Urban transport for a more sustainable mobility

Successful solutions from international good practices

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ABSTRACT

Recognizing the crucial role of mobility in cities' management, towards a people-oriented urbanism and more sustainable future, this research explores good practices and indicators as theoretical reference platform on sustainable mobility. Based on this theoretical framework, the research identified three international case studies of recognized success in terms of mobility policy and strategies, set as good practices.

It is sought to understand the type, structure and operation processes of good practices in these case studies with a metropolitan dimension according to more sustainable mobility objectives. It's performed a comparative analysis, qualitative (goals, levels, and results) and quantitative (main indicators) to extract the main good practices.

Successful solutions obtained by the study of good practices can help clarify planning processes towards the future of cities. In the current context of contraction investment and changing *urban paradigm,* it is suggested a theoretical framework adopting good practices to Lisbon Metropolitan Area, towards a more sustainable mobility model.

Keywords: Cities, Sustainable Mobility, Modal Share, Public Transportation, Active Modes

1 INTRODUCTION

The evolution of cities benefits from a dialogue between technological advances with strong impact on urban infrastructure and social changes with a strong impact on the citizens' quality of life. On this diachronic evolution, due to the industrial revolution cities underwent a massive growth, starting a path of unprecedented global urbanization.

The increasing complexity of urban systems is associated with car use, particularly when cities acquire metropolitan dimension where modal share dominated by it. This leads to removing competition to the urban transport system, compromising accessibility levels for basic functions and support of economic activities and decreasing levels of efficiency. At the same time, these urban systems contribute to: high levels of greenhouse gas emissions into the atmosphere, (with serious consequences for the health and well-being of citizens), and high levels of inactivity (with high rates of obesity and overweight).

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In the current context of economic contraction and the new urban paradigm, cities are faced with the challenge of making a change towards sustainable mobility policies.

2 OBJECTIVE

The overall goal of this research is to seek the current understanding of sustainable urban mobility. To do so it is considered the cities growth theory and their challenges, as well as some good practices that promote adequate and effective results towards sustainability.

The first milestone is to characterize the three international reference cities – Portland, Stockholm and Singapore – and to analyze and compare good practices. The focus will regard the increasing share of public transportation (PT) and active modes, and the reducing of car use, based on key urban and mobility indicators.

The second milestone is to give a theoretical contribution to the mobility policy in Lisbon Metropolitan Area (LMA). The purpose is to identify good practices that can favor a systemic and qualitative change in the modal share, with the benefit of the use of PT aiming at a more sustainable mobility.

3 STATE OF THE ART

3.1 THE CHALLENGES OF CITIES AND KEY TRENDS

The segregated urban cities growth led to the massive car use, which stems from the theoretical references of *Le Corbusier* in 1928[2] and *Frank Lloyd Wight* in 1934[3], leading to the creation of suburbs.

From the decline of North American neighborhoods, emerges strong opposition by Jane Jacobs in 1962[4], with a new urban theory based on the diversity of uses, leading to rethink cities.

The sustainable development begins to be discussed in the '60s by the Club of Rome, becoming known with the publication of "*The Limits to Growth*" in 1972. It is through the document "*Our Common Future*", also known as the *Brundtland Report*, in 1987, that the concept of "sustainable development" was adopted as "development that meets present needs, without compromising the ability of future generations to meet their own needs".

A more sustainable mobility system is a contribution to more efficient cities, where people live better with less pollution, less car dependency, with greater use of PT and active modes. Cities should evolve in such a way that no longer promotes the car fetish (Whitelegg, 2015).

The path of sustainable urban mobility gives today's cities a number of challenges that can be highlighted as follows:

- Avoiding extending urban sprawl and redirect investment to densify cities is not only an environmentally objective, but also a promoter of economic growth (Glaeser, 2012);
- Reduction in road accidents in urban areas, improving the safety of citizens;
- Car demand reduction and promoting pedestrian and cycling trips, refocusing priorities on PT and active modes through the planning and redesign of cities (CCE, 1990)., in the light of the *proximity urbanism*;

[2] Within the modern movement, Le Corbusier comes up with "*Urbanisme*" in 1928, and with the "*Cité Radieuse*" in 1935;

[3] The "*Masterplan for Broadacre City*" in 1934 although it has not been implemented it influenced the onset "urban sprawl" of North American suburbs.

