



# Lifting peripheral fortunes: Upgrading transit improves spatial, income and gender equity in Medellín



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## ABSTRACT

New transit development often try to provide low-carbon mobility, and improve accessibility. However, it is often unclear who profits most from new transit developments, whether these transit developments can improve equity, and if yes, in which dimensions. Here we study the change in quality of life, instrumentalised as perceived and measured social capital, socio-economic well-being, and quality of public infrastructure after transit developments in Medellín, Columbia. We make use of a detailed questionnaire of 187 questions from 2009 and 2012, aggregate responses into 14 indicators, and compare changes in quality of life between three transit developments zones (comunas), three non-intervention zones, and between income levels and gender. We find that equity improved overall across geographical zones, income, and gender, even as changes in specific quality of life dimensions varied. Our results demonstrate that well-designed transit interventions and participatory planning processes can make cities not only more climate friendly but also more equal.

## 1. Introduction

Cities and municipalities have to pragmatically navigate multiple challenges and demands. Surprisingly often, urban development and redevelopment are structured around transport systems, including the build-up of European cities, like Berlin and London, around a new subway system, and the North-American suburbanization along highways (Cervero & Landis, 1995; Wolf, 1994). While transit-oriented development is as old as the streetcar, the modern usage was conceptualized by Peter Calthorpe in the North American context (Calthorpe, 1993). Successful examples and model projects include the transit systems in Curitiba, Brazil (Rabinovitch & Leitman, 2004), Arlington, and Denver, both United States (Ratner & Goetz, 2013), and Freiburg, Germany (Creutzig, Mühlhoff, & Römer, 2012). Worldwide, municipalities demonstrate an increasing or re-emerging interest in public transport and transit-oriented development (TOD) because it provides economic, social, and environmental benefits (Belzer & Autler, 2002; Bongardt, Breithaupt, & Creutzig, 2010; Bongardt et al., 2013; Creutzig & He, 2009; Curtis, Renne, & Bertolini, 2009; Newman & Kenworthy, 1999; Renne, 2008). However, most of these studies focus on the climate, environment, and health benefits of transit interventions. But - while less well studied - TOD also can shape citizen's quality of live and social interactions (Dempsey,

Brown, & Bramley, 2012; Glaeser & Gottlieb, 2006). This issue is of rising and profound importance because of two global trends. First, the rising global inequality (Piketty, 2014) leaves its particular footprint on cities, often discussed as gentrification (Holm, 2006; Kahn, 2007). Gentrification often pushes out the poor to the periphery of cities, and to districts with less transport access. Second, climate change is likely to hit the urban poor and women most, but also urban climate mitigation strategies will impact different segments of the population unequally (Reckien et al., 2017). These trends emphasize the value of identifying opportunities to render cities and the urban landscape more equal.

We use the case of Medellín (Colombia) to evaluate the social benefits of participatory TOD. Medellín has been widely used as a benchmark for its transit development in general and its urban planning in marginalized areas in particular (Blanco & Kobayashi, 2009; Brand, 2010; Dávila, 2014; Echeverri & Orsini, 2011; Fukuyama & Colby, 2011; Hylton, 2007). Empirical evidence demonstrates a reduction of violence and transport emissions (Cerdeña et al., 2012; Dávila, 2012a), but there is a lack of understanding how TOD influences equity and perceived quality of life in general. Our methods – based on data from the annual citizen survey - allow us to evaluate citizen's changes in socioeconomic variables, their perception of public interventions, and their social capita for two comparison groups according to their modal changes. By comparison, we evaluate equity outcomes for all variables across

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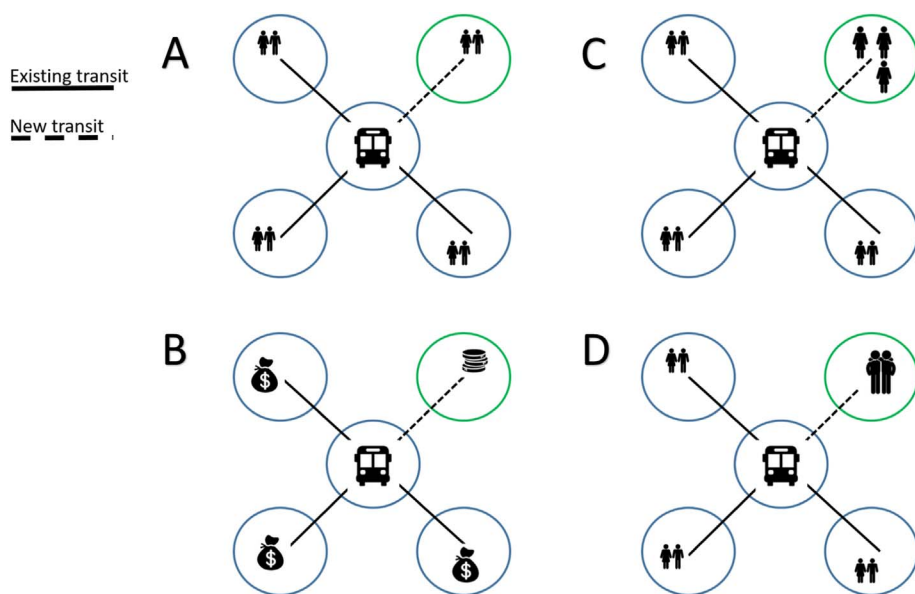


Fig. 1. Theoretical equity effects of transit-oriented development. A) Horizontal spatial equity: adding a new transit connection provides equal access to all areas. B) Vertical economic equity: the new transit line improves access specifically for the less well-off. C) Vertical gender equity: the new transit line helps women specifically. D) Vertical social equity: transit-oriented development improves the social capital of residents.

geographical zones, income groups, and gender.

