Antonio Leone Carmela Gargiulo
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Environmental and territorial modelling for planning and design

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Smart City, Urban Planning for a Sustainable Future

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This book collects the papers presented at the 10th International Conference INPUT 2018 which will take place in Viterbo from 5th to 8th September. The Conferences pursues multiple objectives with a holistic, boundary-less character to face the complexity of today socio-ecological systems following a systemic approach aimed to problem solving. In particular, the Conference aims to present the state of art of modelling approaches employed in urban and territorial planning in national and international contexts.

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This book is the latest scientific contribution of the "Smart City, Urban Planning for a Sustainable Future" Book Series, dedicated to the collection of research e-books, published by FedOAPress - Federico II Open Access University Press. The volume contains the scientific contributions presented at the INPUT 2018 Conference and evaluated with a double peer review process by the Scientific Committee of the Conference. In detail, this publication, including 63 papers grouped in 11 sessions, for a total of 704 pages, has been edited by some members of the Editorial Staff of "TeMA Journal", here listed in alphabetical order:

- Rosaria Battarra;
- Gerardo Carpentieri;
- Federica Gaglione;
- Rosa Anna La Rocca;
- Rosa Morosini;
- Maria Rosa Tremiterra.

The most heartfelt thanks go to these young and more experienced colleagues for the hard work done in these months. A final word of thanks goes to Professor Roberto Delle Donne, Director of the CAB - Center for Libraries "Roberto Pettorino" of the University of Naples Federico II, for his active availability and the constant support also shown in this last publication.

Rocco Papa
Editor of the Smart City, Urban Planning for a Sustainable Future" Book Series
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INTRODUCTION

Between 5th and 8th September 2018 the tenth edition of the INPUT conference took place in Viterbo, guests of the beautiful setting of the University of Tuscia and its DAFNE Department.
INPUT is managed by an informal group of Italian academic researchers working in many fields related to the exploitation of informatics in planning.
This Tenth Edition pursed multiple objectives with a holistic, boundary-less character, to face the complexity of today socio-ecological systems following a systemic approach aimed to problem solving. In particular, the Conference will aim to present the state of art of modeling approaches employed in urban and territorial planning in national and international contexts.
Moreover, the conference has hosted a Geodesign workshop, by Carl Steinitz (Harvard Graduate School of Design) and Hrishi Ballal (on skype), Tess Canfield, Michele Campagna.
Finally, on the last day of the conference, took place the QGIS hackfest, in which over 20 free software developers from all over Italy discussed the latest news and updates from the QGIS network.
The acronym INPUT was born as INformatics for Urban and Regional Planning. In the transition to graphics, unintentionally, the first term was transformed into "Innovation", with a fine example of serendipity, in which a small mistake turns into something new and intriguing. The opportunity is taken to propose to the organizers and the scientific committee of the next appointment to formalize this change of the acronym.
This 10th edition was focused on Environmental and Territorial Modeling for planning and design. It has been considered a fundamental theme, especially in relation to the issue of environmental sustainability, which requires a rigorous and in-depth analysis of processes, a theme which can be satisfied by the territorial information systems and, above all, by modeling simulation of processes.
In this topic, models are useful with the managerial approach, to highlight the many aspects of complex city and landscape systems. In consequence, their use must be deeply critical, not for rigid forecasts, but as an aid to the management decisions of complex systems.

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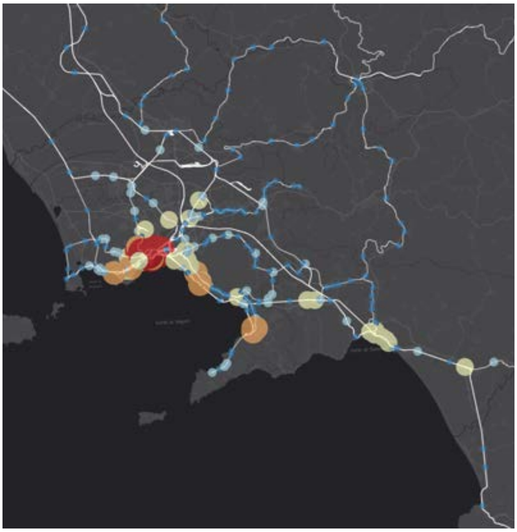

