Assessing Local Human Development in Poland: Insights from 2010 and 2023

Veranika Kaleyeva(✉), Piotr A. Werner, and Mariusz Porczek

Faculty of Geography and Regional Studies, University of Warsaw, Warsaw, Poland
v.kaleyeva@gmail.com, {peter,mt.porczek}@uw.edu.pl

Abstract. The Local Human Development Index (LHDI) serves as a region-specific human development assessment tool measuring fundamental aspects like health, education and standard of living at the subnational level. This study explores the LHDI in Poland for the years 2010 and 2023, focusing on its spatial distribution and component variables. By analysing regional disparities, we identify trends and changes in LHDI across different areas. The findings provide insights into the evolving socio-economic landscape of Poland and highlight regions requiring targeted policy interventions.

Keywords: Local Human Development · LHDI · polarization · Poland

1 Introduction

The approach to human development measurement has changed substantially throughout history, moving away from exclusive reliance on economic metrics like GDP to more inclusive methods that evaluate social and human well-being factors. The Human Development Index (HDI) which originated from the United Nations Development Programme (UNDP) in 1990 stands as one of the most influential development measurement tools. Developed by economist Mahbub ul Haq, with conceptual contributions from Amartya Sen, the HDI was designed to provide a broader assessment of development by incorporating three key dimensions: health as measured by life expectancy at birth and education represented by average years of schooling and expected years of schooling along with standard of living evaluated through Gross National Income per capita adjusted for purchasing power parity [1, 2].

The HDI has successfully expanded development discussions past economic growth but hides substantial socio-spatial inequalities within countries according to national and regional HDI statistics [3]. Researchers and policymakers turned their attention to Local Human Development Index (LHDI) frameworks which modify HDI methodology for smaller regions like cities and districts because of this understanding [4]. By revealing subnational disparities, LHDI equips governments and organizations with insights into regional development, helping them craft targeted policies for specific local challenge [5, 6].

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The research investigates the importance of LHDI as well as its methodological approach and its role in evaluating socioeconomic differences to inform local policy strategies. Through spatial and comparative analysis of the Local Human Development Index (LHDI) in Poland for the years 2010 and 2023, we illustrate the robust analytical capacity of LHDI in assessing developmental progress and detecting disparities. These insights aim to provide a foundation for supporting sustainable development measures at local level.

2 Foundations and Analytical Perspectives of Local Human Development Index

2.1 Determinants of LHDI

The Local Human Development Index (LHDI) is a composite metric derived from a series of closely related economic, social, and governance factors important for economic growth, resource distribution, and overall quality of life. It incorporates both the traditional components of HDI and area-specific measures, considering the unique characteristics and development context of a given location.

The regional economic performance stands as the most reliable factor influencing LHDI through its measurement via Gross Regional Domestic Product (GRDP). The increase of income levels leads to better access to vital services and higher living standards which support human development processes [7–9]. Research has shown that public spending on health care, education, and infrastructure directly leads to better development results in local areas [10–12]. The distribution and operational effectiveness of these resources are often determined by the broader framework of fiscal decentralization, which, depending on the context, may either empower local authorities or generate coordination challenges and inefficiencies [13, 14].

Social factors including poverty incidence and unemployment rates play an essential role in determining the quality of life and future development prospects [15, 16]. The ability of people to obtain education and health care becomes restricted when poverty rates are high which reduces social mobility for both people and their communities. Moreover, the research highlights the role of social capital – such as trust, civic engagement, and institutional cooperation – emphasizing the importance of community participation and governance transparency in driving developmental outcomes [17, 18].

Infrastructure development and a reliable energy supply are also fundamental elements that drive economic growth, improve service delivery, and raise quality of life standards. Inequalities in these domains create deeper development gaps between regions [19].

Additional dimensions, such as migration patterns, demographic change, and environmental health risks may influence human development trajectories by reshaping access to services and shifting local priorities. Studies indicate that limited social networks among migrants can hinder access to essential resources [5]. Furthermore, local health conditions, such as cancer incidence and mortality rates, provide critical insights into regional disparities in healthcare access [20, 21].

Together, these determinants form a dynamic framework emphasizing that LHDI is not simply a statistical construct but a reflection of interconnected processes that shape the opportunities and well-being of local populations.

2.2 Expanding LHDI Dimensions

The traditional focus on health, education and income in LHDI has faced recent academic pressure to expand its scope for better understanding modern human development complexities. The proposed extensions into environmental sustainability, equity and cultural inclusion aim to enhance local indices for responding to new societal challenges.

