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Real Estate Values and Ecosystem Services: Correlation Levels

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Abstract. The market value of urban property depends not only on its specific characteristics, but also on reference macro-economic variables such as socio-demographic, productive, infrastructural, and environmental quality and associated ecosystem services. The links between urban property real estate values and ecosystem services, particularly those generated by urban forests, are not yet sufficiently investigated and hence are the focus of this research.

The study site is the City of Syracuse, New York, USA, with well characterized urban forest ecosystem services and property values. The study correlated real estate values and parameters of economic condition (per-capita income), ecosystem services (carbon sequestration), and urban forestry system (tree canopy area). The median home value correlation with both per capita income had an $R^2 = 0.8748$ and with carbon sequestration it had an $R^2 = 0.7757$. The data was obtained in the online i-Tree Landscape tool. Geographic information systems analysis was used to create maps that support analysis of the correlation levels between the involved variables.

Keywords: Real estate value · Ecosystem services · Correlation analysis

1 Introduction and Work Aim

The housing market values depend on both intrinsic and extrinsic variables. The intrinsic variables relate to specific characteristics of the property unit. The extrinsic variables relate to the territory in which the building resides, and include: grey infrastructure quality (quality of roads, buildings, squares), green infrastructure quality (public parks and gardens), social and demographic context, public transport, proximity to the central business district (CBD), landscape views, historical significance of the area, and pollution level (air, water, soil) that affect the real estate value [1–3].

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Research studies have found a correlation between Median Home Value (MVH) and extrinsic variables, per capita income of the inhabitants, and population density [4, 5]. Other studies show the link between MVH-distance of the property, both on urban parks and water bodies (lakes, rivers) [6–9] and on mobility services [10–12]. Few examples describe the connection with MVH and factors including the urban heat island, the distribution of greenery, building density and geometry, and air quality [13].

It is known that natural elements, such as aggregated trees in urban forests, generate on average a net $2.25 benefit for each $1 invested due to their provision of valuable ecosystem services [14, 15]. According to the classification provided by the Millennium Ecosystem Assessment (MEA) on ecosystem services, the benefits produced by urban forests are of environmental (e.g. carbon sequestration), economic (e.g. property increase value) and social (e.g. well-being citizens improvement) type [16]. A study of the world's megacities showed these urban forest ecosystem services could deliver benefits exceeding $500 million per year [17]. In several studies, the existence of a function between tree canopy cover, ecosystem services and neighbourhood socio-economic characteristics is discussed. In someone, correlation analysis to identify the existing logical-functional dependence is implemented [18–27].

The aim of this work is to investigate the correlation between median home value and per capita income, tree canopy cover, and ecosystem services. Among the ecosystem services the carbon sequestration, which measures the environmental quality of a territory due to existing trees, is considered.

2 Materials and Methods

2.1 Study Area

The analysis focuses on the urban area of City of Syracuse in New York State, USA. The City of Syracuse serves as the major city for many surrounding rural communities in 4 counties (Cayuga, Madison, Onondaga and Oswego), and together this area of 7,892 km^2 is the Syracuse Metropolitan Statistical Area (MSA). The City of Syracuse has an area of 66 km^2 and a population of about 145,000. The U.S. Census Bureau uses 133 Census Blocks within Syracuse to track economic and social data, each block on average is 0.5 km^2.

Average household income in Syracuse was $32,704 in 2016 [28]. The City of Syracuse area covered by tree canopy was 33.34% [29]. Nowak and O'Connor (2001), determined the City of Syracuse contains about 890,000 trees, and the largest tree species present are: sugar maple (14.2% of the total tree population), arborvitae (9.8%), European buckthorn (6.8%), boxelder (6.3%) and Norway maple (6.1%).

Ecosystem services from this forest in 2017 included a net annual carbon uptake of 3,870 tonnes [29]. The corresponding monetary value was $3,000 million for storage and $71,500 per year for the CO2 sequestration from the atmosphere. In addition to carbon removal, the existing tree population eliminates about 169 tonnes of other pollutants (PM25, NOx) per year for an equivalent of $850,000 [29].

