



Sustainable development of rural areas: a dynamic model in between tourism exploitation and landscape decline

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Abstract

This work investigates how to prevent sustainable tourism from turning into over-tourism dynamics. As a matter of fact, the former has shown to be capable of bringing profit to traditional rural activities (i.e. agriculture), the tourism sector, the environment and the cultural heritage of a region; whereas the latter, more often than not, harms and brings detriment to the natural landscape. Hereof, landscape heritage is a fundamental resource at the base of both rural tourism (RT) and traditional rural activities, and it is reasonable that to adequately support RT a certain degree of built-up growth (i.e. new accommodation facilities and cognate areas) is somewhat needed. However, we want to problematize that these dynamics shall be carefully calibrated and appropriately regulated in a non-conflictual way. We modeled that: (i) land can be either devoted to RT-hosting facilities or agriculture; (ii) RT impacts landscape resources more harmfully, thus diminishing profitability of both sectors. We also posit a policy instrument to preserve landscape resources, financed through RT revenues. The analysis shows that if no policy is applied, over-RT is ineluctable. Conversely, with such a policy instrument it is possible to determine an economic space where all rural economic activities peacefully coexist, and landscape impacts are minimized.

Keywords Negative environmental externalities · Two-sector growth model · Rural tourism · Sustainable development · Nature-based development

JEL Classification (2010) O44 · R11 · Z32

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1 Introduction

Rural tourism (RT) has grown globally and is today a stable source of economic support for many rural communities (Sharpley and Sharpley 1997; Long and Lane 2000; Roberts and Hall 2001; Saxena and Ilbery 2008; Zanni et al. 2008); nevertheless, in some privileged contexts, it has grown to such an extent, that it assumed a predominant role within local economy (Beteille 1996; Champion et al. 1998; Hall et al. 2005; Randelli et al. 2014). In some instances, this led regional/local development planning to prioritize economic growth over landscape conservation (Rodriguez-Pose and Fratesi 2004), with the risk of an excessive land transformation (Ward and Brown 2009), soil sealing, and landscape fragmentation (Amato et al. 2013; Martellozzo et al. 2018), as it happened in the coastal regions to satisfy the growing demand fueled by the (unwisely) triggered mass-tourism dynamics (Sanagustin Fons et al. 2011).

Also the Sustainable Development goals (SDGs) of the UNWTO (World Tourism Organization and United Nations) recognises that tourism has the potential to contribute to all 17 SDGs (WTO 2017) although for the focus of this paper is of particular interest the SDG 15 - Protect, restore and promote sustainable use of terrestrial ecosystems and halt biodiversity loss - because tourism “can play a major role if sustainably managed in fragile zones, not only in conserving and preserving biodiversity, but also in generating revenue as an alternative livelihood to local communities” (WTO 2017, p.17). In line with SDGs of UNWTO, the standpoint we base our work upon, is the one pursuing sustainable development.

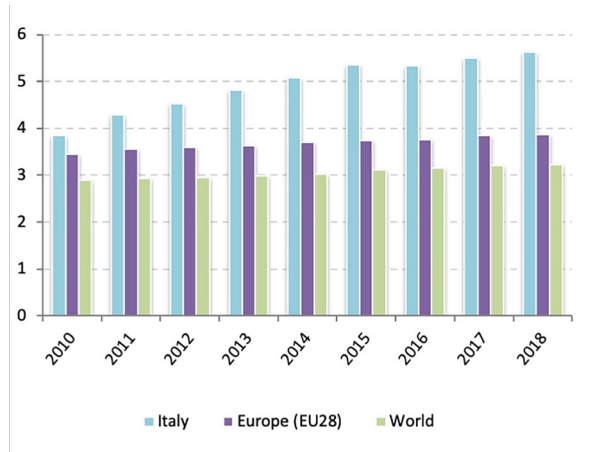
In literature is well underlined how and why the development of RT should follow radically divergent dynamics from those of the development of coastal tourism (Randelli and Martellozzo 2019). In particular, since the latter has often induced highly depleting dynamics of the natural and semi-natural landscape. For the attractiveness of coastal regions this may not be critical as much as it is for rural areas, because the sea remains an invariant element of the landscape, whereas in rural areas the landscape natural heritage is the fundamental resource both for RT and other traditional rural human activities (e.g. primarily agriculture; Cánoves et al. 2004; Daugstad 2008; Randelli and Martellozzo 2018). Broadly speaking, we believe that rural and coastal tourism may show a similar early evolutionary stage, but we also argue that RT shall radically diverge from tourism massification dynamics while approaching a mature stage. As a matter of fact, coastal tourism has often been initially fuelled by aspirational values similar to the ones associated (and overmarketed) to RT; for example it began in several places with people visiting small fishermen’s villages and with the development of facilities and accommodation to host them; however, over time some of these villages have started sprawling onto surrounding landscapes (Sanagustin Fons et al. 2011; García-Ayllón 2015; Weaver 2017; Valdivielso and Moranta 2019). On the drawback side though, in several coastal region the intense urbanization consequential to tourism development has caused a decrease in the environmental value in the long term, with no progressive influence on the magnitude of tourism increment (i.e. the central-west and north-east coasts in Italy, Costa Brava

etc.). In fact, several scholars argue and bring evidence that “classical beach tourism” have become obsolete (i.e. loss of attractiveness) in different regions from Great Britain (Agarwal 2002; Gale 2005) to Spain (Priestley and Mundet 1998), from Croatia (Vukonić 2001) to Italy (Mazzette 2004). In this regard, our supporting argument advocating for a necessary divergent path for RT, builds upon the fact that in the case of coastal tourism the attractive environmental variable cannot be fully depauperated (i.e. it is not possible to build over the sea), hence the main environmental resource to which tourism attractiveness is coupled cannot be completely eroded; whereas in the case of rural areas the environmental landscape elements conveying the added value attracting tourism, can be little by little irreparably weakened (i.e. full functional substitution). Hence, once the environmental value of the landscape is completely erased, the path for RT is irreversibly traced. It follows that while in rural areas a massive urbanization of land can compromise future tourism development, in coastal areas this may not be the case because the environmental resource can never be completely substituted by built-up development.

Furthermore, Oueslati et al. (2019) brought generalized evidences from Europe that even low level of fragmentation due to built-up expansion may significantly curb agricultural productivity in the urban-rural fringe. However, it is important to note that on the one hand, in order to adequately support rural economies also through the development of RT activities, a certain level of built-up growth (e.g. new accommodation and leisure facilities and cognate infrastructures) is needed, and shall be considered inevitable. Nonetheless, sometimes it also allows the opportunity for public and private stakeholders to intervene by coupling built-up expansion with the restoration and securing of critical situations (e.g. hydrogeological risk, conservation and recovery of historical heritage, etc.). On the other hand, when over-RT is in place and mass-tourism dynamics are replicated in rural areas, this can lead to a depletion of the landscape resource (Akgün et al. 2011) that necessarily negatively affects the attractiveness of RT and also the productivity/profitability of traditional rural activities. Therefore, it entails as a paradigmatic example for the sustainable development paradox (Temenos 2009; Horlings and Marsden 2014; Martellozzo et al. 2018), and hence is of crucial importance for local development authorities to a priori: (i) assess a threshold value for RT development that should not be exceeded, so to prevent a harmful depletion of the landscape natural resource base; and (ii) hypothesize how that goal can be achieved while maximizing profits (both for traditional rural economic activities and for RT) without compromising the landscape resource.

