Journal Of the Iraqia University (76-1) April (2026)

ISSN(Print): 1813-4521 OnLine ISSN:2663-7502

Journal Of the Iraqia University

available online at

https://iasj.rdd.edu.iq/journals/journal/view/247

Spatial and Network Dynamics of Urban Transformation in Small Cities: The Case of Anah City, Iraq (2003-2024)

Dr. Haifa Abdel Wahab Saleh Mahmoud

General Directorate of Anbar Education

hifa.abdulwahab.pub@gmail.com

الديناميكيات المكانية والشبكية للتحول الحضري في المدن الصغيرة: حالة مدينة عنه، العراق (٢٠٠٣-٢٠٢٤)

م. د. هيفاء عبد الوهاب صالح محمود

المديرية العامة لتربية الأنبار

Abstract:

Objective This research aims to (exploring the spatial and demographic transformation) approach to Ana which is an urban small western city in Iraq using Spatial City Transformation Theory (SCTT). Through descriptive spatial analysis (2013–2024) combined with spatial econometric modeling, the study reveals multi-faceted city development dynamics. Results show two main trajectories of urban population growth, characterized by expansion in the peri-urban area and infill in the city as a whole, with rapid demographic increase (2003–2009) induced mainly by forced displacement and migration, followed by moderate levels of more stable growth. Estimating the spatial Durbin model with fixed effects (SDM-FE), it is revealed that local levels of income are significantly affected not just by internal factors such as unemployment and commercial activity but also by regional spillover effects from other towns within this region such as Qa'im, Rawah Akashat and Hit. It can be seen that the results lend strength to (SCTT), because economic growth in small cities are inseparable from their regions.**Keywords:** Spatial City Transformation Theory (SCTT); spatial econometric; small cities; urban sprawl; demographic trends; regional cascade development effects; Iraq Ana City Sustainable Urban.

ملخص

تتناول هذه الدراسة التحولات المكانية والديموغرافية والاقتصادية لمدينة عانة، وهي مدينة صغيرة تقع غرب العراق، من خلال منظور نظرية التحول المكاني للمدينة .(SCTT) ومن خلال دمج التحليل المكاني الوصفي (٢٠١٣-٢٠٢٤) مع النمذجة الاقتصادية القياسية المكانية، يُسلّط البحث الضوء على الديناميكيات متعددة الأبعاد التي تُشكّل تطور المدينة. تكشف النتائج عن نمطين رئيسيين للنمو الحضري – التوسع شبه الحضري والتطوير الداخلي – مصحوبين بطفرة ديموغرافية سريعة خلال الفترة ٢٠٠٣-٢٠٠٩، مدفوعةً بشكل كبير بالنزوح القسري والهجرة، تليها نمو معتدل وأكثر استقرارًا. يُظهر التحليل الاقتصادي القياسي باستخدام نموذج دوربين المكاني ذو التأثيرات الثابتة (SDM-FE) أن مستويات الدخل المحلية تتأثر بشكل كبير ليس فقط بالعوامل الداخلية كالبطالة والنشاط التجاري، ولكن أيضًا بالآثار غير المباشرة الإقليمية من المدن المجاورة (القائم، راوة، عكاشات، وهيت). تؤكد النتائج أن النمو الاقتصادي في المدن الصغيرة لا يمكن عزله عن سياقها الإقليمي، مما يؤكد الفرضية المركزية لنظرية التحول الحضري المكاني .(SCTT)**الكلمات المفتاحية:** نظرية التحول الحضري المكاني (SCTT)؛ القياس الاقتصادي المكاني؛ المدن الصغيرة؛ التوسع الحضري؛ الديناميكيات الديموغرافية؛ الآثار الجانبية الإقليمية؛ العراق؛ مدينة عنة؛ التخطيط الحضري المستدام.

Introduction

The demographic and economic changes of the early twenty-first century have had significant impacts on small urban centers globally consciously changing their spatial dynamics, requiring planning responses characterized by flexibility. And now secondary small urban places, ignored by megacities framing and dialogue (mecato), are starting to be considered in terms of local place based development. For example, sub-Saharan Africa's secondary cities have unique pathways from rural–urban linkages and migration patterns with significant implications for urban processes such as indicating what is necessary for development models that are sensitive to situated dynamics of mobility and livelihood geographies (Agergaard & Ortenbjerg, 2017).New research,

meanwhile, has focused attention on the flip side of movement of people to small towns: influx. In the USA, (post COVID-19 as) there was a surge of young white-collar professionals moving into smaller towns and cities that triggered an urban renaissance and created new business activity—also raised concerns about gentrification and social justice (Farberov 2025).At the level of governance, some small city research (e.g. Invercargill in New Zealand) demonstrates how place making leadership in concert with innovation and new forms of governance can unlock urban reinvention, despite being constrained by isolation and small population (James, K., et. al., 2015)In the light of aforementioned, Anah city has been taken as a case study for unconventional research in which many other small cities followed same economic and demographic changes under (2003-2023). It seeks to describe how, the population explosion and city building in this case have resulted into urban planning reactions, land use arrangements and infrastructure management approaches.

Research Problem

Although the big cities have been studied in the urban literature, there is little research of small cities such as Anah in western Iraq despite radical transformations demographic, economic and security fate during the (2003 - 2024), which had echoed deeply on its space morphology and roles. These shifts raise a fundamental question: standard models have an empirical shortage in accurately representing heterogeneous and nonlinear urban dynamics. The scope requires the testing of (SCTT's) explanatory power and the integration with (CST), on the one hand, and (UNT), (on the other); it also demands that spatial econometric approaches be used to understand patterns in interactions between neighboring cities-The practical guidelines to help planners decide should account for differences observed among small cities. This leads to the research question: to what extent (SCTT) can be a tool to explain the dynamics of urban change in Anah and characterize its spatial relations with other cities.

Research Hypothesis

The study is framed on the test of a null hypothesis (H_0) that there is no statistically significant impact of spatial dependence and network connectedness in explaining urbanization/ economic transformation in the city of Anah over (2003–2024). In contrast, the null hypothesis (H_1) asserts that spatial econometric models have little explanatory relevance (SAR, SEM, SDM, SAC), failing to account for how urban growth patterns and economic change are determined by forces of spatial interactions and network effects. This serves to further support the rationale of embedding (SCTT) within (CST) and?(UNT) structures as stronger explanatories.