[4] With the book "*The Death and Life of Great American Cities*".

- Making the most efficient urban system energy consumption, the reduction of CO_2 emissions and dependence on fossil fuels through smarter and greener vehicles, and the use of information and communication technologies (ICT).

The answers to the cities' challenges may include new approaches in management and mobility planning (Macário, 2011), revitalization of cities public spaces in order to accommodate integrated coexistences of alternative transport modes (Newman & Kenworthy, 2015), introducing changes at the local level, block and neighborhood with *urban acupuncture* interventions with diffusers effects (Lerner, 2014), and a vision of smart streets, flexibility, comfort and safety, which are extremely attractive and dynamic for livable cities (Schwartz, 2015).

3.2 GOOD PRACTICES AND INDICATORS

In this research, it is proposed to trigger the analysis of good practices in various contexts and not necessarily similar or comparable to the context of the LMA, in order to gather a set of good examples that lead to a more sustainable urban transport system.

Indicators should be chosen taking into account their relevance to the issue at hand, existing background information, comparability, easily identifiable and interpreted. The key indicators were selected (Table 1), and given time series, with a maximum span of 10 years, the evolution of some of this indicators is compared.

Table 1 – Key indicators selected to compare case studies

Indicator	Theme	Definition and components
Modal share	Transports	% of trips made in each of the transport modes (motorized and non-motorized) in a given geographical area
CO_2 Emissions	Environment	Million ton per year or ton/inhabitants
Accident injury	Road safety / Health	Nº victims (killed and seriously injured) in urban areas

As referred by Davis, 2014, the performance of an urban transport system using health indicators is becoming more relevant however the practice of this association has not yet become widespread. Indeed, the case studies do not determined in sufficient detail the evidence of the correlation between the transportation system and health indicators.

3.3 SOME EVIDENCES OF GOOD PRACTICES

In cities, the bicycle is in fact a viable alternative and with advantages to cars in many trips. Taking into account that in Europe about 50% of urban journeys are less than 5 km long, it can be concluded that, in most cases, the bicycle is a means of transport as fast as the car (time reckoned from door to door) (DG Ambiente, CE, 2000).

The weight of the bicycle in the model share is above 20% in some European cities, such as: Münster and Karlsruhe in Germany; Lund and Malmö in Sweden; Copenhagen in Denmark and; Amsterdam in the Netherlands. The increase of bicycle use in these cities is due to: building safe and functional cycle lanes networks, supported by parking structures, integration with PT through *bike & ride* systems (parking next to transportation interfaces), as well as information campaigns to capture new users (EPOMM, 2013).

It seems evident that the increase in transit ridership and active modes has an effect in reducing the end consumers' energy bill, and at country level it reduces the energy importing requirements, particularly when this energy is based on oil. Now it is essential that energy efficiency is part of a

sustainable transport strategy and for that the demand for this energy source it must be reduced, encouraging the use of less polluting vehicles and more technologically advanced.

A built environment of mixed uses and a more urban densification, within what is known as *urbanism of proximity*, combines various urban functions, reducing the distances between them and promotes livable spaces. This environment is more likely to influence options for more sustainable travel modes, thereby stimulating the PT, travel by bicycle and walking.

Also new public road transport schemes known as Bus of High Level of Service (BHLS) increase the attractiveness of PT by improving the reliability of service, passenger information and marketing component.

One of the most known BHLS schemes is the *TransMilenio* in Bogotá, Colombia, Bus Rapid Transit (BRT) system with gains in terms of average travel speeds and increase in passengers, which was built on the successful experience in Curitiba, Brazil.

The report produced by COST, 2011 (*European Cooperation in Science & Technology*) described the implementation of various BHLS services in 35 European cities and analyzed them between 2007 and 2011. There have been verified that: (i) increase of ridership, when combined with cutting cost, contributes to the financial sustainability of PT; (ii) offer better service in terms of speed, comfort and reliability; (iii) lower fuel consumption; (iv) reduction in emissions, particularly when the fleet was based on green vehicles; (v) vehicle kilometers reduction made by private car.

