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Laboratory of Land Use Mobility and Environment
DICEA - Department of Civil, Architectural and Environmental Engineering
University of Naples "Federico II"
Piazzale Tecchio, 80
80125 Naples
web: www.tema.unina.it
e-mail: redazione.tema@unina.it

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SUSTAINABLE URBAN MOBILITY TOWARDS SMART MOBILITY

THE CASE STUDY OF BARI AREA, ITALY

RAFFAELLA NIGLIO[a], PIER PAOLO COMITALE[b]

[a,b] Department of Civil, Architectural and Environmental Engineering (DICEA) - University of Naples Federico II
e-mail: [a] raffaella.niglio@unina.it, [b] pierpaolo.comitale@gmail.com

ABSTRACT

In the last decades, sustainable mobility policies have seen a growing interest. Furthermore, in the international debate, this concept has increasingly been linked to the most innovative one of smart mobility, which is part of the more general paradigm of Smart City. This paper discusses primary findings of a Research Project conducted at University of Naples, DICEA, funded by EU (PON REC 04A2_00120 Asse II), "Smart Energy Master – Toward Energy-based approaches for Regional Planning".
The primary goal of the work is to make a review of policies, programs, projects for sustainable urban mobility and of smart mobility solutions in Bari area. The second goal is to make an assessment on trends of urban mobility in order to evaluate its sustainability and smartness. A comforting picture, focused on matching the local strategies to European programs, is shown. Finally, a consideration on how the framework "smart" may improve urban mobility planning is proposed.

KEYWORDS:
sustainable urban mobility, smart mobility, Bari

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从可持续城市交通迈向智能交通

意大利巴里地区个案研究

RAFFAELLA NIGLIO[a], PIER PAOLO COMITALE[b]

[a,b] Department of Civil, Architectural and Environmental Engineering (DICEA) - University of Naples Federico II
e-mail: [a] raffaella.niglio@unina.it, [b] pierpaolo.comitale@gmail.com

摘要

在过去的几十年中，可持续交通政策引发了日益密切的关注。此外，在国际辩论中，这个概念已经被越来越多地与最具创新性的智能交通相联系，这是智能城市更为普遍的模式的一部分。这项工作的首要目标是考察可持续城市交通的政策、计划和项目以及巴里地区的智能交通解决方案。第二个目标是对城市交通的趋势进行评估以评价其可持续性和智能性。如图所示集中体现了当地战略与欧洲计划的契合。最后一个目标就是，针对如何让“智能”框架改善城市交通规划进行提议。

关键词

可持续城市交通，智能交通，巴里

1 INTRODUCTION

This paper discusses primary findings of a Research Project conducted at University of Naples, DICEA, funded by EU (PON REC 04A2_00120 Asse II), "Smart Energy Master – Toward Energy-based approaches for Regional Planning".

The primary goal of the work is to make a review of policies, programs, projects for sustainable mobility and of smart mobility solutions which may be currently distinguished in Bari area. In Bari, which is the second metropolitan city in Southern Italy, a wide range of initiatives and solutions of urban transformation in which sustainability is the key element has recently been proposed.

The second goal is to make an assessment on the trends of descriptive parameters of urban mobility in order to evaluate its sustainability and smartness. Diffuse pollution, climate change and energy resources' crisis require cities of the future to increase their energy efficiency as a whole, improving performance and reducing consumption, primarily energy. Undoubtedly, the choices and behaviors in the field of mobility, transport modes and their characteristics, as well as, more generally, the way in which travel decision are made have a high impact on carbon footprint of cities.

In the case study of Bari, traffic measures and investigations driven for the strategic plan MTB show a strong imbalance towards private car. Considering 100 people moving, more than 70 use private car; public transport system, as a whole, captures only 30% of commuting. However since 2004, a coordinated and increasingly shared government program on urban mobility, put in place a wide range of actions aiming at reducing the use of private vehicles. These actions brought benefit to the circulation and livability of the city and a not negligible reversal trend was registered.

In the following section the main European policies on sustainable mobility, which affect both national and local development, are described; in the third section, structural characteristics of mobility in the metropolitan area of Bari are defined; in the fourth section, policies, programs, actions for sustainable mobility and solutions for smart mobility are outlined and effects and effectiveness are measured, where possible for this work, through the assessment of actual trends; in the fifth and final section we summarize the results of this first step of research.

2 SUSTAINABLE MOBILITY IN EUROPE AND ITALY: A BRIEF REVIEW

Sustainable mobility policies and transport planning at urban scale have seen an increasing interest by European Commission. The first policy proposals in the area of urban mobility, the "Citizens' Network", date back to 1995 and 1998. They resulted in the launch of a series of initiatives based upon a "best practice" approach. In 2001 Transport White Paper (EC, 2001) "European transport policy for 2010: time to decide" suggested 60 specific measures to be taken at EU level in the transport sector. In 2005, in order to reduce the energetic and environmental impact of transport, the European Commission adopted the Green Paper (EC, 2007) "Towards a new culture for urban mobility" whose key issues are: free-flowing and greener towns and cities, smarter mobility and urban transport which is accessible, safe and secure for all European citizens. In 2009 the European Commission adopted the Action Plan on urban mobility (EC, 2009). In 2011, Transport White Paper "Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system", had a vision for the future of European transport until 2050. It recommended profound changes in the strategic planning and proposed a series of objectives and concrete measures that focused on transport integration (EC, 2011). In these last two documents is explicitly invoked the Sustainable Urban Mobility Plan (SUMP) as a new planning instrument for solving energy and environmental problems and inefficiencies of transportation in cities with an integrated and sustainable approach (Socco, 2010).