In the following, we refer to the transit developments in Medellín as transit-oriented (re)-development, or TOD. TOD is often defined as an integrated urban development focusing on increased usage of public transport in area of plus or minus of 800 m around transit stations (Calthorpe, 1993; Dittmar & Poticha, 2004). Here we make somewhat wider use of that concept and refer to TOD as an integrated urban development concept, in which urban spaces and transit options are designed to increase the usage of low-carbon intensity transport modes while improving accessibility (Belzer & Autler, 2002; Curtis et al., 2009; Nahlik & Chester, 2014; Newman & Kenworthy, 1999; Rahul & Verma, 2013; Vickerman, 2008).

The structure of the paper is as follows: Section 2 reviews the literature on TOD and social capital, Section 3 introduces the case of Medellín; Section 4 explains the methods and data on which our research relies. Section 5 reports the main results, which are then discussed in Section 6 together with the conclusion remarks.

## 2. Social capital in transit development – an overview

Transit-oriented development can generate a number of different benefits. By modifying urban form and inducing modal shift, it supports climate change mitigation and can reduce congestion (Creutzig, 2014; Kahn Ribeiro et al., 2012; Lohrey & Creutzig, 2016; Sims et al., 2014), reduce health costs (Nahlik & Chester, 2014; Newman & Kenworthy, 1999; Rahul & Verma, 2013; Vickerman, 2008) but also household expenditures of passenger and goods transportation (Belzer & Autler, 2002; Newman & Kenworthy, 1999). If mixed land use is integral part, transit development may also enhance natural ecosystem's quality and increase location values (Dubé, Rosiers, Thériault, & Dib, 2011; Hasibuan, Soemardi, Koestoer, & Moersidik, 2014; Nahlik & Chester, 2014; Rahul & Verma, 2013). Moreover, well-designed transit systems attract additional investment, create jobs, and expand the catchment urban area, ultimately enhancing the regional competitiveness of the city (Knowles, 2012). However, the social and equity perspective of urban transport development has been less studied.

The majority of studies on equity and transit-oriented development, or transit projects in general, have focused on the North America setting, reflecting the origin of authors (e.g., (Cervero, 2004; Deakin, 2001; El-Geneidy et al., 2016). These studies reflect the North American land-use transport setting that is dominated by expansive cities and highway systems (Anas, Arnott, & Small, 1998; Gillham, 2002). Segregation dynamics had given rise to impoverished downtowns (Clark,

1986; Wylie & Hammel, 2004), a dynamic that partially reversed in the last decade, reflected in tightening real estate prices in inner cities (Burayidi, 2013). In this context, inequality in access is dominated by low-income groups that cannot afford cars, and those unable to use cars, such as kids, disabled, and seniors (Garrett & Taylor, 1999). Together with segregation dynamics, improving equity in access implies a focus of serving low-income areas with public transit (Garrett & Taylor, 1999; Martin, 1998; Nelson, Sanchez, Wolf, & Farquhar, 2004). However, this is an uphill battle as car dependency implies sparse transit networks that cannot profit from economics of density and scope (Creutzig, 2014; Frank & Pivo, 1994).

Other parts of the world have vastly different land-use transport settings, and hence, other challenges. However, studies on equity in transport are not frequent (but see, e.g. studies on Cali, Columbia (Delmelle & Casas, 2012); Copenhagen, Denmark (Kaplan, Popoks, Prato, & Ceder, A. (Avi), 2014), and Perth, Australia (Ricciardi, Xia, & Currie, 2015). More dense urban settings translate into better economics of public transit. In this context, the main equity challenge is less related to car ownership but is the spatial exclusion of areas not served by public transit. In Cali, Columbia, the provision of a bus-rapid-transit line increased access for middle income-groups but less for lower and higher income groups (Delmelle & Casas, 2012). In well-developed public transit systems, the inclusion of the physically disabled becomes a major area for equity improvement, e.g. by stairless access to transit systems (Grüber, Ackermann, & Spörke, 2011).

The literature suggests that equity improvements can be distinguished into different categories even as these are often overlapping (Kaplan et al., 2014). Horizontal equity concerns the equal provision of access for everyone; specifically spatial horizontal equity requires the equal provision of transit access to different spatial areas. In contrast, vertical equity specifically requires the improved access of those with fewer resources, such as income. However, there are additional dimensions in vertical equity. For example, women have sometimes less access to means of transport. In those situations, transit-oriented development can at least partially improve gender equity. But transit-oriented development is not only about an improvement of access. Depending on design solutions, and the process of execution (e.g., whether planning is participatory or not), transit developments can also improve the quality of the physical environment, and social capital. These different equity outcomes are conceptualized in Fig. 1.

Here we investigate all equity dimensions above, taking the provision of cable cars in Medellín as an example. Our emphasis is on the process-related outcomes, notably social capital that has previously

received very little attention. The Medellín case provides a useful case for such an investigation, as municipal decision makers of Medellín put social capital into the centre of their upgrading projects (see also below).

Social capital comprises all institutions, relationships, and customs that shape the quality and quantity of social interactions in a community (The World Bank, 2011). Improving social capital often translates directly into higher equality, but also indirectly, by enabling improvement in other dimensions. Findings suggest that the built environment influences social capital, but the empirical relationship remains unclear. For example, although TOD fosters dense development, denser neighbourhoods do not always provide higher social capital (Dempsey et al., 2012; Glaeser & Gottlieb, 2006). Mixed land uses, another intrinsic characteristic of TOD, also shows inconsistent outcomes (Leyden, 2003; Lund, 2003). Public transport accessibility levels typically fosters social inclusion, but its relationship with other social capital dimensions is still unknown (Currie & Stanley, 2008; Janet Stanley & Lucas, 2008; Stanley, Stanley, Vella-Brodrick, & Currie, 2010; Stanley & Vella-Brodrick, 2009; Stanley, Stanley, & Hensher, 2012). In contrast, it is clear that walkable neighbourhoods perform better in terms of overall social sustainability. Specifically, pedestrian-oriented neighbourhoods foster a sense of community (Du Toit, Cerin, Leslie, & Owen, 2007; Leyden, 2003; Lund, 2002), trust, political participation, and social engagement (Leyden, 2003; Mason, 2010; Wood, Giles-Corti, & Bulsara, 2012). Until today, only a study of Brisbane (Australia) compares TOD and non-TOD areas, showing a significantly higher level of trust and reciprocity and connection with neighbourhood in TOD areas compared to non-TOD ones (Kamruzzaman et al., 2014). Still, the relationship between the design of TOD, the built environments and other aspects of social capital (i.e. participation in networks, civic engagement, the existence of pooled community resources and social norms) remains understudied.

