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CRISIS ACCOMMODATION AT THE EU'S EASTERN FRONTIER: RELATIVE RECONFIGURATION OF REGISTERED ACCOMMODATION USE IN EASTERN POLAND DURING THE RUSSIAN–UKRAINIAN WAR

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Abstract

This study examines how the use of registered accommodation changed across Eastern Poland during the first year of Russia's full-scale invasion of Ukraine. It combines daily Polish–Ukrainian border-crossing flows with monthly county-level accommodation data for 2021-2022 and applies a synthetic index based on registered-user intensity, foreign-user intensity and average length of stay. Results reveal spatially differentiated rather than uniform changes, with stronger relative positions in selected urban and corridor counties and weaker outcomes in peripheral areas. Although the longer-stay signatures emerge in some counties, they do not directly identify refugee accommodation, stay purpose or establishment-level functional conversion.

Keywords

crisis accommodation • temporary accommodation • transport corridors • mobility regimes • uneven resilience • Eastern Poland • Russian–Ukrainian war

Introduction

Accommodation utilisation is a core operational indicator of place-based service systems and an observable outcome of how mobility, housing pressure, and local capacity interact (Trojanek & Gluszak, 2022). In frontier regions exposed to geopolitical turbulence, accommodation utilisation becomes more than a market metric: it is a policy-relevant signal of how border governance, emergency response, and urban–regional systems of provision adjust under stress.

For urban and regional governance, the mobility shock created pressures extending beyond conventional leisure tourism. Registered accommodation establishments may serve different functions along a continuum ranging from short leisure or business stays, through emergency and transit accommodation, to longer stays that may temporarily resemble residential use. In this paper, temporary accommodation refers broadly to short-term or transitional stays outside a permanent residence, whereas temporary housing refers to the wider housing-policy function of providing a provisional place of residence. Quasi-residential use denotes a possible longer-stay pattern in an accommodation establishment that functionally resembles temporary residence without necessarily involving a formal change in the establishment's legal or statistical status. These categories may overlap in practice, but they are not directly distinguished in the accommodation statistics used in this study. Understanding their possible interaction across urban nodes, corridors and peripheral areas is central to debates on uneven resilience and crisis governance in city-regions (Waldron et al., 2024; Dreher & Bauder, 2026).

Accordingly, registered accommodation use is the directly observed category, whereas crisis-related, temporary, quasi-residential and labour-related uses are treated only as contextual interpretations of particular utilisation profiles and cannot be distinguished directly in the aggregate data.

Existing work on tourism crises often focuses on short-lived shocks, destination image repair, or post-crisis recovery trajectories (Avraham, 2016; Hall, 2010). Less is known about how accommodation systems in regions along the EU's external borders reorganise during a protracted war in a neighbouring state, when public authorities must simultaneously manage border procedures, humanitarian assistance, and regional development goals. This paper therefore treats hospitality-sector dynamics in Eastern Poland not only as a business phenomenon but also as an arena where crisis management, spatial planning, and cross-sectoral coordination become critical components of tourism resilience (Becken & Hughey, 2013; Brouder et al., 2020).

The outbreak of full-scale war displaced at least 10 million Ukrainians. In the first month, more than three million were forced to leave the country, with women and children accounting for over 90% (Lloyd & Sirkeci, 2022; Ramsay, 2022). The majority of those leaving Ukraine initially headed to Poland, primarily to its southern and western regions, with some remaining there and seeking refuge with relatives (Kravchenko & Zhuk, 2022; Stepura et al., 2022), while for others it served as a transit point on their onward journey. In the longer term, many found shelter in northern and eastern regions of Poland (Źróbek-Różańska, 2024).

The scale and pace of arrivals raised concerns about a massive influx of refugees that could quickly overwhelm border-crossing capacity. Therefore, on 25 February 2022, by the decision of the Commander-in-Chief of the Polish Border Guard, pedestrian border checks were enabled at all road border crossings (The Polish Border Guard, 2022).

The war-induced mobility shock required rapid institutional responses that directly shaped accommodation demand and the operational environment of hospitality providers in Eastern Poland. Policy measures and governance arrangements affected (i) the speed and organisation of border procedures, (ii) the scale and modalities of temporary protection and related support instruments, and (iii) the allocation of resources across emergency assistance, housing, and public services.

In practice, this produced a multi-level governance setting in which national agencies, regional and local authorities, civil-society actors, and market providers interacted under conditions of high uncertainty.

Research focused specifically on Poland has likewise demonstrated the importance of the spatial dimension of war-induced displacement and subsequent mobility. Śleszyński (2025) examined Poland's territorial capacity to absorb war refugees from Ukraine, while Komornicki et al. (2025) analysed their spatial distribution using registrations in the Polish PESEL system. More recent studies have extended this perspective beyond the initial reception phase. Łaźniewska et al. (2025) examined crisis-driven mobility in relation to labour-market processes in the Polish–Ukrainian borderland, whereas Komornicki et al. (2025) analysed cross-border mobility in Eastern EU countries through the lens of external shocks and regional resilience. Taken together, this literature highlights the spatially differentiated character of displacement, settlement and cross-border mobility and provides an important regional context for analysing changes in registered accommodation use.

This context makes spatial differentiation central to the analysis: transport corridors and institutional nodes can sustain accommodation utilisation, while peripheral leisure-oriented areas may face prolonged demand erosion when risk perception and functional reallocation dominate.

The invasion also reshaped the risk environment for local service and accommodation systems in Eastern Poland. Key pressures included security perceptions, humanitarian displacement and service overload, rising operating costs (notably energy), macroeconomic uncertainty and inflation, shifts from leisure-oriented demand toward crisis- and work-related occupancy, and the low-probability but high-impact risk of escalation (Hess, 2024; UNHCR, 2025; Gradzewicz et al., 2024). We use this risk framing to contextualise changes in the relative utilisation profiles of registered accommodation across urban nodes, corridors and peripheral areas as mobility regimes evolved. The analysis does not directly observe refugee stays or the functional conversion of individual establishments. The probability–impact scale and the detailed risk matrix used to contextualise the accommodation-sector risk environment are provided in Appendix A (Tables A1–A2).

Building on this literature, the present study focuses specifically on how successive stages of cross-border mobility coincide with spatial changes in registered accommodation use at the county level. By combining daily border-flow data with year-on-year accommodation indicators, the analysis complements existing research on refugee distribution, crisis-driven mobility and regional resilience with an accommodation-use perspective.

Against this background, the study addresses the following research questions: RQ1: How did Polish–Ukrainian cross-border mobility evolve across the successive stages of the first war year, and what contextual implications does this staging have for interpreting changes in registered accommodation use across the wider frontier region? RQ2: How did registered accommodation utilisation reconfigure spatially across Eastern Poland during the first war year, as captured by a synthetic index reflecting utilisation intensity, foreign-visitor signals, and length of stay? RQ3: To what extent do the observed shifts within the registered accommodation system display longer-stay signatures consistent with possible quasi-residential or labour-related use under prolonged crisis, and what are the implications of such patterns for cross-sector governance (mobility–housing–services) in frontier regions?

Building on crisis and resilience scholarship, the paper advances the hypothesis: H1: The war-year trajectory of registered accommodation utilisation in Eastern Poland shifts from shock-driven, institutionally mediated variation (early mobility stages) toward spatially differentiated adaptation (later stages), increasingly characterised by longer-stay signatures consistent with quasi-residential and work-related use of accommodation capacity.

H1 concerns the temporal and spatial reconfiguration of registered accommodation-use profiles observed during the war period, interpreted in the context of independently measured cross-border mobility. It does not test whether these changes were caused by Ukrainian nationals or refugees. Longer-stay signatures are treated as indicative profiles and do not identify refugee accommodation, individual motives for staying or the formal conversion of accommodation establishments.

We examine H1 by comparing stage-level patterns in year-on-year change in the synthetic index (ΔS) and the component dominance captured by the Quasi-Residential Index (QRI) between early (shock) and later (regularised) mobility stages.

Empirically, the hypothesis is examined by combining two analytical components. First, daily border-crossing data are used to stage the period from January 2022 to February 2023 into distinct mobility stages. Second, monthly accommodation statistics for 2021-2022 are summarised through a synthetic index and analysed comparatively across identical months to control for seasonality. This design allows the paper to connect mobility regimes to spatial patterns of accommodation utilisation, providing evidence that is relevant not only for tourism theory but also for governance debates on how EU frontier regions can manage tourism systems under prolonged crisis conditions.

Research Area

Two voivodeships in Eastern Poland were selected for analysis: the Lubelskie voivodeship and the Podkarpackie voivodeship (Fig. 1a,b). Their choice was dictated, first of all, by the immediate proximity to Ukraine. In the case of both voivodeships, data on counties were used.

The study area includes counties differentiated by direct border adjacency, access to major transport corridors, urban administrative status and mountain location. These spatial characteristics, shown in Figure 1, provide the basis for the descriptive county typology used later in the analysis. This configuration provides an appropriate spatial setting to examine how registered accommodation utilisation reconfigured under protracted geopolitical stress.

Not all counties included in the study are directly adjacent to the Polish–Ukrainian border. The term border-adjacent is reserved for counties that directly share the state boundary with Ukraine. The analysis nevertheless covers all counties in the Lubelskie and Podkarpackie voivodeships in order to examine spatial differences in registered accommodation use across the wider study region.