The goal of this work is to build upon the unequivocal decadence of a tourist destination, as evidenced by the well-known Butler’s rationale (Butler 1980), when a critical carrying capacity threshold for system’s resources is reached, by proposing a model that maximizes the profits of both main components of rural economies (i.e. tourism and agriculture), without compromising the ecological landscape resource at the base of rural systems (that in this study is exemplified through a peculiar input factor representing the added value of the land available). In this regard, a dynamic theoretical model is proposed in which is assumed that the land is homogeneous, and that it can be devoted indistinctly to RT, or to agricultural activities. Besides,

Fig. 1 Direct contribution to GDP (in %) deriving from tourism activities between 2010 and 2018 in Italy, Europe (EU28), and globally. Source: World Travel and Tourism Council 2018



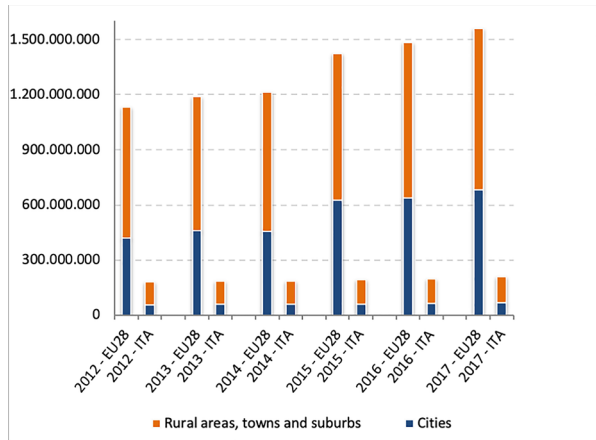
the model also posits that the depletion of the landscape resource is proportional to the growth of RT revenues. At this point, as reasonable, if no exogenous elements intervene, the system's evolution will see RT growing until rural systems' landscape resources are exhausted, given that it is generally more profitable to devote land to RT than to agriculture activities. In this case, the model mimics exactly a dynamic like tourism massification.

However, in order to allow a control over the progressive erosion of the landscape component in the dynamics described so far, we hypothesized the introduction of a policy tool¹ aimed at restoring the landscape resource base, for a quota inversely proportional to the posited detriment caused to the ecological landscape resource. As said, the analysis shows that in the event of the absence of any regulatory activity, RT soon exhausts the landscape resource, determining the ineluctable decline of the tourist destination, hence confirming the Butler's model. Vice versa, the dynamics characterized by a landscape restoration policy tool, as the one proposed here, shows that a desirable (borrowing from Pareto's vocabulary) coexistence of both components of rural economies is possible, yet favorable, while sustainably preserving the landscape resource.

The paper is structured as follows: Section 2 introduces the recent RTs' developments, Section 3 presents the dynamic model analyzed in Section 4, Section 5 reports the results, and Section 6 provides some final remarks.

¹ The policy intervention posited here assumes the form of a tax, given that taxation is generally considered the most used corrective instrument, besides being also easier to formalize.

Fig. 2 Number of nights spent by tourists in accommodations in Rural areas, towns and suburbs and in Cities (both in EU28 and Italy) between 2012 and 2017. Source: Eurostat, Tourism Database



2 Characterizing recent RT development and its ecological landscape base

Tourism in general and RT in particular, lately have been growing phenomena in many areas of the planet (see Figs. 1 and 2). RT typically refers to tourism outside densely populated areas (Pesonen and Komppula 2010), although some scholars underline its complexity as it occurs in both natural and built rural environments, it takes numerous forms and, as a consequence, the reasons or motivations for participating in RT are equally numerous (Tervo-Kankare and Tuohino 2016). In this paper we refer to RT as tourism in rural areas that, accordingly to OECD (Organisation for Economic Co-operation and Development) are those with a low density of population (< 150 inhabitants per km^2).

The growth of RT in academia is often associated with a more general trend to escape from increasingly congested and denser urban areas, even at the cost “to forego higher urban earnings for the quality of life found in places endowed with natural amenities” (Marull et al. 2011) and to return (albeit temporary in the case of RT) to a more nature-friendly lifestyle (Beteille 1996; Champion et al. 1998; Romei 2000). Besides, in some instances it has also been observed that numerous Environmentally focused Social Economy Enterprises (ESEE) are within the tourism sector “because [it] is the most likely to bring financial gain to the local businesses through spin-off benefits of their activities” (Davies and Mullin 2010).

For example, in several of the most iconic rural areas in Italy, RT has seen an initial period of development accompanied by a growth in both demand and supply, which have characterized its evolution during the 1990s (Randelli et al. 2014). Subsequently, RT evolutionary dynamics followed a more complex pattern (Long and Lane 2000), to the point of becoming a not negligible factor – if not even predominant – for local, regional, and national administrations (Hall et al. 2005). In Fig. 1 is visible as in 2018 for Italy the tourism sector alone represented (as a direct contribution) over 5% of the national GDP (World Travel & Tourism Council 2019); while Fig. 2 shows that (at least) since 2012 the number of nights spent by tourists in

accommodations in “Rural areas, towns and suburbs”,² both in the European Union (EU28) and Italy, represents stably the biggest share of total number of nights spent, and namely quite twice as much as the nights spent in “Cities”. In fact, according to the Tourism Database from Eurostat (2017) in 2017 the share of the number of nights spent in “Rural areas, towns and suburbs” in Italy was $\approx 68\%$ and in Europe of $\approx 56\%$, hence capping the nights spent in “Cities” respectively to $\approx 32\%$ and $\approx 44\%$.

In the regions where RT³ has reached a stable stage of maturity, it is synergically integrated into the territorial economic, social, and cultural structures (Saxena et al. 2007; Saxena and Ilbery 2008). For some rural communities, RT growth has been a driver able to countersign depopulation and rural economic decline, encourage cultural-commercial exchanges between urban and rural areas, enhance and promote the traditions of rural life, and nevertheless it also contributed to the general diversification of the economy, thus ensuring greater stability and security (Sharpley and Sharpley 1997; Roberts and Hall 2001; Cánoves et al. 2004).

2.1 Evolution of RT, coastal tourism, and speculative dynamics

In a first phase, RT started with filling the empty spaces (both anthropic infrastructures and fields) that have been progressively abandoned due to the decline of rural areas (Randelli et al. 2014). The ability of incumbent farmers to develop multifunctionality together with a lively local entrepreneurship has opened the door for profitable income diversification dynamics within rural areas (Garrod et al. 2006; Wood 2007). This evolutionary path transformed many traditional rural houses and barns into second homes and/or tourist accommodations facilities (accommodation in the farm, B&B, hostels etc.). Since the very beginning, RT – even if marginal – was perceived as an important mean to support local rural economies, given also the peculiar vulnerability of such areas/communities (Saxena et al. 2007). Hence, public authorities almost immediately recognized its importance and focused on fostering and supporting it through ad hoc policy instruments (Marques 2018), so that it quickly became (in numerous cases) a

² Coastal areas are local administrative units (LAUs) that are bordering or close to a coastline. A coastline is defined as the line where land and water surfaces meet (border each other). Due to the existence of several measures (for example, the mean or median tides, high- or low-tides), the European Commission has adopted the harmonised use of the mean high tide in order to delineate EU coastlines. All other municipalities are non-coastal. Coastal areas are a classification based on the following two categories: 1) coastal areas: LAUs that border the coastline or LAUs that have at least 50% of their surface area within a distance of 10 km from the coastline; 2) non-coastal areas: LAUs that are not “coastal areas”; in other words, LAUs that do not border the coastline and have less than 50% of their surface area within a distance of 10 km from the coastline.

