Territorial Contradictions of Intensive Agriculture: The Incompatibility between Modern Agriculture and the Construction of a Sustainable Landscape

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Abstract

The paper starts from the necessity of new paradigms for the future of cities and landscape. Circular economy and the connected saving and reuse of resources are fundamental. In this sense, it is necessary to introduce some of the pre-modern fundamental features: the resources recycle and the strict connection between urban and rural landscape, which modernity forgot, to pursue the present consumerist model, too simple and linear, and therefore ineffective in relation to the contemporary complexity. Technology, smart city and the related apparatus (agriculture of precision, industry 4.0 etc.) are important, but their goal should not consist in filling the cities with electronic toys, but in taking care of the whole urban environment in a clever way. After discussing these concepts, this paper proposes a more thoughtful approach, aimed at environmental sustainability, through the prevention and treatment of territorial pathologies. In order to cope with these pathologies, it is necessary a theoretical framework based on the concepts of thermodynamics.

Keywords

Town and regional planning - Circular economy - Landscape.

1. Introduction

The world is in constant demographic growth and, even more, in constant growth of demand for raw materials and foodstuffs, also as a consequence of the global spread of the Western, energy-consuming and consumerist model, which is not concerned with natural resources.

In this question, the city-countryside relationship has a fundamental role, both because it embodies and because stress consumerist models for wider and wider segments of the

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world population. Without forgetting the advantages that this entails (civil and cultural development, well-being and quality of life), this is a threatening process because in sharp contrast with the laws of nature, first of all those of thermodynamics and, in particular, the second principle, whose formulation fully embodies, on a scientific basis, the concept of sustainability, as Scandurra already observed in 1995 (see also Leone *et al*., 2018).

This is a problem that has been felt for a long time (Meadows *et al*., 1972; WCED, 1987) and has been approaches from a variety of angles: sustainable development, happy de-growth, green and blue economy, low carbon economy etc. Nevertheless, in practice, policies environmental protection prove to be more and more ineffective. The consequences of this lack effectiveness has not attracted the interest of the economic and societal (and consequently of political) powers, as is demonstrated, for example, by the difficulties in the concrete applications of Paris climate agreements of 2015 (COP21).

A recent conceptual formulation, perhaps more open to real needs is that of circular economy, which aims at overcoming the traditional, eminently linear model acquisition-consumption-disposal of waste, in which each step is situated in a watertight compartment.

The European Union is concretely coping with this issue through the proposed waste directive (COM/2014/0397, final), focused on closing cycles. But the circular economy should not be a simple support for waste recycling technologies, but a new way of acting, thinking and linking demand and supply of resources, with all the infinite and unpredictable ranges of possible feedbacks. In other words, the circular economy has to be conceived as a way to restore the lost complexity, in opposition to the linearity of modern models, which has greatly simplified society, despite the enormous technological progress.

While open agro-pastoral spaces present in the Mediterranean region have been characterised for centuries by this linearity, other pre-modern socio-economic systems were much more circular and complex, also because technologically poor. In consequence, they needed to emulate and deal with nature, which, on the contrary, modern man continually challenges and deludes himself of being able of taming, having stolen - according to the Promethean myth - the fire to the gods. These forms of pre-modern economy were circular, because they were based on the close interaction and integration of resources and food supply. The system of *ager*, *silva* and *saltus*, initially organized for the self-sufficiency, maintained its circularity when it was opened to the export of surpluses, because the surpluses were integrated in the cities' metabolism (cfr. fig. 1).

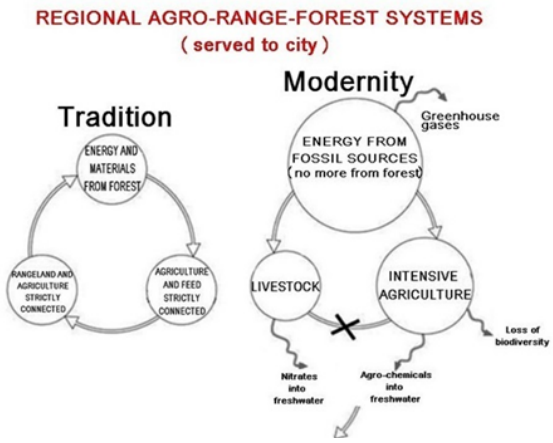


Fig. 1. Tradition and modernity. Balance and imbalance.