2.2 Data Collection and Map Representations

In order to investigate the correlations between Median Home Value and factors indicative of the socio-economic and environmental features of the territory, the data set is constructed with the values of the variables considered: Median Home Value, Per capita Income, Canopy Cover, Carbon Sequestration. The data refer to the Census Blocks falling within the administrative boundaries of the City of Syracuse. The values of the variables are collected using *i-Tree Landscape* Tool that gives information on tree cover, land use and basic demographic characteristics of the census areas in United States of America [30]. Canopy Cover data are taken directly from 2011 National Land Cover Data (NLCD), while U.S. Per capita Income and Median Home Value from U.S. Census Bureau data. An excerpt from the dataset referring to the city of Syracuse is in Table 1.

A thematic map representative of the corresponding numerical values is constructed for each variable (Fig. 1 and Fig. 2). This is done through Geographical Information Systems (GIS). The realization of such thematic maps allows a first comparison among values, useful to highlight the correlation levels.

From the two maps in Fig. 1, it is clearly a marked association between the Median Home Value and Per capita Income variables, especially in the Census Areas near the University. Moreover, it is also possible to notice a low, almost absent, functional link including the two variables in the Census Blocks arranged along the administrative boundaries of the city.

On the basis of Fig. 2, it is then visible the strong correspondence with regard to the values of the Tree Cover and those of the Carbon Sequestration. This highlights the expected functional connection of Tree Cover with environmental benefits.

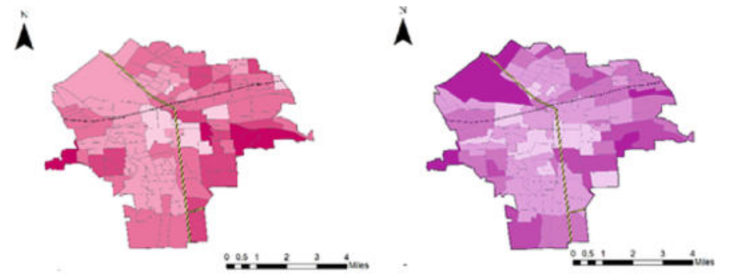
The comparison of the cartographies of Fig. 1 with those in Fig. 2, i.e. the comparison between the socio-economic variables (Median Home Value and Per Capita Income) and the environmental-forestry factors of the urban territory synthetically represented by Canopy Cover and Carbon Sequestration, is more complicated. This analysis is conducted according to the statistical approach of the variables linear correlation. The methodology implemented is described in Sect. 2.3, and the related numeric and graphic elaborations are in Sect. 3.

2.3 Data Processing Method for Variables Correlation Analysis

The functional link between variables is expressed mainly by using two statistical methods: the linear regression method and the correlation one. Linear regression method tries to determine the best linear relationship of the variables, while correlation method assesses their association. In both, groups of two or more variables can be considered. In the case of only two elements, the monotonic analysis based on the construction of a linear, crescent or descending, function including the parameters is implemented. When, on the other hand, the number is greater than two, multivariate analysis is used. In this case, the dependence of variables is estimated as a function depending on the simultaneous change of two or more random factors [31].

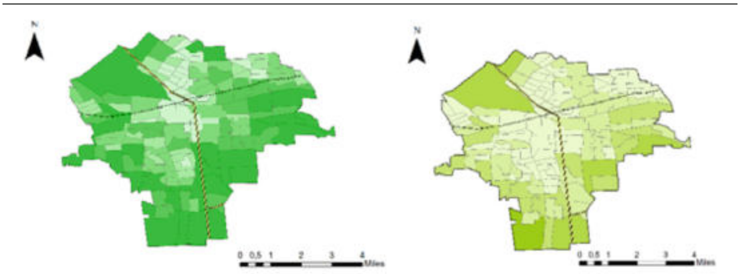
Table 1. Extract from the dataset for the city of Syracuse (USA).