³ In this study we refer to RT to identify all forms of tourism that are carried out and/or involving rural areas (Sanagustin Fons et al. 2011; Su 2011; Randelli et al. 2014). However, some authors prefer to diversify between RT tout court – which is connected to rural spaces and features some activities in contact with nature (Cánoves et al. 2004) – and agriturismo – a form of tourism carried out and connected directly to functioning farms (Pearce 1990; Beteille 1996). Nonetheless, for the purposes of this study this distinction is neither functional nor decisive.

characterizing factor influencing the development of planning policies and steering regional rural growth at large.

Today, in a context of a growing and appealing market, the evolution of rural areas makes them facing the challenge of an over exploitation of local resources and excessive land transformation, either where these are characterized by a lively agriculture (Randelli and Martellozzo 2019), or by lower agricultural rents (Wu and Chen 2016). Nowadays, built-up growth fueled by speculative interests threatens numerous highly valued rural areas, for instance Cataluna in Spain (Cuadrado-Ciuraneta et al. 2017), Tuscany in Italy (Randelli et al. 2014), and Provence in France (Farmer 2016). Furthermore, in order to have access to the quality of life found in places endowed with natural amenities (Marull et al. 2011) or to be a farmer - for instance a wine maker - in many rural areas the land is purchased by wealthy individuals and therefore also rural gentrification has become a threat (Hines 2010). This process of exploitation of the rural landscape has been amplified in recent years by the dynamics of globalization that have brought foreign capital and new residents into the countryside: all of these trends have caused a commodification of rural areas (Wood 2007). The commodification of rural areas entails the risk for over-exploitation of local resources, to the point of completely distorting the originality that the landscape and the territory had in the beginning (Swain 1989; Dearden and Harron 2004; Go 1997).

However, unlike coastal tourism – whose attractiveness is represented by the seaside and water activities – where anthropogenic pressure is catalyzed by (and concentrated on) the coastline; RT is (at least in principle) inspired by a different relationship with the surrounding territory and with the resources (both ecological and cultural) characterizing the landscape hosting it. In this perspective, is reasonable to portray RT as a form of tourism more incline to sustainability and sustainable activities. Its attractiveness crucially builds-upon multi-sensory experiences stimulated by the various elements of the landscape; thus, for that reason, one of its main aims is the respect and non-alteration of the balance between the ecological and cultural elements composing the landscape system in which it is offered. From this standpoint, the amount of landscape and its ecological value are at the same time the foundation of RT and the elements at risk in case of overexploitation of RT. More precisely, it is the mixture of the various elements composing the eco-cultural paisage (e.g. valleys, plains, spontaneous vegetation, streams, agricultural lands, vineyards, olive groves, villages and settlements of historical-cultural interest etc.), and their proportion (also in terms of quantitative surface), that characterize landscape's attractiveness; therefore, it can be defined through its ecological and cultural value and its potential for RT exploitation.

Hence, we ultimately posits that the elements characterizing the success, and the attractiveness, of RT for a region (nature-friendly lifestyle, contact with the natural environment, cultural authenticity, environmental quality, quality and peculiarity of the local agriculture production etc.) are basically the ones composing its ecological and cultural landscape, and these must be considered finite since are not easily renewable. Therefore, the elements onto which RT attractiveness builds-upon, are at the same time the ones limiting its further exploitation.

It follows that in a fragile environment such as rural areas, the regulation of local investments is crucial. For instance, due to the lack of a formal regional master plan for settlements and infrastructures, in Catalonia urban planning policies were unable to contain the expansion of built-up areas (Cuadrado-Ciuraneta et al. 2017). Furthermore, according to a 1994 Municipality survey on coastal tourist areas in Greece, about 40% of the buildings were constructed without any building license (Triantafyllopoulos 2017). Also in Italy coastal areas have undergone urbanization dynamics of a similar magnitude (Trono 2012) and the “urbanization of the protected 300-m strip from shoreline has reached levels of over fifty per cent in some parts of the country” (Falco 2017) and the highest levels are registered in the southern part of Italy (e.g. in Lazio and Campania). In this paper, we want to draw attention to the fact that RT growth should not mimic coastal tourism development, because the latter is often characterized by mass tourism.

For a sustainable RT, this evolutionary path is inappropriate because mass tourism requires the expansion of built-up areas to accommodate the larger number of tourists, and in rural areas, this will certainly compromise a fundamental local resource for RT such as landscape beauty (Randelli and Martellozzo 2019). Furthermore, the type of construction built-up to accommodate coastal mass tourism is inappropriate for RT because it often takes the shape of holiday resorts, artificial villages, and residential high-density condos.

In conclusion, in the case of coastal tourism, a massive urbanization can erode the environmental resource, but it cannot cancel it, hence it cannot be fully reduced to 0 in our model (i.e. in simple terms because it is not possible to build over the sea). Anyway, today many regions have prohibited to build up within a 300-m strip from the shoreline to fully protect the main environmental resource which is the coastline. In the case of RT a widespread built-up expansion can erode the “environmental” value of the landscape resource - theoretically up to 0 – so to negatively impact also the economic evolution of a RT destination. In this perspective RT development must necessarily refute and diverge from the Butler’s evolution model of tourist destinations, because the degradation of its ecological and cultural components would inevitably trigger the decline of the rural tourist destination; hence, the over-exploitation of ecological and cultural components of the landscape must be intended as sufficient, yet not necessary, cause for RT decline. Nonetheless, as said, once the environmental resources are exhausted, their ecological capability is vanished, and cannot be restored; therefore, landscape remains unattractive not solely for RT exploitation, but it is also unproductive for agricultural purposes.

3 A dynamic model for exploring RT sustainable potential

Butler’s model was aimed at explaining the development path observed of many coastal tourism destinations, which often had to struggle to identify (create) new attractive resources as alternatives to the simple seaside (beaches and sea) that had characterized their first stage of development. Although the massification of tourist resorts is common to many coastal areas, it has been seldom observed in rural areas where RT is important and with high ecological and cultural landscape value.

However, in some cases have appeared the first signs of a possible over-exploitation, for example these have been detected in some hilly municipalities of central Tuscany (Randelli and Martellozzo 2018), the hinterland of the Côte d'Azur (Jovicic 2014), the countryside around Barcelona (Marull et al. 2010), etc.

In here we want to propose a theoretical model to systematically support sustainable principles in the study of RT development in rural areas. The model focuses on the potential impact imputable to RT growth onto the ecological cultural and land components of the landscape of rural areas. This is exemplified through soil sealing (due to build-up development) and through the consequential ecological detriment of landscape heritage. Besides, a second aim of this work is to produce a tool to support sustainable policy making and regional planning (within an evolutionary framework; Rafiqui 2009); therefore, the model assumes that local authorities can intervene through a policy instrument conceived to foster sustainability. This instrument is designed to restore and preserve the ecological landscape heritage lost due to built-up expansion, and it is financed by (and proportional to) RT revenues.

3.1 Formalization of the dynamic model

Let us consider a small open economy with three production factors (land, physical capital, and a renewable free-access environmental landscape resource) and two groups of agents: "Agricultural land owners" (A-agents) and "Holiday investors" (H-agents). The A-agent can sell her land to the H-agents or use it for the agricultural production process (she can invest exclusively in the local economy). The H-agent can buy the land from A-agents and invest in rural tourism in the local economy or invest in an another economy. Both populations are composed of a continuum of identical individuals. It follows that our model focuses only on a fraction of the total rural development dynamics taking place, which are namely the ones interplaying between tourism and agriculture, and in particular in areas where the landscape value is particularly precious and where the threat for sustainable development from built-up expansion is sensible.