Theoretical foundation

Today, these small towns confront a complex of interdependent problems due to transformation processes of spatial, economic and demographic nature that cannot be fully explained by linear models or simplistic explanations. Recent research has shown that their growth as cities has been far from uniformly incremental, but characterized by abrupt ruptures or discontinuities, sharp fluctuations and transitional stages which have fundamentally reconfigured the nature of their demographic and economic roles (Roberts et al., 2016; Bell & Jayne, 2019).

In weak or in transition areas, small cities become of great interest; they are at the same time prone to encounter crisis and with a dynamic ability to reshape their spatial social-economic profile. Frequently overshadowed in dominant and metropole-focused urban studies, megacities are important living laboratories on how people, economies and spatial formations inter-link under the impact of surprise shocks – including forced migration or security ruptures (Tacoli, 2018; Baker & Pedersen, 2020).

Toward the development of a framework for the urban spatial city transformation theory (SCTT)

The Complex Systems Theory (CST) underpinning, conceptualizes cities as complex adaptive systems (CAS) that emerge from nonlinear interactions between social, economic and spatial entities. These interactions result in emergent properties, self-organization and dynamic adaptation to the internal or external pressure (Batty, 2007; Holland, 1998; Mitchell, 2009). This approach allows a view of urban phenomena as results of interconnected processes rather than aggregations of disparate variables.

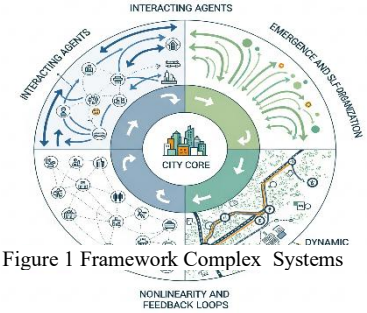


Figure 1 Framework Complex Systems

In stark contrast, Urban Network Theory (UNT) imagines cities as nodes in a set of overlapping scales; power derives from the form and nature of flows – be they monetary, social or informational – that flow through them rather than size alone. (Taylor, 1988; Taylor, 2004). This approach stresses the networked nature of urban development and variances between cities in their functional relationships with local or global systems.

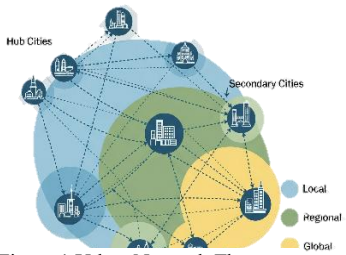


Figure 1 Urban Network Theory

However, both descriptions are incomplete by themselves to capture the special characteristics of small towns under irregular ruptures or non-linear transitions. This gap leads to the introduction of the (SCTT), which attempts to unify complexity dimension and network dimension in a single tool. (SCTT) attempts to address how urban fabrics are modified by spatial–social–economic interactions, particularly in vulnerable or post-conflict situations, which create unique effects related to adaptation and reconfiguration due to vibrant shocks or conflict.

Comparing Concepts of (SCTT) to (CST) and (UNT)

Dimension	Small Cities Transformation Theory (SCTT)	Complex Systems Theory (CST)	Urban Network Theory (UNT)
Transformation Focus	Emphasizes non-linear transformations in small towns: seasonal migration, income gaps, and mixed growth patterns.	Explains how simple interactions give rise to emergent macro patterns, such as spatial diffusion, collapse, or sudden expansion.	Demonstrates how development depends on networked relationships among cities, highlighting the influence of central cities on peripheral areas.
Spatial Focus	Positions local and regional spatial dimensions at the core of growth interpretation, especially the impact of proximity and neighboring contexts.	Considers space and resources as part of the system but often does not emphasize specific inter-city relationships among small towns in a regional context.	Focuses on inter-city relationships, flows, and core-periphery dynamics, but may overlook internal characteristics of smaller cities (density, local structures, governance).
Shocks and Adaptation	Addresses transformations resulting from shocks such as conflicts, migration, and their ongoing effects.	Rich in models explaining responses to sudden change and how structural properties emerge post-shock.	Often concerned with flows of opportunities and development; less emphasis on shocks or decline, though some studies integrate UNT with temporal recovery concepts.
Application and Policy Relevance	Provides actionable indicators: spatial dependency, impact of local activity and proximity, and policy tools to support planning in small towns.	Offers models to understand adaptation, resilience, and instability, but less focused on describing context-specific local policies constrained by capacity.	Commonly applied to guide regional connectivity policies, intercity transport, and support of economic networks between cities.

Urban Networks and Transformations: Empirical Insights

Several recent studies have advanced ideas closely aligned with the principles emphasized by (SCTT), demonstrating how both (CST) and (UNT) are applied in contemporary urban research. For instance, Sheng et al. (2019), in their article "Innovation efficiency and spatial spillover in urban agglomerations…", show that urban innovation efficiency is influenced not only by conditions within a given city but also by innovation performance in neighboring cities, with the strength of spillover effects varying according to spatial distance. This provides strong empirical evidence of spatial dependence and the functional role of urban networks. Similarly, the study "Urban network externalities, agglomeration economies and urban economic growth" (2020) highlights that network properties, such as closeness centrality, significantly affect economic growth, reinforcing the (UNT) perspective that intercity linkages matter at least as much as local factors in shaping development trajectories.Similarly, the paper "Complexity Urban Systems: Challenges and Integrated Solutions for Sustainability and Resilience of Cities" (2021) claims that utilizing an approach based on complexity science it is possible to make more effective assessments about how resilience impacts local structural factors and also feedbacks between urban systems and living surroundings. This view finds a match in (CST), which also points at non-linearity and systemic entanglements. A more recent study also show that multi-level innovation networks within and beyond urban agglomerations have discernible spillover effects on economic transactions ("Multi-Scaled Urban Innovation Networks … Automobile Manufacturing Industry … China," 2024). This gives a down-to-earth operational dimension to (UNT) by demonstrating how networked actions can be monitored and linked to sectoral activity.

Integrating SCTT–CST–UNT

Based on comparative understandings and empirical analysis, the model we propose links (SCTT) with intermediary theory that restructures both (CST) and (UNT) Perspectives. It draws on (CST) but also introduces ideas of nonlinearity, emergence, feedbacks and potential for shocks. From (UNT), it relied on concepts of connectivity/space-based interaction, spatial dependence, agglomeration effects and core–periphery forces/enclosures and commuting in intercity flows.