Census Block	Area [sqkm]	Canopy Cover [sqm]	Canopy Cover [%]	Per capita Income [$]	Median Home Value [$]	Carbon Sequestration [t/yr]
1	6.13	718,722	15	48,011	58,200	111
2	0.36	179,275	50	30,000	168,400	23
3	0.44	219,744	50	6,785	0,000	12
4	0.21	114,526	53	34,595	106,800	11
5	0.33	156,613	47	25,521	96,700	8
6	0.80	415,207	52	38,160	271,100	86
7	0.68	348,029	51	30,424	114,100	37
8	0.50	282,470	57	39,384	162,700	32
9	0.76	226,219	56	46,868	162,500	36
10	0.43	85,793	20	11,603	75,000	11
11	0.67	161,065	24	20,667	83,100	18
12	0.26	43,301	17	38,064	84,800	4
13	0.31	79,318	25	16,883	84,600	10
14	0.32	42,492	13	17,068	84,700	3
15	0.27	46,943	17	19,308	94,500	4
16	0.48	180,894	38	10,549	55,800	10
17	0.76	123,429	16	5,270	9,999	6
…	…	…	…	…	…	…
117	0.35	110,883	31	13,721	48,900	11
118	0.18	76,485	42	6,773	48,000	3
119	0.26	105,218	41	13,543	59,600	8
120	0.28	163,088	58	24,465	138,900	18
121	0.20	102,385	50	9,793	124,000	12
122	0.13	31,565	25	10,894	65,000	0
123	0.36	35,612	10	6,416	45,000	2
124	0.22	29,137	13	8,108	0,000	2
125	0.19	25,090	31	4,810	0,000	2
126	0.79	337,508	43	17,461	60,600	43
127	0.76	123,429	16	5,270	9,999	6
128	0.93	272,353	57	20,966	80,200	21
129	0.19	37,231	19	18,300	79,500	1
130	0.86	116,954	14	10,941	116,400	10
131	0.56	168,754	30	23,289	75,600	13
132	0.75	224,196	65	20,825	71,500	14
133	0.50	129,094	26	12,947	46,400	8



Legend		Legend	
Median Home Value [$]		Per-Capita Income [$]	
	from 0 to 24,400		from 29,66 to 10,000
	from 24,401 to 67,700		from 10,001 to 20,000
	from 67,701 to 100,000		from 20,001 to 30,000
	from 100,001 to 150,000		from 30,001 to 40,000
	from 150,001 to 271,100		from 40,001 to 50,000

Fig. 1. Spatial distribution of median home value and pre-capita income in Syracuse (NY).



Legend		Legend	
Canopy Cover [sqKm]		Carbon Sequestration [t/yr]	
	from 13,760 to 54,227		from 0.20 to 9.50
	from 54,228 to 88,626		from 9.51 to 24.00
	from 88,627 to 123,429		from 24.01 to 52.10
	from 123,430 to 226,219		from 52.11 to 111.00
	from 226,220 to 1,559,660		from 111.01 to 245.90

Fig. 2. Spatial distribution of canopy cover and carbon sequestration in Syracuse (NY).

With regard to linear regression, two main types of linear regression techniques exist: parametric and non-parametric. Parametric methods include ordinary (or least squares) linear regression (OLR) and Deming's linear regression (DR). The non-parametric methods include Passing Bablok linear Regression (PBR) [32–34].

A monotonic linear regression analysis is conducted in the study. In order to measure the association level of the Median Home Value with each of the other parameters considered, the linear regression coefficient R^2 is estimated. Values of R^2

close to the unit denote a strong functional link, while values of R^2 close to zero express an independence state. The results of the elaborations are in the following paragraph.

3 Assessment of Correlation Levels Between Variables

The relationships highlighted with mapping are now evaluated in correlations. The measurement of association levels was carried out by analysing census areas with the same infrastructure system and biome. Specifically, from a naturalistic point of view, both census areas with water bodies (Green Lakes, Onondaga Lake, Onondaga Creek) and those with large green areas are neglected, such as, for example, the golf courses of Bellevue Country Club and those of Tecumseh Golf Club.