- Agriculture is not only ‘trivial’ food production, but also a place of recovery and reuse of resources, primarily urban waste and livestock. This is a huge problem of contemporary societies, whereas it constituted an important resource for the traditional societies: for example it contributed to the take off, since the Renaissance, of the Padana Valley economy, now-a-day one of the richest area in Europe (Cazzola, 2002).
- The forest is not impenetrable wood, but it is a source of energy and building materials, and, in case of famine, it is a food reserve for livestock and even for man.
- Livestock production constitutes non only a source of noble proteins, but also a reserve of labour force (plowing) and of fertilizers, thanks to the dejections that return to the fields and close the cycles.

In this scheme the rejection is practically unknown and the traditional economy emulates the ecological systems, reducing the increase of the entropy. The crisis of modern linear technological systems is patent, and the possibility of a new development lies in the rediscovery of ancient circularity, obviously in a contemporary key, without renouncing the advantages acquired up to now by humanity. The restauration of the old circularity of the *urbs-ager-silva-saltus* system would produce particular kinds of landscape, balanced, aesthetically valued and charged of identities’ resources (Leone, 2007). On a territorial scale, the tools of circularity are: symbiosis, connection, accumulation of resources (Stemke and Koh, 2011; Pelorosso *et al.,* 2014).

2. Enlarge the concept of smartness from city to landscape

The approach known as smart city is one of the most debated themes of contemporary urban planning. Smart city was founded in 2007 by the European Union policies on energy saving, and the consequent technological infrastructure (Franz, 2012). Although this concept has been gradually enriched, involving ICT (Information and Communication Technologies), it is to be considered only a starting point for the new circularity of urban and territorial systems.

A semantic notation is however necessary, because it allows to point out important aspects of this analysis. Unlike Italian, alongside the term ‘smart’, English language has term ‘clever’, which is not its perfect synonym. Clever indicates the ability to solve a problem, the ability to find robust solutions, resulting from reflections and deep analysis, and to interpret processes well beyond the sum of available data. Clever can therefore be empathic intelligence that includes the different features of a given situation and establish a harmony among them. Smartness denotes a more superficial kind of intelligence; it concerns the sphere of quick and immediate solutions, beyond any reflection on the systems and its basic rules. Both these forms of intelligence are important, the latter for everyday practice, the former for strategic development.

In the modern linear economy, efficiency is the ratio between the result achieved and the resource used. But generally this ratio, expressed as a percentage, is rather low; for example, from the most technological sophisticated automobiles, to the most sophisticated power plants, machine yields have now reached the ceiling of 30-35%, a practically insurmountable limit-value. From this point of view, the industrialist modernity is now stuck and it is useless to insist on the product side. The new growth should be sought in the integration, pursuing the path of quality, having now exhausted that of quantity.

The aforementioned reasoning has, as its theoretical reference, the laws of thermodynamics, a fundamental basis for the study of complex systems such as city and landscape. The conceptual effort to be done is therefore to transfer the principles of thermodynamics to these systems, in order to fund the concepts of environmental sustainability.

3. Second principle of thermodynamics, efficiency and sustainability

First of all, referring to the classical thermodynamic state variable, entropy is the measure of the disorder caused by each transformation (i.e. energy corruption), that is of the inexorable degradation of the system, an hourglass associated with the arrow of time[1] (Leone *et al*., 2018). This definition already gives to the concept of sustainability an operational content, which is essential if environmental protection is to come out of the sphere of auspices and enter the problem solving area.

Entropy S is defined by the following relation:

$$\Delta S = \frac{\Delta Q}{T} \qquad [1]$$

S is an indicator of variation of the system status (ΔQ) with respect to the specific energy situation T in which this process takes place. In classical thermodynamics, ΔQ is energy degraded compared to the ‘noble’ ones (mechanical, chemical, electrical), difficult to re-use. In the generalization to the environment and to the landscape proposed in this article, ΔQ is equivalent to the environmental impact, which, just like ΔQ, is never absolute, but depends on the characteristics of the system in which it manifests itself: the systems are more or less vulnerable, due to their intrinsic characters, which can be synthesized through an ‘internal’ status variable corresponding to the T of the equation 1.

