/Commercial land use. The shift from Pavement to Mixed surfaces suggests several potential factors. One likely contributor is the demolition of existing structures to accommodate new commercial and residential development projects. Additionally, it could be indicative of industrial areas that are no longer actively maintained or utilized. In the second phase, from 2002 to 2011, the most significant change involved the reversion from Mixed surfaces back to Pavement, covering an area of 62,550 square meters. This period witnessed the construction of two residential areas and the development of the Stockyards Centre commercial plaza. The latter notably hosts essential services like grocery stores and banking facilities. The shift from Mixed to Pavement may be attributed to the establishment of these new residential zones and the accompanying commercial infrastructure. The final phase, spanning from 2011 to 2018, witnessed the most substantial change from Mixed surfaces to Rooftops, encompassing an area of 51,895 square meters. This transformation is predominantly evident in the newly constructed Stockyards Village commercial center.

A key observation throughout the study period is the decreasing rate of change across the land cover categories. Between 1995 and 2002, a total of 413,990 square meters experienced transformation. This figure decreased to 267,238 square meters during the 2002 to 2011 period and further reduced to 136,895 square meters between 2011 and 2018. This declining rate of change could reflect the maturation and stabilization of land use patterns over time or a reduced need for extensive transformations as the area evolves.

Figure 6 illustrates the changes in Commercial/Industrial and Residential Rooftops over the 1995–2018 analysis period.

Figure 7 illustrates areas of redevelopment and change in Landuse/Landcover (From/To) for each time period (1995–2002, 2002–2011, 2011–2018) and overall for the 1995–2018 analysis period.

One of the goals of this research was to determine commercial/industrial and residential area changes. Table 7 and Figure 8 show the proportion of these categories for each analysis year. The areas of each category fluctuate over the 23-year period. In 1995, commercial/industrial encompasses most of the rooftop total. By 2002, there is a large reduction in this category due to the removal of some meat-packing operations. In 2011, the lowest total is observed, however that increased by 2018. Most of this growth can be attributed to the new power center development replacing the former industrial rooftop footprint.