TOD areas benefit from parallel investments in housing, schools, and public spaces within the catchment area (Peter Brand & Dávila, 2011a). Beyond the health benefits, TOD projects also create public spaces and transform pre-existing ones, thus improving interaction within communities. How new public spaces are built influences trust and cooperation levels, and fosters mutual understanding among citizens and with government institutions. Public spaces also constitute a fundamental scenario for political and social engagement (Chen, Acey, & Lara, 2015, n.d.; Leyden, 2003; The World Bank, 2011). Hence, rather than only improving access, transit projects also have the potential to foster participation and engagement, increasing quality of life in broader, partially subjective dimensions. Citizens' perception in transit projects is plausible as important as the formal access benefits. But the comprehensive effect of TOD on socioeconomic variables and citizen's perceptions on how their quality of life has changed remains less well understood.

### 3. How TOD interventions seek to maximize social outcomes in Medellín

Medellín was known as the Colombian city in the middle of the rainforest (see Fig. 2), where cartels and other factors made it one of the most insecure urban areas worldwide (Alcaldía de Medellín & IDB, 2008). Its population has remained stable around 2,5 million people.<sup>2</sup> Since mid-2000s, Medellín's development plans aim at enhancing natural environments, urban mobility, public space and housing conditions and security and coexistence (Alcaldía de Medellín, 2015; Alcaldía de Medellín, 2004, 2008, 2012; Brand, 2010). In particular, the construction of the mass transit system Metrocable and the works around stations through participatory urban upgrading projects (Proyectos

Urbanos Integrales, PUIs) have transformed the poorest peripheral areas, characterized by dramatic socioeconomic conditions with high levels of social exclusion and crimes (Brand & Dávila, 2011a, 2011b) (see Fig. 3). Prior to these interventions, these areas showed typical peripheral location characteristics with dense urban expansion and territorial disorder resulting from irregular development. There was a lack in public infrastructure and private appropriation of public spaces. All this affected mobility and travel security, lengthening travel times within the neighbourhood and transport systems connecting with the rest of the city. Consequently, inhabitants of these areas were highly vulnerable to natural risk (e.g., due to topography). In addition, a history of inappropriate public interventions created dissatisfaction, and the existence of widespread regulatory ignorance (Puerta Osorio, 2011).

In the light of these conditions, the government decided to intervene through upgrading programs designed on a case-to-case basis, adapting its interventions to the requirements of each neighbourhood. The aim was to provide equal opportunities to all citizens, and to those traditionally excluded in particular in order to have a more socially homogeneous city (Puerta Osorio, 2011) as it is read in the planning programs “for a just city” (Alcaldía de Medellín, 2004, 2008, 2012; Alcaldía de Medellín, 2015; P. Brand, 2010). Three lines of action were adopted: 1) the improvement of the urban environment; 2) the strengthening of citizen involvement; and 3) strengthening of institutions.

#### 3.1. Improvement of the urban environment with a specific focus on mobility and accessibility, especially for pedestrians

These infrastructure interventions included the construction and improvement of collective facilities such as libraries, health centres, schools and urban parks, and transit infrastructures like bridges and walkways. Altogether, they generated new public spaces and social facilities. Also, increasing access to the health care and the education system became a main priority (Blanco & Kobayashi, 2009). Housing conditions were improved through regularization, rehabilitation, and new development. Inhabitants targeted communities were chosen to participate in the construction works (Arenas Madrigal & Arenas Madrigal, 2015; Bateman, Ortiz, Pablo, & Maclean, 2011). A number of social programs were launched on child protection, social reintegration, and support of victims of human rights violations, among others. Environmental care was supported through wildlife conservation, rehabilitation of degraded environmental spaces and improved water treatment (Brand & Dávila, 2011a, 2011b; Dávila & Daste, 2011; Dávila, Daste, & Millan, 2015).

#### 3.2. Strengthening of citizen involvement generated local appropriation of TOD services

Participatory planning processes legitimized actions on the territory through NGOs and Community Local Administrative Action Boards, creating spaces for discussion, exchange, and dissemination. Community involvement occurred before, during and after the infrastructure works. A wide variety of participation tools were used: tours, committee meetings and other public meetings, workshops and training processes, census, inter-institutional coordination activities, open calls, home visits, dissemination and promotion campaigns, free press (number of letters) and information booths, conferences and social events. Already at the diagnostic phase, citizens were involved in the identification of key areas together with technical experts. At the project design phase, they were involved in the decision-making of intervention projects based on social and economic feasibility. After the finalisation of the construction phase, dissemination and appropriation was done through cultural activities where all Medellín citizens were invited to show the renovated image among all Medellín population, creating pride among locals (Farajado Valderrama, Cabral, & Tonkiss,

<sup>2</sup> Population 2009: 2.608.109; 2012 2.692.991 and 2016: 2.780.636 (Gobierno de Medellín, 2016).



Fig. 2. Map of the city location (OpenStreetMap, 2016).

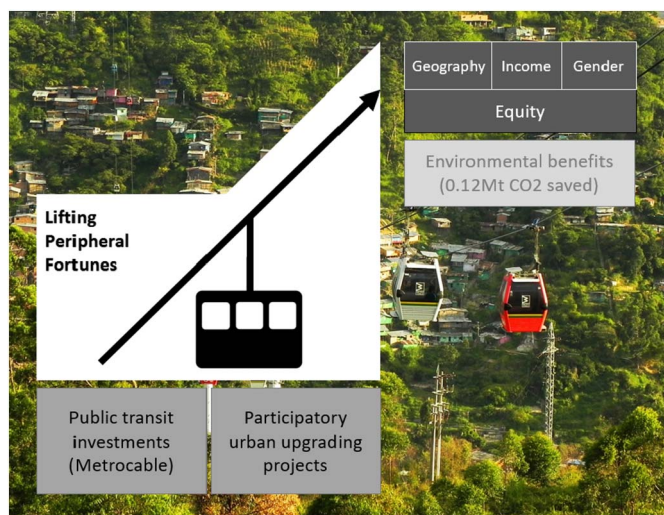


Fig. 3. Two intervention tools (Metrocable upgrading projects) to enhance environmental and socio-economic realities.