With respect to infrastructures, on the other hand, Census Blocks with neighbourhood school buildings, Syracuse University facilities, sports structures as the Lampe Athletics Complex and the Thomas J Niland Sports Complex, social and cultural centers like the Museum of Science & Technology and/or the Syracuse Center for Peace and Social Justice, hospitals as the Syracuse VA Medical Center, neighbourhood gardens, shopping malls, i.e. the Marshall Square Mall, are excluded. Also those crossed by I-81 and I-690 expressways, and by railways that pass in the Syracuse Railway Station. All these Census Blocks define surfaces with strong specificity, therefore not able to define the functional relationships that Per-capita Income, Canopy Cover and Carbon Sequestration have with Medium Value Homes.

Figures 3, 4 and 5 illustrate the monotonic linear correlation between Medium Value Homes and respectively Per-capita Income, Canopy Cover and Carbon Sequestration. For each variables pair the coefficient R^2 is estimated, and the corresponding linear function is determined. There is a strong association of Median Home Value with Per-capita Income, as demonstrated by the high value of R^2 equal to 0.8748. Same strong correlation is between Median Home Value and Carbon Sequestration, with R^2 of 0.7797. Although evident the link including Median Home Value and Canopy Cover, albeit with a lower value of R^2 equal to 0.6197.

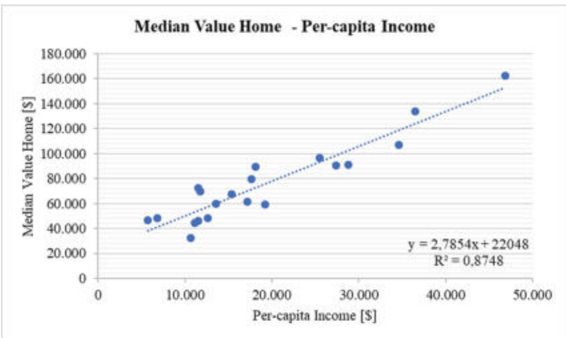


Fig. 3. Median home value and per capita income correlation.

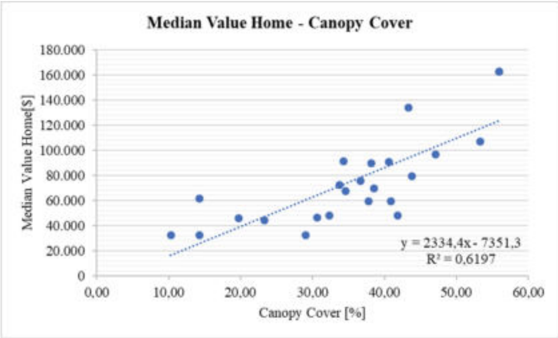


Fig. 4. Median home value and canopy cover correlation.

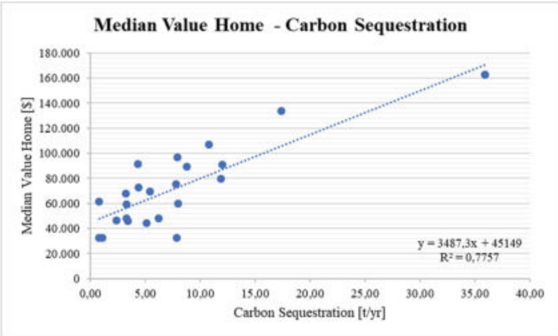


Fig. 5. Median home value and carbon sequestration correlation.

4 Conclusions

The estimate of the functional relationship between real estate values, socio-economic parameters and eco-system services of a territory requires the preliminary selection of the study variables: Median Home Value, Per-Capita Income, Canopy Cover and Carbon Sequestration. The use of Geographic Information Systems (GIS) and the implementation of statistical methodologies allows, on the one hand, the construction of thematic maps and, on the other, to measure the spatial correlation levels between variables.

