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Institutional Settings and Effects on Agricultural Land Conversion: A Global and Spatial Analysis of European Regions

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Abstract: Spatial planning systems and institutions have a significant role in managing non-agricultural land growth in Europe and the assessment of how their implementation impacts on agricultural land consumption is of great significance for policy and institutional improvement. Reducing the area of agricultural land taken for urban development, or eliminating such conversion, is an international policy priority aiming to maintain the amount and quality of land resources currently available for food production and sustainable development. This study aimed to evaluate the impact of land use planning systems and institutional settings on urban conversion of agricultural land in the 265 NUTS2 level EU27 and UK regions. Taking these regions as the unit of our analysis, the research developed and used global and local econometrics models to estimate the effect based on socio-economic, institutional and land use data for the 2000–2018 period. There is limited research focusing on the impacts of institutional settings and planning types of the European countries on the conversion of agricultural land. Furthermore, existing research has not considered the spatial relationships with the determinants of agricultural land conversion and the response variable, therefore, our research aimed to contribute to the literature on the subject. The results showed that the types of spatial planning systems and institution variables significantly impact the conversion of agricultural land to urban uses. Socio-economic indicators and areas of agricultural and urban land have significant impact on agricultural land conversion for any type of spatial planning system. A further result was that decentralization and political fragmentation were positively associated with agricultural land conversion while quality of regional government and governance was negatively associated. A local regression model was assessed to explore the different spatial patterns of the relationships driving agricultural land conversion. The main empirical finding from this model was that there was spatial variation of driving factors of agricultural land conversion in Europe.

Keywords: agricultural land conversion; spatial planning systems; institutional settings; global and local models; Europe

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1. Introduction

More than half of the world's population live in cities and the UN has predicted that the urban population will more than double its current size by 2050 [1]. Population growth and the process of urbanisation are associated with conversion of large areas of agricultural land to urban development, which has been a common trend in many countries including European states [2–4]. Specifically for Europe, the majority (64%) of regions are characterised by a combination of highly suitable land for agriculture experiencing a high degree of urbanisation with less suitable land for agriculture experiencing low degrees of urbanisation [5]. The loss of fertile agricultural land to urban development has created serious environmental and socio-economic impacts. Conversion from natural lands suitable for food production to urban uses has affected food security [6], agricultural labour and productivity [7], carbon cycle [8], hydrological processes [9], surface energy balances [10], as well as led to major changes in culture, the environment, and the life of local people [11]. Consequently, understanding agricultural land use change processes is important not only to examine future land use change dynamics but also to assess the influence of land related policies [1].

Policy measures and regulations at the European and country levels, such as the Common Agricultural Policy (CAP) (in conjunction with EU environmental directives, such as the Habitats Directive, Water Framework Directive, and Nitrates Directive) and the Least Favoured Area (LFA) Policy, influence agricultural land use change and urban development [12]. Critically, although similar policies prevail across Europe, the differences in governance structure alongside a situation where policy is implemented at different speeds and in different environmental conditions has led to regions with different outcomes in terms of landscapes and economies [13]. Therefore, in Europe, different land use patterns have emerged: for instance, hotspots of land abandonment can be observed in Eastern Europe, Southern Europe, and in many European marginal areas [3,14,15]. In North-Western Europe, agricultural intensification by landowners is observed along with specialisation in farming [16]. Parts of Eastern Europe are also experiencing agricultural intensification in production methods due to favourable agricultural conditions and removal of barriers related to trade and economic policy [13]. These examples show that agriculture is an important economic activity where there are favourable farming conditions, and farming will decline in marginal areas even in suitable land type areas based on the policy support context.

This conflicts with established EU environmental policies, as since 2011, the EU Roadmap to a Resource Efficient Europe [17] has promoted a move towards a situation where 'No Net Land Take' is occurring in the EU by 2050, aiming to mitigate the effect of urban sprawl and other environmental concerns. The concept of reducing the area of land being taken for urban development, or eliminating such conversion, essentially aims to maintain the amount and quality of land resources currently available for food production and sustainable development. This aim corresponds to Target 15.3 of the UN Sustainable Development Goals (SDGs), which, by 2030, strives to combat desertification and to restore degraded land and soil and is also closely linked to the broader land and environmental policies globally. The European Environmental Agency [18] noted that the resulting increases in artificial surfaces associated with changes in land use often causes the impairment or disruption of valuable ecological functions of soils giving examples such as biomass provision, soil biodiversity and soil carbon pool, or water infiltration potential. This contributes to negative climate change impacts.

In developing countries as well as in major economies, urbanisation dominates land use changes with agricultural land mainly converted to accommodate urban uses [19]. For instance, between 2000 and 2018, the total agricultural land area in European States decreased continuously associated with an increase in built-up areas (Figure 1). The rate of decrease in agricultural land was considerably lower between 2012 and 2018 compared to the pre-2012 period (Figure 1) representing the negative impact of economic crises on urban development. Many jurisdictions went from a property development surge to a crash and cessation of developments over this period [20]. Indeed, there was a positive change in built-up areas between 2000 and 2018 but the rate of change decreased considerably in the post-crises recovery period. From Figure 1, it also follows that forest and semi-natural areas declined in the 2000–2018 period though the rate of change was minor in comparison to the change in agricultural landscapes. Wetlands decreased while there was a small increase during the 2006–2012 period. Water bodies, which comprise inland waters (i.e., water courses, water bodies) and marine waters (i.e., coastal lagoons, estuaries, sea, and ocean), also decreased during 2000–2018 period.

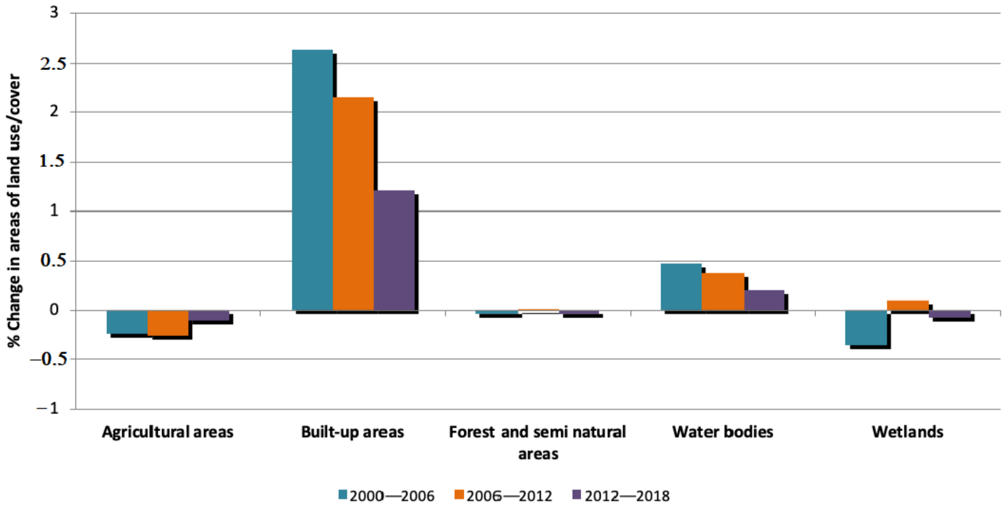


Figure 1. Land use/cover change in EU27+UK in the 2000–2018 period (Source: The Figure created by authors based on CLC 2000, 2018 data obtained from EEA [21]).

The main pattern, as mentioned by Rienks [22], is a polarisation between areas and regions with either marginal or intensive agricultural production. These macro level changes are resulting from local and regional development trends, which are related to the interaction of driving factors such as regional economic development, population growth, migration patterns, and processes [23]. They may lead to relative stability in some areas and hot spots of land use change in other areas [3,24].

The magnitude of these changes has given rise to the issue of land use sustainability, a term referring to the 'optimal spatial configuration of ecosystems and land uses to maximize ecological integrity, achievement of human aspirations or sustainability of an environment' [25]. The understanding of the drivers of the land use change has been at the centre of landscape research, and large volumes of literature have been devoted to the study of landscape change, and especially to the concept of "driving forces". Landscape change studies include examples on the drivers of desertification [26], agricultural intensification [27], deforestation [28], wetland conversion [29], and urban expansion [30], among others. The dynamics of landscape changes based on fine-scale land cover/use data were investigated at the global [31], country [32], regional [33], or local [34] levels. These studies have constructed a framework for understanding the causes, processes, actors, and outcomes of landscape change, and has become a crucial input for the evaluation of policy interventions. Knowledge on the drivers of landscape change has gained more importance recently given the rise of integrated landscape approaches that represent an important shift from the previous more limited conservation and development strategies. With such approaches involving the acknowledgement of interdependencies of human and natural systems, more integrated strategies could be designed to enhance local well-being while reducing environmental degradation [35,36]. In the European context, this view is represented by the European Landscape Convention that aims at promoting the protection, management, and planning of the landscapes through international coordination and co-operation on landscape issues.

The concept of the drivers of land use change can be linked to proximate and underlying drivers of change [37]. Proximate drivers relate to human activities and immediate actions at the local level resulting in landscape change such as deforestation and expansion of urban settlements [38]. In contrast, underlying drivers are based on the fundamental societal and natural processes that drive these proximate causes operating either at the local level or having an indirect impact from national or global level [38]. Underlying drivers may include demographic, economic, socio-political, cultural, science and technology, and natural factors [23]. Agricultural land use change and its proximate and underlying drivers are known to differ considerably from one location to another, as the subject has been widely investigated in local case studies. Examples include northeast Iran [39], Pampas and Chaco (Argentina) [40], Asia region [41], Wuxian city (China) [42], Southern Germany [43], South-eastern US [44], East Java (Indonesia) [45], Pyrenees [46], Nepal [47], and others. It is obvious that case study findings cannot be generalised easily and driving factors cannot be adapted from one area to another. With an aim of aggregating case study findings, meta studies have been conducted that synthesize evidence on land use change studies [48,49]. Case studies at the local level can provide evidence on the drivers of agricultural land change in a local context and these can be locally specific in causes, processes, and outcomes. However, a systematic analysis at the European scale aims at providing a generalised insight concerning the analysis of landscape change so that the drivers can be generalised and understood across locations [50]. Among the few studies at the pan-European level, there are some on agricultural land change drivers through application of a meta-analysis based on case studies from different regions in Europe [2,37]. Kuemmerle et al. [3] conducted the other European-wide study, which examined hotspots of urban and agricultural landscape change based on a high-resolution land cover data. Contrastingly, Hatna and Bakker [51] examined agricultural abandonment and expansion in Europe through applying regression analysis. More recently, Ustaoglu and Williams [4] explored the drivers of agricultural land conversion to urban uses focusing on a regression analysis approach based on socio-economic, natural, geological, climate, and policy related data.

A major shortcoming of the above literature is that there is no explicit analysis on how the legal system, strategic planning, and investment decisions influence the agricultural land consumption in the European framework. Spatial planning practices and regulations such as zoning, agricultural support programmes, land consolidation, infrastructure development, or nature conservation decisions, can be highly influential determining the agricultural land use change and production. However, there is limited literature examining the relationship between planning systems, policy settings, and agricultural land use change in Europe. The literature at the pan-European level has either focused on the role of institutional settings in determining the spatial variation in urban sprawl [52] or investigated the role of governance and spatial planning in the management of construction materials [53]. Stürck et al. [54], in contrast, examined the impact of flood and climate regulations on the spatio-temporal land use change dynamics in Europe. The impacts of macro policies on agricultural land use change were captured through application of an integrated macro modelling approach by Van Meijl et al. [55] and Renwick et al. [56]. Cortinovis et al. [57] researched the main spatial strategies promoted at the EU-level and investigated whether the development trends are aligned with the directions suggested by the strategies. A conceptual framework was constructed by Hersperger et al. [58] to analyse the role of spatial planning in urban land change. Others assessed the planning and governance systems with an aim of sustainable land use management and development of better integrated planning approaches across Europe [59–61]. There are also local studies examining the role of territorial planning and regulations in land use change and environmental quality covering Lithuania [62], US [63], and China [64,65].

The main contribution of this paper is to establish a new analytical framework to quantify the relationship between spatial planning and agricultural land consumption at the European scale. This study provides a new research area for quantifying the relationship between planning systems/institutional settings and the urban conversion of agricultural land at the regional level using both global and local regression models. The changing conditions of socio-economic development, land use and spatial processes are all diverse and complex. Therefore, an operative approach was followed to extract planning, institutional, and socio-economic determinants of spatial processes. The paper will identify the factors influencing agricultural land conversion to urban uses and analyse the spatial distribution of these factors throughout in the jurisdictions used in the analysis. The areal units used in the analysis consist of 265 regions at the so-called NUTS2 level in the EU27 states and the UK. High quality satellite images provide cost-effective and timely information in the assessment of long-term processes and patterns of agricultural land use change and urban development. This paper uses satellite images from Corine Land Cover (CLC) (EEA) [21] for the years 2000 and 2018 for quantifying the agricultural land conversion to urban uses during this period. Other socio-economic, land use, planning, institutional, and policy related factors were obtained from various official European Union and European sources. The paper will first analyse the potential drivers of agricultural land conversion in Europe based on political, socio-economic, and legislative determinants of spatial processes using a global ordinary least square (OLS) regression model. A problem identified with the global regression models is that these models assume independence of input variables and unchanged relationships between variables across space. In fact, the relationships between agricultural land consumption and response variables may vary in different locations [66,67]. Local spatial regression approaches such as geographically weighted regression (GWR) can be used to capture the spatial relationships, providing an enhanced understanding of spatial processes. The subject method has been applied in various land use studies for providing appropriate predictions of the geographical interactions [68–70]. By focusing on a limited number of socio-economic factors, this paper establishes a refined version of GWR, i.e., multi-scale geographically weighted regression (MGWR), to analyse the spatial heterogeneity of factors, which provides a framework to analyse the spatial variation of the factors across different planning systems in Europe.