In addition, information on the existing passenger border crossings as well as those created during the analysed period was used. Information on the existing road and rail networks was of great importance as well.

Materials and Methods

This study examines relative changes in registered accommodation use across the wider frontier region during the Russian–Ukrainian war, using linked temporal and spatial evidence. The empirical strategy links (i) daily cross-border mobility, used to delineate crisis stages, with (ii) monthly accommodation-utilisation indicators aggregated at the county level in Eastern Poland. The accommodation component is analysed for all counties (including city counties – cities with county rights) in the Lubelskie and Podkarpackie voivodeships. To capture registered accommodation utilisation beyond a single measure, the study constructs a synthetic index that integrates Defert-based registered accommodation-user intensity, foreign-visitor registered accommodation-user intensity and average length of stay, and then compares identical calendar months across 2021 and 2022 to reduce seasonal confounding.

The first dataset consists of daily counts of crossings of the Polish–Ukrainian border in both directions for the period 1 January 2022 to 28 February 2023 (Poland's Data Portal, 2023). This series is used to identify major

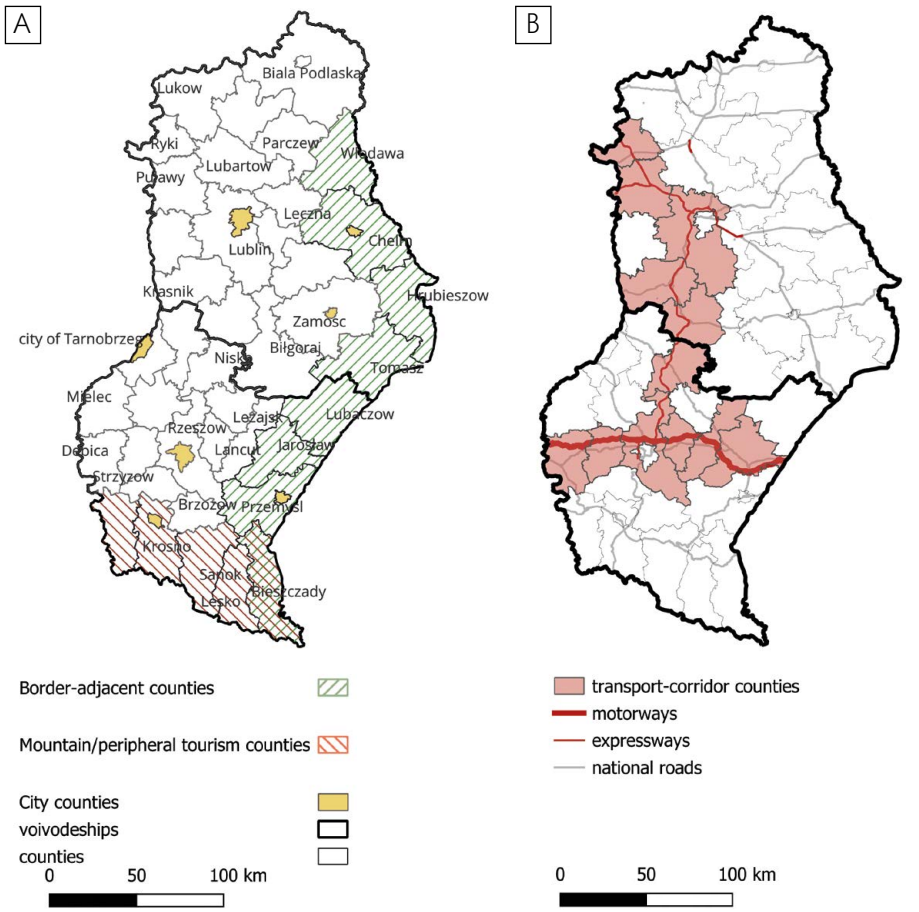


Figure 1. Spatial characteristics of the study area: (A) counties in the Lubelskie and Podkarpackie voivodeships, including border-adjacent counties, city counties and the mountain area; (B) major road infrastructure, including motorways and expressways used to identify transport-corridor counties

shifts in the level and direction of mobility and to delineate six characteristic stages of cross-border mobility. These stages provide temporal context for interpreting how shifts in cross-border mobility coincide with changes in registered accommodation use across the wider frontier region.

The six mobility stages were defined through a rule-based descriptive segmentation of the daily border-crossing series. The procedure was based on the joint examination of: (i) daily crossings to Poland, (ii) daily crossings to Ukraine, (iii) the daily net balance between the two directions, (iv) the relative share of crossings to Poland, and (v) the persistence of changes beyond isolated daily peaks. Public and religious holidays in Poland and Ukraine were used as contextual markers for interpreting calendar-related fluctuations, rather than as independent statistical criteria.

The segmentation was not based on an automated change-point model, and the stage boundaries should not be interpreted as statistically estimated break dates. Instead, boundaries were assigned where a sustained change in the level, direction or regularity of mobility was visible in the

daily series and could be related to a clearly identifiable geopolitical or calendar context. The stages therefore constitute a transparent descriptive framework for interpreting the evolution of cross-border mobility. They provide temporal context for the registered accommodation-use analysis but do not identify the purpose, legal status or accommodation arrangements of border crossers.

The individual boundaries were defined as follows. Stage 1 ends on 23 February 2022, immediately before the full-scale invasion. Stage 2 begins on 24 February, when the series shifts abruptly to an exceptional and consistently Poland-oriented inflow. The boundary of 15 April marks the transition from the acute, predominantly one-directional displacement phase to a more balanced and increasingly return- or circulation-oriented mobility pattern. The boundary of 11 October marks the transition to a more regular and moderately Poland-oriented regime, with greater directional symmetry and lower dominance of the earlier return flow. The boundary of 11 December identifies the beginning of a distinct Christmas travel window characterised by a temporary shift toward Ukraine. Finally, 7 January marks the end of the Orthodox Christmas period and an immediate return to a moderately Poland-oriented post-holiday pattern.

Because the accommodation dataset covers 2021-2022, only Stages 1-5 contribute to the year-on-year accommodation analysis. For Stage 5, the accommodation results are based exclusively on the part of the stage falling within 2022, namely 11-31 December. The border-flow series is nevertheless retained through 28 February 2023 because the post-holiday period helps distinguish the temporary Christmas travel window from the subsequent return to a more regular, moderately Poland-oriented mobility pattern. Stage 6 therefore serves only as descriptive mobility context and is not used to calculate or interpret ΔS or QRI.

The second dataset consists of monthly accommodation statistics for the counties of the Lubelskie and Podkarpackie voivodeships for 2021-2022 (Statistical Office in Lublin, 2023; Statistical Office in Rzeszów, 2023). The accommodation dataset covers all categories of tourist accommodation establishments included in the official statistical reporting system of Statistics Poland (GUS) for the analysed period. The statistics used in this study concern establishments with 10 or more bed places and include hotel establishments (hotels, motels, boarding houses and other hotel establishments) as well as other categories of tourist accommodation establishments reported by GUS, including hostels, holiday centres, shelters and youth hostels, campsites, guest rooms, private lodgings and agritourism establishments. The analysis is therefore limited to accommodation captured by the GUS reporting framework and does not include informal hosting or other accommodation activity outside the official statistical system. For each county i and month t, the dataset includes: (i) the number of registered accommodation users $U_{i,t}$, (ii) the number of foreign (non-resident) accommodation users $U_{i,t}^{for}$, and (iii) the number of overnight stays $N_{i,t}$. County land area A_i (km^2) is used to standardise tourism intensity components. The accommodation analysis compares 2022, the first war year, with 2021 as the pre-war comparison year. Comparing identical calendar months reduces the influence of recurring seasonal patterns, but it does not establish a counterfactual trajectory or isolate the causal effect of the invasion.

In a small number of county–month cells, values were suppressed by the statistical offices for confidentiality reasons. In the analytical dataset, these suppressed entries were coded as zero before the component indicators were calculated. This treatment is reported explicitly because a suppressed value represents an undisclosed value rather than a confirmed absence of registered accommodation use.

The accommodation statistics measure use within the registered accommodation system at the county–month level. They do not identify the nationality or legal status of all accommodated persons, the purpose of individual stays, the number of refugees

accommodated, or whether particular establishments formally changed function. The analysis therefore concerns relative changes in registered accommodation-use profiles. Interpretations referring to temporary, quasi-residential or labour-related use are based on the joint pattern of foreign-visitor intensity, length of stay and staged cross-border mobility and should be understood as indicative rather than as direct measurement.

For terminological clarity, the study distinguishes between indicators and functional interpretations. The Defert-based component measures the number of registered accommodation users per unit of county area. Although the Defert index is conventionally used as a tourism-intensity indicator, in the present crisis context the numerator may include stays that were not leisure-tourism related. We therefore refer to this component as registered accommodation-user intensity. The foreign-visitor component measures the corresponding intensity of registered non-resident users and is not treated as a direct measure of refugee or Ukrainian accommodation. Average length of stay captures the number of overnight stays per registered user. Temporary accommodation, temporary housing, quasi-residential use and labour-related use are not separately observed variables. They are possible functional interpretations considered in relation to the combined component profile and the wider mobility context.