The differences between SUMP and the traditional mobility plans are in the three principles that inspired the whole process of drawing up and implementation of the plan: integration, participation and evaluation in

terms of increasing the efficiency, attractiveness and the overall quality of the urban transport system (http://www.bump-mobility.eu/). The different approach ensures that the focus moves from traffic to people, from mainly infrastructural measures to a combination of demand management actions and policies, from large investments projects to the introduction of the concept of limit in economic, energetic and land resources (EC, 2013). The benefits of the SUMP implementation are: better quality of life, SUMP means planning for people rather than cars and traffic; furthermore, health benefits due to the reduction of air polluting and noise and the promotion of active modes of transportation (walking and cycling); finally, economic benefits: a healthier environment and reduced congestion helps to substantially reduce costs to the local community and attract new businesses (Korver et al., 2012).

Moreover, a European Commission study on mobility plans, which were implemented in Europe, places Italy among the countries with a well-established transport planning with its regulatory support and availability of guidelines (Orchi, Valentini 2014). In Italy the Law 340/2000 (art. 22) (Legge 24 novembre 2000, n. 340) introduced the PUM (Plan for Urban Mobility) as a long term (10 years), systemic and integrated planning instrument for managing mobility in urban areas. This law did not become immediately operational for lack of both necessary funds and the inadequate definition of the approval procedures for plans. This law and the national guidelines, issued in 2005, promote sustainable approaches aimed at reducing levels of congestion, pollutant and noise emissions and energy consumption. In addition, they promote other more general issues like safety, accessibility and the use of sustainable modes of transport, focusing on land use-transport integration. Such scientific and regulatory efforts in the field of urban mobility appear to assume an increasing emphasis. They underline the need to limit the environmental impacts of transport systems and to encourage sustainable mobility policies.

3 THE CASE STUDY OF BARI AREA: RELEVANT FEATURES OF TRANSPORTS' SUPPLY AND DEMAND

The metropolitan city of Bari covers an area of more than 3,800 km² and includes 41 municipalities in which approximately 1,260,000 inhabitants live. It is a polycentric system wherein Bari represents the main but not dominant center because of the presence of three towns with a population exceeding 50,000 inhabitants (Altamura, Molfetta and Bitonto) and a dense network of surrounding medium-sized towns. The road network of the metropolitan city consists of two main routes: the first one is parallel to the coast whilst the second one goes inward the metropolitan area. With regard to the rail transport, Bari area is provided of sufficiently widespread infrastructures network but installations and rolling stocks are often obsolete. The railway network consists of a radial monocentric structure converging in the node of Bari Centrale, from which all the railway lines depart and arrive.

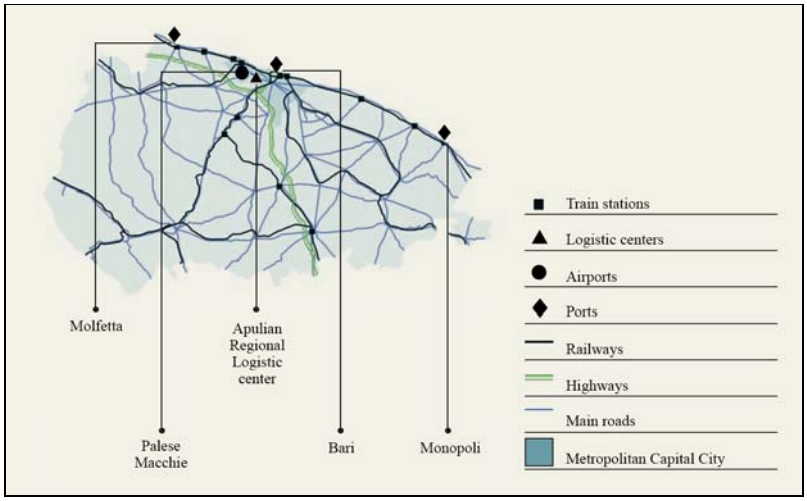

Fig. 1 Mobility infrastructures in Bari area. Source: Cittalia report on metropolitan cities, 2013

Considering public transport supply, four different rail operators act in the given area. Bari is the metropolitan city with the smallest amount (4%) of railway stations compared with the total number of stations in the 10 Italian metropolitan cities[1].

Road transport supply consists of about 60 buses that every day connect Bari with the other municipalities located in the metropolitan area with a total of around 6 million-km per year of road transport services. With reference to public transport, Bari has 38 public transport lines. Three of them (shuttles A, B and C) provide a "Park & Ride" service, connecting interchange parking areas, located next to the access routes with the highest levels of vehicular traffic, and the center of the city. In the following part, relevant data, that mainly characterize the qualitative and quantitative structure of the mobility, are shown. They also help to understand mobility problems. Apulian public transport system serves over 300,000 users a day, providing over 10,000 bus trips and 600 trains. This supply requires a public co-financing amount of about one million euros. It is delivered to the operators of the Local Public Transport who directly employ more than 6,000 people (approximately 1.2 % of the total of the region's workers).

The overwhelming majority of systematic daily travels, with origin and destination in the metropolitan city of Bari, use private car. In fact, daily travels by private car directed to or coming from the center of Bari are 675,000 out of a regional total of about 1,720,000. At same time, with respect to road transport, daily travels inside the city of Bari are more than 125,000. The average rate of car utilization, according to ISTAT 2001 data, scores nearly 1.4 passengers per vehicle. According to some surveys on vehicular flows, carried out by Tecnopolis in 2007 under the Implementation Plan 2009-2013 of the Regional Transport Plan, the total quantity of travels, both on entry and exit from the metropolitan area, is approximately 73,000 meanwhile those related only to the municipality of Bari their rate is respectively 134,000, for entering flows, and 140,000 for exiting flows.