In its definition, therefore, entropy’s theory promises much in terms of understanding and management of complex systems. The equation 1 clearly indicates that there is no absolute environmental impact action (ΔQ), positive or negative, because this is always related to the T state in which it manifests itself. The consequence of the same action, is very variable depending on the specificity of the system. In these cases, therefore, thinking in a uniform and linear way is decidedly erroneous.

Applying a similar approach based on entropy to the landscape, it is possible to define an indicator useful to problem solving.

[1] Inexorable, but slow: this is the core for concrete and measurable sustainability.

$$S_{landscape} = \frac{impact = deterioration}{energy = regeneration\ potential} \qquad [2]$$

In appendix to the manuscript of Leone *et al*. (2018) it is shown an example of the concrete application of equation 2 for the case of a lake basin. Basin's land use entropy is calculated in terms of spilling into the lake of a pollutant (phosphorus), which is a degradation factor of the system. Not all the basin contributes in the same way; it depends on the intrinsic characteristics of each landscape unit. Then the numerator of equation 2 has included the impact, i.e. the spilling of the phosphorus from the different units of landscape, the denominator the vulnerability, or the propensity of the surrounding environment to favour the spilling of the phosphorus to the lake, by slope, proximity to the water body etc. The final result is a synthetic index (entropy) of land use impact on the water body.

These elaborations on entropy's theory have some consequences on efficiency of resources' use. Common sense and engineering sciences value most the maximization of efficiency; however, the second law of thermodynamics points out that, even theoretically eliminating all the 'inefficiencies', frictions, etc., it is impossible to have 100% returns. Formally:

$$E = 1 - \frac{T_f}{T_c} \qquad [3]$$

where T_f is the temperature of the cold source and T_c that of the hot source. In practice, a machine receives energy in the form of heat from the fuel, which burns at T_c temperature. Inevitably, for the second law of thermodynamics, a part of this energy is dispersed[2], at temperature T_f. Beyond certain limits, which are relatively low, we cannot go and the only possibility is the heat recovery (cogeneration), the only case in which yield can reach very high values (about 90%). But to recover heat, we need the organization necessary to make the offer meet the demand, both in the classic thermal machine and in the landscape (Stemke and Koh, 2007).

Like the [1], also the equation [3] has dual nature, the medal always has two sides and the efficiency can grow in two ways: reducing T_f and/or increasing T_c:

[2] In the form of unusable heat, i.e. degraded energy.

– on T_f you cannot act that much, if not with an organization similar to that of cogeneration;

– to act on T_c, the technological ability to produce very high temperatures is required.

By transferring these concepts to the territory, we arrive at the scheme of fig. 2: to reduce T_f, network organization is required, with the largest possible number of synapses that always allow integrations corresponding to cogeneration, for example the reuse of wastes, in cascade among different areas as they are produced[3]. Increasing T_c, on the other hand, means increasing a well-conceived and hierarchical organization, like building phosphorous barriers, as in the previous example concerning the lake.

