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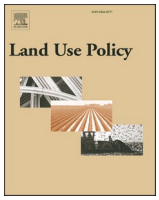

Land use institutions and social-ecological systems: A spatial analysis of local landscape changes in Poland

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ABSTRACT

Understanding the complex impacts of human settlement patterns on social and natural systems is critical for immediate and long-term policy decisions and ecosystem preservation. Land-use patterns can be conceptualized as a form of integrated natural-human system within urban regions. However, extant scholarship on urban development and sprawl often overlooks the institutional diversity which exists across countries and regions. Development and land-use are politically charged governance issues, and these studies have rarely examined the influences of local political institutions on land-use changes across countries and over time. To help build cumulative knowledge on such urban systems, this study examines landscape change in Poland, which has undergone significant institutional evolution since the fall of the Soviet Union. Drawing from the urban and social-ecological systems (SES) literatures, we estimate spatio-temporal models of the interactive effects of socio-economic and political variables on land-use intensity. Consistent with an SES approach, the analysis finds that characteristics of the institutional design of land-use regulation – local autonomy, the productivity of the resource, and the predictability of land-use dynamics – influence more-intensive landscape changes over the study period (2006–2018). Specifically, both the electoral stability of the mayor and wealth of the community have a positive interactive effect on the conversion of landscapes to more urban uses. Development is also influenced by spatial and temporal dependency, and the availability of European Union "cohesion" investments intended to address economic inequality and promote sustainable development. The findings advance our understanding of the complexity of urban land-use patterns and sustainability goals.

1. Introduction

Urban development and sprawling land-use patterns continue to pose significant challenges for the developed and developing world (Goodman, 2019; Inostroza et al., 2013; Musakwa and van Niekerk, 2014; Patacchini et al., 2009). Understanding the complex impacts of human settlement patterns on social and natural systems is critical for immediate and long-term policy decisions and ecosystem preservation (Ostrom, 2009a; Ramaswami et al., 2018). A number of efforts have been made to integrate scientific understanding of ecological systems with governance scholarship (Anderies et al., 2004; Carpenter et al., 2001; Garcia et al., 2019; Lubell et al., 2002; Ostrom, 1990). While making great strides, these efforts are still hindered by the lack of a unifying framework for defining concepts (Ostrom, 2009b) and the difficulty in empirically linking these constructs to observable but slow-moving changes in social and natural systems (Anderies et al., 2007, 2006). Frameworks and theories are only as practical as the cumulative knowledge and shared understanding they facilitate.

This article adapts a social-ecological systems (SES) framework for studying urban development (Ostrom, 2009a). It then empirically examines landscape change in Poland in order to gain a clearer understanding of how governance and resource systems interact within an understudied and evolving institutional context. Land-use patterns can be conceptualized as a form of integrated natural-human system within

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urban regions (Anderies et al., 2002). An implication of this integration is that changes in the characteristics of human settlements, such as population density, wealth, economic or political institutions, may feedback into degrading the natural system, while ecological-system decline similarly impacts the health, well-being and sustainability of human communities (Synes et al., 2018). Managing sprawling development of land and conversion of natural ecosystems to artificial ones is a critical front in global efforts to combat climate change and enhance the sustainability of urban systems.

Land-use policies intended to manage growth have been extensively studied in the U.S. context, described as powerful instruments to protect environmentally-sensitive areas, promote open space, urban infill, transit-oriented systems and higher density housing, all of which contribute to urban sustainability (Deslatte, 2018; Gerber and Phillips, 2004; Hawkins, 2014; Lubell et al., 2009). However, these studies often fail to consider the institutional diversity which exists across countries and regions. Development and land-use are politically charged governance issues, and extant research on land-use policies has rarely focused on the influences of local political institutions on changes across countries and over time. Moreover, actual landscape changes – as opposed to land-use changes – reflect actual transformation of the biophysical conditions of land and the ecosystems therein. The interaction of biophysical and social systems has received less attention in the policy or urban literatures, particularly in emerging democratic institutions.

The contextual setting of Poland has undergone significant institutional evolution from communism to capitalism since the fall of the Soviet Union. Applying urban theories on growth within the SES framework, we estimate spatio-temporal models of the interactive effects of socio-economic and political variables on the intensity of the biophysical landscape change across the country. The analysis finds several characteristics of the institutional design of land-use regulation – local autonomy, the productivity of the resource, and the predictability of land-use dynamics – drive more-intensive biophysical landscape changes over the study period (2006–2018). From an institutional perspective, both the electoral stability of the mayor and wealth of the community have a positive interactive effect on the conversion of landscapes to more urban uses. Within the social-environmental system, development is also influenced by spatial and temporal dependency, afforestation and the availability of European Union "cohesion" investments intended to address economic inequality and promote sustainable development. By situating these findings within an SES lens, the article advances our understanding of the complexity of urban land-use patterns and sustainability goals.

2. Land use: growth machines as social-ecological systems

Urban land-use and biodiversity are increasingly important areas for policy and management as climate change and development degrade human settlements and habitat alike. Analyzing the sustainability of urban systems requires ways to organize research which links measures of system performance (e.g., public health, natural resource stocks, economic growth) with collective decision-making forums (Anderies et al., 2013). For instance, research examining alternative regulatory approaches has identified how some government policies result is greater resource destruction while others facilitate more sustainable management (Ostrom, 2009).

For more than three decades, research on SESs has largely focused on the institutions which shape incentives for managing commons areas and resources, such as forests, wetlands, watersheds, fisheries and open lands (Ostrom, 1990; Ostrom et al., 1994; Poteete et al., 2010; Villamayor-Tomas et al., 2014). Urban development, while widely examined within the planning, policy and urban politics literatures, is an under-utilized issue lens within this SES literature (Niewöhner et al., 2016; Synes et al., 2018). Applying an SES framework to urban development patterns requires paying attention to variables likely to help us better understand the processes within specific system components, how they can be classified, and then connected to the larger whole. Using the SES framework developed by Elinor Ostrom and colleagues (2009), urban regions can be conceptualized as dynamic systems made up of "first-level" components: resource systems, resource users and resource units, all governed by rules. Fig. 1 displays the core subsystems of an SES applied to urban development. (Figs. 2–5).

Here, urban regions are combinations of both resource units (RUs) and users (U) – neighborhoods with varying economic, social and natural endowments, commons areas, industrial and commercial zones – along with the governance system (GS) of rules or norms which enable or inhibit collective-action. Human collectivities produce their own institutions, histories of development, dependence upon resources, and connections to surrounding areas, which are conceptualized as the social, economic and political settings (S). Resource users via their governance institutions interact (I) with ecological components of the resource system (RS), process RUs into outcomes (O), and typically

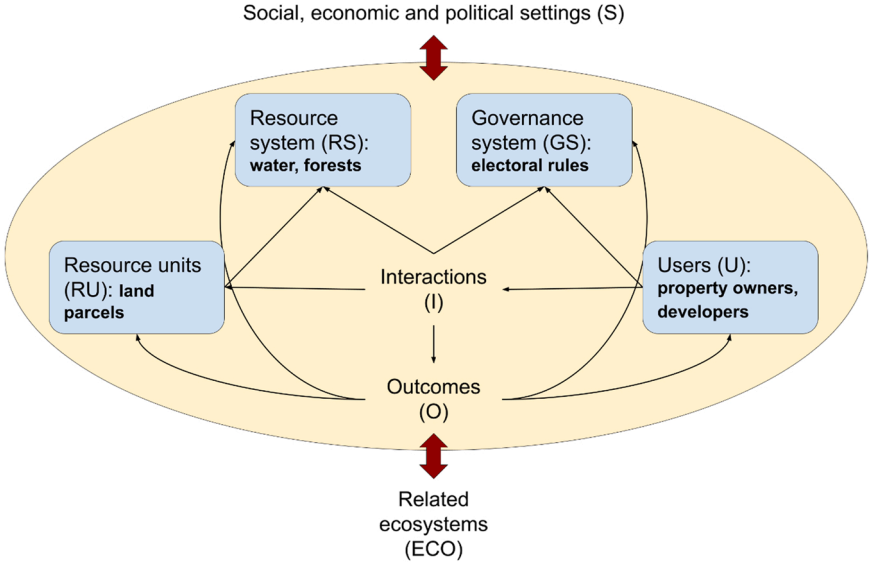

Fig. 1. The core subsystems of the Social-Ecological Systems (SES) Framework (Ostrom, 2009a) adapted for urban development patterns.