The study, developed for the city of Syracuse, New York State, USA shows that Median Home Value are affected by Per-capita Income, as well as by the tree cover and the environmental quality of the urban context. The implementation of regression analysis provides high R^2 values. This is in the comparison of Median Home Value with both Per-Capita Income (R^2 = 0.8748) and Carbon Sequestration (R^2 = 0.7757) with regard to the survey census areas. These results show that real estate values also depend on the ecosystem services that urban forests generate.

Research perspectives concern the generalization of the results achieved for Syracuse, as well as the characterization of a multi-varied function able to explain the formation mechanisms of urban real estate values.

References

1. Benson, E.D., Hansen, J.L., Schwartz Jr., A.L., Smersh, G.T.: Pricing residential amenities: the value of a view. J. Real Estate Financ. Econ. **16**, 55–73 (1998)
2. Bolitzer, B., Netusil, N.R.: The impact of open spaces on property values in Portland, Oregon. J. Environ. Manage. **59**, 185–193 (2000)
3. Bateman, I.J., Day, B., Lake, I., Lovett, A.A.: The effect of road traffic on residential property values: a literature review and hedonic pricing study. Scottish Office and the Stationary Office, Edinburgh (2001)
4. Bencardino, M., Granata, M.F., Nesticò, A., Salvati, L.: Urban growth and real estate income. A comparison of analytical models. In: Gervasi, O., et al. (eds.) ICCSA 2016. LNCS, vol. 9788, pp. 151–166. Springer, Cham (2016). https://doi.org/10.1007/978-3-319-42111-7_13
5. Bencardino, M., Nesticò, A.: Urban sprawl, labor incomes and real estate values. In: Gervasi, O., et al. (eds.) ICCSA 2017. LNCS, vol. 10405, pp. 17–30. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-62395-5_2
6. Tajima, K.: New estimates of the demand for urban green space: Implications for valuing the environmental benefits of Boston's big dig project. J. Urban Aff. **25**(5), 641–655 (2003)
7. Wu, J.J., Adams, R.M., Plantinga, A.J.: Amenities in an urban equilibrium model: Residential development in Portland, Oregon. Land Econ. **80**(1), 19–32 (2004)
8. Troy, A., Grove, J.M.: Property values, parks, and crime: a hedonic analysis in Baltimore. Landscape Urban Plan. **87**, 233–245 (2008)
9. Poudyal, N.C., Hodges, D.G., Merrett, C.D.: A hedonic analysis of the demand for and benefits of urban recreation parks. Land Use Policy **26**, 975–983 (2009)
10. Debrezion, G., Pels, E., Rietveld, P.: The impact of railway stations on residential and commercial property value: a meta-analysis. J. Real Estate Financ. Econ. **35**, 161–180 (2007)
11. Schaerer, C., Baranzini, B., Ramirez, J.V., Thalmann, P.: Using the hedonic approach to value natural land uses in an urban area: an application to Geneva and Zurich. Économie publique/Public Econ. **20**, 147–167 (2007)
12. Jim, C.Y., Chen, W.Y.: Value of scenic views: hedonic assessment of private housing in Hong Kong. Landscape Urban Plan. **91**, 226–234 (2009)
13. Nichol, J., Wong, M.S.: Modeling urban environmental quality in a tropical city. Landscape Urban Plan. **73**(1), 49–58 (2005)
14. Endreny, T.: Strategically growing the urban forest will improve our world. Nat. Commun. **9**(1), 1160 (2018). https://doi.org/10.1038/s41467-018-03622-0
15. Fan, C., Johnston, M., Darling, L., Scott, L., Liao, F.H.: Land use and socio-economic determinants of urban forest structure and diversity. Landscape Urban Plan. **181**, 10–21 (2019)
16. Millennium Ecosystem Assessment: Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC (2005)