A notable effort to reconceptualize the human development framework is the Human Sustainable Development Index (HSDI), which incorporates ecological sustainability into the assessment of development [22]. While still on the margins of mainstream research, such proposals recognize that sustainable access to natural resources and environmental resilience are increasingly essential to long-term human well-being.

Other studies have suggested incorporating less conventional elements – such as ethical values or religious practices – into localized indices. The Islamic Human Development Index (I-HDI), for example, includes cultural elements relevant to specific populations [23]. While such initiatives highlight the diversity of human development understandings, their applicability tends to remain context-specific and should be approached with caution when designing comparative metrics.

In the present study, we deliberately refrained from expanding the LHDI framework. Our primary objective was to ensure comparability with the original Polish LHDI report from 2012, which was based on 2010 data [24]. The arguments supporting the selection of particular sub-indicators were presented in detail in that foundational publication. The evaluation of temporal changes in this article used the same framework to maintain methodological consistency.

2.3 Methods to Study LHDI

The study of LHDI involves the application of diverse analytical methods, each chosen to reflect both the complexity of human development and the specificity of local contexts. Central to this approach is the construction of composite indices, which combine multiple normalized indicators into a single, interpretable metric. These composite indicators typically use geometric or arithmetic means and reflect normalized measures of health, education, and income dimensions. The flexibility of this method has allowed for its adaptation across various local and regional studies, including modifications for sector-specific assessments or population-targeted metrics [15, 17, 25, 26].

Beyond index construction, statistical techniques are widely employed to analyze patterns and disparities in LHDI scores. Regression analysis, correlation matrices, and multidimensional scaling help researchers identify the relationships among determinants and highlight areas of concern [27, 28]. More advanced econometric models, including panel data analysis and structural equation modelling, are increasingly used to investigate causal pathways and long-term trends in human development indicators.

Geospatial methods also play a vital role in LHDI research. Techniques such as Geographically Weighted Regression (GWR), spatial autocorrelation (e.g., Moran's I) and cluster analysis allow scholars to visualize and interpret the geographic distribution of development inequalities. These tools are particularly useful in identifying regional clusters of high or low development and exploring the spatial dependencies between variables [14, 18, 29].

Comparative approaches – both cross-regional and longitudinal – enable the assessment of development trajectories over time or across spatial units. By applying consistent metrics across different regions or timeframes, researchers can draw robust conclusions about structural shifts, policy impacts, and regional convergence or divergence in development [11, 30–33].

Overall, the methodological landscape of LHDI research continues to evolve, reflecting both the theoretical complexity of human development and the practical demands of policy evaluation. Future research may benefit from integrating emerging data sources and further refining tools for spatial-temporal analysis, while maintaining a commitment to transparency, comparability, and context sensitivity.

3 Methodology of Evaluation of Local Human Development Index (LHDI) in Poland

The key aspect of contemporary scientific studies is the ability to repeat the methodological steps. The approach aims to either verify previously obtained results or obtain new, comparable results for different time points or spatial locations, all using the same research schema. The first evaluation of LHDI in Poland (2012) has been precisely and in detail described in the published report [24]. Recently, these steps were repeated with the goal of comparing the final LHDI coefficients in 2023 across Polish counties, along with their three main components. The main reasons for repeating these research procedures were the 'wild cards' at the global and continental (European) scale, i.e., outbreaks of the COVID-19 pandemic (2020–2022, still marking its presence in 2023), and the ongoing war in Ukraine (from February 2022). These factors rearranged the main values and priorities as perceived by Polish society and have undoubtedly left their mark on the global and domestic economies.

The situation of Poland in the first years of the XXI century was shaped by two main global phenomena: the financial crisis (2007–2009) and the earthquake, tsunami, and nuclear crisis at Fukushima, Japan, which, in turn, changed the global perception of electric energy acquisition from nuclear plants (similarly to the nuclear catastrophe of the nuclear plant in Chernobyl, Ukraine, 1986). Two main phenomena emerged at the local scale. The first was Poland's accession to the European Union in 2004 and its continued negative foreign migration balance until 2015. Minor mass event, but important (at the continental scale, and from a recent historic perspective) was the 2012 UEFA European Football Championship (Euro 2012) co-hosted by Poland and Ukraine, which also marked itself in public opinion, different sectors of the local economy, and tourism. The publication of the 2012 LHDI report preceded this event, and it's likely that this initiative had a connection to it.