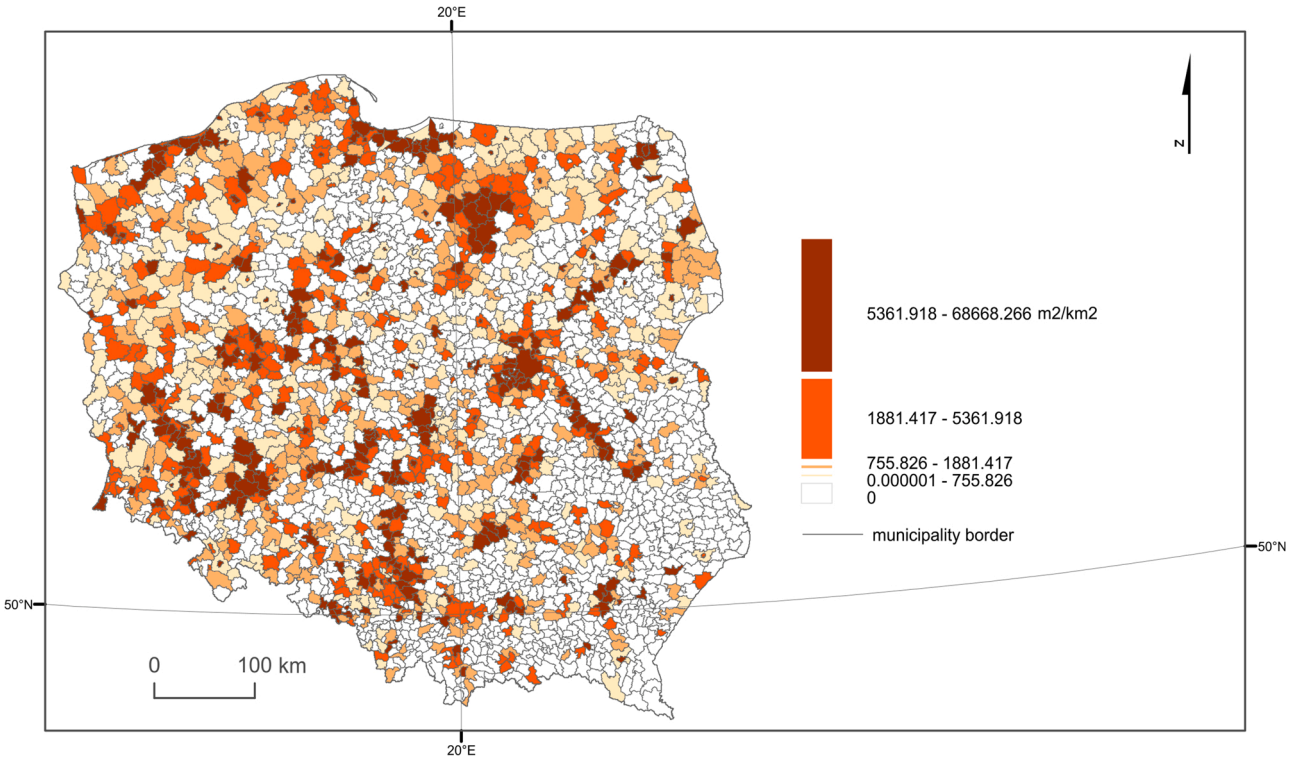

Fig. 2. Spatial distribution of Land Use Change Index 2012–2018 (dependent variable) in relation to the municipal borders in Poland.

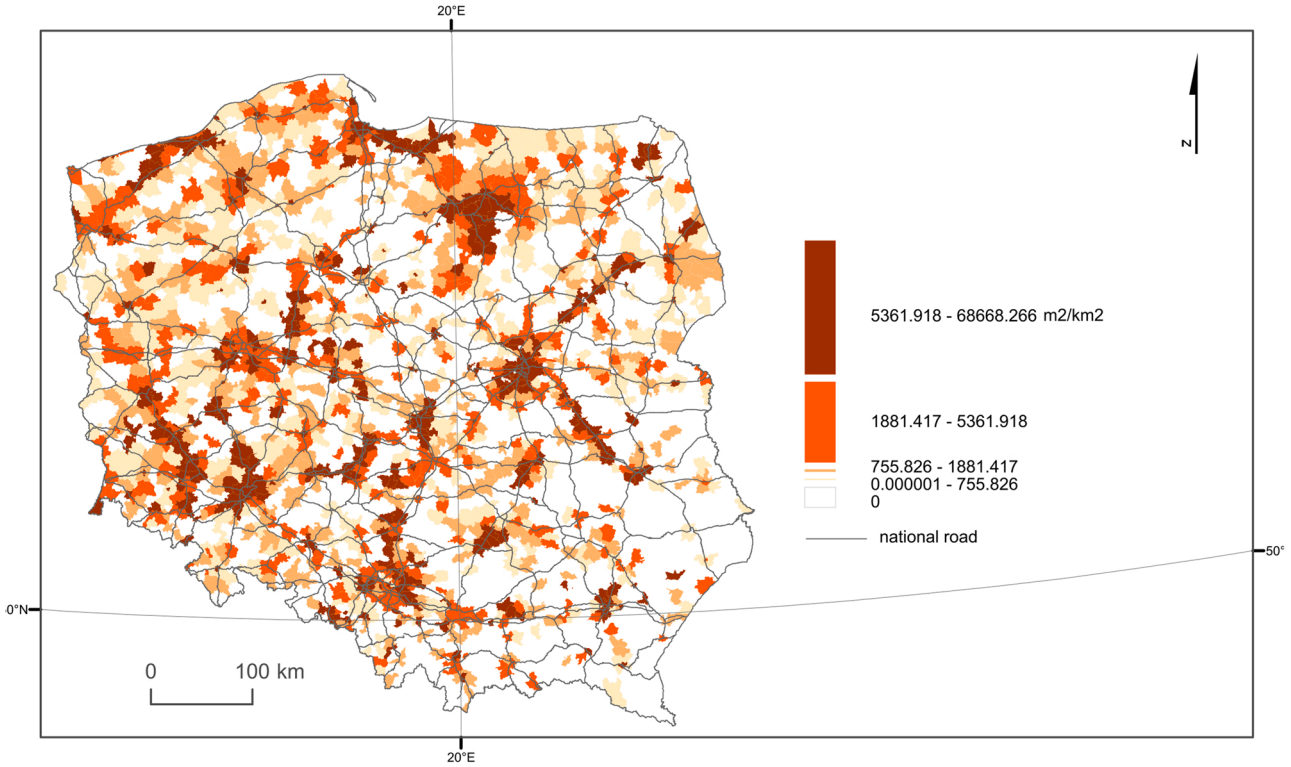

Fig. 3. Spatial distribution of Land Use Change Index 2012–2018 (dependent variable) in relation to the main roads in Poland.

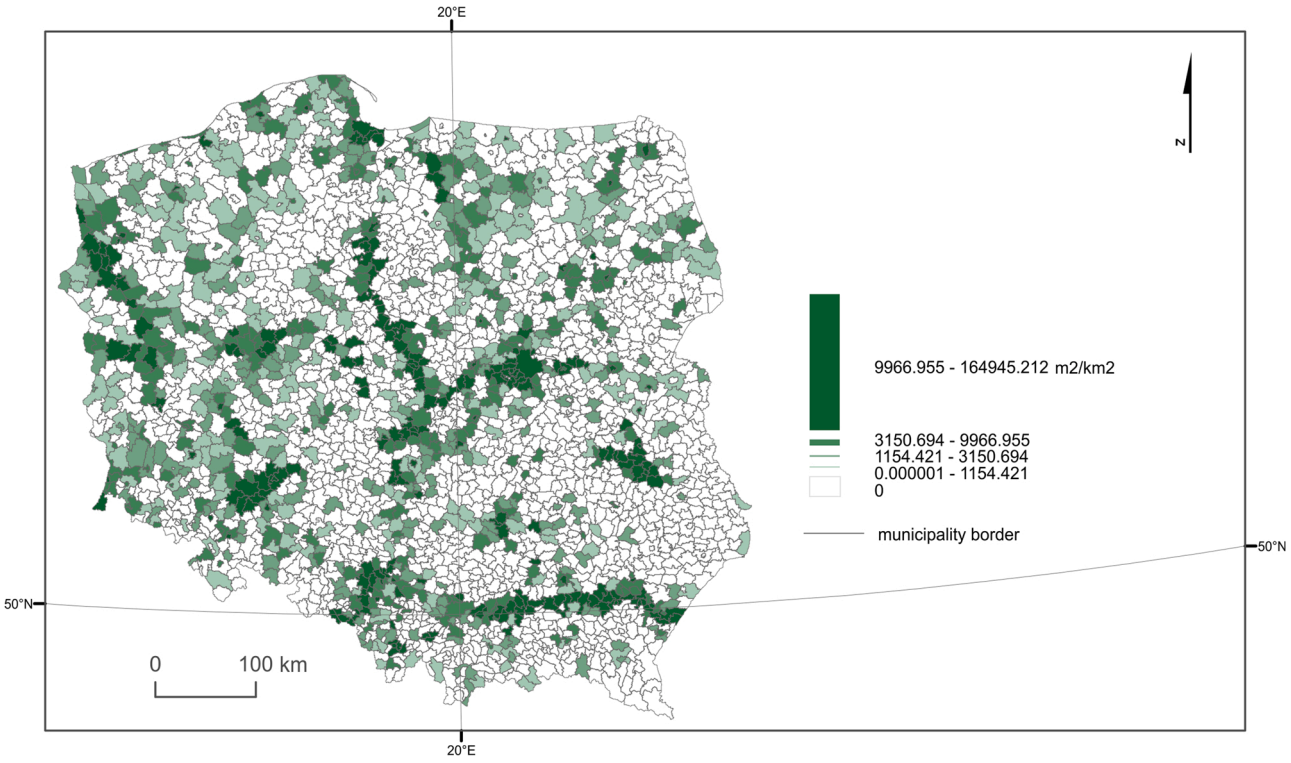

Fig. 4. Spatial distribution of Land Use Change Index 2006–2012 (path dependency variable) in relation to the municipal borders in Poland.

either degrade or find ways to sustain them. Understanding the interactions between these subsystems is critical for developing a better appreciation for why some urban regions develop in more or less sustainable patterns (Ostrom, 2009a).