2014).

3.3. Strengthening of institutions through the enhancement of transparency and communication, the clear definition of responsibility roles and decentralized processes to empower communities

Over 20 municipal departments participated in managerial assemblies together with civil society and private organizations as well as international cooperation agencies. Financing was on the premise that the development of the neighbourhood may become self-sustaining at one point (Carvajal, 2009; Dávila & Daste, 2011). Strategies to improve public financial management included a tax payer assistance centre, awareness programs on taxpayer and regular updates of cadastral values (Echeverri & Orsini, 2011).

Although the case of Medellín has been studied, the effect of TOD changes on social sustainability in general and social capital, quality of

life in particular, and resulting distributional equity effects has not been empirically evaluated. So far, Cerda et al. (2012) showed that the enhancement of physical structures reduced violence in Medellín for their study period (2003–2008). Bocarejo Suescún and Velásquez Torres (2011) and Agudelo Vélez, Beatriz Mejía Gutiérrez, Eliecer Córdoba Maquilón, and Reinaldo Sarmiento Ordosgoitia (2011) studied the neighbourhood impact of the first Metrocable line between 2000 and 2005 on socioeconomic variables. (Bocarejo Suescún & Velásquez Torres, 2011) found an increase in job accessibility levels and (Agudelo Vélez et al., 2011) specifically looked at social indicators but with inconclusive results. Others investigate microenterprise development to foster sustainable development (Bateman et al., 2011) and the effect of the participative budgets on governance transparency and institutional renewal (Carvajal, 2009; Dávila, 2009). Several contributions discuss the so-called “PUI methodology” and highlight its transformative power based on community-oriented planning (Blanco & Kobayashi, 2009; Brand, 2010; Brand & Dávila, 2011b; Dávila, 2014; Echeverri & Orsini, 2011; Fukuyama & Colby, 2011; Hylton, 2007; Brand & Dávila, 2011a). However, none of these studies explicitly consider the effect of TOD and participatory processes on social capital empirically.

Finally, the work of Dávila (2012a) discusses the simultaneous social and environmental benefits of the recent planning interventions in Medellín. Although the original drive for transit infrastructure development hinged on social and mobility concerns, potential environmental effects were considered at some point (Alcaldía de Medellín, 2015; Metro de Medellín, 2015a, 2015b). For example, the replacement of the fossil fuel operating vehicles by a system of hydroelectric-powered aerial cable cars contributed to a reduction of up to 0.12MtCO<sub>2</sub> between 2010 and 2016 (> 60% less compared to baseline emission scenarios<sup>3</sup>) and also helped to reduce the levels of trans-boundary air pollutants (mainly carbon monoxide and sulphur dioxide) (CDM Executive Board, Grütter Consulting, & TÜV SÜD Industrie Service GmbH, 2009).

<sup>3</sup> Baseline emissions were defined as those that would have resulted from the use of other modes of transport to cover the required origin and destination distances. Medellín's modes available were minibuses, taxis and jeeps using fossil fuels such as petrol and diesel

**Table 1**

Topic categories (3) Variables (14) and comparison groups. Group variables are compared with Medellín average. Income levels include low (L), medium (M), and high (H). Zones include the comunas 1,2,3,4,5,6. Gender: female (F), and male (M).

N	Topic category/variable name	No. questions	Description
	<b>Socioeconomic variables</b>	<b>8</b>	
1	Housing	3	Housing affordability and supply
2	Education	3	Enrolment
3	Job	2	Employment, Identification as poor
	<b>Public infrastructures</b>	<b>89</b>	
4	Education (satisfaction)	1	Satisfaction with education
5	Environment	16	Air, water, noise, visual environment
6	Health	3	Quality of health service, satisfaction
7	Public Infrastructure	26	Phone, internet, waste, gas, electricity
8	Public space	27	Access to parks, security, pedestrian streetscapes
9	Transit	16	Commuting time, satisfaction
	<b>Social capita</b>	<b>90</b>	
10	Collective action	6	Own contribution and engagement
11	Groups and Networks	16	Participation in neighbourhood organizations
12	Information & communication	15	Perceived importance of participation
13	Social inclusion	35	Respect given to different social groups
14	Trust	18	Trust in public institutions and security in transport

#### 4. Study design and methods: ex-post evaluation

We assess the effect of TOD interventions on social sustainability in Medellín using an ex-post evaluation approach, valuable in the role of ex post policy evaluation (Herrick & Sarewitz, 2000). In particular, we investigate whether TOD correlates with changes in three dimensions of quality of life: Socioeconomic well-being, public infrastructure, and social capital. Each dimension is evaluated by a set of indicators (Table 1, below). In addition, we investigate if these changes have had an impact in the overall equity at the city level.