With a view to reducing car traffic, especially at the level of city centers, and the increase in financing revenues of PT, some cities choose to implement demand management schemes such as *congestion charge schemes* or *specific fuel price increases*. Both schemes are based on price-demand elasticity studies, which determine the sensitivity of the change in demand in relation to changes in the price of the good or service[5].

Increasing fuel prices can be associated with reductions in consumption and traffic volume[6]. There are several studies on price-demand elasticity which state that 10% increase in fuel price will result in a reduction of consumption by 2-4% in the short term (about one year), and 5-8% in the long term (about 5 years) according to the authors Sipes & Mendelsohn, 2001; Graham & Glaister, 2002; Goodwin, Dargay, & Hanly, 2004 cited by the report Pub. Health & O. Univ., 2009. The volume of traffic will be reduced 1-2% in the short term and about 3% in the long run (Graham & Glaister, 2002; Goodwin, Dargay, & Hanly, 2004) according to authors quoted in the same report.

4 CASE STUDIES AND GOOD PRACTICES ANALYZES

4.1 CASE STUDIES ANALYZES

Portland, Stockholm and Singapore are the three case studies analyzed where it is demonstrated some good practices (GP) in terms of increase of transit ridership, reduction of car use, promotion of active modes and reduction of pollutant emissions. A brief characterization is performed in Table 2.

[5] Changing the transport supply conditions, particularly the modification of the monetary costs associated with commuting (...), for example, leads to changes in the demand, as users change their decision consumption due to the change of the perceived costs (Marques da Costa, 2007, p. 58);

[6] The value of elasticity is usually negative, since the demand for a good or service tends to decrease with the increase of the market price, either by the decline in consumption, as the replacement for other good or equivalent service (Marques da Costa, 2007, p. 59).

Table 2 – Case studies' region and city characterization

City / region	PORTLAND	STOCKHOLM (capital)	SINGAPORE (City-State)
Country	EUA (52 States)	Suécia (21 counties)	Singapore (1 Region)
Estate	Oregon (3 counties)	-	-
Region or metropolitan area	MA (3 counties)	Region centred na City de Stockholm	Singapore
Population *	State = 3.831.074 inhab MA = 2,2 millions inhab City = 583.776 inhab	- Region = 2,1 millions inhab City = 881.235 inhab	City = 5.312.000 inhab
Area*	State = 248.600 km^2 MA = 17.310 km^2 City = 344 km^2	- Region = 6.526 km^2 City = 188 km^2	City = 716 km^2
Population Density*	State = 16 inhab/km^2 MA = 129 inhab/km^2 City = 1.700 inhab/km^2	Region = 326 inhab/km^2 City = 4.687 inhab/km^2	City = 7.421 inhab/km2
Urban Structure	Located in the confluence of 2 rivers; reticulated structure	Comprising 14 islands; star structure	Consisting of a set of island
GDP per capita**	State = 23.950 € City = 28.440 €	Country Region = 62.300 € City = 64.300 €	City = 56.976 €
Motorised rate***	State = 336 vehicles/1000 inhab	Region = 452 vehicles/1000 inhab	City = 116 vehicles/1000 inhab

* Portland: http://quickfacts.census.gov/ 2010; Stockholm: Stockholm, facts and figures, 2013; Singapura:
** Portland: http://quickfacts.census.gov/ 2013; Stockholm: Eurostat 2013; Singapura: Index Economic Freedom 2013
*** Portland: http://www.oregon.gov 2014; Stockholm: Eurostat 2011 ; Singapura: www.lta.gov.sg 2013

The Stockholm and Singapore urban systems stand out for more favorable results in terms of their PT and active modes indicators, resulting from long-term investment on PT and its integration on land use planning.

The evidence in the case of Singapore demonstrate the effectiveness of PT investments, ensuring the expansion of the rail network and the growth of the bus fleet, increasing service levels in terms of frequency, speed and reliability while offering services to target different demand. Therefore, PT becomes competitive comparing to the car, attracts new users and keeps the growth of market share in relation to the PT.

Regarding Portland, it should be noted the growth of bike users between 2000 and 2009, which came following a coordinated policy of construction of cycle paths, parking facility for bicycles, promotion campaigns, users and potential users' surveys, as well as the integration with PT.

The relation between population density and the use of transport modes in Figure 1 suggests that cities with a denser urban system appear to induce to a more sustainable mobility showing high market shares of PT and active modes.