The 2012 Poland LHDI report presented local HDI coefficients by counties as the set of composite indices for the year 2010 that combined normalized indicators (geometric means, at the scale 1–100): life expectancy, education level, and per capita income, which in turn contained composite, detailed, absolute (also normalized) values of particular subindices. The 2023 approach is a replication of this procedure aimed at revealing time and spatial changes of these features.

3.1 Poland HDI 2010–2022

The methodology for evaluating a country's HDI differs from that of LHDI, though the overall approach to estimating the country's total coefficient is similar. Poland's HDI

rose almost without breaks but slightly shrank during the COVID-19 pandemic (Fig. 1) [34], returning to its level in 2022.

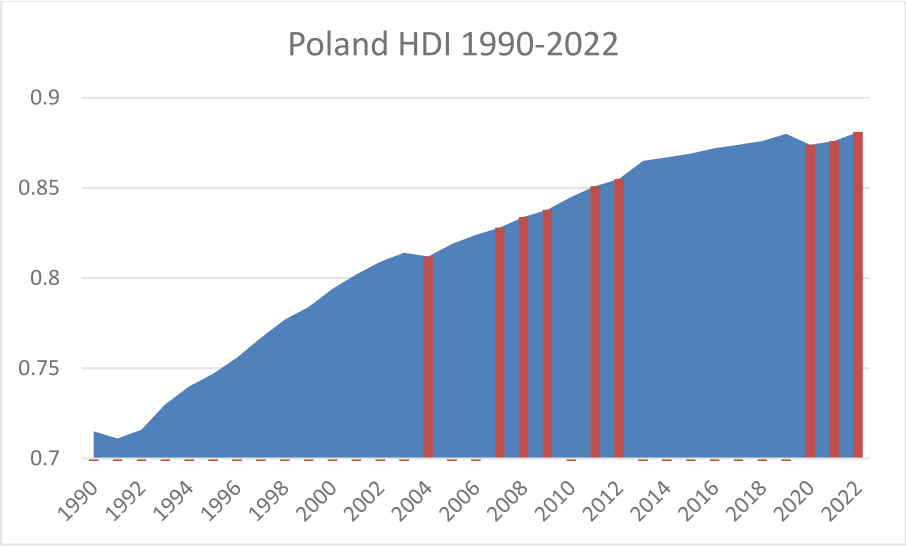

Fig. 1. HDI Poland 1990–2022, data source: [33]; 2004 Poland's accession to the EU; 2007–2009 global financial crisis; 2011 Fukushima; 2012 Euro 2012; 2020–2021 COVID-19; 2022 war in Ukraine.

4 LHDI in Poland: Changes from 2010 to 2023

The analysis begins with a brief overview of Poland's Human Development Index (HDI) at the national level to provide contextual background and highlight temporal trends. With its advantages, HDI has limits – such as masking internal disparities and omitting environmental or political dimensions, but it is still a robust tool for understanding and comparing human progress at an international level. It also serves as an appropriate introductory step to analyze the further Local Human Development Index at the subnational level.

There is a scatter matrix graph (Fig. 2) that shows the comparison of the final LHDI indices and their sub-indices for each county in Poland in 2010 and 2023. The diagonal charts display the self-dispersion of the indices themselves. The rest of the graphs show the comparison of particular indices (as variables) by counties (at the regional level, i.e., county – 'powiat'). The scatter matrix graph starts the analysis of LHDI in Poland at a local level, showing how each pair of LHDI subcomponents and LHDI itself changes over space and time. The footprints of each pair show the general tendency of spatial and time dispersion of the subcomponents. Each footprint shows where all 380 regions (counties) are located in relation to the compared subcomponents and the overall LHDI at specific times. The diagonal presents histogram of the LHDI subcomponents and overall LHDI strictly to the related point in time.

The Local Human Development Indices show the tendency to multidirectional polarization between the counties (LHDI 2023 vs. LHDI 2010) over the past thirteen years.

In spite of Educational sub-indices (LHDI_EI_2023 vs. LHDI_EI_2010), which display a certain linear trend with easily noticeable margins (which reveals stability between the counties). Conversely, the Health sub-indices (LHDI_HI_2023 vs. LHDI_HI_2010) reflect deeper and more varied polarization, indicating increasing divergence in health-related development. The Wealth sub-indices (LHDI_WI_2023 vs. LHDI_WI_2010) show an almost linear trend with a few top counties (with max values) as hot-spot outliers.