Production functions of the two sectors satisfy Inada conditions, namely are concave, increasing and homogeneous of degree 1 in their inputs. The production function of the representative A-agent is given by:

$$Y_a = K_a^\alpha L^{1-\alpha} E^\gamma \quad (1)$$

where K_a is the physical capital accumulated by the representative A-agents, L is the amount of land used in the agricultural sector production, E is the stock of the environmental landscape resource, a crucial factor for RT development; $0 < \alpha, \gamma < 1$. The A-agent's total endowment of land is normalized to 1 and all the land is allocated between sector, thus $1 - L$ represents the A-agent's land sells to H-agent.

The production function of the representative Holiday investors is given by:

$$Y_h = K_h^\beta (1 - L)^{1-\beta} E^\theta \quad (2)$$

where K_h denotes the stock of physical capital invested by the representative H-agent; $0 < \beta, \theta < 1$. The representative H-agent chooses her land demand $1 - L$ and the stock of physical capital K_h in order to maximize her profits, namely:

$$\max_{1-L, K_h} \left[(1 - \tau) K_h^\beta (1 - L)^{1-\beta} E^\theta - p(1 - L) - rK_h \right] \quad (3)$$

where $\tau \in [0, 1)$ is a parameter that measures the environmental taxation,⁴ p and r are, respectively, the land price and the opportunity cost of capital invested by Holiday investors. Therefore, H-agent invests in the local economy only if the return on capital is higher than r , otherwise she invests in other economies. While r is an exogenous parameter, p is endogenously determined by the land market equilibrium condition such that the demand of land (from H-agent) is equal to the supply of land (from A-agent). We assume that the K_h inflow is potentially unlimited.

The representative A-agent chooses the allocation of her land between the two sectors in order to solve the following maximization problem:

$$\max_L \left[K_a^\alpha L^{1-\alpha} E^\gamma + p(1 - L) \right] \quad (4)$$

The dynamics of K_a follows a Solow (1956)-type accumulation process:

$$\dot{K}_a = \sigma \left[K_a^\alpha L^{1-\alpha} E^\gamma + p(1 - L) \right] - \delta K_a \quad (5)$$

where \dot{K}_a is the time derivative dK_a/dt of K_a , $\sigma \in (0, 1)$ represents the constant propensity to save and $\delta \in (0, 1)$ is the depreciation rate of agricultural capital.⁵ For the sake of simplicity, we assume that the prices of the goods produced in both sectors are equal to unity.

The evolution of the environmental landscape resource is assumed to be the following:

$$\dot{E} = E \left(\bar{E} - E \right) - \phi \bar{Y}_h + \eta D \quad (6)$$

where \dot{E} is the time derivative dE/dt of E ,⁶ $\bar{E} > 0$ is the landscape carrying capacity, $\phi > 0$ is a parameter that measures the environmental negative impact caused by the rural tourism sector,⁷ \bar{Y}_h represents the economy-wide rage value

⁴ See Baldwin and Okubo (2014) and Borghesi et al. (2019) for applications of exogenous taxation in economic geography and environmental economics, respectively.

⁵ This means that the representative A-agent chooses the level of capital in order to maximize profits, but she does not invest optimally, formally she does not solve an inter-temporal optimization problem. We introduce this assumption of bounded rationality because in rural areas, as well as in developed countries, financial markets are usually segmented (see, among others, Antoci et al. 2014, 2015).

⁶ See Noailly et al. (2003) and Blanco and Lozano (2015) for further details of natural resources dynamics in a bounded rational context.

⁷ For the sake of analytical simplicity, we assume that only the holiday sector reduces the environmental landscape resource. Similar results would apply if we assumed that also the agricultural sector is polluting but less than the holiday sector.

of Y_h ,⁸ D are the landscape restoring expenditures financed by taxation of tourism sector ($D = \tau \bar{Y}_h$), and $\eta > 0$ captures the policy effectiveness.⁹

Equation 6 is composed of three parts. The first is the time evolution of natural resources without human activity, namely the standard logistic equation. The second is the impact of the tourism sector determined by parameter ϕ . The third part is represented by the policy, since incomes from taxes are used by the government to mitigate the negative effects of the tourism sector. Since we are assuming a continuum of identical agents, then the average output \bar{Y}_h coincides, ex post, with the per capita value Y_h . Therefore, we can rewrite the dynamic system as follows:

$$\begin{aligned} \dot{K}_a &= \sigma [K_a^\alpha L^{1-\alpha} E^\gamma + p(1-L)] - \delta K_a \\ \dot{E} &= E \left(\frac{\bar{E}}{E} - E \right) - (\phi - \eta\tau) K_h^\beta (1-L)^{1-\beta} E^\theta \end{aligned} \quad (7)$$

4 Analysis of the model

In this section we deal with the equilibrium values, the dynamics that may arise, and the stationary states.

4.1 Equilibrium values

The solutions of the maximization problems (3)–(4) allow to determine the equilibrium values of L and K_a . In particular, the maximization problem of the representative A-agent gives rise to the following first order condition:

$$(1 - \alpha) K_a^\alpha L^{-\alpha} E^\gamma = p \quad (8)$$

Equation 8 represents the supply of land. Similarly, the maximization problem of the representative H-agent gives rise to the following first order conditions:

$$(1 - \beta)(1 - \tau) K_h^\beta (1 - L)^{-\beta} E^\theta = p \quad (9)$$

$$\beta(1 - \tau) K_h^{\beta-1} (1 - L)^{1-\beta} E^\theta = r \quad (10)$$

⁸ The average output \bar{Y}_h is taken as exogenously given by the two representative agents, thus each economic agent considers as negligible the impact of her behaviors (see, among others, Antoci et al. 2012, 2019). Therefore, the agents do not internalize the negative externalities generated by the rural tourism sector due to coordination failures. In such a context, the role of a policy instrument to “correct” these negative externalities is essential to preserve the environmental landscape resource.

⁹ Obviously, taxation is not the only one instrument to mitigate the negative impact of tourism sector on the environment. For example, Antoci et al. (2013) use financial instruments to counterbalance negative externalities from tourism sector.

Equation 9 represents the demand of land, while Eq. 10 is the external capital marginal product. Assuming that land market is perfectly competitive and prices are flexible, to obtain the market clearing condition we can equalize (8) to (10):

$$(1 - \alpha)K_a^\alpha L^{-\alpha} E^\gamma = (1 - \beta)(1 - \tau)K_h^\beta (1 - L)^{-\beta} E^\theta \tag{11}$$

In each instant of time the land price equals demand and supply (instantaneous adjustments). From Eq. 10 we obtain the value of holiday capital:

$$K_h = \left(\frac{\beta}{r}(1 - \tau) \right)^{\frac{1}{1-\beta}} (1 - L) E^{\frac{\theta}{1-\beta}} \tag{12}$$

Substituting (12) in (11), we obtain:

$$L = \Omega K_a \tag{13}$$

where

$$\Omega := \left[\frac{(1 - \alpha)E^\gamma}{(1 - \beta)(1 - \tau)^{\frac{1}{1-\beta}} \left(\frac{\beta}{r} \right)^{\frac{\beta}{1-\beta}} E^{\frac{\theta}{1-\beta}}} \right]^{\frac{1}{\alpha}}$$

Function (13) identifies the equilibrium land allocation value \tilde{L} of L if the right side of Eq. 13 is lower than 1; otherwise $\tilde{L} = 1$, that is:

$$\tilde{L} = \min \{ 1, \Omega K_a \} \tag{14}$$

Consequently, from Eq. 12 the equilibrium value \tilde{K}_h of holiday capital K_h is determined by:

$$\tilde{K}_h = \left(\frac{\beta}{r}(1 - \tau) \right)^{\frac{1}{1-\beta}} (1 - \tilde{L}) E^{\frac{\theta}{1-\beta}} \tag{15}$$

The economy is specialized in the production of the holiday sector if $\tilde{L} = 1$ (and, consequently, $\tilde{K}_h = 0$). Setting $\tilde{L} = 1$, function (13) becomes:

$$K_a = \tilde{K}_a := \Omega^{-1} \tag{16}$$

The graph of Eq. 16, represented in red in Fig. 3, separates the region of the plane (E, K_a) where $\tilde{L} = 1$ (above it) from the region where $\tilde{L} < 1$ (below it).