2. Data and Method

2.1. Land Cover Data

Aiming to assess determinants of agricultural land consumption in Europe, the response variable in the regression model was quantified by processing and analysing the existing CLC database (2000, 2018) [24]. The CLC programme is the European Community initiative that was implemented in 1985 [71]. In total, the CLC inventory includes five waves—1990, 2000, 2006, 2012, and 2018—for a panel of the European countries. The CLC development process is based on satellite image interpretation (LANDSAT, SPOT, TM, and MSS) and regional land cover information including aerial photography, local knowledge, and statistics [72]. The CLC database contains information about land cover as well as land use. There are five main classes of land cover including: (1) Artificial surfaces (e.g., residential areas, commercial and industrial areas, mines and urban green spaces); (2) Agricultural areas (e.g., arable land, permanent crops, meadows, pastures, land principally occupied by agriculture including areas of natural vegetation); (3) Forests and semi-natural areas (e.g., forests, shrubs, open areas with little or no vegetation); (4) Wetlands (e.g., inland marshes, peatbogs, salt marshes, saline); and (5) Water bodies (e.g., inland waters and marine waters). Currently, the CLC datasets represent the only spatial data available for the entire European area with satisfactory resolution. The CLC 2000 and 2018 datasets both covering the EU27, and UK were therefore used in the present study to quantify the agricultural land conversion to urban uses during the study period. By urban uses, we refer to residential areas, industrial and commercial areas, and urban recreation sites, and this will be used throughout the text to refer to the subject land uses. To specify the quantity of agricultural land consumption over the study period, the agricultural land use dynamics model can be formulated as:

$$\Delta AU = \frac{AU_{t_2} - AU_{t_1}}{AU_{t_1}} \times 100 \quad (1)$$

where ΔAU is the change of agricultural land consumption over the period t_2–t_1, and AU_{t1} and AU_{t2} represent the area of agricultural land converted to urban uses at time t_1 and t_2, respectively. From the analysis of the agricultural land use model (Equation (1)), we quantified agricultural land converted to urban uses in the study period and the findings are shown in Figure 2. Figure 2 shows that the largest amount of agricultural land consumption was observed in the eastern European regions as well as western and southern France, southern Spain, south and south-eastern UK, and southern and Northern Ireland. There were also regions in northern Italy, southern Greece, Bulgaria, and many other regions in central Europe that have experienced considerable amount of conversion of agricultural land to urban uses. In Figure 2, the spatial variations of agricultural land use change according to different planning systems can also be seen. The details of the European planning systems are elaborated in the following sub-section.

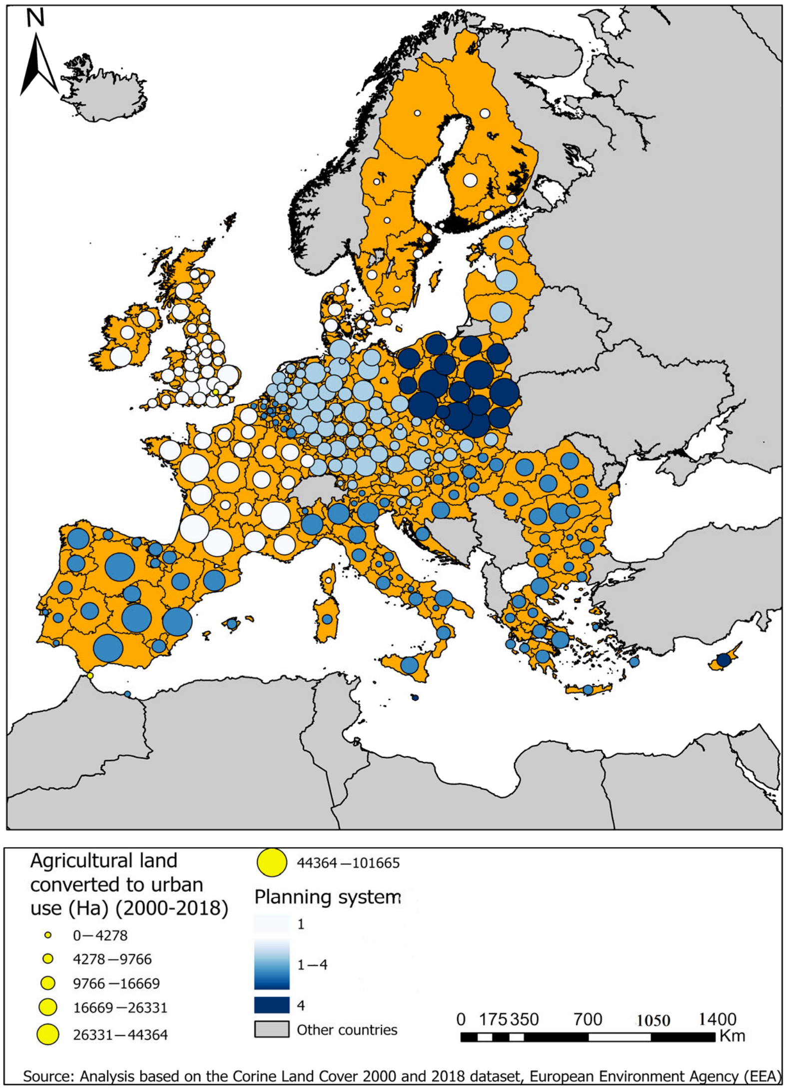


Figure 2. Distribution of agricultural land converted to urban use at the NUTS2 level in the EU27+UK between 2000 and 2018. Source: The Figure was created by the authors based on CLC data from EEA [21]. Note: Planning systems (from light blue to dark blue): 1: State-led systems; 2: Market-led neo-performative systems; 3: Conformative systems; 4: Misled performative systems.

2.2. Explanatory Variables

To analyse the relationship between urban conversion of agricultural land and its determinants, we gathered data from various European sources. We included socio-economic factors, land use, institutional data, and data on planning systems, based on a review of the related literature [4,52,53] and availability of data at the regional level during the study period. To keep the model more focussed to institutional settings and planning systems, we included these key variables and excluded other factors such as local environmental conditions, climatic factors, and farm management variables, as was also the case in research by Ehrlich et al. [52] and Dombi [53].

2.2.1. Spatial Planning

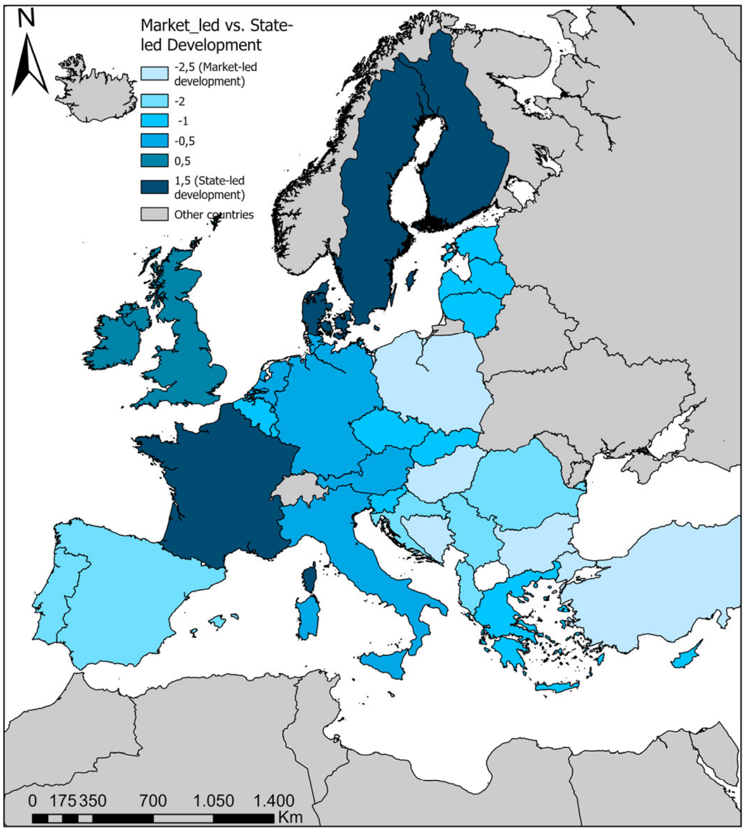
The seminal EU Compendium of Spatial Planning Systems and Policies project [73] defined spatial planning as being a combination of land use regulation and the coordination of the territorial impacts of sector policies. Spatial planning is often used to describe the national systems of land use planning, while territorial governance has evolved to describe the role of planning in coordinating various sectoral policies. Working definitions adopted in the European Union ESPON/Compass project [74] provide a suitable platform for a discussion of alternative planning systems and an updated comparative analysis of spatial planning in Europe. Spatial planning systems can be viewed as the combination of institutions that are used to mediate competition over the use of land and property, to allocate rights of development, to regulate change and to promote preferred spatial and urban form.

Williams [75] described a wide spectrum of planning systems and consequent land use and real estate outcomes, with alternative approaches to planning structures, scope of activities, locus of key powers, and legal systems. These range from primarily state-led systems in the traditional Scandinavian typology, to purely market-driven approaches (Figure 3). State-led systems principally require mandatory conformance with official guidance as set out in plans. Development or market driven approaches are often based on a strong legal and regulatory framework for development with development objectives reliant on functioning property markets and private finance for their implementation. In effect, the development plan seeks development that aligns with the agreed development interests, needs of the area, and has flexibility to cope with changes in demand. In such discretionary systems, development plans are not legally binding, as in many European countries, but are directional and aspirational.

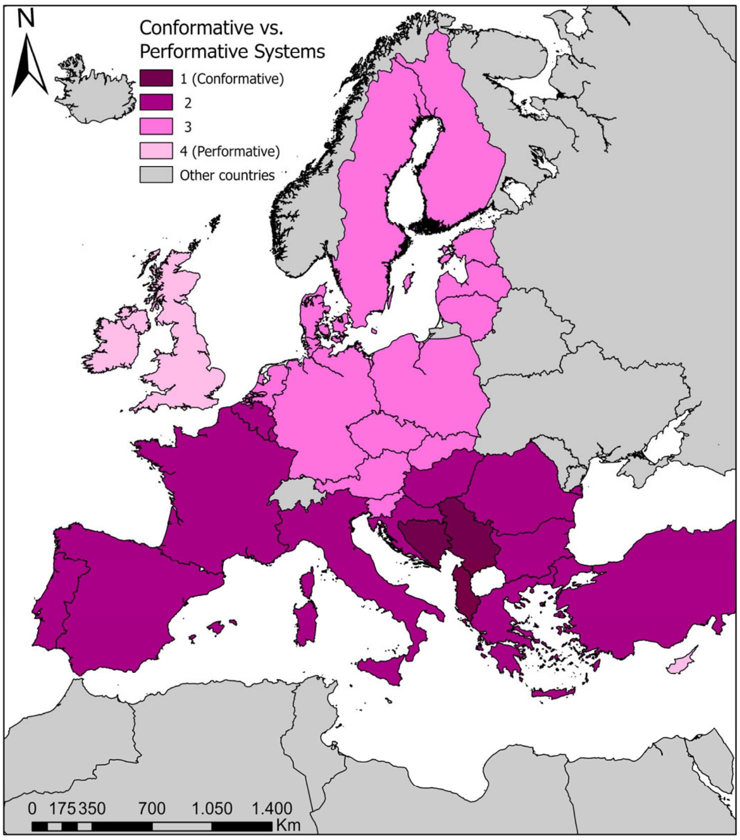
Dombi [53], in 2021, discussed the presence of a wide variety of systems in Europe due to the relatively large number of independent states in the region [76]. Using the evaluation of spatial planning models applied in ESPON Compass projects and citing Berisha et al. [60], Dombi [53] clustered the countries of Europe into systems characterized by the two aspects of spatial governance and planning; first, whether a system was market or state-led addressing power relations between the market and the state, and second, its positioning with regard to the contrast between conformative and performative models of planning. This second concept addresses whether a planning decision on an investment is an object of predefined land use regulation such as zoning (conformative planning) or alternatively is subject to a process of individual evaluation and discretionary judgment termed as performative planning [2] (Figure 3).

A conformative spatial planning system dedicates all land use and development rights through generally applicable binding plans. This classification involves investment and development decisions having to conform to prescribed planning and building guidelines. Compulsory or conformative plans provide applicable or binding plans which are often legally bound to be implemented. The main land uses and other important development details are decided following consultation processes. Such binding land development plans can be criticised as inflexible and not open to rapid changes in the economic and social context.

In contrast, a performative or discretionary spatial planning system applies a case-by-case evaluation based on a spatial development strategy. Such negotiable planning approaches, while of significant importance in setting out the policy aspirations, give guidance only for implementation. They are then subject to individual development applications which are negotiated and agreed prior to development implementation. Developments permitted in systems using this approach may include proposals which contravene or were not included in the original development plans. Where such flexibility is built into systems, this can also lead to a negotiations process that is subject to appeals by both applicants and third parties. Such negotiations and appeal processes can in turn lead to a complex legal adversarial approach. The original purpose of development planning becomes linked with the property rights of all parties affected by the planning process especially development land interests and those of adjacent landowners.