Local Human Development Index values (LHDI_year) by counties in Poland 2023 shows slight more dispersion than in 2010 looking at the particular indices using the box-plots (Fig. 3). There are more top (hot-spots) outliers as well a slight lower (bottom) outlier (that confirms again greater polarization between counties). But the first quartile

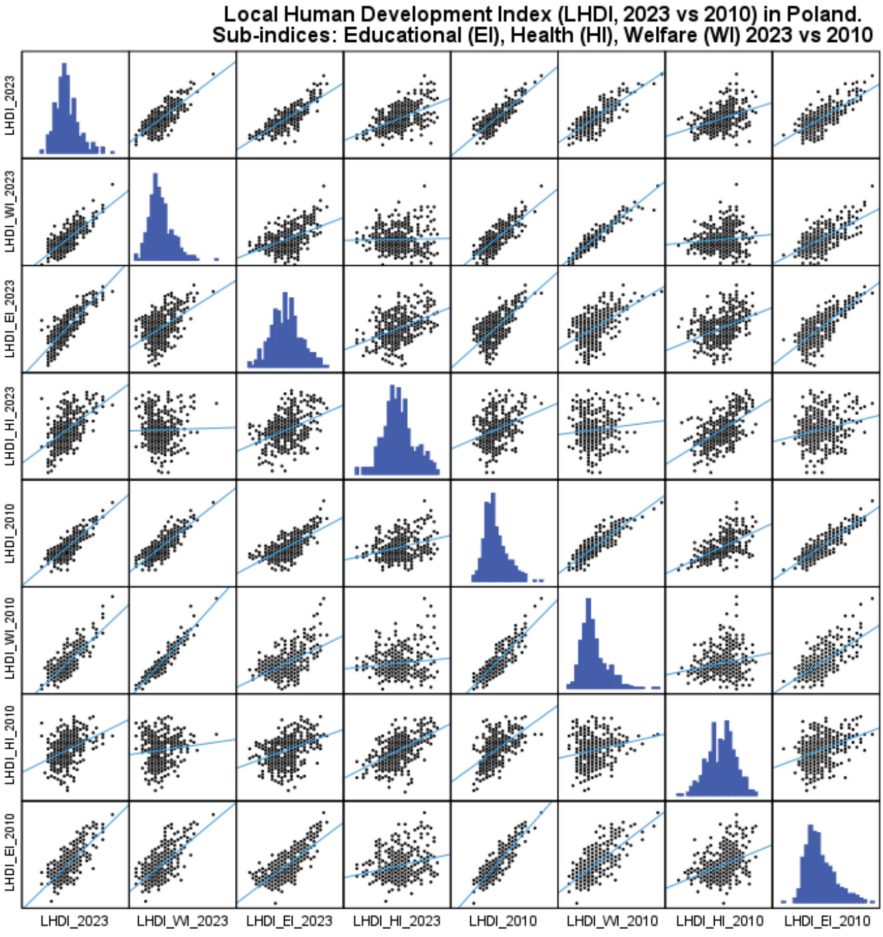

Fig. 2. Scatter matrix graph. Comparison of Local Human Development Indices (LHDI_year), and Educational (LHDI_EI_year), Health (LHDI_HI_year) and Wealth (LHDI_WI_year) Sub-Indices of 380 counties in Poland in 2023 and 2010. The data was processed using the PS IMAGO PRO software, with the analytical engine being IBM SPSS Statistics.

and median are a little bit greater in 2023 than in 2010. The reduction of polarization is visible for education by counties (LHDI_EI) in 2023 but dispersion shrunk and simultaneously, for set of education sub-indices of counties: first and third quartiles rose, as well as median. Conversely, the set of health sub-indices (LHDI_HI) in 2023 reveal greater dispersion, with top and low outliers, as well the lower values of all quartiles (greater polarization). This schema of greater polarization (greater dispersion) in 2023 is repeated also for set of wealth sub-indices by counties with rose of the quartiles and shrunk of former (in 2010) top outliers.