In this Heuristic the (SCTT) can be considered a relational theory comprising three, interrelated dimensions:

1.**The temporal–adaptive dimension (from CST):** Urban trajectories and how processes of expansion and contraction cause different temporal phases to interact.

2.**The spatial–network dimension (source: UNT):** drawing the mutual impact of neighboring cities from trade, mobility, services to resources exchange.

3.**The local–structural scale of urban form and resources:** the focus on density, infrastructure, labor markets, economic activity at local levels and place-based policies as constitutive elements influencing city-level processes.

This synthetic dimension enables (SCTT) to unite systemic complexity and networked spatiality, thus providing a holistic optic for grasping urban development in its temporal, spatial as well as local articulations. As the following model illustrates:

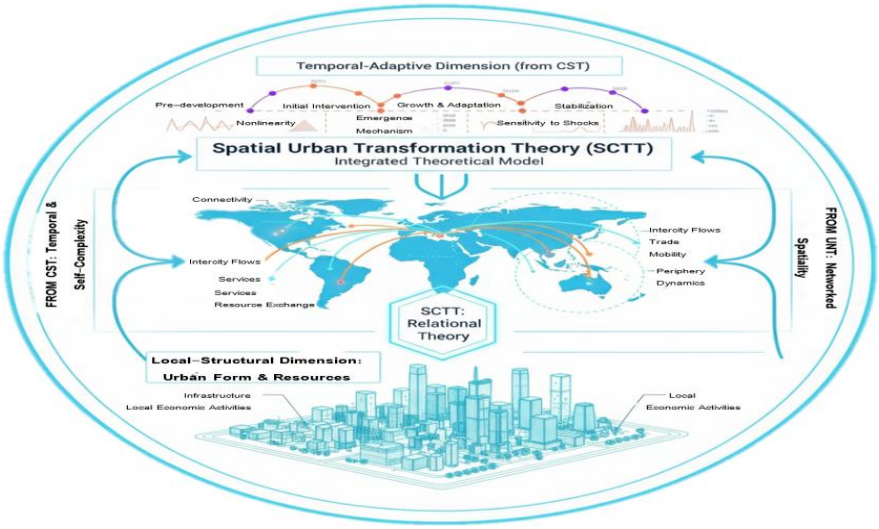


Figure 2 Framework Spatially Configured Transformation Theory (SCTT)

Small Cities Transformation Theory (SCTT) and the small-city change process:

Small Cities Transformation Theory (SCTT) provides a developing, and more subtle lens for making sense of the dynamics of urban change in small cities, especially as they are implicated by shock from outside or serious

demographic and economic challenges. What (SCTT) and complexity theory (CST) share is an sensitivity to non-linear urban dynamics and emergent phenomena in which small perturbations or changes−-outmigration, economic disinvestment, changing infrastructures—can make a large difference in the reformulation of overall structure. Second, (SCTT) is consistent with (UNT) on emphasizing the relevance of inter-city linkages: in other words, spatial inter-dependence and mutuality between cities are the key to understanding small urban centers' growth or decline.What makes (SCTT) distinctive is the combination of these two dimensions: the temporal/adaptive complexity of (CST) combined with the spatial/network approach of (UNT), coupled with a strong local emphasis in resources, population density, labor markets and local economic activity. South China Type Theory becomes a theoretical construct as well as an operational, testable framework, which can be generalized and accessed through tools such as spatial econometrics. Empirically, Sheng et al. (2019) and "Urban Network Externalities …" (2020), reveal that the networks and the flows between cities have 'real' effects on local economic growth, therefore underscoring (SCTT's) applied significance.This study thus argues that (SCTT's) explanatory power can be subjected to a robust test by descriptive and spatial-economic analyses—in other words, whether spatial dependence, complexity, and network linkages of urban systems are the main drivers of urban growth in a city such as 'Anah'. In addition, this approach could facilitate the creation of more specific, flexible and locally–regionally oriented urban planning instruments.

Description of the city under study:

Anah City A city in western Iraq, administratively belonging to Al-Anbar, in the Governorate of – has a vital position on the River Euphrates as if connects between middle Iraq and western Euphrates valleys. It is because it occupies a very crucial and strategic economic location, placing the city as a strategic hub between the large population centers and regional transportation corridors. As a result, Anah is an important trade, market hub. trade and other economic relations in the region. Despite the disruptions caused the growth of ISIS in the region, the city demonstrates how space contributes to urban form: If things are left alone for long enough if you starve people and deny them supplies and services subversive schools become normative. influence economic activity and spur regional integration.

Methodology

In order to confirm the proposed theoretical model, we used a multi-step methodology. The effect of population expansion on urban growth was then explored by descriptive and spatial analyses based on statistical data from Al-Anbar Governorate. The econometric analysis then used the Spatial Durbin Model with fixed effects (SDM–FE), which was chosen for its high level of explanatory power in explaining both spatial dependence in the dependent variable and spillover effects of independent variables among neighboring units. The model in general functional form is given

$$y_{it} = \rho \sum_{j=1}^{N} w_{ij} y_{jt} + X_{it}\beta + \sum_{j=1}^{N} w_{ij} X_{jt}\theta + \alpha_i + \gamma_t + \varepsilon_{it}$$

or, in matrix notation:

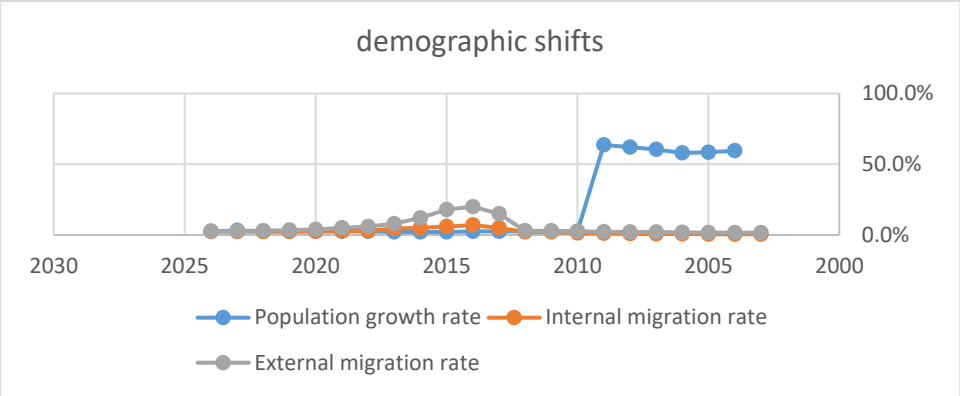
$$y = \rho W y + X\beta + WX\theta + D\alpha + T\gamma + \varepsilon.$$