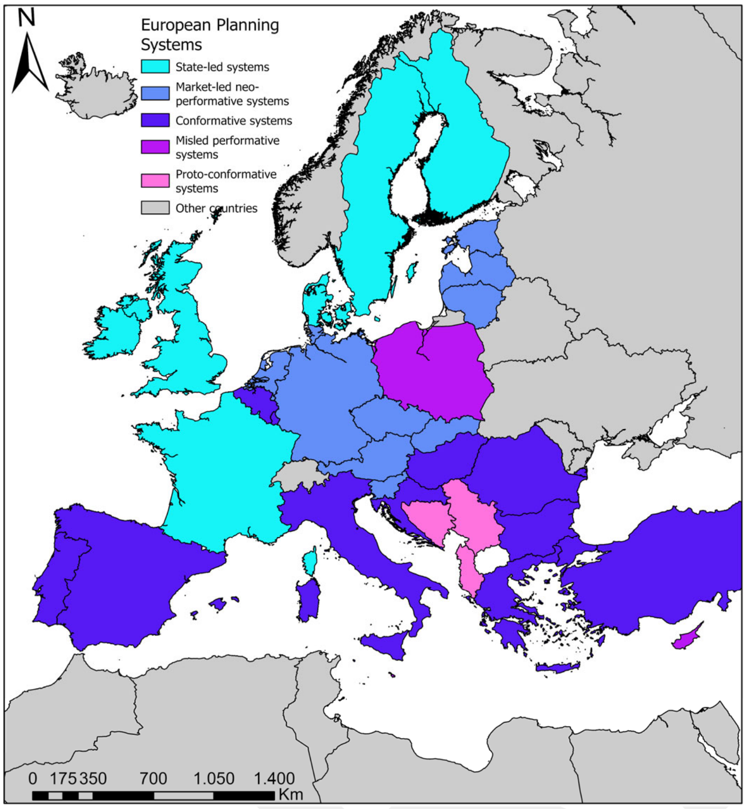


(A)



(B)

Figure 3. *Cont.*



(C)

Figure 3. Spatial governance and planning systems in European countries based on Berisha et al. [60]; (**A**): Market-led vs. state-led development; (**B**): Conformative vs. performative systems; (**C**): European planning systems. Source: Figures were created by the authors based on the data given by Berisha et al. [60].

In turn, the issue of development gain or planning gain is treated differently across multiple planning jurisdictions, with some approaches granting virtually all the land value uplift following planning consent to private land interests and other approaches representing a sharing of development profits between land interests and public interests. Some systems blend both approaches with a neo-performative system operating with the conformative allocation of rights for land use and development at the local scale but with binding plans being context and project dependent and objects of inputs and negotiations with the actors [76].

Dombi [53] found that the types of spatial governance and planning systems significantly shape the effects of urban form with such effects ranging from −67% to 215% relative to the most widespread system, i.e., the conformative system. Dombi [53] also found that economic structure and urbanization have a positive feedback effect on the accumulation process at any level of development. This raises the question for this research of whether explanatory variables within spatial planning typologies have an impact on both the management of available space and land conversion rates.

2.2.2. Decentralisation

Along with the typology of planning systems for land use change, such change may also be influenced by the degree to which decisions and policies are subject to controls at a local or centralised level. Spatial planning systems with strong state direction require a comprehensive or integrated approach at local level if they are to succeed. Conflicts can emerge as regional and local decentralisation occurs in fiscal, administrative, and political systems.

It is of significance, therefore, to provide a distinction between fiscal, administrative, and political decentralization. Fiscal decentralization gives the right to subnational authorities to control subnational revenue generation and spending; administrative decentralization is the right of subnational governments to set goals and implement policies;

and political decentralization refers to direct elections for subnational offices [77,78]. There is also constitutional decentralization as highlighted by Treisman [79], which refers to an explicit right possessed by subnational governments to participate in central policy making. The case for decentralization includes the potential for localized experimentation leading to more policy innovation and that interjurisdictional competition allows politicians to provide an efficient bundle of public goods through limiting their ability to overtax the citizens [80]. Several decentralisation measures have been repeatedly suggested in the literature [80–84]. Our first measure was an index that represents whether a country's constitution provides authority to subnational governments to exercise goals and policies in relation to financial, legal, policy, representational, and constitutional competences or assigns residual powers to subnational governments. This is the Regional Autonomy Index (RAI) as given in Table 1 from Hooghe et al. [78]. Specifically, RAI is a composite indicator that aggregates decentralization measures computed at sub-national levels. There are ten sub-indicators entering the RAI index [3] where low values correspond to heavily centralized institutional settings and high values to heavily decentralized ones.

As a second measure, this research considered whether a country is classed in its constitution as a federal or quasi federal state in comparison to a unitary state. Here the aim was to measure whether the government has a hierarchical, bureaucratic mechanism of top-down management, or whether there is a system of nested self-governments characterized by participation and cooperation. A well-ordered federal system can support governance in several ways, "*providing strong incentives for higher quality policy making and tighter reins of accountability to the governed* . . . ". Further to this, "*a federal system increases the elasticity of political demand for politicians at every level and increases their competitive incentives to offer better public services*" (Faguet, [85], p. 4). The information on whether the European countries are either a federal or unitary state is from OECD (2017). Finally, our third measure was based on the data derived from Treisman [79], which measures how many of levels of government there are in a country, named as 'TIER' (see Table 1). The number of tiers in a country represents the decentralization level in that country where high numbers relate to more decentralization and low numbers to less decentralization.

2.2.3. Corruption in Public Sector

The Corruption Perceptions Index (CPI), used as a variable in our regression model, aims to measure the perceived levels of public sector corruption that may be observed in European countries. The CPI is a composite index developed by the Internet Center for Corruption Research (www.egg.org) based on surveys of business representatives and assessments of country analysts from overall eleven independent institutions [4]. All these sources apply a definition of corruption as the misuse of public power for private benefit, such as bribing of public officials, corrupt payments in public procurement, or embezzlement of public funds. These sources also evaluated the 'extent' of corruption among public officials and politicians in the corresponding countries. The CPI was used in this research as a proxy to represent political corruption in the land sector for private gain. Opportunities for this kind of corruption result from privatization of state-own land, zoning limits and building permits, expropriation of private land for government-related projects, negotiation of large-scale land acquisitions by investors, and others [90]. Land is one of the key factors of production alongside with labour and capital; failure to manage land properly may lead to uprisings and questioning of the legitimacy of governments given that land provides revenue through land taxation or provides the basis for claims to other revenue sources [91]. The act of good governance is based on balancing the exercise of the governments' functions, yet conflicts may appear as one function interferes with another. In this context, the policymaking related to land conversion process should be transparent or inclusive enough to allow public participation; therefore, there should be no space for rent seeking and corruption [92]. Higher levels of corruption in the land sector may lead to higher rates of conversion of agricultural land to non-agricultural uses, particularly the built-up land. The reason for this can be related to the corruption in agricultural subsidies, agricultural support programs, land acquisition, or distribution of resources [93].

Table 1. Summary of the variables.

Variable	Description	Data Source	Mean	Standard Dev.	Min	Max
Dependent variable						
LAND_CONV	Area of agricultural land converted to urban use (Ha)	Corine Land Cover (EEA [24])	15,587	14,825	48	101,665
Independent variable						
Economic factors						
AGRI_RENT	Agricultural GVA (million €) per agricultural land (Ha) in a region	Eurostat [86]	0.0018	0.0036	0.0001	0.0036
URBAN_RENT	Industrial and services sector GVA (million €) per urban land (Ha) in a region	Eurostat [86]	0.289	0.248	0.0094	2.216
CAP_LABOUR	Agricultural capital to labour ratio	Eurostat [86]	0.0903	1.351	0.0001	22
G_GVA_AGRI	Growth rate of agricultural GVA between 2000 and 2018	Eurostat [86]	20.56	55.07	−94.1	392.2
G_GVA_IND	Growth rate of industrial/services sector GVA between 2000 and 2018	Eurostat [86]	101.23	92.46	−63.9	544.2
INCOME_CAP	Income to CAP (Common Agricultural Policy) subsidies ratio	Eurostat [86]	1.908	3.278	0.068	43.949
Population factors						
POP	Population (thousand)	Eurostat [86]	1.810	1.443	25.7	11,000
G_POP	Population growth rate between 2000 and 2018	Eurostat [86]	5.091	10.354	−30.08	42.78
Land use factors						
AGRI_LAND	Area of agricultural land (Ha) including all the agricultural activities	Corine Land Cover (EEA [24])	755,165	778,395	385	4,911,564
URBAN_LAND	Area of residential, industrial/commercial, and recreational land (Ha)	Corine Land Cover (EEA [24])	78,607	52,816	842	299,184
Planning systems						
STATE_LED	Dummy equal to 1 if there is state-led system	Berisha et al. [60]	0.294	0.456	0	1
MARKET_LED	Dummy equal to 1 if there is market-led neo-performative system	Berisha et al. [60]	0.286	0.453	0	1
CONFORM	Dummy equal to 1 if there is conformative system	Berisha et al. [60]	0.351	0.478	0	1
	Base category (Misled performative system)	Berisha et al. [60]				
CONFORM_PERFORM	An index where lower values show conformative planning and higher values performative planning	Berisha et al. [60]	2.716	0.711	2	4
MARKET_STATE	An index where lower values show market-led development and higher values show state-led development	Berisha et al. [60]	−0.613	1.199	−2.5	1.5
Decentralisation						
FED_COUNT	Dummy equal to 1 if federal or quasi federal country		0.283	0.451	0	1
	Base category (unitary countries)	OECD [87]				
TIER	The number of government levels in a country	Treisman [79]	3.592	0.529	2	4
RAI	Regional autonomy index summarising different dimensions of governmental decentralisation	Hooghe et al. [78]	18.818	11.057	1	35
Corruption in public sector						
CPI	Corruption Perceptions Index measuring the perceived levels of public sector corruption	downloaded 12 July 2022 from: www.icgg.org	6.466	1.781	3.5	9.3
Regularity quality and government effectiveness						
REG_Q	Ability of the government to formulate and implement sound policies and regulations that promote private sector development	Kaufmann et al. [88]	85.736	9.983	66.34	99.03
GOV_EFFECT	The quality of public services, policy formation and implementation and the credibility of the government's commitment to such policies	Kaufmann et al. [88]	82.831	12.317	43.27	99.04
Institutional fragmentation						
MUNICIP	Number of municipalities in a NUTS region	Eurostat [89]	452.93	538.59	1	3020

Table 1. *Cont.*

Variable	Description	Data Source	Mean	Standard Dev.	Min	Max
Land value capturing						
IMPACT_FEE	Dummy equal to 1 if impact fees are paid by landowners for the construction of infrastructure	OECD [87]	0.516	0.5	0	1
JOINT_DEV	Dummy equal to 1 if public bodies and private developers develop land jointly and share the profit	OECD [87]	0.169	0.376	0	1
PROP_TAX	Dummy equal to 1 if landowners pay property or land value taxes	OECD [87]	0.064	0.245	0	1
LAND_BANK	Dummy equal to 1 if land banks assemble small plots for further development or sale	OECD [87]	0.26	0.439	0	1
TAX_INC	Dummy equal to 1 if investments are financed by borrowing against expected increases in future tax revenues	OECD [87]	0.166	0.373	0	1
BET_LEVY	Dummy equal to 1 if increase in property values due to a public action (e.g., Re-zoning, infrastructure investment) is captured	OECD [87]	0.061	0.239	0	1
	Base category (no value capture)	OECD [87]				
Spatial policy integration						
NAT_POL	An index showing the degree of integration of the agriculture, rural and environmental policies at the national level	ESPON [74]	2.807	1.151	1	4.5
SUB_NAT_POL	An index showing the degree of integration of the agriculture, rural and environmental policies at the sub-national level	ESPON [74]	3.662	0.795	1	5
LOC_POL	An index showing the degree of integration of the agriculture, rural and environmental policies at the local level	ESPON [74]	3.883	0.755	1	5

2.2.4. Regularity Quality and Government Effectiveness

We considered two indices for the regularity quality and government effectiveness. These indices were computed as part of the Worldwide Governance Indicators (WGI) Project, which cover over 200 countries measuring six dimensions of governance including voice and accountability, political stability and absence of violence/terrorism, government effectiveness, regularity quality, rule of law and control of corruption. Among these dimensions, we focus on government effectiveness and regularity quality, which we expect to be negatively correlated with agricultural land consumption, i.e., with high index values resulting in minor changes of agricultural land, whereas low index values leading to major changes of agricultural land use. The aggregated indicators of government effectiveness and regularity quality are based on several individual underlying variables reflecting the views on governance of survey respondents and public, private, and NGO sector experts worldwide. Each of these data sources provides a set of empirical proxies for the different categories of governance and these many different measures of governance were combined into a composite indicator that summarises their common component. The underlying source data and the methodology for the construction of composite indicators measuring regularity quality and government effectiveness can be found at www.govindicators.org.

The subject indicators provide measurement for good governance, which was defined by Klimach et al. [94] as a process that societies and organisations use to make important decisions, select the key participants, and hold them accountable for their actions. In fact, good governance in the land sector aims at protecting the property rights of economic actors through promoting transparency, accountability, efficient and effective public administration, rule of law, equity, participation, and effectiveness in land administration. Research has highlighted the relationship between good governance as a determinant of sustainable development and the land administration system aiming to keep different elements of sustainable development in balance [95–98]. This literature suggests that good governance practices support sustainable landscape management, particularly of agricultural lands, which may involve some change in land use and/or management. The nature of this change can range from a minor shift in management practices to conversion to an alternative land use (e.g., urban use). It is expected that countries' governance performance exerts significant impacts on land use patterns affecting conversion of high-quality agricultural land to other land uses such as residential, industrial, or commercial land. Reducing the pressure on land consumption requires implementing adequate public policies, which can be achieved through understanding the drivers of land consumption, their relative importance, and interconnections, as well as the impact of existing public policies through intended and unintended effects [99].

2.2.5. Institutional Fragmentation

We used the number of municipalities to proxy the degree of country-specific institutional fragmentation. This is shown by the variable MUNICIP (Table 1) representing the number of municipalities in each NUTS region obtained from the Eurostat [89] database. Conditional on the degree of decentralisation, we expect more fragmented states to show higher levels of agricultural land consumption in comparison to less fragmented counterparts.