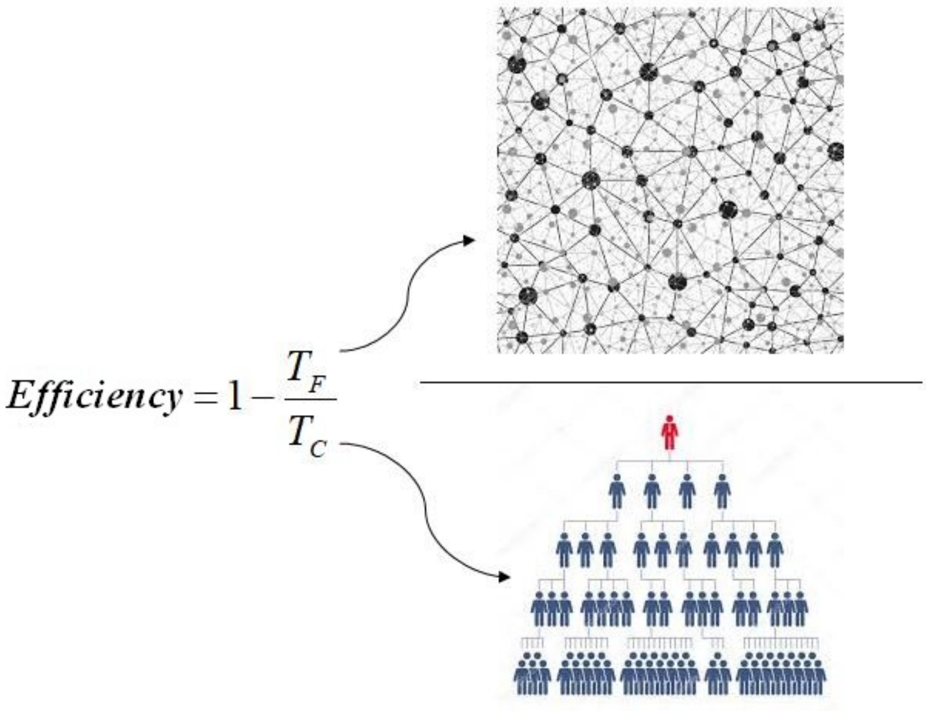


Fig. 2. Efficiency analysis.

Neither approach prevails over the other one. Therefore, the planner must not foster a competition, but know how to measure, discern and favour, case by case, the right mix between holism (T_f) and mechanicism (T_c).

These organizational models must be integrated. Therefore, it is necessary to know their peculiarities, as in the parallel between animals and plants proposed by Stefano Mancuso (2017). The plants grow according to the network model, the animals according to the hierarchical one. As always, there is a functional motivation behind this differentiation: plants cannot move, so they evolved without specific vital organs that would make them more vulnerable to aggression and they developed without central organs. Plants present a form of passive resilience, which leads to an organization more complex than that of animals, which is, on the contrary, centred on a single command centre (the brain) that

[3] Similarly to what happens in the food chain, where each element has a position.

coordinates a series of subaltern and peripheral organs. This approach privileges the individual. It follows the need for a hierarchical organization of animal communities, which, in human social systems, become oligarchies and bureaucracies.

These are the internal worms of the organization itself, because they generate inefficiency, as theorized by the Canadian psychologist J. Peter Laurence in 1969 (Laurence and Hull, 2008). He stated the principle of incompetence, according to which every member of a hierarchical organization naturally tends, along his own career, to climb various positions, until reaching his level of incompetence, which leads to lowering the efficiency of the system. Over the time, the organization will be composed of members having inadequate competencies, causing its collapse. Hierarchical systems are normally profitable, but they have a short life, due to the rapid deterioration of the organization, which is equivalent to the increase in the entropy-disorder of the thermodynamic systems.

The bureaucratic procedure is essential, but it is also a factor in the degradation of the system, which is equivalent to the increasingly usable heat of the equation [1]. This is not due to the ineptitude of the bureaucrats, but to the fact that their function is the control of the procedures, indispensable but unproductive at the level of the process. If I need a few photocopies, I do it myself and the chain of command is so simple that the efficiency is very high. As photocopies increase in number, I will need a hierarchical organization, but as the number of its members increases, they are more and more distant from the final product and not involved in the process.

It follows that demanding high efficiency alone in large organizations based on hierarchy is a chimera; it works for a short time. Mancuso states that the organizational model of plants is better suited to interpreting the complex contemporary world: global, strongly interconnected, with a distributed structure. This seems to be another clue that might explain the decline of industrial modernity, or at least the exhaustion of its innovative drive, while, in very general terms, it should be thinkable a re-evaluation of the model of pre-modern economies mentioned above. These economies had a distributed structure with a strong connection between its components (left side of fig. 1), primarily the relationship between producer and consumer, but also the mutual function and usefulness of each social category, which was a guarantee of protection even of the weaker ones. Pillar of territorial organization were, for example, civic uses, today's defined as 'common goods', a very powerful and concrete factor of resilience, ganglia of network organizations. The 2009 Nobel Prize for Economics to Elinor Ostrom for her studies on this topic is very encouraging in this regard, because, beyond social equity, they underline the economic relevance of the local organization of populations for a truly sustainable use of resources (Ostrom, 2012).