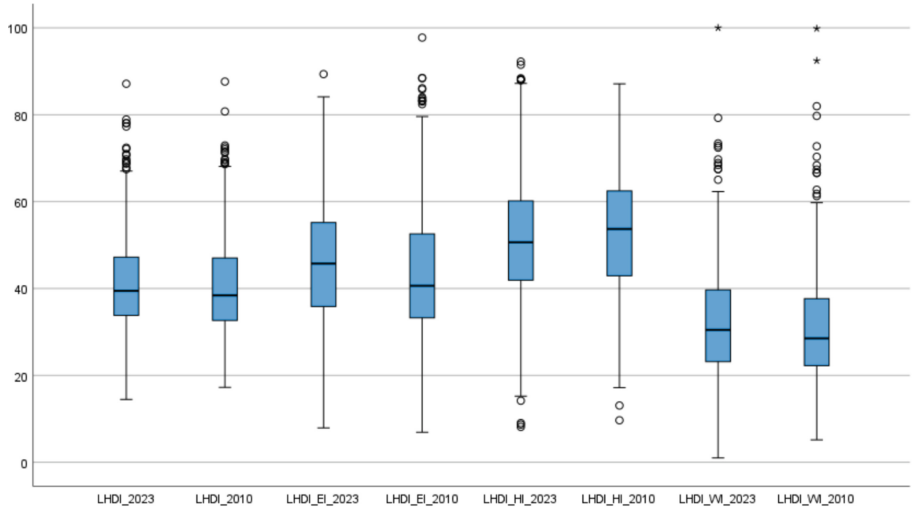

Fig. 3. Box-plots: comparison of Local Human Development Indices (LHDI_year), and Educational (LHDI_EI_year), Health (LHDI_HI_year) and Wealth (LHDI_WI_year) Sub-Indices of 380 counties in Poland in 2023 and 2010. The data was processed using the PS IMAGO PRO software, with the analytical engine being IBM SPSS Statistics.

Simple calculations of the difference, representing the decrease or increase in LHDI (Fig. 4), illustrate changes in the index over a 13-year period. An attempt to maintain uniform class sizes resulted in only five counties being classified in the highest category (counties: Wrocławski, Płocki, Pińczowski, Kazimierski, and Miechowski), marked in dark red, and one in the lowest category (Ciechanowski county), marked in deep blue. The increase observed among peri-urban counties indicates an improvement in the quality of life in metropolitan or agglomeration areas. In general, central urban areas do not exhibit significant growth, as their LHDI values were already high in 2010. Instead, the

cities typically experience a decline in the index. It is also worth noting the decline in LHDI along anthropogeographical boundaries (e.g., the borders of the West Pomeranian and Greater Poland Voivodeships, as well as the Masovian and Warmian-Masurian Voivodeships), in Greater Poland, and in the Sudetes Mountains.

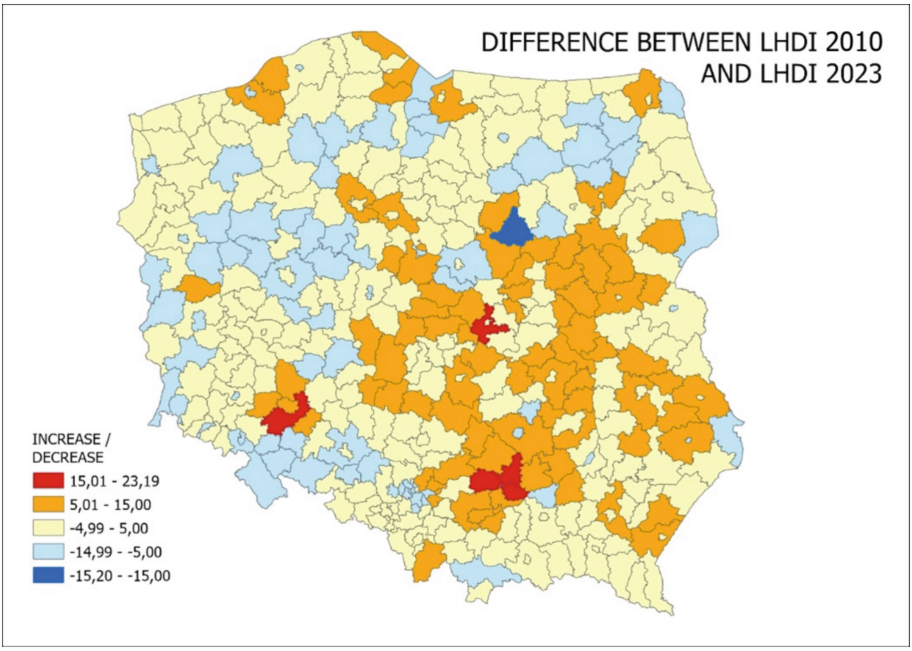

Fig. 4. Difference between LHDI in 2010 and 2023.