2.2.6. Spatial Policy Integration

When analysing the role and performance of spatial planning, it is important to identify the extent to which spatial planning systems and the related territorial governance practices can coordinate or integrate with other sectoral policies. As part of the ESPON COMPASS Project, national experts were asked to make qualified judgements in relation to 14 spatially relevant sectoral policies including agricultural and rural policy, cohesion and regional policy, environmental policy, housing policy, waste and water management, and others. Based on these judgement results, we developed three indicators which aimed to measure degree of integration of the agriculture, rural and environmental policies at the national, sub-national and local levels. The analysis of sectoral policies in this research was developed from ESPON [74] COMPASS Report.

2.2.7. Other Explanatory Variables

Population is one of the common factors adopted in the literature to explain agricultural land use change. There is evidence on positive and significant influence of population growth on urban expansion and this relationship varies across and within countries. In developed economies, urbanised land grows faster than population or even without population growth, for example in eastern Germany [100], Spain [101] and other regions in Europe [102]. Given that population growth is a significant predictor of urban expansion in many studies, we included population and population growth rate as explanatory variables.

The conversion of agricultural land to non-agricultural uses is strongly influenced by land rents and prices of different land uses. For instance, in the regions with lower agricultural rent, it is cheaper to convert agricultural land to urban uses. Therefore, in the current study, both agricultural land rent and urban land rent in a NUTS2 region were considered. In the former case, agricultural output divided by agricultural land area was used as a proxy for agricultural land rent while in the latter, the value of gross industrial/commercial output divided by industrial and commercial land area was used as a proxy for urban land rent (see [103,104]). Here, we could have covered housing, tourism, holiday/weekend residents to measure the urban land rent; however, regarding the housing market, there are no data on the value of residential activities in Europe; and regarding holiday/weekend residents, there are no spatial data in the CLC dataset showing the locations of holiday/weekend houses. Because of these data issues, we could not include the residential sector in the calculation of urban land rent, but these could be included in the future research based on the availability of the subject data. Because growth in economic output and rising income are found to increase land consumption through the rising demand for housing, production and leisure spaces, growth rates of both agricultural and commercial/industrial gross value added (GVA) were included in the analysis.

Technological factors have influence on land use change decisions through their influence on the productivity of labour and capital that are employed in the agricultural sector. Technological improvements in agriculture are associated with decreasing labour demand leading to movement of labour to metropolitan areas. Alternative working opportunities in other sectors and low proportion of workers in agriculture are among the factors leading to land use change [105]. To consider the impact of technological factors on agricultural labour, capital-labour ratio was included in the analysis where an increase in this ratio in agricultural sector is associated with an increase in conversion of agricultural land to urban uses.

The other important factor affecting agricultural land uses are the Common Agricultural Policy (CAP) subsidies, which are managed and funded at the European level from the resources of EU budget. The CAP programme is described as a bridge between agriculture and society and between Europe and its farmers (https://agriculture.ec.europa.eu/common-agricultural-policy_en; (accessed on 15 October 2022)). The subsidies in the form of farm income support may affect rural labour allocation decisions through increasing marginal value of farm labour and household wealth and decreasing income variability [106]. Farmers receiving the CAP subsidies may prefer to continue their agricultural activities even in marginal areas; therefore, we expect CAP subsidies to reduce the amount of agricultural land being converted to urban uses.

Finally, we included the areas of agricultural land and urban land as explanatory variables. The urban land variable can be considered as a potential driver of urban expansion process as it represents attractivity of existing urban locations that may influence new urban development and expansion. The existence of abundant agricultural land in a region may influence the agricultural land consumption as it indicates that it is cheaper to convert agricultural land to urban uses. The amount of agricultural land supports urban expansion process given that there is presumably more land available at the urban-rural periphery ready for development at cheaper prices.

2.3. Regression Methods

We applied several multivariate regressions to quantify the determinants of agricultural land conversion to urban uses in Europe. Equations were fitted to explain the variance in agricultural land consumption based on economic, population and land use factors, planning systems, fiscal decentralisation, corruption in the public sector, regulatory quality and government effectiveness, institutional fragmentation, land value capturing, and spatial policy integration (Table 1) using a straightforward OLS technique. The ordinary least square (OLS) regression model was estimated with the form

$$Y_i = \alpha_0 + \sum \beta_k X_{k,i} + \varepsilon_i \quad (2)$$

where Y is the dependent variable representing the consumption of agricultural land between 2000 and 2018, α is the constant term, X are the independent variables described in Table 1, β is the vector of estimated coefficients, and ε is the error term. We tested the spatial distribution of the OLS residuals using Moran's I measure of spatial autocorrelation. The OLS regression models have been used to estimate land use change by including determinant variables to account for their influence on the land use change. Incorporating many determinant variables into the OLS regression model has the advantage of enhancing the fit and parameter estimates of the model. The spatial coordinates of land use reflecting its geographical location can also be directly used in the OLS model to enhance modelling performance. However, the OLS regression model has drawbacks in the estimation of land use change including functional specification, heterogeneity, and nonlinearity among variables. Related to the specification of the functional form, there is no specific form the relationship between the response and covariates should take. Therefore, scholars extensively use the Box-Cox transformation, linear, semi-log, and log-log functional forms in land use change analysis. Furthermore, they employ two weighted least squares (WLS) techniques with weights assigned to the dependent variable and independent variables to account for heteroscedasticity. It has been shown that the logarithmic transformation provides optimal performance over other functional forms. This is because it attempts to handle the nonlinearity among the variables to reduce bias arising from unusual observations. Despite it is theoretically and conceptually sound, the OLS regression model has other problems including spatial dependence and spatial heterogeneity, which are tackled in spatial regression models.

In the second stage, we followed a spatial regression modelling approach given that the OLS model cannot capture the characteristics of spatial non-stationarity in the modelled relationship between agricultural land consumption and its determinants. In the OLS approach, if the spatial autocorrelation is positive, it implies that the data points with similar geographical positions have greater similarity and vice versa [107]. Therefore, the parameter estimations from the OLS regression model are likely to be biased and inefficient. Geographically Weighted Regression (GWR) is an extension of the general OLS model, which incorporates the existence of spatial interaction between parameters across locations. By contrast to the OLS model, the GWR model carries out separate regressions at each location considering other observations within a specific distance to that location. The model weights the attributes of nearby locations more highly than those of distant ones. It follows that

$$Y_i = \beta_0(u_i, v_i) + \sum \beta_k(u_i, v_i) X_{k,i} + \varepsilon_i \quad (3)$$

where (u_i, v_i) denotes the spatial coordinates of the ith region, ε_i is the error term that satisfies the spherical disturbance hypothesis, $\beta_0(u_i, v_i)$ is the intercept term, $\beta_k(u_i, v_i)$ is the kth regression coefficient of the *i*th region, which is a function of the geographical position. The regression coefficient of the *i*th region can be estimated using the spatial weighting function. The weights are commonly expressed as the distance-decay function of location (u_i, v_i) within all neighbouring observations. To calculate the weighting scheme, geographical kernel functions are used. For the calibration of the GWR model, the bandwidth can either be specified as fixed or as an adaptive geographic kernel. In the former, the bandwidth parameter is fixed across all locations, while in the latter, the extent of the kernel is adjusted by the number of neighbouring locations, which allow the kernel to be different across the locations.

Despite the improvements in the spatial analysis attributed to the standard GWR model, the model may be inappropriate in situations where different predictor variables were defined over different spatial scales and, therefore, these display unique spatial relationships with the response variable [108]. In such situations, the standard GWR approach may be limited given that it assumes the same spatial scale for each predictor variable and these scales may be incorrect. To handle this issue, Fotheringham et al. [108] developed the multiscale geographically weighted regression (MGWR) approach as an extension of GWR. The MGWR allows locally varying relationships to operate at changing geographical scales. In this regard, the MGWR model uses individual bandwidth instead of a constant bandwidth over the study area. It concludes that each geographic relationship at each data point can have a different location weight matrix. The scale of relationship non-stationarity varies for each response and predictor variable relationship is described as

$$Y_i = \beta_0(u_i, v_i) + \sum_{k=1}^{m} \beta_{bwk}(u_i, v_i) X_{ki} + \varepsilon_i \quad (4)$$

where *bwk* in $\boldsymbol{\beta}_{bwk}$ indicates the bandwidth used to calibrate the *j*th conditional relationship. The MGWR model is calibrated using the Generalised Additive Model (GAM), which is an iterative back-fitting procedure given by

$$Y_i = \sum_{k=0}^{m} f_{ik} + \varepsilon_i \quad (5)$$

where f_{ik} (replaced by $\boldsymbol{\beta}_{bwk} X_{ik}$) is the *k*th additive term which is a smoothing function that applies to predictor variable at location *i*. [109]. Those regressions were performed using several selected independent variables in *X*. The selection of those variables was based on the correlations identified by the Pearson correlation coefficient analyses. The global regressions were estimated using STATA 15.1 software and the local regression models were performed with MGWR 2.2 software (https://sgsup.asu.edu/sparc/mgwr; (accessed on 2 October 2022)).

3. Results

3.1. Main Findings

The distribution of agricultural land consumption and the industrial GVA across different spatial planning systems is presented in Figure 4a,b, the spatial development models in Figure 4c,d, and the spatial planning and governance system in Figure 4e,f. Compared to the spatial development model, the spatial planning system provides a more precise explanation of both agricultural land consumption and industrial GVA reported in the European countries. The distribution of agricultural land consumption varies significantly in the case of spatial development model where the number 1.5 corresponds to state-led and −2.5 to market-led systems. Here, in the former case, spatial development was mainly driven by state while the latter points to spatial development that was mainly driven by the market. In general, northern countries as well as France were in the former category, while most eastern European countries group into the latter (Figure 3). In relation to the spatial planning systems, we note that conformative and performative systems were more homogeneously distributed with regards to agricultural land consumption and industrial GVA compared to those observed in the spatial development model. Here, an ideal conformative planning system would allocate spatial development rights according to binding plans whereas an ideal performative system would allocate on a case-by-case basis based on the spatial development strategy imposed. Most systems generally follow a conformative style globally, but performative systems are also preferred as it ensures flexibility in the application of spatial planning [53]. In Europe, there was a north-south divide where southern countries were characterised by principally conformative systems and those of northern countries by principally performative systems (Figure 3).

From Figure 4e,f, it can be seen that agricultural land consumption and industrial GVA did not follow the same path in the case of mis-led performative systems compared to the other spatial planning and governance systems. Cyprus, Malta, and Poland were identified as following the mis-led performative system where the government authority tends to assign land use and development rights on a case-by-case basis or through the adoption of detailed negotiated plans; the overall result is that spatial development is mainly driven by market interests. Figure 4e indicates that mis-led performative spatial planning system was associated with higher levels of agricultural land converted to urban uses compared to those of state-led, market-led neo-performative, and conformative systems. It is also worth mentioning that both state-led and market-led systems in the spatial development model recorded higher levels of agricultural land consumption compared to the cases that were between the state-led and market-led systems (the scores of the intermediate systems are between −2 and 1.0) (Figure 4c). There was also high consumption of agricultural land in some of the in-between systems, but most in-between systems recorded lower levels of agricultural land consumption. Finally, we note that there was more homogeneous distribution of industrial GVA compared to agricultural land consumption in the spatial development model, which implies that there is poor interaction between agricultural land consumption and industrial GVA.

The figures in Appendix A depict the agricultural land use change over time for the countries in our sample. It is evident that agricultural land use is declining in all European countries except Finland, Spain, and Portugal. To comply with international and EU stated policy aims, any decrease of agricultural land consumption in European countries should be guided by plans and policies that promotes sustainable food production while agricultural land conversion to urban uses be restrained. Therefore, it is essential for urban planners and policy makers to actively manage urban expansion and agricultural land conversion processes simultaneously.