Notice that from condition (14) we can distinguish two possible cases: (a) if either $E = 0$ or $K_a = 0$, then no production occurs in the economy (also $K_h = 0$, see Eq. 15); and (b) if $E, K_a > 0$, instead, two sub-cases may arise, that is: (i) coexistence between sectors ($0 < \tilde{L} < 1$) and (ii) specialization in the agricultural sector ($\tilde{L} = 1$).

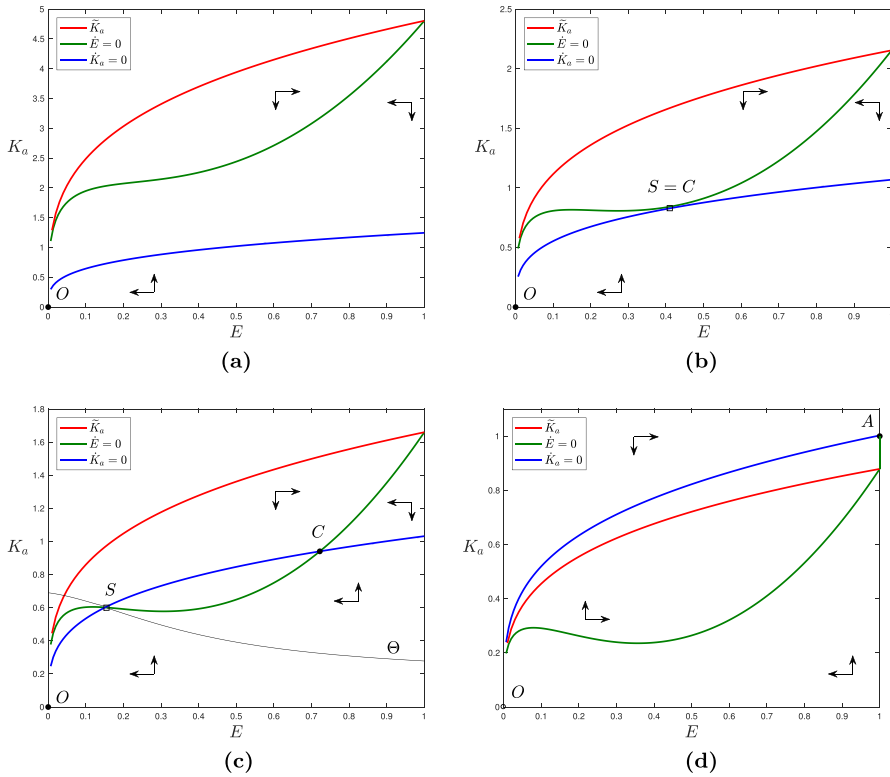


Fig. 3 Dynamic regimes. Legend: · sinks, □ saddle points, ° sources

4.2 Dynamics

Below the separatrix (16), namely if $\Omega K_a < 1$ (see function (13)), then the representative A-agent sells a positive fraction of her total land endowment to the representative H-agent. In this case, substituting (12) in (9) (obviously, assuming that land market is always in equilibrium, the same result is obtained substituting (13) in (8)), the equilibrium land price is given by:

$$\tilde{p} = (1 - \beta)(1 - \tau)^{\frac{1}{1-\beta}} \left(\frac{\beta}{r} \right)^{\frac{\beta}{1-\beta}} E^{\frac{\theta}{1-\beta}} \tag{17}$$

Notice that the land price is not constant, but it is an increasing function of the environmental landscape resource. The dynamic system in the case of coexistence between sectors is the following:

$$\begin{aligned} \dot{K}_a &= \sigma \left[\alpha \Omega^{1-\alpha} K_a E^\gamma + (1 - \beta)(1 - \tau)^{\frac{1}{1-\beta}} \left(\frac{\beta}{r} \right)^{\frac{\beta}{1-\beta}} E^{\frac{\theta}{1-\beta}} \right] - \delta K_a \\ \dot{E} &= E \left(\bar{E} - E \right) - (\phi - \eta \tau) \left(\frac{\beta}{r} (1 - \tau) \right)^{\frac{\beta}{1-\beta}} (1 - \Omega K_a) E^{\frac{\theta}{1-\beta}} \end{aligned} \tag{18}$$

Above and along the separatrix (16), namely if $\Omega K_a \geq 1$, the A-agent allocates all her land endowment to the production activity of the agricultural sector and the dynamic system is the following:

$$\begin{aligned} \dot{K}_a &= \sigma K_a^\alpha E^\gamma - \delta K_a \\ \dot{E} &= E \left(\bar{E} - E \right) \end{aligned} \tag{19}$$

4.3 Stationary states

Under dynamic system (7), a stationary state in which the economy is specialized in the rural tourism sector does not exist.¹⁰ Therefore, three types of stationary states may be observed:

- the stationary state $O = (0,0)$, that always exists, in which the environmental landscape resource is completely depleted and thus no production occurs;
- the stationary state $A = \left(\bar{E}, \left(\frac{\delta}{\sigma \bar{E}} \right)^{\frac{1}{\alpha-1}} \right)$, derived from Eq. 19, in which the economy specializes in the agricultural sector and the environmental resource is equal to the carrying capacity;
- stationary states in which both sectors coexist (see Eq. 18).

The following proposition illustrates the conditions for the existence and the stability analysis of the stationary state when the economy is specialized in the agricultural sector.

Proposition 1 The state $A = \left(\bar{E}, \left(\frac{\delta}{\sigma \bar{E}} \right)^{\frac{1}{\alpha-1}} \right)$ is a stationary state of the system (19) if and only if

$$(1 - \alpha) \geq \left[\left(\frac{\delta}{\sigma \bar{E}} \right)^{\frac{1}{\alpha-1}} \left(\frac{\bar{E}^{\frac{\gamma(1-\beta)-\theta}{1-\beta}}}{(1 - \beta)(1 - \tau)^{\frac{1}{1-\beta}} \left(\frac{\beta}{r} \right)^{\frac{\beta}{1-\beta}}} \right)^{\frac{1}{\alpha}} \right]^{-\alpha} \tag{20}$$

¹⁰ Notice that, if the economy specializes in the rural tourism sector, then $K_a = 0$. If this is the case, from Eq. 7 it follows $\dot{K}_a = \sigma p$, with σ and p strictly positive (see Eq. 17). Indeed, $K_a = 0$ only if also $E = 0$, and, if this holds, no production occurs in both sectors.

When existing, it is always attractive.

Proof See [Appendix](#). \square

As Proposition 1 points out, the stationary state of specialization in the agricultural sector A , when existing, lies always along or above the separatrix \tilde{K}_a (where $\tilde{L} = 1$) and it is always attractive. Moreover, the specialization in the agricultural sector occurs only if the output elasticity of land in the agricultural sector $1 - \alpha$ is high enough. The following proposition describes the global dynamics of the system (7).

