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Developing the green location quotient (GLQ): An integrated approach to identifying sustainable economic base sectors in Malang City, Indonesia

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Abstract

This study developed the Green Location Quotient as a modification of the conventional Location Quotient, integrating the Environmental Quality Index as a correction factor to assess economic base sectors not only through their comparative output advantage but also through the environmental carrying capacity in which such activities occurred. The approach was applied to Malang City in 2024, using gross regional domestic product at current prices across seventeen economic sectors, sourced from the statistics agencies of Malang City and East Java Province, together with Malang City's 2024 environmental quality score of 63.37, classified as moderate. The green index was calculated by multiplying the conventional location quotient by the ratio of the environmental quality score to one hundred. The results identified seven base sectors, which retained their base ranking after correction, though with magnitudes reduced proportionally. The study was positioned as a proof-of-concept employing a single-period cross-sectional design, with recommendations for future extension toward multi-region designs to more comprehensively test the discriminatory power of the proposed index. The study offered a methodological contribution relevant for economic development planning at the city level.

Keywords: Green Location Quotient, Economic Base Sector, Environmental Quality Index, Sustainable Development, Malang City

Abstrak

Penelitian ini mengembangkan Green Location Quotient sebagai modifikasi Location Quotient konvensional, dengan mengintegrasikan Indeks Kualitas Lingkungan Hidup sebagai faktor koreksi guna menilai sektor basis ekonomi tidak hanya dari sisi keunggulan komparatif output, tetapi juga dari daya dukung lingkungan tempat aktivitas tersebut berlangsung. Pendekatan ini diterapkan pada Kota Malang tahun 2024, menggunakan produk domestik regional bruto atas dasar harga berlaku menurut tujuh belas lapangan usaha yang bersumber dari Badan Statistik Kota Malang dan Provinsi Jawa Timur, serta skor indeks kualitas lingkungan hidup Kota Malang tahun 2024 sebesar 63,37, yang tergolong kategori sedang. Indeks hijau dihitung dengan mengalikan location quotient konvensional dengan rasio skor kualitas lingkungan hidup terhadap seratus. Hasil penelitian mengidentifikasi tujuh sektor basis yang tetap mempertahankan urutan basisnya setelah dikoreksi, meskipun magnitudo-nya menurun secara proporsional. Penelitian ini bersifat bukti konsep dengan desain satu periode, dengan rekomendasi pengembangan lanjutan menuju desain multiwilayah untuk menguji daya beda indeks yang diusulkan secara lebih komprehensif. Penelitian ini memberikan kontribusi metodologis yang relevan bagi perencanaan pembangunan ekonomi di tingkat kota.

Kata kunci: Green Location Quotient, Sektor Basis Ekonomi, Indeks Kualitas Lingkungan Hidup, Pembangunan Berkelanjutan, Kota Malang.

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1. Introduction

Regional economic development in Indonesia has long relied on Location Quotient (LQ) analysis to identify base sectors as a foundation for formulating regional economic policy. This approach has been widely applied across various studies, ranging from the provincial level (Afif, F., & Ciptawaty, 2020) to the city/regency level (Fadlli, 2022), yet, based on a review of the literature, most of these studies remain focused on measuring the relative concentration or specialization of sectoral output, without accounting for the environmental implications of the processes generating that output.

Meanwhile, the Environmental Kuznets Curve (EKC) framework has long suggested a non-linear relationship between economic growth and environmental quality (A'yun et al., 2023), and several recent studies in Indonesia find that development indicators including the Human Development Index, population density, and green fiscal policy significantly affect the Environmental Quality Index (IKLH) across provinces (Ahadiyah & Setyadharma, 2023; Esther & Agustina, 2023; Soeparno et al., 2024). In this study, the EKC framework serves solely as a conceptual basis for why environmental conditions need to be considered alongside economic growth, rather than as a theory that is empirically tested or that directly underlies the construction of the GLQ.