17. Endreny, T.A., Santagata, R., Perna, A., De Stefano, C., Rallo, R.F., Ulgiati, S.: Implementing and managing urban forests: a much needed conservation strategy to increase ecosystem services and urban wellbeing. Ecol. Model. **360**, 328–335 (2017). https://doi.org/10.1016/j.ecolmodel.2017.07.016
18. Heynen, N.C., Lindsey, G.: Correlates of urban forest canopy cover: implications for local public works. Public Works Manage. Policy **8**(1), 33–47 (2003)
19. Grove, J.M., Troy, A.R., O'Nell-Dunne, J.P.M., Burch, W.R., Cadenasso, M.L., Pickett, S. T.A.: Characterization of households and its implications for the vegetation of urban ecosystems. Ecosystems **9**(4), 578–597 (2006)
20. Landry, S.M., Chakraborty, J.: Street trees and equity: evaluating the spatial distribution of an urban amenity. Environ. Plan. A **41**(11), 2651–2670 (2009)
21. De Mare, G., Nesticò, A., Tajani, F.: The rational quantification of social housing. In: Murgante, B., et al. (eds.) ICCSA 2012. LNCS, vol. 7334, pp. 27–43. Springer, Heidelberg (2012). https://doi.org/10.1007/978-3-642-31075-1_3
22. Morano, P., Tajani, F.: Estimative analysis of a segment of the bare ownership market of residential property. In: Murgante, B., Misra, S., Carlini, M., Torre, Carmelo M., Nguyen, H.-Q., Taniar, D., Apduhan, Bernady O., Gervasi, O., et al. (eds.) ICCSA 2013. LNCS, vol. 7974, pp. 433–443. Springer, Heidelberg (2013). https://doi.org/10.1007/978-3-642-39649-6_31
23. Saaty, T.L., De Paola, P.: Rethinking design and urban planning for the cities of the future. Buildings **7**, 76 (2017)
24. Nesticò, A., Moffa, R.: Economic analysis and operational research tools for estimating productivity levels in off-site construction [Analisi economiche e strumenti di Ricerca Operativa per la stima dei livelli di produttività nell'edilizia off-site]. Valori e Valutazioni **20**: 107–126 (2018). DEI Tipografia del Genio Civile, Roma
25. Nesticò, A., Guarini, M.R., Morano, P., Sica, F.: An economic analysis algorithm for urban forestry projects. Sustainability **11**(2), 314 (2019). https://doi.org/10.3390/su11020314
26. Troisi, R., Alfano, G.: Towns as safety organizational fields: an institutional framework in times of emergency. Sustainability **11**(24), 7025 (2019)
27. Nesticò, A., Maselli, G.: Sustainability indicators for the economic evaluation of tourism investments on islands. J. Cleaner Prod. **248**, 119217 (2020). https://doi.org/10.1016/j.jclepro.2019.119217
28. US Census Bureau (2010). http://www.census.gov. Last Accessed 02 Jan 2020
29. Nowak, D.J., O'Connor, P.R.: Syracuse urban forest master plan: guiding the city's forest resource into the 21st century. General Technical Report. NE-287. Newtown Square, PA: US Department of Agriculture, Forest Service, Northeastern Research Station 50, 287 (2001)
30. https://landscape.itreetools.org/. Last Accessed 03 Jan 2020
31. Black, W., Barry, J.B.: Multivariate data analysis: its approach, evolution, and impact. In: Babin, B., Sarstedt, M. (eds.) The Great Facilitator, pp. 121–130. Springer, Cham (2019)
32. Gunst, R.F.: Regression Analysis and Its Application: A Data-Oriented Approach. Routledge, Boca Raton (2018)
33. Kutner, M.H., Nachtsheim, C.J., Neter, J., Li, W.: Applied Linear Statistical Models. McGraw-Hill/Irwin, New York (2005)
34. Hair, J.F., Black, W.C., Babin, B.J., Anderson, R.E., Tatham, R.L.: Multivariate Data Analysis, vol. 5, no. 3. Prentice Hall, Upper Saddle River (1998)