Registered accommodation use is summarised using three component indicators computed for each county–month. The first component is a Defert-based registered accommodation-user intensity measure:

$$D_{i,t} = \frac{U_{i,t}}{A_i},$$

where:

$U_{i,t}$ – the total number of accommodation users registered in county i in month t,

A_i – county land area (km^2).

Foreign-visitor registered accommodation-user intensity, calculated as a foreign-visitor variant of the Defert measure, was defined as:

$$F_{i,t} = \frac{U_{i,t}^{for}}{A_i},$$

where:

$U_{i,t}^{for}$ – the number of foreign (non-resident) accommodation users registered in county i in month t,

$F_{i,t}$ – the foreign-visitor component captures the intensity of registered non-resident accommodation use. It is interpreted as a broad foreign-guest signal considered alongside staged Polish–Ukrainian border flows. It does not distinguish nationality, refugee status or purpose of stay and is therefore not treated as a direct measure of Ukrainian, refugee or crisis-related accommodation demand.

Average length of stay was calculated as:

$$L_{i,t} = \frac{N_{i,t}}{U_{i,t}},$$

where:

$N_{i,t}$ – the number of overnight stays in month t.

Each component is standardised using monthly z-scores across counties, so the composite index is not driven by scale differences. For each month t and component $k \in \{D, F, L\}$, the standardised value is computed as:

$$Z_{i,t}^{(k)} = \frac{X_{i,t}^{(k)} - \mu_t^{(k)}}{\sigma_t^{(k)}},$$

where:

$X^{(k)}$ – the raw component value (e.g., $D_{i,t}$, $F_{i,t}$, or $L_{i,t}$),

$\mu_t^{(k)}$ – the mean of that component across all counties in month t,

$\sigma_t^{(k)}$ – the standard deviation of that component across all counties in month t.

The synthetic index is defined as an equal-weighted composite of the three standardised components:

$$S_{i,t} = \frac{Z_{i,t}^{(D)} + Z_{i,t}^{(F)} + Z_{i,t}^{(L)}}{3},$$

The three monthly standardised components were assigned equal weights of one third each. Equal weighting was selected as a transparent and parsimonious rule because no independently validated theoretical or empirical basis was available for prioritising one dimension over the others. The weights were therefore specified by the analytical design rather than estimated from the data and should not be interpreted as empirically optimal. Because the components are standardised by month across counties, the resulting ΔS values capture changes in counties' relative positions rather than absolute changes in registered accommodation use.

A direct month-to-month comparison within a single year is heavily confounded by tourism seasonality. Therefore, temporal variation is assessed primarily through year-on-year differences of identical calendar months. For each county *i* and month *m*, the year-on-year change in the synthetic index is computed as:

$$\Delta S_{i,m} = S_{i,(2022,m)} - S_{i,(2021,m)}.$$

Because the six mobility stages delineated from daily border-crossing data (Section *Results – Border crossings*) do not coincide with calendar-month boundaries, monthly year-on-year differences $\Delta S_{i,m}$ were aggregated to the stage level using a day-weighted mean. For each county *i* and stage *s*, we computed:

$$\Delta S_{i,s} = \frac{\sum_m w_{m,s} \cdot \Delta S_{i,m}}{\sum_m w_{m,s}},$$

where:

$w_{m,s}$ – the number of days of stage falling within month *m*.

Stage-level aggregation is weighted by the number of stage-days falling in each month to handle boundary months. When a month falls entirely within one stage, the weighted result is equivalent to an unweighted aggregation. The resulting stage-level values $\Delta S_{i,s}$ were presented as a single heatmap (county and stage) using fixed discrete thresholds:

- > 1
- 0.5 to 1
- 0.1 to 0.5
- -0.1 to 0.1
- -0.5 to -0.1
- -1 to -0.5
- < -1

Accordingly, ΔS represents the difference between a county's relative standardised profile in 2022 and its corresponding profile in the same calendar month of 2021. It does not represent a causal estimate of the effect of the war, because changes between the two years may also reflect other temporally varying and spatially uneven processes.

To support a compact interpretation of spatial differences in registered accommodation-use profiles, counties were additionally assigned to four non-mutually exclusive descriptive types: city counties, border-adjacent counties, transport-corridor counties and mountain/peripheral tourism counties. The typology was introduced to organise the spatial interpretation of stage-level ΔS and QRI patterns rather than to establish mutually exclusive territorial regions or estimate causal effects. Membership was binary, remained fixed across all mobility stages and allowed a county to belong to more than one type.

The four county types were selected to capture spatial characteristics that could plausibly differentiate registered accommodation-use profiles under conditions of cross-border disruption: direct exposure to border flows, access to major transport infrastructure, concentration of administrative and service functions in urban centres, and the greater dependence of mountain/peripheral areas on leisure-oriented tourism. These dimensions were defined independently of the observed ΔS and QRI values and were used solely as a descriptive framework for organising spatial variation.

City counties were identified on the basis of their formal administrative status as cities

with county rights. The remaining types were defined using geographical and transport criteria established independently of the stage-level ΔS and QRI values. Border-adjacent counties were defined as counties directly sharing the state border with Ukraine. Transport-corridor counties were defined as counties crossed by a motorway or an expressway. This operational definition is based on road class rather than on formal European-route designation. Consequently, international routes such as E372 and E373 are not treated as separate corridor criteria where their Polish sections do not have motorway or expressway status, whereas S19 is included because it meets the adopted high-capacity-road criterion. The category should therefore be interpreted as an indicator of high-capacity road accessibility rather than as an exhaustive representation of international transport connectivity. Mountain/peripheral tourism counties were identified on the basis of their geographical characteristics and location within the mountain belt extending along the Polish–Slovak border.

Using the stage-level values of ΔS, we summarised the distribution of each county type in every stage by reporting the number of counties (n), mean, median, standard deviation, interquartile range (Q1–Q3), and the shares of counties with positive and negative ΔS. Because the stage-level ΔS values had already been calculated as day-weighted aggregates for months intersected by stage boundaries, no additional temporal weighting was applied when computing the within-type stage summaries. The same county membership was used for the component decomposition and QRI summaries. The resulting statistics are reported in Appendix B, Table B1. Because ΔS is defined only for 2022 relative to 2021, the Stage 5 accommodation summaries are based exclusively on the part of that stage falling within 2022, namely 11-31 December 2022. Stage 6 is not included in these summaries because it falls outside the accommodation-data comparison period.

Counties were ordered automatically via hierarchical clustering of the five-stage profiles $\{\Delta S_{i,s}\}_{s=1}^{5}$ so that adjacent rows represent counties with similar change trajectories.

Since ΔS is defined only for 2022 relative to 2021, a five-stage heatmap is reported. Stage 6 (Jan–Feb 2023) is discussed in the mobility staging (Section *Results – Border crossings*) but is not mapped here because it lies outside the 2021-2022 comparison window. These outputs are interpreted in relation to transport accessibility and corridor–periphery patterns (Fig. 1).

First, we mapped the mean value of ΔS across the 12 months for each county, capturing the overall direction and magnitude of year-on-year relative change. Second, we mapped within-year variability of ΔS, measured as the standard deviation (SD) of monthly $\Delta S_{i,m}$, to identify counties with more volatile versus more stable relative accommodation-utilisation outcomes (ΔS). The mean-ΔS map used the same fixed discrete thresholds as the heatmap to keep interpretation consistent, whereas the SD map was classified separately using discrete classes (because variability is non-directional and non-negative).

Spatial analysis is then conducted by examining the distribution of $\Delta S_{i,m}$ across counties and months and interpreting patterns in relation to transport accessibility and corridor effects versus more peripheral mountain or rural areas (Fig. 1). Finally, the six-stage mobility framework derived from daily border crossings is used to contextualise the timing and direction of accommodation dynamics, linking shifts in cross-border mobility regimes to observed reconfigurations of hospitality-sector utilisation.

The resulting stage-level values $\Delta S_{i,s}$ provide the basis for the presentation and interpretation of results in the *Results* section (*The synthetic index*), where patterns of accommodation-utilisation change are linked directly to the six mobility regimes identified in Section *Results – Border crossings*.

To examine whether changes in registered accommodation-use profiles were relatively more strongly shaped by longer stays than by user-intensity components, we decomposed stage-level synthetic-index change into its

three standardised components. Using the same day-weighted aggregation as for ΔS, we computed stage-level component changes for each county: ΔZD (Defert component), ΔZF (foreign-visitor Defert component), and ΔZL (length-of-stay component). We then defined a Quasi-Residential Index (QRI) as:

$$QRI_{i,s} = \Delta ZL_{i,s} - \frac{1}{2}(\Delta ZD_{i,s} + \Delta ZF_{i,s})$$

Positive QRI indicates that the change in the length-of-stay component is more favourable, or less negative, than the average change in the two accommodation-user intensity components. Negative QRI indicates the opposite. QRI therefore measures the relative composition of the change profile rather than its overall direction. A positive QRI may coexist with a negative ΔS and does not necessarily imply that average length of stay, total overnight stays or overall registered accommodation use increased. It identifies only the relative dominance of the length-of-stay component within the year-on-year change profile.

Positive QRI is interpreted as a longer-stay signature that may be consistent with quasi-residential or labour-related use, but it does not demonstrate growth in total accommodation use, identify the purpose or status of accommodated persons, or establish the functional conversion of individual establishments. Group–stage summaries of ΔS, its component changes and QRI are reported in Appendix B (Tab. B1).

