XLIII Incontro di Studio del Ce.S.E.T.: 203-224

Salvatore Giuffrida[1],
Filippo Gagliano[2]

[1] *Department of Civil Engineering and Architecture, SDS Architecture, University of Catania*
[2] *professional*

E-mail: *sgiuffrida@dica.unict.it*
fm.gagliano@gmail.com

Keywords: *RET, wind energy, regional energy planning, GIS, landscape assessment, economic/ landscape performances, environmantal responsibility*

The geography of values and the land of energy

This study provides a wind farm valuation/planning model, for territorial wind energy policies at a provincial scale. With reference to the case of territory of Syracuse, the pattern identifies the best layout of the plants under different conditions. The pattern, based on the integration of spatial-GIS and numeric calculation, provides a wide range of scenarios able to define a trade off *energy/ information* function characterising the decision pattern of a whole land-energy policy. Energy function includes energy production and the consequent Net Present Value of each plant; *Information* function includes the visual impacts of each plant given the qualities and the distances of the areas, which the plant is visible from. The best layout maximizes the energy/information-value function.

Introduction

The environmental issue, because of its generality, ubiquity, and urgency, has nowadays redirected the land approach from both scientific and politic points of view. Scientific observations and political decisions are interfaced by the value system, a wide range of motivations, which the science of assessment should define as the basis of the valuation patterns.

Particularly, in the case of energy, each of the sources arising as an alternative to the immense chain of fossil fuels, implies the involvement of new resources and impacts, the production of new land facilities, the development of new industries and the decline of the traditional ones.

In contrast to fossil fuels, the off-grid energy facilities, and specifically the wind farms, have a definite land location whose impact isn't yet clearly understood, measured and valued because of a general discordance of opinions about the concept of landscape.

The landscape notion exceeds the panorama one for including many structural and superstructural components. Among the structural ones, the land shape and the natural and climate phenomena, whereas the connected wealth distribution pattern, the modification of the value soil map, the set of externalities which can be produced and, from the anthropologic point of view, the acceptance of new and different capacities and uses of the land - which heavily involves psychological and cultural features as well - can be considered among the superstructural ones.

The wide range of the interpretations of landscape raises several valuation and decisional issues about which assessment science, because of its scientific authority and its axiological determination, assumes not generic responsibilities. The value layer is the one upon which choices are made and decisional processes develop, so specific valuation patterns should be drawn in order to make land policies less arbitrary and contingent. Above all, the different layer of values should be distinguished and integrated so that the decisions can look both nearer and farther.

The responsibilities associated with energy production and its distribution could be considered the most general level of value. The fossil chain can be valued highly unfair if we consider the political and military relationships between owners, producers, and users - as a result of which the price of energy is so low - and the history and geography of the consequences reflecting the "out of sight, out of mind pattern" (Pasqualetti, 2000, p. 384). On the contrary, an almost autarchic energy model, in which producers and users bear the impact as well, should be considered the fairest.

"Producing no global warming, wind power floods no canyons, demands no water, contaminates no soil, and leaves no permanent and dangerous waste. Wind generators can be installed and removed quickly; they are well suited to isolated, off-grid locations; and the cost of the electricity they produce is now comparable with that from conventional sources. In short, wind power is too good to be ignored" (ib. p. 382).

As in the past, from this point of view, wind power is one of the approaches to land policy we could assume in order to attribute to the consumers the cost of its consumption, a sort of direct internalization of the environmental and human costs.

As in the past the form of the energy can become the landmark of sustainability and environmental responsibility for a local community.

A lower level of value could concern the distribution of these impacts into a defined territorial context, which dimension should be related to the population and the energy needs. The space interdependence between the producer district and the consumer area (including high consumption equipment such as factories) can be influenced and guided by a coordinated system of government incentives bargained between the different economic subjects.

The third layer of values, specifically treated in this work, is the consistency and compatibility of the energy production model and the land(scape) values.

The different layers of values involved by the turn of the energy production pattern from fossil to renewable, should be combined taking into account the responsibility that the local energy policy attributes to a specific territory, considering: on one hand, the general commitment to reduce the GHG emissions and the consequent specific competence of that territory; on the other, the landscape characteristics as the limits which should be imposed to the development of the wind farms.

The need for a regulation of the landscape values comes from the subjectivity of the individual judgement about the introduction of artificial signs in natural (and sometimes cultural as well) contexts (NUI/Basilicata, 2013): in general, from a perceptive point of view, some types of plants (such as the photovoltaic fields) could be considered quite heavy. On the contrary the wind-towers, whose thinness and elegance could be appreciated, could contribute to imprint a specific character into a deserted and/or not characterized place. By contrast, whereas the wind turbines stand out and are visible from far away, the photovoltaic fields are perceived only from a short distance, so they might be preferred.

The more the relationship between natural context and artificial sign has been controversial, the more the profit motives have prevailed, especially because of the capability of increase in value caused by the government incentives (Bocca, 2013).

As a result of the distortion of the soil market values, there was a heavy infiltration of the criminal organizations both in procurement management and in defining (by deforming) the landscape limits to apply to the location and dimension of the wind farms (Palazzolo and Baldessarro, 2012).

Therefore, the role of values becomes strategic in conforming policies as well as the role of policy in maintaining values. Public communication should explain the human, environmental and landscape costs of energy and its sustainability as well, so that consumers can express their preferences contributing to renovate the value system.

Materials

The Regional Sicilian Environment Energy Plan

"Wind energy is the best opportunity for Sicily to produce clean energy reducing pollutant emissions, therefore it is necessary to optimize the planning of its exploitation. The estimation of the economic potentials gives rise to very high values of the installable power and the energy which can be produced. These values are so high that they represent an unrealistic situation of utilization of wind power" (Industry Department of the Sicilian Region, 2009, p. 52). This passage implicitly states the need (and the opportunity) for choosing the most suitable locations.

Since the ninth recital of the Decision of the Regional Government No 1 – February 3rd 2009 – approving the Regional Sicilian Environment Energy Plan (RSEEP) (Sicilian Region, 2009), politic, economical, technical and environmental purposes are listed: diversification of sources and rationalization of the whole energy system; development of a free energy market; environmental sustainability of the exploitation of hydrocarbons; improvement of the BAT (best available technologies) by supporting the diffusion in small and medium-size business; the compatibility of the thermal power plants with the limits set by the Kyoto Protocol; completion of the natural gas infrastructure; improvement of sustainability in the transportation; sustaining of biofuels; land sustainability by the means of energy systems conversion; promotion of a strong energy saving policy by improving zero emission buildings; promotion and diffusion of RET (renewable energy technologies); encouraging the take-off of RET industrial chains and competition; improvement of smart network energy systems in electrical energy transportation; promotion of the hydrogen system for the storage of the energy produced by non continuous sources (wind, sun, water, geothermal).

Therefore, wind energy is considered part of the general renovation of the energy system in Sicily which is in need for the storage and transportation infrastructure adjustment.

The Sheet S05, among the organizational tools of the Action Plan of the RSSEP, is aimed at the GIS for the creation of a Regional Energy Observatory for the monitoring of final consumption by sector and areas, the results expected by the specific actions planned with the measured data, the CO2 equivalent avoided emissions, the relationship between investment and energy savings and the employment induced by the actions that take place in the production cycles and innovation implemented energy systems.

Regarding these guidelines, we propose the extension of this observatory by means of the implementation of a GIS aimed at representing the land values. By means of such information system the data acquisition and the information management can become the most objective foundation of shared values which can be used for locating and dimensioning the wind farms, as farther exposed.

The Sheets R05-R09 focus on: the wind energy system production, short-long period and micro-turbines; the different types of incentive concerning facilities and capital funding; the type of agreement like the net metering or green certificates (Rowlands, 2013) in case of plants exceeding 20 kW overcoming the limit of 25.000 kWh/y.

The incentives depend on clearness and transparency of the projects as checked by the Department.

Plant Districts are recommended especially in suburbs, industrial and rural areas.

The Guidelines indicates the maximum height, the number of turbines and the minimum distances.

The incentives are related to the payback period and to the cost per spared ton of CO2.

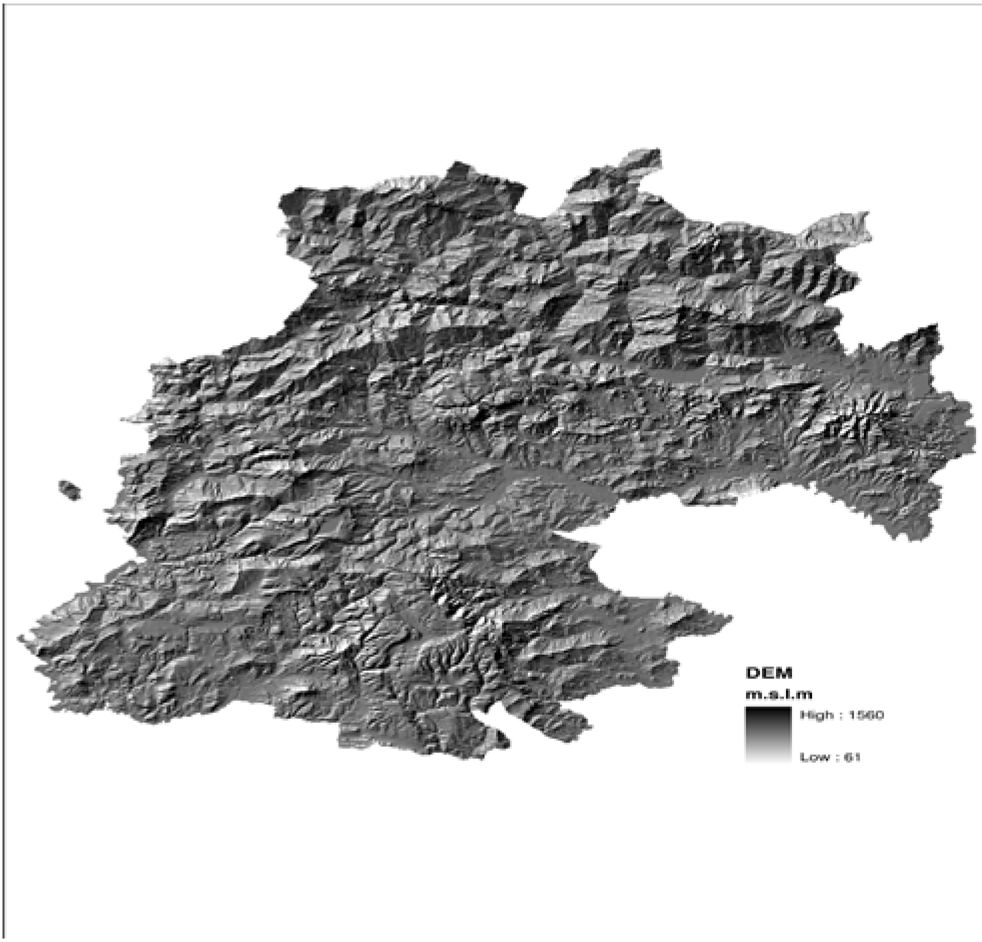
Current and potential energy production in local context: the case study of the Province of Enna

The proposed case study concerns the territory of the Province of Enna. The Province Territorial Landscape (Superintendence of Enna, 2008) provides the useful elements for the formation of a model for the valuation of the landscape impact of the wind power plants at a provincial scale. The territory of the Province of Enna has an extension of 2.561 sq km, and its territory, mainly hilly and mountainous, is favourable for the instalment of wind farms (Fig. 1).