Malang City's identity as an education hub is rooted in the 1962 Tri Bina Cita declaration by the Gotong Royong Municipal Parliament of Malang (DPR Gotong Royong Kotapraja Malang), which designated the city as a City of Students/Education, City of Industry, and City of Tourism (Portal Resmi Kota Malang, n.d.; Tribunjatim, 2026). This designation is reinforced by BPS data indicating that the service sector dominates Malang City's economic structure, with the Education Services sector contributing 7.11% to Malang City's GRDP in 2025 (BPS Kota Malang, 2026). Against this backdrop, Malang City faces the challenge of balancing economic growth with environmental quality. Malang City's IKLH data shows a fluctuating trend, declining from the good category (7.54 in 2020) to the Moderate category (63.37 in 2024), indicating environmental pressures that are not yet fully aligned with the growth of the city's leading economic sectors. This condition raises a fundamental question: do the sectors conventionally identified as the city's economic base sectors truly reflect a sustainable development base, or does this economic advantage occur amid mounting ecological pressure?

Building on this conceptual gap, this study aims to develop a new index, the Green Location Quotient (GLQ), which integrates the conventional LQ logic with IKLH as an environmental weighting factor. The contribution of this study is twofold: methodologically, it offers a base-sector measurement framework sensitive to the sustainability dimension; and empirically, it presents an application of GLQ to the case of Malang City in 2024 as a proof-of-concept study that can be replicated in other regional and temporal contexts.

2. Literature Review

A central methodological question in constructing the GLQ is why and how an aggregate, region-level indicator such as IKLH can be used to adjust a sector-specific measure such as LQ. This is justified on the grounds that environmental quality, unlike output, is not readily decomposable by economic sector: publicly available environmental monitoring data in Indonesia, including IKLH, are reported at the regional rather than sectoral level (BPS Kota Malang, 2026). Aggregate IKLH is therefore treated not as a sector-specific correction, but as a regional environmental context that conditions all economic activity within that region, including the sectors identified as economic base sectors through LQ. Under this logic, a sector's LQ-based specialization is reinterpreted in light of the environmental conditions prevailing in the region where that specialization occurs, providing the conceptual bridge between LQ, IKLH, and the GLQ formula developed in this study (Basri, 2020; Pratama et al., 2019).

Location Quotient Theory and the Identification of Base Sectors

The Location Quotient has become a standard instrument in regional economics for measuring the relative concentration of an economic sector in a given region compared to a broader reference region, rooted theoretically in economic base theory, which distinguishes export-oriented (basic) activities from locally-oriented (non-basic) activities within a regional economy. Various empirical studies in Indonesia consistently use LQ to map regional leading sectors, either combined with shift-share analysis or Klassen Typology, with findings that vary depending on each region's economic structure (Rosmeli, 2022; Zain, 2022). At the regency level, identified base sectors are often dominated by primary sectors such as agriculture and mining, while at the city level they tend to be dominated by services and trade, reflecting the structural distinction between agrarian and urban regions.

Despite its wide use, a number of studies also note LQ's inherent limitations, including the assumption of homogeneous consumption patterns across regions, dependence on a single point in time that ignores structural dynamics, and the central focus of this study the absence of non-economic dimensions such as environmental quality in its computation. Several methodological extensions have been proposed to address the temporal limitation, such as the Dynamic Location Quotient (DLQ), which accommodates sectoral growth rates over time, yet such extensions remain confined to the realm of pure economic analysis without environmental weighting.

Environmental Quality Index as a Regional Sustainability Indicator

IKLH is an official composite index developed by Indonesia's Ministry of Environment and Forestry, comprising the Water Quality Index, Air Quality Index, and Land Quality Index, and has been widely used as both a dependent and independent variable in various studies of environmental quality determinants (Iswari & Kusuma, 2022; Wulandari & Faridatussalam, 2023; Yani et al., 2023). These studies generally find that human development factors correlate positively with IKLH, while population pressure and certain economic activities tend to correlate negatively (Dewi & Fitria, 2022). At the provincial level, factors such as environmental budget allocation, fiscal policy

instruments like motor vehicle fuel tax, and poverty rates have also been identified as significant determinants of IKLH (Ningsih & Putranti, 2022; Yani et al., 2023).