Results

Border crossings

Daily Polish–Ukrainian border-crossing data for 1 January 2022-28 February 2023 were organised into six descriptively defined mobility stages using the procedure specified in the Materials and Methods section. The stages capture persistent changes in the level, direction and regularity of mobility and provide a temporal context for the registered accommodation-use analysis. They should not be interpreted as formal statistical regimes or as direct classifications of accommodation demand.

Stage 1 (1 Jan–23 Feb 2022: Pre-invasion baseline). The baseline regime was stable

Table 1. Operational delimitation and descriptive statistics of Polish–Ukrainian cross-border mobility stages, 1 January 2022-28 February 2023

Stage	Date range	Days (n)	Mean to Poland	Mean to Ukraine	Mean net (PL–UA)	Share to Poland (mean)	% days net > 0	Cumulative net
Pre-invasion baseline	1 Jan–23 Feb 2022	54	15,685	10,537	5,148	0.595	94.4	278,002
Acute displacement shock	24 Feb–14 Apr 2022	50	55,020	13,023	41,997	0.748	100.0	2,099,833
Adaptation and circular mobility	15 Apr–10 Oct 2022	179	23,289	25,140	–1,851	0.483	30.2	–331,285
Regularised mobility	11 Oct–10 Dec 2022	61	23,042	21,951	1,091	0.513	72.1	66,567
Christmas travel window	11 Dec 2022-6 Jan 2023	27	23,579	25,662	–2,083	0.482	29.6	–56,245
Post-holiday inflow	7 Jan–28 Feb 2023	53	22,172	19,783	2,389	0.528	73.6	126,601

Note: The stage boundaries were defined through descriptive segmentation of persistent changes in the level, direction and regularity of daily border flows. They were not estimated using a formal statistical change-point model. Stage labels describe mobility regimes and do not identify the purpose of travel or the type of accommodation subsequently used.

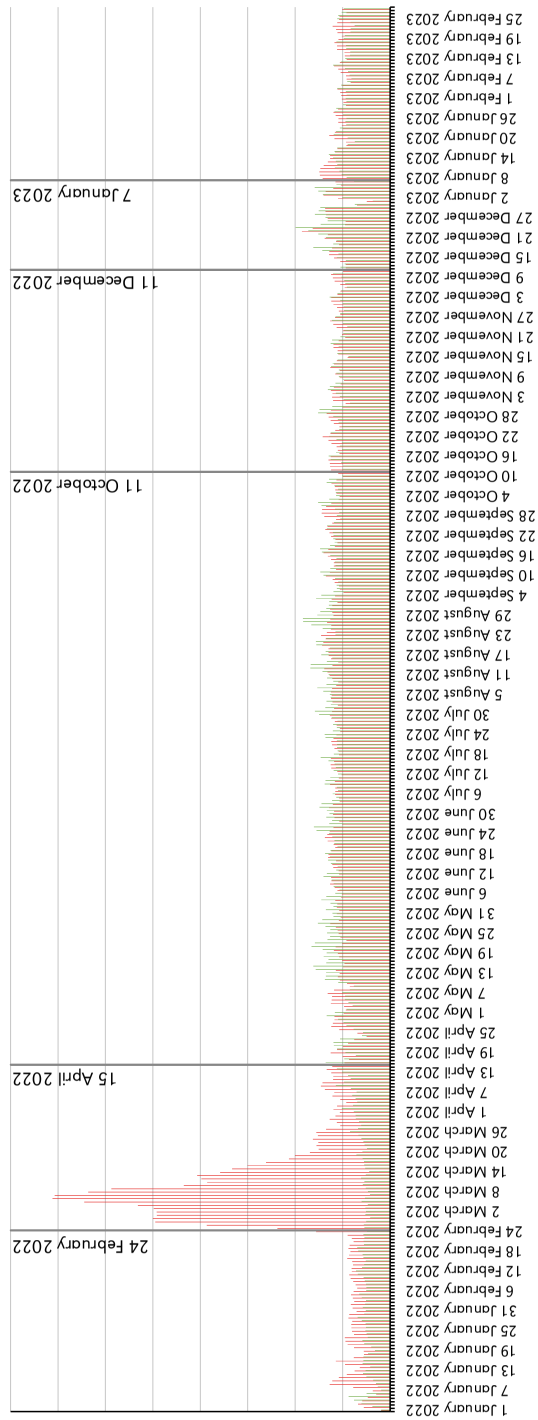


Figure 2. Crossing the Polish–Ukrainian border between 1 Jan 2022 and 28 Feb 2023

and inflow-oriented: on average 15,685/day crossings to Poland vs 10,537/day to Ukraine, yielding +5148/day net (mean "to Poland" share 0.595, 94.4% net-positive days). For accommodation markets, this corresponds to standard seasonal and weekend mechanisms, with no sustained disruption signals.

Stage 2 (24 Feb–14 Apr 2022: Acute displacement shock). Mobility shifted abruptly to crisis mode: mean crossings to Poland rose to 55,020/day, while crossings to Ukraine averaged 13,023/day (net +41,997/day, "to Poland" share 0.748, 100% net-positive days). The inflow peak occurred on 6 March (142,298 crossings to Poland). Within the same stage, inflows decline while returns gradually increase, suggesting a shift from acute mass displacement to more differentiated mobility strategies. The border-flow pattern is consistent with substantial emergency and transit-related accommodation pressure during this stage. However, the accommodation dataset does not identify which stays were refugee-related or whether individual establishments were functionally reallocated.

Stage 3 (15 Apr–10 Oct 2022: Adaptation and circular mobility). Volumes remain high but directionality reverses: 23,289/day to Poland and 25,140/day to Ukraine (net –1851/day, "to Poland" share 0.483, only 30.2% net-positive days). This directional reversal is consistent with more circular mobility, although the border-flow data do not identify specific trip purposes. For the interpretation of registered accommodation-use patterns, this stage provides a context of the fading of purely emergency demand and rising spatial heterogeneity: transport nodes and urban centres tend to be more resilient than leisure-dependent markets.

Stage 4 (11 Oct–10 Dec 2022: Regularised mobility). Mobility becomes more symmetric and predictable: 23,042/day to Poland vs 21,951/day to Ukraine (net +1091/day, share 0.513, 72.1% net-positive days). Day-to-day variability aligns less with "shock" events and more with weekly rhythms and socio-economic determinants. For the interpretation of registered accommodation-use patterns, this stage provides a context of a stronger role of "normalising" demand (work, education, family visits) and greater dependence on local market characteristics and connectivity.

Stage 5 (11 Dec 2022-6 Jan 2023: Christmas travel window). The calendar temporarily flips the balance: 23,579/day to Poland vs 25,662/day to Ukraine (net –2083/day, share 0.482). Peaks occur on 23 Dec (crossings to Poland 37,183) and 24 Dec (crossings to Ukraine 39,870, the maximum of the "to Ukraine" series). This is short-term, predictable volatility ("travel windows"), relevant for occupancy and capacity planning, while also sensitive to border and transport bottlenecks.

Stage 6 (7 Jan–28 Feb 2023: Post-holiday inflow). A moderately inflow-oriented pattern crossings: 22,172/day to Poland vs 19,783/day to Ukraine (net +2389/day, share 0.528, 73.6% net-positive days). The boundary shift is immediate after the Orthodox-holiday window, and flows become more regular–best interpreted through economic and social mechanisms (circular mobility, work, household rotation). After the holiday window, flows returned to a moderately Poland-oriented and more regular pattern. Because the accommodation dataset ends in 2022, Stage 6 is used only as descriptive mobility context and is not interpreted in terms of accommodation outcomes.

Overall, the six stages form a coherent sequence: pre-war normality, a refugee-mobility shock, adaptation, stabilisation, and short-lived seasonal/calendar deviations. This provides the interpretive backdrop for the accommodation-utilisation patterns analysed in the subsequent subsections.

The synthetic index

The outbreak of Russia's full-scale invasion of Ukraine in February 2022 created a new context for cross-border mobility and for the dynamics of accommodation utilisation in Eastern Poland. Throughout this section, the foreign-user component (F/ΔZF) refers to registered non-resident accommodation users irrespective of nationality and is interpreted alongside, rather than attributed to, the