Land use is one process which produces such socio-ecological impacts. The development of land affects ecosystems, producing outcomes which feedback into the system, driving either sprawling or more compact development patterns (Deslatte, 2018). For instance, development is often associated with an increase in artificial or impervious surfaces (Patacchini et al., 2009), which may facilitate ease of transportation and commerce but produce greater stormwater runoff which degrades watersheds (Yoder et al., 2020). Prior empirical studies addressing the determinants of land use policy changes have been conducted primarily in the United States and are frequently criticized as ethnocentric (Harding, 1994) and of limited use for cross-country comparative analyses (Shaw, 1993; Wood, 1996). Here, however, we embrace the idea that these U.S.-derived theories, when situated within an SES framework, allow us some leverage over explanations in cross-national research (Harding, 1996). In particular, the notion of coalition-building and bargaining between public and private actors in urban settings, which is present in growth machine and urban regime theories, can be extended to help explain land use changes in a cross-national perspective (Harding and Blokland, 2014). From an SES perspective, growth machines reflect the GS, or working rules or norms which have emerged in specific social, economic and political settings (S), and they may function much differently across such contexts. For instance, countries with strong property rights and market-based economic and political systems likely produce much different rules and norms than centrally planned economies or those with weaker property rights. An SES approach can help by highlighting the rules, norms and strategies which determine who is involved in land-use decisions, the constraints or incentives of their positions, and the interactions between natural and human system components.

In *Urban Fortunes*, Logan and Molotch (1987) argued that the activism of entrepreneurs in urban environments is largely responsible for the outcomes of development processes. In particular, the authors distinguish between 'user value' and 'exchange value' of properties. User value is derived from the daily use of property, whereas exchange value is associated with the financial gain obtained from property transactions. Landowners, however, are rarely able to extract surplus value of their properties and often rely on builders, real estate developers, and financiers to maximize their rents (Harding and Blokland, 2014). In turn, these urban development interests depend upon favorable conditions set up by local government officials to be successful. If economic growth is the fundamental driver of a community, local government officials will tend to facilitate investments and promote land use changes favoring growth machines (Logan and Molotch, 2007). In contrast, when groups defending user values dominate a community, such as existing neighborhood, agricultural or environmental organizations, local officials may attempt to limit these accelerated development processes (Teske et al., 1993). Moreover, groups which advocate for differing land uses will compete to control local governments to further their interests, be they economic or social-oriented goals (Trounstine, 2009). The growth machine thesis developed by Logan and Molotch (1987) is grounded on the idea that local politicians, business leaders and other pro-growth entrepreneurs are members of a coalition aimed at bringing investment and development to communities.

In more recent work conceptualizing land use policy changes as transactions (Lubell et al., 2009) describe the potential for a "sustainability paradox" whereby efforts to preserve natural amenities may make areas more desirable for development as affluent residents and developers attempt to capitalize on their appeal, degrading the resource in the process. In this systems-oriented scenario, efforts at land-conservation can backfire when the rules which structure incentives of a public economy facilitate both types of demands. This is the type of interaction whereby policies or regulatory approaches meant to sustain ecosystem services may inadvertently contribute to their collapse.

In the U.S.-style of federalism, states delegate land-use decisions primarily to local governments. As a result, American cities are seen as engaged in fierce competition for resources and investments, often generating zero-sum games across regions and metropolitan areas. How

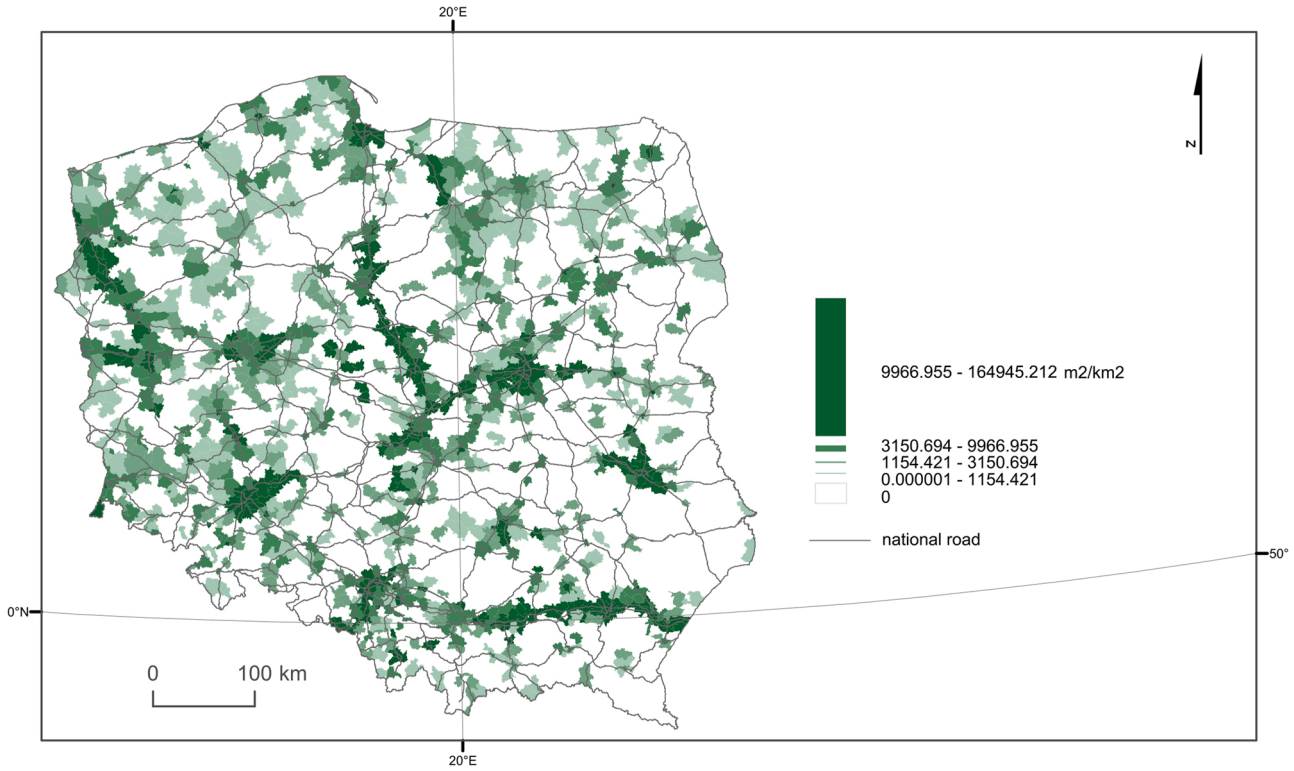

Fig. 5. Spatial distribution of Land Use Change Index 2006–2012 (path dependency variable) in relation to the main roads in Poland.

would these ideas fare in contexts outside the U.S.? In the case of the United Kingdom, Logan and Molotch (1987) argue that when the national government holds significant power over land use decisions and the funding of local services is heavily centralized, the growth machine is likely to be partly jammed by the direct actions of the central government over growth development policies. However, neither Logan and Molotch (1987) nor the abundant research conducted under the headings of urban regime theory or the growth machine thesis were able to provide an answer to this question.

In the following section, we outline general propositions for the interactions of resource (land) users and units within resource systems, along with the working rules which govern their functions. Thus, we use the SES framework to synthesize across contexts via the abstract conceptual categorization of drivers within the core system components. We then empirically examine landscape change as an outcome in Poland over a 12-year period. The Polish context is important because it has experienced a recent evolution of land-use institutions from Soviet-style central-planning to a more westernized capitalist approach. Institutions filter human agency in a way likely to influence landscape conversion, either directly through the regulation of change processes themselves or indirectly through the actors' use and manipulation of rules. These influences are not always linear or intended, and function in the presence of other second-level influences that present spatial and temporal dependencies. Recognizing this, we aim to move beyond simplistic "panaceas" or one-size-fits-all theories or models which may poorly generalize to differing property rights regimes (Ostrom et al., 2007).