In the international literature, the use of composite environmental indices as policy instruments has also expanded considerably, ranging from cross-country green growth indicators integrating dimensions of natural resources, socio-economic outcomes, environmental productivity, and environmental policy into a single index (Sarkodie et al., 2023), to critical reviews of the proliferation of composite environmental indices that highlight the importance of weighting transparency so that such indices do not mislead cross-regional comparisons (PMC, 2023). These studies reinforce the relevance of using official, standardized indices such as IKLH rather than ad hoc index construction, given their greater comparability across time and regions.

Environmental Kuznets Curve and the Growth–Environment Nexus

The Environmental Kuznets Curve (EKC) framework explains a non-linear, inverted-U relationship between economic growth and environmental pressure, whereby early-stage development is associated with declining environmental quality, while later stages are associated with environmental improvement as mitigation capacity and public preference for quality-of-life increase. In this study, the EKC is not used as a theory that directly yields the GLQ formula, but rather as the theoretical justification for why environmental conditions represented here by IKLH need to be considered alongside indicators of economic advantage (LQ) to assess a region's economic base more comprehensively. Empirical evidence on the EKC in Indonesia shows mixed results: several studies confirm an inverted-U pattern with a turning point at a particular income level (Massagony & Budiono, 2023), while others find a more complex pattern, such as an N-shaped curve, indicating that the growth–environment relationship in a developing-country context like Indonesia is not always linear. At the regional level, a study in West Java Province employing the STIRPAT framework linking population density, per-capita income, and industrial investment to CO2 emissions found that these socio-economic factors significantly affect regional environmental pressure (Kurniawan et al., 2025).

These regional-level EKC findings are relevant to this study's argument, as they indicate that the relationship between sectoral economic structure and environmental quality is dynamic and may vary across regions depending on their respective development stage providing additional justification for why economic base sector indicators should not be treated as static with respect to the environmental dimension, but rather need to be contextualized against a region's sustainability conditions at a given observation period.

Integrating Economic and Environmental Dimensions into a Single Index

To the extent of the literature reviewed, no framework has been found that explicitly integrates LQ logic with an official environmental quality indicator such as IKLH into a single composite index at the sectoral level of Indonesian cities/regencies. Most LQ studies and IKLH determinant studies proceed along separate methodological tracks: LQ studies focus purely on the sectoral distribution of economic value added, while

IKLH studies focus on macro-level regression of environmental quality determinants without sectoral disaggregation. Some IKLH determinant studies even explicitly include agricultural sector GRDP as an explanatory variable without linking it to a broader sectoral economic base framework (Stevens et al., 2023; Yani et al., 2023). This gap forms the foundation for the conceptual contribution of the Green Location Quotient (GLQ) in this study: bridging sectoral economic base analysis with an official sustainability indicator within a single, consistent measurement framework applicable at the city/regency level in Indonesia.

3. Research Method

This study develops a method for identifying economic base sectors that builds upon the conventional Location Quotient (LQ), an analytical tool widely used in regional economics to measure the relative concentration of a given sector in a region compared to a broader reference region. Formally, LQ is defined as

$$LQ_i = \frac{(E_i/E_t)}{(E_{i,ref}/E_{t,ref})}$$

where E_i is the value added of sector i in Malang City, E_t is Malang City's total GRDP, while $E_{i,ref}$ and $E_{t,ref}$ are the corresponding values for East Java Province as the reference region. The underlying logic is that an $LQ > 1$ indicates that the sector is relatively concentrated (specialized) in Malang City compared with East Java Province as the reference region, and is classified as having export-base potential. It should be emphasized that LQ is an indicator of relative specialization, not a direct empirical measure of inter-regional export activity. However, this measure is based purely on the logic of economic value added and does not account for how that value added is generated, including its implications for environmental quality a sector may achieve a high LQ even though its production process imposes substantial ecological pressure, and this is precisely the conceptual gap underlying the further development pursued in this study (Basri, 2020; Pratama et al., 2019).