4 POLICIES, PLANS, PROGRAMS, ACTIONS OF SUSTAINABLE MOBILITY AND SMART MOBILITY SOLUTIONS. EVALUATION OF ONGOING TRENDS

In the following section different geographic scales (regional, metropolitan and municipal) will be analysed as it is specifically stated in the title of each paragraph.

In 4.1 paragraph, regional strategies will be illustrated together with capital and current expenditure of Apulian municipalities. In 4.2 paragraph, plans and programs for the metropolitan area of Bari will be described and their effects on Supply of public transport by bus, Index of road accidents and Level of motorization and level of motorization Euro 4 or higher, will be analysed. In 4.3 paragraph, the measures implemented by the City of Bari, at a municipal scale, will be summarized and a first evaluation of their effects will be conducted through a set of performance indicators. In 4.4 paragraph, smart mobility solutions, underway and/or planned in Bari area, at a municipal scale, will be described and then their potential or effective success will be identified.

We are aware that trends in urban mobility are a consequence not only of implemented measures but also of a general change in urban mobility patterns in Italian cities. In this sense, a comparison with trends in other cities, through Istat indicators, will represent the second step of this research.

4.1 REGIONAL STRATEGIES

Regional policies in the field of sustainable mobility are contained primarily within the Regional Transport Plan (PRT) and in the Regional Plan for Space and Landscape (PPTR). Among the most important measures

[1] The list of stations derives from RFI source and relates to the year 2009. The stations here considered are the most important based upon the freights and passengers traffic as well as the services supplied.

identified in the transport network by the Implementation Plan of the PRT for the years 2009-2013, those that concern forms of "clean" mobility are:

- the construction of parking lots and facilities for modal shift;
- the introduction of a co-modal integration model;
- the implementation of measures to improve speed performance of railway lines;
- the promotion of integration between traditional and LRT systems;
- the creation of an integrated and safe network for cycle;
- the promotion of bike sharing and car sharing;
- the implementation of information systems;
- the promotion of alternative mobility services, such as carpooling, through the training of mobility manager.

The Implementation Plan of the PRT for the years 2015-2019 adds directions for the development of intelligent mobility infrastructure through:

- the deployment of ITS (Intelligent Transport Systems) to support the processes of integration between operators, services and users;
- the spread of grids for charging electric vehicles.

With regard to The Regional Plan for Space and Landscape (PPTR), approved in February 2015, it encourages soft mobility and the redevelopment of the railway system, through a "horizontal co-planning" process. A first measurement of the target implementation of regional policies can be made by analyzing the variable of total expenditure of all Apulian municipalities in the field of roads and transport.

In the first phase, current expenditure has been separated from capital expenditure, in order to identify how much money is allocated to roads and traffic sector and how much is destined to public transport; in the second phase, they are compared with the evolution of the demand for public and private transport.

Data regarding the expenditure values have been taken from a study carried out by the Foundation Caracciolo - ACI 2013 whilst data on transport demand come from an elaboration of the Ministry of Infrastructure and Transport on different sources' data.

Analyzing expenditure in the field of roads and transport[2], which includes both road traffic and local public transport, the amount of resources allocated to public transportation can be detected. Moreover not only the attention that municipalities have in regards of the topic but also the margins of intervention for the implementation of government policies of sustainable urban mobility can be consequently detected.

ITEM OF EXPENDITURE	2008	2011	VAR. % 2008-2011
Tot. Traffic and transport	160.259.060	331.959.170	107.14%
Road traffic	63.002.166	238.584.263	278.69%
Public transport	97.256.894	93.374.907	-3.99%

Tab. 1 Current expenditure of Apulian municipalities

Table 1 shows that current expenditure, which is aimed at fulfilling the momentary needs relating to mobility, is more than doubled in the period 2008-2011 but with an unequal distribution in the two sectors of road traffic (+ 279%) and public transport (- 4%). This trend could be a consequence of the relevant operations of maintenance and construction made for the road network or for the establishment of interchange parking and cycle paths. This happened in the city of Bari.

[2] For the analysis the item "functions in the field of roads and transport" of individual municipal budgets have been considered.

It is clear that the relationship between the two areas of spending is highly unbalanced. This relation markedly penalizes the offer of public transport whose effect could be the widespread dependence on private cars. Therefore this trend is confirmed, first of all, by the slight decrease of the public transport demand, which lowered about 1.5% between 2008 and 2010, and, secondly, by the increase of private transport demand by approximately 6% (Table 2).

TRANSPORT DEMAND	2008	2009	2010	VAR. % 2008-2010
Pass-km public transport	1.498.319.537	1.565.710.159	1.479.291.574	-1.27%
Pass-km motorized transport – private vehicles	45.745.587.029	49.852.414.803	48.511.618.008	6.05%

Tab. 2 Transport demand

Moving to capital expenditure, which is important for the development of a safer and more efficient mobility and to implement sustainable mobility policies, a dramatic decline of Apulian municipalities' investments can be seen in Table 3.