CLASSIFYING RAILWAY STATION CATCHMENT AREAS

AN APPLICATION OF NODE-PLACE MODEL TO THE CAMPANIA REGION

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ABSTRACT

In the last decades the local and regional authorities worldwide have expressed an increasing interest in the application of development strategies that combine transport and land use actions to reduces the impacts of the negative environmental and socio-economic consequences generated by the mobility needs in the urban area. Like many other regional authorities in the world, the Campania Region faces the problem to improve the existing transport network and optimize the land-use. The regional railway network consists over 3.017 km of lines and 339 stations, operated by three transport companies. The main action of the regional authority in next years is not just renewal of transport infrastructures, also to improve the land-use component in the catchment areas of the urban and peripheral nodes of transport. In order to support the policymakers and technicians, this contribute proposes a quantitative analysis of railway nodes in Campania Region in terms of transport and land-use characteristics, by drawing on the recent advances of node-place smart modelling literature. To increase the strength of our analysis, we used only open data referring to the catchment area (CA) size and analysed through an open source GIS software. Based on this systematic station inventory, we conducted a cluster analysis for all CA. In conclusion, this contribute proposes a GIS quantitative methodology of spatial analysis to support the strategic governance of regional/metropolitan railway network and the related application to the Campania Region.

KEYWORDS

Accessibility; Node-Place Model; Railway Network; GIS

1 INTRODUCTION

In the 2017, over 54% of the world population lives in the urban areas (The World Bank, 2018). Actually, the number of total urban population is equal 3.9 billion and the future prevision estimate over 6.4 billion of urban citizens (United Nations, 2017). Through these data, it is possible to understand the importance of developing new urban planning solutions to solve the present and future urban problems (De Gregorio et al., 2015). So, it will be important to develop new tools, approaches and guidelines for the analysis, quantification and solution the urban challenges. Some of the main challenges, of urban planning, concern the reduction of traffic congestion (use of the private car) and the unfriendly built environment. In particular, the urban areas are characterized by low level of density for the population and the activities, a monofunctional land-use destination of the areas and a no integration in the planning practice with transport planning (Papa and Bertolini, 2015). In metropolitan areas around the world, there is a growing interest in a more coordinated integration of transport and land use developments (Curtis et al., 2009; Curtis and Scheurer, 2016), as a result of mounting concerns over the adverse environmental and socio-economic effects of mobility systems dominated by individual motorized transport. In order to evaluate the present and the future impacts deriving from the application of integrated land-use and transport strategies, in recent years the need has emerged to develop several models of spatial analysis ex-post and ex-ante (Papa et al., 2018).

The most used model, in literature, is the Node-Place analysis model, proposed for the first time by Bertolini in 1998. It has been used numerous times and with some modifications to adapt it to different territorial contexts (urban and regional) (Zempt et al., 2011; Papa and Bertolini, 2015; Lyu et al., 2016; Caset et al., 2018). The model analyses the level of integration between transport (node index) and land-use (place index) systems by a set of indicators.

The original structure of the model is not applicable univocally at the different territorial contexts. In particular, the number and type of indicators must be changes to consider the different physical-functional characteristics of the case study and the availability of data for the calculation of the indicators.

For the application of the Node-Place model at a case study, it is essential to use the GIS spatial analysis software. So, it is possible to integrate spatial analysis for understanding the transport networks and urban areas in a more quantitative and more clearly interpretable way (Cheng et al., 2012). The paper is organized in three section as follows: Methodology (selection of node-place indicators, the GIS-based procedure); Case study (Campania Region Railway network); and Conclusions and future developments.

2 METODOLOGY

In consideration of the specific needed to apply at Campania Region railway network, the original node-place methodology has undergone some adjustments. We defined two different steps in the methodology. In the first, we selected a set of indictors through the studies of scientific literature on the application of Node-Place model at a metropolitan rail network. In the second step, we defined the GIS-based procedure to collect the data and to calculate the value of each indicator.

2.1 SELECTION OF NODE-PLACE INDICATORS

Several researches have proposed or selected different indicators to evaluate the characteristics of Node and Place index in different regional or metropolitan areas (Bertolini, 1999; Reusser et al., 2008; Zempt et al. 2011; Higgins and Kanaroglou, 2016; Lyu et al., 2016; Caset et al., 2018). For the development of this

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procedure, we selected a set of fourteen indicators (seven for Node and six for the Place) by systematic review of the recent scientific literature. This select set indicators also resulted from the use of the following two criteria: questionnaires at ten local experts (two urban researches, two transport researches, three urban planners and three transport planners); and publicly accessible of data (open data).