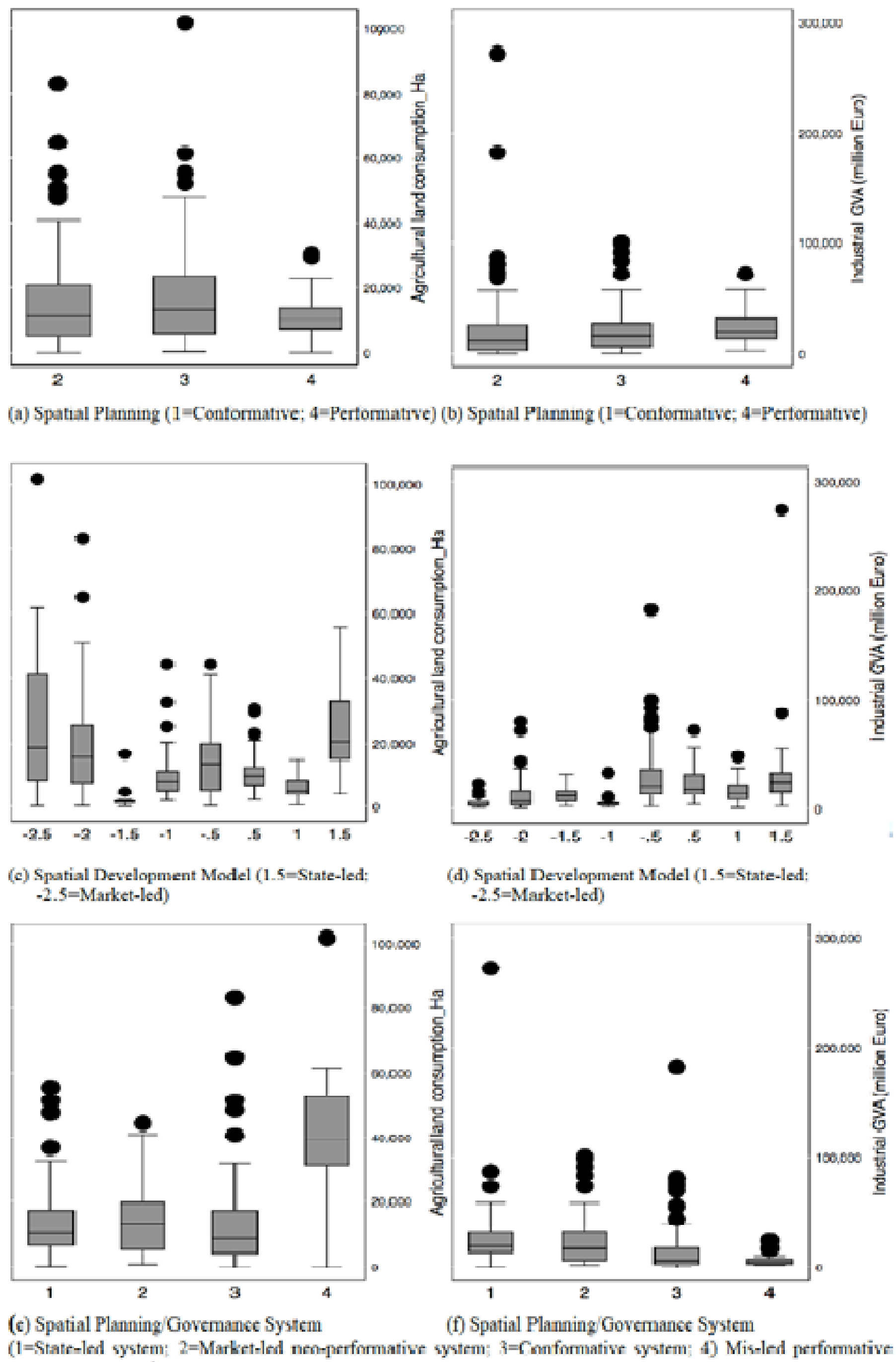


Figure 4. Box plot distribution of socio-economic variables based on Europe's spatial governance and planning system classification obtained from Berisha et al. [60]. Scheme 24 and Eurostat.

3.2. Results from OLS Regression Models

The global OLS regression model outputs are shown in Table 2, including five different model estimations. The values in Table 2 represent the elasticity of a percentage change in the response variable of a percentage change in the explanatory variable. In these models, we focused on planning systems and institutional setup while controlling for the state of social and economic development. In Table 2, we present the effects of alternative variables of planning systems, decentralisation, public sector corruption, regularity quality, institutional fragmentation, land value capturing, and spatial policy integration on agricultural land consumption. In each of these specifications, we controlled for the state of socio-economic development by including population, population growth rate, urban and agricultural land rent, industrial and agricultural GVA growth rate, capital-to-labour ratio, and income-to-CAP subsidies ratio.

Table 2. The drivers of agricultural land conversion to urban use (OLS model estimations). Values in bold are statistically significant.

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	−7.001 ** (1.02)	−4.678 ** (1.07)	30.81 ** (5.34)	24.959 ** (4.83)	23.195 ** (4.82)
lnPOP	0.630 ** (0.14)	0.699 ** (0.14)	0.445 ** (0.18)	0.213 * (0.16)	0.251 * (0.15)
lnAGRI_RENT	−0.109 (0.08)	−0.096 (0.08)	−0.021 (0.07)	−0.059 (0.07)	−0.006 (0.06)
lnURBAN_RENT	0.09 (0.09)	0.188 ** (0.09)	0.216 * (0.11)	0.176 * (0.09)	0.114 (0.09)
lnAGRI_LAND	0.610 ** (0.05)	0.633 ** (0.05)	0.654 ** (0.05)	0.476 ** (0.05)	0.492 ** (0.05)
lnURBAN_LAND	−0.187 (0.16)	−0.375 ** (0.15)	−0.142 (0.18)	0.205 (0.17)	0.197 (0.16)
lnCAPIT_LABOUR	0.015 (0.03)	0.071 ** (0.03)	0.001 (0.03)	−0.012 (0.04)	−0.047 (0.03)
lnINCOME_CAP	−0.06 * (0.04)	−0.092 ** (0.04)	−0.021 (0.04)	−0.08 * (0.04)	−0.081 * (0.04)
lnG_POP	0.218 ** (0.13)	0.212 ** (0.13)	0.132 (0.12)	0.191 ** (0.11)	0.239 ** (0.09)
lnG_GVA_IND	−0.181 ** (0.07)	−0.190 ** (0.07)	−0.143 * (0.07)	−0.106 * (0.06)	0.007 (0.06)
lnG_GVA_AGRI	0.072 (0.07)	0.026 (0.06)	0.032 (0.06)	0.047 (0.06)	0.006 (0.05)
CONFIRM_PERFORM	0.207 ** (0.06)	0.204 ** (0.098)	0.273 * (0.142)	0.55 ** (0.19)	2.874 ** (0.42)
MARKET_STATE	−0.099 ** (0.05)	−0.204 ** (0.11)	−0.288 * (0.15)	0.186 (0.20)	0.814 ** (0.21)
STATE_LED	-	0.073 (0.33)	0.338 (0.49)	0.171 (0.81)	1.352 ** (0.79)
CONFIRM	-	−1.071 ** (0.18)	−1.02 ** (0.23)	−1.219 ** (0.55)	−6.73 ** (0.99)
MARKET_LED	-	−0.096 (0.22)	0.496 * (0.33)	1.721 ** (0.59)	4.267 ** (0.67)
FED_COUNT	-	-	−0.101 (0.16)	−1.429 ** (0.3)	−0.722 ** (0.35)
lnTIER	-	-	1.337 ** (0.31)	1.353 ** (0.34)	4.932 ** (0.68)
lnRAI	-	-	0.127 (0.09)	0.074 (0.09)	0.251 ** (0.09)
lnCPI	-	-	1.991 ** (0.45)	2.805 ** (0.47)	4.772 ** (0.62)
lnMUNICIP	-	-	−0.02 (0.03)	0.055 (0.03)	−0.024 (0.03)
lnREG_Q	-	-	−8.528 ** (1.41)	−7.674 ** (1.26)	−9.615 ** (1.29)
lnGOV_EFFECT	-	-	−0.687 (0.67)	−0.747 (0.61)	−2.353 ** (0.62)
IMPACT_FEE	-	-	-	−0.271 (0.21)	−0.632 ** (0.22)
JOINT_DEV	-	-	-	−0.195 (0.15)	−0.035 (0.15)
PROP_TAX	-	-	-	−0.461 * (0.26)	−1.539 ** (0.31)
LAND_BANK	-	-	-	−1.092 ** (0.31)	−0.229 (0.4)
TAX_INC	-	-	-	0.394 (0.25)	2.261 ** (0.6)
BETTER_LEVY	-	-	-	2.163 ** (0.47)	6.234 ** (0.76)
lnNAT_POL	-	-	-	-	1.937 ** (0.35)
lnSUB_NAT_POL	-	-	-	-	−0.896 ** (0.16)
lnLOC_POL	-	-	-	-	−1.244 ** (0.28)
Number of observations	265	265	265	265	265
R-square	0.74	0.78	0.83	0.88	0.9
Adj R-square	0.73	0.77	0.82	0.86	0.88
F-statistic	F(12,252) = 59.91	F(15,249) = 59.93	F(22,242) = 53.74	F(28,236) = 60.1	F(31,233) = 64.83
Root MSE	0.605	0.556	0.49	0.43	0.39
Breusch-Pagan Test	Chi2(1) = 27.81 **	Chi2(1) = 61.7 **	Chi2(1) = 54.9 **	Chi2(1) = 45.1 **	Chi2(1) = 36.9 **
VIF's	Min(1.22) Max (9.8)	Min (1.3) Max(11)	Min(1.8) Max(15)	Min(1.9) Max(45)	Min(2.0) Max(62)
Ramsey RESET Test	F(3251) = 0.77	F(3248) = 3.94 **	F(3242) = 3.23 **	F(3236) = 3.59 **	F(3233) = 3.96 **

Table notes: * Statistically significant *p*-value ($p < 0.10$ or $p < 0.05$). In parenthesis are standard errors regarding the coefficients; VIF is the Variance Inflation Factor.

We also included two variables measuring agricultural and urban land areas in each NUTS2 region under the category 'land use factors'. These variables captured surface areas of urban land and agricultural land; the former was a proxy for urban services and infrastructure, and the latter shows abundance or lack of agricultural land in a region. In all the regressions, agricultural land area was positive indicating that there was an abundance of agricultural land which has been converted to urban uses. Urban land was negative in the first three models while it was positive in the rest of the models, implying that the subject variable may not be a robust estimator in the regression models.

Under the ‘population factors’, population and population growth rate had positive and significant coefficients in nearly all models, indicating that increase in population results in an increase of conversion of agricultural land to urban uses. Population has been specified as one of the most significant drivers of urban expansion in Europe [4,110,111]; our study confirmed the findings of these studies that population is a significant driver of urban expansion and agricultural land conversion.

Among the ‘economic factors’, the capital-to-labour ratio had an expected positive sign in the first three models indicating that technological improvements in agriculture results in conversion of agricultural land to urban uses to house the activities of newly emerged labour force that shifted from agriculture to the industrial and commercial sectors [112]. Though insignificant, agricultural rent had a negative impact on agricultural land conversion while urban rent had an expected positive impact. This implies that higher returns in agricultural sector may reduce the agricultural land consumption and higher returns in industrial/commercial sectors may result in an increase of conversion of agricultural land to urban uses. The income-CAP ratio had an expected negative and significant impact on the urban conversion of agricultural land. Therefore, CAP had a significant role in influencing the agricultural land conversions in the 2000–2018 period. The industrial and agricultural GVA had unexpected coefficient signs; most probably these variables were correlated with the other variables included in the model such as urban rent and agricultural rent.

Regarding the ‘decentralization factor’, we found that it was significantly positively correlated with agricultural land consumption concerning the variables RAI and TIER and it was negatively correlated concerning FED_COUNT. Countries characterised as federal or quasi federal state have a system of nested self-governments characterised by participation and coordination, which can be considered as important functions decreasing agricultural land consumption. In case of RAI and TIER, it was noted that giving autonomy in certain areas or residual powers given to subnational governments increased agricultural land consumption. This is consistent with the findings of literature which suggest that regional competition and lack of inter-regional coordination in decentralised settings increase urban expansion and conversion of agricultural land to urban uses. For instance, our findings confirmed the results of Ehrlich et al. [52], that found the number of tiers of government was strongly positively associated with urban sprawl as well as regional autonomy index had a strong impact on urban sprawl in the European countries. The number of municipalities was the measure of ‘institutional fragmentation’, and it was found that it was negatively related to agricultural land consumption though it had an insignificant sign. We note that the signs of variables representing decentralisation and institutional fragmentation varied indicating that the results may not be robust to using alternative measures of decentralisation in the European context.

Regarding ‘corruption in public sector’, the Corruption Perceptions Index (CPI) had an expected positive sign indicating that an increase in corruption in the government sector results in an increase of conversion of agricultural land to urban uses. Under ‘regularity quality and government effectiveness’, we had government effectiveness and regularity quality variables both having the expected negative signs indicating that good governance decreases agricultural land consumption and promotes sustainable development where the land management system aims to keep different elements of sustainable development in balance. Under the ‘land value capturing’ factor, some of the land value capture mechanisms including impact fees, joint development, property tax and land banking were effective in reducing agricultural land consumption as all these had coefficients with negative signs, whereas tax increment financing and betterment levy had positive signs. Externalities of land development can be better captured with the use of the former tools and our findings show that the latter mechanisms had a positive sign indicating that these were unsuccessful in properly integrating externalities in the land development process, and they contribute to expansion of urban areas at low densities through converting agricultural land uses. Regarding the ‘spatial policy integration’ factor, the indicators measuring the degree of integration of the agriculture, rural and environmental policies had a positive sign at the national level and negative signs at the sub-national and local levels. This finding implies that it is significant to integrate policies at the sub-national and local levels to reduce agricultural land consumption, and national level integration is not effective according to our findings.

Concerning 'planning systems', when there was a shift from conformative to performative planning systems, urban consumption of agricultural land increased. This implies that a fragmented system where land use is allocated on a case-by-case basis supports conversion of agricultural land, whereas this conversion is less significant in the case of conformative planning systems that allocate spatial development rights according to binding plans. MARKET_STATE is an index where lower values show market-led development and higher values show state-led development. It was not a robust indicator as its coefficient was positive in models 4 and 5 and negative in the other models. State-led and market-led neo-performative spatial planning systems were associated with high levels of agricultural land conversion whereas conformative systems led to lower levels of land conversion compared to our base category, i.e., mis-led performative systems. Among the state-led countries, UK, Denmark, and France reported more than 1.5% land converted to urban use in the 2000–2018 period (Figure 5). Ireland, Finland, and Sweden had less than 1% land converted in the same period (Figure 5). The UK and France are the two countries where the largest clusters of high sprawl values were located [99]. Netherlands, Belgium, and western Germany were the other countries where sprawl was the most pronounced [98]. Some of the market-led countries (e.g., Austria, Germany, The Netherlands, Slovenia, and Slovakia) were associated with more than 2% change, which was the highest amount of change observed among the European countries (Figure 5). The agricultural land converted to urban uses varied across conformative systems where it ranged from 2.6% in Greece to 0.8% in Belgium (Figure 5). The rate of agricultural land conversion was between these two values observed in other countries classified as conformative systems.