ITEM OF EXPENDITURE	2008	2011	VAR. % 2008-2011
Tot. Traffic and transport	206.395.756	149.715.646	-27.46%
Road traffic	204.261.127	149.431.194	-26.84%
Public transport	2.134.629	284.452	-86.67%

Tab. 3 Capital expenditure of Apulian municipalities

It is noticeable that public transport is still the most penalized field with a reduction of approximately 87% (Table 3). This cut on investments could be particularly dangerous and it could hinder the transition process to forms of "clean" mobility in Bari area and, more generally, in Apulia region.
To sum up, it can be said that actions in the field of road traffic, contained in the Implementation Plan of the PRT 2009-2013, have been prioritized in comparison to measures for the enhancement of local public transport. Similarly, the strong programmatic push toward creating intelligent infrastructure for mobility, contained in the Implementation Plan 2015-2019 of the PRT, does not seem to be supported by funds operated by municipalities.

4.2 PLANS AND PROGRAMS FOR THE METROPOLITAN AREA

At metropolitan scale, there are two governance instruments that suggest the main lines of action and intervention for mobility in the metropolitan area of Bari: the Urban Plan for Mobility of the metropolitan area (PUM) and the Sustainable Mobility Programme (PMS).
The specific goals of PUM, approved in 2009, are: the reduction of air polluting, the increase of the safety level of transport, the decrease of energy consumption, the improvement of the accessibility and, finally, the promotion of alternative modes of transport to private car. Furthermore, the main projects for the core of the metropolitan city include new rail transport infrastructures and a modal interchange terminal located next to the Central Station. It will allow modal change to trains, urban and extraurban buses (Papa, Nulli 2010). For those areas which stand outside the core, PUM includes, on one hand, the implementation of the rail transport network, which will enhance accessibility, interconnectivity and multimodality and, on the other hand, the managing measures to integrate schedules, fees and services of supply.

Also PMS, approved in 2009, focuses on rail network, parking and modal interchange, cycle and walk mobility, and, finally, road safety and tariff integration. Yet importantly, PMS indicate goals, related actions, indicators and quantitative targets to achieve in 2015 (Table 4).

GOAL	ACTION	INDICATOR	UNIT OF MEASUREMENT	TARGET
Increase public transport use	MTB Mobility Consortium	Increase of ticket sales	number	30%
	Multimodal station	Decrease of station access time	min.	30%
	Capruzzi Terminal bus	Increase of quality extraurban bus transport	respondent synthetic judgment	50%
	Tram-rail	Increase of rail-served residents in the center of Bari	resident	40%
	Coastal tram	Reduction of passenger cars in coast highways	passenger car	-20%
Ensure sweet mobility	Cycling Network (bike-sharing included)	Increase bicycle paths	km/resident	40%
Reduce car emissions	Car-sharing	Increase of car sharing vehicles	users/veh.	20%
	Transition to hydrogen and electric vehicles	Reduction of high pollution vehicles	vehicles	-20%
Increase quality and traffic safety	Suburban road network	Reduction of travel time	min.	-20%
	Infomobility	Quality of mobility information	respondent synthetic judgment	50%

Tab. 4. Goals, measures, indicators and targets to 2015 – PMS BA2015

Remarkable was the effort made by the municipalities' administrations of the metropolitan area to enhance public transport, in full accordance with the provisions of PUM and PMS. In fact, in Figure 2 it can be seen that supply of public transport by bus, in 2007-2013 time reference, increased of almost 20%.

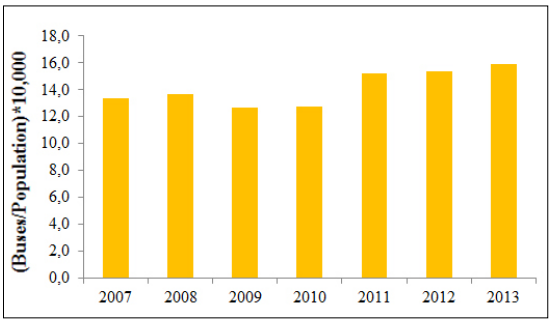

Fig. 2 Supply of public transport by bus

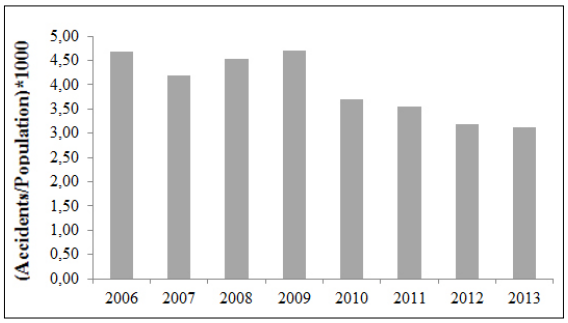

Fig. 3 Index of road accidents

Then we will analyze the trends of some sustainable mobility indicators over the years to evaluate the effectiveness of interventions suggested by plans and programs for the metropolitan area. According to a survey (Testa, 2013), between 2002 and 2013, the rate of motorization decreased by 15%, and in 2011 it is the lowest, after Genoa and Venice, among the 10 Italian metropolitan cities. Moreover Bari is the metropolitan city with the lowest percentage (36%) of ecological cars, followed by Naples (29%) and Reggio Calabria (32%). However, the growing trend of green cars (Figure 4) is probably due more to the replacement of old cars with new ones (Euro 4 or higher) than to the few traffic limitation actions in restricted traffic zones.