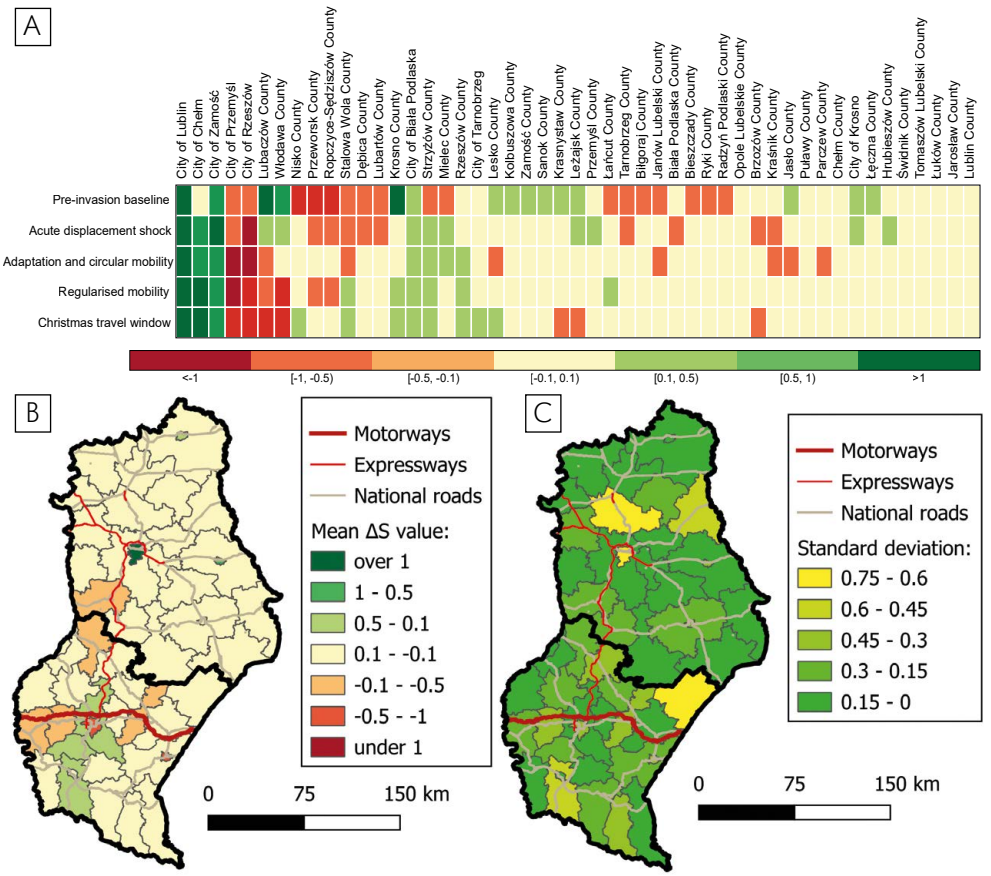


Figure 3. Stage-level year-on-year change in the synthetic accommodation-utilisation index (a) stage heatmap of day-weighted ΔS; (b) mean ΔS; (c) within-year variability of ΔS (SD)

Polish–Ukrainian cross-border mobility stages. Therefore, year-on-year differences in the synthetic index (2022 relative to 2021) at the monthly–county level (Fig. 3) are interpreted as relative shifts (ΔS) in accommodation-utilisation profiles, i.e., changes in counties' within-month cross-county positioning rather than absolute utilisation changes, within a "hybrid" logic that links spatial and seasonal patterns to the mobility stages identified in Section *Results – Border crossings* (Tab. 2).

Figure 3 synthesises the spatio-temporal differentiation of year-on-year relative accommodation-utilisation change (ΔS, 2022 vs 2021) using the mobility-stage framework. Panel A (heatmap) reports stage-aggregated ΔS values for Stages 1-5, while Panels B–C provide two spatial summaries: the mean ΔS level and the within-year variability of change (SD) in 2022.

Panel A reveals three contrasting trajectories. First, a clearly positive profile concentrates in major urban nodes, most notably the City of Lublin, where ΔS is already positive in Stage 1 (≈ 1.02) and peaks in Stage 2 (≈ 2.85), remaining high in Stages 3-5 (≈ 1.59, 1.37, 1.26). A similar, persistently positive pattern is visible for the Cities of Zamość and Chełm across Stages 1-5. Second, a persistent negative trajectory characterises selected city counties, especially the City of Przemyśl and the City of Rzeszów, with negative values across all stages and Stage-3-to-Stage-5 levels around –0.9 to –1.2 (e.g., City of Przemyśl: ≈–1.21, –1.19, –1.00, City of Rzeszów: ≈–1.06,

−0.90, −0.89). Third, several counties shift from negative or near-neutral values early in the year to positive values in late-2022 Stages 4-5, a pattern that can be described as "delayed normalisation" (e.g., Nisko County: ≈−0.72 → 0.07 → 0.43, Stalowa Wola County: ≈−0.49, −0.19, −0.15 → 0.17, 0.17).

The strongest heterogeneity occurs in Stage 2 (the mobility shock): some counties, especially the largest cities, record very large increases, whereas many counties remain close to zero or on the negative side. In Stage 3, corresponding to sustained high flows with changed directionality, polarisation persists: stable positive urban nodes coexist with counties showing sustained decline (notably selected city counties) and with border-adjacent counties that turn negative towards the end of the year (e.g., Lubaczów County, moving from positive Stages 1-2 to negative Stages 3-5).

Panel B (the mean ΔS map for 2022) indicates that positive relative shifts (ΔS > 0) are concentrated in a small number of counties, led by the City of Lublin (mean ≈ 1.62), followed by the City of Zamość (≈ 0.94) and the City of Chełm (≈ 0.74). The City of Biała Podlaska is also positive (≈ 0.31). In contrast, the two strongest negative outliers are the City of Przemyśl (≈ −0.97) and the City of Rzeszów (≈ −0.95). Most land counties cluster near zero, implying that average year-on-year relative shifts (ΔS) are generally moderate, while the strongest net reconfiguration is concentrated in selected urban nodes. Panel C (SD) highlights where change was most turbulent within 2022. The highest variability is observed for Lubaczów County (SD ≈ 0.74) and the City of Lublin (≈ 0.69), followed by counties with high sensitivity to demand reallocation (e.g., Krosno County ≈ 0.56, Włodawa County ≈ 0.46, the City of Zamość ≈ 0.43, the City of Przemyśl ≈ 0.42, the City of Chełm ≈ 0.42, the City of Rzeszów ≈ 0.41). Low SD in several counties (e.g., Łuków County ≈ 0.01, Świdnik County ≈ 0.03, Lublin County ≈ 0.04) points to a stable, weakly reactive year-on-year profile. Taken together, Panels A–C suggest that the mobility shock interacted with local market structure: some counties absorbed a sustained positive utilisation impulse, some experienced consistent weakening, and high-variability areas reflect intensive within-year adjustment.

Table 2 provides a compact interpretive bridge between monthly ΔS patterns (Fig. 3) and the six mobility regimes identified in Section *Results – Border crossings* (Tab. 1), enabling a consistent "hybrid" reading that combines mobility dynamics, seasonality and local market structure.

In addition, Appendix B (Tab. B1) provides stage-level summaries by county type. Because county-type membership may overlap, these results are interpreted as within-type descriptive summaries supporting the corridor–periphery comparison rather than as mutually exclusive group comparisons.

Table B1 in Appendix B shows that the strongest positive relative shift during the shock stage is concentrated in city counties (Stage 2 mean ≈ 0.50, median ≈ 0.30, 75% with ΔS > 0), while border-adjacent counties are positive mainly in Stage 2 (mean ≈ 0.10) but turn negative in Stages 3-5 (means around −0.03 to −0.08). Mountain counties are strongly positive Pre-invasion baseline (Stage 1 mean ≈ 0.32) but negative in Stage 3 (mean ≈ −0.08), consistent with higher sensitivity of leisure-oriented markets. Corridor counties shift from a negative Stage 1 profile (mean ≈ −0.26) towards predominantly positive outcomes by Stage 5 (mean ≈ 0.07, 92% with ΔS > 0), indicating late-year normalisation along better-connected axes.

ΔS and QRI describe different dimensions of the same component profile. ΔS summarises the overall direction of the three component changes, whereas QRI compares the length-of-stay component with the average of the two user-intensity components. Consequently, a county or county type may have a negative ΔS but a positive QRI when user intensity declines more strongly than the length-of-stay component.

Component decomposition provides additional information on the relative structure of accommodation-use change. Table B1 in Appendix B shows that mountain/peripheral

Table 2. Linking mobility regimes (Section *Results – Border crossings*) to monthly changes in the synthetic index (Section *Results – The synthetic index*)

Stage	Date range (mobility)	Months observable in 2022 (Fig. 3)	Dominant mobility mechanism	Expected / observed relative ΔS signal (2022 vs 2021)	Typical spatial imprint (Fig. 3)	Accommodation-demand interpretation
Pre-invasion baseline	1 Jan–23 Feb 2022	Jan–Feb*	Seasonality + weekend rhythm	Mostly moderate shifts; corridor-type increases	Transport corridors, larger centres	Demand largely seasonal; no abrupt functional shift
Acute displacement shock	24 Feb–14 Apr 2022	Mar (plus parts of Feb* and Apr*)	Shock + inflow absorption	Strong heterogeneity (up and down simultaneously)	Nodes/ corridors vs peripheries	Overlap of emergency demand and weaker leisure demand
Adaptation and circular mobility	15 Apr–10 Oct 2022	Apr*, May–Sep	Circulation and adaptation	Pattern consolidation; possible mid-summer declines	More stable corridors; higher sensitivity of leisure areas	Substitution and demand-profile change
Regularised mobility	11 Oct–10 Dec 2022	Oct*, Nov (plus part of Dec*)	More regular flows	No uniform rebound; locally contingent deviations	Mixed, uneven picture	Local market structure matters more
Christmas travel window	11 Dec 2022–6 Jan 2023	Dec*	Calendar effect	Short deviations; sign not necessarily stable	Nodes/cities differ from peripheries	Peaks/troughs in holiday windows; more predictable timing
Post-holiday inflow	7 Jan–28 Feb 2023	– (outside 2022 / Figure 3)	Regularisation + economic component	Outside Figure 3 (no 2023 in 2021-2022 comparison)	–	Relevant for 3.1, not observed in 2022 monthly ΔS

* mixed month

Note: Stages are defined on daily border-crossing data (Section *Results – Border crossings*), whereas ΔS is measured at the monthly level (Section *Results – The synthetic index*). Therefore, months that straddle stage boundaries (February, April, October and December 2022) should be treated as transition months and interpreted as reflecting mixed mobility mechanisms

counties have positive median QRI in Stage 1 (0.75), Stage 4 (0.13) and Stage 5 (0.05), with ΔZL being the largest component in 80%, 60% and 60% of counties, respectively. Transport-corridor counties have negative median QRI in Stages 1-4 (–0.33, –0.36, –0.16 and –0.09) and a neutral median in Stage 5 (0.00). City counties remain QRI-negative throughout (–0.89 to –0.27), while border-adjacent counties show only a small positive median QRI in Stage 2 (0.03). These patterns describe the relative composition of change and should not be interpreted as direct evidence of particular accommodation functions.