Index	ID	Indicator	Measurement	Data source
Node	N1	Frequency	Count the number of trains per day	GTFS data and RFI
	N2	Level of service	Count the number of different rail service (metropolitan service; regional service; long distance service; high-speed service)	GTFS data and RFI
	N3	Intermodality	Count the different mobility modality located in the node service area	Google maps data and RFI
	N4	Interconnection	Count the number of directions served	GTFS data
	N5	Infrastructure features	Typology of railway infrastructure (Single-track railway; Double-track railway; Single-track railway with electrification; Double-track railway with electrification)	OSM
	N5	Degree of attendance	Level of station use by the users considering the functioning time of rail service	Google maps data
	N6	Population trips	Count the trips of the resident population for reasons of work and study	ISTAT
	N7	Jobs trips	Count the trips of the resident population for reasons of work and study	ISTAT
Place	P1	Population density	Density of resident population within station catchment area	ISTAT
	P2	Jobs density	Density of jobs within station catchment area	ISTAT
	P3	CA Surface	Extension of station catchment area	OSM
	P4	Walking topography	Ration between walking catchment area and theoretical radius catchment area	OSM
	P5	Not urbanized area	Count the surface extension of the no urbanized areas	Corine Land Cover
	P6	Functional mix	Calculate on the basis of numbers of establishments in different sectors, and housing in the catchment area	ISTAT

Tab. 2 The selected Node and Place indicators

2.2 THE PROCEDURE OF ANALYSIS

After the selection of indicators and collect the data necessary for the analysis, we defined a procedure of the numerical and spatial analysis to calculate the two synthetic indicators of "Node" and "Place". Following, we describe the phases of our procedure:

- Building a GIS geodatabase to organize multiple sources spatial and alphanumeric data of the study area to calculate the value of selected indicators;
- Defying the pedestrian stations catchment areas (CA) by network analysis tool of ESRI ArcGIS Pro software (see Fig. 2). For this analysis, we considered Open Street Map (OSM) roads network and a walking distance limit of 10-minute from the station exits (amounts at 800m walking distance) (Vale, 2015);
- Calculating the values of fourteen indicators for each station node and CAs (place) of the network. Also, all indicators are normalized in to numerical range from 0 to 1 (Reusser et al., 2008);

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- Calculating the two synthetic indexes of Node and Place as the average of all standardized value of the same indicators category;
- Classifying the stations by the Cluster analysis tool of software package SPSS 20.00. In particular, we used two-step clustering method, that is frequently used in the Node-Place model application at regional scale (Norušis, 2008; Zemp et al., 2011). Also, the optimal number of clusters for the analysis can be calculated by the Bayesian Information Criterion (BIC) (Reusser et al., 2008);
- Illustrating the outcomes of analysis by the Node-Place diagram, GIS maps and tables.

Fig.2 Examples of calculated pedestrian catchment areas (CA) for some station areas of Campania region rail network

3 THE CASE STUDY

The study area is the Campania Region (a surface of 13,670 km^2 and a population of over 5,820,000 inhabitants) and its rail network (291 active stations, 3,017 km of lines and 3 transport companies). The region is divided in five provinces (Avellino, Benevento, Caserta, Napoli and Salerno) and 550 municipality authorities. A great part of population and economy activities of the region are located in the territory between the cities of Naples, Caserta and Salerno. In the last two decades, the Campania region government and some municipality authorities invested a lot of recourses to increase the efficiency of the regional railway network and to improve the quality of urban texture (denser and more land-use mix) around the stations (Comune di Napoli, 1997; Pagliara and Papa, 2011). For this application of Node-Place model at the Campania region, all data refers to the year 2011.