We use data from the Medellín citizen survey “Medellín Como Vamos” (Medellín Como Vamos, 2015). This survey is conducted annually with a cross-sectional sampling technique, having four different levels for each sampling group: comunas, barrios, zonas and “cuadras” (blocks) – this one being the sample unit (Medellín Como Vamos, 2015). Sample sizes hence depend on income, gender and zones. Total sample size is 1503. The percentage of population included in the sample size is not available. Medellín (Medellín Como Vamos, 2015) uses these estimates to evaluate their policies and strategies. Our study compares data from 2009 and 2012 to conduct an ex-post evaluation. Although the Metrocable lines were opened before, walking paths and other interventions related to urban mobility started only after 2009 – “ex-post”: > 80% of the interventions were finished by 2012 (Alcaldía de Medellín, 2004, 2008, 2012; Arenas Madrigal & Arenas Madrigal, 2015; Puerta Osorio, 2011). Answers are available for three comparison groups besides Medellín average according to the geographic zones (Comunas 1, 2, 3, 4, 5, 6), income levels (high, middle, low level), and gender (male, female). Income levels are defined by responses to the questionnaires, as low: insufficient income to cover basic needs (13% of population in 2012); middle: adequate income to cover basic needs (65%); high: more than enough income to cover basic needs (20%). Income and gender are variables not-specific for TOD and n-TOD zones. Hence, improvements and gender and income may not only be related to the TOD intervention but also other issues. However, the TOD/PUI intervention was the most notable policy intervention in Medellín municipality, with public safety and accessibility to jobs as significant correlates. Hence, our results are to some degree indicative on the effects on income and gender.

One metrocable (Line K) opened in 2004 and links comunas 1 and 2, which were further improved by participatory urban upgrading projects between 2009 and 2012. Another metrocable (Line J) opened in 2008 and links comunas 7 and 13, however participatory processes have not yet been evaluated at the time of this research (see Fig. 4). For each comparison group, we make a two group sub-sample according to the change of TOD observed between 2009 and 2012 and compare their

scores on the variables for quality of life and social capita. TOD groups include the sub-sample of groups where there has been a positive change in the use of TOD modes (TOD). Non-TOD groups include those where the use of TOD modes has remained stable or decreased (n-TOD).

##### 4.1. Quality of life and social capital

The survey database consists 187 questions asked to 1503 individuals. We regroup them into three socioeconomic variables, six variables on the quality of public intervention, and five variables on social capital (Table 1). We refer to the totality of the 14 variables as quality-of-life variables.

We use feature scaling for data preparation, a method used to normalize from nominal and ordinal to scale values and further re-scaling to the [0, 1] range (Table 1). This allows us to use all available questions simultaneously (12 questions were also reversed to have homogeneous scale direction). Hence, each variable X in Table 1 should be read as “State of X and satisfaction with X”. Specific definition of underlying variables (questions asked) is provided in the supporting information.

Our ex-post analysis is done in the following way: First, we calculate the % change between 2009 and 2012 for each variable and topic category (“Change”). Second, the homogenization effect between different groups – or inequality reduction effect - is evaluated comparing the different groups with Medellín average. This is done by calculating the deviation to Medellín average (“Deviation”) for 2009 and 2012 determined by the ratio between each group score and the Medellín average score (value below or above 1, where = 1 means that the value is equal to Medellín average, < 1 means that it the group scores worse, and > 1 means that it the group scores better than Medellín average). We then calculate “Change in deviation”, which is the % change of “Deviation” for each group.

Finally, we compare TOD and n-TOD groups for the % changes in “Change” and “Change in deviation” to see whether TOD changes influence the socioeconomic variables, perception of public intervention, and social capita. We use the Wilcoxon Mann-Whitney Rank Sum Test, a nonparametric test with the null hypothesis that two samples come from the same distribution against an alternative hypothesis, that a particular distribution tends to have larger mean value than the other. It allows the statistical comparison of contributions even when they are not normally distributed. For each statistical test, we report the median value of each group, and statistical significance.

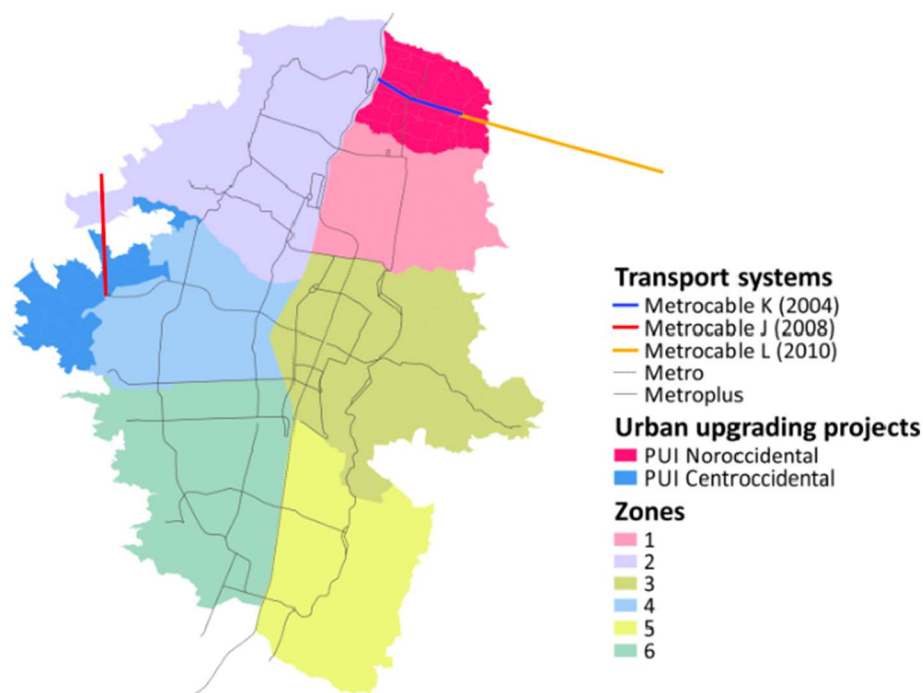


Fig. 4. Medellín: zones, TOD and urban upgrading projects distribution for the study period area.

## 5. Results

This section presents the main results, divided into two main parts. First we report the TOD-modal changes between 2009 and 2012 for all groups to identify TOD and non-TOD groups for the different zones, income levels and gender. Second, we report the variable scores, deviation to Medellín average and group comparison.