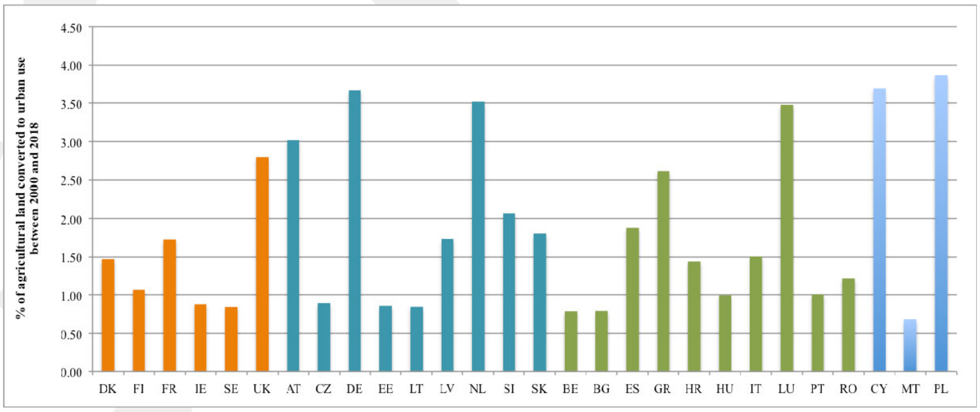


Figure 5. Percentages of agricultural land converted to urban uses in different planning systems. Note: The colours from left to right represent 'state-led', 'market-led neo performative', 'conformative' and 'mis-led performative' systems. Source: Figure was created by the authors based on the CLC data obtained from EEA [24].

To check the validity of the regression models regarding multicollinearity, heterogeneous variances, and model specification, we used Variance Inflation Factors (VIFs), the Breusch–Pagan Test and the Ramsey Reset Test. Besides low VIF values corresponding to specific variables, the existence of high VIFs in all regression models indicated that there was a multicollinearity problem with some of the variables used in the models. From the Breusch–Pagan tests, the hypothesis of the existence of homogeneous variances was rejected as all p-values were less than 0.5. Apart from model 1, the Ramsey Reset Test rejected the hypothesis that there was correct model specification, as all the p-values were less than

0.5. Considering these problems as well as the existence of spatial autocorrelation, we will focus on local regression approaches that will be explained in the following sub-sections.

Planning system-specific regression models were estimated for four different types of planning systems and the results are presented in Table 3. Here we included only socio-economic and land use factors as explanatory variables and excluded other variables because they were highly correlated with the included socio-economic and land use variables. Population and agricultural land contribute significantly to the conversion of agricultural land to urban uses. The signs of agricultural land and population were positive across different planning systems except for a few negative coefficients of populations estimated for market-led neo-performative and mis-led performative systems. The negative signs of the population coefficient show that the higher the population the lower the conversion of agricultural land to urban uses. This points to urban densification process that is common to urban areas of increasing of population in the subject planning systems [111]. Agricultural rent had an expected negative coefficient and urban rent had a positive coefficient, the former was estimated for the state-led systems and the latter for market-led neo-performative systems. Capital-to labour ratio and population growth rate were found significant with expected signs for state-led, conformative, and mis-led performative systems. Income-to-CAP ratio was ineffective for state-led systems while it was more pronounced for the market-led neo-performative and confirmative systems.

Table 3. The socio-economic drivers of agricultural land conversion to urban use across different planning systems (OLS model estimations).

	State-Led Systems	**Market-Led Neo-Performative Systems**	**Conformative Systems**	**Misled Performative Systems**
Variable	**Model 6**	**Model 7**	**Model 8**	**Model 9**
Constant	−9.851 ** (1.97)	0.193 (1.517)	−8.513 ** (1.51)	−7.186 (7.85)
lnPOP	0.639 ** (0.22)	−0.390 * (0.21)	0.980 ** (0.24)	−0.035 * (0.95)
lnAGRI_RENT	−0.192 * (0.12)	−0.070 (0.11)	−0.026 (0.16)	−0.177 (0.45)
lnURBAN_RENT	−0.054(0.14)	0.616 ** (0.14)	0.075 (0.17)	−0.478 (0.87)
lnAGRI_LAND	0.527 ** (0.06)	0.444 ** (0.07)	0.689 ** (0.19)	0.216 * (0.29)
lnURBAN_LAND	−0.274 (0.26)	0.952 ** (0.23)	−0.766 ** (0.16)	1.279 ** (0.62)
ln CAPIT_LABOUR	−0.103 * (0.07)	−0.047 (0.04)	−0.124 * (0.06)	−0.018 * (0.18)
lnINCOME_CAP	0.422 ** (0.13)	−0.079 * (0.05)	−0.240 ** (0.06)	0.515(0.38)
lnG_POP	1.117 ** (0.29)	−0.304 (0.19)	0.441 ** (0.18)	1.831 ** (0.75)
lnG_GVA_IND	0.09 * (0.05)	0.084 (0.08)	0.382 (0.27)	0.074 * (0.39)
lnG_GVA_AGRI	−0.019 (0.11)	−0.141 (0.22)	−0.279 (0.19)	−1.682 ** (0.79)
Number of observations	78	76	93	18
R-square	0.85	0.88	0.82	0.98
Adj R-square	0.83	0.86	0.8	0.97
F-statistic	F(10, 67) = 38.35	F(10, 65) = 45.6	F(10, 82) = 37.8	F(10, 7) = 57.8
Root MSE	0.383	0.333	0.59	0.25
Breusch-Pagan Test	Chi2(1) = 4.70 **	Chi2(1) = 4.70 **	Chi2(1) = 2.99 **	Chi2(1) = 0.53
VIFs	Min(1.04) Max(15.9)	Min(1.73) Max(14.1)	Min(1.73) Max(15.3)	Min(2.35) Max(57.3)
Ramsey RESET Test	F(3.64) = 5.68 **	F(3.62) = 0.90	F(3.79) = 0.45	F(3.4) = 8.23 **

Table notes: * Statistically significant *p*-value ($p < 0.10$ or $p < 0.05$). In parenthesis are standard errors regarding the coefficients; VIF is the Variance Inflation Factor.

The growth rate of industrial GVA was positive and significant for the state-led and mis-led performative systems. The growth rate of agricultural GVA was negative and significant for only the mis-led performative systems. These findings show that socio-economic and land use determinants of urban conversion of agricultural land vary across different planning systems and considering this spatial variation, we adopted the MGWR model to estimate the spatial distribution of the coefficients of some selected variables.

3.3. Results from MGWR Models

Urban conversion of agricultural land in different regions of Europe may display substantial diversity during the study period, and these can be explained by spatial heterogeneity. Our analysis confirmed that the OLS model might lead to errors due to spatial autocorrelation (Table 4), so the MGWR model was used to explore the different spatial patterns of the agricultural land conversion driving relationships. Table 5 presents the MGWR model estimation results.

Table 4. Results from spatial autocorrelation statistic for the models explaining agricultural land conversion.

	OLS (Linear)	OLS (Logarithmic)	MGWR
Inverse-distance (Euclidian)			
Moran's index	0.179	0.155	−0.001
Z-score	49.828	42.813	−0.235
p-value	0.001	0.001	0.814
Fixed-distance band			
Moran's index	0.107	0.091	−0.002
Z-score	63.892	54.611	−0.916
p-value	0.001	0.001	0.359

Table 5. Summary of MGWR model output.

OLS		MGWR	
Number of parameters	7	Effective number of parameters	67.511
AIC	514.253	AIC	254.153
Adjusted R_2	0.611	Adjusted R_2	0.878
R_2	0.622	R_2	0.909
		Spatial kernel	Adaptive bisquare
		Criterion for optimal bandwidth	AICc
		Number of iterations used	41

The MGWR model provides a significant improvement over the OLS model. The MGWR model had a smaller AIC (254.153) than the OLS model (514.253); the adjusted R2 increased from 0.622 in the OLS model to 0.909 in the MGWR model, which indicates that 91% variation in agricultural land conversion can be explained by the selected six variables: POP, AGRI_RENT, AGRI_LAND, URBAN_LAND, G_GVA_IND, and INCOME_CAP. Local R2 values showed spatial variation over the study area (Figure 6) and the intercept values were all significant and vary between negative and positive values (Figure 6). The variables POP, AGRI_RENT and INCOME_CAP had spatially varying positive and negative estimates (Figure 7), suggesting that there were non-stationary relationships with agricultural land conversion. Other variables including AGRI_LAND, URBAN_LAND and G_GVA_IND were significant and had positive estimates (Figure 7); therefore, these were characterised by having stationary relationships with agricultural land conversion. The local coefficients of all these variables varied across the NUTS2 regions in Europe, which reflects that urban conversion of agricultural land exhibits spatial heterogeneity within Europe.

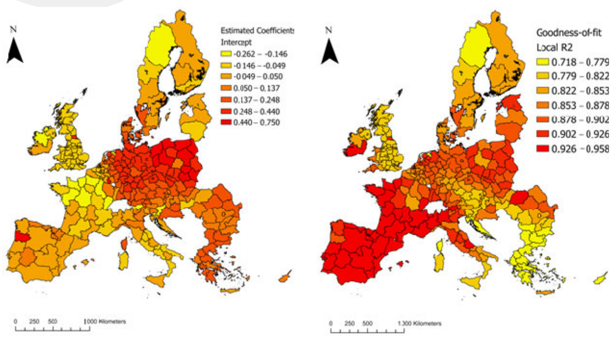


Figure 6. Spatial distribution of the intercept parameter and local R2 estimates in the MGWR model. Source: authors' own work.

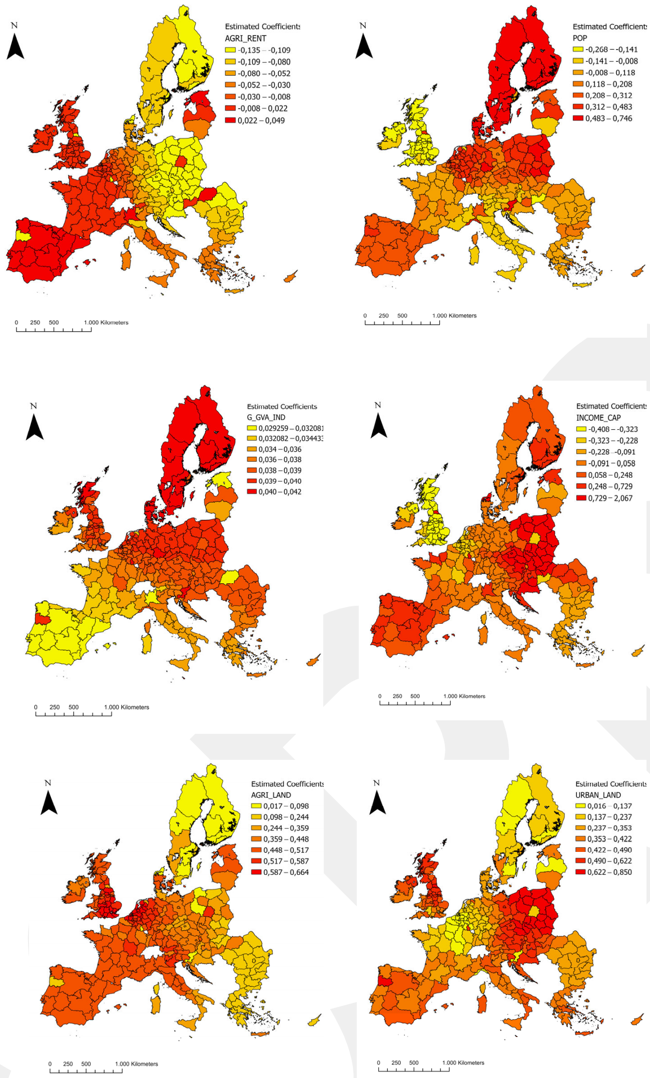


Figure 7. Spatial distribution of local coefficients in MGWR model. Source: authors' own work.

To investigate the differences in the spatial distribution of estimated coefficients across different planning systems, we computed average values of estimated coefficients for each country corresponding to the related planning system (Table 6). Population had a negative impact on agricultural land conversion for Ireland, UK, Latvia, and Italy; all other countries were positively associated with agricultural land conversion. Population increase had the highest impact on land conversion concerning state-led and mis-led performative systems and had the lowest impact concerning the other planning systems. Agricultural land rent had both positive and negative impacts on land conversion and there was no substantial difference across different planning systems. Regarding agricultural land and urban land, the highest impacts were homogeneously distributed across the countries classified as one of the four planning systems. Income-to-CAP ratio was not influential for Ireland, UK, Lithuania, Latvia, Netherlands, Belgium, Bulgaria, Greece, Cyprus, and Malta as the estimated coefficients on the subject variable were negative. For the rest of the countries, an income-to-CAP ratio was positive, so that the CAP subsidies were effective in reducing the agricultural land consumption. Growth rate of industrial/commercial GVA was positively related to agricultural land conversion and its impact was homogeneously distributed across different planning systems.

Table 6. Average values of estimated coefficients (from MGWR model) across countries applying different planning systems.