The remainder of this subsection interprets the month-by-month ΔS pattern (2022 vs 2021) while consistently referencing the stage framework from Section *Results – Border crossings*.

In January–February 2022 (Stage 1: Pre-invasion baseline), the pattern of change

remains closest to "normal" seasonality: positive relative shifts in ΔS more often emerge along major accessibility axes and in larger centres, consistent with the absence of a sustained functional shift in the accommodation market before 24 February and with localised positive ΔS values plausibly reflecting winter tourism combined with early signals of cross-border mobility.

In March 2022 (Stage 2: the onset of the invasion and crisis mobility), the index becomes markedly heterogeneous: some counties record sharp positive relative shifts in ΔS, while others remain near zero or turn negative, illustrating the dual pressures affecting accommodation systems under shock – simultaneously absorbing demand associated with short, often transit-oriented stays by foreigners while losing part of leisure demand in segments more sensitive to uncertainty.

Across April–May (the Stage 2 boundary and the transition into Stage 3: adaptation and increasing circulation), these tendencies partly consolidate: relatively stronger relative outcomes (higher ΔS) more often appear in node-type and transit-oriented locations, particularly along key transport corridors such as the A4 motorway and the S19 expressway, and in selected mountain areas, whereas more peripheral counties show weaker dynamics, indicating the growing importance of local supply characteristics and demand composition.

Summer 2022, especially July and August (Stage 3), is characterised by a reversal: despite seasonally favourable conditions, many counties exhibit negative relative shifts in ΔS, with the most pronounced negative ΔS values observed in parts of the Carpathians and in selected border-adjacent counties, supporting a substitution interpretation whereby some traditional leisure demand may have been redirected to alternative destinations while, in parallel, the observed combination of lower visitor intensity and changing length-of-stay profiles may be compatible with a greater role of non-leisure stays. The aggregate data do not allow these stays to be attributed to particular user groups or to the functional conversion of specific establishments.

From September onwards (late Stage 3), spatial differentiation intensifies again and does not converge into a single recovery mechanism: counties along the A4 corridor more often maintain relatively stable ΔS levels, whereas mountain areas more often show persistent weakness, and the September–October pattern remains irregular, suggesting the absence of one dominant "engine" of improvement.

In November and December 2022 (Stage 4: Regularised mobility and the beginning of Stage 5: Christmas travel window), fluctuations appear more seasonal and locally conditioned than event-driven, monthly data do not reveal a clear short-run imprint of the Przewodów incident (15 November 2022), implying that brief geopolitical shocks do not necessarily translate into statistically visible changes in accommodation utilisation and that observed movements are better explained by seasonality and local capacity constraints.

In cross-sectional terms, the 2021-2022 comparison shows that most counties exhibit positive ΔS values, while negative ΔS concentrated in a limited set of counties (including Bieszczady, Brzozów, Chełm, Kraśnik, Łuków, and Włodawa Counties), which may reflect higher structural vulnerability, more limited adaptive capacity, or stronger dependence on demand segments less resilient to uncertainty.

Figure 3 shows that the mobility shock overlapped with tourism seasonality and produced both gains and losses across space. The synthetic index helps separate stage-level disruption from county-level reconfiguration in utilisation profiles.

Together, the heatmap and the mean/SD maps show that reconfiguration aligned with the mobility regimes identified in Section *Results* (*Border crossings*) – from shock absorption in Stage 2, through adaptation and increased circulation in Stage 3, to more regular and locally contingent deviations in Stages 4-5.

Discussion

Our results show that year-on-year changes in registered accommodation use in Eastern Poland are better characterised as a spatial reconfiguration of relative utilisation profiles than as a uniform decline. As summarised in Figure 3, corridor and nodal counties tend to sustain or improve their relative positions, whereas peripheral mountain and rural counties show more persistent weakening. In some of the latter areas, the component structure is dominated by longer-stay signatures. These signatures may be compatible with temporary, quasi-residential or labour-related use, but they do not directly demonstrate the repurposing of accommodation establishments.

The registered accommodation statistics capture users and overnight stays but do not classify stays by motive. Accordingly, the empirical results identify changes in utilisation profiles, whereas leisure, emergency or transit, labour-related and quasi-residential functions remain contextual and potentially overlapping interpretations. Temporary accommodation is used as the broader category, while quasi-residential use refers more narrowly to longer stays that may resemble temporary residence.

QRI is used only to characterise the relative composition of these changes. A positive QRI indicates that the length-of-stay component is more favourable, or less negative, than the two user-intensity components on average. It may therefore coexist with a negative ΔS and does not by itself indicate overall growth in registered accommodation use or establish that temporary housing occurred.

Building on the mobility-stage framework, we interpret these patterns as a shift from short-run shock absorption to spatially differentiated adaptation in registered accommodation utilisation. Combining border-crossing data with the synthetic accommodation index lets us track how demand and utilisation changed as the crisis evolved. Early in the war we see sharp swings, but over time ΔS points to spatial reconfiguration rather than a uniform decline across the region.

In the first weeks after 24 February 2022, tourism and accommodation patterns in Eastern Poland changed abruptly. The observed surge in border crossings corresponded to an extraordinary influx of refugees, temporarily reshaping accommodation demand and relative utilisation patterns (as reflected in ΔS). This kind of short-run disruption has also been reported for other conflict-adjacent regions (Hall, 2010). Unlike cases that show a clearer post-crisis decline (Avraham, 2016; Tkalec & Žilić, 2021), Eastern Poland does not show a uniform long-term weakening in relative ΔS. The dominant pattern is spatial reconfiguration consistent with adaptation. Instead, the evidence points to structural adaptation: ΔS becomes increasingly spatially differentiated, and part of the accommodation stock appears to shift toward quasi-residential use. Component decomposition supports this interpretation: in peripheral mountain counties (and, during the shock, some border-adjacent counties), positive QRI means longer stays (ΔZL) dominate over intensity shifts (ΔZD, ΔZF), consistent with quasi-residential or labour-related use rather than leisure turnover (Appendix B). This fits an adaptive-resilience view: accommodation and tourism-related service can reorganise rather than simply contract under an external shock (Brouder, 2020).

The synthetic index, combining the Defert-based accommodation-user intensity, its foreign-visitor variant, and average length of stay, highlights spatial asymmetries that are less visible in single indicators. Counties along major transport corridors maintained relatively stable or improving relative index outcomes (ΔS), whereas more peripheral tourist areas recorded persistent negative ΔS values. This spatial polarisation suggests that accessibility and diversification of accommodation functions played decisive roles in determining regional resilience. Previous research similarly suggests that infrastructure and economic conditions can cushion tourism systems against shocks (Becken & Hughey, 2013; Duro et al., 2021).

Figure 3 summarises the direction and stability of ΔS across counties and stages.

Table B1 in Appendix B provides descriptive support for H1 by showing how ΔS and its component structure vary across mobility stages within the four county types. In Stage 2, positive ΔS concentrates in city counties and, temporarily, border-adjacent counties–consistent with institutionally mediated mechanisms such as humanitarian inflows, border procedures, and emergency coordination. In later stages, the border-adjacent advantage fades, while corridor counties turn more positive by Stage 5–consistent with regularised socio-economic mechanisms (circular mobility, labour travel, and predictable calendar windows) rather than purely political drivers.

The temporal trajectory of changes in the synthetic index is consistent with the hypothesised shift from politically driven to economically driven determinants of ΔS. ΔS is observed only for 2022 relative to 2021 (Stages 1-5). Stage 6 (Jan–Feb 2023) is used only to contextualise mobility, not to map accommodation change. In early 2022, geopolitical and humanitarian factors likely played a dominant role in shaping relative accommodation-utilisation patterns (ΔS), whereas by late 2022 and early 2023 the observed regularisation is more consistent with socio-economic mechanisms linked to regularised socio-economic mobility (work- and household-related circulation). A similar gradual normalisation has been reported for other regions exposed to prolonged shocks (Biggs et al., 2012; Simmie & Martin, 2010). Resilience in the wider frontier region likely reflects both sector flexibility and the stabilising role of state policy and EU support.

Monthly ΔS does not show a clear break after high-profile incidents (e.g., Przewodów), but monthly aggregation may miss short-lived effects. The observed patterns are therefore more plausibly attributed to seasonality and local market structure than to single-day events. This observation aligns with Fuchs and Reichel (2011) and Cahyanto et al. (2016), who argue that risk perception in tourism is mediated by institutional credibility and effective crisis communication.