To bridge this limitation, this study builds the argument that a region's economic base advantage needs to be relativized against the environmental quality conditions -- rather than environmental carrying capacity in the full conceptual sense -- under which that activity takes place: a high LQ in a region with good environmental quality should be interpreted differently from a high LQ in a region with poor environmental quality, since the latter reflects economic advantage occurring amid ecological stress. Operationalizing this logic requires a representative, standardized composite environmental indicator, and this study selects the Environmental Quality Index (IKLH) an official composite of the Water, Air, and Land Quality Indices published by the Regional Environmental Agency because of its official status, its 0 - 100 scale, and its integration of three major environmental dimensions without requiring the construction of a new index. Because IKLH is scaled $0 - 100$ while LQ is a ratio centered around one, IKLH needs to be transformed through simple normalization

$$w_t = \frac{IKLH_t}{100}$$

so that it can function as a proportional environmental weight: the higher the $IKLH$, the larger w_t (approaching one), so that the base sector score is preserved close to its original LQ value; conversely, the lower the $IKLH$, the smaller wt, so that the base sector score is adjusted downward this directional logic matters because poor environmental quality should lower, not raise, the assessment of a sector's base economic advantage (Stevens et al., 2023).

Based on this chain of reasoning, the Green Location Quotient (GLQ) is formulated as the product of the conventional LQ and the normalized environmental weight:

$$GLQ_{it} = LQ_{it} \times \left(\frac{IKLH_{it}}{100}\right),$$

where i denotes the unit of analysis (economic sector or region, depending on the study design) and t denotes the observation period. Mathematically, GLQ can be regarded as a version of LQ "discounted" by environmental quality, so that its range becomes $GLQ_{it} \in [0, LQ_{it}]$, with $GLQ = LQ$ achieved only under the ideal condition of $IKLH = 100$. The classification of base sectors under GLQ still refers to the original LQ threshold, since wt does not change the direction of the ratio, only its magnitude, but is supplemented with a qualitative interpretive layer: a GLQ value close to its original LQ value indicates a base sector occurring under favorable environmental conditions (an environmentally reinforced economic base), whereas a GLQ value substantially lower than its original LQ indicates a base sector that remains economically identified but occurs under environmental stress (an economic base under environmental stress), signaling the need for sustainability policy intervention in that sector (Ershad Hussain & Haque, 2019; Sugiawan & Managi, 2016; Yanto et al., 2024).

This study uses Malang City's single 2024 IKLH value as the basis for calculation (a cross-sectional design with t held constant), so that the value of wt is uniform across all sectors i, and GLQ at this stage functions as a linear transformation of LQ the ranking of base sectors does not change, only its magnitude is proportionally adjusted. This condition is explicitly acknowledged as an intentional scope limitation at the method-development stage (proof-of-concept), rather than an unrecognized weakness, with a future research agenda consisting of an extension to a panel design in which i represents regencies/cities and t represents multiple years of observation, so that spatial-temporal variation in IKLH can provide more substantive discriminatory power for GLQ results across units of analysis and strengthen the empirical validity of this method for publication in reputable journals.

The data used are GRDP at current prices across 17 economic sectors for Malang City in 2024 and for East Java Province in 2024 as the reference region (Statistics Indonesia/BPS), together with Malang City's 2024 IKLH of 63.37, categorized as Moderate (Malang City Environmental Agency).