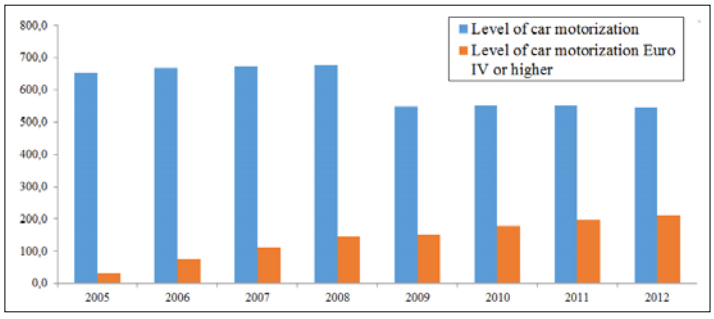

Fig. 4 Comparison between level of motorization and level of motorization Euro 4 or higher

Therefore, car use reduction can have affected on the decrease of road accidents' index; indeed, in the metropolitan area, between 2006 and 2013, accidents have decreased by nearly a third (Figure 3). Therefore, even if the trend towards sustainable mobility is positive there will be satisfactory results only when the planned measures will be implemented.

4.3 SUSTAINABLE MOBILITY MEASURES IN THE CITY OF BARI

Sustainable mobility measures implemented by the City of Bari since 2004 represent a good integration model for public transport and parking policies. This system has gradually reduced car flows within the city by promoting modal interchange (Gargiulo, 2014).

The main measures have been:

- the construction of 4 peripheral "park and ride" lots linked to the city centre by three bus lines served by electric shuttles;
- the implementation of an overall parking system through the development of an integration model which combines public transport and parking policies and the introduction of a parking pricing zones (ZSR);
- the introduction, in 2007, of restricted traffic zones (ZTL) in the city centre;
- the implementation since 2007 of bike sharing service. Today it counts 31 stations installed next to the main attractors.

Furthermore, in 2006 the Municipality of Bari adopted the Environmental Energy Plan; in 2010, the Municipality joined the Covenant of Mayors that entails the implementation of the Plan of Action for Sustainable Energy (PAES). This Plan sets targets to achieve in 2020 in terms of reduction of CO_2 emissions by 30% (328,698 tons CO_2), compared to 2002. The measures planned by the SEAP in the field of urban mobility were in particular:

- the increase of bike-sharing stations (1300 bikes in 2020);
- the expansion of the cycle paths network (90 km in 2020);
- the construction of new "park and ride" lots;
- the implementation of electric car sharing;
- the promotion of walk modes;
- the introduction of Zone 30, in which the vehicle's speed will be limited to 30 km/h;
- the enhancement of rail transport;
- the replacement of municipal vehicles with low-emission vehicles.

In the following part of this section, the evaluation of the effects of measures will be conducted through the construction of a set of control variables, which have been selected in order to understand whether measures have affected, and in which way, the sustainability of mobility. Istat databases (Indicators on urban transport) have been used for the selection of the indicators. Moreover, the time reference considered (2000-2011) is long enough to read the effects of practices on increasing sustainable mobility, particularly in reference to reducing vehicular congestion levels.

In Table 5, data referred to the control variables have been reported. Every column records data by year whilst the three last columns record the percentage variation of three time references:

- 2000-2005, before the implementation of measures, by the city administration, aimed at bringing benefit to circulation and livability of the city;
- 2006-2011, in which effects of technical solutions towards a more sustainable mobility can be registered;
- 2006-2011, in which the total variation is recorded.

CONTROL VARIABLE	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	VAR. % 2000-2005	VAR. % 2006-2011	VAR. % 2000-2011
Public Transport Demand (PT passengers per year per inhabitant)	56.2	57.8	61.1	58.5	57.6	53.5	55.1	64.9	70.0	76.1	79.2	61.5	-4.7	11.8	9.5
Density of bus networks (km per 100 sqm of municipal area)	234	234	234	234	234	234	234	225	238	251	242	242	0.0	3.3	3.3
Availability of buses (vehicles per 10,000 inhabitants)	6.5	6.7	7.1	6.9	5.4	5.2	4.4	5.5	6.6	7.3	7.3	7.3	-20.3	67.5	12.9
Places-km offered by buses (millions)	843	876	883	881	848	912	907	995	1001	1020	1017	1017	8.2	12.2	20.7
Density of bus stops	26.9	26.9	26.9	26.9	26.9	26.9	26.9	27.9	30.0	30.2	26.2	26.2	0.0	-2.4	-2.4
Availability of pedestrian areas (sqm per 100 inhabitants)	9.3	9.5	10.9	10.9	10.7	10.5	10.5	10.6	16.1	16.2	16.2	16.2	13.0	54.0	74.9
Parking lots with fee (for 1000 cars in use)	11.6	11.5	17.8	17.7	16.2	16.1	15.9	15.9	18.7	18.8	35.9	36.0	38.5	126.3	210.4
Density of cycle paths (km per 100 sqm of municipal area)	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	6.5	6.5	6.5	7.5	0.0	59.1	59.1
Level of car motorization (cars per 1.000 inhabitants)	536	556	577	580	555	549	557	561	564	566	566	565	2.4	1.5	5.4
Level of motorcycles' motorization (motorcycles per 1,000 inhabitants)	53.2	61.3	68.8	74.8	76.0	80.9	86.9	92.4	98.0	103.7	106.4	107.3	52.0	23.5	101.6
Vehicular density (vehicles per 1 sqm of municipal areae)	1874	1913	1951	1970	1932	1968	2002	2016	2032	2015	2022	2018	5.0	0.8	7.7

Tab. 5 Summary table of the control variables of sustainable mobility

Table 5 illustrates that in the first time reference, the demand for public transport (number of passengers who used the local public transport) had a decreasing trend (-4.7%), whereas since 2006, after the opening of the first park and ride lot, there was an increase of around + 12% with a peak in 2010. Consequently, also density of bus networks, which went up of +3.3% between 2006 and 2011, has been positively affected by measures, implemented by municipalities, to reduce vehicular congestion of central locations.