3. Institutional incentives shaping urban development

Land parcels, the RU of interest, are often governed by complex property-rights regimes which blur governance systems with cultural or social norms. The characteristics of property rights pertaining to urban development are distinct from common-property resource use in two important ways. The first distinction is excludability. The "tragedy of the commons" scenario, in which Garrett Hardin (2009) argued resource users were locked in a downward spiral of overuse, depends on open-access to an exhaustible resource. Conversely, developable land is usually privately or publicly held with rights of access and use determined by scarcity and the difference between user and exchange value (Alston et al., 1996; Fischel, 1987; Haber et al., 2003; Schlager and Ostrom, 1992). Developable land parcels can have their rights of access and use controlled by owners, although the property-rights of a private owner are likely to be constrained to some degree by the potential impacts of land-uses on neighbors or the larger community (Maser et al., 1977). The second distinction is the perception that developable land may be abundant. Scarcity of land shapes the incentives for how it is used. While individual municipalities may confront a scarcity of developable land as they build out, metropolitan areas typically consist of concentric circles of municipalities which may offer developers lower-cost alternatives. Thus, property-rights regimes which impose strict growth management rules to lock-in present user value may be undermined by the mobility of capital investment to neighboring locales (related ecosystems, or ECOs) as growth actors seek higher exchange value returns. As a result, several "second-level" SES variables thought to influence common-property resource management are also relevant to the development of private or public property in urban areas (Ostrom, 2009a). These include the collective-choice rules which govern land-use decisions, the productivity of the resource, and the predictability of system dynamics. For reasons we articulate below, we focus on Poland as an empirical setting for this study due to its evolving first- and second-level characteristics.

3.1. Collective-choice rules: characteristics of local autonomy

In property rights regimes, "rights" need to be distinguished from the institutional "rules" which bestow the range of actions which can be taken within a specific domain (Commons, 1968; Fischel, 1987; Schlager and Ostrom, 1992). Institutional rules, norms or strategies may exist at three levels: the constitutional choices which legitimize entities to take actions; the collective choices which set policy in accordance with

constitutional parameters; and the operational choices which implement decisions and regulate behavior (McGinnis, 2011; Ostrom, 2011). The rights to use a resource, earn income from it, enforce and transfer ownership are core to the traditional economic and legal descriptions of property rights (Eggertsson et al., 1990), and are established and adjudicated through broadly agreed-upon rules at all three levels. With unclear or conflicting rules authorizing rights, establishing decision-making processes and regulating land uses, it becomes difficult to govern any resource.

The institutions governing land-use in Poland over the past three decades have evolved to reinstate stringent private property rights since the fall of the former Eastern Bloc (Halleux et al., 2012; Łowicki, 2008). Government administration in Poland is organized into three levels: 16 *voivodeships* (or provinces); 380 *powiats* (counties or districts, including 66 cities large enough to be classified as powiats) and 2478 *gminas* (communes or municipalities), with some land-use management delegated down these levels. The initial land-regulation system post-1989 reflected an ad hoc mix of central-planning elements from the previous system and market-oriented planning (Newman and Thornley, 2011). In the early days after 1989, disputes over ownership resulted in uncontrolled development and the appearance of small businesses and unauthorized construction on the periphery of cities (Hunter and Ryan, 2005; Newman and Thornley, 2002).

At the constitutional level, the national government defines how much discretion the districts (*powiats*) have over administrative decisions to issue building permits. However, collective-choice authority over land-use is divided amongst the districts and municipalities. The district issues decisions in accordance with the building code established by the central government and handles administration of building regulations. Meanwhile, municipal (*gmina*) councils are allowed to issue Local Zoning Plans (LZP, *Miejscowy Plan Zagospodarowania Przestrzennego,* hereafter "local plan"). Much like a comprehensive plan, the local plan is a spatial planning tool used to determine the use of land, identify current conditions, locate future public investments, and identify the means of land development (Feltynowski and Szajt, 2021). However in 1994, the Polish central government adopted a Planning Act which invalidated all previously adopted legally-binding local plans. In 2003, the government eliminated the requirement for cities to have local plans at all, part of a reform referred to by some as a "quasi-complete dismantling" of the prior land-use regulation regime (Halleux et al., 2012). By April 2017, only 30% of the country areas – mostly urban cities – were covered by local plans. For municipalities not covered by a local plan, a 'decision on building and land development' (DBLD) may be issued by the executive (mayor). This reflects operational-level choice delegated to mayors, and is cited as one of the most important reasons for the land use chaos in Poland and the failure of some local communities in the 'game for space' (Kolipiński, 2014). At the same time, this type of collective-choice arrangement makes mayors important objects of research on land use changes.

Empirical analyses in the U.S. tend to differentiate between administratively and politically centered authority in cities via the council-manager form of government, which is prevalent in the U.S. but not widely used in European countries (Carr, 2015; Nolting, 1959; Zhang and Feiock, 2009). European municipal governments do not have a comparable delineation between mayoral and managerial executive authority. Rather, mayors tend to hold executive authority and administrative oversight. Because of their positions overseeing administrative and regulatory processes, mayoral authority is the primary institutional factor in filtering land-use policy demands and mayoral authority is enhanced with greater political stability.

One measure of stability is the size of the electoral majority. Political economy explanations of urban development hold that elected officials should consistently make policy decisions in anticipation of reciprocal political support from favored groups (Molotch, 1976; Schneider, 1989). Elected officials have discretion to speed up or delay development approval as a mechanism to solicit forms of reciprocal political support from constituents (Deslatte et al., 2016). The direction they push may depend on the dominant political coalitions or interests within the community. Officials may favour pro-growth pressures due to the presence of strong pro-development interest groups (Feiock et al., 2008). Or, they may yield to pro-conservation preferences if environmental attributes are seen as key to driving investments and growth (Lubell et al., 2009). Chanel et al. (2014) analyze farmland preservation in Southeastern France and find that stronger majorities increase the ability of the municipal council to resist pressure to develop. However, Delattre et al. (2015) find that local governments in France without political competition can choose a policy further away from the preferences of the median voter. Poland presents a different context given its transition from central-planning to market-based land-use pressures. Beginning in the mid-1990 s, cities in Poland faced heightened pressure to make more land available for investments around existing urban areas at the same time that farmers faced increased competition from EU states (Łowicki, 2008; Łowicki and Mizgajski, 2013). The result is that farmland was replaced with settlement areas around existing municipalities. Studies of landscape changes during this period also identified a "widening gap" between the fastest- and slowest-developing areas, indicative of competition for growth which is in keeping with the growth machine thesis (Łowicki, 2008). Given the autonomy delegated to local executives through collective-choice arrangements, political stability may afford mayors more discretion to approve development with fewer constraints. Translated into low electoral competition for the mayor, political stability will generate more consistent pro-development land uses. We hypothesize that mayors which have experienced larger majority-victories will generally support larger pro-development landscape changes than those whose re-elections are less assured.

H1. Mayoral margin of electoral victory will be positively associated with pro-development landscape changes.

3.2. Productivity of the resource: user versus exchange value of land

The productivity of the resource – whether as a present use or through exchange – depends on the stability of transaction costs established by political institutions. For all interest-groups, influencing the land-use policy process imposes transaction costs, or the non-financial commitment of time and effort to lobby, bargain and monitor political agreements for land-use changes. Unlike some common-pool resource dilemmas in which the costs and benefits may be broadly diffused throughout the community, land use decisions are likely to generate winners and losers among existing groups in each community. Political institutions are important for land use decisions because they influence who gets what and when.

Under stable political institutions, antigrowth groups can seek 'user' value by slowing some development from going forward through the costs resulting from bargaining, negotiation, and litigation. While developers wish to utilize private property for production and profits, new urban design advocates fight for slowing growth and creating "livable cities," and environmental interests often favor restricting land uses to preserve natural ecosystems. Many development proposals involve projects opposed by environmental, social equity or NIMBY (Not In My Back Yard) groups (Gerber and Phillips, 2004). In Europe, conflicts over land use and land cover change (LUCC) have expanded beyond the traditional development versus environmental conservation divide. Some authors suggest that stakeholders are now making functional claims along the lines of an "agriculture versus nature versus urban development" triangle (Henle et al., 2008; Kerselaers et al., 2013). Antigrowth resource users such as environmental coalitions, homeowners associations, and agricultural interests may generally prefer slower growth. Yet, these interests tend to be more heterogeneous, and face greater transaction costs in forging coalitions and influencing policy than typical pro-development demanders, particularly in the case of farmland interests. Delattre et al. (2015) distinguish between

"landowner farmers (with a preference for development if agriculture doesn't seem profitable enough to them)" and "tenant farmers (with a preference for regulations that protect agriculture)." This heterogeneity in farmland interests is confirmed by the findings of Chanel et al. (2014) suggesting that a larger proportion of farmers "increases the probability of a municipality's increasing its amount of developable land" (p.425).

In countries with emerging political institutions, the transaction costs for achieving preferred policy outcomes may be prohibitively high for lower-resourced groups. In Poland, farmers faced increased market-based pressure from other EU states to either allow development or afforestation on less-productive farmlands (Łowicki, 2008). One way in which we can operationalize agricultural resource users' influence over land-use is via farmers' presence on the municipal councils. Communes which elect farmers to their councils place actors in collective-action positions in which their preferences for "user value" for land may carry more weight. Such communes may experience less conversion of land to higher-intensity uses as the representation of agricultural interests on the governing board acts to weaken the relationship between mayoral stability and development. Thus, we hypothesize that the presence of farmers on the council will negatively moderate this relationship:

H2. The presence of farmers on municipal councils will negatively moderate the effect of mayoral margin of victory on pro-development landscape changes.