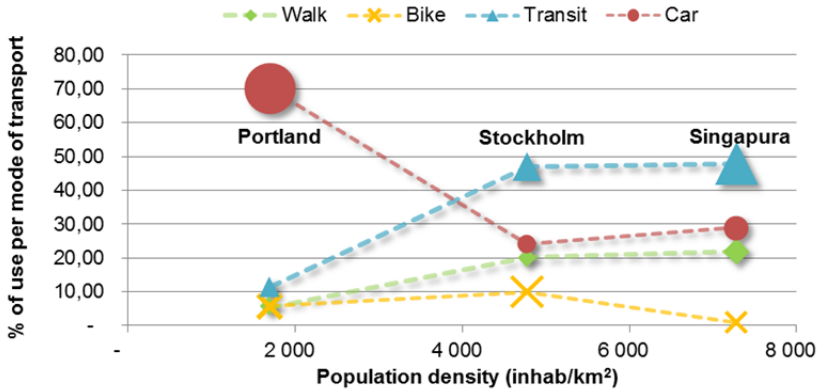

Figure 1 - Modal share vs. population density for the three case studies

4.2 COMPARISON AND ANALYZING GOOD PRACTICES

The GP implemented in each case study are systematized and organized by strategic areas of intervention in Table 3.

Table 3 – Good practices in each case study organized by strategic areas of intervention

Intervention areas	Good practices	PORTLAND	STOCKHOLM	SINGAPORE
Governance	**B1.G** Long term visions and strategies in the field of sustainability		X	X
	B2.G Authority with responsibilities at the level of transport and land uses	X		X
	B3.G Effective communication with citizens	X		X
	C1.G Updating plans preceded by technical studies, benchmarking and surveys	X		
Spatial planning	**A1.O** Transit-Oriented Development (TOD)	X	X	X
	C2.O Structuring large green areas		X	
Transports (infrastructures and services)	**A2.T** Investment in BHLS	X	X	X
	B4.T Construction and expansion of cycle network	X	X	
	C3.T Increasing the efficiency levels of transit			X
Mobility	**A3.M** Promote the purchase of friendly vehicles	X	X	X
	B5.M Congestion charge system		X	X
	B6.M Implementation of bike share schemes	X	X	
	B7.M Traffic calming measures	X	X	
	C4.M Restricting the ownership and use of motor vehicles			X

Legend: A common to three B common to two C restrict to one

It stands out that Transit Oriented Development (TOD) is referred as a GP in the three case studies, although regarding their urban structures it seems to suggest that has emerged more entrenched in Stockholm and Singapore. Nevertheless, according to the research carried out these principles were also observed in the implementation of the new *Streetcar* in Portland.

It should be noted that in the three case studies it was implemented new Bus of High Level of Services between 1999 and 2001, which led to restructuring the existing PT network.

Briefly, in Figure 2 are the main achieved goals and the good practices associated with each of them.