Therefore, the trend analysis on the availability of public buses demonstrates the institutional interest in promoting the use of the collective modes of transport carried out since the middle of the first years of 2000 (+ 67.5%); by contrast in the previous years, it scored a sharp decline (-20.3%). It is also clear that public transport supply in the City of Bari, expressed in terms of seat-kilometers, grew up with reference to the bus service, with a restrained pattern in the 2000-2005 time reference (+ 8.2%) and a more significant one in 2006-2011 (+ 12.2%). By contrast, density of bus stops recorded, in the first stage, a steady pattern and then a drop (-2.4%), probably due to the pedestrianization of some areas of the city centre.

Overall, it can be said that the goal of reducing emissions related to vehicle traffic has resulted in a wide range of measures to discourage car use, such as creating pedestrian areas, fixing fees for some parking areas of the city center or designing cycle paths in order to rehabilitate degraded roads and increase the number of systematic travels by bike for commuters.

Furthermore, the introduction of restricted traffic zones (ZTL) and the promotion of walk modes has led to a 54% increase in the availability of pedestrian areas within the City of Bari, between 2006 and 2011. Meanwhile the introduction of parking pricing zones (ZSR) has produced a noticeable increase by 126.3% of the parking areas: the rate of parking spaces per 1,000 inhabitants rose up from about 12 in 2000 to 36 in 2011. Table 5 shows also that the kilometers of urban cycle paths have increased by about 60%, thanks to the implementation of bike sharing service. However, in the city of Bari, the creation of park and ride lots, the introduction of the ZSR and ZTL had no significant effect on reducing the rate of motorization that remains almost constant, registering a slight increase of 2.4% between 2000 and 2005 and of 1.5% between 2006 and 2011. By contrast, a growth in motorcycles per capita can be stated; they grew in the first time reference (+ 52%) and lowered in the second one (+ 23.5%). This may be linked to the introduction of some "green streets" within the urban center, where only mopeds, motorcycles and bicycles are allowed to circulate. Finally, with regard to the vehicular density pattern in the decade analyzed, the

relationship between the vehicles in circulation and the municipal area of Bari records a growth rate of + 5% until 2005 and of +0.8 % in the following five years.

After that, some of the variables analyzed have been standardized, according to the equation:

$$z = x_i = \frac{x - \bar{x}}{\sigma}$$

where $\bar{x}$ and σ are respectively the mean and standard deviation of the considered variable in 2001-2011 time reference.

First of all, by charting the standardized values of demand and supply of public transport in the city of Bari, it can be observed (Figure 5) that since 2000 to 2004, demand is greater than supply; since 2004 the public transport demand decreases until 2005 when it has a continuous and significant rise until 2010. With regard to public transport supply its rate considerably grows between 2004 and 2007, probably due to measures aimed at improving TPL service implemented by the municipality, and reaches a stable value over time since 2007 onwards.

Subsequently, by comparing the trends of the "positive" variables, pedestrian areas and density of cycle paths, with the "negative" one, which is the motorization rate, it can be said (Figure 6) that citizens of Bari since 2004 own substantially less cars than in the previous years and they probably make less use of private modes of transport. Since 2007, when ZTL was introduced and bike sharing was implemented, the amount of pedestrian areas and cycling routes, to be used to move within the city, has changed over time, starting with a medium-low trend until 2007 and having a considerable increase between 2007 and 2008.

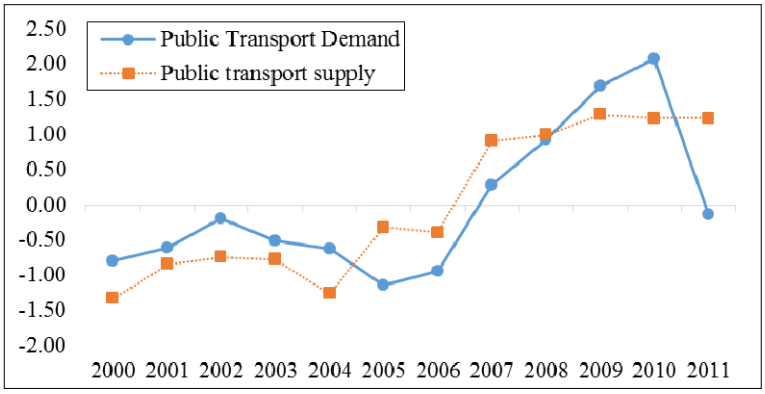

Fig. 5 Comparison between public transport

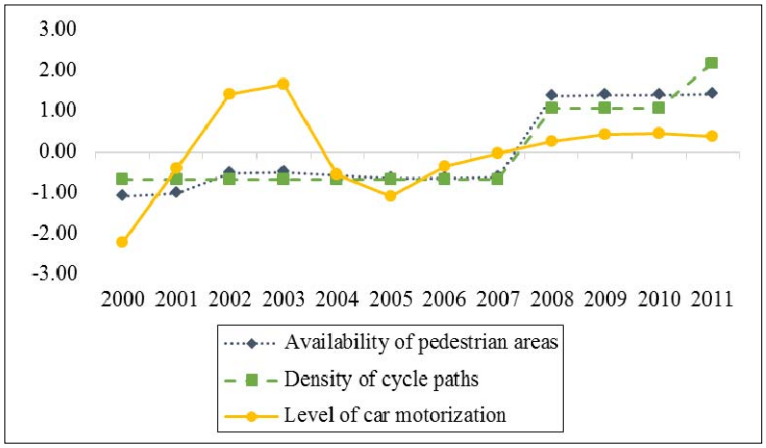

Fig. 6 Comparison between availability of demand and supply pedestrian areas, density of cycle paths and level of car motorization

Finally, by comparing two factors which help to understand some aspects about the evolution of the phenomenon of vehicular congestion, it can be seen that the trend of the supply of parking areas grows in the years 2000-2002, it is stable up to 2009, and, after the introduction of parking pricing zones (ZSR), it records a remarkable increase, between 2009 and 2011. Vehicular density, except for 2004, has a steady but significant rise until 2008, when it begins to decline (Fig. 7).