This is the basis of construction of a good landscape. There is no alternative, because modern, intensive agriculture does not build landscapes; moreover, it is not sustainable (Rasmussen *et al*., 2018). Just as plants do not need high efficiency in acquiring energy from the sun, networked systems do not need mechanical perfect solutions, because their development does not depend on a single path, and the space of 'inaccuracy' can create new and unexpected opportunities, which increase the resilience and the overall growth of the system. Paradoxically, many small inefficiencies, provided they are not fatal, can create something better. In this case, more than efficiency should be spoken of anti-fragility (Blečić, Cecchini, 2016). In holistic systems, efficiency is organic; it cannot be expressed by a formula like [3]: the system is more productive because the serendipity it enjoys allows unpredictable and better solutions.

For this reason, as the complexity of the system increases, specialization can become pathology. As the landscape complex system follows these same rules, the current landscapes show the distortions derived by innovation-specialization in agriculture (Leone, 2012; see, as well, the right side of fig. 1). The specialization has pervaded everything, not only the world of industry. The ‘Green Revolution’[4] of the ‘50s and’70s of the last century has transformed the countryside into a dissipative system from the entropic point of view: isolated, dependent on external resources and without connection with its city. Again, the current twilight phase of modernity is paying the entropic account of this unbalanced approach. The arrow of time is becoming faster and faster. The developed countries have undoubtedly achieved full food security; but we must take account of the fact that they started long before the green revolution. By now the supply of food stuffs is emancipated from the climatic variability, but the entropic account (the externality would say an economist) has grown: we could mention the millions of third world farmers kept outside the markets, the pathological hyper-nutrition of the West (1,4 billion obese and related health costs), the hypo-nutrition for billions of men or even hunger for 800 million (and relative risk of uncontrollable migratory flows) and the 1,2 billion tons per year of still edible food which becomes waste to be disposed of.

On a different scale, the maps in fig. 3-4 are eloquent of the distortion caused by this sort of modernisation. They show the land use change between the Fifties and Sixties of the 20th century, the time-span preceding the effects of the ‘green revolution’ in agriculture, and the current situation. Both the metropolitan area of Rome and the rural Apennines (province of Rieti, Central Italy) have in common the polarization between man-made territory (urbanized and intensive agricultural) and the advancement of the woods. The two extreme poles of the anthropized and the renaturalised are advancing: on the one hand the ‘small’ hilly and peri-urban agriculture, on the other hand the green spaces as deep pasture of the maps of the Campagna Romana. The consequences are two epochal problems, such as the depopulation of the mountainous and hilly inland areas and the consumption of soils due to their downstream shifting.

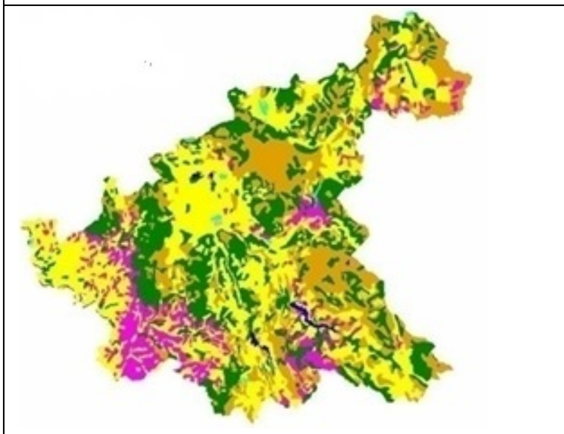
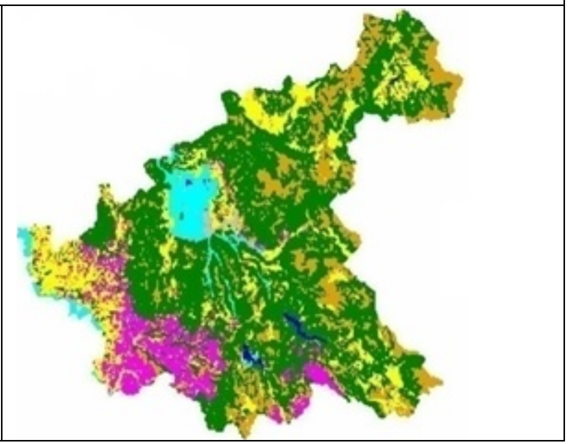
1960	2000
Yellow=Pasture/arable land Green=Forest/renaturalization Blue=waters	
	

Fig. 3. Province of Rieti. Variations in land use/land cover 1960-2000 before and after the ‘green revolution’.