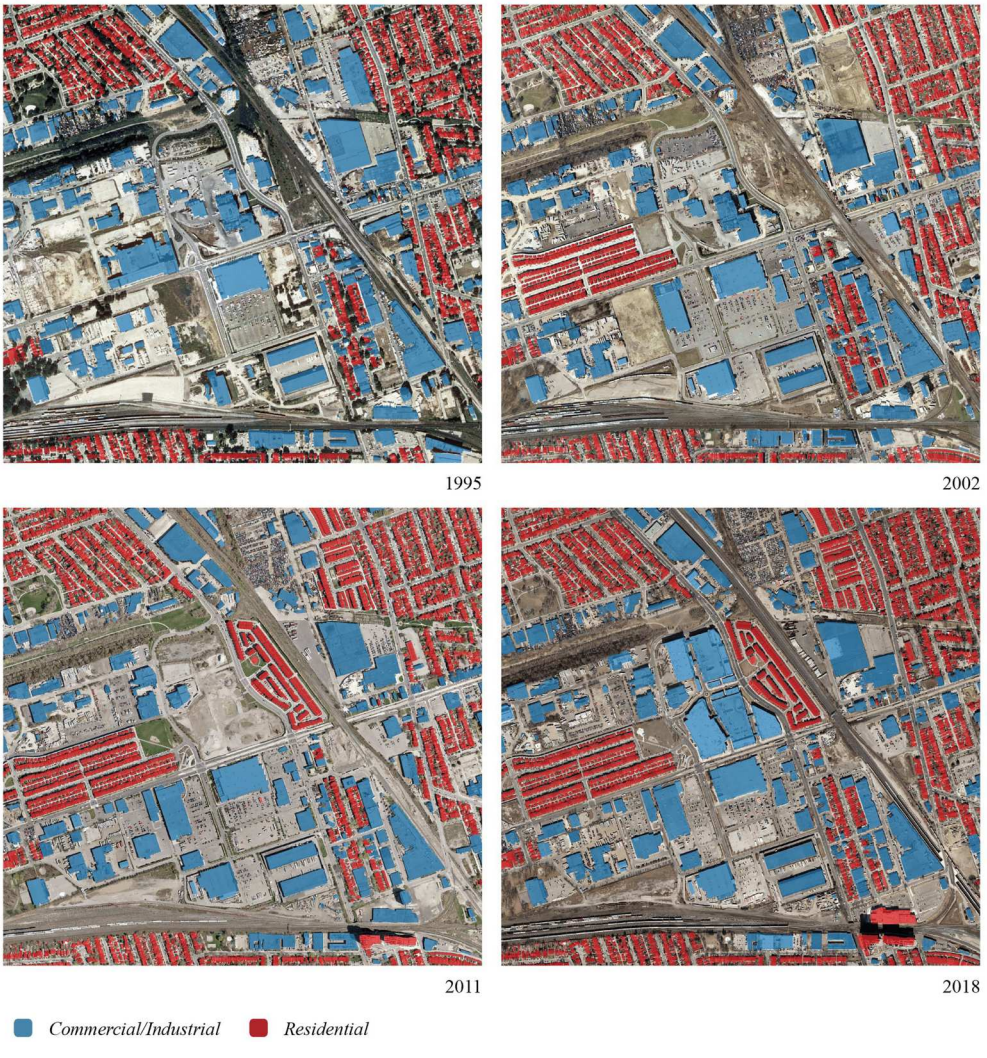

Figure 6. Commercial/Industrial vs. Residential Rooftops.

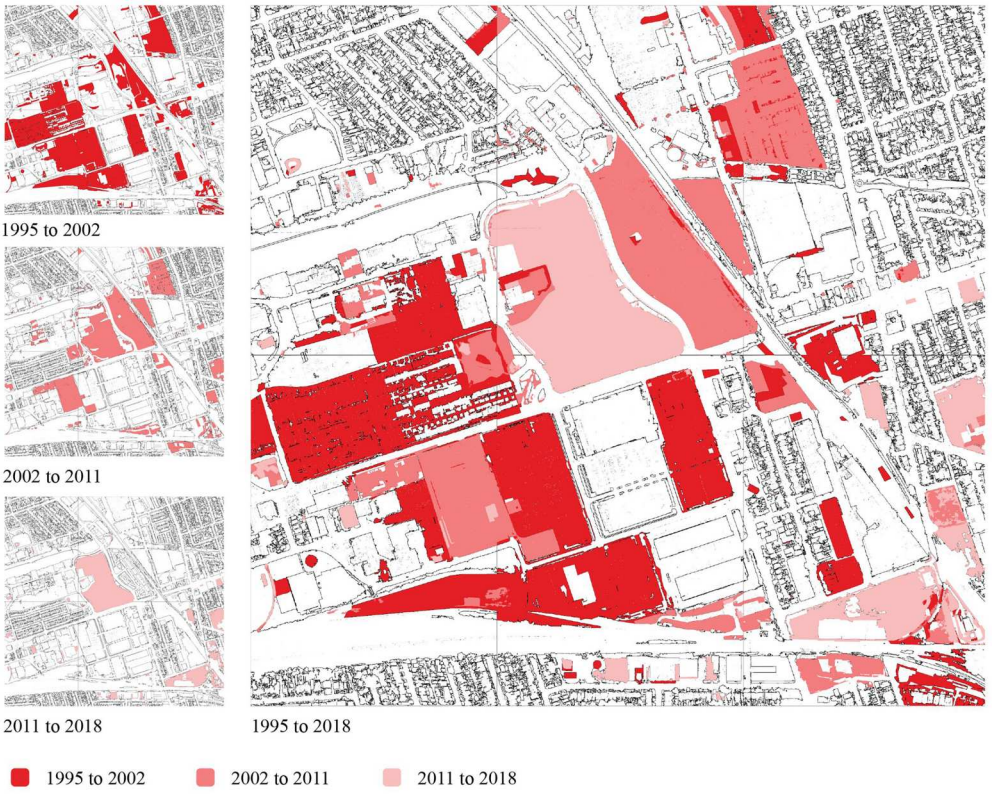

Figure 7. Areas of redevelopment and change.

Table 7. Changes in rooftops (Commercial/Industrial vs. Residential) land use (m^2).

Year	Total *Rooftops*	*Commercial/Industrial* (% of Total *Rooftops*)	*Residential* (% of Total *Rooftops*)
1995	495,389	324,492 (65.5%)	170,502 (34.4%)
2002	512,165	294,066 (57.4%)	217,728 (42.5%)
2011	535,622	278,191 (51.9%)	258,786 (48.3%)
2018	588,609	325,461 (55.3%)	264,534 (44.9%)

Overall, the total rooftop area and residential rooftops display a similar upward trend. Area rejuvenation appears to be concurrent with retail development, spurring on residential growth as amenities that can be tied to the power center are brought online. The power center in essence encourages varied development opportunities.