### 5.1. TOD-modes increased in 5 groups

TOD-modes changed in all groups between 2009 and 2012. TOD-modes increased in zones 1, 2, and 4, as well as in the low income and female group. On the contrary, zones 3, 5 and 6, middle and high income, and the male group show a decrease in TOD-modes (see Fig. 3). Hence, where interventions upgraded transit (areas 1 and 4) there has been an increase in the use of TOD-modes, disproportionately taken up by the lower income segment and women (Fig. 5). Crucially, insecurity issues in mobility for women had also been a number one priority in the urban upgrading programs. Hence - and considering the high concentration of positive TOD-modes in lower areas - these variations may indeed indicate a great success of the intervention for low and middle-income women previously reluctant to use transit modes for security issues.

### 5.2. Variable scores, deviation to Medellín average and group comparison

Table 2 reports the score of the different variables and topic categories for all groups for both 2009 and 2012. Overall, there is a general increase in the scores for all socioeconomic variables, perception of public intervention and social capital. However these changes are different for each topic category, variables and groups. For all the groups included, housing shows the lowest scores among the socioeconomic variables. Income improves; education deteriorated from 2009 until 2012 in all zones. Regarding citizen's perception on public intervention and social capital, the only one decreasing among all groups is satisfaction with education quality. Satisfaction with health and transit-related interventions slightly decrease for Medellín average, but this tendency differs among groups. Satisfaction with policies aiming a enhancing the environment and public infrastructure increase while

public space remains almost constant. Social capita variables also score very different depending on the dimension we look at. Whereas collective action and trust have rather high scores, groups and networks and information and communication scores are surprisingly low. Overall, although Medellín averages show minor changes, positive and negative changes are clustered according to different groups. We further analyse this variation by looking at “Change in deviation” and the results of the statistical analysis.

To investigate Medellín's inequalities, Table 3 shows the change (in per cent) of the groups' deviation to Medellín averages between 2009 and 2012 (“Change in deviation”), including all socioeconomic, public intervention and social capita variables. Our analysis demonstrates that most positive changes appear in groups where 2009 values were below Medellín average (bold numbering), indicating a reduction in inequalities between high-scored and low-scored groups, and consequently, among the whole urban population. This effect is clearly seen in the TOD zones 1, in the low-income group, and the female group (see also Fig. 3).

Our results suggest that there is a statistically significant difference between the underlying distributions of TOD groups and non-TOD groups for all three comparison groups - geographic zones, income levels, and gender, all testing highly significantly ( $p < 0.01$ ) in aggregate metrics (see Table 4). Specifically, those zones with transit interventions increased more in quality-of-life variables than the others; lower incomes profited more than middle and higher incomes; and women's quality of life improved more than men's. Notably, in sum this represents an improvement of groups that were previously disadvantaged.

It is worthwhile to investigate the change in specific metrics. Socio-economic variables improved only statistically significant for the low-income groups in TOD versus non-TOD zones ( $p > 0.01$ ), mostly reflecting an improvement in housing affordability and supply ( $p < 0.05$ ). However, a similar improvement in comparison of geographic zones and gender was not statistically significant.

In the public intervention variables, there was only a statistically significant difference between the geographic zones ( $p > 0.01$ ), reflecting an improvement in ambient environment (air, water, noise, visual aesthetics) and transit (satisfaction with mobility services and security). The improvement in transit was mirrored also for the lower

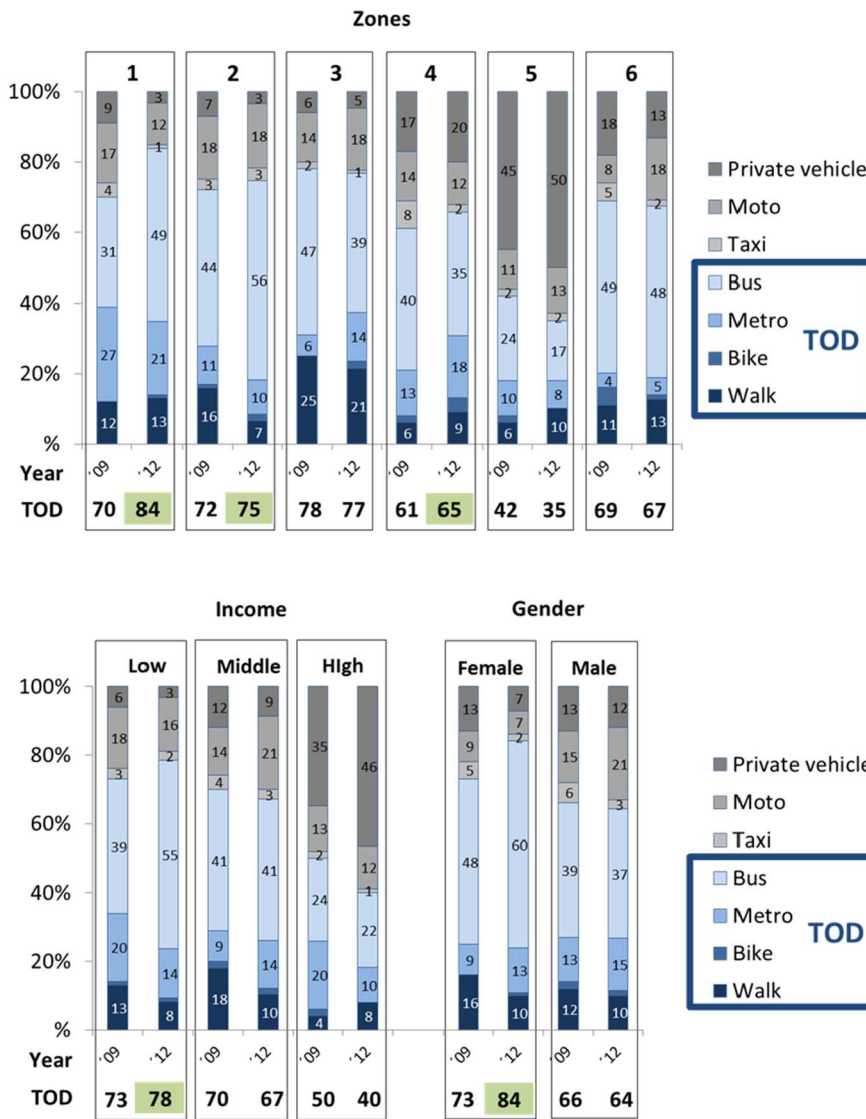


Fig. 5. Modal shares changes between 2009 and 2012 for the study groups. Zones with TOD intervention show higher use of metrocycle, benefiting lower income groups and women most.

income group ( $p < 0.01$ ); however the same group saw a slight deterioration in environment ( $p < 0.01$ ), render overall public intervention non-significant.