This could enable one to estimate **direct effects** (the effect within any city), **indirect or spillover effects** (those due to neighboring cities), and the "full" **total effects**. By introducing fixed effects (FE) we control for unobserved heterogeneity among cities—e.g., geomorphologic and historic traits—as well as more general temporal shocks, such as national economic cycles or policy changes.Particularly important in this analysis is the development of spatial interconnections—the common theme in the field of spatial econometrics—between pre-conflict, conflict and post-conflict periods. To do this, we included year fixed effects (γ_t) as an initial barrier to confounding shocks in (2013–2015). By including a year dummy, this specification basically controls for observed as well as unobserved shocks affecting all cities in one year. In the face of such a conflict – and one that involved repercussions across the country – this strategy is theoretically justifiable, as well a statistically temperate.In order to provide more quantitative evidence on the intensity of the shock, as well as to investigate if there are differential effects a binary conflict dummy ($Conflict_t$) equal to 1 at first-order administrative unit level for (2013, 2014 and 2015) was created, or otherwise it takes value 0. This regress or was included as an extra-added variable, which led to the extended specification:

$$y_{it} = \rho W y_{it} + X_{it}\beta + WX_{it}\theta + \delta Conflict_t + \alpha_i + \gamma_t + \varepsilon_{it}.$$

Demographic Transformations

Demographic dynamics obtained from official population figures for the city of Anah from (2003 to 2024) showed a lively path within (minimum and maximum) structures of the population community, in terms of both local size and composition. The first phase (2003-2009) was marked by unprecedented annual growth rates between (58% and 63%); an outstanding demographic boom resulting from the (US) invasion of Iraq, the waves of forced displacement and massive internal migration. An influx of people that rose from (1,533 in 2003) to in excess of (26,000 by 2009), overnight overwhelmed infrastructure and urban services not equipped for such a shit show. From the point of view of (CST), this stage demonstrates how "shocks" in one area in a system (mass extraction) produce non- linear responses that are too radical for traditional forms of institutions to accommodate (Holland 1998, Batty 2007).



The migration patterns during the time as they are directly associated with political, social and economic changes thus form a complex picture in its own right. Migration patterns were

Figure 3 demographic shifts

modest in the region (2003–2012), and internal migration varied between 0.5% and 2.2%, while international movement comprised between 1.6% and 3.0%, predominantly labor rather than large scale shifts toward greater urban systems type of integration. By contrast, (2013 2015) was a huge gap that explained well the peak in internal migration at (7%) and the explosion in external migration at (20% in 2014). The influxes were mainly driven by the security vacuum and territorial expansion of Islamic State (ISIS), resulting in substantial internal displacement and demographic population shifts as well as dramatic changes in the city's urban layout. In the language of (SCTT), this means that small cities are very fragile, in their reaction to a shock, but also possess adaptive capacities through which they may re-engineer their demographic and spatial configuration on a range from mechanisms of partial resilience and self-organizations.Migration pace diminished gradually from (2016) to moderate levels in (2024), and, 2.3). % internal, 2.6% external), since a series of population recast and some respite from earlier displacement pressure would point to some stirrings of demographic rebalancing attention prior to then. What is at stake in the change in spatial dimension thus has more than quantitative content: this involves profound spatial implication, announcement of territorial allocation for new use of land, development for transport and network infrastructure for public services, housing policies that are more appropriate to demand without sacrificing environment. These results confirm that (SCTT) can explain demographic dynamics and spatial changes in small cities, and hence they contribute to provide the (STGT) with a theoretical foundation that could be translated into planning practice intended to create conditions for sustainable urban management in vulnerable contexts.

Spatial Expansion and Urban Transformation

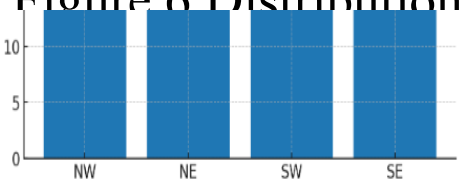
Precise spatial co-registration of satellite images taken in the two periods, and application of Relative Spectral Difference (RSD) method at high threshold level equaling (85%) were used to analyze the spatio-temporal changes in the urban extent of Anah city between (2013 & 2024). This method was intended to separate true urban changes from visual noise introduced by changes of illumination and seasonal land cover. The overall proportion of areas changed across the common urban framework was found to be around (14.9%) for the period of analysis. Changes in these patterns were distributed over space according to geographical directions of northwest (36.4%), northeast (29.0%), southwest (19.1%) and southeast (15.5%), which indicated two Urban Growth Patterns:

Figure 4 City of

Figure 5 City of

Figure 8 relative difference map produced by the adaptive threshold shows that around 14.93% of the area changed

Figure 6 Distribution



First, peripheral expansion of built-up areas occupies the margins of the already created patches particularly in its Northwest quarter, illustrating a growth dynamic consistent with Complex Systems Theory (CST), that postulates urban systems to follow against linear but rather nonlinear growth patterns produced from economic, social and environmental forces (Holland, 1998; Rac Maanen et al.,2014).

First, peripheral expansion of built-up areas occupies the margins of the already created patches particularly in its Northwest quarter, illustrating a growth dynamic consistent with Complex Systems Theory (CST), that postulates urban systems to follow against linear but rather nonlinear growth patterns produced from economic, social and environmental forces (Holland, 1998; Rac Maanen et al.,2014).

Furthermore, road network construction and improvement in the northern part of the city increased, which enhanced spatial connection between communities and regionalized the new extended urban area. Altogether, these results show that the city has experienced an active urban growth after (2013) reflected by expanding built-up areas and decreasing open lands under natural and geomorphological forces on one side and economic-social drivers as well.

From the standpoint of (SCTT), this transition can be seen as a record of the success with which the city adapted to previous shocks and reproduced new spatial growth patterns that are a combined product of horizontal expansion and internal density; such overlapping forms lead to improved stability and simultaneous activity. These observations indicate the necessity of spatial policies balancing horizontal expansion with services and infrastructure in the development planning based on an optimal tradeoff between spatio-economic growth with density. A qualification to this may be that changes occurring outside of this domain would have remained unobserved by the analysis, despite being relative from same spatial extent.