Accuracy assessment

To assess the accuracy of the results achieved through object classification, 243 objects across various classes were selected. The accuracy assessment was performed on tile four from the 2011 imagery. The statistics are reported in Tables 8 and 9. The overall accuracy achieved by the Support Vector Machine (SVM) algorithm was 84.8%. The Rooftops class of interest had a producer's accuracy of 84.3% and a user's accuracy of 91.5%.

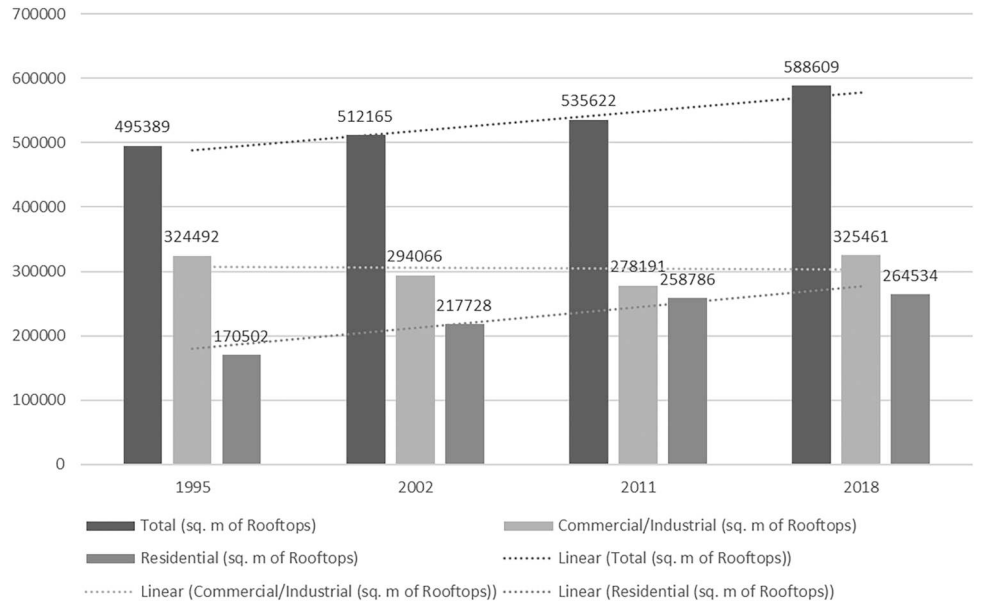

Figure 8. Changes in Rooftop Landuse (Commercial/Industrial vs. Residential) 1995–2018 (m^2).

Table 8. 2011 Accuracy Statistics Report of 243 sampling objects in tile 4.

Class Name	Producer's Accuracy	95% Confidence Interval	User's Accuracy	95% Confidence Interval	Kappa Statistic
Mixed	76.316%	(61.482% 91.149%)	60.417%	(45.540% 75.293%)	0.531
Pavement	81.818%	(70.716% 92.921%)	83.333%	(72.467% 94.199%)	0.785
Vegetation	100%	(98.571% 100%)	100%	(98.571% 100%)	1
Rooftops	84.348%	(77.272% 91.424%)	91.509%	(85.731% 97.288%)	0.839
Overall Accuracy: 84.774%			95% Confidence Interval (80.051% 89.497%)		
Overall Kappa Statistic: 0.780			Overall Kappa Variance: 0.780		

Table 9. 2011 Error (confusion) matrix in tile 4.

	Reference Data				
Classified Data	Mixed	Pavement	Vegetation	Rooftops	Totals
Mixed	29	6	0	13	48
Pavement	4	45	0	5	54
Vegetation	0	0	35	0	35
Rooftops	5	4	0	97	106
Totals	38	55	35	115	243

Discussion and conclusion

In this study, the role of retail-led regeneration policies in urban development using remote sensing technology is examined. The goal was to investigate the effectiveness of such policies in revitalizing urban areas and promoting economic growth. Through the analysis of aerial photography, insights into the spatial patterns and changes in land use were identified, shedding light on the impact of these policies on the overall