The wind speed map provides higher values in the central and northern areas. The territory is characterized by significant naturalistic and socio-cultural values. If the surface of the urban areas and the related fixtures is detracted from the general surface, the restraint area is the 36,6 %, and the surface of the available area is 1623 sq Km (Fig. 2).

The here prefigured hypothesis: verify the instalment capability of the plants considering the landscape impact restraint inside a unitary policy. Therefore the

Figure 1. The Digital Elevation Model of the Province of Enna.



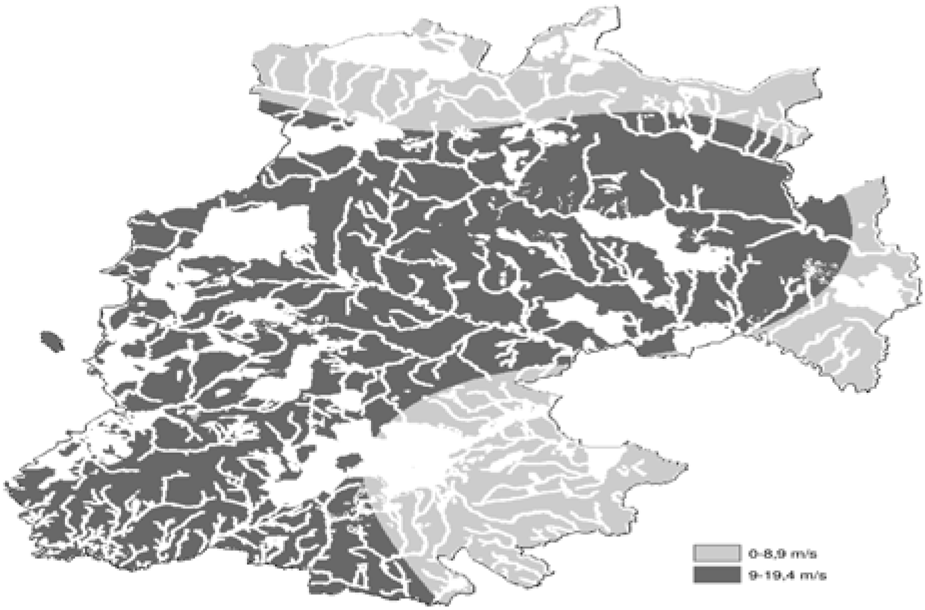
whole provincial territory is considered homogeneous regarding the choices of the single municipalities. As a consequence, the "irradiated" impacts from a municipality to the others due to the size and the height of the plants are meant as compensated by means of the royalties which can be paid according to the incentive system.

Methods

Concepts

The issue of the spatial cost of wind energy cannot be addressed without involving the quality of the space committed and as a consequence the space cannot be considered without any reference to the landscape.

Figure 2. Allowed wind farm areas and wind speed areas.



The approach to the renewable energy technologies confirms that physical space and landscape are connected as well as energy and (in)form(ation).

The general question of the relationship between energy and information (the shape of territory we have assumed as landscape) has been widely addressed by F. Rizzo (1983; 1989; 1999, 2013) both in theory and concerning cultural heritage and environment. He starts from the similarity between the measure of entropy both in thermodynamics and in theory of information, gets through the issue of the dissipative structures (Prigogine) as natural communicative entities, and continues connecting them with autopoietic organizations and political-administrative systems described by a huge set of indicators gathered into an interactive matrix assumed as a valuation pattern (2003).

One of the most challenging issue of his theory is the relationship between probability and possibility, coming from the theory of the generative properties of a s-code formerly discussed by U. Eco (1988). In the specific case of wind farms we address the question of the trade off between wind energy production and landscape shape (information) loss.

The meaning (value) attributable to an object (a reference) depends on the characteristics (the signifier) as they are selected in social communication that is the space of relations (the semantic field) in which each object can be valued. Landscape can be considered the set of the semantic fields in where the relationships between the objects (included the environmental context) and their values evolve. A double relationship between land and plants arises: 1. land(scape) can be considered the (binary, yes/not) code (a system of symbols) by the means of which the plant is selected: the plant shapes the "new landscape", then its shape should enhance the landscape. Therefore, landscape should be assumed as matrix that generates the territory in its indistinguishable unit of energy (functions) and information (shape) so that the visual approach to landscape (European Landscape Convention, 2000, art. 1) should be overcame (Di Bene and Scazzosi, 2006).

Energy fairness and sustainability can be included into the bundle of landscape values if they are perceived as a solution to the environmental issue as well as a street is considered a value and a part of landscape if (and only if) its benefits are strictly connected with the whole community interests.

The Italian Ministry of Heritage and Cultural Activities (2012), in the Wind Farm Guidelines, provides general assessment criteria (historicity, antiquities, natural/wilderness, tranquillity, symbolism, rurality, identity factor, original/new meanings) and planning directions (compliance with the prevailing tracks, morphology, size relationships, homogeneity of the provision of the turbines, height, disposition, colours and models) which we assume in two steps.

The first one concerns the selection of the areas more suitable to the plants settlement. This area changes depending on the power of the turbines and the landscape impact of the entity that you are willing to endure, so the global energy production potential can be calculated as an important item of a wide area energy policy.

The second one concerns the selected plant areas in which the best layout will be chosen.

In both cases the spatial evaluation model has been used in order to make easier the scenario analyses that can be helpful in the local energy planning in which environmental costs and economic advantages converge as main decisional items.

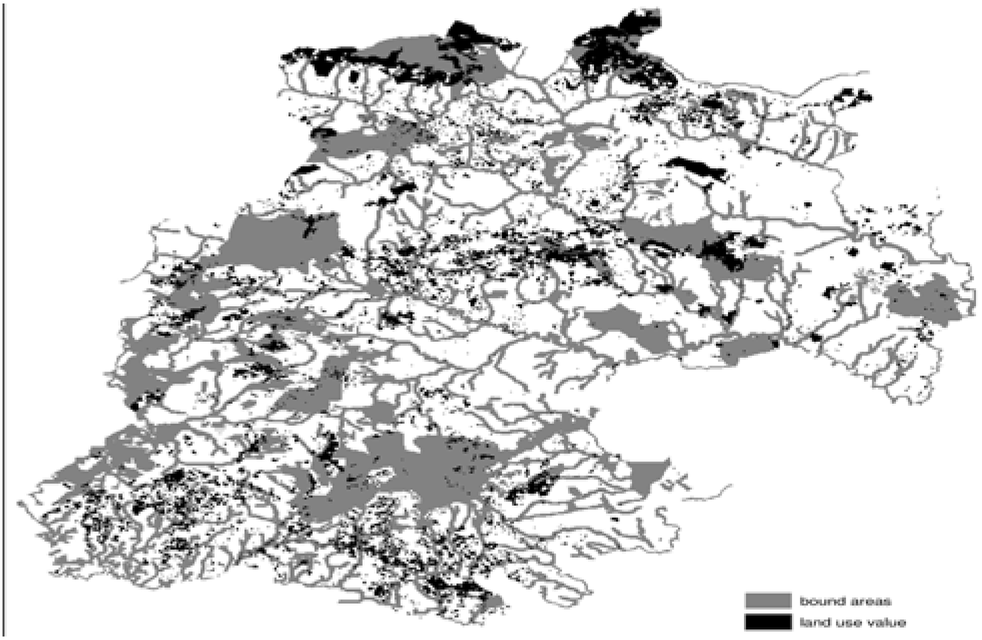
Cerroni and Venzi (2008) have carried out the "comparison between different location of a wind farm reconciling productivity and visual impact" considering the perceptual impact as perceived by interviewed users about different possible layouts; Nesticò (2012) provides a helpful detailed project financing model for the valuation of the best management option of the investment typology.

In this case study we aim at providing a model in which three issues have been compared at the wide scale, and impact is due not to the perception, but to some general landscape characteristics as drawn by the Province Territory Landscape Plan (PTLP).

The planning/valuation model

For each typology (height) of turbines a plant area has been established considering the optimal distance between the turbines (five diameters), whose hypothesized layout is regulated by a 400x400 m square grid. In the here reported hypothesis 80 m hub height 2000 kW turbines have been chosen. Each plant area is a 10x10 turbine square (3,6x3,6 km) inside which different layouts can be hypothesized, concerning number and dislocation of the turbines according to the

Figure 3. Landscape values: in whit the allowed areas.



design criteria indicated by the Ministry. The maximum turbine number for each plant area is reduced proportionally to the quota which would be comprised in protected areas (Fig. 4), according to the prescriptions by the Department of Land of Sicilian Region (2006).

For each anemometric station the calculation of the windy days for each speed class was made adapting a Gauss function to the observed distribution, as shown in Tab. 1 and Fig. 5

Associating to the turbines of each area the anemometric characteristics it is possible to calculate the specific producibility (Tab. 2).

Once the expected production has been calculated, it is necessary to compare it to the plant costs.