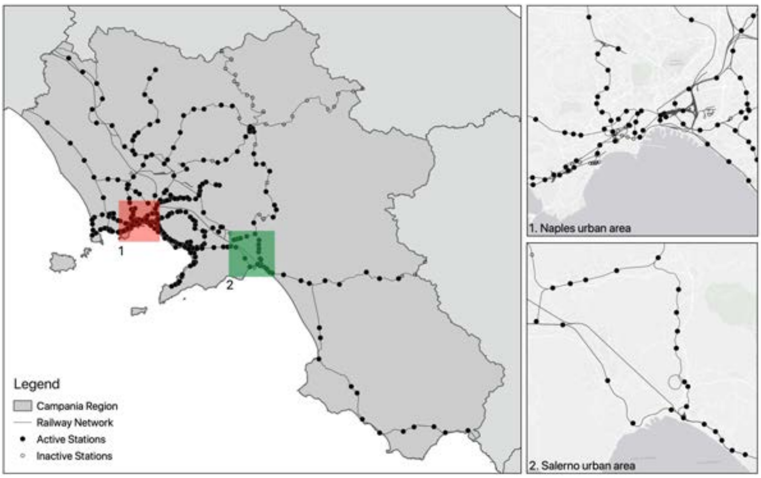

Fig.3 Railway network of Campania region

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3.1 RESULTS

In the Tab.3, Fig.4 and Fig.5 are illustrated the clustering structure obtains with the application at Campania Region railway netwoek of Node-Place model. The Cluster 1 includes the "Poorly served station areas" and counts 35 station areas. Most of these station areas are located along the secondary railway lines of the network. In the node-place diagram, these stations are located in the "Dependency" and in the "Unsustained Place" area. The place and node index values are low, only the value of Not urbanized areas (P5) index is over the mean value.

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Network
Number of Stations	35	40	16	111	66	23	291
N1 - Frequency	0.036	0.102	0.080	0.192	0.376	0.742	0.255
N2 - Level of service	0.200	0.237	0.313	0.667	0.939	0.978	0.556
N3 - Intermodality	0.143	0.250	0.300	0.249	0.391	0.800	0.356
N4 - Interconnection	0.229	0.200	0.281	0.204	0.237	0.449	0.267
N5 - Infrastructure features	0.391	0.867	0.063	0.868	0.985	0.978	0.692
N6 - Degree of attendance	0.015	0.683	0.633	0.581	0.639	0.805	0.559
N7 - Population trips	0.005	0.220	0.705	0.184	0.194	0.370	0.280
N8 - Jobs trips	0.014	0.060	0.059	0.070	0.171	0.679	0.176
P1 - Population density	0.051	0.048	0.131	0.187	0.463	0.673	0.259
P2 - Jobs density	0.016	0.013	0.044	0.047	0.114	0.444	0.113
P3 - CA Surface	0.268	0.233	0.543	0.513	0.612	0.741	0.485
P4 - Walking topography	0.250	0.220	0.502	0.487	0.580	0.698	0.456
P5 - Not urbanized areas	0.579	0.624	0.398	0.238	0.110	0.084	0.339
P6 - Functional mix	0.215	0.312	0.314	0.308	0.229	0.404	0.297
Node index	0.129	0.327	0.304	0.377	0.492	0.725	
Place index	0.230	0.242	0.322	0.297	0.351	0.507	

Tab.3 Results of cluster analysis by Two-steps method SPSS statistic software

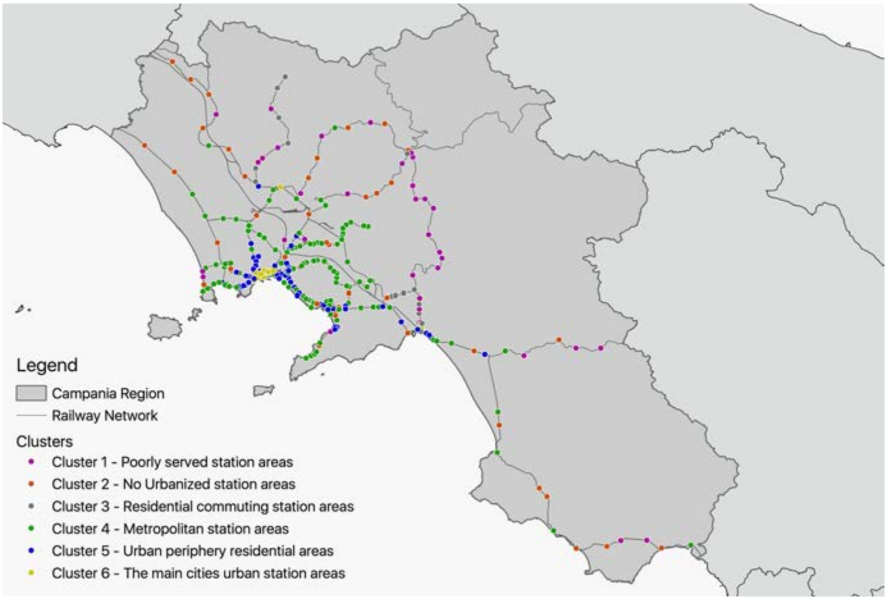

Fig.4 The classification of railway station areas in Campania Region based on the Node-Place model