urban landscape. The Ontario Stockyards neighborhood in the City of Toronto has witnessed a remarkable transformation over the past three decades. In 1995, the area was predominantly characterized by industrial land use, with a particular focus on the meat packing industry. Historical imagery from this period depicts the stockyards during its heyday. While the presence of meat packing facilities generated employment opportunities the area remained undesirable for both commercial and residential development, ultimately hindering its potential for economic growth. It was not until after 2002, when the majority of the industrial buildings were removed, that the Ontario Stockyards neighborhood began to experience significant changes. Between 1995 and 2002, the largest transformation was from Pavement to Mixed surfaces (totaling 116,235 m^2). Much of the former Pavement surface supported infrastructure for Industrial/Commercial land use. The transition from Pavement to Mixed surfaces is potentially due to the demolition of nearby structures to make way for new commercial and residential development, or industrial areas that are no longer maintained. This redevelopment of the area primarily took the form of retail establishments. Retail growth has been widely recognized as a key driver of economic and social development in both regional and local communities (Cummins et al., 2008; Emery, 2006; Lowe, 2005; Mitchell & Kirkup, 2003; Slach et al., 2020). The introduction of diverse land uses emerged as a pivotal driver in revitalizing the neighborhood, underscoring the effectiveness of retail-led regeneration policies in stimulating both economic growth and urban rejuvenation. By transforming formerly unused or underutilized areas for retail purposes, this strategy not only diversified land usage but also created opportunities for job generation and community development. These findings illustrate the interconnectedness between retail-led regeneration, commercial and industrial transformations, and the expansion of residential areas. However, it is worth noting that the presence of a power center, while initially revitalizing the commercial landscape, prompts a counterargument that it represents a temporary land use strategy. This approach involves acquiring economical former industrial land, extensive land paving, and construction of budget-friendly, low-density structures, thereby enhancing land value over time. The augmented land value, in conjunction with favorable planning policies, makes the construction of mid- and high-rise mixed-use properties economically viable. In most mixed-use scenarios, retail takes a secondary role, with developers primarily profiting from mid/high-rise residential units and subsequently divesting ground-level retail spaces. Nonetheless, the impact of the power center extends beyond commercial revitalization, serving as a catalyst that encourages various other forms of development, including residential expansion. This underscores the multifaceted nature of retail-led regeneration, which not only drives economic growth but also facilitates the adaptive reuse of urban spaces and contributes significantly to the overall revitalization of the neighborhood. The results of this study provide valuable insights into the process and dynamics of retail-led regeneration, particularly in relation to land use changes. Understanding these patterns is crucial for urban planners and policymakers as they seek to promote sustainable and inclusive urban development.

The revitalization of the Stockyards area through retail development has largely coincided with the growth of residential properties. Between 2002 and 2011, the largest change occurred from Mixed surfaces back to Pavement, (62,550 m^2). In that period, two residential areas were constructed as well as the Stockyards Centre commercial plaza, hosting a variety of essential services such as groceries and banking.

As amenities associated with the power center are introduced, it creates an attractive commercial environment which in turn stimulates residential growth. Therefore, it is clear that the development of the power center largely acted as a growth pole, which encouraged other forms of development. The development of both the retail and residential land uses emphasizes the connection of these two aspects of urban revitalization. The presence of retail establishments (e.g. the power center), not only rejuvenates the commercial landscape but also serves as a catalyst for residential growth. This reinforces the notion that the provision of retail amenities and services play a critical role in attracting residents and enhancing the overall desirability of the neighborhood (Guimarães, 2017).

The findings also highlight the significant increase in neighborhood density, which is recognized as a key element of smart building solutions (Daniel, 2021; Grimaldi et al., 2019). Higher-density development can contribute to more efficient land use and promote sustainable urban growth. There are, however, some potential trade-offs associated with increased density that can be seen in the results of this study. In the case of the Ontario Stockyards neighborhood, one notable trade-off is the significant loss of greenspace. This raises concerns about land preservation and the negative impacts on quality of life. With greenspaces (e.g. parks and open areas), providing substantial benefits, including opportunities for recreation, stress relief, and environmental sustainability (Hedblom et al., 2019; Venter et al., 2020). The reduction in greenspace may have implications for the overall livability and environmental sustainability of the neighborhood. This sheds light on the need for a more holistic approach to retail-led regeneration where greenspaces are strongly prioritized within the development plans.

The analysis of commercial/industrial and residential area changes in the Ontario Stockyards area reveals the transformative power of retail-led regeneration. The presence of a power center not only revitalized the commercial landscape but also facilitated residential growth, contributing to the overall rejuvenation of the area. These findings highlight the importance of integrated and strategic approaches to urban development, where retail-led regeneration can serve as a catalyst for broader community transformations.

The economic and social benefits of shopping centers are undeniable, as these entities have consistently drawn consumer interest, serving not only as retail destinations but also as community hubs. However, while they are marketed as centers of community life, it's important to acknowledge that these spaces are tightly managed, privatized environments that commodify social interaction. Such management can lead to the overshadowing of existing local retail, potentially disrupting traditional urban retail ecosystems. Furthermore, the development of shopping centers transcends mere economic revitalization; it signifies profound urban change. While these centers bring about retail-led regeneration, offering economic uplift and social gathering spaces, they also represent a shift towards privatized, managed urban environments. This evolution reflects a significant transformation in urban landscapes, where spaces traditionally accessible and organically integrated into the community fabric become curated experiences.