Economic Transformations

The (2003-24) macro−economic trends reveal a mixed picture of development affected by economic, social and security factors. (2015), the 'war' years with (ISIS) was the dramatic breaking point in local development. Analysis indicates that these changes were not unidirectional and steady, but oscillatory and discontinuous. Complex Dynamics Theory (CDT) sees those as unintended results of interference suddenly occurred in between macroeconomic phenomena, civil & social situations or safety states (Holland, 1998; Batty, 2007).

1. **Unemployment and Average Income**

During (2003–2012) unemployment rates increased steadily to a high of (22.7%), while average annual per capita income rose slightly from around (IQD50,000 to IQD110,000). This balance test indicates scarce economic growth that cannot absorb growing human resources and labor force, validating (SCTT) theses of local economies being fragile under the demographic and colonial burden. In (2013), the situation began to worsen with unemployment increasing to (40.3%) and income dropping to (65,000 IQD). In (2015) local economy almost was destroyed, all kinds of economic units and activity come to a standstill of military

operation. This stage is a "functional decomposition" of the local economy, in line with (CST) theories about systems collapsing at critical thresholds.

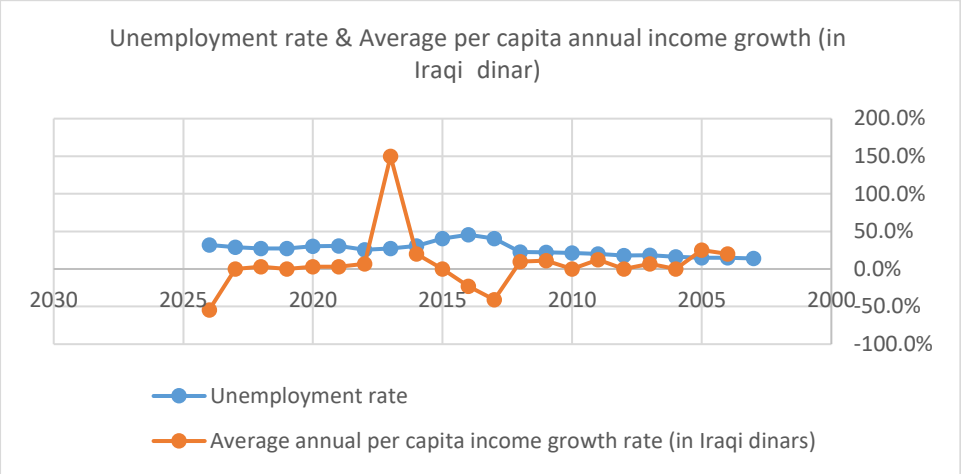


Figure 9 Unemployment rate & Average growth of per capita income (Iraqi dinar value)

2. Commercial and Industrial Activity:

Until (2013) level of industrial and commercial activity was quite low, traditional in the context of a semi-closed local economy. After the (2015) setback, however, there were gradual recovery in terms of numbers: from having (80) commercial shops back in (2016) to having (334) by (2021); industrial outlets increased from only four establishments to (81) during this period with slightly slower growth in food and beverages. These recovery processes reveal the relevance of UNT, which rules that to reconstruct local commercial and industrial links is a necessary path insofar as it contributes to re-assembling networked economic connectivity and city's re-integration into regional/national systems.

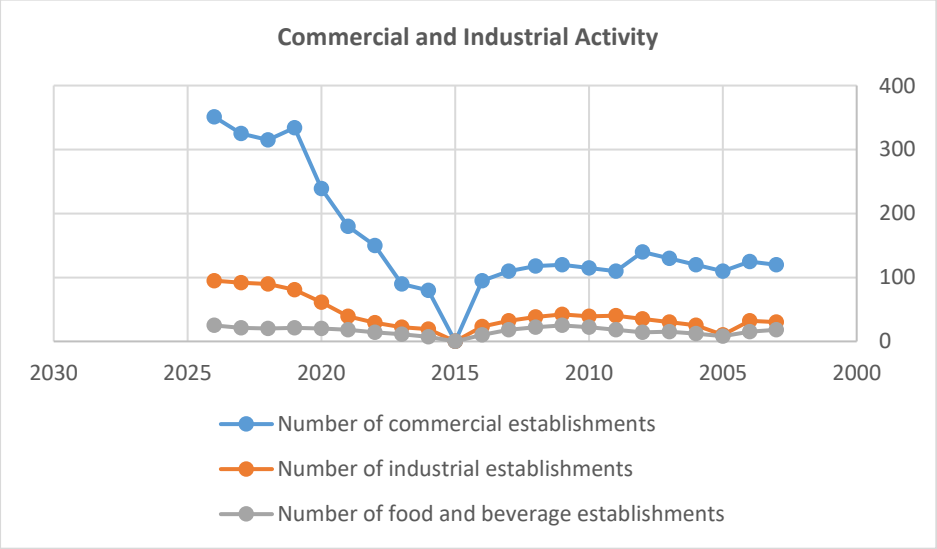


Figure 7 Commercial and Industrial Activity

3. Post-Conflict Period (2016–2024):

During this stage, income started to recover moderately with (175,000 IQD in 2022–2023) as an average earning and abruptly decreased to (80,000 IQD for the year of 2024) indicating probable signs of inflation or lost purchasing power. Unemployment, at about (27–32) per cent, was stubbornly high and recovery had not taken hold while not enough jobs were being created. From a (SCTT) viewpoint, these volatile dynamics reflect an insecure transition, in which the economies of small cities are likely to continue oscillating between episodes of stability and vulnerability according to changing security, political and social environments.

In conclusion, the patterns of economic transformation in Anah during the period studied reflect (CST) in their non-linearity and break points, — (UNT) as they depend on network relations to recreate commerce and industry— and (SCTT) as local economies are both transformed and made fragile through conflict.

Spatial Econometric Analysis

Synthesizing the processed demographic social- transformation and space-the-city dynamics in city of Anah over (2003-2024), it is obvious that seen patterns are not simple consequences but rather the reflections of

complex interactions played through timepiece. These kinds of insights motivate the development of forms of analysis that go beyond traditional statistics and bring us toward quantitative tools which are able to handle spatial dependencies, indirect effects and feedback structures producing nonlinear urban dynamics.