The most important and pervasive changes in variables were in social capital ( $p < 0.01$  for geography, income, and gender), inter alia reflected in changes in group networking and affiliations (the most significant social capital variable seeing gender improvements), social inclusion, trust, and collective action. The information and communication variable is only statistically significant for the income-group comparison (Table 4).

## 6. Discussion

With the election of Sergio Fajardo as Mayor of Medellin in 2004, a program including a Social Urbanism was enacted, aiming to promote peace and social equity through urban policies, in particular by making use of investments into the transit system. Rather than predetermined investments, decisions were made within participatory processes enabling a buy-in of local communities, and place-specific design. Our investigation shows that the available data support that this program, so far, has been a success where it has been implemented. Zones where transit investments and participatory urban upgrading projects were implemented show an increase in the quality of life, but especially in social capital. At the outset, inequality dominated in TOD groups, an

observation that legitimizes the equity intention of the interventions. As a result of the TOD interventions, the previously disadvantaged parts of Medellin improved and became less disadvantaged. Notably, zone 1 demonstrates better results than zone 4. Possibly this is due to the fact that the participatory urban upgrading project in zone 1 started before the one in zone 4 and the works were more advanced (Puerta Osorio, 2011).

Together, these measures increased the quality of life for Medellin population and minorities in particular. Urban upgrading projects achieved to work with and for the community on the different proposals and intervention designs. This may have led to synergies between participatory urban planning and the development of new public spaces and transport infrastructure, promoting ownership of the environment, and close bonds of trust within and between communities and authorities; thus making them feel taken into account regarding their views improving social interactions.

Our inferences are made based on statistical analysis, qualifying causal conclusions. One question is whether the Columbia peace process also helped to improve social capital. However, the peace process formally only started in September 2012 after the questionnaires had been answered. More importantly, we control for the relative change in intervention and non-intervention groups. Hence, we feel confident that the results were brought up by the interventions. However, the data prohibit inference about the specific contribution of specific

**Table 2**  
Scoring of the variables for the years 2009 and 2012 (“Change”) (see Fig. A.1 for illustration). Values range from 0 to 1, where 0 is the minimum and 1 the maximum.

Group	Medellin						Zone						Income						Gender						
	Average		1		2		3		4		5		6		Low		Middle		High		Female		Male		
	2009	2012	2009	2012	2009	2012	2009	2012	2009	2012	2009	2012	2009	2012	2009	2012	2009	2012	2009	2012	2009	2012	2009	2012	
Topic category	Variable																								
Socioeconomic variables	1	0.35	0.38	0.26	0.26	0.31	0.35	0.31	0.36	0.38	0.48	0.50	0.54	0.37	0.28	0.26	0.37	0.36	0.47	0.31	0.29	0.55	0.36	0.34	
	2	0.70	0.66	0.73	0.70	0.71	0.64	0.71	0.68	0.73	0.67	0.67	0.64	0.67	0.64	0.71	0.68	0.71	0.63	0.58	0.71	0.71	0.71	0.72	0.65
Public intervention	3	0.81	0.87	0.72	0.79	0.81	0.86	0.80	0.86	0.83	0.89	0.91	0.96	0.81	0.84	0.74	0.80	0.82	0.87	0.90	0.95	0.80	0.85	0.77	0.84
	4	0.84	0.79	0.81	0.77	0.85	0.80	0.86	0.76	0.83	0.85	0.87	0.82	0.81	0.73	0.83	0.79	0.83	0.77	0.85	0.83	0.84	0.80	0.82	0.76
	5	0.42	0.44	0.44	0.46	0.43	0.48	0.40	0.41	0.38	0.46	0.42	0.42	0.44	0.42	0.44	0.46	0.41	0.44	0.39	0.44	0.42	0.46	0.42	0.45
	6	0.54	0.53	0.52	0.52	0.50	0.49	0.59	0.53	0.52	0.52	0.58	0.64	0.55	0.50	0.53	0.52	0.53	0.51	0.52	0.55	0.53	0.52	0.53	0.51
Social capita	7	0.80	0.85	0.77	0.82	0.78	0.85	0.77	0.83	0.82	0.85	0.84	0.88	0.81	0.85	0.76	0.83	0.80	0.85	0.87	0.79	0.85	0.80	0.85	0.85
	8	0.55	0.55	0.54	0.57	0.56	0.52	0.55	0.53	0.55	0.57	0.57	0.54	0.54	0.57	0.55	0.55	0.55	0.53	0.56	0.55	0.56	0.55	0.54	0.54
	9	0.66	0.65	0.64	0.66	0.69	0.65	0.71	0.62	0.62	0.65	0.69	0.64	0.62	0.65	0.65	0.66	0.66	0.64	0.67	0.64	0.63	0.61	0.65	0.64
Socioeconomic variables	10	0.74	0.72	0.73	0.78	0.71	0.69	0.79	0.62	0.69	0.77	0.80	0.75	0.69	0.69	0.73	0.69	0.75	0.71	0.77	0.74	0.66	0.70	0.75	0.71
	11	0.21	0.21	0.18	0.18	0.22	0.20	0.18	0.15	0.21	0.27	0.27	0.30	0.20	0.15	0.16	0.21	0.19	0.19	0.25	0.31	0.18	0.19	0.21	0.19
	12	0.42	0.43	0.37	0.42	0.44	0.43	0.42	0.43	0.44	0.45	0.47	0.48	0.38	0.40	0.39	0.44	0.42	0.42	0.46	0.45	0.40	0.42	0.43	0.43
	13	0.49	0.50	0.46	0.52	0.49	0.53	0.51	0.49	0.48	0.49	0.52	0.50	0.46	0.48	0.45	0.52	0.48	0.48	0.51	0.50	0.46	0.50	0.49	0.51
Social capita	14	0.61	0.64	0.61	0.65	0.58	0.66	0.63	0.64	0.58	0.63	0.65	0.64	0.61	0.63	0.60	0.66	0.60	0.63	0.64	0.63	0.61	0.65	0.60	0.64
	Total	0.62	0.64	0.57	0.58	0.61	0.62	0.60	0.63	0.64	0.68	0.69	0.72	0.61	0.58	0.57	0.62	0.63	0.62	0.67	0.62	0.60	0.70	0.62	0.61
Pub. intervention		0.64	0.63	0.62	0.63	0.64	0.63	0.65	0.62	0.62	0.65	0.66	0.65	0.63	0.62	0.63	0.63	0.63	0.64	0.65	0.63	0.63	0.63	0.63	0.63
Social capita		0.49	0.50	0.47	0.51	0.49	0.50	0.51	0.47	0.48	0.52	0.54	0.53	0.47	0.47	0.46	0.50	0.49	0.48	0.52	0.53	0.46	0.49	0.50	0.50
Total		0.58	0.59	0.55	0.58	0.58	0.58	0.59	0.57	0.58	0.62	0.63	0.64	0.57	0.56	0.55	0.59	0.58	0.61	0.60	0.56	0.61	0.58	0.58	0.58