Future research should explore the social and economic impacts of retail-led regeneration in more depth to inform effective policies and planning strategies that promote sustainable, inclusive, and vibrant urban environments. The findings from the Ontario Stockyards neighborhood can serve as valuable insights for urban planners and

policymakers seeking to revitalize urban areas through retail-led initiatives. Therefore, more case studies and comparative studies are required in to further test the method and to determine the value of the approach to stakeholders involved in development and redevelopment activities. Another key area for future research involves examining how OBCD data correlates with planning policies. This analysis could uncover potential relationships between the development of shopping centers and the socio-economic dynamics of the area, offering insights into the broader impacts of urban planning decisions. Further exploration could address broader capital flows and their impacts, alongside more localized patterns of retail and residential investment. By expanding the scope of data and incorporating a more varied range of sources, the analysis could provide a nuanced understanding of how these factors interact within the urban fabric.

Limitations

This study is one of the first to use remotely sensed data to identify the effect of retail-led regeneration. The techniques used in this study provided valuable information on the proximity of retail establishments to residential areas, transportation networks, and green spaces. These data allowed for the evaluation of land use factors that contribute to social cohesion, community interaction, and sustainable urban development. While remote sensing proved to be a valuable tool in our research, it is important to acknowledge some limitations. One notable limitation of OBCD lies in its ability to only measure surface land area. Urban developments often exhibit a mixed-use pattern, where retail spaces occupy the ground level and residential units, often mid to high-rise, rise above. Therefore, an examination that includes vertical change may be useful. Consequently, a significant challenge in capturing and quantifying change, particularly in urban settings, revolves around the intricacies of documenting this vertical dimension—a limitation that warrants careful consideration in OBCD-based analyses. The temporal resolution of and the availability of high-quality aerial photography constrained our ability to capture real-time changes in retail activities. Future studies could benefit from the integration of real-time data sources, such as crowd-sourced information and mobile sensing technologies, to overcome these limitations and provide a more dynamic assessment of the impact of retail-led regeneration policies.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Data availability statement

Due to the nature of the research, due to [ethical/legal/commercial] supporting data is not available.

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References

Adeniyi, O., Brown, A., & Whysall, P. (2020). Retail location preferences: A comparative analysis. *Journal of Retailing and Consumer Services*, *55*, 102146. https://doi.org/10.1016/j.jretconser.2020.102146

Atkinson, R. (2004). The evidence on the impact of gentrification: New lessons for the urban renaissance? *European Journal of Housing Policy*, *4*(1), 107–131. https://doi.org/10.1080/1461671042000215479

Bailey, M. (2020). Urban disruption, suburbanization and retail innovation: Establishing shopping centres in Australia. *Urban History*, *47*(1), 152–169. https://doi.org/10.1017/S0963926819000178

Bansal, P. (2005). Evolving sustainably: A longitudinal study of corporate sustainable development. *Strategic Management Journal*, *26*(3), 197–218. https://doi.org/10.1002/smj.441

Bouzguenda, I., Alalouch, C., & Fava, N. (2019). Towards smart sustainable cities: A review of the role digital citizen participation could play in advancing social sustainability. *Sustainable Cities and Society*, *50*, 101627. https://doi.org/10.1016/j.scs.2019.101627

Chen, G., Hay, G. J., Carvalho, L. M. T., & Wulder, M. A. (2012). Object-based change detection. *International Journal of Remote Sensing*, *33*(14), 4434–4457. https://doi.org/10.1080/01431161.2011.648285

City of Toronto. (2017). Official Plan Overview. Retrieved September 28, 2023, from https://www.toronto.ca/wp-content/uploads/2017/10/96c4-06-City-Planning-Official-Plan-TLAB-Orientation.pdf.

Cloete, C. E. (2020). Socio-economic impact of shopping centres in Gauteng, South Africa. *The Business & Management Review*, *11*, 51–58.

Cummins, S., Findlay, A., Petticrew, M., & Sparks, L. (2008). Retail-led regeneration and store-switching behaviour. *Journal of Retailing and Consumer Services*, *15*(4), 288–295. https://doi.org/10.1016/j.jretconser.2007.06.002

Daniel, C. (2021). Smart growth impacts on commercial services structure. Unpublished Doctoral Dissertation, PhD in Environmental Applied Science and Management, Toronto Metropolitan University, Toronto, ON, Canada.