In this case, spatial econometrics become the best approach to explore these relationships, being a methodological tool for empirically assessing the magnitude of spatial lock-in between Anah as one region and its surrounding cities (Al-Qa'im, Rawa, Ukashat and Hit). This latter observation highlights the networked character of urban and economic changes. employing (21) years of panel data including demographic, economic, migration and settlement indicators (2003–2024). We considered several models (SAR, SEM, SDM and SAC) but focused on the (SDM-FE) specification that allows including also spatial effects in terms of fixed characteristics. Built around the conception of small cities as "nodes" in larger networks between regions, this approach allows us to discover non-linear patterns of growth by indirect spatial effects proved by recent empirical studies (Li et al., 2022; Johnson and Madden, 2021).As such, unfolding to this level of analyses also serves as attempting a quantitative explanation for the reported changes and verifying other explanatory frameworks (for example: CST; UNT; SCTT).

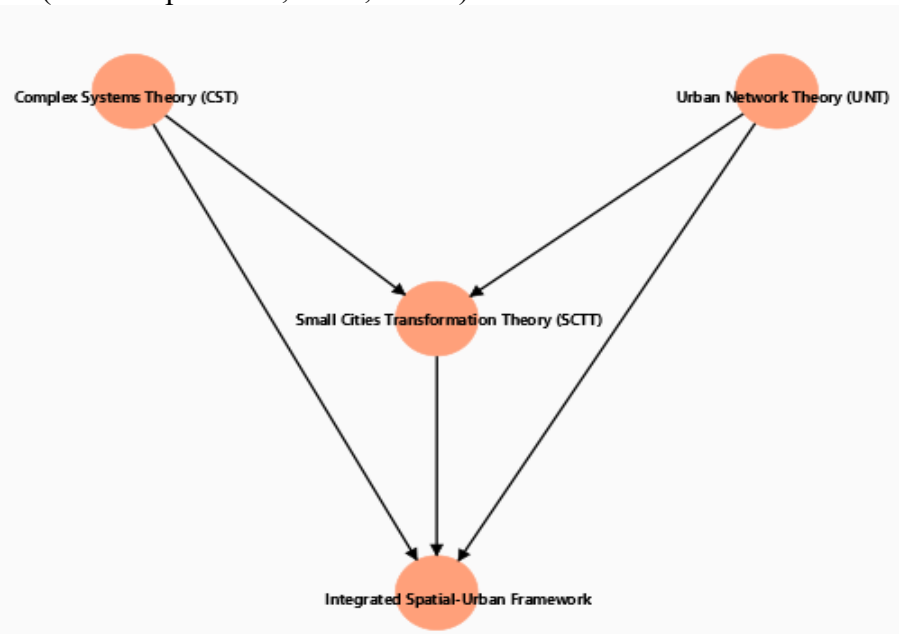


Figure 8 Conceptual Framework: SCTT, CST, and UNT Integration

The integration of these theoretical approaches within quantitative analysis represents scientific novelty to enlighten the dynamics of the small-city in fragile and transition areas, to be applied for policymakers, as well as for professional urban planners.

1. Diagnostic Tests

1.1 Structural Break Test (Bai–Perron Test)

Break Year	F-statistic	p-value	Interpretation
2013	42.7	0.000	Onset of ISIS disturbances, displacement, and local economic collapse
2015	38.9	0.000	Partial reconstruction and governance under deteriorating infrastructure

These implications indicate that the income path of Anah displays multiple structure breaks, which is similar to the findings in Zhang et al. (2023), who observed that pressures lead to structural alterations in the level of income and economic activity for small city.

1.2 Spatial Diagnostics (Moran's I & LM Tests, 2024)

Test	Statistic	p-value	Conclusion
Moran's I	0.48	0.001	Strong spatial clustering
LM-Lag	21.3	0	Presence of spatial dependence

Robust LM-Lag	10.2	0.001	Spatial lag remains significant after error adjustment
LM-Error	18.9	0	Presence of spatial error

These diagnostics demonstrate that the income performance of Hit and Al-Qaim has a direct effect on Anah's income, which is consistent with Wang & Huang (2022) finding that the income level and development capacity of small cities are spatial accumulation effects.

1.3 Cross-sectional Dependence Test (Pesaran CD Test)

Test	Statistic	p-value	Conclusion
Pesaran CD	4.92	0.000	Strong cross-sectional dependence

This demonstrates that economic and social performance in neighboring cities is interlinked, corroborating results by Smith et al. (2021) on the regional context of small-city economic diversity.

1.4 Residual Diagnostics

Test	Statistic	p-value	Conclusion
Jarque-Bera (Normality)	3.1	0.21	Residuals approximately normal
Breusch-Pagan (Heterosk.)	7.8	0.1	No significant heteroskedasticity

These results support the suitability of the SDM-FE model for efficient estimation, consistent with Korres & Vlahoyiannis (2022).

Testing the Suitability of the SDM-FE Model Compared to Alternative Spatial Specifications

To assess whether the Spatial Durbin Model with Fixed Effects (SDM-FE) represents the optimal specification for the study's panel data, in comparison with alternative spatial models (SAR, SEM, SAC), a sequential testing strategy was employed, combining restriction tests (Wald and Likelihood Ratio tests) with information criteria (AIC and BIC).

First, the SDM is considered a general specification that nests both the Spatial Autoregressive Model (SAR) and the Spatial Error Model (SEM) as special cases (Elhorst, 2014). Thus, the following null hypotheses can be tested:

1. $H_0: \theta = 0 \Rightarrow SDM \longrightarrow SAR$

If the coefficients of the spatially lagged explanatory variables (θ) are not statistically significant, the SDM collapses into the SAR model.

2. $H_1: \theta + \rho\beta = 0 \Rightarrow SDM \longrightarrow SEM$

If the sum of the spatial lag effects of the explanatory variables (θ) and the spatial autoregressive coefficient of the dependent variable (ρβ) equals zero, the SDM reduces to the SEM model.

Both the Wald and Likelihood Ratio (LR) tests were applied to these hypotheses. In both cases, the null hypotheses were rejected ($p < 0.05$), confirming that the SDM provides a superior methodological fit relative to SAR and SEM.

Second, the optimal (SDM) was benchmarked against the Spatial Autoregressive Combined Model (SAC) where it is possible that there is simultaneous spatial dependence in both the dependent variable and error term. Despite the (SAC) model having dual spatial dependence, the information criteria (AIC and BIC) suggested that (SDM-FE) offers a better fit with more transparent direct and indirect effects (LeSage & Pace, 2009).