4.1 Cluster Analysis – Grouping Based on LHDI Coefficients

The analysis was conducted using SAGA GIS with a combined method for nine clusters, which were grouped by software based on similarities in LHDI parameters for 2010 and 2023. Due to the varying index values, clusters were assigned descriptive names to better illustrate their essence, relative rank, and trend direction. In every cluster's range, extreme values ('min' and 'max') and the average value ('avg') are presented in Table 1.

Table 1. Value ranges and colour representation in county clusters.

No. of Cluster	Cluster Name	Short Name	Trend Direction	LHDI Level	No. of Elements	Std. Dev.	2023 avg	2023 min	2023 max	Spread 2023	2010 avg	2010 min	2010 max	Spread 2010
0	Down Worst	DW	↓ Decline	Very Low	36	4,81	**24,07**	14,46	29,27	14,81	**31,26**	20,47	39,44	18,97
1	Up Worst	UW	↑ Increase	Low	41	5,04	**31,75**	24,39	41,30	16,91	**25,99**	17,24	31,08	13,84
2	Down Low	DL	↓ Decline	Medium-Low	50	3,48	**32,89**	28,04	36,88	8,84	**36,79**	31,68	42,55	10,87
3	Up Low	UL	↑ Increase	Low-Medium	50	3,88	**38,90**	34,44	48,99	14,55	**32,38**	23,24	36,26	13,02
4	Down Medium	DM	↓ Decline	Medium	37	3,73	**39,18**	34,38	43,57	9,19	**44,65**	40,71	51,30	10,59
5	Up Medium	UM	↑ Increase	Medium	59	3,65	**42,53**	38,33	51,28	12,95	**38,61**	33,70	42,70	9,00
6	Little High	LH	— Stable	Medium-High	48	4,81	**48,76**	41,78	56,48	14,70	**48,65**	41,70	57,12	15,42
7	Medium High	MH	— Stable	High	43	6,10	**56,40**	47,87	69,33	21,46	**58,07**	50,70	68,62	17,92
8	Very High	VH	— Stable	Very High	16	8,39	**72,50**	64,65	87,12	22,47	**70,64**	61,54	87,63	26,09

While this alone may not provide significant insights, the distribution is more clearly depicted in the following chart (Fig. 5).

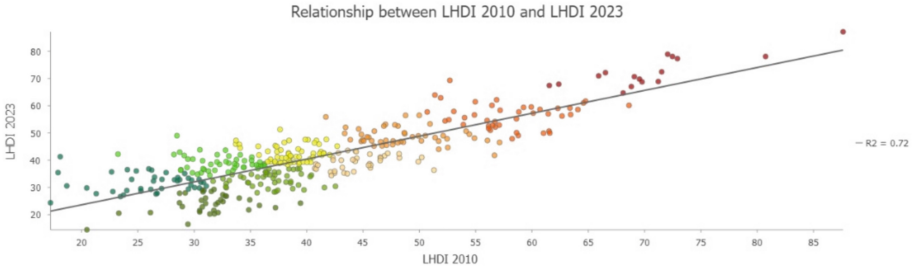

Fig. 5. Relationship between LHDI in 2010 and 2023.

The three most intensely red-shaded clusters are labelled as High (specifically Very High, Medium High, and Little High), representing counties with the highest LHDI values in both 2010 and 2023. The grouping of the remaining counties was based on the direction of LHDI change – either growth or decline. Each of the three object groups (Medium, Low, and Worst) was further divided according to LHDI trends: Up (increase) and Down (decrease). This classification clearly illustrates where the LHDI index has risen and where it has declined.

