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Dispersion of urban areas and indicators in the spread area SEA: the Gini index

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The urbanized shreds, marking by now metropolitan systems as well as valleys and national coasts, express the binomial 'growth, dispersion' representative of many Italian urban plans in the last decade; the immoderate growth of the building property has been noticeable for the stressed urban dispersion of the consolidated centres towards urbanizable rural spaces, without evaluating its suitability with the territorial frame, measuring the only efficacy at a proximity scale, and compromising the involvement of the undefined spaces of the suburban transitional area: insufficient is the saturation of the existent building structure, the re-use of many urban areas currently abandoned and disused, the willing to mend the incompleteness of the dissipated borders as well as the historical continuation of the structure of the urbanized centres and the territorial hierarchies preservation. These features of non-centricity brought the creation of many different not-places, not-locations, where the centre, fundamental principle to arrange explicit *limes* (from Latin: 'borders') that have the function to defend agricultural spaces against the uncontrolled diffusive urbanization processes, as well as against the waste of soil and against the historical city framework already consolidated. To sum up, the response of the plan turned out to be strongly inadequate to the environmental sustainability demand, and a solution, at the provincial scale at least, is required to deal with the urban-agricultural conflict for the physical resources exploitation. One way out could be to designate 'centred' localities where urban expansion can be planned, where alternatives to the actual urban settles dispersion can take place, where the irresponsible waste of not-renewable and finished resource, such as the soil, can be obstructed, where the good government of the territory can be expressed in a moment of synthesis of the plan.
Therefore is required to start evaluating, selecting, addressing the local choices at the wide scale in order to make the competition between urban growth and rural spaces come to an end, so that the municipal instruments have to face up to the environmental sustainability questioning about the use limits of physical resources and about most effective tools to measure them: the problem, too long laying in vague, pretends now new shapes of planning, in which the focus on physical resources is the absolute presupposition to propose urban and agricultural places where the main terms of conflict with land sustainability are identified, evaluated and explicitly faced: from lacked conservation of natural heritage to pollution and waste of finished physical resources, to the indifference in construction and re-construction processes of cultural and historical landscapes and to the deterioration and ratification of local peculiarities and urban individualities.
In effect we are able to see a so wide range of pressures generated by processes of urban expansions (fragmentation of rural texture and natural habitat, banalization and alteration of sensible landscape, loss of high quality soils, increase of pollution load on waters, gain of environmental costs due to sprawl phenomena), to make necessary a control of municipal plans location choices, towards the consumption and alteration of soil, waters, air, landscapes, so to determine their sustainability degree and to modify (in case of negative evaluation) the quantitative characters and the consequent spatial options, though it is demonstrated a very little interest towards the evaluation of the environmental consequences of the plan; just to cite one case, the attention towards the EIA was at the beginning as high as it was, secondarily, the methods and the analytical contents oversimplification, besides the adoption of routinely instruments and the lack of strategic assessment. The EIA has been degraded as 'optional accessory' among the amount of documents considered compulsory by law. The environmental strategic assessment future will be the same, actually the few evaluations produced by now seem to reveal weak analytical tools, masked by a just theoretical and effectiveness lacking framework of sustainability theories; as methodological protocols not really able to evaluate sustainability of new development urban areas with regards to environmental variables. It is urgent to equip plans of evaluation instruments with the double rule of 'assessment tools' of choices for new urban areas and also sort of 'simulator' of alternative options, supported by specific spatial performance indicators able to identify particular sustainability thresholds and to provide numeric measures to found assessment on.
With the environmental impact assessment the need of quantitative evaluations comes up from the very beginning of the plan, and, to this purpose, appropriate indicators are required to express the limitation in use of the physical resources. In the adopted interpretative model the sustainability of expansive locations chosen by municipal plans has been considered function: of urban shapes compactness (under the same quantities of urbanized soils, compact perimetric morphologies produce shorter distances from centres, less interference in rural and natural lands and consequently less economical and environmental costs); of number and extension of new urbanized areas (urbanistic choices for small centres or, what worse, for puntiform centres bring about a pulverization of settles weave, higher soil consumptions and greater transport and environmental costs); of settles dispersion (i.e. of ways in which urban weave is arranged in the space; choices of new urban areas referred to: the saturation of existing urban porosities; the sewing of fringe urban zones in city planning; the urban weave continuity, represent sustainable urbanistic models contrary to discontinuous, diffusive and centreless configurations, with serious consequences of rural and forest systems fragmentation and alterations of their functions); of consumption of high capability use soils (expansive choices often don't often consider the pedological quality of interested soils); of hydraulic risk connected to new urban areas located in fluvial expansion zones; the pressures on natural systems (sustainable choices of new urban areas have a prefer for locations far away from woods, reserves, wetlands, potentially alterable by human activities).