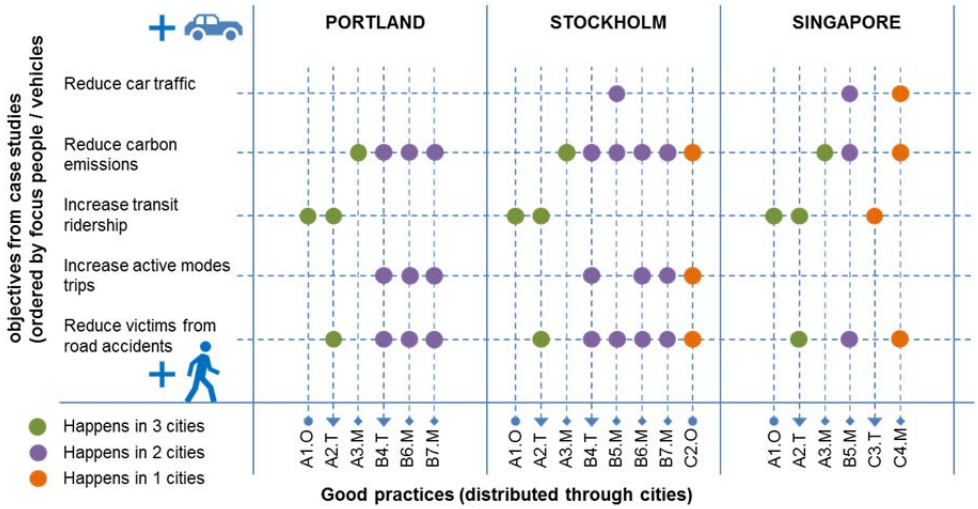

Figure 2 - Relation between good practices and the achieved goals

Regarding the objectives of "reducing carbon emissions" and "reducing victims from road accidents", the relationship suggested with each GP in Figure 2, is based on the assumptions described in Table 4, indicating the direct or indirect effects that a particular set of GP can have in achieving those goals.

Table 4 – Theoretical assumptions of the direct or indirect effects of good practice

		Directs or indirect effects	
Objectives	**Reduce carbon emissions**	The theoretical assumption that having more trips made by bicycle, there will be reduction in car use	Fewer cars in circulation will reduce congestion, which contributed to lower CO_2 emissions.
	Reduce victims from road accidents	According to the direct correlation between urban systems with increased use of bicycle and those with a smaller number of victims of road accidents in urban areas.	Releasing public space for other uses, prioritizing pedestrian trips, bike lanes and PT will have practical consequences in reducing conflict between pedestrians and vehicles.
		GP which incentive active modes	**GP which incentive the car traffic reduction**

The performance of the three analyzed urban systems is systematized through the indicators for each goal, which translates the results of each good practice. The used data is based by parameters extracted from the findings on the documents analyzed in each case study and its calculations.

Table 5 - Some performance indicators of three case studies

Goals	Indicators	PORTLAND	STOCKHOLM	SINGAPORE
Increase in transit ridership	% PT	11,5% (2009)	47% (2014)	48,00%
	Smart card use (cards/capita)	-	0,6 (2014)	2,9 (2014)
	Transit ridership evolution (%)*	-6% (between 2000 e 2009)	97% (between 2004 e 2014)	97,10%
Reduce car traffic	% of car traffic reduction	9 to 12% (year 2006)**	22% (between 2007 e 2010)	From 3% to 0,5% (entre 1990 e 2013)***
Increase active modes trips	% active modes	11,5% (2009)	30% (2014)	23,00%
	Bike trips evolution (%) *	230% (between 2000 e 2009)	196% (between 2004 e 2014)	-
	Cycle paths density (km/ths km^2)	1.424	4.041	280
Reduce CO_2 emissions	Emissions per inhab evolution (%)	-14% in relation to 1990	-25% in relation to 1990	-
Reduce traffic victims	Traffic victims (Death/Millions inhab)	33,9 (2008)	9,4 (2013)	29,6 (2013)

* The evolution of indicators with the exception of Singapore is based on market shares and not absolute figures.
** Through the Smart Trips program and limited to a certain area.
*** The reduction is in relation to reduction of traffic volume increase.

5 CONTRIBUTIONS TO GOOD PRACTICES APPLICATION IN LMA

From a theoretical approach of GP application is intended to formulate a strategy, identifying some GP that good fit in the context of LMA, and at the same time understands at what extent to which it may be applied, taking into account the constraints in the LMA, and the main challenges and strategic objectives towards a more sustainable transport system.

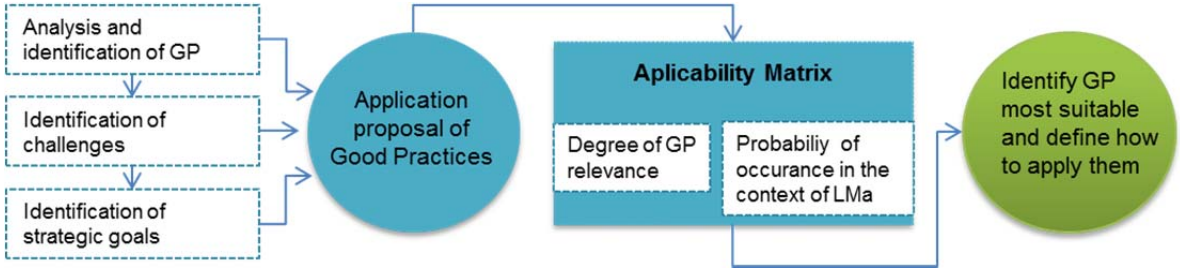

Figure 3 – Path to determine Good Practices

Between 1991 and 2011, major changes occur, with regard to the modal share of LMA where the car's market share increased from 22% in 1991 to 51% in 2011, and PT's share reduced from 47% to 29%.