Proposition 2 The set

$$\Psi = \left\{ (E, K_a) : 0 \leq E \leq \bar{E} \text{ and } 0 \leq K_a \leq \bar{K}_a \right\}$$

where

$$\bar{K}_a > \max \left\{ \left(\frac{\delta}{\sigma \bar{E}^\gamma} \right)^{\frac{1}{\alpha-1}}, \hat{K}_a \right\}$$

and

$$\hat{K}_a$$

is the maximum of the function (16), is positively invariant under the dynamic system (7). Every trajectory starting outside Ψ enters it in finite time. When the stationary state with specialization $A = \left(\bar{E}, \left(\frac{\delta}{\sigma \bar{E}^\gamma} \right)^{\frac{1}{\alpha-1}} \right)$ does not exist, then both sectors coexist.

Proof See [Appendix](#). \square

Proposition 2 shows that coexistence between sector is possible. Indeed, if the stationary state A does not exist (namely, the economy can not specialize in the agricultural sector), then trajectories that enter the set Ψ can approach or the stationary state O or a stationary state (or a limit cycle) in which both sectors coexist.

It is not possible to compute analytically the number of internal stationary states that may be observed. However, from numerical simulations emerge that there may exist at most two stationary states with $E > 0$ and $K_a = 0$, namely the attraction point C and the saddle point S . These are further described in [Appendix](#).

5 Discussion of the results

From the analysis of the model emerges that at most three stationary states may arise: the state O in which there is no production ($K_a = E = 0$), the inner states S and C in which there is, at least at the equilibrium, coexistence between sectors, and the

state A in which there is specialization in the agricultural sector. Numerical simulations¹¹ show that the system (7) admits three dynamic regimes:

- i) The case in which the state O is globally attractive. This occurs either when the isocline $\dot{E} = 0$ always lies above the isocline $\dot{K}_a = 0$ (see Fig. 3a); or when the isoclines $\dot{E} = 0$ and $\dot{K}_a = 0$ are tangent (see Fig. 3b).
- ii) The case in which the states O and C are locally attractive and their basins of attraction are separated by the stable manifold of the saddle point S (represented by Θ ; see Fig. 3c). This occurs when the isoclines $\dot{E} = 0$ and $\dot{K}_a = 0$ intersect at two distinct points.
- iii) The case in which the state O is repulsive and all the trajectories converge to the globally attractive state A . This occurs when the isocline $\dot{E} = 0$ always lies below the isocline $\dot{K}_a = 0$ (see Fig. 3d).

Figure 3a and b indicate that the state O is globally attractive. In this dynamic regime the natural resource is projected to be always designated to a complete destruction; consequently, after the complete loss of the landscape resource it won't be possible any further production either for the agricultural sector or for the tourist sector. This scenario occurs in the absence of a taxation instrument, or when it is too weak to obtain an effect of any sort. Figure 3b shows, in fact, that despite $\tau = 0.155$, the tax is not sufficient to prevent the destruction of the landscape resource.

However, even higher values of the tax (such as $\tau = 0.2$ in Fig. 3c) do not allow to completely avoid the scenario of complete destruction of the resource. In fact, in Fig. 3c the dynamics is bi-stable, i.e. it depends on the initial conditions. If we start from a point in the geometrical space where the agricultural capital is sufficiently high (i.e. we sit above the stable manifold θ) then the economy will converge to the state C where both sectors coexist and $E > 0$.

This last finding is particularly interesting, because it implies that the strength of the policy intervention does not really matter, since this alone won't suffice to preserve the integrity (in the long run not even the simple existence) of the environmental and cultural heritage landscape. The latter it is then projected to a complete destruction implying a zero production for both the economic sectors considered, and this result underlines once more how crucial is the conservation of the environmental and cultural landscape to grant long term sustainable (both ecological and economic) development.

Consequently, this observation let us speculate that: the policy instrument hypothesized must be coupled with other policy interventions aiming at supporting traditional rural economic activities (such as agriculture) to produce a positive effect of any sort, from a sustainable perspective. In fact, the model shows that the policy

¹¹ The parameter values have been chosen so as to illustrate the various dynamic regimes that can emerge from the analysis of the model. The states shown in the diagrams hold with different sets of parameter values, therefore the figures can be considered as representative of other parametric scenarios. The parameter values are all the same, that is, $\alpha = 0.3$, $\beta = 0.3$, $\gamma = 0.2$, $\delta = 0.1$, $\eta = 0.5$, $\theta = 0.2$, $\sigma = 0.1$, $\phi = 0.5$, $r = 0.1$, $\bar{E} = 1$. Taxation is the only parameter that varies, since we want to investigate how dynamics changes at different values of τ .

instrument here proposed is effective only when the initial agricultural capital is “strong enough”. In that regard, Richards similarly observed that “the likelihood of an area being [devoted to] agriculture appears to reflect the dynamic socio-economic conditions of a location’s surroundings.[thus implying that] agricultural agencies or experts seeking to support developing agricultural regions should recognize the importance of returns to scale and local clustering and that [...] land use modeling can be [used as an effective tool to foster the] suitability and land uses in nearby locations” (Richards 2018). In other words, that is to say that in order to preserve environmental and cultural landscape, which is of dramatic relevance for long-term sustainable exploitation of economic and agricultural potential in rural areas, to support and incentive agriculture is crucial (i.e. traditional rural activities).

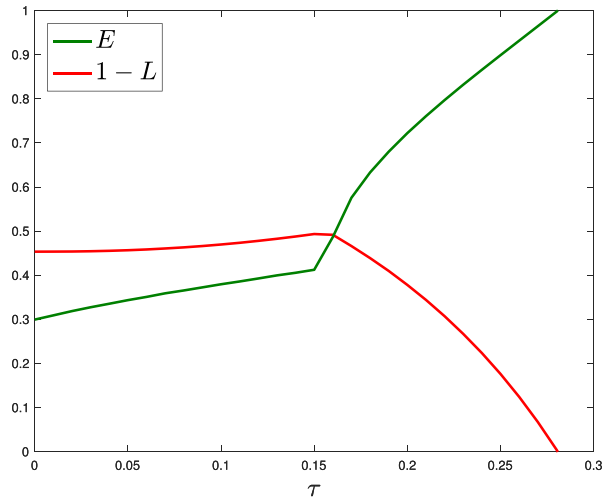
Finally, the dynamic shows that in case the policy instrument, i.e. the taxation, is too high, the tourism sector disappears and all the land is allocated to the agricultural sector (Fig. 3d). In this case, the tax is so high that for H-agents is not convenient anymore to buy land from A-agents, and the tourist capital flees the rural economic system under investigation. This basically reproduces a same dynamic where agricultural production is so profitable that capital is more attracted to invest in agriculture than in tourism. For instance, this is the case of some wine regions in France as Aquitaine and Champagne, where the agricultural production (wine) is too strong and successful to enable a novelty like tourism to take root (Frochot 2000; Lignon-Darmaillac 2009).

To sum up, the dynamic model helps understand that a regulatory intervention, such as the one proposed (i.e. τ), has a “null” effect until it is set to a value “too low” to produce any tangible repercussions. Hence, having a weak intervention, or not having it at all, will produce the same effect, and the progressive and complete destruction of the environmental and cultural landscape resource is ineluctable due to the excessive exploitation from H-agents. It is implicit that not only a regulatory tool is useful to foster sustainable development, but it is necessarily important to avoid an irreversibly harmful (i.e. complete and permanent) depletion of the fundamental base resource.