Conversely, governments and existing residents also benefit from growth, because this translates into increased tax revenues and/or lower-tax burdens for services. In this sense, systems powered by growth – the extraction of exchange value from land – are more likely to favor continued development. Pro-development groups such as construction companies and real estate agencies will prefer less government intervention, particularly if regulation might adversely redefine property rights and resource allocations, or result in negative consequences for their private interests (Eggertsson et al., 1990; Lubell et al., 2005) Development and construction interests have a substantial economic interest in the 'exchange value' of land and favor land-use decisions which allow for the conversion of rural or undeveloped lands to more continuous, urban uses. The actors involved in these transactions include builder-developers, real estate agents, financiers, and other facilitators (i.e. lawyers and consultants). They are often well organized and financed, making them powerful political demanders (Pacione, 2013). Organization and resources allow such groups to more easily gain access to influence metropolitan or citywide elected officials to reap gains. This advantage is reinforced by their perceived importance to local economies (Schneider, 1989). Where builders and developers are better organized and more influential in local politics, we expect that land use decisions accommodating growth pressures are more likely to emerge.

H3. The size of real estate presence in a municipality will be positively associated with pro-development landscape changes.

Another important characteristic of the resource user is wealth. The urban literature has frequently described the slow growth movement as exclusionary, elitist, and status-biased (Molotch, 1976; Navarro and Carson, 1991). According to these exclusionary motivations for growth management, higher-income increases the preference for growth regulation because individuals wish to exclude undesirable land uses and lower-income groups (Feiock, 2004; Maser et al., 1977). However, researchers have noted that in Poland the transition from communism to capitalism fueled the "dismantling of comprehensive planning" and emergence of large suburban zones (Halleux et al., 2012). This is analogous to the "sustainability paradox" in which urban development is desirable in areas where more amenities or environmental attributes are present (Lubell et al., 2009), thereby degrading the resource which had made the area attractive. The personal income tax (PIT) represents the main source of Polish municipalities' own-source income. Higher PIT reflects the presence of wealthy inhabitants in the community, and has been used as an explanatory factor in previous research (Lubell et al., 2009, 2005). We expect that wealthier Polish communities will pursue development in the absence of strong comprehensive planning laws. This is because existing residents are able to benefit – at least over shorter time horizons – from the positive spillovers of land development. In the aftermath of communism, the returns from making new lands available for settlement in Poland created a path dependency that sustains development decisions (North, 1990). In other words, the exchange value of the resource disproportionately outweighs the user value in emerging market economies. We expect that the present wealth within the commune – benefited from the exchange value of property – will mediate the authority of mayors in land-use. The distinction between mediation and moderation here is an important consideration (Bolin, 2014). While the autonomy of local executives sets the conditions for land-use outcomes and authorizes them to make development decisions, their incentives to do so are likely driven by a constituency-based logic of delivering growth benefits to existing populations. If mayors are enabled to make more growth decisions by the sizes of their electoral majorities, this implies that such actions are mediated by existing community wealth and resources. Given prior empirical evidence of inequality in development patterns, we hypothesize that communes compete for growth and that existing wealth will positively mediate the political relationship:

H4. Wealth of the community will positively mediate the relationship between mayoral margin of victories and pro-development landscape changes.

3.3. Predictability of system dynamics

Resource systems need predictability for users to appreciate the consequences of their use decisions (Ostrom, 2009a). Predictability is one of the primary benefits of land-use regulation, as expectations for property rights are delineated in order to achieve more desirable environmental, social and economic outcomes (Deslatte et al., 2017). Europe is one of the most intensively developed landscapes on the planet, with roughly 80% of the continent used for settlement, production or infrastructure. Despite this, there are significant differences in the developed landscapes across EU countries (Bengs and Schmidt-Thomé, 2006). While land-use decisions are predominantly made at the local or regional levels, there is considerable variation in planning processes across countries. Dating back to the times of Napoleon, the French style of planning characterized by stringent codes and centralized governance has been influential throughout Western Europe (Chanel et al., 2014). Local officials set up land use regulations in accordance with a national planning framework (Hirt, 2012). More importantly, property tax systems are primarily based on property revenues and added value rather than property values themselves. As a result, local land use regulations are the main policy tool to control land changes and fiscal tools are less used for this purpose (Chanel et al., 2014).

However, under the old Soviet zone of influence, urban density was promoted to foster a sense of collective identity (Stanilov and Sýkora, 2014), with housing constructed by the public sector in central cities and substantially less urban sprawl across Central and Eastern European countries (Nuissl and Rink, 2005). Under communism, some elements of land-use system dynamics – such as the containment of urban sprawl – were more predictable through central planning. But others were less predictable, such as the enduring shortages of housing Polish urban planners were unable to remedy (Halleux et al., 2012). The Soviet-era

focus on urban density gave way to unbridled urban sprawl under capitalism, as investment fueled settlement along transportation routes and at the periphery of cities (Halleux et al., 2012). Today, most private landowners may develop their property without significant regulatory oversight, so long as the development is similar to adjacent land-uses (e.g., housing), has transportation access, and adheres to local environmental requirements. Thus, ribbon-development along transportation corridors has exploded (Jakobczyk-Gryszkiewicz, 2002).

While comprehensive land-use planning can provide more predictability about future land uses, urban sprawl remains one less-predictable outcome given the spatial limits of local planning (Halleux et al., 2012; Nuissl and Rink, 2005). Cities with stringent zoning or land-use regulations cannot extend their vision or will beyond their borders. Land-use development patterns tend to spill over jurisdictional lines, as cities and less-developed areas compete for growth (Brown et al., 2005; Veldkamp and Fresco, 1997). Given the widespread failure to adopt more stringent local plans in Poland, we hypothesize that land development will be highly path dependent and influenced by development patterns in adjacent jurisdictions, consistent with land-use studies which identify such spatial and temporal dependencies (Deslatte et al., 2019):

H5. Past development and neighboring land-development will be positively associated with current pro-development landscape changes.

Just as the transition from communism to capitalism led to chaotic, competitive pressure to develop, we also expect that efforts to enhance stability from EU member countries also fueled market-based development. Post-Communist Poland did seek to implement some strategic planning reforms in the years prior to joining the EU in the wake of its "anarchic urbanization" (Lisowski et al., 2014; Halleux et al., 2012; Solecka et al., 2018). Polish local governments receive roughly one-fourth of their investment expenditures from EU Cohesion Funds resources (Dąbrowski, 2012; Florio and Vignetti, 2004). The Fund provides financing to reduce economic and social disparities in member countries whose gross-national income is less than 90% of the EU average, and has been an important source of investments expenditures on the municipal level in Poland since 2004. We expect that these investments play an important role in the landscape changes, and at the same time they depend on factors like institutional efficiency and the ability of local governments to provide matching funds. Therefore, they may also distribute benefits unevenly across municipalities if they simply fuel development where it was already likely to occur:

H6. EU Cohesion Funds investments will be positively associated with pro-development landscape changes.

In the following analysis, we operationalize these second-level SES variables by estimating how facets of the collective-choice rules, alternative uses of land, and predictability of system dynamics influence conversion of landscapes in Poland over a 12-year time span.

4. Data and methods

We utilize a spatial durbin error modeling approach for the analysis, using spatial data adapted from the Corine Land Cover (CLC) database. The data was obtained online through Copernicus Earth Monitoring Service. They are standardized land use data created with the help of Geographic Information Systems for the European Environment Agency (EEA).[1] The analysis focuses on land use changes over the years 2012–2018, but the changes in the years 2006–2012 have been taken into consideration as one of the explanatory variables. The datasets on land use changes at the local level in Poland were created by computing land use change and border shapes data with ArcGIS v 10.3 advanced, mainly the geoprocessing toolbox. Spatial data on land-use classes were overlaid with administrative units to generate the proportion of particular land use changes in each administrative unit (municipality). According to metadata of Copernicus database, the features are delineated and classified on satellite images with better than 100 m positional accuracy and with 5 ha minimum mapping unit into the standardized Land Cover nomenclature (44 CLC classes). The area of the smallest municipality in Poland is 335 ha and the mean area size is 12,624 ha (median 11,190 ha). The small size of the changes described in the Copernicus database in comparison to the size of territorial units in Poland, enables the inference on land use changes within the municipalities.

The analysed dataset also includes theoretically relevant variables at the local level – government institutions, interest group characteristics, economic and sociodemographic variables available in the databases of EUROSTAT and statistical offices in Poland.