[4] This is a mystifying definition, unmasked already in 1962 by the Rachel Carson’s *Silent Spring*.

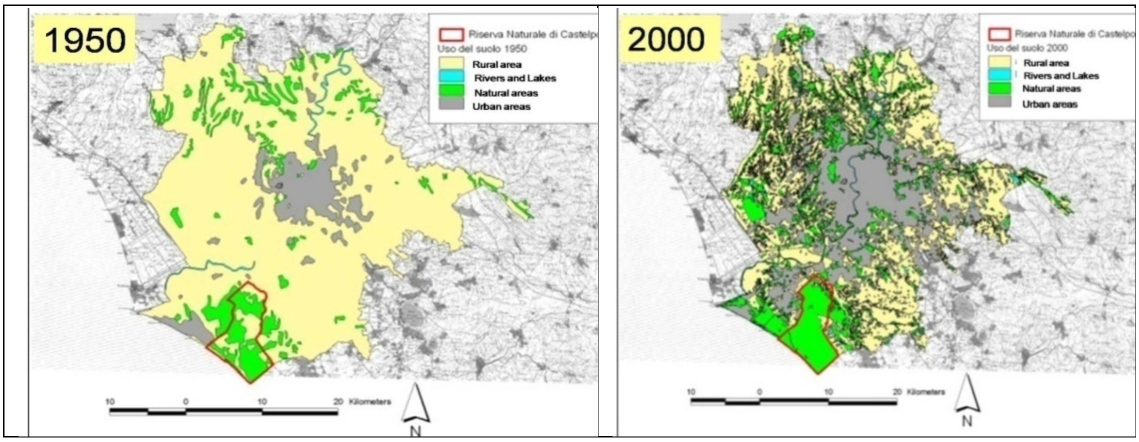


Fig. 4. Rome metropolitan area. Variations in land use/land cover 1950-2000 before and after the 'green revolution'.

The breakdown of the organicist interactions has led to the imbalances of modernity. Energy production from fossil fuels is practically unlimited, but, as we know, it is associated with climate changes. It follows the degradation of the system, because the woods have lost their function and role; agriculture is standardized and dependent on chemistry and on energy that is external to the system, which is much greater than the biomass produced. This provokes an increase of entropy, a real schizophrenia, comparable, for example, to turning on the heating in summer and then needing the air conditioner to lower the temperature. Animal breeding is confined to stables-lagers, which dispose of wastewater with extreme difficulty and however with high environmental, food and health risks.

We can therefore discuss what we want about the landscape, its protection, etc., but one fact is certain: the mechanized, 'industrial' agriculture of the '50s - '70s green revolution of the last century does not produce a landscape because it simplifies and standardizes. To produce identity and a beautiful landscape, it is necessary synergy added to a virtuous governance of the territory and environment. The concept of landscape is not based only on 'beauty', it implies a wise use of resources, whose aesthetic result is not a direct goal, but an added value, a sort of quality certification of good territorial governance, as suggested by the frescos of Lorenzetti. The mechanization of the cultivation cycles is not coherent with the territorial complexities, of hedges, groves, terraces, small walls, small ditches that are the elements that define a 'beautiful' landscape, especially the Italian one, illustrated by the examples in the pictures placed above in fig. 3.

Fig. 3. Traditional agricultural systems (above) are diversified and allow ecological connections that ensure biodiversity and environmental resilience, those of intensive agriculture (below) are simplified and not interconnected.

Given the markedly dynamic nature of the landscape, with the constant need for adaptation and transformation, not producing new landscapes is equivalent to not protecting it. Circular economy (in the specific case related to agricultural productions) is the road to be taken for more complex systems. The reference point is the ecological system model, which represents the quintessence of complexity. And here comes the concept of efficiency, not the simple one that refers to energy transformation, but the one that refers to the whole system.