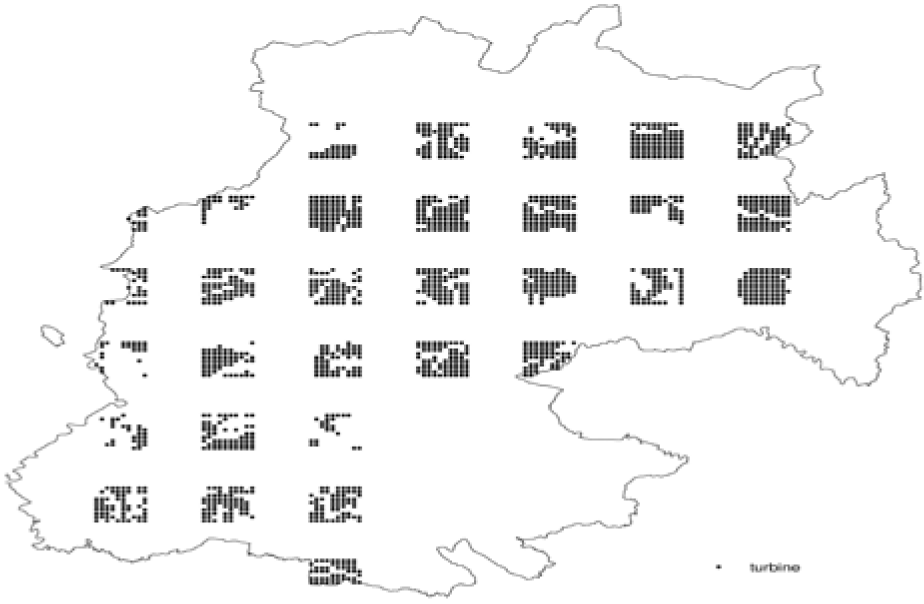
The calculation model is shown at Tab. 3 and comprises the voices relating to the investment and management costs.

Some of the unitary costs are functional to the localization, as for the case of the presence of roads or sloping ground, which are taken into account on the basis of the GIS spatial analysis, and the number of turbines, due to the scale economies which allow to reduce the fixed costs (Tab. 3).

The total cost has been calculated by adding the initial costs to the management costs (Tab. 4) in the twenty years investment span. This way it is possible to compare costs to revenues.

The annual revenues are calculated multiplying the produced energy by the sale price, as the consideration of the mechanism of the (Rowland, 2013) certifi-

Figure 4. First hypothesis about plant areas location by considering allowed and high wind speed areas: in each area the allowed turbines.



cates will be subject to following analyses (Nesticò, 2012). The annual revenues will be capitalized the same way (Tab. 5).

The landscape impact is assessed with regard to the perceptual involvement of the areas from which the plants are visible and with regard to the different areas' importance. The landscape evaluation has quantitative and qualitative dimensions and the proposed method is based on a simplified version of the Bernetti and Marinelli study (2010).

The space analysis carried out with GIS tools provides the information basis starting from the Territorial Landscape Provincial Plan.

For this purpose two intervisible area measuring modes and three types of area have been taken into account:

1. the intervisible area is measured:
   1.1. in absolute terms, to assess the potential impact and the incidental overlapping between areas at different intervisibility;
   1.2. in relative terms, reducing the entity of the visible area with a coefficient which keeps into account the distance and the actually visible size of the turbines;
2. the considered intervisible area is articulated in:
   2.1. total intervisible area;
   2.2. intervisible area comprised in the protected areas;
   2.3. intervisible area comprised in natural areas, that means characterized by non productive and non transformative land uses (Tab. 6 and Fig. 6)

Table 1. Calculation of the probability function of wind speed for each anemometer station – h=10m; yo=data; y=estimation.

Aidone

x	y	yo	c	a	x0	b
1,3				8	1,8	7,07
1,3	1,66		3	8	1,8	7,07
1,5	4,94	7	3	8	1,8	7,07
1,7	7,86	8	3	8	1,8	7,07
2,0	6,68	7	3	8	1,8	7,07
2,2	3,03	3	3	8	1,8	7,07
2,4	0,74		3	8	1,8	7,07
2,6	0,10		3	8	1,8	7,07
2,8	0,01		3	8	1,8	7,07
3,0	0,00		3	8	1,8	7,07
3,2	0,00		3	8	1,8	7,07
3,4	0,00		3	8	1,8	7,07
3,6	0,00		3	8	1,8	7,07
3,9	0,00		3	8	1,8	7,07
4,1	0,00		3	8	1,8	7,07
4,3	0,00		3	8	1,8	7,07
4,5	0,00		3	8	1,8	7,07
4,7	0,00		3	8	1,8	7,07
4,9	0,00		3	8	1,8	7,07
5,1	0,00		3	8	1,8	7,07
5,3	0,00		3	8	1,8	7,07

Enna

x	y	yo	c	a	x0	b
5,6				13,1	8,1	8,65
5,6	0,00		3	13,1	8,1	8,65
5,9	0,00		3	13,1	8,1	8,65
6,2	0,00		3	13,1	8,1	8,65
6,5	0,00		3	13,1	8,1	8,65
6,8	0,00		3	13,1	8,1	8,65
7,1	0,00	2	3	13,1	8,1	8,65
7,5	0,38	2	3	13,1	8,1	8,65
7,8	5,29	4	3	13,1	8,1	8,65
8,1	13,09	13	3	13,1	8,1	8,65
8,4	5,77	1	3	13,1	8,1	8,65
8,7	0,45	3	3	13,1	8,1	8,65
9,0	0,01		3	13,1	8,1	8,65
9,4	0,00		3	13,1	8,1	8,65
9,7	0,00		3	13,1	8,1	8,65
10,0	0,00		3	13,1	8,1	8,65
10,3	0,00		3	13,1	8,1	8,65
10,6	0,00		3	13,1	8,1	8,65
10,9	0,00		3	13,1	8,1	8,65
11,2	0,00		3	13,1	8,1	8,65
11,6	0,00		3	13,1	8,1	8,65

Nicosia

x	y	yo	c	a	x0	b
4,7				10	5,58	11,3
4,7	0,00		3	10	5,58	11,3
5,0	0,12		3	10	5,58	11,3
5,2	1,41		3	10	5,58	11,3
5,4	6,21		3	10	5,58	11,3
5,6	10,00	10	3	10	5,58	11,3
5,8	5,89	9	3	10	5,58	11,3
6,0	1,27	4	3	10	5,58	11,3
6,2	0,10	2	3	10	5,58	11,3
6,4	0,00		3	10	5,58	11,3
6,6	0,00		3	10	5,58	11,3
6,8	0,00		3	10	5,58	11,3
7,1	0,00		3	10	5,58	11,3
7,3	0,00		3	10	5,58	11,3
7,5	0,00		3	10	5,58	11,3
7,7	0,00		3	10	5,58	11,3
7,9	0,00		3	10	5,58	11,3
8,1	0,00		3	10	5,58	11,3
8,3	0,00		3	10	5,58	11,3
8,5	0,00		3	10	5,58	11,3
8,7	0,00		3	10	5,58	11,3

Piazza Armerina

x	y	yo	c	a	x0	b
2,5				9,3	7	1
2,5	0,00		3	9,3	7	1
3,2	0,00		3	9,3	7	1
3,8	0,00	4	3	9,3	7	1
4,5	0,02	4	3	9,3	7	1
5,2	0,31	4	3	9,3	7	1
5,8	2,29	9	3	9,3	7	1
6,5	7,07	9	3	9,3	7	1
7,1	9,13	7	3	9,3	7	1
7,8	4,95	7	3	9,3	7	1
8,5	1,12	7	3	9,3	7	1
9,1	0,11	4	3	9,3	7	1
9,8	0,00	4	3	9,3	7	1
10,4	0,00	1	3	9,3	7	1
11,1	0,00	1	3	9,3	7	1
11,7	0,00	1	3	9,3	7	1
12,4	0,00		3	9,3	7	1
13,1	0,00		3	9,3	7	1
13,7	0,00		3	9,3	7	1
14,4	0,00		3	9,3	7	1
15,0	0,00		3	9,3	7	1

Agira

x	y4	yo	c	a	x0	b
7,8				7	10,2	3,56
7,8	0,00		3	7	10,2	3,56
8,1	0,00		3	7	10,2	3,56
8,4	0,00		3	7	10,2	3,56
8,6	0,00		3	7	10,2	3,56
8,9	0,02		3	7	10,2	3,56
9,2	0,15		3	7	10,2	3,56
9,4	0,81		3	7	10,2	3,56
9,7	2,72	5	3	7	10,2	3,56
9,9	5,58	5	3	7	10,2	3,56
10,2	7,00	7	3	7	10,2	3,56
10,5	5,36	5	3	7	10,2	3,56
10,7	2,51	3	3	7	10,2	3,56
11,0	0,72		3	7	10,2	3,56
11,3	0,13		3	7	10,2	3,56
11,5	0,01		3	7	10,2	3,56
11,8	0,00		3	7	10,2	3,56
12,1	0,00		3	7	10,2	3,56
12,3	0,00		3	7	10,2	3,56
12,6	0,00		3	7	10,2	3,56
12,8	0,00		3	7	10,2	3,56

Calascibetta

x	y	yo	c	a	x0	b
6,7				8	10,8	1,65
6,7	0,00		3	8	10,8	1,65
7,1	0,00		3	8	10,8	1,65
7,6	0,00		3	8	10,8	1,65
8,0	0,00		3	8	10,8	1,65
8,5	0,00		3	8	10,8	1,65
8,9	0,02		3	8	10,8	1,65
9,4	0,26	3	3	8	10,8	1,65
9,8	1,54	3	3	8	10,8	1,65
10,2	4,78	8	3	8	10,8	1,65
10,7	7,82	5	3	8	10,8	1,65
11,1	6,72	5	3	8	10,8	1,65
11,6	3,04	5	3	8	10,8	1,65
12,0	0,72	2	3	8	10,8	1,65
12,5	0,09	2	3	8	10,8	1,65
12,9	0,01	2	3	8	10,8	1,65
13,3	0,00		3	8	10,8	1,65
13,8	0,00		3	8	10,8	1,65
14,2	0,00		3	8	10,8	1,65
14,7	0,00		3	8	10,8	1,65
15,1	0,00		3	8	10,8	1,65

Figure 5. Probability function for each anemometer station - h=80m.