In previous works (synthesized by Paolillo 2005) indicators and procedures have been selected and used to quantify the components of

the model (building new indicators and adapting some old ones to measure the urban settles spatial pattern as well as the distributive spatial pattern, two components for which, since concrete reference from literature is missing, the need to find classificatory models to the urban framework, against the soil waste, appears more urgent).
Finally a path was delineated in the following six components: I1 *the perimetrical morphology* (indicator j1,1 = CF shape coefficient); I2 *the distributive spatial pattern* (indicators j2,1 = DISP1, urban puntiform dispersion coefficient; j2,2 = DISP2, dispersion of smaller urban centres area <1,5 ha; j2,3 = DISP3, dispersion of bigger urban centres area >1,5 ha); I3 *the urban settles spatial pattern* (indicators j3,1 = DIFF, diffusion of urban polygons coefficient; j3,2 = CONN, connectivity coefficient; j3,3 = ETE spatial heterogeneity coefficient; j3,4 = CONT continuity coefficient); I4 *the pedological structure* (indicator j4 = Q pedological quality of soil interested by urban expansion); I5 *the hydraulic risk* (indicator j5 = RI hydraulic risk coefficient); I6 natural elements sensibility (indicator j6 = INT interference coefficient quantifying here the entity of the influence that new urban areas act to natural zones).
We'll be able to estimate, for each of the six components, the intensity of the phenomena at t0 (the consolidate urban settle) and at t1 (the PRG thresholds put into practice). From these intensity values it can be drawn the D , i.e. the difference between the two temporal thresholds: raising the D it has a decrease of the sustainability degree of location choices (Paolillo, La Rosa, Gabaldi 2005).
Is also true that, except for I4, I5, I6 expressing peculiar physical factors not replaceable by different nature synthetic indicators, the other urban components I1, I2, I3 could appear redundant in the estimate of the territorial dispersion, and therefore we would like to experiment different descriptors, carrying useful, not-pleonastic information, such as the Gini index (1912, 1955) used to calculate the concentration-dispersion degree intended as distribution of the area of each urban nucleus over the total urbanized area of that Commune, varying from the extreme case of all the urbanized nuclei having the same surface (maximum dispersion, perfect inequality, index 0), to the maximum concentration case (only one nucleus with measurable dimension and all the others with puntiform dimension, index 1).
Gini index has been estimated for all the municipal urban polygons settles pattern of Cremona province, splitted into four intensity classes and for three different temporal thresholds: *in the second post-war*, Cremona, Crema and few other Communes have higher index values, they show a central nucleus bigger than the one in the Communes nearby (where there is a lower urban nuclei number, having more less the same dimensions, that means homogeneous distribution and centred urban settles pattern: it comes out in the post-war period the diffusive model was not started yet); *nowadays*, the urban settle framework threshold ongoing, brings to a Gini index increase in the overall province (currently there are many more bigger urban nuclei compared to the previous small ones, so that the Gini index increase and the curve goes closer to the perfect inequality curve, this draws to the conclusion the diffusive model has taken place); *in the last temporary threshold*, as a consequence of the PRG expansion choices it can be noticed the increased cities sprawling and the correspondent soil waste, although the urban nuclei number remains the same, or it can even decrease, due to the fact that the generalized urban expansion brings to the absorption of the smaller centres nearby, in the bigger urban centres, demonstrated by a perfect linear correlation with the decrease of DISP1 (urban puntiform dispersion coefficient) and DISP2 (dispersion of smaller urban centres), and the increase of DISP3 (dispersion of bigger urban centres).