4.1. Outcome variable

The outcome variable in our models accounts for the area (part of the municipality) on which land use in the past was different from the one in the moment of the data gathering.[2] This approach was previously adopted by researchers in the U.S. to measure change in the balance of pro-environmental and pro-development policy changes (Lubell et al., 2009). We adapt the approach in two ways: first, we use geospatial data of actual landscape changes rather than policy statements in documents to assess actual physical change; second, we relate the size of the area which changed towards more intensive use within the municipality to the size of the municipality to account for the intensity of the change experienced by the local community. The dependent variable is based on Corine Land Cover classes (Table 1). CLC classification consists of three levels. The structure of the classification has the casket form – each class of the lower level is assigned to one of the classes of the upper level. The classes of land use are ordered from the most intensive to the most extensive ones in reference to human activity. There are five main classes – (1) artificial surfaces, (2) agricultural areas, (3) forests and semi natural areas, (4) wetlands, and (5) water bodies. These five classes are internally diversified but at the same time highly distinctive from each other. The classification is the same for all European countries. We investigate changes of land use between classes on the first level of the classification – the most generalised one (Table 1). The internal diversification of the classes on the second and third level corresponds with changes that can be caused by nature or by humans while the changes on the first level of classification are changes caused by humans in analysed time perspective, they attract public interest, and are an object of local government formal decisions. These are also more permanent changes than changes on the second and third level of classification.

The dependent variable is a measurement of the RU called the Land Use Change Index (LUCI), constructed for each municipality. It is the *size of an area with changed land-use in a direction to a more intensive use in the years 2012–2018 related to the size of the municipality* (m^2/km^2). It was computed in accordance with the following assumptions:

[1] Version 18.5.: https://land.copernicus.eu/pan-european/corine-land-cover/lcc-2006–2012?tab=metadata

[2] Our dependent variable is calculated based on the Corine Land Cover change database. The product aims to produce coverage of real land cover changes which are detectable on satellite and occurred between 2012 and 2018. The database is prepared by national teams of satellite image interpreters and derived from a comparison of CLC2012 and CLC2018, later validated at the European Environmental Agency level (European Environment Agency, 2017). The production process is rather complicated, time and resource consuming, hence the final product does not contain year by year results, only values of changes observed in 2018 compared to 2012 between different CLC classes. The available data do not enable the use of a panel model rather cross-sectional analysis with a reference point in the past. We also use respective values of changes between 2006 and 2012 as an explanatory variable to account for path dependency. Our ex-ante and ex-post model estimation and validation strategy reported in the text follows similar recent works, e.g. the paper by Kauano et al. (2020).

Table 1
Resource units: the corine land cover classification.

1. Artificial surfaces	**3. Forests and semi natural areas**
1.1. Urban fabric	3.1. Forests
1.1.1. Continuous urban fabric	3.1.1. Broad-leaved forest
1.1.2. Discontinuous urban fabric	3.1.2. Coniferous forest
1.2. Industrial, commercial and transport units	3.1.3. Mixed forest
1.2.1. Industrial or commercial units	3.2. Scrub and/or herbaceous vegetation associations
1.2.2. Road and rail networks and associated land	3.2.1. Natural grasslands
1.2.3. Port areas	3.2.2. Moors and heathland
1.2.4. Airports	3.2.3. Sclerophyllous vegetation
1.3. Mine, dump and construction sites	3.2.4. Transitional woodland-shrub
1.3.1. Mineral extraction sites	3.3. Open spaces with little or no vegetation
1.3.2. Dump sites	3.3.1. Beaches, dunes, sands
1.3.3. Construction sites	3.3.2. Bare rocks
1.4. Artificial, non-agricultural vegetated areas	3.3.3. Sparsely vegetated areas
1.4.1. Green urban areas	3.3.4. Burnt areas
1.4.2. Sport and leisure facilities	3.3.5. Glaciers and perpetual snow
2. Agricultural areas	**4. Wetlands**
2.1. Arable land	4.1. Inland wetlands
2.1.1. Non-irrigated arable land	4.1.1. Inland marshes
2.1.2. Permanently irrigated land	4.1.2. Peat bogs
2.1.3. Rice fields	4.2. Maritime wetlands
2.2. Permanent crops	4.2.1. Salt marshes
2.2.1. Vineyards	4.2.2. Salines
2.2.2. Fruit trees and berry plantations	4.2.3. Intertidal flats
2.2.3. Olive groves	**5. Water bodies**
2.3. Pastures	5.1. Inland waters
2.3.1. Pastures	5.1.1. Water courses
2.4. Heterogeneous agricultural areas	5.1.2. Water bodies
2.4.1. Annual crops associated with permanent crops	5.2. Marine waters
2.4.2. Complex cultivation patterns	5.2.1. Coastal lagoons
2.4.3. Land principally occupied by agriculture, with significant areas of natural vegetation	5.2.2. Estuaries
2.4.4. Agro-forestry areas	5.2.3. Sea and ocean

a. change towards more intensive use was identified if an area's land-use was changed from any class towards one of the classes on upper level of classification, for example from *agricultural areas* into *artificial surfaces* (1 class up) or from *forests and semi natural areas* into *artificial surfaces* (2 classes up). We did not take into account how much higher in the classification the area is assigned after the change but only the fact of the change towards more intensive use of the area
b. analysed size of the changed area within the municipality is a sum of the changed fragments
c. size of the area within the municipality which changed towards more intensive use was related to the size of the municipality, so dependent variable is the ratio of changed to total area.

4.2. SES subsystems: explanatory variables

We built three sets of explanatory variables which are organized according to the core subsystems of an SES outlined above. The Governance System is characterized by rules and norms which condition collective- choice decisions. In order to assess H1, we employ a measure of the GS in margin of victory in mayoral elections, as mayors in Poland have been directly elected since 2002 and Poland falls into the group of countries in Europe with a strong executive mayor system (Mouritzen and Svara, 2002; Heinelt and Hlepas, 2006). Margin of victory is the difference in percentage points between the winner and the runner up in the first round of each mayoral race in the 2010 election cycle.

We employ several proxies as measures of key characteristics of Resource Users. H2 is tested using a proxy for the presence of farmers interest groups at the local level (see Fałkowski, 2018). This variable is measured as the share of seats occupied by farmers in the municipal council in 2012. Following Lubell et al., (2005, 2009), we employ the number of real estate companies per 1000 inhabitants as a proxy to the strength of construction interests in each community. Personal income tax (PIT) is the main source of income in Polish municipalities and it has been used as a proxy for the wealth of the local community (Swianiewicz and Brzóska, 2020). Here, we employ PIT to test the role of wealth as a mediator of the relationship between margin of victory and pro-development landscape changes (H4).

To capture Resource System (RS), the empirical model also includes three property rights variables accounting for land scarcity in the municipality. The size of the areas classified in the CLC classes 1.1.1. to 1.4.2. were taken into consideration to calculate the proportion of land heavily transformed by humans (artificial land) in the municipality. The areas classified as 4.1.1. to 5.2.3 in the CLC classes were employed to calculate the proportion of water-related areas in the municipality. The third variable related to land scarcity uses the 3.1. CLC class to calculate the proportion of land in the municipality occupied by forest. Finally, a number of measures capturing the social, economic and political Settings (S) were included. In order to assess H5, model specifications include a proxy for path dependency between past and current changes in land use. The variable *LUCI_2006–12* is the proportion of area in the municipality transformed towards more intensive use in the 2006–2012 period. It was computed exactly in the same way as the dependent variable but refers to the previous period. The last hypothesis (H6) is tested using the mean value of municipal expenditures from European Union funds per capita in PLN, for the period 2012–2018. The European

Table 2
SES Subsystem Variable Descriptions and Sources.

Variable	Description	Source
Resource Users (RU): interest groups variables		
PIT	Share of Personal Income Tax inflow to the municipal budget, per capita, PLN, 2012	Ministry of Finance
construction	Number of real estate companies, per 1000 inhabitants, 2012	Main Statistical Office
farmers in a council	share of seats in the municipal council occupied by farmers, %, 2012	Main Statistical Office
Governance System (GS): Institutional and interactive variables		
margin of victory	Difference in percentage points between the votes gained by the first and the second candidates in the first round of mayoral elections, 2010	National Electoral Commission
margin x PIT	margin of victory multiplied by PIT, multiplicative term	Own calculation
margin x farmers in a council	margin of victory multiplied by farmers in a council, multiplicative term	Own calculation
Resource System (RS): Property rights variables		
artificial	proportion of artificial land in the municipality, 2012	Copernicus
water	proportion of area occupied by water in the municipality, 2012	
forest	proportion of area occupied by forest in the municipality, 2012	
Contextual Settings (S) influencing Resource Units (RU): Control variables		
LUCI_2006–12	area of the municipality transformed towards more intensive use, m^2/ 1 km^2, 2006–2012	Copernicus
roads2012–18	dichotomous variable, 1 = highway and/or national road development between 2012 and 2018, 0 otherwise	General Direction for National Roads and Motorways
roads2006–12	dichotomous variable, 1 = highway and/or national road development between 2012 and 2018, 0 otherwise	General Direction for National Roads and Motorways
AR partition	dichotomous variable, 1 = municipalities under Austrian or Russian rule in the 1795–1918 period, 0 if otherwise.	
EU expenses	Mean value of municipal expenditures from European Union funds in PLN per capita, 2012–2018	Ministry of Finance

Table 3
Descriptive statistics.