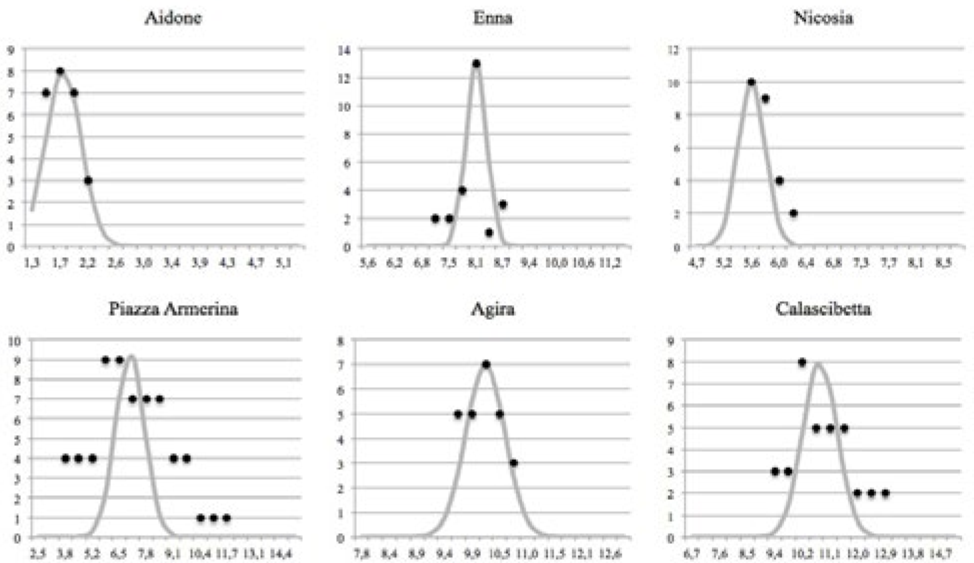


Table 2. Calculation of the productivity of the 31 plant areas.

id trb	turbine dimensions					land cell											
#	hhub	diameter	htotal	trbns power	widenes	lenght	area	Pe1 kW	Pe2	Pe3	Pe4	Pe5	Pe6	Pe7	Pe8	Pe9	Pe10	E MWh
1	80	90	125	3000	450	450	202500	505	746	1.054	1.438	1.904	2.462	3.119	3.884	4.765	5.770	3.335
2	80	90	125	3000	450	450	202500	808	992	1.202	1.440	1.707	2.006	2.338	2.704	3.106	3.547	4.320
3	80	90	125	3000	450	450	202500	808	992	1.202	1.440	1.707	2.006	2.338	2.704	3.106	3.547	4.320
4	80	90	125	3000	450	450	202500	808	992	1.202	1.440	1.707	2.006	2.338	2.704	3.106	3.547	2.163
5	80	90	125	3000	450	450	202500	505	746	1.054	1.438	1.904	2.462	3.119	3.884	4.765	5.770	2.726
6	80	90	125	3000	450	450	202500	505	746	1.054	1.438	1.904	2.462	3.119	3.884	4.765	5.770	2.726
7	80	90	125	3000	450	450	202500	505	746	1.054	1.438	1.904	2.462	3.119	3.884	4.765	5.770	2.581
8	80	90	125	3000	450	450	202500	27	101	250	503	885	1.424	2.147	3.080	4.251	5.686	2.338
9	80	90	125	3000	450	450	202500	808	992	1.202	1.440	1.707	2.006	2.338	2.704	3.106	3.547	4.320
10	80	90	125	3000	450	450	202500	808	992	1.202	1.440	1.707	2.006	2.338	2.704	3.106	3.547	3.463
11	80	90	125	3000	450	450	202500	505	746	1.054	1.438	1.904	2.462	3.119	3.884	4.765	5.770	3.021
12	80	90	125	3000	450	450	202500	27	101	250	503	885	1.424	2.147	3.080	4.251	5.686	2.213
13	80	90	125	3000	450	450	202500	27	101	250	503	885	1.424	2.147	3.080	4.251	5.686	2.475
14	80	90	125	3000	450	450	202500	4	9	18	32	50	75	107	147	195	253	527
15	80	90	125	3000	450	450	202500	4	9	18	32	50	75	107	147	195	253	527
16	80	90	125	3000	450	450	202500	27	101	250	503	885	1.424	2.147	3.080	4.251	5.686	2.475
17	80	90	125	3000	450	450	202500	27	101	250	503	885	1.424	2.147	3.080	4.251	5.686	2.782
18	80	90	125	3000	450	450	202500	4	9	18	32	50	75	107	147	195	253	527
19	80	90	125	3000	450	450	202500	27	101	250	503	885	1.424	2.147	3.080	4.251	5.686	1.801
20	80	90	125	3000	450	450	202500	27	101	250	503	885	1.424	2.147	3.080	4.251	5.686	1.524
21	80	90	125	3000	450	450	202500	4	9	18	32	50	75	107	147	195	253	527
22	80	90	125	3000	450	450	202500	289	405	550	725	934	1.180	1.466	1.794	2.168	2.591	1.906
23	80	90	125	3000	450	450	202500	289	405	550	725	934	1.180	1.466	1.794	2.168	2.591	2.633
24	80	90	125	3000	450	450	202500	179	234	299	376	464	566	681	812	957	1.119	1.224
25	80	90	125	3000	450	450	202500	179	234	299	376	464	566	681	812	957	1.119	1.110
26	80	90	125	3000	450	450	202500	505	746	1.054	1.438	1.904	2.462	3.119	3.884	4.765	5.770	3.175
27	80	90	125	3000	450	450	202500	289	405	550	725	934	1.180	1.466	1.794	2.168	2.591	1.398
28	80	90	125	3000	450	450	202500	179	234	299	376	464	566	681	812	957	1.119	1.110
29	80	90	125	3000	450	450	202500	179	234	299	376	464	566	681	812	957	1.119	628
30	80	90	125	3000	450	450	202500	179	234	299	376	464	566	681	812	957	1.119	848
31	80	90	125	3000	450	450	202500	179	234	299	376	464	566	681	812	957	1.119	656

Therefore the decisional problem concerns the maximization of the landscape value function given the economic performance restraint, or, vice versa, the maximization of the latter minimizing the impact; the quantitative and qualitative articulation of the consideration of the intervisible surface allows to perform these maximizations on the basis of the different scenarios which correspond to the mode to assume the territory, i.e. considering it as a unity independently from its qualities, or raising the weight of the cultural or naturalistic aspects in order to make the plan more adaptable.

Some method specifications about the use of GIS

The calculation of the characteristics of the intervisible areas has been carried out using some spatial analysis functions on the basis of the data deduced from the landscape plan of the Province of Enna, converted in raster format with a 40 metre side, overlay functions between thematisms, anemometric data of the eight stations of the province, and the numeric cartography. In particular:

Table 3. Calculation of the investment cost for each plant area. The unit for elementary cost is kW.

4	streets	turbine numb	site	turbine	engine cabin	dwell cabin	works	project	env assessm	preliminary	workers	advises	insurance	firm constit		total investment cost		total inv cost/kW
			1	2	3	4	5	6	7	8	9	10	11	12				
	300	20	unit	unit	unit	unit	unit	unit	unit	unit	unit	unit	unit	unit		unit		
1	3173	33	6,25	1175	3,56	0,88	12,9	38,8	14,6	7,31	88	32,4	5,5	22,7	€	4.222.082	€	1.407
2	7609	86	6,25	1175	2,52	0,63	8,63	36,3	7,86	3,93	63	17,4	4,5	12,2	€	4.012.997	€	1.338
3	10289	59	4,75	1175	3,04	0,75	10,8	37,5	11,2	5,62	75	24,9	5	17,4	€	4.113.040	€	1.371
4	1874	56	6,25	1175	3,04	0,75	10,8	37,5	11,2	5,62	75	24,9	5	17,4	€	4.117.540	€	1.373
5	12589	22	4,75	1175	3,56	0,88	12,9	38,8	14,6	7,31	88	32,4	5,5	22,7	€	4.217.582	€	1.406
6	13548	64	4,75	1175	3,04	0,75	10,8	37,5	11,2	5,62	75	24,9	5	17,4	€	4.113.040	€	1.371
7	24419	68	4,75	1175	3,04	0,75	10,8	37,5	11,2	5,62	75	24,9	5	17,4	€	4.113.040	€	1.371
8	4061	83	6,25	1175	2,52	0,63	8,63	36,3	7,86	3,93	63	17,4	4,5	12,2	€	4.012.997	€	1.338
9	14607	73	4,75	1175	3,04	0,75	10,8	37,5	11,2	5,62	75	24,9	5	17,4	€	4.113.040	€	1.371
10	7065	76	6,25	1175	3,04	0,75	10,8	37,5	11,2	5,62	75	24,9	5	17,4	€	4.117.540	€	1.373
11	2419	49	6,25	1175	3,04	0,75	10,8	37,5	11,2	5,62	75	24,9	5	17,4	€	4.117.540	€	1.373
12	14963	62	4,75	1175	3,04	0,75	10,8	37,5	11,2	5,62	75	24,9	5	17,4	€	4.113.040	€	1.371
13	15034	83	4,75	1175	2,52	0,63	8,63	36,3	7,86	3,93	63	17,4	4,5	12,2	€	4.008.497	€	1.336
14	5821	73	6,25	1175	3,04	0,75	10,8	37,5	11,2	5,62	75	24,9	5	17,4	€	4.117.540	€	1.373
15	7118	58	5,5	1175	3,04	0,75	10,8	37,5	11,2	5,62	75	24,9	5	17,4	€	4.115.290	€	1.372
16	5726	89	6,25	1175	2,52	0,63	8,63	36,3	7,86	3,93	63	17,4	4,5	12,2	€	4.012.997	€	1.338
17	2603	45	6,25	1175	3,04	0,75	10,8	37,5	11,2	5,62	75	24,9	5	17,4	€	4.117.540	€	1.373
18	9841	58	4,75	1175	3,04	0,75	10,8	37,5	11,2	5,62	75	24,9	5	17,4	€	4.113.040	€	1.371
19	8255	64	4,75	1175	3,04	0,75	10,8	37,5	11,2	5,62	75	24,9	5	17,4	€	4.113.040	€	1.371
20	11199	85	4,75	1175	2,52	0,63	8,63	36,3	7,86	3,93	63	17,4	4,5	12,2	€	4.008.497	€	1.336
21	4079	87	6,25	1175	2,52	0,63	8,63	36,3	7,86	3,93	63	17,4	4,5	12,2	€	4.012.997	€	1.338
22	17525	27	4,75	1175	3,04	0,75	10,8	37,5	11,2	5,62	75	24,9	5	17,4	€	4.113.040	€	1.371
23	8404	66	4,75	1175	2,52	0,63	8,63	36,3	7,86	3,93	63	17,4	4,5	12,2	€	4.008.497	€	1.336
24	5318	57	6,25	1175	3,04	0,75	10,8	37,5	11,2	5,62	75	24,9	5	17,4	€	4.117.540	€	1.373
25	9751	59	4,75	1175	3,04	0,75	10,8	37,5	11,2	5,62	75	24,9	5	17,4	€	4.113.040	€	1.371
26	12827	65	4,75	1175	2,52	0,63	8,63	36,3	7,86	3,93	63	17,4	4,5	12,2	€	4.008.497	€	1.336
27	5023	14	4,75	1175	3,04	0,75	10,8	37,5	11,2	5,62	75	24,9	5	17,4	€	4.113.040	€	1.371
28	5133	26	4,75	1175	3,04	0,75	10,8	37,5	11,2	5,62	75	24,9	5	17,4	€	4.113.040	€	1.371
29	3684	23	6,25	1175	3,04	0,75	10,8	37,5	11,2	5,62	75	24,9	5	17,4	€	4.117.540	€	1.373
30	5827	27	4,75	1175	3,04	0,75	10,8	37,5	11,2	5,62	75	24,9	5	17,4	€	4.113.040	€	1.371
31	3150	60	5,5	1175	3,04	0,75	10,8	37,5	11,2	5,62	75	24,9	5	17,4	€	4.115.290	€	1.372