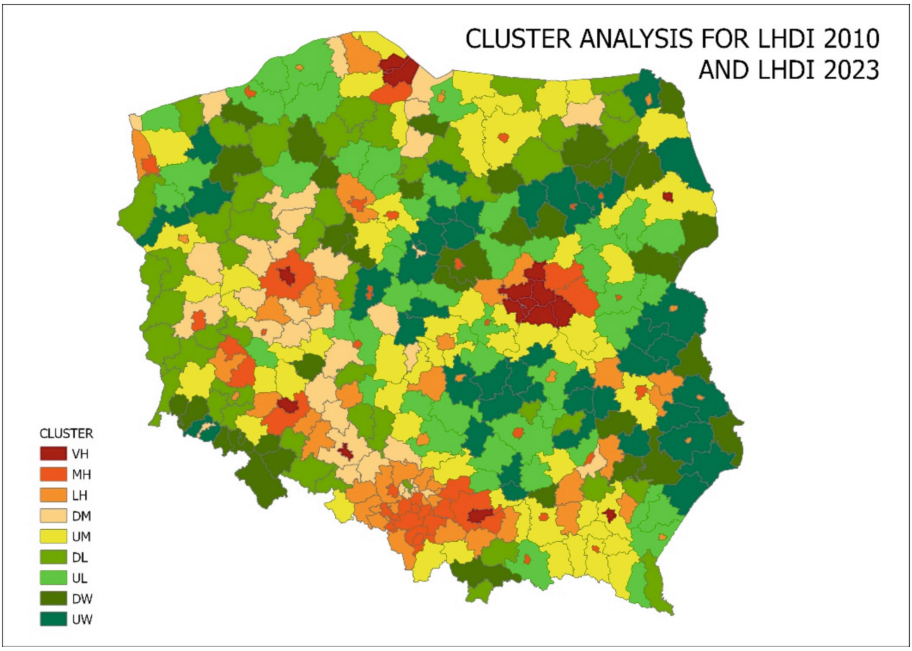

Fig. 6. Spatial distribution of county clusters for LHDI 2010 and 2023.

The map visualization (Fig. 6) indicates that the three High classes primarily represent cities and large metropolitan areas (e.g., the Silesian-Zagłębie Metropolis, Warsaw, the Tri-City, Poznań, Wrocław, etc.). While smaller cities exhibit high LHDI values, their surrounding areas do not necessarily follow this trend. However, most of these regions have noted LHDI growth. An exception is Opole and several smaller county towns. A decline in LHDI is mainly observed in peripheral areas, where the index was already low in 2010 and has since decreased further (Fig. 7).

4.2 Local Sub-Indices in Poland (2010 vs 2023)

Health Sub-index (HI). This parameter exhibited the most significant change among all three parameters. Growth is observed across all clusters. Notably, there is no decline in LHDI within the VH group, whereas a pronounced decrease is evident among DW counties, primarily located in northern Mazovia and the Sudetes. Among lower-performing counties, a substantial increase can be observed in the Lublin and Kielce regions.

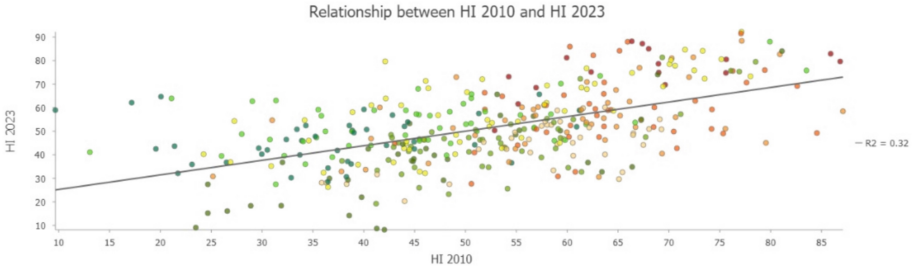

Fig. 7. Relationship between the health sub-index (HI) in 2010 and 2023.

Education Sub-index (EI). The education parameter exhibits significantly lower dispersion. Warsaw initially demonstrated the highest EI value in 2010; however, its subsequent decline allowed other units to reach comparable levels. At present, Kraków records the highest EI index. This parameter may also contribute to the observed decline in total LHDI value across a range of counties within the DW and DL groups, particularly in northern Poland. Conversely, a significant increase has been recorded in counties located in the eastern part of the country (UW cluster) (Fig. 8).

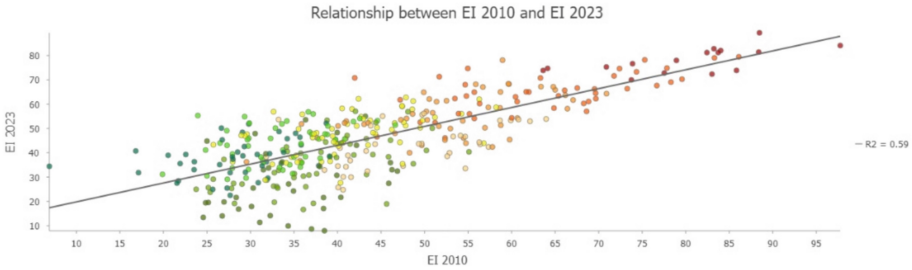

Fig. 8. Relationship between the education sub-index (EI) in 2010 and 2023.