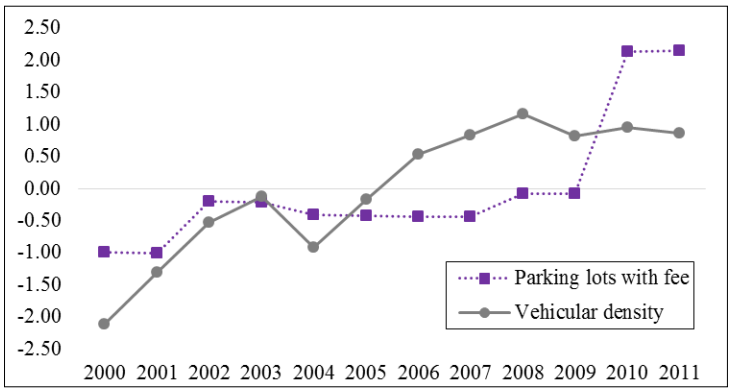

Fig. 7 Comparison between parking lots with fee and level vehicular density

To conclude, Bari instance shows that policies, which provide for measures aimed almost exclusively at implementing an overall parking strategy may promote behavioral changes for citizens, a more efficient use of the entire transport system, the reduction of traffic congestion and the gain of positive results in terms of environmental livability of urban spaces (Papa, De Caro 2009).

4.4 SMART MOBILITY SOLUTIONS IN THE CITY OF BARI

In recent years, the paradigm of sustainable mobility has gradually been linked to the most innovative smart mobility in the international debate. Smart mobility is part of the more general paradigm of Smart City, by which we mean the set of policies, plans and projects that aim at raising the quality of urban life by using ICT and forms of participatory governance (Papa, Niglio 2014). One of sectors of Smart City in which the city of Bari is more active is the Smart Mobility one.

By Smart Mobility (Manville et al., 2014) we mean ICT supported and integrated transport, which is also sustainable, safe, interconnected and multimodal. Smart can be considered a clean mobility, not motorized, supported by real-time information more accessible to users, in order to save time and improve commuting efficiency, save costs and reduce CO_2 emissions.

Moreover, smart mobility is able to give relevant information to the operators of transport networks as well as to users, who might also provide their own real-time data and contribute to long-term planning.

It is estimated that smart mobility technologies can increase energy efficiency by 20% and reduce vehicular congestion by 15% (TTS Italia, 2010).

More concretely, smart mobility solutions, underway and/or planned in Bari area, consist principally in technological innovative products and research projects, promoted by local authorities and municipal companies and implemented thanks to the technical and scientific support provided by local excellence companies. They are:

- SEMINA (Evolved Systems for Intelligent Mobility in Agile Networks), a research project aimed at developing an information system for the management of sustainable mobility in urban areas, provided through web portal, apps for smartphones and tablets, information panels and social network. Thanks to SEMINA, users can monitor the arrival time at the bus stops, technicians may reprogram the service, car users are able to control the traffic situation, municipal police can detect level of congestion and, finally, Mobility Office might manage actual and updated plans for urban mobility;

- Get Easy Bike, an experimental research project dedicated to the development of a new generation of bike sharing that allows a community of cyclists to share bikes, own or collective. By using Get Easy Bike people can move within a given urban area without the constraints (and the costs) generated by the presence of picking and release stations which characterize the traditional systems of bike sharing. Get Easy Bike represents a new model of user generated, virtual and interactive bike sharing. It is based on the balance of three distinct but linked components: technological innovation, mobility analysis and public participation;
- Bari Digital, a mobile ticketing system for public transport which allows to pay parking fees directly from your smartphone;
- Bari Smart, an app that provides a geo-location function, which is useful for orientation and to find the nearest bus stops. It also makes possible to consult timetables and bus lines;
- Project Summit - Sustainable Urban Mobility, a project that aims at creating a network among Apulian and Greek port cities. It also attempts to rise accessibility to urban centers through the introduction of innovative solutions for sustainable mobility;
- CiELo – City-port Eco Logistics, a project that aims at enhancing the accessibility of the city center of Bari, through the introduction of innovative solutions for mobility;
- BariMo, a car sharing service which is still in a pilot stage. It will provide electric, hybrid, LPG and CNG shared cars, available 24 hours a day.

Another important thing that needs to be taken into account is the installation, which has still not been completed, of infrastructures for recharging electric cars which can be used through prepaid cards.

According to the study "Mapping Smart Cities in the EU", published in 2014 (European Parliament's Committee on Industry, Research and Energy) (Manville et al., 2014), evaluating factors that contribute to the successful deployment of smart solutions are:

- a clear *vision* which sets high level principles and ensures measureable targets (*Vision*);
- participation of both relevant stakeholders and citizens. The first one ensures a high degree of coordination, the access to relevant information and the potential to influence processes and decisions on this issue while the second one means more opportunity for people to participate directly (*People*);
- an effective and successful process management of all the phases (information, guidance, practical support, evaluation and measurement of targets) provided for the implementation of solutions (*Process*).