Variable	Measurement	N	Min	Max	Mean	SD
Dependent: LUCI	m2/km2	2477	0	68668.266	2058.030	4976.576
PIT	PLN per capita	2477	98.366	2733.961	386.971	227.629
construction	companies per 1000 inhabitants	2477	0.626	49.485	10.765	4.294
farmers in a council	percent	2477	0	100.000	25.751	23.137
margin of victory	percentage points	2477	0	95.5138	33.901	25.711
artificial	percent	2477	0	89.691	9.003	13.105
forest	percent	2477	0	93.939	28.478	19.306
water	percent	2477	0	80.683	1.914	4.383
LUCI_2006–12	m2/km2	2477	0	164945.213	3480.268	10945.543
roads2012–18	dichotomous	2477	0	1	0.04	0.185
roads2006–12	dichotomous	2477	0	1	0.12	0.320
AR partition	dichotomous	2477	0	1	0.59	0.492
EU expenses	PLN per capita	2477	0	3633.423	175.359	149.003

Union cohesion policy funds are an important source of investments expenditures on municipal level in Poland since 2004. According to the official records on municipal budgets, the European Union funds accounted for 28% of all municipal investment expenditures in the years 2012–2018.

Additional measures include a dichotomous variable taking the value of 1 if the municipality experienced central government investments in the development of highways and/or national roads in the 2012–2018 period. The second variable is similar to the first, with 1 indicating that the municipality experienced similar investments in the 2006–2012 period. Both variables are used as controls due to the fact that the highest values of the dependent variable are spatially distributed along the main roads and the main roads are under central government responsibility. The last control variable is also dichotomous and takes the value of 1 if the municipality was under Austrian or Russian rule in the 1795–1918 period. This variable accounts for the different impacts this partition has had in the political, social, and economic realms in Poland (Zarycki, 2000; Tridico, 2006; Herbst and Rivkin, 2013). Table 2 contains variable descriptions and sources.

The variables that operationalize the space of interaction between interest groups and mayoral electoral competition have been mean centered, since there is an inevitable multicollinearity between the variables and their products – interaction variables. From a micro focus on multicollinearity (looking at the regression coefficients not at the overall fit of a model) mean centering reduces standard errors, benefits p-values and the likelihood of finding βs significant (Iacobucci et al., 2016). Descriptive statistics of all variables are reported in Table 3.

4.3. Spatial durbin error model estimation strategy

We estimate four spatial durbin error models (SDEM) using the open-access R software with packages: rgdal (Bindings for the 'Geospatial' Data Abstraction Library) and spdep (Spatial Dependence: Weighting Schemes Statistics) to address spatial and temporal dependence across municipalities and over time. SDEM accounts for exogenous interaction effects (dependent variable *y* of unit *A* depends on independent variable *x* of unit *B*) and spatial error correlation (error term *u* of unit *A* depends on error term *u* of unit *B*) (Elhorst, 2014). It takes the form:

$$Y = \alpha + X\beta + WX\theta + u$$

$$u = \lambda Wu + \quad \varepsilon$$

where Y is the dependent variable; α is the constant term parameter; X denotes an NxK matrix of exogenous explanatory variables with the associated parameters β contained in a Kx1 vector; WX is the exogenous interaction effects among the independent variables since W is an NxN spatial matrix describing the spatial unit arrangements; θ as β represents a $Kx1$ vector of parameters, to be estimated, λ is the spatial autocorrelation coefficient, Wu is the interaction effects among the disturbance terms of the different spatial units, and ε is a vector of disturbance terms (Elhorst, 2010, 2014). The first model is basic and does not include any multiplicative terms, the second and the third include interactions between the institutional variable (margin of victory) and the interest groups variables (personal income tax and share of farmers in a council, respectively), and the fourth model incorporates both interaction terms. To address spatial dependence (landscape changes in neighboring municipalities), we developed several spatial weights matrices for Polish municipalities (N = 2477) for comparison, selecting the first order contiguity matrix whereby only neighbours of the examined region (municipality) are considered. We then estimated a full regression model and assessed spatial dependence with the contiguity matrix using R. The results of the tests for spatial dependence showed a statistically significant value for all the models (respectively: 1st model *Moran's I=0.149, p = 0.0000*, 2nd model *Moran's =0.1466, p 0.00000*, 3rd model *Moran's I=.148, p = 0.000*, and 4th model *Moran's I=.146, p = 0.000*) indicating spatial dependence, and the Lagrange Multiplier Diagnostics (LM) showed that the Robust LM Error test was statistically significant (p = 0.000 for all models), indicating that a spatial error model should be used to correct for the spatial dependence in the model (Anselin, 2005). Utilizing the Durbin component is required given the control of the adequate level of interest groups activity. The Wald and likelihood ratio *a posteriori* tests compare OLS models with SDEM indicating added value of the spatial models.

5. Findings

The analysis illustrates the usefulness of an SES approach and supports our expectations about the importance of "second-level" factors such as the collective-choice rules, resource productivity and predictability. Results for four models – with and without interaction terms – are reported in Table 4.

The analysis finds that collective-choice autonomy afforded to Poland's local executives creates conditions for increased development. Specifically, the margin of victory for city mayors ($p < .05$) is positively associated with pro-development landscape changes during the 2012–16 period in three of the four models (H1). The only model where this result becomes statistically insignificant is Model 1 which does not include interaction terms. Cities where mayors faced less-serious threats to their election were more likely to experience greater development, which is consistent with the growth machine thesis.

Evidence suggests the conflicts over productivity of the resource also influence landscape changes. In SESs confronting common-pool dilemmas, users tend to have less incentive to manage a resource when the stock appears either exhausted or abundant. Applied to land, the resource has two potential uses – in its current form or through transactions and development – and the abundance or scarcity of developable land influences these 'user' or 'exchange' evaluations. Just as farmers have faced continued pressure to develop less-productive land, farmer presence on municipal councils appears to offset the effect of mayoral

Table 4
Results.

	1	2	3	4
PIT	0.159***	0.185***	0.161***	0.186***
	(0.032)	(0.033)	(0.032)	(0.033)
construction	0.034	0.037	0.035	0.037
	(0.026)	(0.026)	(0.026)	(0.026)
farmers in a council	-0.043*	-0.036	-0.039	-0.038
	(0.025)	(0.025)	(0.025)	(0.025)
margin of victory	0.025	0.038**	0.031*	0.037**
	(0.018)	(0.018)	(0.019)	(0.019)
margin x PIT		0.104***		0.115***
		(0.019)		(0.021)
margin x farmers in a council			-0.032*	0.022
			(0.018)	(0.021)
artificial	0.086***	0.085***	0.087***	0.084***
	(0.027)	(0.026)	(0.027)	(0.026)
forest	-0.099***	-0.101***	-0.099***	-0.101***
	(0.028)	(0.028)	(0.028)	(0.028)
water	-0.013	-0.016	-0.015	-0.015
	(0.024)	(0.023)	(0.023)	(0.024)
contr:LUCI_2006–12	0.166***	0.164***	0.165***	0.164***
	(0.022)	(0.022)	(0.022)	(0.022)
contr: roads2012–18	0.780***	0.804***	0.786***	0.805***
	(0.120)	(0.120)	(0.120)	(0.120)
contr: roads2006–12	-0.243***	-0.262***	-0.246***	-0.263***
	(0.070)	(0.070)	(0.070)	(0.070)
contr: AR partition	-0.033	-0.037	-0.026	-0.039
	(0.170)	(0.169)	(0.170)	(0.169)
contr: EU expenses	0.049**	0.052***	0.050**	0.051**
	(0.019)	(0.019)	(0.019)	(0.019)
spatial lag				
PIT	0.080	0.108*	0.085	0.109*
	(0.057)	(0.057)	(0.057)	(0.057)
construction	-0.016	-0.022	-0.016	-0.023
	(0.043)	(0.042)	(0.043)	(0.042)
farmers in a council	0.063	0.068	0.069	0.069
	(0.049)	(0.048)	(0.049)	(0.048)
margin of victory	-0.100***	-0.083*	-0.087*	-0.084*
	(0.044)	(0.044)	(0.045)	(0.044)
margin x PIT		0.127*		0.130**
		(0.048)		(0.054)
margin x farmers in a councill			-0.055	0.002
			(0.046)	(0.051)
artificial	0.0003	0.007	0.002	0.007
	(0.076)	(0.075)	(0.076)	(0.075)
forest	0.049	0.053	0.049	0.053
	(0.046)	(0.046)	(0.046)	(0.046)
water	0.026	0.017	0.022	0.017
	(0.044)	(0.043)	(0.044)	(0.043)
contr:LUCI_2006–12	-0.006	-0.002	-0.006	0.004
	(0.054)	(0.054)	(0.054)	(0.054)
contr: roads2012–18	-0.025	0.006	-0.016	0.001
	(0.218)	(0.217)	(0.218)	(0.217)
contr: roads2006–12	-0.022	-0.053	-0.020	-0.056
	(0.133)	(0.132)	(0.133)	(0.132)
Contr: AR partition	-0.157	-0.134	-0.167	-0.131
	(0.180)	(0.179)	(0.180)	(0.179)
contr: EU expenses	-0.042	-0.036	-0.040	-0.37
	(0.045)	(0.044)	(0.045)	(0.044)
constant	0.115**	0.109**	0.116**	0.109**
	(0.051)	(0.051)	(0.051)	(0.051)
observations	2477			
Lambda	0.363***	0.356***	0.362***	0.356***
Nagelkerke pseudo-R-squared	0.223	0.233	0.224	0.233
Wald Test (df = 1)	178.155***	170.230***	176.451***	170.510***
LR Test (df = 1)	138.339***	133.389***	137.197***	133.577***