De Wit, V. (2022). Geographic object-based image analysis change detection in a Shrinking City: Detroit, Michigan, 2014-2018. Unpublished MSA Thesis, Master of Spatial Analysis Program, Department of Geography and Environmental Studies, Ryerson University, Toronto, ON, Canada.

De Wit, V., & Forsythe, K. W. (2023). Urban structure changes in Three Areas of Detroit, Michigan (2014–2018) utilizing geographic object-based classification. *Land*, *2023*(12), 763. https://doi.org/10.3390/land12040763

Eduful, A. K. (2021). Economic impacts of shopping malls: The Accra (Ghana) case study. *Cities*, *119*, 103371. https://doi.org/10.1016/j.cities.2021.103371

Emery, J. (2006). Bullring: A case study of retail-led urban renewal and its contribution to city centre regeneration. *Journal of Retail & Leisure Property*, *5*, 121–133. https://doi.org/10.1057/palgrave.rlp.5100020

Erkip, F., & Ozuduru, B. H. (2015). Retail development in Turkey: An account after two decades of shopping malls in the urban scene. *Progress in Planning*, *102*, 1–33. https://doi.org/10.1016/j.progress.2014.07.001

ESRI. (2022). ArcGIS Pro software. https://www.esri.com/en-us/arcgis/products/arcgis-pro/.

Fernandes, J. R., & Chamusca, P. (2014). Urban policies, planning and retail resilience. *Cities*, *36*, 170–177. https://doi.org/10.1016/j.cities.2012.11.006

Fuller, C. (2012). Worlds of justification'in the politics and practices of urban regeneration. *Environment and Planning D: Society and Space*, *30*(5), 913–929. https://doi.org/10.1068/d19710

Gao, Y., & Mas, J. F. (2008). A comparison of the performance of pixel-based and object-based classifications over images with various spatial resolutions, *GEOBIA 2008-Pixels, Objects, Intelligence. GEOgraphic Object Based Image Analysis for the 21st Century*, (G.J.Hay, T. Blaschke and D. Marceau, editors). University of Calgary, Alberta, Canada, ISPRS Vol. No.XXXVIII-4/C1. Archives ISSN No.:1682-1777, 373p.

González, S., & Waley, P. (2013). Traditional retail markets: The new gentrification frontier? *Antipode*, *45*(4), 965–983. https://doi.org/10.1111/j.1467-8330.2012.01040.x

Greenberg, M., Lowrie, K., Mayer, H., Miller, K. T., & Solitare, L. (2001). Brownfield redevelopment as a smart growth option in the United States. *Environmentalist*, *21*, 129–143. https://doi.org/10.1023/A:1010684411938

Grimaldi, D., Fernandez, V., & Carrasco, C. (2019). Heuristic for the localization of new shops based on business and social criteria. *Technological Forecasting and Social Change*, *142*, 249–257. https://doi.org/10.1016/j.techfore.2018.07.034

Guimarães, P. P. C. (2017). An evaluation of urban regeneration: The effectiveness of a retail-led project in Lisbon. *Urban Research & Practice*, *10*(3), 350–366. https://doi.org/10.1080/17535069.2016.1224375

Hallsworth, A. G., & Johnson, R. B. (2001). The perceived impact of an off-centre factory outlet mall: The local community dimension. *International Journal of Retail & Distribution Management*, *29*(10), 462–471. https://doi.org/10.1108/09590550110405349

Hedblom, M., Gunnarsson, B., Iravani, B., Knez, I., Schaefer, M., Thorsson, P., & Lundström, J. N. (2019). Reduction of physiological stress by urban green space in a multisensory virtual experiment. *Scientific Reports*, *9*(1), 10113. https://doi.org/10.1038/s41598-019-46099-7

Hernandez, T. (2003). The impact of big box internationalization on a national market: A case study of Home Depot Inc. in Canada. *The International Review of Retail, Distribution and Consumer Research*, *13*(1), 77–98. https://doi.org/10.1080/0959396032000065364

Hernandez, T., & Simmons, J. I. M. (2006). Evolving retail landscapes: Power retail in Canada. *The Canadian Geographer/Le Géographe canadien*, *50*(4), 465–486. https://doi.org/10.1111/j.1541-0064.2006.00158.x

Hossain, M. D., & Chen, D. (2019). Segmentation for Object-Based Image Analysis (OBIA): A review of algorithms and challenges from remote sensing perspective. *ISPRS Journal of Photogrammetry and Remote Sensing*, *150*, 115–134. https://doi.org/10.1016/j.isprsjprs.2019.02.009