Conversely, an intervention, whose “strength” even slightly exceeds the threshold value for which no effect is produced in the dynamic system, makes the resulting effect to depend only on the system’s initial conditions. In particular, the “strength”, or value, of the agriculture capital (K_a), which is in practice a proxy of the relevance of the agricultural production in the region of interest. Hence, if the agricultural sector is *important* (certified products such as PDO, Protected Designation of Origin or PGI, Protected Geographical Indication as proposed by the European Commission) and *strong* (well established and profitable), an appropriately calibrated policy intervention will increase the value of the resource (E) and also of the agricultural production, while at the same time stimulating tourism sector. But, if the agricultural sector is not strong (enough), the development dynamics can only bring a detriment to the system and greatly reduce the value of the landscape resource and consequently also the value of the agricultural sector.

The model also indicates a third situation in which the regulatory intervention assumes a force that is “too high”. In this case, the dynamics will only lead to a maximization of the environmental and cultural landscape resource, disregarding

Fig. 4 Trend of the value of the resource (E), and of the land allocated to the tourism sector ($1 - L$) as functions of the initial value of the policy instrument (τ)



what value is assumed by the agricultural capital. However, this also implies the alienation of the tourism sector from the system, which as we saw earlier, when adequately proportioned; it may instead bring benefits to system as a whole.

In Fig. 4 it is evident that the landscape resource E and the land used by the tourism sector (i.e. $1 - L$) vary according to the value assumed by the hypothetical policy intervention (τ). In fact, only for values above a certain threshold value (i.e. 0.155) it is possible to obtain a land containment effect for the tourism sector, whilst fostering an increase of the value of the landscape resource (E). On the contrary, for values lower than this threshold value the land destined for the tourism sector does not decrease, and the dynamics (Fig. 2) highlights that in the long term the system is destined to necessarily exhaust the resources, and in doing so it will mimic the dynamics that we could define as a characteristic of “coastal tourism development”.

Nonetheless, the values identified by the model are not “absolute” at all, but these shall be considered functional to show peculiar states for theoretical purposes and then its application at the regional level is probably one of the main challenges for the policy making. In fact, once the described dynamic is understood, the main aim is to be able to adequately calibrate the regulatory intervention, so to identify a value (or more likely a range) that can produce a containing - but not oppressive - effect on the tourism sector, thus producing wealth while at the same time preserving the values of the system’s resources and of the agricultural capital.

Under this perspective, in order to adequately calibrate the regulatory intervention for any given territory, it is important to observe its geographical variables’ evolution. It follows that a deep analysis of the rural configuration is crucial (Coisson et al. 2014; Randelli et al. 2014), because – as we have seen – it gives us the opportunity to understand whether the rural region needs to support the agricultural system, the rural tourism sector or both of them. Besides, it is also necessary to monitor the rate and the increase of land devoted to built-up expansion in rural areas, and the simultaneous increase of tourist presences (Randelli and Martellozzo 2019), which

may be indicative of potentially harmful and irreversible dynamics, such as tourism massification similar of coastal tourism development.

We should however bear in mind that built-up growth can also be stimulated both by an increase in the resident population, and by an expansion of the commercial and industrial areas, and other factors (Henderson and Wang 2005; Percoco 2015). Furthermore one shall also consider the high degree of endogeneity between such factors. Nevertheless, it must also be noted that some authors show that effective agriculture-supportive policy may lead to unwanted rebound effect such as suburban expansion (into rural areas; Coisson et al. 2014). Therefore, intelligibly linking the expansion of built-up rural areas to the increase of RT is not straightforward; hence, once more we want to underline the importance of diachronically contextualizing the geographical peculiarities of the region of interest in order to appropriately, yet efficiently, calibrate the model proposed. As a matter of fact, although in practice a degraded landscape won't necessarily and automatically diminish tourism attractiveness (because the characterization of tourist destination may change over time), rural areas are more prone to this because the environmental resource with which their attractiveness is intertwined is limited (geographically), while for coastal tourism is (almost) not. Hence, rural areas may will to fuel land development and tourism at the same time, but doing so without limits and remaining within the realm of sustainable development at the same time won't unfortunately be an option. Our model aims precisely at defining a rationale for determining some sort of threshold for that dynamic. One of the interesting challenges that we have not addressed in here (nor it was the scope of this manuscript), is how to handle coefficients calibration in a unique fashion although fitting to the peculiarities of different geographical regions and scales, and still being able to evaluate adequately the degree of the dynamic described (if any). We believe this bit extremely relevant, because it permits to shift from a theoretical level to an applied research framework.

6 Conclusions

Although this study can be considered a preliminary investigation of the evolutionary dynamics at the base of RT development, it appears appropriate that its growth – in order to preserve the environmental and cultural landscape resource of a given territory – must follow a radically different path from those characterizing the territorial development associated with coastal tourism and mass tourism. From a purely theoretical point of view, this work aims to demonstrate that for a sustainable growth of RT, encompassing the cultural economic and environmental dimensions, it is necessary to diverge from the evolutionary model by Butler regarding tourist destinations, because although it posits the decline of a tourist destination with the reached carrying capacity of the system's resources, is also theorizes a renewal of the attractiveness through a simple and mechanic substitution of attractive features, which in the case of RT are not possible because the features characterizing environmental and cultural landscape heritage cannot be simply “replaced” nor restored once exhausted. Our thesis is that the decline of RT destinations is inevitable if coupled with the degradation of the ecological and cultural components enriching the

landscape (the variable E in our model), and therefore Butler's idea of a potential rejuvenation phase following such environmental and cultural detriment cannot be based on sustainable and authenticity principia, which are distinctive characters of RT.

Due to the many speculative interests that RT can represent, the increase in built-up area endangers the value and landscape heritage of many rural areas around the world, (e.g. Catalonia in Spain, Tuscany in Italy, Provence in France). As a consequence, any given rural territory characterized by a valuable landscape heritage, and in which the agricultural sector is of interest, built-up expansion must be constantly monitored, and if appropriate halted, as: it often happens at the expenses of the agricultural resource (Martellozzo and Clarke 2013; Martellozzo et al. 2015); and it is the first cause of detriment for landscape resources (Randelli and Martellozzo 2019). Thus, our model highlights the need to adequately regulate the amount of land use change, in order to foster sustainable and stable development.

In this paper, we show that where RT is an attractive and favorable investment option, the over-exploitation of rural areas (i.e. over-urbanization) for tourism purposes can be a threat for the sustainability of RT itself and the territory as a whole. Building new homes/facilities to increase accommodation capacity in rural areas can have a double negative effect: on the one hand it compromises the beauty and the integrity of the environmental and cultural landscape heritage, which, as said, are fundamental local resources to maintain RT attractive; on the other hand it can create prodromal fertile conditions for tourism massification dynamics, which are usually attributed with further depletion of the cultural and environmental heritage (Marull et al. 2011; Balestrieri 2005). These harmful dynamics have already proved their destructive power, especially in coastal areas (where anyway the variable E cannot be fully reduced to 0 because the sea is an invariant element of the coastal landscape); and the rationale presented here is aimed precisely at the preventive observation of these dynamics.

This paper shows that without any regulations the risk to deplete the environmental and cultural resources within rural areas is high. The hypothesized policy tool wants to be a constructive proposal aimed at identifying a path that can support sustainable policy making in the construction of more resilient territories, where RT and the landscape can coexist and co-create sustainable development. As a matter of facts, we are aware of the limits of such theoretical approach because it is not capable to offer a measure of the thresholds (i.e. built-up area, number of tourists, utilized agricultural area) to drive the policy makers. On the other hand, it prevents to consider RT development as a neutral factor, as its unregulated growth may put under risk the fragile balance within rural areas between agriculture, traditions, ecology and landscape.