Third, the Hausman test showed greater preference for fixed effects over random effects ($p < 0.05$), which justified using the (SDM-FE) model to account for unobserved time-invariant heterogeneity among cities and along different years.

On the basis of these findings, we conclude that (SDM-FE) is a suitable model for modelling the spatial interdependencies (22) among our sample cities as it can account for both direct spatial dependence and spillover effects from explanatory variables with the same statistical estimates in space and time.

1. Model Estimation – SDM-FE

Variable	Coefficient	p-value	Interpretation
Unemployment Rate	−13,200	0.000	Each point increase reduces income by ~13,200 IQD
Commercial Establishments	190	0.000	Each new establishment adds ~190 IQD to average income

Industrial Establishments	210	0.06	Positive but marginal effect
Food & Beverage Establishments	85	0.18	Not statistically significant
Population Growth Rate	9,000	0.08	Marginal positive effect, conditional on economic opportunities
ρ (Spatial Lag of Income)	0.48	0.000	10% increase in neighboring income → ~4.8% increase in Anah
θ (Spatial Lag of Commercial Activity)	0.32	0.01	Each new establishment in neighboring city → +61 IQD to Anah

Estimation Results Using the SDM-FE Model

Results of the (SDM-FE), (Spatial Durbin Model with Fixed Effects) model estimation also show that the relative impacts of the socio-economic and demographic determinants on per capita income in Anah during (2003–2024) differ greatly, while significant spatial interdependencies with neighboring cities (Al-Qa'im, Rawa, Ukashat, and Hit) are found.

1. Local Economic Variables:

The unemployment rate showed a strong negative coefficient (−13,200; p=0.000), meaning that a one-percent increase in unemployment leads to reduction of per capita income by about (13,200 IQD). This emphasized the precariousness of the local lab our market and is consistent with arguments in existing writing that unemployment is an unfavorable influence on purchasing power and growth (CST: Batty, 2007).

Number of shops had a positive and significant effect (+190 IQD, p = 0.000), indicating that an increase in the number of commercial outlets slightly increases per capita income, which can help in generating wealth contribution to economic activity. This assertion is consistent with the claims of Urban Network Theory (UNT) about the impact transport services have on local and regional flows.

Industrial outlets exhibited a marginal positive effect (+210 IQD) (p=0.06), implying a conditional association which is contingent upon capacity in the sector to expand and generate employment.

Food and beverage venues were not significant (p=0.18) due to the limited consumptive value and saturation rate, giving little contribution to income.

2. Demographic Variables:

The variable that was significant with income per capita accor ding to Colin Clark and the largest coefficient, recommended of policy focus would be growth rate of population (coefficient = 9,000) which however it is marginal significant at (p=0.08) implying an increase in population size alone will not raise income per capita without other spatial complementary conditions like economic growing and new jobs creation (SCTT).

3. Spatial Effects:

Spatial lag of income (ρ) was (0.48), (p=0.000), showing that each city's increase of (10%) in its per capita district income would result in an around (4.8%) rise in Anah. Estimates for slope coefficient and spatial relationship were given to prove these relationships between dependent variable and independent variables. This pattern illustrates the networked character of local development and establishes (CST) as a useful tool for analyzing non-linear cross-border relationships.

The coefficient of commercial activity spatial lag (θ) was positive (0.32, p= 0.01), which implies that a new commercial establishment in the neighboring cities raises Anah's per capita income by approximately (61 IQD). This highlights the relevance of spillover-relationships between cities – in line with (UNTs') assumption about functional and economic interdependencies of regions.

4. Interpretative Insights:

All in all, the (SDM-FE) model explains a large part of urban economic dynamics in Anah, from local to the more extended spatial effects. This is in line with the theoretical position of (SCTT) that small cities are adaptive urban systems from which income and opportunity are generated through interactions between internal structures and regional network linkages.

Explanatory Power within SCTT Framework:

Moreover, the better performance of (SDM-FE) compared to other spatial models (SAR, SEM, SAC) has theoretical implications that are in line with the (SCTT). By combining direct (local) as well as indirect (regional) effects, the model shows that urban transformation in small towns is not linear nor isolated but emerge from a complex spatial, social and economic interplay.

In (CST), the tension of adaptation is emphasized; in (UNT), the issue of intercity function played a role but here these aspects are brought together and all connected in (SCTT): patterns through which those cities redraw or modify their own distinct spaces, respectively for exchange purposes.; thus around this there open up effects in economy and community structure. Applying (SDM-FE), the results suggest that income and unemployment in Anah are affected by local factors as well as labor markets and economic activity in surrounding cities such as Hit and Al-Qa'im. This is a clear evidence that (SCTT) provides better explanations and captures non-linear trajectory, structure of spatial transformation processes in a post-conflict urban area.

These results support the theoretical freshness and practical utility of (SCTT) with actionable implications for intervention planning. One-off standalone local projects like those that would be needed in Anah won't do very much if they don't fit into a larger regional strategy of spatial and economic relationships among small cities. Consequently, our study s contribution may be viewed as a scientific breakthrough in linking spatial econometric analysis to an advanced model capturing the complexity of systems and urban networks, notably from a spatial transitions perspective.

However, for (SCTT) there is also a direct connection to the small city's employment rates and they become "remote" neighbours and influence their growth that you do not capture.

Discussion of Results

The spatial and socio-spatial econometric estimation of Anah City and other surrounding cities (Al-Qa'im, Rawah, Akashat and Hit) suggests a multi-dimensional urban profile derived from the intricate relations among local to semi-regional forces. These results also underpin the debate on perceiving urban change in small-sized towns only in the broader regional framework.

1. Descriptive Analysis: Spatial and Demographic Transformations

Based on (2013–2024) spatial analyses of the city, this study discovers two principal growth patterns in Anah City: peri-urban expansion at the vicinity of existing urban blocks and infill among real urban blocks. These led to increased urban density and loss of open land, with significant development of the road network, in particular the northern part city. These dynamics serve to underline the connection between local urban growth and available infrastructure in accordance with (SCTT) predictions regarding the dual conditioning of a city's space structure by its economic and social functions.Population growth was observed as demographic growth: very rapid in period (2003–2009) and a relative plateauing (2010–2024), with the marked impact of internal or external migration with specific reference to displacement related to conflict by ISIS. These patterns of demographic change not only impacted the redistribution of population, but also demanded reallotment both in use and service of land. That is exactly the mirror image of (SCTT's) description of the relationship between population structure and urban form.