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We named station areas belonging to Cluster 2 "No Urbanized station areas" and counts 40 station areas. A lot of station areas are localised in the peripheral areas of the region. The cluster is characterized by the lower value of Population density (P1) and Job density (P2). The station areas of this cluster are located in the bottom of the accessibility area in the node-place diagram.

The Cluster 3 groups "Residential commuting station areas" and counts 16 station areas. The areas of this cluster are localized along the no electrified single-track railway in the north of province of Salerno and in the province of Caserta. These are positioned in the accessibility area of node-place diagram. The value of population trips (N7) is high but the frequency of service (N1) and infrastructure features (N5) are very low.

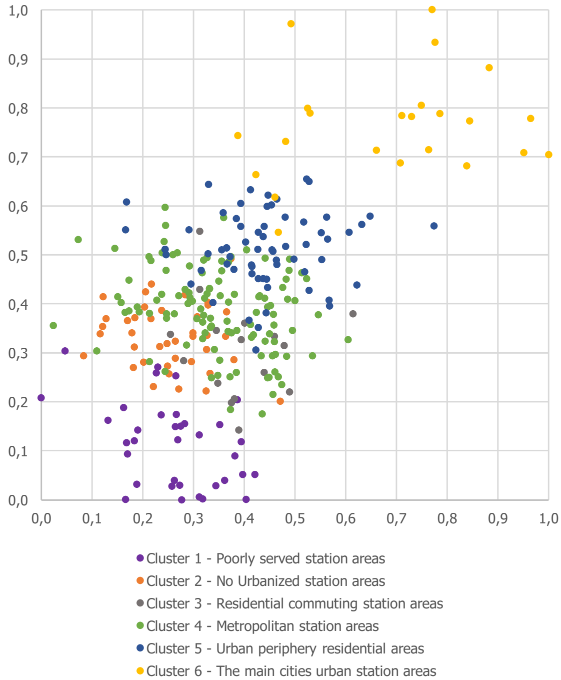

Fig.5 The Node-Place diagram of Campania Region railway station areas

The Cluster 4 includes "Metropolitan station areas" and counts 11 station areas. In the Node-Place diagram, the elements of this cluster are located between the bottom and central of "Accessibility" area. A lot of stations are included in the part of the region between the three cities of Naples, Salerno and Caserta. The numerical values of fourteen indicators are near the respective average values.

The Cluster 5 includes "Urban periphery residential areas" and counts 66 station areas. These stations are located in the central part of "Accessibility" area. The station areas are localized very close to the city centre of Naples and Salerno, on the most served (N2) and powerful (N5) railway lines.

Finally, the Cluster 6 includes "The main cities urban station areas" and counts 23 station areas. The stations of this cluster are located in the "stress" area of Node-Place diagram. This cluster are characterized by the low value of not urbanized areas (P5) and high values of a lot of indicators.

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3 CONCLUSIONS

This first application of Node-Place model at the Campania region railway network as a preliminary step of research work to define integrated land-use and transport guidelines to improve the transit orientation of station areas. The selected set of indicators (7 for the Node and 6 for the Place components) was improved by the study of scientific literatures on Node-Place applications, experts knowledge and availability of open data. The application of cluster analysis at the selected indicators of the 291 railway stations determined six type of stations groups. The application of the cluster analysis at the selected indicators for the 291 railway stations determined six type of stations groups. Each group is distinguished by specific characteristics of infrastructure, the transport service, socio-economic conditions and geographical location. These results from the application of the proposed procedure are useful for pre-selecting stations or corridors needing further investigation in the transport and land-use planning process.

Further elements of investigations might include, in our opinion, increase the number of selected indicators, apply a correlation analysis to choose the final set of indicators, define a set of planning strategies for each group of stations and propose specific transport and land-use planning solutions to increase the balance between the Node and Place components of the stations for each group.

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