Despite the overall stability of relative spatial patterns in many counties, disparities persist: the largest negative signals concentrate in selected city counties, notably the Cities of Przemyśl and Rzeszów, while several counties exhibit mixed, stage-dependent trajectories rather than monotonic decline. This pattern suggests higher vulnerability where accommodation depends heavily on seasonal, leisure-oriented demand. As Cheer & Lew (2017) note, diversification remains the key determinant of resilience in peripheral tourism economies.

The results speak to how geopolitical instability reshapes tourism dynamics over time. They suggest that disruption can accelerate structural change and push tourism systems toward more multi-functional forms (Biggs et al., 2012; Brouder, 2020). For practice, tourism policy in frontier regions exposed to geopolitical risk should link risk management with spatial planning and cross-sector coordination.

The risk matrix is contextual rather than a test, but the ΔS/QRI patterns align most clearly with demand-structure shifts and risk-perception/security mechanisms summarised in the Introduction and detailed in Appendix A.

Beyond sectoral adjustment, the findings point to resilience as a governance issue in EU frontier regions. The observed corridor–periphery polarisation suggests that relative accommodation-utilisation outcomes (ΔS) under geopolitical stress depend not only on market recovery but also on how mobility infrastructures, administrative capacity, and cross-sectoral arrangements channel and stabilise demand. Hospitality capacity can act as a regional buffer in crises, but the costs and benefits of that role are unevenly distributed across space.

At the EU's eastern frontier, resilience is not only a tourism-sector issue. Accommodation dynamics respond to mobility regimes and institutional responses, which calls for coordination across tourism, transport, social policy, and crisis management. Spatial planning and regional development strategies should recognise that prolonged crises can reconfigure the functions of accommodation

infrastructure, potentially shifting parts of the sector toward quasi-residential use. Policies aimed at sustaining tourism in frontier regions need to account for geopolitical risk and spatial differentiation, rather than assuming a uniform recovery.

Where longer-stay use persists, its long-term local effects may be ambivalent. Registered accommodation may provide a transitional buffer, sustain accommodation businesses and employment, and reduce immediate pressure on the rental market. Prolonged reliance on it as de facto housing may, however, delay access to stable housing, constrain tourism capacity and concentrate demand for schools, health care, transport and social assistance in particular municipalities. It may also conceal shortages in the conventional housing stock and shift part of the organisational and financial burden to local authorities. These are plausible implications of longer-stay profiles rather than outcomes measured directly in this study.

Implications for urban and regional policy

The findings suggest that accommodation infrastructure in frontier regions should be treated as part of crisis housing and service capacity, not solely as a tourism asset. First, city and regional authorities can improve preparedness by integrating hotels and guesthouses into emergency planning frameworks (procurement, minimum standards, information-sharing and reimbursement mechanisms) alongside welfare and housing services. Second, the corridor–node pattern indicates that transport accessibility and administrative capacity shape where temporary accommodation demand concentrates. Capacity planning should therefore prioritise nodal cities and corridor municipalities where mobility pressure and service demand co-locate. Third, where longer-stay profiles persist, authorities should monitor them alongside rental availability, housing costs and demand for local services. This would help distinguish short-term buffering from longer-term substitution for stable housing and identify municipalities bearing disproportionate service costs. Cross-sector coordination across border/mobility governance, housing/temporary accommodation, spatial planning and regional development is thus central to building resilient frontier city-regions under protracted geopolitical stress.

Limitations

This study has several limitations concerning the scope of inference. The accommodation statistics cover establishments included in the official GUS reporting framework and therefore do not capture informal hosting or other accommodation activity outside that statistical system. The data do not identify refugee status, the nationality composition of all accommodated persons at the required county–month level, the purpose of individual stays or the formal conversion of particular establishments. Accordingly, the results should be read as evidence of relative changes in registered accommodation-use profiles, not as direct estimates of refugee accommodation or establishment-level repurposing. The foreign-visitor component is treated only as a broad contextual signal considered alongside border-crossing flows, and the interpretation of longer-stay patterns as potentially quasi-residential or labour-related remains inferential.

The mobility stages are based on a transparent but descriptive segmentation of the daily border-flow series rather than on formal statistical change-point estimation. Alternative boundary dates could modify the day-weighted stage aggregates, particularly for transition months.

The county typology is descriptive, non-mutually exclusive and based on a limited number of counties within each type. Its purpose is to organise spatial patterns rather than to estimate causal differences between territorial categories. Results for overlapping types should therefore be read as separate within-type summaries, and individual counties may contribute to more than one set of group statistics.

The use of 2021 as the reference year limits the interpretation of ΔS. Although comparison of identical calendar months reduces seasonal differences, 2021 may still reflect pandemic-related disruption and uneven recovery. The results should therefore be interpreted as relative year-on-year differences rather than as the isolated causal effect of the invasion.

The equal weighting of the three standardised components is also an analytical assumption. Although it provides a transparent specification without assigning a priori priority to any component, alternative weighting schemes could alter county rankings and the magnitude of ΔS. The findings should therefore be interpreted as conditional on the adopted equal-weight specification.

In a small number of county–month cells, values suppressed for statistical-confidentiality reasons were coded as zero. Because suppressed values are undisclosed rather than confirmed zeros, this treatment may affect the component indicators, ΔS and QRI, particularly in counties with small registered accommodation markets.

Future research should therefore employ microdata and combine quantitative and qualitative approaches, including surveys of accommodation providers and travellers, to capture the full spectrum of adaptive strategies and behavioural responses.

Overall, ΔS suggests that the hospitality sector in Eastern Poland remained flexible and adapted under severe geopolitical stress. The developed synthetic index enabled a nuanced assessment of these transformations, offering a potentially useful tool for comparative analyses in other crisis-affected frontier regions. The integration of political, economic, and social dimensions into a unified analytical framework provides both theoretical and practical insights into the functioning of tourism systems under extreme conditions.

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Data availability statement

The data and associated files are available in Mendeley Data at DOI: 10.17632/vvm2d-pxc4y.1. The data will be made publicly available upon acceptance.

Appendices

Appendix A presents the probability-impact scale and risk matrix used to contextualise the wider risk environment affecting accommodation and related service systems. Appendix B contains Table B1, which reports stage-level summaries of relative accommodation-use change (ΔS), its component decomposition and the Quasi-Residential Index (QRI) by county type. Both appendices accompany the revised manuscript and provide supporting material for the interpretations presented in the main text.

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During the preparation of this work, the authors used ChatGPT (GPT-5.2) in order to improve the clarity and language of the text. After using this tool, the authors reviewed and edited the content as needed and takes full responsibility for the content of the published article.

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Unless otherwise stated, the sources of tables and figures are the authors', on the basis of their own research.

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Appendix A. Risk framing: probability–impact scale and risk matrix

This appendix reports the probability–impact scale used to contextualise the risk environment affecting accommodation and related service systems in Eastern Poland during the first year of the Russian–Ukrainian war (Tab. A1) and the resulting assessment of key risks (Tab. A2). The framework is descriptive and intended to make prioritisation explicit and comparable across risks. It is not used as a statistical test. The main text draws on this framing only to situate observed changes in relative registered accommodation-use profiles within the broader crisis-governance context.

A.1 Risk categories (overview)

Against this governance backdrop, we identify the main risks affecting the hospitality sector in Eastern Poland and assess them using a probability–impact framework. The principal risk factors with the potential to influence the trajectory of the hospitality sector in the prevailing context include:

- humanitarian crisis – some organisations may focus on providing humanitarian aid and support to refugees, which may affect tourism infrastructure and the promotion of the region;
- a deterioration in security conditions – encompassing both a diminished psychological sense of safety (associated with geographical risk perception) and tangible threats (evidenced by an increased presence of military forces, as well as heightened cybersecurity vulnerabilities);
- rising operational costs – driven by increasing energy prices as a consequence of instability in raw material markets;
- macroeconomic instability and inflation – heightening the risk of recession across Europe, thereby dampening tourist flows;
- shifts in demand structure – the growing number of refugees contributes to a short-term increase in accommodation needs, yet this does not necessarily translate into revenue from leisure-oriented tourism;
- risk of conflict escalation – any expansion of military operations would further exacerbate uncertainty and could virtually halt tourist activity.

While framed here in hospitality-sector terms, these risks have direct implications for city-regional governance because they shape temporary accommodation demand and the capacity of local service systems to absorb mobility shocks under protracted crisis conditions.

The risk assessment framework applied in this study was designed to capture both the likelihood and severity of threats arising from the geopolitical situation and their potential impact on the hospitality sector in Poland. We first define a 0-10 probability–impact scale (Tab. A1) and then apply it to rate the main threats to the hospitality industry in Poland, drawing on the literature and empirical observations (Tab. A2).