A long with urban and demographic factors, the key challenges and the following strategic objectives will set the basis of application of good practices (GP):

Challenges of LMA

Recover the loss of public transportation passengers.
Reduce congestion at Lisbon entrances and exits.
Take advantage of the potential growth of travel by bicycle.

Strategic Goals

1. Increase in transit ridership
2. Car use reduction
3. Increase trips in active modes

The theoretical methodology for applying a particular GP to the LMA context, should take into account (i) the degree of GP relevance in achieving the objectives and (ii) the probability of occurrence in the context of LMA, according to institutional, financial or organizational factors.

According to the identified goals, it is shown in Table 6 the GP probability of occurrence, involving the following criteria:

- High = 7, as they are already applied in LMA with greater or lesser intensity and efficiency;
- Moderate = 5, there are application conditions, although there may be constraints from the institutional, organizational and financing point of view;
- Weak = 3, to the extent that there are strong institutional / organizational and funding constraints.

Table 6 – Analysis of good practices for LMA according to the set goals

	Goals outlined			Analyses for LMA	
Best Practices	**Increase in transit ridership**	**Car traffic reduction**	**Increase trips in active modes**	**Medium-Long term (L) or short term(S)**	**Probability of occurence**
Long term visions and strategies	9	9	7	ML	3
Authority with transport and land uses competences	7	7	3	ML	5
Effective communication with citizens	7	7	7	S	7
Updating plans with strong effectiveness	3	3	3	S	3
Development TOD	9	7	7	ML	3
Structuring large green areas			7	ML	3
Investment in BHLS	9	7	5	ML	3
Increasing the efficiency levels of transit	9	3	3	S	5
Construction and expansion of cycle network	3	3	9	ML	7
Congestion charge system	3	9	3	S	5
Bike share schemes	3	3	9	S	7
Traffic calming measures		5	9	S	7
Restricting the ownership and use of motor vehicles		9		S	3

Relevence of Good Practices in achieving the goals: High Relevant: 9 | Relevant: 7 | Neutral: 5 | Probable but unknown: 3
Probability of ocurrence of Good Practices in LMA: High: 9 | Medium: 7 | Low: 5 | Unknown: 3

The consequences of the new regulatory framework for public passenger transportation are yet uncertain, in which has been transferred to municipality levels public transportation competences regarding municipal and inter municipal network. Some constrains relate to organizational framework and financing conditions are associated to low or moderate probability of occurrence in the context of LMA and reflected in Table 6.

It is worth mentioning the low probability of occurrence of public investment in *Bus of High Level of Services* (BHLS) due to the current economic situation and future perspectives. In this context, there is still room to invest in increasing service levels of existing PT network before those projects come to reality.

It is shown in Figure 4 the resulting matrix of crossing the two previously studied variables. It is determined that the GP able to be applied to the LMA are those located in the upper right quadrant (green boxes), combining both the maximum degree of relevance (High relevant) in the range of at least one of the goals and moderate to high probability of occurrence.