State-Led Systems	POP	AGRI_RENT	AGRI_LAND	URBAN_LAND	INCOME_CAP	G_GVA_IND
DK	0.521	−0.081	0.442	0.287	0.169	0.036
FI	0.458	−0.091	0.158	0.145	0.313	0.036
FR	0.104	0.010	0.466	0.266	0.038	0.029
IE	−0.133	0.003	0.445	0.432	−0.134	0.031
SE	0.541	−0.092	0.238	0.150	0.085	0.037
UK	−0.119	0.004	0.597	0.446	−0.378	0.035
Market-led neo performative system						
AT	0.039	−0.081	0.391	0.487	0.352	0.031
CZ	0.293	−0.114	0.335	0.601	0.901	0.032
DE	0.268	−0.052	0.478	0.316	0.032	0.033
EE	0.224	0.074	0.463	0.430	0.351	0.026
LT	0.345	0.000	0.527	0.127	−0.175	0.032
LV	−0.054	0.014	0.222	0.404	−0.044	0.022
NL	0.355	−0.019	0.611	0.217	−0.055	0.035
SI	0.074	−0.084	0.336	0.507	0.524	0.030
SK	0.224	−0.082	0.322	0.580	0.739	0.033
Conformative systems						
BE	0.281	0.003	0.593	0.100	−0.273	0.033
BG	0.282	0.014	−0.080	0.235	−0.190	0.029
ES	0.254	0.066	0.446	0.443	0.307	0.025
GR	0.107	0.051	0.057	0.339	−0.170	0.026
HR	0.127	−0.066	0.182	0.458	0.727	0.030
HU	0.132	−0.071	0.173	0.440	0.751	0.031
IT	−0.057	−0.012	0.381	0.417	0.032	0.027
LU	0.440	−0.128	0.068	0.403	1.147	0.035
PT	0.264	0.270	0.300	0.275	0.244	0.229
RO	0.087	0.049	0.067	0.091	0.069	0.065
Misled performative system						
CY	0.189	0.040	−0.069	0.272	−0.270	0.027
MT	0.348	−0.024	0.625	0.243	−0.027	0.035
PL	0.474	−0.113	0.329	0.677	1.121	0.033

4. Discussion and Findings

Many fertile agricultural lands are currently undergoing widespread change to urban use, especially in European countries. These land use changes result in reduction in agricultural commodities and lead to substantial losses in native vegetation, ecosystem services, and biodiversity. Understanding what causes urban conversion of agricultural land is, therefore, important to identify policies that aim to mitigate the trade-offs and steering sustainable land use change dynamics. Here, we address this research gap by exploring patterns of agricultural land conversion and their determinants across Europe, focusing on socio-economic factors, institutional settings, and spatial planning. Land use planning and institutional structure can be considered as important tools to control non-agricultural land growth and their effectiveness needs to be assessed. To evaluate their effectiveness, this study focused on 265 NUTS2 regions as the unit of the analysis and analysed them using global and spatial econometrics models. Prior to regression analysis, regional trends of agricultural land use change were analysed, which showed that agricultural land consumption is prevalent in Eastern and Central Europe but also in southern Europe, south and south-eastern UK, Ireland, and Northern Ireland during the 2000–2018 period. These coincide with the regions reported by the EEA [99] that were shown to exhibit higher levels of sprawled development in 2009. To a lesser extent, agricultural land consumption was also common for the regions in Nordic countries, and many other regions in central Europe. This confirms the findings of the study by Ehrlich et al. [52] that showed that central and Eastern Europe and Alpine and some of the Southern European countries have experienced increased urban sprawl. Plieninger et al. [37] and Salvati et al. [113] also found that high levels of land consumption were a significant issue for various European regions (especially in western, eastern, and southern countries).

Our findings confirm that the increase in population results in an increase of conversion of agricultural land to urban uses and that population is one of the most significant drivers of urban expansion in agricultural land conversion. Population was also a major driver of urban expansion between the 1950s and 1990s in 15 European cities according to the findings of Kasanko et al. [114]. This was also confirmed by Plieninger et al. [37] and Van Vliet et al. [2], who analysed more than 100 cases in Europe to uncover the drivers of natural land use change. The results also imply that land rent, land area, capital-to-labour ratio, CAP subsidies, and economic growth rate impact urban conversion of agricultural land; however, vary significantly between spatial governance and planning systems. Therefore, the variation of the magnitudes of the coefficients of the subject variables can be explained by the differences in the existing spatial planning system of a country.

Urban conversion of agricultural land was sensitive to land rent variables referring to economic rent developed by Ricardo [115], which reflects rents for agricultural land depending on land fertility. This is consistent with the land rent theory developed by Alonso [116] suggesting that the decision to use the land for urban or agricultural purposes may be motivated by changes in profit at the margin of these land uses. In other words, if there were small changes in agricultural rent compared to urban rent, we would expect conversion of agricultural land to urban uses because these systems are both highly profitable and land use actors are willing to shift from one land use to another. Our findings on the estimated coefficients of the land rent variables coincide with the results of the studies conducted by Seto and Kauffman [103], Jiang et al. [104], and Ustaoglu and Williams [4], that found cultivated land conversion was positively related to urban land rent and it was negatively related to agricultural land rent. Therefore, higher economic rents generated by the urban sector led to shrinking of land used for agricultural purposes.

Our results have also shown that the larger the agricultural land area in a European region, the higher is urban land expansion, confirming that land abundant regions experience higher rates of conversion of agricultural land to urban uses. On the other hand, urban land area was not a significant factor in explaining urban expansion in European regions. We found that its coefficient was positive in some regression models and negative in others. A positive relationship implies that a large urban footprint leads to more urban expansion through conversion of agricultural land to urban uses. At the same time, there may be a negative relationship indicating that there was densification in urban land which results in slightly less conversion of agricultural land to urban uses. Unlike our study, these variables were found to be insignificant in Ustaoglu and Williams [4] and significant but with a different sign in Ustaoglu and Jacobs-Crisioni [111].

Another important finding of the study relates to the CAP subsidies, as these promoted sustainable agricultural land use using subsidies and direct payments and potentially limited the conversion of agricultural land to urban uses. This result conforms with the findings of Olper et al. [117] that CAP subsidies assisted job creation in the agricultural sector across the EU countries in the recent decades. The CAP program includes income support, market measures and rural development support measures. Income support comprises direct payments to ensure income stability and promotes environmentally friendly farming and delivering public services not normally paid by the markets. Through income supports to farmers along with market measures and other rural development supports, CAP subsidies can contribute to a reduction of rural to urban migration by retaining employment and economic activity in rural areas [117]. The effect of subsidies, which are given based on the agricultural land used by farmers, can increase the value of agricultural land, i.e., its price and rent.

Conversion of natural landscapes to urban uses is associated with negative impacts (ex. land fragmentation, biodiversity loss, land degradation) reflecting a variable effectiveness of policy instruments and institutional quality. The results from our regression model analyses indicated that institutional factors and spatial planning systems are indeed important in determining agricultural land conversion, most likely through determining restrictiveness of land use policies and fiscal incentives to develop at the local level. For instance, potential impacts on agricultural land conversion of the different typologies of spatial planning systems were evaluated. This was often linked with whether the approach was state led or market led, and whether decisions were conformative and mandatory, or discretionary and performative. This addresses key questions as to whether investment and development decisions must conform to planning guidelines or whether decisions are on an individual or performative or discretionary basis. In the research, we found that while state-led and market-led spatial planning systems, and systems categorised as in-between, were associated with high levels of agricultural land conversion with a positive coefficient for the CONFORM_PERFORM variable (Table 2). However, conformative systems were shown to lead to lower levels of land conversion given that the coefficient of CONFIRM was negative across all the models in Table 2. Therefore, this research confirmed recent research findings [53], which found that the types of spatial governance and planning systems significantly shape the effects on urban form. Dombi [53] found such effects to range from −67% to 215% relative to the most widespread system, i.e., the conformative system. In fact, we found that (Model 5) the elasticity of agricultural land conversion with respect to the planning system ranged from 1.35 for the state-led systems to 4.26 for the market-led systems. Conformative systems had a mitigating or negative impact on agricultural land conversion with an estimated elasticity of −6.73. Furthermore, population, economic structure and urbanization have a positive feedback effect on the accumulation process at any level of development. Spatial governance and planning systems and specific planning culture can have a determining influence on urban form and land use change.

Holding socio-economic conditions constant, decentralized European regions had elasticities (Model 5) that varied between 0.25 and 4.93, implying that they had higher level of agricultural land conversion compared to centralized regions. This points to regions having greater political fragmentation and a greater degree of interjurisdictional competition and poorer coordination. This results in higher amounts of agricultural land consumption in comparison to centralized ones. Ehrlich et al. [52] reported similar findings, which demonstrated that decentralized European countries had a 25–30% higher level of sprawl compared to centralized countries. In addition, this research produced evidence of the impact of a range of policy related inputs impacts on the land use conversion process. The results highlight the important role that low public sector corruption and good governance can play in reducing agricultural land conversion. The results also indicated that the degree of integration of the agriculture with rural and environmental policies can have a significant impact on outcomes. This finding implies that it is necessary to comprehensively integrate policies at the sub-national and local levels along with national level integration to reduce agricultural land consumption.

Accounting for non-stationarity within the agricultural land use model led us to geographically map the driving factors of agricultural land conversion in Europe using the MGWR model. Compared with the global model, a local model provides a significant improvement, so it was more appropriate to analyse the relationship between agricultural land conversion and its drivers through providing spatial variability of the regression coefficients. We identified six factors related to agricultural land consumption in Europe: POP, AGRI_RENT, AGRI_LAND, URBAN_LAND, G_GVA_IND, and INCOME_CAP, which explained 70% to 95% of the total variation of agricultural land converted to urban uses. Population showed both negative and positive correlation with agricultural land, which displayed an increasing trend from west and south to northern Europe. A similar study, which focused on local factors, explaining the reforestation/deforestation process in China also found both negative and positive coefficients for the population variable that vary across space [118]. A different study by Naikoo et al. [119] found positive coefficients for the population variable for Delhi National Capital Region in India. Although population has a unique sign in the global regression models [4,111], spatial distribution of the regression coefficients can be captured in the local models as it was the case of MGWR model of this study.

The variable AGRI_RENT had negative estimates in Eastern Europe, and it shifted to positive values in Western Europe, and we found that there was no substantial difference across different planning systems. Similarly, Bonfilio Pineda Jaimes et al. [120] found a negative correlation between the value of forest products and deforestation in Mexico forests using local regression models. This was also confirmed by Sheng et al. [118]. The CAP subsidies were effective in reducing agricultural land consumption in the regions located in Eastern and Western Europe as well as Nordic countries but not influential for the rest of the regions. Urban land had a positive correlation with agricultural land consumption with an increasing trend from west to east in most regions in Europe. A similar pattern was captured by Su et al. [121], who analysed the relationship between urbanization, agricultural landscape patterns and their determinants in China and found that the coefficient of urbanization intensity index was positive and displays spatial variation. Agricultural land was also positively correlated with natural land consumption with an increasing trend from eastern to Western Europe. Regarding agricultural land and urban land, the highest impacts were homogeneously distributed across the countries classified as one of the four planning systems. The positive correlation between industrial GVA growth and agricultural land consumption was more pronounced in northern Europe than southern Europe but it was not evident in Baltic States. The impact of industrial GVA growth rate was homogeneously distributed across different planning systems. Similar results were obtained by Deng et al. [122], who analysed the impact of industrial GDP on the scale of farmland conversion. From their results, an increase in GDP from industrial sector leads to decrease in the surface area of agricultural land. This finding was also verified by Ustaoglu and Jacobs-Crisioni [111] and Sroka et al. [123]. From the findings of the MGWR model, it was evident that there was spatial variation of driving factors of agricultural land conversion in Europe but there was no spatial pattern captured across different spatial planning systems.

5. Conclusions

This study aimed to explore the impacts of socio-economic, institutional factors, and spatial planning on the urban conversion of agricultural land in European regions. The drivers of agricultural land conversion were conceptualised and quantified via global and local regressions models; the latter aiming to consider spatial non stationarity which has been neglected by previous global regression models. The data from 265 NUTS2 level EU27 and UK regions for the period 2000–2018 were collected for this empirical study.

Our findings reveal that institutional factors and different planning systems play a promoting role in the conversion of agricultural land to urban uses. Specifically, we found that the degree of integration of the agriculture and rural and environmental policies have a negative impact on land consumption at the sub-national and local levels. This implies that it is essential to integrate policies at the subject levels to reduce agricultural land consumption. The research also indicates a potential for making such agriculture and environmental policies more efficient by linkages with general planning and public policy aims. Increasing public concern allied with the increased focus on climate change, energy and environmental sustainability means that the environmental performance of agriculture land resources will be major policy concern in the coming decade. Specific policy measures addressing key environmental issues in agriculture will need to be integrated into a broader policy framework. Policy measures which have traditionally been specific to the agricultural sector will have to be integrated into broader national environmental and planning and development programmes.

There remains an absence of serious engagement with implementation of agreed international and EU stated policy aims to reduce agricultural land take for urban development. Any decrease of agricultural land consumption in European countries should be guided by plans and policies that promote sustainable food production with agricultural land conversion to urban uses restrained to a minimum level. It is essential that both urban planners and policy makers actively manage urban expansion and agricultural land conversion processes simultaneously. A further important policy aspect is to promote and ensure implementation of densification policies that can be translated into actions aimed at redeveloping existing derelict and abandoned urban areas. Such developments would reduce the pressure of developing new urban land on the outskirts the city through converting agricultural landscapes. This can support urban regeneration policies through reduction in the consumption of agricultural land use and it can increase densification in urban areas.

Broadening the role of public policy objectives while maintaining food production levels and living standards in the agricultural sector presents a politically challenging decision environment. A traditional policy mix included a focus on the welfare of the agriculture and food sector along with protection of special amenity areas and the general physical environment. However, a broadening and integration of planning and public policy relating to agricultural lands also raises considerable opportunities for the maintenance and continued use of agriculture lands. Such opportunities include the use of such lands for sustainable energy generation whether solar or wind power, agritourism, and the adoption of sustainable farming practices with positive environmental effects, and/or providing public goods such as preserved or enhanced landscapes and, biodiversity projects.