A.2 Probability–impact scale

Table A1. Risk assessment scale for the hospitality industry

Rating	Likelihood	Severity
0	None – no risk	None – no impact
1	Very low – exceptionally rare; may occur once in several decades	Minimal – almost imperceptible
2	Low – unlikely but possible over a long period	Very low – easily mitigated
3	Moderately low – may occur once per decade	Low – noticeable but without significant operational consequences
4	Low-medium – may occur every few years	Moderately low – partially affects operations
5	Medium – fairly likely, recurring every few years	Medium – requires operational adjustments
6	Moderately high – expected in some years	Moderately high – may threaten profitability of weaker accommodation establishments
7	High – occurs regularly	High – significantly impacts financial performance
8	Very high – almost certain in the short term	Very high – significant risk to liquidity
9	Critical – almost certain and constant	Critical – serious threat to the entire sector
10	Certain – ongoing and inherent risk	Catastrophic – practical paralysis of the industry

A.3 Risk justifications (brief narrative)

The risk of a humanitarian crisis is associated with the likelihood of reallocating resources toward refugee assistance, potentially at the expense of investment in tourism. It is projected that in 2025 nearly one million refugees from Ukraine will require financial support, with more than USD 392 million allocated for this purpose (United Nations High Commissioner for Refugees [UNHCR], 2025). For the hospitality sector, this situation creates a dual challenge: while short- and long-term accommodation demand may temporarily rise due to refugee inflows, the diversion of public resources limits opportunities for structural investment in tourism infrastructure and service development. Consequently, accommodation establishments may experience asymmetric effects, with certain establishments benefiting from increased occupancy, while the broader sector faces constraints in modernisation and competitiveness.

The negative impact on safety does not necessarily need to reflect an actual security threat, but may instead manifest in a decline in tourists' perceived sense of safety. This perception is frequently shaped by international media narratives that portray Poland as being directly linked to the conflict zone. A comparable case was observed in the Balkans, where a study on Croatia during the Kosovo bombings in 1999 found that tourism enterprises, primarily accommodation establishments, experienced revenue losses of approximately 16.6% (Tkalec & Žilić, 2021).

The increase in business operating costs should be primarily analysed through rising prices, for which Russia had been the main foreign supplier prior to the outbreak of the war. The introduction of sanction packages, combined with attempts to diversify energy sources, significantly increased costs for end-users, resulting in a 10.3% rise in consumer prices in 2022 alone (Gradzewicz et al., 2024). The most notable change concerned natural gas prices: the Dutch TTF benchmark shows that between January 2021 and August 2022, the price rose from approximately EUR 20/MWh to over EUR 200/MWh (Dzierżanowski & Nowak, 2023).

Economic instability and inflation are closely linked to the risk of a recession in Europe, which may translate into a contraction in tourism demand. The rise in energy commodity prices has already contributed to a 2.8% decline in Poland's GDP (Gradzewicz et al., 2024). Furthermore, according to the European Commission's economic report (European Commission, 2023), Poland has consistently recorded one of the highest inflation rates within the EU since the outbreak of the war.

The concept of demand structure risk should be understood, inter alia, as rising demand for short-term accommodation that does not stimulate the expansion of the recreational tourism sector (EFE, 2023; Hess, 2024). Concurrently, decisions by numerous international corporations and Ukrainian enterprises to relocate employees and their families to Poland have generated substantial demand for long-term accommodation. This demand, only partially absorbed by the accommodation sector, underscores a structural reconfiguration of the market (Okhrimenko et al., 2024).

The risk of conflict escalation, although assessed as the least probable among the identified threats, would nevertheless have the most profound consequences for the hospitality sector. This vulnerability is supported by survey findings from Lithuanian travel agencies (Variakojienë et al., 2023), where 76% of respondents cited a "dangerous situation" as the primary reason for reservation cancellations.

A.4 Risk matrix

Table A2. Risk assessment of key threats to the hospitality industry in Poland

Risk	Likelihood (0-10)	Severity (0-10)	Justification of Likelihood / Severity
Humanitarian crisis	7 (recurring phenomenon since 2022)	6 (affects promotion and infrastructure, but does not paralyse the sector)	Hess, 2024; Okhrimenko et al., 2024
A deterioration in security conditions	8 (persistent in the perception of foreign visitors)	9 (mass cancellations of bookings in neighbouring regions)	Müller, 2022
Rising operational costs	9 (almost certain in the short term)	8 (may threaten profitability)	Gradzewicz et al., 2024
Macroeconomic instability and inflation	8 (economic forecasts remain uncertain)	8 (affects both demand and operating costs)	Szczepanik, 2022; OECD, 2025
Shifts in demand structure	7 (observed since 2022)	5 (local impact, without generating stable revenues)	Kiczmachowska, 2025
Risk of conflict escalation	5 (real but uncertain)	10 (practical paralysis of tourism activity)	Dieckelmann et al., 2024; UN Tourism, 2022

A.5 Regulatory context (brief note)

In addition to the risks that shape the situation within the accommodation sector, legal and regulatory conditions constitute a critical factor influencing the functioning and development of the hospitality industry. Łysienica (2023) highlighted the legal and political challenges associated with providing refugees access to accommodation facilities. She described the most significant discrepancies between Polish law and the Council Implementing Decision (EU) 2022/382

of 4 March 2022, as well as the legislative changes introduced to swiftly implement these regulations into national law.

A broader perspective on housing assistance for refugees from Ukraine was presented by Bőgel et al. (2024). In their study, they compared initiatives undertaken by residents and authorities in Kraków (Poland) and Tbilisi (Georgia). They highlighted the scale of financial aid and rapidly established accommodation facilities following the outbreak of the full-scale war. However, their analysis did not account for the prolonged nature of the conflict.

Appendix B. Stage-level summary of relative accommodation-use change (ΔS) and component decomposition by county type

This appendix reports group–stage summaries of component-level changes underlying the synthetic-index difference ΔS. For each county and mobility stage, we computed stage-level, day-weighted changes in the three standardised components: ΔZD (Defert-based registered accommodation-user intensity component), ΔZF (foreign-visitor registered accommodation-user intensity component), and ΔZL (length-of-stay component). To provide an empirical proxy for the dominance of longer stays relative to visitor-intensity signals, we defined the Quasi-Residential Index (QRI) as:

$$QRI_{i,s} = \Delta ZL_{i,s} - \frac{1}{2}(\Delta ZD_{i,s} + \Delta ZF_{i,s})$$

Positive QRI indicates that, relative to 2021, the county's change profile in a given stage is dominated by longer stays rather than by higher visitor intensity. Negative QRI indicates the opposite. Table B1 presents group–stage summaries of ΔS and group–stage medians of ΔZD, ΔZF, ΔZL and QRI, together with the share of counties for which ΔZL is the largest component within a given stage.

Table B1. Stage-level summary of relative accommodation-use change (ΔS) and component decomposition by county type

County type	Stage	ΔS mean	ΔS median	ΔS SD	%ΔS > 0	ΔZD median	ΔZF median	ΔZL median	QRI median	Share (L max)	n
Border-adjacent	1	0.00	-0.04	0.33	12%	0.01	0.01	-0.14	-0.17	12%	8
Border-adjacent	2	0.10	0.04	0.21	75%	0.02	0.01	0.06	0.03	62%	8
Border-adjacent	3	-0.03	-0.02	0.03	0%	0.00	0.01	-0.09	-0.09	0%	8
Border-adjacent	4	-0.08	-0.00	0.20	38%	0.01	0.01	-0.05	-0.06	25%	8
Border-adjacent	5	-0.08	-0.02	0.19	38%	0.01	0.01	-0.11	-0.12	12%	8
City counties	1	0.18	0.06	0.50	62%	0.78	0.00	-0.14	-0.89	0%	8
City counties	2	0.50	0.30	1.30	75%	1.28	0.28	-0.03	-0.39	0%	8
City counties	3	0.16	0.18	0.95	75%	0.79	0.31	-0.00	-0.27	0%	8
City counties	4	0.21	0.22	0.91	75%	1.13	0.48	-0.06	-0.37	12%	8
City counties	5	0.22	0.22	0.87	62%	1.13	0.30	-0.04	-0.34	12%	8
Transport-corridor	1	-0.26	-0.16	0.33	33%	0.03	0.00	-0.28	-0.33	10%	12
Transport-corridor	2	-0.06	-0.06	0.12	42%	0.06	0.00	-0.29	-0.36	20%	12
Transport-corridor	3	-0.02	-0.01	0.08	50%	0.03	0.00	-0.12	-0.16	30%	12
Transport-corridor	4	0.00	0.00	0.10	50%	0.01	0.00	-0.06	-0.09	30%	12
Transport-corridor	5	0.07	0.02	0.13	92%	0.01	0.00	0.01	0.00	50%	12
Mountain/peripheral	1	0.32	0.25	0.44	80%	0.07	0.00	0.75	0.75	80%	5
Mountain/peripheral	2	-0.04	-0.05	0.04	20%	0.03	0.01	-0.20	-0.23	20%	5
Mountain/peripheral	3	-0.08	-0.08	0.05	0%	0.00	0.00	-0.24	-0.25	0%	5
Mountain/peripheral	4	0.05	0.01	0.11	60%	0.00	0.00	0.10	0.13	60%	5
Mountain/peripheral	5	0.12	0.02	0.21	60%	0.00	0.00	0.05	0.05	60%	5

Note: The Defert-based components measure registered accommodation-user intensity and do not classify the purpose of stay. QRI measures the relative dominance of the length-of-stay component over the two user-intensity components. Positive QRI does not imply overall growth in registered accommodation use and may coexist with negative ΔS when the length-of-stay component declines less than the user-intensity components. It should not be interpreted as a direct measure of temporary housing, refugee accommodation or establishment-level functional conversion.