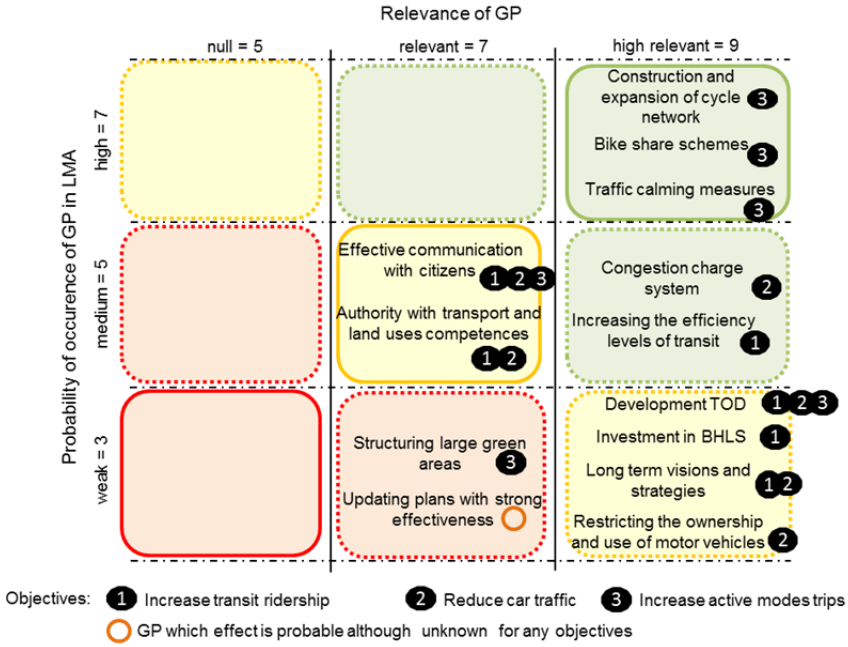

Figure 4 – Applicability matrix of good practices in the context of LMA

The increase in transit ridership can be achieved by "increasing the efficiency levels of transit". This GP can be applied, improving service levels subject to certain conditions of the new regulatory transport framework, developing the existing network, increasing the frequency, improving the interconnection between the different territories and the diverse modes of transport, with particular focus between modes with pre-set scheduling (boat/bus, train/bus). Additionally, it can be implemented through the construction of more PT dedicated lanes, improvements in the speed and regularity of services supplied and improvements in information and ticketing of the tariff system.

Regarding the car use reduction objective, it is proposed a *congestion charge system* that, theoretically, has a good chance of being implemented. It is believed that the greatest obstacles should be on the level of acceptance among citizens and political decision-making itself.

In order to offer its practical application it would be necessary to develop further studies, namely a cost-benefit analysis to assess the costs and revenues that such a system could generate in Lisbon.

Finally, the objective of increasing the active modes, it is proposed to implement a *cycling network* to a metropolitan scale, integrated with the PT system, along with parking spaces construction and *bike & ride* schemes strategic located nearby the public transport interfaces, commercial and leisure equipment's.

6 CONCLUSIONS

Mobility sector need to change in order to fulfil cities sustainability challenge. Additionally recent lack of investment produced strong impact on this sector.

Urban mobility, including PT system and active modes, should take part of metropolitan public policy agenda, where mobility should be achieved without compromising people' life quality. Regarding sustainable mobility principles, present challenge to this sector should consider visons and strategies for medium and long term, which ensure harmony and coherence. Since PT exist to serve people, to generate value for cities, and to support urban dynamics, they are essential to urban economy. Overall, urban transportation system is complex, with specific requirements such as strengthen (coherent and stability favor), adaptability (flexible to people' needs), diversity (tackling different

demands), and efficiency (ensuring operational reliability). However, an efficient urban system should be based in urban planning, understood as stimulation tool for the use of PT and active modes. Urban planning should shift cities towards sustainable mobility.

The cities with the best performance according to mobility indicators: Portland, Stockholm, and Singapore; was chosen as case studies. They present measures that obtain success, called as good for this research purposes. Conclusions from case studies analysis show that a new generation of policies must be created, due to sustainability agenda.

The challenges in the context of LMA are to recover transit ridership loss, take advantage from cycling potential growth, and reduce Lisbon entrance traffic congestions. Strong benefits are expected for people's health, air quality improvement and mobility safety, favoring urban regeneration opportunities and more tariff revenues of PT.

All efforts must be made so that successful solutions are implemented; meeting new business models that seek efficient solutions, and more results with less resources consumption. Such analysis was not studied in the present document; still recent alternative solutions like *Uber* should not be ignored. Maybe different business models could capture new target groups, improving competiveness to overcome car use dominance.

At LMA, the good practice suggested is the implementation of congestion charge schemes (traffic tolls to limit access to central areas) forcing strong private car use reduction. Still, it is expect that car use should be reduced whenever alternatives exist. These alternatives should be created through medium long term visions and programs, according to sustainable development principles.

In regions like LMA, sustainability agenda is still to accomplish. Nevertheless, the research made on successful case studies reveal that "change" in short period of 10 years period is possible, if PT and land use policies are convergent continuously at metropolitan system level.

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