- For the calculation and the representation of the intervisibility values the tool of the Spatial Analyst has been used after constructing the DEM (Digital Elevation Model) model with cells the square size of 40 m side in raster ambient. Through the DEM the intervisibility analysis has been launched on all the provincial territory of the 31 areas of the plant, keeping into account the parameters of the heights of the turbines at the hub, and the Zenith and Azimuth angle. The results represent the portion of territory visible from the wind farm in comparison to the portion which it is not possible to see;
- the slops method, necessary to define a cost coefficient of the localization of the turbines, was carried out starting from the DEM expressed in degrees as well;
- The naturalistic value on the botanic point of view has been calculated referring

Table 4. Operative costs and total discounted cost.

4	site 13 unit	royalties 14 unit	maintainance 15 unit	services 16 unit	management 17 unit		total operating cost unit		capitalized operating cost 20 2,5%		total cost per turbine		total cost/kW		turbines 15		total cost
1	6,3	6,3	0,125	2	5,42	€	60.125	€	937.298	€	5.159.381	€	1.720	40%	15	€	77.390.711
2	4,8	4,8	0,125	2	5,42	€	51.125	€	796.996	€	4.809.993	€	1.603	20%	15	€	72.149.894
3	5,5	5,5	0,125	2	5,42	€	55.625	€	867.147	€	4.980.187	€	1.660	30%	15	€	74.702.803
4	5,5	5,5	0,125	2	5,42	€	55.625	€	867.147	€	4.984.687	€	1.662	25%	15	€	74.770.303
5	6,3	6,3	0,125	2	5,42	€	60.125	€	937.298	€	5.154.881	€	1.718	50%	15	€	77.323.211
6	5,5	5,5	0,125	2	5,42	€	55.625	€	867.147	€	4.980.187	€	1.660	20%	15	€	74.702.803
7	5,5	5,5	0,125	2	5,42	€	55.625	€	867.147	€	4.980.187	€	1.660	20%	15	€	74.702.803
8	4,8	4,8	0,125	2	5,42	€	51.125	€	796.996	€	4.809.993	€	1.603	20%	15	€	72.149.894
9	5,5	5,5	0,125	2	5,42	€	55.625	€	867.147	€	4.980.187	€	1.660	20%	15	€	74.702.803
10	5,5	5,5	0,125	2	5,42	€	55.625	€	867.147	€	4.984.687	€	1.662	20%	15	€	74.770.303
11	5,5	5,5	0,125	2	5,42	€	55.625	€	867.147	€	4.984.687	€	1.662	30%	15	€	74.770.303
12	5,5	5,5	0,125	2	5,42	€	55.625	€	867.147	€	4.980.187	€	1.660	20%	15	€	74.702.803
13	4,8	4,8	0,125	2	5,42	€	51.125	€	796.996	€	4.805.493	€	1.602	20%	15	€	72.082.394
14	5,5	5,5	0,125	2	5,42	€	55.625	€	867.147	€	4.984.687	€	1.662	20%	15	€	74.770.303
15	5,5	5,5	0,125	2	5,42	€	55.625	€	867.147	€	4.982.437	€	1.661	20%	15	€	74.736.553
16	4,8	4,8	0,125	2	5,42	€	51.125	€	796.996	€	4.809.993	€	1.603	20%	15	€	72.149.894
17	5,5	5,5	0,125	2	5,42	€	55.625	€	867.147	€	4.984.687	€	1.662	50%	15	€	74.770.303
18	5,5	5,5	0,125	2	5,42	€	55.625	€	867.147	€	4.980.187	€	1.660	20%	15	€	74.702.803
19	5,5	5,5	0,125	2	5,42	€	55.625	€	867.147	€	4.980.187	€	1.660	20%	15	€	74.702.803
20	4,8	4,8	0,125	2	5,42	€	51.125	€	796.996	€	4.805.493	€	1.602	20%	15	€	72.082.394
21	4,8	4,8	0,125	2	5,42	€	51.125	€	796.996	€	4.809.993	€	1.603	20%	15	€	72.149.894
22	5,5	5,5	0,125	2	5,42	€	55.625	€	867.147	€	4.980.187	€	1.660	70%	15	€	74.702.803
23	4,8	4,8	0,125	2	5,42	€	51.125	€	796.996	€	4.805.493	€	1.602	20%	15	€	72.082.394
24	5,5	5,5	0,125	2	5,42	€	55.625	€	867.147	€	4.984.687	€	1.662	20%	15	€	74.770.303
25	5,5	5,5	0,125	2	5,42	€	55.625	€	867.147	€	4.980.187	€	1.660	20%	15	€	74.702.803
26	4,8	4,8	0,125	2	5,42	€	51.125	€	796.996	€	4.805.493	€	1.602	20%	15	€	72.082.394
27	5,5	5,5	0,125	2	5,42	€	55.625	€	867.147	€	4.980.187	€	1.660	100%	15	€	74.702.803
28	5,5	5,5	0,125	2	5,42	€	55.625	€	867.147	€	4.980.187	€	1.660	60%	15	€	74.702.803
29	5,5	5,5	0,125	2	5,42	€	55.625	€	867.147	€	4.984.687	€	1.662	70%	15	€	74.770.303
30	5,5	5,5	0,125	2	5,42	€	55.625	€	867.147	€	4.980.187	€	1.660	50%	15	€	74.702.803
31	5,5	5,5	0,3438	3	9,56	€	70.219	€	1.094.651	€	5.209.941	€	1.737	20%	15	€	78.149.118

to the entity of the local vegetation, which approaches or coincides with the potential one, that means the one which would grow in the absence of antropization; the utilized scale value gives the naturalistic botanic value on the grounds of the evolution stadium of phytocenosis and the degree of conservation in the studied area. No value has been attributed to the not appraisable cases, as they are almost without vegetation (urbanized areas, active quarries);

- The anemometric analyses are performed on the basis of the data of the meteorology stations
- of the Informative Agro-meteorology Service of the Sicilian Region. The con-

Table 5. Operative total discounted revenues and 0 discounted rate Payback Period.

id trb								wind		producibility			incentives			
4	stazione	wind speed GIS			2			average speed	€/kWh	Cp	ro	E	D coeff	unit revenues (€/kwh)	tot revenues (€)	PbP (r=0)
			e	a	xo	xm	b				kg/mc	MWh		1		
1	6	11,3	3	8	7,9	7,9	1,6	93,4	€ 0,19	0,43	1,225	3.335	0,9	0,13	381.245	13,5
2	5	14,4	3	7	8,0	8,0	1,8	110,2	€ 0,19	0,43	1,225	4.320	0,9	0,13	493.790	9,7
3	5	14,7	3	7	8,0	8,0	1,8	110,2	€ 0,19	0,43	1,225	4.320	0,9	0,13	493.790	10,1
4	5	12,3	3	7	7,5	7,5	1,8	59,8	€ 0,19	0,43	1,225	2.163	0,9	0,13	247.272	20,2
5	8	10,4	3	8	7,5	7,5	1,6	88,6	€ 0,19	0,43	1,225	2.726	0,9	0,13	311.579	16,5
6	7	10,5	3	8	7,5	7,5	1,6	88,6	€ 0,19	0,43	1,225	2.726	0,9	0,13	311.579	16,0
7	6	9,9	3	8	7,4	7,4	1,6	87,1	€ 0,19	0,43	1,225	2.581	0,9	0,13	295.044	16,9
8	4	14,2	3	9	7,2	7,2	1,0	84,3	€ 0,19	0,43	1,225	2.338	0,9	0,13	267.218	18,0
9	5	14,3	3	7	8,0	8,0	1,8	110,2	€ 0,19	0,43	1,225	4.320	0,9	0,13	493.790	10,1
10	5	10,5	3	7	7,8	7,8	1,8	91,8	€ 0,19	0,43	1,225	3.463	0,9	0,13	395.876	12,6
11	7	12,8	3	8	7,7	7,7	1,6	91,2	€ 0,19	0,43	1,225	3.021	0,9	0,13	345.323	14,4
12	4	11,0	3	9	7,1	7,1	1,0	83,5	€ 0,19	0,43	1,225	2.213	0,9	0,13	252.892	19,7
13	4	14,5	3	9	7,3	7,3	1,0	85,3	€ 0,19	0,43	1,225	2.475	0,9	0,13	282.895	17,0
14	1	14,0	3	8	5,0	5,0	7,1	59,3	€ 0,19	0,43	1,225	527	0,9	0,13	60.238	82,8
15	1	9,5	3	8	5,0	5,0	7,1	59,3	€ 0,19	0,43	1,225	527	0,9	0,13	60.238	82,7
16	4	10,9	3	9	7,3	7,3	1,0	85,3	€ 0,19	0,43	1,225	2.475	0,9	0,13	282.895	17,0
17	4	13,3	3	9	7,5	7,5	1,0	88,0	€ 0,19	0,43	1,225	2.782	0,9	0,13	317.949	15,7
18	1	12,4	3	8	5,0	5,0	7,1	59,3	€ 0,19	0,43	1,225	527	0,9	0,13	60.238	82,7
19	4	9,5	3	9	6,7	6,7	1,0	80,3	€ 0,19	0,43	1,225	1.801	0,9	0,13	205.798	24,2
20	4	11,1	3	9	6,4	6,4	1,0	76,3	€ 0,19	0,43	1,225	1.524	0,9	0,13	174.243	27,6
21	1	10,3	3	8	5,0	5,0	7,1	59,3	€ 0,19	0,43	1,225	527	0,9	0,13	60.238	79,9
22	2	14,4	3	13	7,2	7,2	8,7	72,5	€ 0,19	0,43	1,225	1.906	0,9	0,13	217.836	22,9
23	2	14,4	3	13	7,4	7,4	8,7	88,7	€ 0,19	0,43	1,225	2.633	0,9	0,13	300.913	16,0
24	3	12,6	3	10	6,2	6,2	11,3	72,9	€ 0,19	0,43	1,225	1.224	0,9	0,13	139.899	35,6
25	3	11,7	3	10	6,0	6,0	11,3	72,0	€ 0,19	0,43	1,225	1.110	0,9	0,13	126.862	39,3
26	7	12,8	3	8	7,8	7,8	1,6	92,4	€ 0,19	0,43	1,225	3.175	0,9	0,13	362.882	13,2
27	2	13,8	3	13	6,6	6,6	8,7	67,1	€ 0,19	0,43	1,225	1.398	0,9	0,13	159.754	31,2
28	3	13,2	3	10	6,0	6,0	11,3	72,0	€ 0,19	0,43	1,225	1.110	0,9	0,13	126.862	39,3
29	3	12,0	3	10	5,2	5,2	11,3	63,0	€ 0,19	0,43	1,225	628	0,9	0,13	71.779	69,4
30	3	11,7	3	10	5,6	5,6	11,3	67,8	€ 0,19	0,43	1,225	848	0,9	0,13	96.891	51,4
31	3	13,3	3	10	5,3	5,3	11,3	62,6	€ 0,19	0,43	1,225	656	0,9	0,13	75.035	69,4