Policy evaluation, as noted by Vojtech [124], remains a long-term and difficult process particularly given the site specificity of many environmental issues and the complexity of valuation and measurement of environmental outcomes. This research hopes to assist with the development of policy and evaluation by developing and examining data and the need for further research. Two limitations are clear in terms of the current research. First, this study focused on a cross-section of data to examine the determinants of agricultural land conversion over the 2000–2018 period while the use of panel data for the subject period is another alternative. Panel data models provide information on the impact of the independent variables on the response variable both across regions and over time. However, the use of panel data is not applicable in the local regression models which are specified based on the use of cross-section data. Further research is recommended to compare the modelling outcomes from a panel data model and the global and local models that were utilised in the current study. Second, given the data availability, the empirical study was conducted using the data for the 2000–2018 period. Applying the spatial analysis and regression modelling for the post-2018 period based on the availability of the data could provide a comparison of the impact of the COVID-19 pandemic on agricultural land use dynamics. Later models could also be compared with the models developed in the current study; relationships with socio-economic factors, institutional structure and spatial planning systems can be quantified and compared with the current modelling outcomes.

Author Contributions: Conceptualization, E.U. and B.W.; methodology, E.U.; software, E.U.; validation, E.U. and B.W; formal analysis, E.U.; investigation, E.U and B.W.; resources, E.U.; data curation, E.U.; writing—original draft preparation, E.U. and B.W.; writing—review and editing, E.U. and B.W.; visualization, E.U.; supervision, B.W.; project administration, E.U. and B.W. All authors have read and agreed to the published version of the manuscript.

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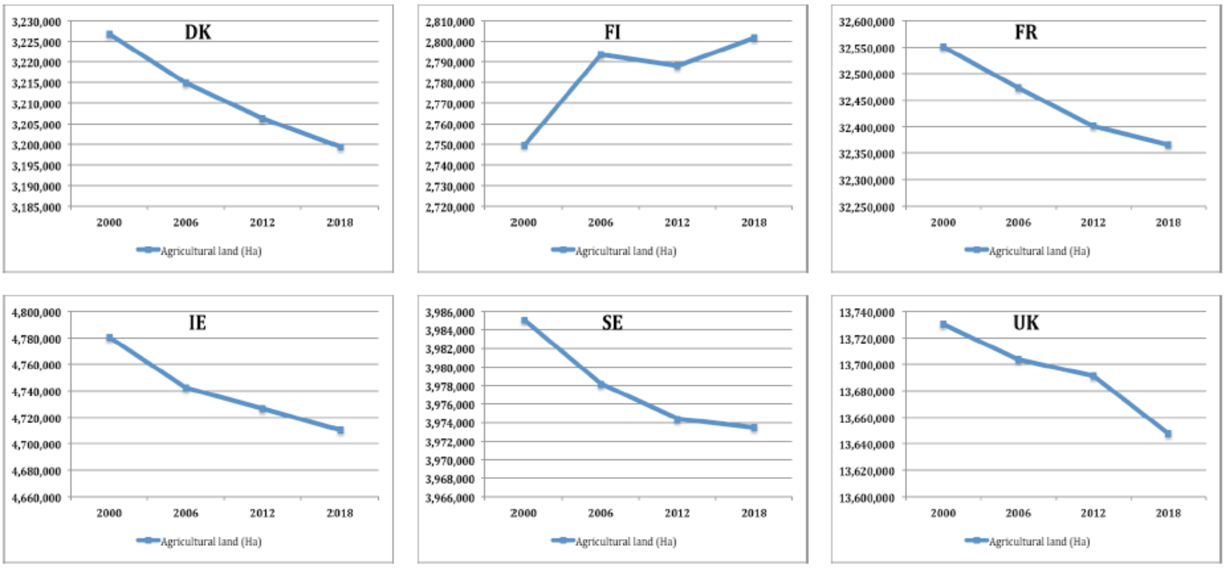
Conflicts of Interest: The authors declare no conflict of interest.

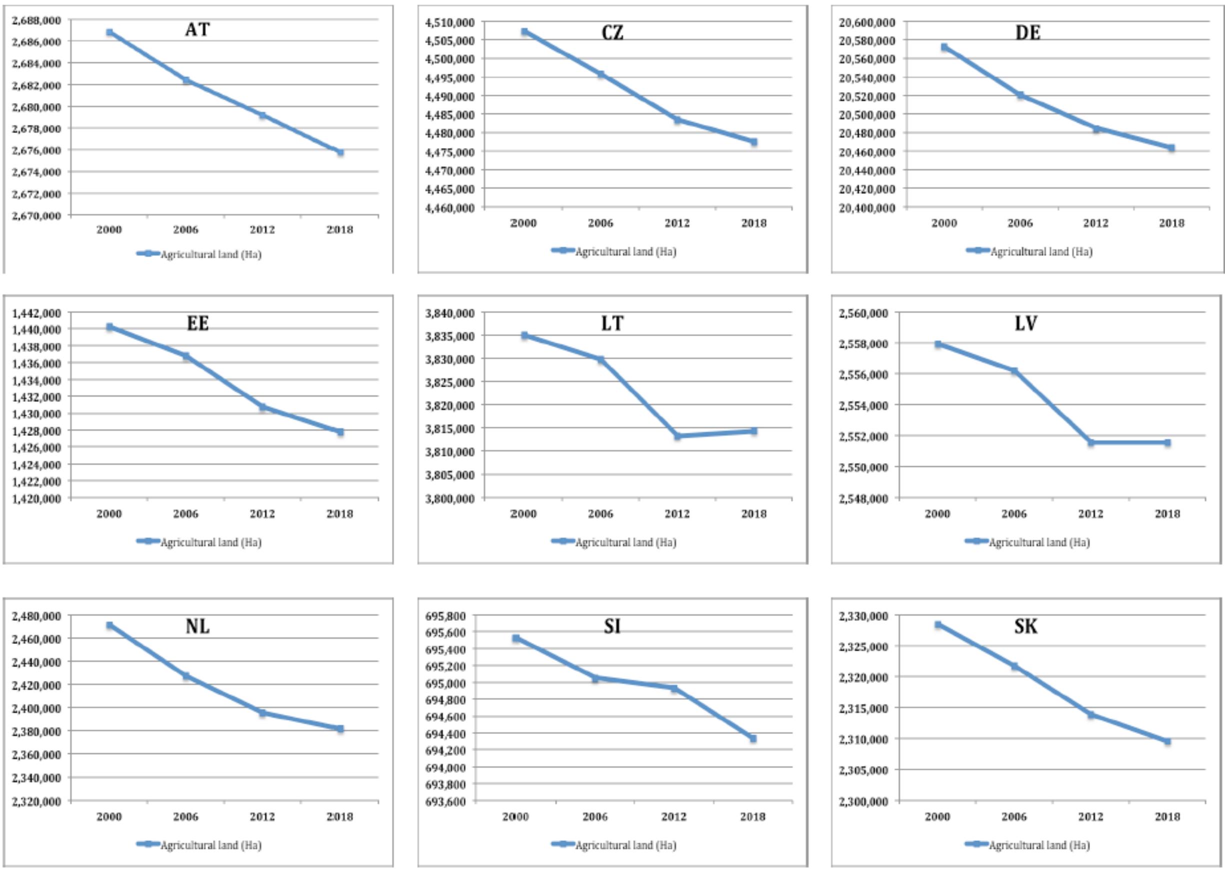
Appendix A

Change in agricultural land area between 2000 and 2018 across different planning systems (Source: created by the authors based on the CLC data from EEA [21]).

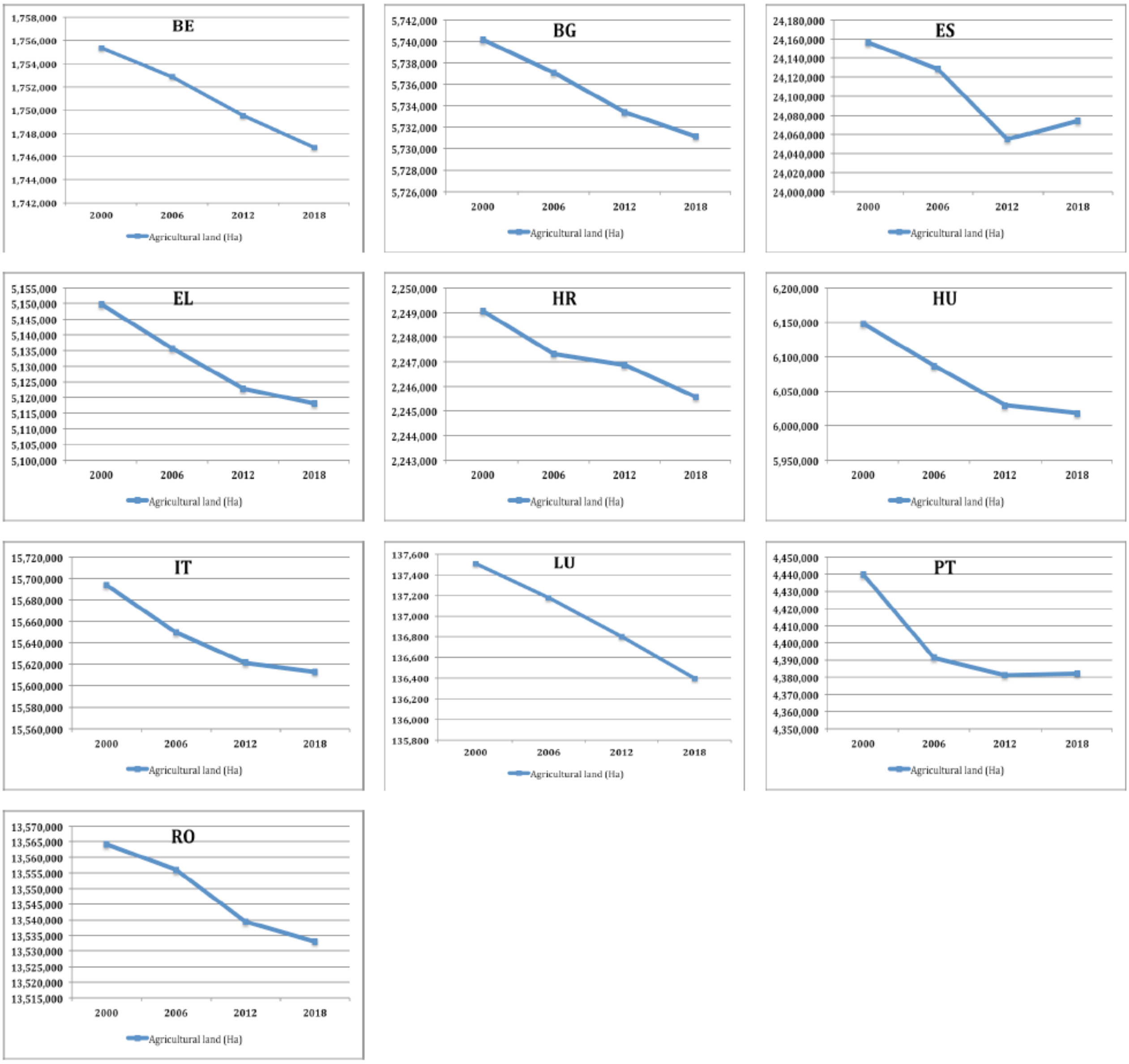
State-led Systems



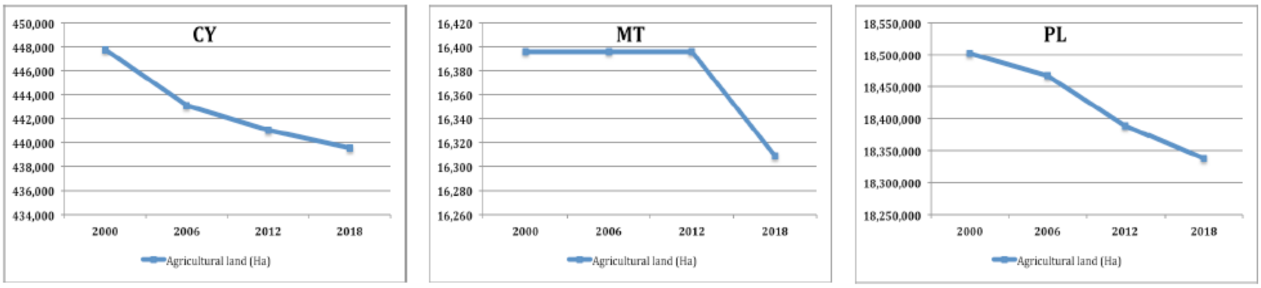
Market-led Neo-Performative Systems



Conformative Systems



Mis-led Performative Systems



Notes

1 In this research, land use change is a process by which human activities transform the actual land use to other land uses, referring to how land has been used, emphasising the functional role of land for economic activities. Land use change and landscape change can be interchangeably used throughout the text.

2 Regarding the respective positions between state-led and market-led models, Berisha et al. [60] classified the scales as follows: 2, spatial development is mainly driven by the state; 1, spatial development is mainly driven by the state and the market, with a prevalence of the former; 0, ideal balance between state and market; −1, spatial development is mainly driven by the state and the market, with a prevalence of the latter; −2, spatial development is mainly driven by the market.

3 The index was constructed based on the sub-indices including institutional depth, policy scope, fiscal autonomy, barrowing autonomy, representation, law making, executive control, fiscal control, barrowing control, and constitutional reform. Their details and scoring can be seen in Hooghe et al. [78].

4 Survey sources for the CPI are: (1) the Country Performance Assessment Ratings by the Asian Development Bank; (2) the Country Policy and Institutional Assessment by the African Development Bank; (3) the Bertelsmann Transformation Index; (4) the Country Policy and Institutional Assessment by the IDA and IBRD (World Bank); (5) the Economist Intelligence Unit; (6) Freedom House Nations in Transit; (7) Global Insight Country Risk Ratings; (8) the International Institute for Management Development; (9) Grey Area Dynamics Ratings by the Merchant International Group; (10) the Political and Economic Risk Consultancy, Hong Kong; (11) the World Economic Forum.

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