authority. The analysis finds a statistically significant direct effect for farmer-presence on the council in Model 1, but this effect becomes insignificant when the interaction term for farmers and the mayoral margin of victory is included (Model 3). This interaction effect is negative and statistically significant ($p < .05$), consistent with H2. This suggests the farmer presence moderates the relationship between mayoral authority and landscape changes. This may be because the presence of more farmers on the governing body reduces the transaction costs for accessing and influencing these governing bodies. In this sense, farmer representation weakens or nullifies the effects of more influential mayors, because both likely hold different perspectives on the value of the land. It may also reflect the fact that communes with more farmer representation on the council are more agrarian and less developed in nature, and witnessed less development pressure than urban areas.

We find no evidence that the size of the real estate industry drives development (H3). However, the analysis finds that wealth – as measured through personal income tax – positively mediates the relationship between mayoral authority and pro-development landscape changes (H4). The measure of personal income taxes displays a positive, statistically significant relationship with development changes across all four models ($p < .05$), and a positive, interactive relationship with development in models 2 and 4 ($p < .05$). The Polish example supports our contention that the exchange value of land disproportionately outweighs the user value in emerging market economies.

Lastly, we considered whether the lack of unifying land-use regulation added to unpredictability of system dynamics and hypothesized that both path dependency, spatial dependency and EU cohesion funds would drive increases in the developed landscape. The evidence supports these expectations. Both temporal ($p < .05$) and spatial ($p < .001$)weighting parameters are statistically significant, indicating that land use change during the study period is also dependent on the recent history of land use changes in a municipality as well as changes in adjacent units (Table 4). In this sense, temporal dependency of landscape changes indicates some predictability that future uses will conform to past ones. However, the influence of neighboring jurisdictions may reflect spatial unpredictability. In other words, communes may have an incentive in emerging market economies not to place restrictive limits on land-uses without assurances that rival localities will do likewise. Similarly, EU cohesion funds – provided to equalize the economic development between EU member countries – are also positively associated with pro-development landscape changes ($p < .05$). Municipalities capable of providing matching funding for these investments appear more likely to translate them into conversion of land to more intensive uses, in keeping with prior research which identified inequities in the landscape changes across communes.

A number of resource system (RS) measures included in the models are also statistically significant. The proportion of artificial land displays positive, statistically significant coefficients across all models, whereas municipalities with a higher proportion of forest area are less likely to change land to more intensive uses. Together, these results suggest the preference for more compact development patterns is not (yet) consistent with the sustainability paradox as development tends to occur in areas already experiencing a higher proportion of artificial land. Conversely, municipalities experiencing investments in highways and/or national roads in the 2012–2018 period display more intensive land use patterns; this finding contrasts with the same dichotomous variable measured for the 2006–2012 period, which displays negative, statistically significant coefficients in all models. This combination of results suggests that more intensive land uses are occurring in municipalities along road corridors, possibly leading to development patterns consistent with those of urban sprawl.

6. Discussion and Conclusion

It has been more than two decades since Elinor Ostrom noted the lack of workable frameworks across scientific disciplines for studying and addressing the worldwide decline of ecological resources (2009a). Understanding and confronting the most pernicious impacts of human settlement patterns on the biosphere still requires broader intellectual engagement across academic disciplines and practice (Anderies et al., 2004; Carpenter et al., 2001; Garcia et al., 2019; Lubell et al., 2002; Ostrom, 1990). Transdisciplinary frameworks which can organize research findings and build cumulative knowledge about SESs still hold

the potential for more fruitfully examining resource use across country and region-contexts. The SES framework used here has the potential to help by identifying clear groupings of variables which represent features or concepts within subsystem components. These features can be operationalized across cases or contexts even when matching data are unavailable. We have argued that the SES framework developed by Ostrom (2009a) and advanced by hundreds of scholars investigating common-pool resource management can be adapted to build cumulative knowledge on urban development and landscape changes. The empirical evidence presented supports this argument.

Land-use policies are critical instruments for staving off many of the negative byproducts of urban development, including sprawl, environmental degradation, and climate change (Hortas-Rico and Gómez-Antonio, 2020). Past research on land use policy at the local level employs the political market framework to develop hypotheses related to the supply and demand for developable land (Lubell et al., 2009; Deslatte et al., 2017; Hawkins, 2014; Huber et al., 2011; Levesque et al., 2017). Our approach extends this political market explanation by adopting the SES framework as a more comprehensive account of land use choices. This approach underscores that policies cannot be considered in a vacuum. Land is a resource and land-use management involves understanding resource system, unit, user and governance dynamics (Cruz, 2018). We adapt the SES framework here to draw attention to three "second-level" groupings of variables influential to land-use patterns: the institutional arrangements which govern collective choices; the productivity of the resource; and the predictability of land-use dynamics. We argue that organizing variables via an SES framework can better facilitate cross-national research on the dynamics of land-use changes.

One element for understanding municipal responses to urbanization challenges is the institutional configurations which filter policy demands from constituent groups. While this contention has been supported by decades of empirical research in the U.S. federalist context, it has rarely been applied in other urbanizing regions of the globe. This study presents evidence that understanding and operationalizing collective-choice conditions in countries has the potential to enrich our theoretical understanding and applied prescriptions for policies across countries. In other words, institutional arrangements and context must both inform our next steps.

Similarly, the productivity or importance of a resource plays a critical role. In Poland, we observe that "exchange value" of land likely dominates and drives pro-development decision-making and outcomes. However, given the highly developed landscapes of more mature Western European market economies and their more comprehensive land-use regulatory systems, a "user value" ethos might be more appropriate for such contexts. The drivers of land-use changes in other Eastern contexts are also likely to vary in terms of the importance of specific variables but not in the "second-level" factors. For instance, Liu et al. (2005) conducted a study in China and found that the cropland loss in Eastern China was driven by a combination of factors, including "increased development to attract foreign capital and technologies, changes in industry structure, rapid urbanization, decreasing farming net income and rapid economic growth stimulated by convenient transportation systems" (p.2231). Thus, identifying the productivity and importance of the resource allows us to consider variation across contexts.

Lastly, the predictability of system dynamics is necessary for users to appreciate the impacts of their cumulative land-use decisions. Here, land-use policies can support property rights and provide certainty as to future allowable uses. The lack of such regulatory consistency across Polish communes likely exacerbates the spatial dependency we observe and highlights how even EU cohesion policies meant to address inequalities across member states may exacerbate sprawling land-use patterns. Poland has no comprehensive planning system, as only 30% of the country area is covered by local zoning plans. In the remaining areas of the country, executive discretion over DBLDs facilitates the promotion of pro-development decisions. The introduction of national legislation requiring the mandatory adoption of comprehensive planning in all Polish municipalities could contribute to curbing development patterns consistent with urban sprawl and significantly improve the predictability of system dynamics. This would also clarify the relationships between the central and the local levels of government in the negotiations with pro-growth interest groups. Improving the rule of law in land use planning would empower local communities and diminish the influence of executive authorities, supra-local interest groups, and the central government in land use policy-making. Furthermore, Poland is home to 33 of the 50 most polluted cities in Europe, so the state of environmental activism and governmental prioritization of sustainable development is likely quite different than elsewhere in Europe, the U.S. and developing countries.[3] The findings suggest that improvements in local civic and political activism have the potential to counteract development pressures and bring more balance to competing pro-growth and anti-growth interests.

Future work should extend this study to compare the roles that these SES factors play in landscape patterns at the local level by including additional countries in the analysis. Ostrom (2011) identified future challenges to institutional analysis research, including the development of dynamic analyses; building research which accounts for more complex settings using experimental designs, and harvesting on spatial methods to account for the patterns as well as the mobility of resources. Most of these challenges have not been overcome. Land use policy analyses building on the contributions of our study should enrich comparisons of systems in different settings defined by the SES framework (economic development, demographic trends, political stability, government resources policies, market incentives, media organization). Also, our study shows the usefulness of spatial analysis. The Polish example indicates that land use policy should take into account interdependencies going beyond the administrative and political system of one municipality and considering the traits of neighboring jurisdictions. This reinforces the need to implement different spatial research strategies, for example by narrowing or widening the scope of analysis to capture the range of policies, actors and resources influencing land use policy in a given political system.

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