This expansion process appears in strong contradiction with the demographic decrease of about 13%, registered from the 1951 to 2001 in Cremona province, with a constant reduction in the period 1951-1991 and a slightly inversion tendency in the last period; besides, in the last decade 2001-1991, looking at the provincial value of the local units, it is decreased (-1.63%) and it does not justify the expansion processes in the productive areas; if, then you look at the growth spatial extent (in the post-war period 26.46 km2, at present threshold 128.35 km2, at predicted threshold 186.00 km2), we have to admit a waste situation that, considering Q = pedological quality of soil interested by urban expansion, has taken place (in the prevision of the most recent municipal urban instruments) for the 50.15% on soils of the I and II classes, above the 28.43% of the III classes, in a province where the agriculture always has been the most important sector, reaching the highest European levels, and now it has to compete for the use of the soil resource with the urban settle diffusive process, as the indicators complex demonstrates: CF = shape coefficient, DISP1 = urban puntiform dispersion coefficient, DISP2 = dispersion of urban centres with area < 1.5 ha; DISP3 = dispersion of urban centres with area >1.5 ha; DIFF = diffusion of urban polygons coefficient; CONN = connectivity coefficient; ETE = spatial heterogeneity coefficient; CONT = continuity coefficient; Gini = urban settles framework concentration.
In the estimate of the Pearson coefficient r, at *the post-war period matrix*, the dispersion of smaller urban centres (DISP2) and the diffusion of urban polygons (DIFF) appear to be the most correlated with r = 0.87; it follows the correlation between connectivity (CONN) and heterogeneity (ETE) with r = 0.66, then between Gini and ETE with r = 0.57; between CONN and DISP2 r = 0.51; instead CONN is inversely correlated to the dispersion of the bigger centres (DISP3) with r = -0.44; in *the present urban settle matrix* the higher correlation is between the dispersion of smaller urban centres (DISP2) and the diffusion of urban polygons (DIFF) with r = 0.86, exactly as in the previous threshold, while the second higher correlation is the one between Gini and DISP3 with r = 0.63 and between Gini and ETE with r = 0.62; inverse correlation is shown between DIFF and Gini (-0.59) and between DIFF and DISP3 (- 0.55); the CONN index is positively correlated to DIFF with coefficient equal to 0.32; at last, in *the expansion urban settle matrix* the most correlated variables appear to be the Gini dispersion index with ETE (0.94), followed by the ones already well correlated at the previous thresholds, DIFF and DISP2, with Pearson 0.87, and the inverse correlated ETE and DIFF with - 0.42 and Gini and DIFF with - 0.39.
At the end a relevant contribution comes from the

Principal Component Analysis (PCA). The model has been performed taking away one variable at a time, for a total of eight variables, and comparing the variance explained in calibration and in validation for each model. For the *historical matrix* the first four PCs explain the 84% of the variance and, of the 25% explained by the second PC, the Gini index describes the 33% (it seems to take new and relevant information, although it does not resume the total system information, it gives an important contribution, and therefore it represents a fundamental component for the description of the historical urban settle pattern of the Province of Cremona); for the *present matrix* it can be deduced the worst predictive model is the one without DIFF and Gini (and the best is the one without DISP1), confirming therefore that the Gini index, together with DIFF, DISP2 and ETE, expresses a high explicative portion; in the last case, *the expansion matrix*, the last temporary threshold taken in consideration (the residential and productive expansions localized by the municipal urban instruments), shows that whereas Gini would be removed, the model would lose a high quantity of useful information, describing, with 5 PCs, only the 90% (to the contrary if DISP1 or CF would not be considered with 5 PCs the 97% can still be explained). Once again, as in case of the previous historical and present thresholds, the Gini index appears to be extremely relevant especially to estimate the new urban processes predicted by the municipal plans, appearing to be rather than a synthetic index (as it is PC1, that describes the 38%, and PC2, describing the 21%) a fundamental variable, together with the other three, considered, by themselves, already enough for the urban settle spreading synthetic description.

In this way there will be a relevant model simplification f (I1, I2, I3) because the analysis dimension would result halves (from 8 to 4 variables), in this case it would not be useful to calculate I1 (expressing the compactness of the urban settles shapes) since we have seen that the perimetrical morphology CF does not play a very significant rule; for I2 the distributive spatial pattern DISP1, urban puntiform dispersion coefficient, can be replaced with DISP2, the dispersion of smaller urban centres of area <1.5 ha; besides the DISP3 calculation can be avoided, since it takes too little and not-innovative information; the CONN indicator can be substituted by DIFF, urban polygonal diffusion; the Gini index must be added to evaluate I3, since it has revealed peculiar features carrying interesting results.