Welfare Sub-index (WI). Among all three parameters, the WI parameter exhibits the lowest dispersion. There are no substantial fluctuations in values, which may indicate a certain stagnation among the poorest counties. A noticeable decline is observed among the wealthiest counties, particularly those surrounding Warsaw, as well as among the poorest ones. This pattern may offer an interesting insight into emerging regional dynamics and warrants further exploration (Fig. 9).

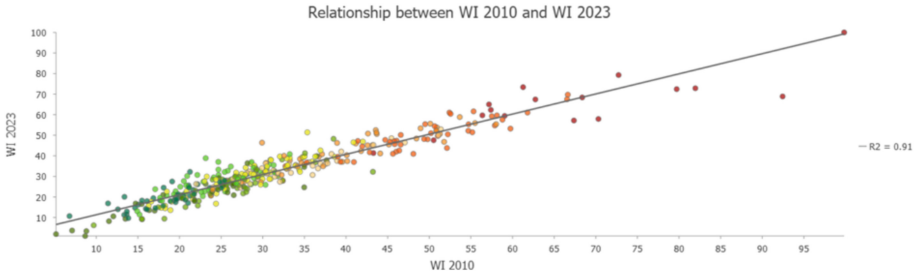

Fig. 9. Relationship between the welfare sub-index (WI) in 2010 and 2023.

5 Discussion

The LHDI in Poland exhibits a trend of multidirectional polarization among counties (LHDI 2023 vs. LHDI 2010). This pattern is concerning because it reflects increasing regional differences that may result in varied availability of resources, services, and opportunities. Such polarization may further exacerbate social and economic inequalities, compromise the overall development, and erode regional coherence [35, 36]. Persistent disparities can also contribute to political instability and weaken economic resilience [37].

The decline in LHDI values is primarily driven by decreases in specific parameters, particularly the health sub-index (HI) in northern Mazovia and the Sudetes, and the education sub-index (EI) in northern Poland. However, the overall trend of the education sub-indices remains relatively linear with well-defined margins, indicating stability across counties. The decline in LHDI is predominantly observed in peripheral areas, where index values were already low in 2010 and have further decreased. This trend may be linked to depopulation and the increasing closure of infrastructure in these regions.

Counties with the highest LHDI values in both 2010 and 2023 are primarily urban centres and large metropolitan areas. The observed increase in peri-urban counties suggests an improvement in quality of life within metropolitan and agglomeration zones, reflecting dynamic suburban expansion and the growth of urbanized regions. This strong suburbanization trend aligns with previous studies on urban development in Poland [38]. Central urban areas show limited LHDI growth, as their values were already high in 2010. In some cases, declines are evident, likely due to the natural urban life cycle and challenges related to overpopulation. Despite the fact that several small cities have high LHDI values and are still growing, their respective regions do not necessarily have similar patterns of suburbanization to those of large metropolitan areas.

Although the national Human Development Index (HDI) has increased positively in the last 10 years, the average Local Human Development Index (LHDI) for 2010 and 2023 has no significant upward or downward shift to justify further in-depth analysis. This lack of significant change in the overall LHDI highlights the limitations of relying solely on national averages and underscores the importance of examining the contextual factors that influence human development at the local scale.

There are numerous potential reasons for regional variation in LHDI, which deserve further exploration to better understand the uneven nature of human development across localities. To calculate and interpret the LHDI, it is crucial to consider local socio-economic, cultural, and environmental factors, as these are key determinants of human development outcomes. Our study outlines the dependencies between LHDI and urban development dynamics, which could benefit from further investigation. This underscores that, in line with well-established research, these dependencies may not always be immediately evident but provide valuable insights into LHDI research. For instance, cultural practices and traditional customs are essential in shaping social and economic behavior. Rajappa et al. (2023) explain that cultural practices, such as tobacco chewing, contribute to health inequalities in certain communities [39].

In conclusion, while the present study highlights key regional variations in LHDI, understanding the complex interplay of socio-economic, cultural, and institutional factors is crucial for developing more targeted policies aimed at fostering balanced human development.

6 Conclusion

The study demonstrates that the Local Human Development Index (LHDI) in Poland displays a pattern of multidirectional polarization among counties between 2010 and 2023.

The main challenge in the estimation of the LHDI is the lack of detailed information at the local scale. The constant evolution of the LHDI methodologies shows that it is crucial to align the measurement instruments with the local socio-economic and environmental realities. Future work should also keep on integrating innovation such as sustainability, equity, and cultural factors to the assessment to offer a better view of local human development.

Disclosure of Interests. The authors have no competing interests to declare that are relevant to the content of this article.

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