struction of the wind speed maps has been carried out with spatial interpolations starting from the punctual data of eight anemometric stations, in order to convert discrete data in a continuous function with the Spatial Moving Average procedure; the latter allows to calculate the values of each point basing on the values of the adjacent points, through one medium weighing of the values in the known points. The weights are inversely proportional to the distance from the considered point;

- The landscape value chart includes: the protected archaeology areas defined with local government decree and the areas of archaeology interest, the hydro-

Table 6. Assessment of landscape impact: total area, bound area and natural area visibility (0 = max impact; 2 = min impact).

	visible area mq			constrained area mq			natural area mq		
id Pl	area	% prov area	weighed vis area	visible	% bound area	weighed vis area	visible	% natur area	weighed vis area
1	187.931.200	7,3%	23.981.073	63.105.600	6,7%	7.622.271	39.283.200	14,6%	5.820.073
2	446.448.000	17,4%	115.299.291	133.862.400	14,3%	32.648.386	133.862.400	49,8%	32.277.382
3	131.171.200	5,1%	12.967.145	38.561.600	4,1%	3.777.821	38.561.600	14,3%	3.734.891
4	261.204.800	10,2%	35.305.182	74.812.800	8,0%	8.921.398	74.812.800	27,8%	8.820.018
5	217.451.200	8,5%	6.904.055	71.212.800	7,6%	2.454.805	71.212.800	26,5%	2.426.909
6	134.793.600	5,3%	5.312.473	44.347.200	4,7%	1.447.246	44.347.200	16,5%	1.430.800
7	150.763.200	5,9%	9.504.727	48.260.800	5,1%	2.411.586	48.260.800	17,9%	2.384.182
8	383.883.200	15,0%	87.551.018	107.241.600	11,4%	22.788.616	107.241.600	39,9%	22.529.655
9	386.900.800	15,1%	108.720.927	112.656.000	12,0%	31.337.710	112.656.000	41,9%	30.981.600
10	342.795.200	13,4%	132.713.836	100.432.000	10,7%	35.926.363	27.969.600	10,4%	10.983.073
11	131.844.800	5,1%	32.149.673	33.379.200	3,6%	7.191.743	22.113.600	8,2%	5.056.873
12	283.878.400	11,1%	51.128.091	89.643.200	9,6%	16.118.841	36.443.200	13,5%	8.441.491
13	404.204.800	15,8%	67.198.545	121.952.000	13,0%	20.549.131	49.513.600	18,4%	10.155.727
14	372.408.000	14,5%	97.262.945	113.123.200	12,1%	37.674.740	28.944.000	10,8%	6.058.055
15	317.596.800	12,4%	67.472.545	100.246.400	10,7%	32.187.770	21.736.000	8,1%	5.882.818
16	488.457.600	19,1%	67.472.545	143.528.000	15,3%	18.103.632	54.432.000	20,2%	11.313.673
17	366.395.200	14,3%	61.472.073	116.777.600	12,5%	19.396.818	31.371.200	11,7%	4.894.964
18	293.964.800	11,5%	64.175.564	95.408.000	10,2%	22.125.076	23.190.400	8,6%	4.073.673
19	230.102.400	9,0%	44.439.964	66.742.400	7,1%	7.894.566	18.660.800	6,9%	3.936.455
20	158.275.200	6,2%	59.238.236	34.083.200	3,6%	7.782.069	10.944.000	4,1%	2.654.436
21	422.422.400	16,5%	143.385.709	125.065.600	13,3%	48.944.552	27.828.800	10,3%	7.481.436
22	126.648.000	4,9%	9.599.291	49.702.400	5,3%	4.189.039	24.424.000	9,1%	1.948.855
23	318.865.600	12,5%	64.080.127	115.996.800	12,4%	26.701.149	40.348.800	15,0%	8.463.473
24	272.796.800	10,7%	27.683.836	93.323.200	10,0%	10.683.733	37.806.400	14,1%	3.935.455
25	296.480.000	11,6%	39.094.927	101.857.600	10,9%	14.931.678	41.084.800	15,3%	5.201.964
26	167.721.600	6,6%	42.157.582	57.540.800	6,1%	13.463.963	23.945.600	8,9%	6.469.455
27	52.857.600	2,1%	2.047.782	24.067.200	2,6%	803.071	8.801.600	3,3%	351.764
28	157.755.200	6,2%	12.462.818	74.592.000	8,0%	5.875.274	24.467.200	9,1%	2.043.327
29	129.640.000	5,1%	7.734.382	66.995.200	7,1%	4.175.320	12.400.000	4,6%	705.873
30	198.123.200	7,7%	21.465.745	80.088.000	8,5%	8.764.855	27.081.600	10,1%	2.242.255
31	180.534.400	7,1%	38.319.818	66.699.200	7,1%	13.287.393	28.936.000	10,8%	5.722.509

geology restraints, the hydrograph network with its respected areas, the SIC and ZPS areas, the woods of the forest domain, the natural reserves and the regional parks, restraints referring to the Dgls 42/2004, 156/2006 e 57/2006 and in particular those referring to Art. 142 – Protected Areas by Law – Forests and Woods (lett. f), the perimeters of the urban centres and their respected areas. The data are deduced from the Landscape Plan of the Province of Enna, converted in raster format with 40 metre side, to launch the overlay functions on the other thematisms.

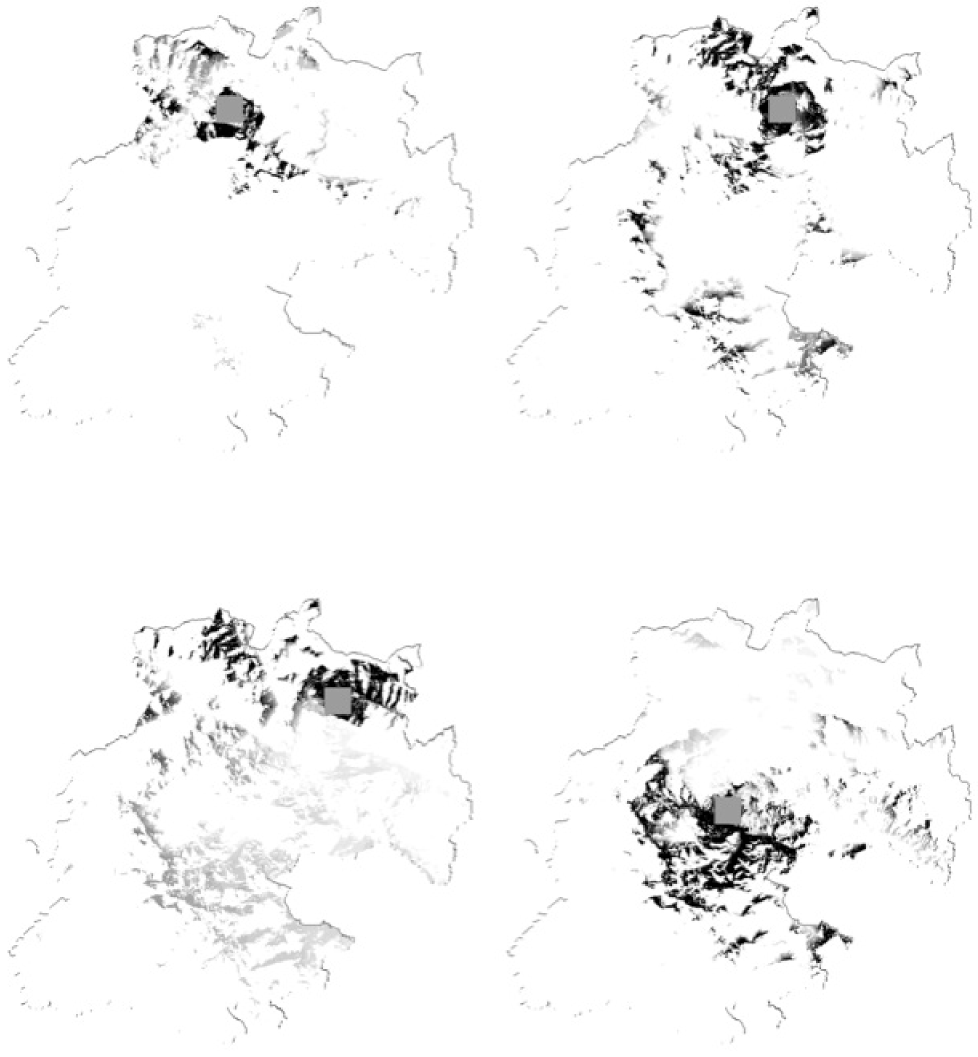
One logic diagram of the above mentioned functions is inserted in Fig. 7.