In conclusion, the findings of the model have important policy implications: if it is true, that a policy regulation is needed and it should be shaped on the specific rural configuration of a region, it is also clear that policy tools should be dynamical in the sense that they have to evolve together with the agricultural and tourist sector within a region. This is probably the biggest challenge that our policy makers are facing nowadays as our communities are changing at a pace and with a geographical variability, which is not easy to be followed.

Appendix: mathematical appendix

A.1 Proof of Proposition 1

According to the system (19), $\dot{K}_a = 0$ for

$$K_a = \left(\frac{\delta}{\sigma \bar{E}^\gamma} \right)^{\frac{1}{\alpha-1}}$$

The dynamic system (19) admits an unique stationary state $A = \left(\bar{E}, \left(\frac{\delta}{\sigma \bar{E}^\gamma} \right)^{\frac{1}{\alpha-1}} \right)$ if and only if it lies above or along the separatrix (16), namely if $\left(\frac{\delta}{\sigma \bar{E}^\gamma} \right)^{\frac{1}{\alpha-1}} \geq \tilde{K}_a$, that is:

$$(1 - \alpha) \geq \left[\left(\frac{\delta}{\sigma \bar{E}^\gamma} \right)^{\frac{1}{\alpha-1}} \left(\frac{\bar{E}^{\frac{\gamma(1-\beta)-\theta}{1-\beta}}}{(1-\beta)(1-\tau)^{\frac{1}{1-\beta}} \left(\frac{\beta}{r} \right)^{\frac{\beta}{1-\beta}}} \right)^{\frac{1}{\alpha}} \right]^{-\alpha}$$

The Jacobian matrix of the system (19) evaluated at point A is:

$$J(A) = \begin{bmatrix} -(1-\alpha)\delta & \gamma\sigma \left(\frac{\delta}{\sigma} \right)^{\frac{1}{1-\alpha}} \bar{E}^{\frac{(\alpha-1)(\gamma-1)-1}{\alpha-1}} \\ 0 & -\bar{E} \end{bmatrix}$$

with strictly negative eigenvalues $-(1-\alpha)\delta < 0$ and $-\bar{E} < 0$. Therefore, when the stationary state A exists, it is always attractive.

A.2 Proof of Proposition 2

Considering (18), and remembering that $\Omega K_a \leq 1$ and $\phi \geq \eta\tau$, it holds $\dot{E} < 0$ for $E = \bar{E}$. Indicating with \hat{K}_a the maximum of the function (16), namely $\tilde{K}_a = \Omega^{-1}$ (that always exists), and remembering that the values of K_a in the stationary state A is $\left(\frac{\delta}{\sigma \bar{E}^\gamma} \right)^{\frac{1}{\alpha-1}}$, it holds $\dot{K}_a < 0$ for every $K_a > \max \left\{ \left(\frac{\delta}{\sigma \bar{E}^\gamma} \right)^{\frac{1}{\alpha-1}}, \hat{K}_a \right\}$. This implies, by the Poincaré-Bendixson Theorem, that every trajectory starting outside Ψ enters it in finite time.

A.3 Number of inner stationary states

According to Eq. 18, $\dot{K}_a = 0$ if:

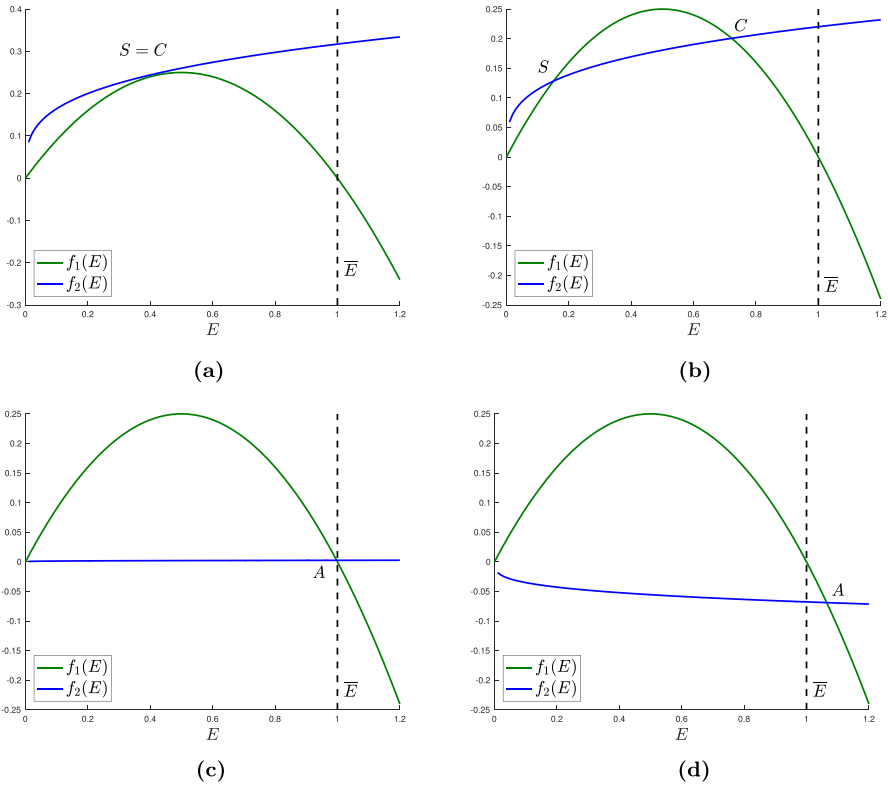


Fig. 5 A numerically taxonomy of the number of internal stationary states for different values of the environmental taxation

$$K_a = K_a^* := \frac{\sigma(1 - \beta)(1 - \tau)^{\frac{1}{1-\beta}} \left(\frac{\beta}{r}\right)^{\frac{\beta}{1-\beta}} E^{\frac{\theta}{1-\beta}}}{\delta - \alpha\sigma\Omega^{1-\alpha}E^\gamma}$$

Substituting $K_a = K_a^*$ we can write the time evolution of E as:

$$\dot{E} = f_1(E) - f_2(E)$$

where

$$f_1(E) = E(\bar{E} - E)$$

$$f_2(E) = (\phi - \eta\tau)\left(\frac{\beta}{r}(1 - \tau)\right)^{\frac{\beta}{1-\beta}} (1 - \Omega K_a^*)E^{\frac{\theta}{1-\beta}}$$

Internal stationary states are therefore defined by the intersections between the graphs of the two functions $f_1(E)$ and $f_2(E)$. Figure 5 shows a numerically taxonomy of possible cases in which at least one intersection point exists. They are obtained by varying only the value of the environmental taxation τ , which is increasing from τ

≈ 0.155 in Fig. 5a to $\tau = 0.3$ in Fig. 5d. The case of tangency between $f_1(E)$ and $f_2(E)$ is shown in Fig. 5a. For $\tau < 0.155$ the two curves do not intersect for positive values of E and, therefore, the system does not admit internal stationary states. When the value of τ increases, the curve $f_1(E)$ does not move, while the curve $f_2(E)$ shrinks and flattens out such that two intersection points between the two curves emerge (one of type S and another of type C), as shown in Fig. 5b. In this case, $E < \bar{E}$ and so there is coexistence between sectors (specialization in the agricultural sectors is possible only if $E = \bar{E}$, since only rural tourism has negative impact on the environmental landscape resource). For $\tau \geq 0.28$, then the two curves intersect in only one point, of type A , in which there is specialization in the agricultural sector and $E = \bar{E}$, namely its maximum value. Therefore, the threshold value $\tau = 0.28$ is such that the environmental landscape resource is completely restored but H-agent prefers to invest in another economy (see Fig. 5c and d).

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Declarations

Conflict of Interests The authors declare that they have no conflict of interest.

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