4. Results and Discussion

Before turning to the results, several interpretive boundaries of the GLQ warrant clarification. The GLQ is best understood as an environmentally adjusted LQ rather than a direct measure of a sector's overall sustainability performance; it reflects the extent to which a sector's economic specialization is tempered by the environmental conditions prevailing in the region, not whether that sector is sustainable in a broader sense. The weighting scheme underlying this adjustment dividing IKLH by one hundred reflects a linear weighting assumption adopted for interpretive simplicity rather than a transformation mandated by theory, leaving room for alternative, non-linear specifications in future refinements of the index. It is also important to distinguish base-sector classification, which remains grounded in the conventional LQ criterion (LQ > 1), from the GLQ score itself, which serves as a supplementary indicator of environmental performance; this distinction explains why sectors such as Trade, Construction, and Financial Services remain classified as base sectors despite recording GLQ scores below 1. In light of these considerations, this study deliberately avoids the stronger claim of a “sustainable economic base,” favoring instead the more precise terms “environmentally adjusted economic base” or “economic specialization under environmental conditions.”

4.1. Results

Malang City's total GRDP at current prices in 2024 reached IDR 100,116.87 billion, with a structure dominated by three main sectors: Wholesale and Retail Trade (IDR 29,250.43 billion, or 29.2% of total GRDP), Manufacturing (IDR 27,119.23 billion, or 27.1%), and Construction (IDR 12,448.58 billion, or 12.4%). These three sectors together account for more than two-thirds of the city's economy, indicating an economic structure that is relatively concentrated in trade and urban support services rather than primary or extractive activities. In contrast, the Agriculture, Forestry, and Fishing sector contributed only IDR 220.17 billion (0.2%), and the Mining and Quarrying sector was even smaller, at IDR 51.79 billion (0.05%) a pattern consistent with Malang City's character as an urban area with limited agricultural and mining land compared to surrounding regencies.

When compared to the structure of East Java Province, where the Manufacturing sector accounts for 30.9% and the Agricultural sector still accounts for 10.7% of total provincial GRDP, it is evident that Malang City has a far more service- and trade-oriented economic structure than the East Java average as a whole. This structural difference underlies the logic of the LQ calculation, namely identifying sectors that are relatively more concentrated in Malang City compared to the average provincial pattern as the reference region.

The calculation of LQ across the 17 economic sectors identifies seven sectors with an LQ value greater than one, which are classified as Malang City's economic base sectors, as presented in Table 1.

Table 1. LQ and GLQ Calculation Results for Malang City Economic Sectors, 2024

Code	Sector	LQ	GLQ	LQ Classification	GLQ Classification
Q	Human Health and Social Work Activities	3.862	2.447	Base	Favorable
P	Education	2.953	1.871	Base	Favorable
E	Water Supply; Sewerage, Waste Management, and Remediation Activities	1.891	1.198	Base	Favorable
R,S,T,U	Other Services Activities	1.865	1.182	Base	Favorable
G	Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles	1.553	0.984	Base	Constrained
F	Construction	1.387	0.879	Base	Constrained
K	Financial and Insurance Activities	1.112	0.705	Base	Constrained
M,N	Business Activities	0.966	0.612	Non-Base	Constrained
C	Manufacturing	0.878	0.556	Non-Base	Constrained
J	Information and Communication	0.856	0.542	Non-Base	Constrained
L	Real Estate Activities	0.835	0.529	Non-Base	Constrained
I	Accommodation and Food Service Activities	0.817	0.518	Non-Base	Constrained
H	Transportation and Storage	0.729	0.462	Non-Base	Constrained
O	Public Administration, Defence and Compulsory Social Security	0.587	0.372	Non-Base	Constrained
D	Electricity and Gas	0.094	0.059	Non-Base	Constrained
A	Agriculture, Forestry, and Fishing	0.021	0.013	Non-Base	Constrained
B	Mining and Quarrying	0.014	0.009	Non-Base	Constrained

The Human Health and Social Work Activities sector recorded the highest LQ value (3.862), followed by Education (2.953), Water Supply and Waste Management (1.891), Other Services (1.865), Wholesale and Retail Trade (1.553), Construction (1.387), and Financial and Insurance Activities (1.112). The high LQ values for the health and education sectors confirm Malang City's character as a center of higher-education and referral health services within the Greater Malang region, which draws economic activity from beyond the city's administrative boundaries. Conversely, the Agriculture sector (LQ=0.021). Mining and Quarrying (LQ=0.014), and Electricity and Gas (LQ=0.094) show very low LQ values, confirming that these three sectors are not the city's economic base and that their presence in Malang City is far smaller relative to their proportion at the provincial level.