Results and discussions

The application of the model provides a classification of the plant areas basing on their economic and landscape performances. Regarding the maximum development of the plants a number of turbines equal to 15 per plant area has been indicated. The best plant areas are indicated by the black cells in the last column of Tab. 7. Due to the different wind speeds, the economic performances are highly variable. No plant area showing a negative economic result has been chosen.

The selected plant areas and their total intervisible area are represented in Fig. 8. A further survey about the environmental performance could concern the hoarded impact of more wind farms, so that a new ranking should be done.

Figure 6. Intervisibility of four of the 31 plant areas. The grey scale indicates the visibility factor.



By using the normalized performances scores the plants can be compared in order to appreciate the trade off relations (Fig. 9) between landscape and economic qualities. The scatters represent the plant areas assessed from the point of view of the y (first) and the x (second) performances. The spatial and landscape performances result significantly related, while the economic ones, because of highly dependent by the heterogeneous wind speeds cannot be valued together.

Therefore, by the information about the localization of the different anemometric stations, the plant have clustered in order to appreciated these relationships into smaller but more homogeneous sets.

Figure 7. Logical scheme of the GIS functions.

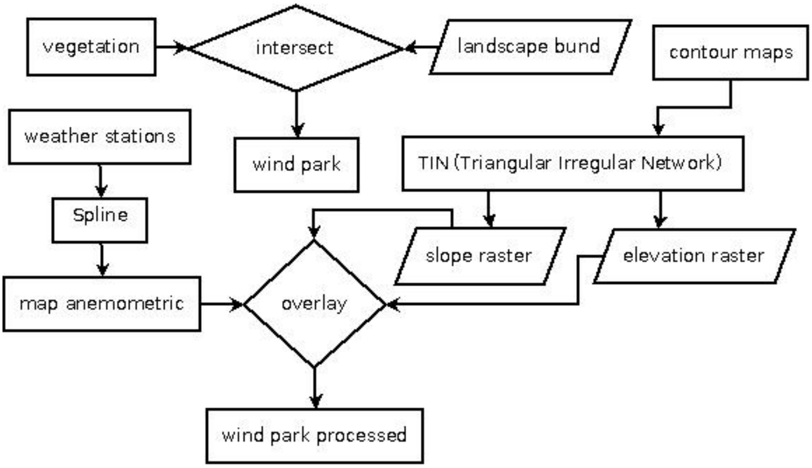


Table 7. General valuation scheme; selection of the best plants area (last column). The grey cells indicate a high level performances (columns) of each plant area (rows).

id	total costs	year revenues	GPV	NPV	(R-C)C	PbP	IRR	surf	bound	natur	aws
1	€ 77.390.711	€ 5.718.676	€ 89.149.371	€ 11.758.660	15,2%	14	4%	1,38	1,35	1,51	1,39
2	€ 72.149.894	€ 7.406.849	€ 115.466.566	€ 43.316.672	60,0%	10	8%	0,19	0,16	0,00	0,14
3	€ 74.702.803	€ 7.406.849	€ 115.466.566	€ 40.763.764	54,6%	10	8%	1,64	1,76	1,52	1,69
4	€ 74.770.303	€ 3.709.080	€ 57.821.446	-€ 16.948.857	-22,7%	20	0%	1,04	1,15	0,94	1,09
5	€ 77.323.211	€ 4.673.682	€ 72.858.791	-€ 4.464.420	-5,8%	17	2%	1,24	1,21	1,00	1,18
6	€ 74.702.803	€ 4.673.682	€ 72.858.791	-€ 1.844.012	-2,5%	16	2%	1,62	1,66	1,43	1,61
7	€ 74.702.803	€ 4.425.655	€ 68.992.252	-€ 5.710.550	-7,6%	17	2%	1,55	1,59	1,37	1,54
8	€ 72.149.894	€ 4.008.264	€ 62.485.485	-€ 9.664.409	-13,4%	18	1%	0,48	0,61	0,43	0,55
9	€ 74.702.803	€ 7.406.849	€ 115.466.566	€ 40.763.764	54,6%	10	8%	0,47	0,52	0,34	0,47
10	€ 74.770.303	€ 5.938.136	€ 92.570.574	€ 17.800.271	23,8%	13	5%	0,67	0,72	1,69	0,91
11	€ 74.770.303	€ 5.179.850	€ 80.749.526	€ 5.979.223	8,0%	14	3%	1,64	1,84	1,79	1,79
12	€ 74.702.803	€ 3.793.387	€ 59.135.730	-€ 15.567.072	-20,8%	20	0%	0,94	0,90	1,56	1,04
13	€ 72.082.394	€ 4.243.424	€ 66.151.418	-€ 5.930.977	-8,2%	17	2%	0,39	0,36	1,35	0,56
14	€ 74.770.303	€ 903.564	€ 14.085.813	-€ 60.684.489	-81,2%	83	-11%	0,53	0,51	1,68	0,75
15	€ 74.736.553	€ 903.564	€ 14.085.813	-€ 60.650.739	-81,2%	83	-11%	0,78	0,72	1,79	0,95
16	€ 72.149.894	€ 4.243.424	€ 66.151.418	-€ 5.998.477	-8,3%	17	2%	0,00	0,00	1,27	0,25
17	€ 74.770.303	€ 4.769.234	€ 74.348.367	-€ 421.935	-0,6%	16	2%	0,56	0,45	1,64	0,71
18	€ 74.702.803	€ 903.564	€ 14.085.813	-€ 60.616.989	-81,1%	83	-11%	0,89	0,81	1,77	1,02
19	€ 74.702.803	€ 3.086.973	€ 48.123.316	-€ 26.579.486	-35,6%	24	-2%	1,19	1,29	1,84	1,38
20	€ 72.082.394	€ 2.613.652	€ 40.744.650	-€ 31.337.744	-43,5%	28	-3%	1,52	1,83	1,97	1,80
21	€ 72.149.894	€ 903.564	€ 14.085.813	-€ 58.064.081	-80,5%	80	-11%	0,30	0,31	1,70	0,59
22	€ 74.702.803	€ 3.267.544	€ 50.938.280	-€ 23.764.522	-31,8%	23	-1%	1,66	1,57	1,75	1,62
23	€ 72.082.394	€ 4.513.695	€ 70.364.730	-€ 1.717.665	-2,4%	16	2%	0,78	0,46	1,50	0,73
24	€ 74.770.303	€ 2.098.480	€ 32.713.553	-€ 42.056.750	-56,2%	36	-5%	0,99	0,84	1,54	1,01
25	€ 74.702.803	€ 1.902.926	€ 29.665.027	-€ 45.037.776	-60,3%	39	-6%	0,88	0,70	1,48	0,89
26	€ 72.082.394	€ 5.443.234	€ 84.855.460	€ 12.773.065	17,7%	13	4%	1,47	1,44	1,76	1,51
27	€ 74.702.803	€ 2.396.308	€ 37.356.438	-€ 37.346.365	-50,0%	31	-4%	2,00	2,00	2,00	2,00
28	€ 74.702.803	€ 1.902.926	€ 29.665.027	-€ 45.037.776	-60,3%	39	-6%	1,52	1,15	1,75	1,35
29	€ 74.770.303	€ 1.076.691	€ 16.784.712	-€ 57.985.591	-77,6%	69	-10%	1,65	1,28	1,94	1,49
30	€ 74.702.803	€ 1.453.371	€ 22.656.834	-€ 52.045.969	-69,7%	51	-8%	1,33	1,06	1,71	1,25
31	€ 78.149.118	€ 1.125.520	€ 17.545.910	-€ 60.603.208	-77,5%	69	-10%	1,41	1,29	1,68	1,39

Figure 8. Intervisibility of the best plant areas.

Figure 9. Relationships between economic and landscape performances.

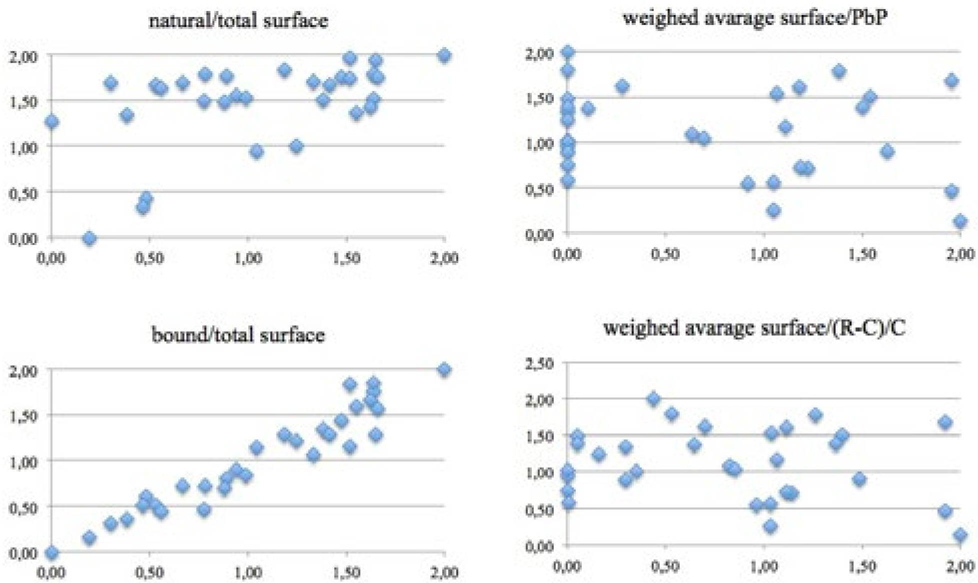


Table 8. Clustering of the plant areas.