Howard, E. (2007). New shopping centres: Is leisure the answer? *International Journal of Retail & Distribution Management*, *35*(8), 661–672. https://doi.org/10.1108/09590550710758649

Hussain, M., Chen, D., Cheng, A., Wei, H., & Stanley, D. (2013). Change detection from remotely sensed images: From pixel-based to object-based approaches. *ISPRS Journal of Photogrammetry and Remote Sensing*, *80*, 91–106. https://doi.org/10.1016/j.isprsjprs.2013.03.006

Instone, P., & Roberts, G. (2006). Progress in retail led regeneration: Implications for decision-makers. *Journal of Retail & Leisure Property*, *5*, 148–161. https://doi.org/10.1057/palgrave.rlp.5100009

Instone, P., & Roberts, G. (2006). Progress in retail led regeneration: Implications for decision-makers. *Journal of Retail and Leisure Property*, *5*, 148–161.

Kim, H. R., & Jang, Y. (2017). Lessons from good and bad practices in retail-led urban regeneration projects in the Republic of Korea. *Cities*, *61*, 36–47. https://doi.org/10.1016/j.cities.2016.11.004

Kim, Y. K., Kang, J., & Kim, M. (2005). The relationships among family and social interaction, loneliness, mall shopping motivation, and mall spending of older consumers. *Psychology & Marketing*, *22*(12), 995–1015. https://doi.org/10.1002/mar.20095

Koschinsky, J., Talen, E., Alfonzo, M., & Lee, S. (2017). How walkable is Walker's paradise? *Environment and Planning B: Urban Analytics and City Science*, *44*(2), 343–363. https://doi.org/10.1177/0265813515625641

Kutz, K., Cook, Z., & Linderman, M. (2022). Object based classification of a riparian environment using ultra-high resolution imagery, hierarchical landcover structures, and image texture. *Scientific Reports*, *12*, 11291. https://doi.org/10.1038/s41598-022-14757-y

Land Information Ontario. (2022). Retrieved October 15, 2022, from https://www.arcgis.com/home/item.html?id=05abf73ee4c84b8088e953c2a3cbc93f.

Lee, J. K. (2013). Mega-retail-led regeneration and housing price. *disP-The Planning Review*, *49*(2), 75–85. https://doi.org/10.1080/02513625.2013.827510

Lowe, M. (2005). Revitalizing inner city retail? The impact of the West Quay development on Southampton. *International Journal of Retail & Distribution Management*, *33*(9), 658–668. https://doi.org/10.1108/09590550510611850

Lu, Y., Nakicenovic, N., Visbeck, M., & Stevance, A. S. (2015). Policy: Five priorities for the UN sustainable development goals. *Nature*, *520*(7548), 432–433. https://doi.org/10.1038/520432a

Mihaescu, O., & Rudholm, N. (2020). How does big-box retail entry affect incumbents in the hospitality industry: Evidence from a natural experiment. *Review of Regional Studies*, *50*(2), 207–229. https://doi.org/10.52324/001c.12933

Mitchell, A., & Kirkup, M. (2003). Retail development and urban regeneration: A case study of Castle Vale. *International Journal of Retail & Distribution Management*, *31*(9), 451–458. https://doi.org/10.1108/09590550310491414

Musil, T. A. (2011). Evaluating development and community benefits of shopping malls: A case study using input/output analysis. *Journal of Financial Management of Property and Construction*, *16*(2), 111–125. https://doi.org/10.1108/13664381111153105

Nappi-Choulet, I. (2006). The role and behaviour of commercial property investors and developers in French urban regeneration: The experience of the Paris region. *Urban Studies*, *43*(9), 1511–1535. https://doi.org/10.1080/00420980600831692

Newton, P. W. (2010). Beyond greenfield and brownfield: The challenge of regenerating Australia's greyfield suburbs. *Built Environment*, *36*(1), 81–104. https://doi.org/10.2148/benv.36.1.81

Old Time Trains. (2021). Retrieved September 28, 2023, from www.trainweb.org/oldtimetrains/stockyards/stock.htm.

Ontario Ministry of Municipal Affairs. (2017). *Growth plan for the Greater Golden Horseshoe area, 2017*. Government of Ontario. https://files.ontario.ca/appendix_-_growth_plan_2017_-_oc-10242017.pdf

Padilla, C., & Eastlick, M. A. (2009). Exploring urban retailing and CBD revitalization strategies. *International Journal of Retail & Distribution Management*, *37*(1), 7–23. https://doi.org/10.1108/09590550910927135

PCI Geomatics. (2022). Catalyst Professional software. https://catalyst.earth/.