Notably, the Manufacturing sector, despite being nominally the second-largest contributor to Malang City's GRDP, obtained an LQ below one (0.878), because its dominance at the provincial level (accounting for 30.9% of East Java's GRDP) far exceeds its proportion in Malang City (27.1%. This finding reaffirms the basic principle of LQ that a sector's large nominal contribution does not automatically make it a base sector, but rather must be assessed relative to the structure of the reference region.

After LQ values are corrected with the environmental weight factor $w_t = IKLH$ 2024/100 = 0.6337, all GLQ values decline proportionally by 36.63% from their original LQ values. The Human Health and Social Work Activities sector, which originally had an LQ of 3.862, is corrected to a GLQ of 2.447, and Education declines from 2.953 to 1.871. As anticipated in the methodological limitations discussed in Section 3, the ranking and base/non-base classification of these seven sectors remain unchanged after correction, because the IKLH used is a single value (one city-level figure for one year) and therefore applies uniformly across all sectors. Thus, in this single-period cross-sectional design, GLQ functions mathematically as a linear transformation of LQ, rather than as an additional source of discriminatory power among sectors.

Nevertheless, the GLQ value retains a distinct substantive meaning from LQ. Whereas LQ answers the question "which sector is economically concentrated in Malang City?", GLQ answers the additional question "how much should this economic advantage be discounted given that the city's current environmental quality falls in the Moderate, not Good, category?". The uniform 36.63% reduction across all base sectors can be interpreted as a quantitative representation of the "implicit environmental cost" accompanying all of the city's economic activity in 2024, consistent with the Moderate IKLH category indicating that environmental quality is not yet optimal. In nominal terms, the gap between the highest-ranked sector (Health, GLQ=2.447) and the lowest-ranked base sector (Financial Services, GLQ=0.705) widens proportionally under GLQ, even though the relative spacing between sectors expressed as ratios remains identical to that under LQ, a direct mathematical consequence of applying a constant multiplicative factor across all observations.

4.2. Discussion

Substantive and Policy Implications

Substantively, the seven base sectors in Malang City, particularly health services, education, and water/waste management are sectors with relatively low emission intensity and natural resource exploitation compared to large-scale manufacturing or mining, and are therefore qualitatively more aligned with sustainability principles. This contrasts with findings in other regions, such as Riau Province, where base sectors are instead dominated by agriculture and mining sectors that inherently carry greater ecological pressure. Malang City's service-based economic structure thus represents a favorable starting point for a transition toward a low-carbon economy, although this cannot yet be confirmed quantitatively through GLQ at this single observation period.

The declining trend in Malang City's IKLH from the Good category (75 ,54 in 2020) to Moderate (63.37 in 2024) suggests that if GLQ were calculated as a time series for Malang City itself, the city's base sectors would likely show a declining GLQ trend even if their LQ values remain stable or increase. This pattern represents an early warning signal with clear policy relevance: the growth of the city's economic base sectors is occurring amid increasing environmental pressure, a condition consistent with the logic of the Environmental Kuznets Curve at a stage prior to reaching its turning point, where economic growth is still associated with declining environmental quality (A'yun et al

2023; Massagony & Budiono, 2023). The policy implication is that Malang City's government needs to consider sector-specific interventions for base sectors with high GLQ values that remain vulnerable to further IKLH decline, particularly the Trade and Construction sectors, which have historically been associated with increased pressure on urban air and land quality.

The comparison between sectors with large nominal contributions but low LQ, such as Manufacturing, and sectors with smaller nominal contributions but high LQ, such as Health Services, indicates that low-carbon economic development policy in Malang City should not focus solely on sectors with large absolute value added, but should also strengthen sectors that already represent the city's comparative advantage and are inherently lower in environmental pressure, The GLQ approach, although at this proof-of-concept stage not yet able to fully differentiate sustainability levels across sectors due to the limited cross-sectional variation in IKLH, has successfully demonstrated a quantitative framework that can be populated with richer data in future research to produce a base-sector map that is genuinely ecologically differentiated (Tian et al 2026; Wu & Xu, 2025; J , Zhang et al 2021).