Living beings derive the energy they need from the sun through the mechanism of photosynthesis, whose yield is on average less than 1% (Oakley, Hall, Rao, 1999). The mechanism of photosynthesis is therefore bankrupt if judged according to the canons of modern-linear economics, but these canons must no longer be the only one to be adopted. Nature has different canons of development[5], based on complexity: symbiosis, creation of tanks, absence of waste (what is waste for one sector is a resource for the other interacting with the first one) and creation of appropriate connections. In a word: circularity.

These concepts must therefore be transferred in a systematic way to landscape and territory planning, through processes of interpretation, optimization and clever use of local resources, i.e. territorial engineering. With these hypotheses, local and locally usable resources have not to worry about the maximum efficiency of each process, because any dissipation is not waste, but a resource for the interaction among the different components of the system. The examples are now numerous in the literature, and the

[5] Equally and differently 'efficient', enough to bring to Homo Sapiens.

proposals elaborated on this basis seem sufficiently mature to enter planning practices. In the field of territorial energy, various experiences show how it is possible to evaluate the energy 'conserved' in the landscape (Pelorosso *et al*., 2014), obtaining significant productions that respect its identity and, at the same time, make it dynamic. Such a clever organization of the territory, based on the recovery of waste, not only increases energy self-sufficiency, but also the resilience of the territory, allowing people to persist and continue to develop.

The development of this approach can be an important contribution to spatial planning, because the proposed actions aim at reducing dependence on fossil energies, the spread of pollutants into water bodies and the exploitation of natural resources. All these issues impact onto the costs endured by the public sector in its ecological functions; in particular, the costs necessary to repair the damage caused by the breakdown of the health of the citizens threatened by pollution and by the necessity of taking care of them.

Referring to the definition of sustainable system elaborated by Mae-Wan Ho (2013), the parallels between organization of ecosystems and planning strategies based on circularity are evident. The more the ecosystem has evolved, the more it maximizes cycles and conservative flows and minimizes dissipative flows and, therefore, the increase of entropy. Territorial organization should be able to foster symbiosis, cooperation and reciprocity of the landscape components. A system is sustainable because it is dynamic and evolves in dynamic equilibrium, increasing its synapses and, therefore, making its cycles automatically more resilient.

Clearly, the achievement of a space-temporal organization of the perfect landscape like that of ecosystems is utopian, but utopia serves as the polar star of virtuous behaviour. The question of landscape is grafted into it: complexity-circularity generates an identifying landscape (therefore 'beautiful'); simplification-linearity not only produces no landscape, but consumes it. The fallow fields of the ancient world were technologically 'backward', but certainly more circular and it generated complexity. A recovery of these practices is needed in order to use the best of modernity.

Conservation-preservation is very important, but, if we stop at it, we remain imprisoned in the logic of simple-linear thought; opposed to that of exploitation, surely, but still imprisoned in the same vicious circle.

4. Concluding proposals

In short, we could state the foundations of a policy of promotion of the circular territorial economy in the following way.

- We should avoid the promotion of industries centred on the efficiency of the energy production, and, on the contrary, promote the diversity and complexity of the territorial organization oriented towards an organic development, which enhances local micro-systems and transform wastes into a resource. In this sense, for example, renewable energy sources like the wind and solar ones are obviously fundamental. On the other hand, turbines and panels should not be concentrate in parks, but should be insert where they are needed, in energy districts in which they can be placed in relationships with other sources of energy, first of all agricultural biomass.

– This logic should be extended to the theme of nutrition, with the district in the role of facilitator of the meeting between supply and demand and of the valorisation of local resources to be channelled into the city-country system.
– Examples of landscape structures to be (re)activated that we can mention are: wetlands for natural phyto-depuration; hedges and riparian vegetation for soil protection and water regulation; groves and agricultural production of environmental value; urban green to increase permeability and mitigate the climate; terracing and micro drainage network.
– In general terms, we should enhance niche agricultures such as that of the Italian internal areas, whose lower economic yield is compensated in terms of the resources brought about by tourism, but, above all, by the ecosystem services it furnishes, such as the defence against hydrogeological instability.

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