In the following part of this section, we will focus on the described smart solutions to identify the potential or effective success by assigning different emphases, such as strong (+), average (o) and no emphases (-).

SOLUTION	SUCCESS FACTORS		
	VISION	PEOPLE	PROCESS
SEMINA	+	+	+
Get Easy Bike	+	0	+
Bari Digitale	+	+	0
Bari Smart	0	+	0
Progetto Summit	0	+	-
Cielo	0	0	-
Barimo	+	+	+

Tab. 6 Overview of success factors for the smart solutions implemented in Bari

Overall, it can be said that in Bari a business model, which includes the active involvement of citizens and all relevant stakeholders (governments, institutions, researchers, companies, professionals), has been put in place in order to test integrated systems of technologies and innovative methodologies to support smart mobility paradigm.
Although the case studies demonstrate that it is still early days for truly smart solutions, it is clear that some solutions, such as SEMINA, Get Easy Bike, Bari Digitale e BariMo, have considerable potential for success. This may be attributed to clear, shared and well defined objectives. Meanwhile other projects (Bari Smart, Project Summit, CiELo) appear to have less emphasis due to a low level of implementation of single process steps, to the reduced scale of reference, for the lack of financial instruments or to low level of technological and social innovation.

5 SUSTAINABLE URBAN MOBILITY TOWARDS SMART MOBILITY

The review of strategies, programs and measures aimed at improving the sustainable mobility of the case-study area, together with a short report of smart mobility solutions, shows a comforting picture. It is focused on matching the local strategies to European programs.
Regional policies, despite the uncertainty on funding perspectives, consider sustainable mobility as a priority area for measures, to be developed in all the different sectors of the transport system. At the metropolitan scale, the approval of two government instruments for mobility, such as PUM and PMS, has been the starting point for the transformation of Bari metropolitan area towards sustainability. Their first positive effects can be revealed by the analysis of recent years' trends for some relevant mobility indicators. The example of Bari shows how measures, aimed at reorganizing the transport system, may encourage behavioral changes for users, a more efficient use of the whole mobility system, and, finally, a reduction of traffic congestion. Yet it may positively affect both environmental protection and quality of life in urban areas. Moreover, smart solutions show that the use of high-technology devices for traffic control, to implement forms of share mobility and to provide info-mobility and mobile-ticketing, may represent a typical measure. Even though smart solutions have not yet measurable effects, they may trigger behavioral changes towards a smarter mobility.
Response times of "self-organized complex systems", to which contemporary cities may certainly be assimilated, do not allow to make scientifically recognized and above all stable considerations, in a too short time reference as that concerned in this work. However, by a preliminary qualitative and quantitative assessment, we can say that shared and coordinated strategies, as part of a global policy framework, seem to achieve significant improvements towards the sustainability of mobility, especially if they are pursued with determination and without interruption.
Conversely, we cannot say the same about "smart mobility" solutions. In most cases, they represent isolated initiatives, without indispensable scientific and disciplinary quality criteria. They seem to be promoted for "making headlines" rather than to find stable solutions in a coordinated framework of measures linked to programs and/or plans for urban mobility.
Even more worrying is the spread of the use of high-tech devices. They need sophisticated management systems and have operating costs which seem to be not comparable with the ephemeral benefits that they provide for. Undoubtedly, it is difficult to measure the real effectiveness of these solutions, if not in terms of the consensus achieved by the local authorities and in budget increase of sellers companies. However, smart mobility solutions may represent a valid support for sustainable mobility planning strategies only if they are coordinated and integrated with the urban transformation governance. Furthermore, they should be used as instrumental support to "traditional" strategies that so far have been developed and tested in the technical-scientific and professional background.

However, by the results of this work it can be said that the actual positive trends certainly represent a starting point for the next phases of the transition process toward a more sustainable mobility. This process ought to include:

- short, medium and long-term measures within mobility plans, with particular attention to land use-transport integration;
- the monitoring of positive and negative effects of choices in the transportation system on environment, safety, economic development, livability, equity and social acceptance;
- an efficient management of the mobility demand which takes into account change modal shares, in the short and long term;
- the development of policies promoting the use of public transport (Transit Oriented Development)
- the promotion of electric and hybrid cars through, for istance, the realization of preferential lanes and infrastructures for recharging electric cars;
- the use of information technologies, including info-mobility in order to maximize urban road network capacity.

The inclusion and integration of measures, which are already in place or still to be programmed, within general, achievable and assessable projects, may represent a valid response to manage mobility strategic priorities. From this perspective it is certainly desirable to introduce a central technical structure for sharing knowledge and monitoring results that also make an efficient use of European funds (Marletto, 2006; FCF, 2013).

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AUTHORS' PROFILES

Raffaella Niglio

Architect, she received a master's degree with honors from the University of Naples Federico II with a thesis in Architectural and Urban Design (project for a sustainable university residence and masterplan for the urban regeneration of a part of the industrial area of Marghera, Venice). She operates in the field of sustainable buildings and environments and since 2014 she works with the Department of Civil , Architectural and Environmental Engineering withinin the research project Smart Energy Master investigating the "smart" performance of the Metropolitan City of Bari.

Pier Paolo Comitale

Engineer, he received a master's degree in Civil and Transport Engineering from the University of Naples "Federico II" with a thesis on "Mobility Management to support the development of sustainable mobility in urban areas. State of art in Naples". He is currently involved in the research project "Smart Energy Master". His research activity is aimed at drafting guidelines for the implementation of innovative Smart Mobility measures for urban areas, in Italy and in Europe.