Methodological and Theoretical Implications

Methodologically, these results confirm that the added value of GLQ will be genuinely tested in a multi-region or multi-year panel design, where variation in IKLH across units of analysis allows GLQ to provide information beyond a simple linear rescaling of LQ , Consistent with prior studies showing that IKLH varies significantly across provinces and over time due to differences in development pressure, population density, and environmental fiscal policy (Soeparno et al 2024; Wulandari & Faridatussalam, 2023; Yani et al 2023). Extending GLQ to a panel design is likely to produce more informative score variation: base sectors in regencies/cities with high IKLH would retain relatively higher GLQ scores, while base sectors with a similar composition in regions with low IKLH would show substantially more discounted GLQ scores a distinction that cannot be captured by the conventional LQ. This is particularly relevant given the EKC evidence reviewed in Section 2.3, which shows that the relationship between economic growth and environmental quality in Indonesia varies considerably depending on a region's development stage, income level, and policy environment (A'yun et al 2023; Massagony & Budiono, 2023). A panel-based GLQ would therefore allow researchers to empirically trace how a region's position on its own EKC trajectory translates into the discounting applied to its economic base sectors, offering a sector-level lens on a relationship that has so far mostly been examined at the aggregate, macroeconomic level (Behera et al 2025; Wang et al 2025; J , Zhang et al 2021).

From a broader theoretical standpoint, the GLQ framework developed here can be situated within the wider literature on composite sustainability indices, which increasingly emphasizes integrating environmental dimensions into established economic indicators rather than treating them as separate analytical tracks (Mattas et al 2026; Sarkodie et al 2023; Sugiawan & Managi, 2016). At the same time, the critical literature on composite environmental indices cautions that weighting choices can substantially affect cross-regional rankings and interpretability (Li et al 2025; Nihayah

& Diastuti, 2023); this concern is directly relevant to GLQ's design choice of using a simple linear weight ($IKLH/100$) rather than a more complex weighting scheme. A choice made deliberately at this stage to preserve interpretability and replicability, but one that should be revisited and stress-tested once panel data become available, for instance by comparing the linear weighting scheme against alternative functional forms (e,g, logarithmic or threshold-based weights) to assess the sensitivity of base-sector rankings to the choice of weighting function (Lian et al, 2026; Stevens et al, 2023; Y, Zhang et al 2025).

The limitations of this study should be read together with its contribution. Because the analysis relies on a single cross-sectional year and a single reference region, the empirical demonstration here should be interpreted as a methodological proof-of-concept rather than a generalizable empirical finding about Malang City's sustainable base sectors. Future studies are encouraged to extend the GLQ framework to a panel of regencies/cities across East Java with multi-year IKLH and GRDP data, which would allow for formal panel econometric testing (e.g., fixed-effects or System GMM specifications) of how GLQ varies systematically with regional characteristics such as urbanization, industrial composition, and environmental governance capacity an agenda that would also allow GLQ to be tested against, and potentially integrated with, the EKC framework discussed in Section 2.3.

5. Conclusion

This study has developed and demonstrated the application of the Green Location Quotient (GLQ) as a modification of the conventional LQ that integrates IKLH as an environmental correction factor. The Malang City 2024 case study identifies seven economic base sectors, with Health Services and Education as the dominant sectors, which after GLQ correction retain their base classification but with proportionally lower magnitude. As a cross-sectional pilot study, this research explicitly acknowledges the limitation that GLQ's discriminatory power has not been fully tested within a single observation period, and recommends further development toward a panel data design across regencies/cities in East Java over time to more comprehensively validate GLQ's methodological contribution and strengthen its policy relevance for low-carbon economic development planning at the city level.

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