	cluster 1		cluster 2		cluster 3		cluster 4		cluster 5	
	(R-C)C	aws	(R-C)C	aws	(R-C)C	aws	(R-C)C	aws	(R-C)C	aws
1	0,00	0,00	0,00	0,00	0,00	0,00	1,36	1,39	0,00	0,00
2	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	2,00	0,14
3	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,92	1,69
4	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,83	1,09
5	0,00	0,00	0,00	0,00	0,00	0,00	1,07	1,18	0,00	0,00
6	0,00	0,00	0,00	0,00	0,00	0,00	1,11	1,61	0,00	0,00
7	0,00	0,00	0,00	0,00	0,00	0,00	1,04	1,54	0,00	0,00
8	0,00	0,00	0,00	0,00	0,96	0,55	0,00	0,00	0,00	0,00
9	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,92	0,47
10	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,49	0,91
11	0,00	0,00	0,00	0,00	0,00	0,00	1,26	1,79	0,00	0,00
12	0,00	0,00	0,00	0,00	0,85	1,04	0,00	0,00	0,00	0,00
13	0,00	0,00	0,00	0,00	1,03	0,56	0,00	0,00	0,00	0,00
14	0,00	0,75	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
15	0,00	0,95	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
16	0,00	0,00	0,00	0,00	1,03	0,25	0,00	0,00	0,00	0,00
17	0,00	0,00	0,00	0,00	1,14	0,71	0,00	0,00	0,00	0,00
18	0,00	1,02	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
19	0,00	0,00	0,00	0,00	0,65	1,38	0,00	0,00	0,00	0,00
20	0,00	0,00	0,00	0,00	0,53	1,80	0,00	0,00	0,00	0,00
21	0,01	0,59	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
22	0,00	0,00	0,00	0,00	0,70	1,62	0,00	0,00	0,00	0,00
23	0,00	0,00	0,00	0,00	1,12	0,73	0,00	0,00	0,00	0,00
24	0,00	0,00	0,35	1,01	0,00	0,00	0,00	0,00	0,00	0,00
25	0,00	0,00	0,30	0,89	0,00	0,00	0,00	0,00	0,00	0,00
26	0,00	0,00	0,00	0,00	0,00	0,00	1,40	1,51	0,00	0,00
27	0,00	0,00	0,00	0,00	0,44	2,00	0,00	0,00	0,00	0,00
28	0,00	0,00	0,30	1,35	0,00	0,00	0,00	0,00	0,00	0,00
29	0,00	0,00	0,05	1,49	0,00	0,00	0,00	0,00	0,00	0,00
30	0,00	0,00	0,16	1,25	0,00	0,00	0,00	0,00	0,00	0,00
31	0,00	0,00	0,05	1,39	0,00	0,00	0,00	0,00	0,00	0,00

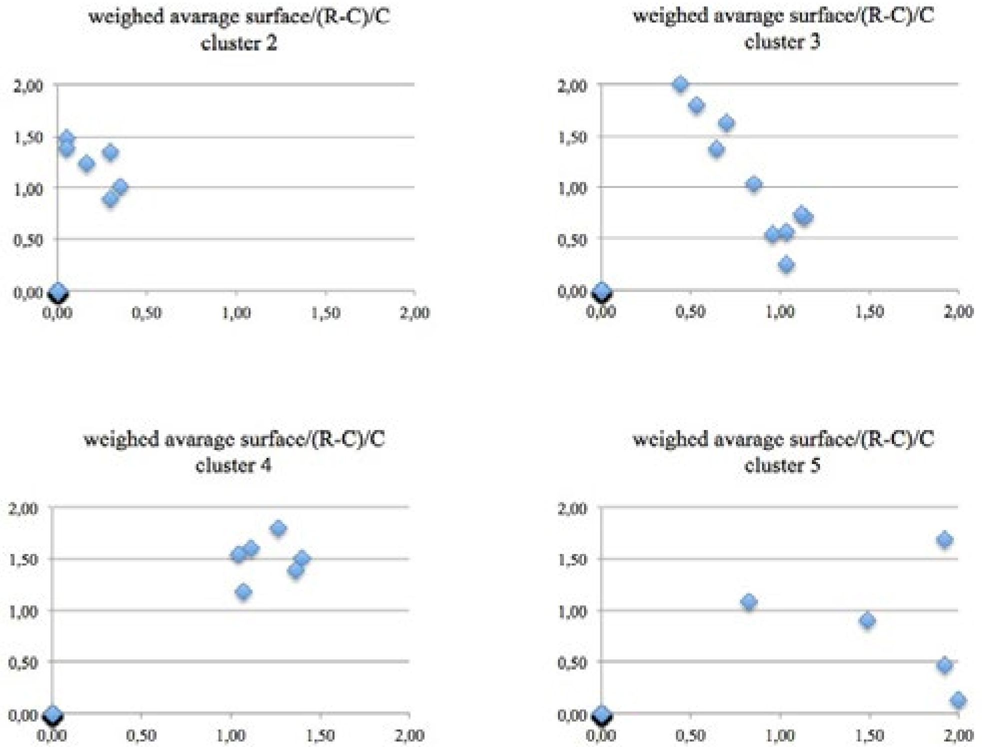
Tab. 8 shows the five clusters, the first of which hasn't be taken into account because of its irrelevant economic performance. The main and most evident trade off relationship can be appreciated using the aggregated intervisibility index (*aws*) related to quantitative and qualitative characteristics of the visible area, and the external rate of return *(R-C)/C*. The fourth graph of Fig. 10 shows the different relationships.

These relationships depend on, and at the same time describe and synthesize, the more general relationship between "natural structures, technological infrastructures and cultural superstructures" (Rizzo, 1999).

Some criticalities of the model concern, as widely reported in literature as well, the correspondence between potential producibility and actual production. For this reason the coefficient which transforms the wind speed from 10 to 80 m has been prudentially reduced in order to avoid overestimates.

This aspect is very important for the correct planning and an accurate incentive, and also to prevent a scarcely productive and very invasive plant from precluding the possibility to install some more performing ones.

Figure 10. Cluster of plant areas: different relationships between economic and landscape performances.



Conclusions

The definition of a geography of values is the most crucial conceptual and evaluative landscape, because of the objectification of a territorial profile in the specific sense of wind energy production. The territory is read referring to its structural capability to generate the most consistent and coherent flows of energy and information, whose combination and specification constitutes the substance of the value and the main argument of the policies of a large area.

The general sense of the proposed experimentation consists of the awareness that renewable energy is a necessary future, and that it is necessary to avoid making the same mistakes made when, thinking of the same for the fossil ones, territories have been devastated carelessly, and models of use of the land at elevated transformative and entropic intensity have been imposed. The Sicilian coasts bear the heavy and irreversible scars of this. Looking with suspicion at the novelties allows to assume a prudent approach, and stimulates the predisposition of preventive tools aimed at acquiring a better knowledge. A knowledge finalized in estimative sense is in itself valorising, in the sense that it allows to raise the planning capability of the territory just highlighting its potentials; this consists of the possibility that the knowledge of the geography of values allows to produce coherent and comparable groups of alternative options – aspect which the project valuation takes highly into account – and these retroact on the reality of values.

This is the reason why providing definitive solutions and layouts has been chosen. The former will be established only as the result of the use of the model, and the production of most part of the valorising information.

The awareness of the spatial ambient and environmental cost of energy, evident when all effects are contained in the space and time of the socio-territorial context of the users, makes clear the level of environmental responsibility of each more watt required in terms of surfaces and areas utilized respectively for the instalment of the plant and the irradiation of its visual presence.

This first information gives rise to a different way of seeing, and therefore or valorising, energy in itself: the landscape impact constitutes a direct, concrete and perceptible measure of the value of energy production, as it internalizes nearly all the costs of the latter, and makes them evident as signs on the territory. As a consequence territorial local planning, and above all energy planning at national and international level, require an axiological transfiguration of the material substance of this cost participating in the multiple measures of value. Apart from the abstraction of the proposed model, a very important aspect of the energy policy is indeed the relation between needs and uses,

which involves the economic and moral and landscape issues as well. In fact, energy landscape means that a territory is responsible for its energy consumption, and the wind farm sign measures its needs.

Acknowledgements

Salvatore Giuffrida edited paragraphs 1, 2, 3.3, 4 and 5, Figs 5, 9 and 10, all the tables, and drew up the economic and qualitative valuation model and calculations. Filippo Gagliano edited paragraph 3.3, Figs 1-4 and 6-8 and drew up the GIS tool.

References

Bernetti, I. Marinelli N. (2010), “Evaluation of Landscape Impact and Land Use Change. A Tuscan Case Study for CAP Reform Scenarios”, Aestimum, 56/2010.

Bocca, R. (2013) “Processo al vento”, L’Espresso - 20 June.

Cerroni, S. Venzi, L. (2008), “Confronto tra diverse localizzazioni di un impianto eolico contemperando produttività ed impatto visivo”, Aestimum, 53/2008: 1-24.

Di Bene, A. Scazzosi, L. (eds.) (2006), Gli impianti eolici: suggerimenti per la progettazione e la valutazione paesaggistica. Linee Guida per l’inserimento paesaggistico degli interventi di trasformazione territoriale, MIBAC, Gangemi Editore, Roma.

Department of Land, Department of Environmental and Cultural Heritage of Sicilian Region (2006) Circular n. 17, Palermo.

Eco U., Trattato di semiotica generale, Milano, Bompiani, 1988, pp. 62-3
European Landscape Convention (2000).
Industry Department of the Sicilian Region (2009), Decision of the Regional Government No 1, February 3rd 2009, approving the Regional Sicilian Environment Energy Plan (RSEEP).
Ministry of Heritage and Cultural Activities (2002), Codice dei beni culturali e del paesaggio Rome.
Ministry of Heritage and Cultural Activities (2012), Wind Farm Guidelines, Rome.
Ministry for the Economic Development (2012), Environment and Sea Protection MD 6 luglio 2012, Rome.
Pasqualetti, M. J. (2000), "Morality, Space, and the Power of Wind-Energy Landscapes", Geographical Review Vol. 90, No. 3 (Jul., 2000), pp. 381-394
National Urban Institute (NUI) of Basilicata (2013), Open letter to the Regional Council, Potenza.
Nesticò, A. (2012), "La finanza di progetto e l'azionariato diffuso nella valutazione finanziaria di un progetto di investimento", In: Stanghellini, S. (2012), Il negoziato pubblico-privato nei progetti urbani, Dei, Roma.
Palazzolo, S. Baldessarro, G. (2012), "I signori del vento", Repubblica-L'Espresso, Le inchieste.
Rizzo. F. (1983), Economia dei beni culturali. Metodologia di stima del valore d'uso sociale dei beni culturali immobiliari, Facoltà d'Ingegneria dell'Università di Catania.
Rizzo F. (1989), Economia del patrimonio architettonico-ambientale, FrancoAngeli, Milano.
Rizzo F. (1999), Valore e valutazioni. La scienza dell'economia o l'economia della scienza, FrancoAngeli, Milano.
Rizzo, F. (2013), Nuova economia. Felicità del lavoro creativo e della conservazione della natura. Infelicità della speculazione finanziaria e dell'inquinamento ambientale, Aracne, Roma.
Rowlands, I. (2013), Green certificate. Retrieved from http://www.eoearth.org/view/article/153130
Superintendence of Cultural Heritage of the Province of Enna, AUD University of Catania (2008), Landscape Territorial Plan of the Province of Enna.