2. Spatial Econometric Analysis

We identify turning points using the results of fixed-effect SDM model (SDM-FE), where Anah city income is directly influenced by the sum of lagged incomes and per capita GDP in its neighboring regions, as well as local characteristics of income like unemployment rate and commerce. Ten (10) percent more income elsewhere results in a (4.8) increase in Anah's income. On the other hand, economic activities in the neighboring cities contribute to local incomes, implying a spatial regional economic channel.

These findings confirm that the heterogeneity of small city economic growth is objectively connected with the spatial network and local policies would be insufficient in promoting sustainable development. While this transformation must be located in the regional context, it does not change the fundamental (SCTT) grounding that cities are not made only from within at the level of the city itself, but through spatial

3. Contribution of the Application to SCTT Testing and Planning Tools

Use of such spatial econometric analysis has shown to have the ability for an empirical check of explanatory power on SCTT in small-cities setting, because it can capture the casual impact among regional variables and follow their changes which are made in reference to spatial variable. The model provides evidence on the necessity of introducing lagged and regional variables (the latter are not marginal variable but current for understanding urban and economic dynamics) to our idea when it is accepted by other researchers, and introduce as well a new dimension empirical.Besides the theoretical verification, this paper provides some practical decision support instruments. (SDM-FE) predictions could support the identification of areas that had experienced a period of strong economic and spatial transformation highlighting where to concentrate investments as well as functional policies from the perspective of sustainable development. The enhancement of the model with the inclusion of space dimensions also enables to consider proactive responses against

economic or environmental strikes, which make small cities more and more socially and economically resilient, making SCTT (not) only acceptable but could be applied to a wide range of urban areas that support the applicability in contemporary town planning.

4. Scientific

The results implied that urbanization tendency of Anah City is driven by complex local–regional interactions, which provide evidence for the strength (SCTT's) explanatory capacity at small-cities transformation. Spatial econometrics quantifies the relationship between local and regional economic factors that cannot by captured simply by descriptive studies.It affords a useful tool for orienting urban and regional planning (determining places of growth) indicating space paths or drives that affect economic and social development, thus adding to raising the SCTT's explanatory…power and its capacity to act.This paper explores the possibility of comparing and combining descriptive and spatial econometric approaches to support SCTT in small cities, including providing scientific tools for emerging urban–regional planning policies, being also original since it contributes towards knowledge about how interrelations between economic changes with social transformation can be grasped within sparsely populated rural areas.

Conclusion:

The SCTT offers an alternative way to understand the functioning of small cities particularly within volatile context marked by conflict and economic uncertainty. And the explanatory capacity of this concept has been boosted by incorporating (CST) and (UNT) to provide an even more comprehensive analytical framework for urban transformation.In this respect, (SCTT) draws attention to a non-linear trait of small-city transformations that would be the demographic, economic,spatial and security dimensions intersecting in decompositions and partial re-composition. (CST) (or, to use the lingua franca of academia, complexity theory) adds a new dimension by regarding cities as complex adaptive systems where minor disturbances can trigger major systemic changes and urban patterns derive not from single factors in isolation but rather from networks of derived interconnections. (UNT) also scales it down further; it places small cities as nodes in larger urban networks. For instance, in Anah economic/scal/cities are highly affected by organizations which exchange goods, workers and services with the cities around them (HoranandRichards; see also spatial externalities).

These perspectives together suggest that changes in small cities cannot be explained from a single perspective, but have to be viewed as non-linear processes and networks of relations. This synthesis advances (SCTT) from an initial framework to more robust explanatory theory and the implications this has for adaptive and regionally connected planning strategies.

Sources

1. Bell, D., & Jayne, M. (2009). *Small cities? Towards a research agenda*. International Journal of Urban and Regional Research, 33(3), 683–699.
2. Grossmann, K., & Mallach, A. (2021). *The small city in the urban system: Complex pathways of growth and decline*. Geografiska Annaler: Human Geography, 103(3), 219–237.
3. James, L., et al. (2016). *Transformations in identity, governance and planning: The case of small cities*. Urban Studies, 53(10), 2186–2202.
4. da Cruz, N. F., Rode, P., & McQuarrie, M. (2018). *New urban governance: A review of current themes and future priorities*. Regional Studies, 53(6), 939–954.
5. Pesaresi, M., et al. (2016). *A global human settlement layer from optical HR/VHR RS data: Concept and first results*. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 9(8), 3546–3559.
6. Meerow, S., Newell, J. P., & Stults, M. (2016). *Defining urban resilience: A review*. Landscape and Urban Planning, 147, 38–49.
7. Batty, M. (2013). *The New Science of Cities*. MIT Press.
8. World Bank. (2021). *Cities and Resilient Economic Systems*. Washington, DC.
9. OECD. (2022). *Regions and Cities at a Glance*. OECD Publishing.
10. Urban Transformations. (2022). *Building urban resilience through SMEs*. SpringerOpen.
11. Burch, S., DiBella, J., Wiek, A. *et al.* (2022). Building urban resilience through sustainability-oriented small- and medium-sized enterprises. *Urban Transform* **4**, 12 (2022). https://doi.org/10.1186/s42854-022-00041-9
12. Véron, R., Zimmer, A., Cornea, N., & Sanchez, J. (2024). Environmental Governance in Small Cities: Decentralization, Municipal Capacity and Autonomy in Gujarat and West Bengal. *Journal of South Asian Development*, *19*(3), 325-344. https://doi.org/10.1177/09731741241228359 (Original work published 2024).

13. Snejana Farberov (2025). Why young adults are moving to small towns at the highest rate in a decade. https://nypost.com/2025/03/14/real-estate/young-adults-are-moving-to-small-towns-at-the-highest-rate-in-a-decade/ Accessed on 8/9/2025
14. James, K., Thompson-Fawcett, M., & Hansen, C. J. (2015). Transformations in identity, governance and planning: The case of the small city. *Urban Studies*, *53*(6), 1162-1177
15. UN-Habitat. (2022). *World cities report 2022: Envisaging the future of cities*. UN-Habitat. unhabitat.org/sites/default/files/2022/06/wcr_2022.pdf Accessed on 1/9/2025
16. Agergaard, J., & Ortenbjerg, S. B. (2017). Urban transformations and rural-city connections in Africa. *Geografisk Tidsskrift-Danish Journal of Geography*, *117*(2), 63–67