Pivo, G. (2005). Is there a future for socially responsible property investments? *Real Estate Issues-American Society of Real Estate Counselors*, *30*, 16.

Pivo, G. (2014). Unequal access to energy efficiency in US multifamily rental housing: Opportunities to improve. *Building Research and Information*, *42*(5), 551–573.

Rai, H. B., Kang, S., Sakai, T., Tejada, C., Yuan, Q. J., Conway, A., & Dablanc, L. (2022). Proximity logistics': Characterizing the development of logistics facilities in dense, mixed-use urban areas around the world. *Transportation Research Part A: Policy and Practice*, *166*, 41–61. https://doi.org/10.1016/j.tra.2022.10.007

Rao, F., & Summers, R. J. (2016). Planning for retail resilience: Comparing Edmonton and Portland. *Cities*, *58*, 97–106. https://doi.org/10.1016/j.cities.2016.05.002

Rice, M., Sorenson, M., & Aversa, J. (2022). The geography of lifestyle center growth: The emergence of a retail cluster format in the United States. *Journal of Retailing and Consumer Services*, *65*, 102835. https://doi.org/10.1016/j.jretconser.2021.102835

Robertson, J., & Fennell, J. (2007). The economic effects of regional shopping centres. *Journal of Retail & Leisure Property*, *6*, 149–170. https://doi.org/10.1057/palgrave.rlp.5100057

Rosenbaum, M. S., Otalora, M. L., & Ramírez, G. C. (2016). The restorative potential of shopping malls. *Journal of Retailing and Consumer Services*, *31*, 157–165. https://doi.org/10.1016/j.jretconser.2016.02.011

Scholars GeoPortal. (2022). Retrieved October 15, 2022, from https://geo2.scholarsportal.info/.

Singh, A. (1989). Digital change detection techniques using remotely-sensed data. *International Journal of Remote Sensing*, *10*(6), 989–1003. https://doi.org/10.1080/01431168908903939

Slach, O., Nováček, A., Bosák, V., & Krtička, L. (2020). Mega-retail-led regeneration in the shrinking city: Panacea or placebo? *Cities*, *104*, 102799. https://doi.org/10.1016/j.cities.2020.102799

Sulaiman, A., & Tenney, M. (2023). *Search of 20-Minute Neighborhoods: Toronto's Pedestrian Network using Walkability to Nearest Amenities. ScienceOpen Preprints*. ScienceOpen Preprints..

Sullivan, P., Bonn, M. A., Bhardwaj, V., & DuPont, A. (2012). Mexican national cross-border shopping: Exploration of retail tourism. *Journal of Retailing and Consumer Services*, *19*(6), 596–604. https://doi.org/10.1016/j.jretconser.2012.07.005

Venter, Z. S., Barton, D. N., Gundersen, V., Figari, H., & Nowell, M. (2020). Urban nature in a time of crisis: Recreational use of green space increases during the COVID-19 outbreak in Oslo, Norway. *Environmental Research Letters*, *15*(10), 104075. https://doi.org/10.1088/1748-9326/abb396

Walter, V. (2004). Object-based classification of remote sensing data for change detection. *ISPRS Journal of Photogrammetry and Remote Sensing*, *58*, 225–238. https://doi.org/10.1016/j.isprsjprs.2003.09.007

Wilson, J. L., & Hodges, N. J. (2022). What does it mean to "shop local"? Examining the experiences of shoppers and store owners within the framework of downtown revitalization. *Journal of Retailing and Consumer Services*, *65*, 102890. https://doi.org/10.1016/j.jretconser.2021.102890

Wyly, E. (2022). Yimby: The latest frontier of gentrification. *International Journal of Urban and Regional Research*, *46*(2), 319–330. https://doi.org/10.1111/1468-2427.13067

Yu, T. H., Cho, S. H., & Kim, S. G. (2012). Assessing the residential property tax revenue impact of a shopping center. *The Journal of Real Estate Finance and Economics*, *45*(3), 604–621. https://doi.org/10.1007/s11146-010-9292-x

Zhong, J., & Hui, E. C. (2021). Real option and vertical mixed-use development. *International Journal of Strategic Property Management*, *25*(5), 382–395. https://doi.org/10.3846/ijspm.2021.15059

Zhuang, Z. C. (2021). The negotiation of space and rights: Suburban planning with diversity. *Urban Planning*, *6*(2), 113–126. https://doi.org/10.17645/up.v6i2.3790ik