**Table 3**

Equity effect (“Change in deviation”) in decimal units. Bold font entries: 2009 values below Medellin average. Most bold entries are positive, i.e. equity has improved (59/77). Specific inequity increases dominate in non-TOD zones (14; compare with 4 in TOD zones).

Topic category	Variable	TOD					n-TOD					
		1	2	4	Low	Female	3	5	6	Middle	High	Male
Socioeconomic variables	1 Housing	<b>-0.05</b>	<b>0.04</b>	0.19	<b>0.31</b>	<b>0.77</b>	<b>0.09</b>	0.01	-0.30	-0.12	-0.38	-0.12
	2 Education	0.01	-0.04	-0.02	0.02	0.05	0.03	<b>0.02</b>	<b>0.00</b>	-0.04	<b>-0.03</b>	-0.04
	3 Job	<b>0.03</b>	<b>-0.01</b>	0.01	<b>0.02</b>	<b>0.00</b>	<b>0.01</b>	0.00	<b>-0.03</b>	-0.01	-0.01	<b>0.02</b>
Public intervention	4 Education (satisfaction)	<b>0.01</b>	0.01	<b>0.08</b>	<b>0.01</b>	0.01	-0.06	0.00	<b>-0.04</b>	<b>-0.02</b>	0.04	<b>-0.01</b>
	5 Environment	-0.01	0.06	<b>0.14</b>	-0.01	0.03	<b>-0.02</b>	-0.06	-0.10	<b>0.01</b>	<b>0.06</b>	0.00
	6 Health	<b>0.02</b>	<b>0.00</b>	<b>0.01</b>	<b>0.00</b>	<b>0.00</b>	-0.09	0.12	-0.07	<b>-0.03</b>	<b>0.08</b>	<b>-0.02</b>
	7 Public infrastructure	<b>0.00</b>	<b>0.03</b>	-0.03	<b>0.02</b>	<b>0.01</b>	<b>0.03</b>	-0.01	-0.01	-0.01	-0.04	0.00
	8 Public space	<b>0.05</b>	-0.07	<b>0.04</b>	<b>0.00</b>	0.02	-0.04	-0.04	<b>0.06</b>	0.00	<b>0.05</b>	<b>0.00</b>
Social capita	9 Transit	<b>0.06</b>	-0.03	<b>0.07</b>	<b>0.05</b>	<b>-0.01</b>	-0.10	-0.05	<b>0.07</b>	-0.01	-0.02	<b>0.01</b>
	10 Collective action	<b>0.10</b>	<b>-0.01</b>	<b>0.14</b>	<b>-0.03</b>	<b>0.08</b>	-0.20	-0.03	<b>0.02</b>	-0.03	-0.01	-0.03
	11 Groups and networks	<b>0.04</b>	-0.08	0.30	<b>0.38</b>	<b>0.04</b>	<b>-0.15</b>	0.10	<b>-0.26</b>	<b>-0.02</b>	0.29	-0.09
	12 Inf. & commun.	<b>0.11</b>	-0.07	-0.03	<b>0.09</b>	<b>0.01</b>	-0.01	-0.02	<b>0.04</b>	-0.05	-0.04	-0.03
	13 Social inclusion	<b>0.10</b>	0.05	<b>0.00</b>	<b>0.13</b>	<b>0.05</b>	-0.07	-0.07	<b>0.01</b>	<b>-0.03</b>	-0.06	0.01
	14 Trust	0.02	<b>0.08</b>	<b>0.03</b>	<b>0.04</b>	0.02	-0.03	-0.05	-0.03	<b>-0.01</b>	-0.06	<b>0.00</b>
Socioeconomic variables		<b>0.01</b>	<b>-0.01</b>	0.03	<b>0.06</b>	<b>0.15</b>	<b>0.03</b>	0.02	<b>-0.07</b>	-0.04	-0.10	<b>-0.03</b>
Public intervention		<b>0.02</b>	0.00	<b>0.04</b>	<b>0.01</b>	<b>0.01</b>	-0.05	-0.01	<b>-0.01</b>	-0.01	0.02	<b>0.00</b>
Social capita		<b>0.07</b>	<b>0.01</b>	<b>0.06</b>	<b>0.07</b>	<b>0.04</b>	-0.09	-0.03	<b>-0.01</b>	-0.03	-0.01	-0.02
Total		<b>0.03</b>	<b>0.00</b>	0.05	<b>0.04</b>	<b>0.07</b>	-0.03	-0.01	<b>-0.03</b>	-0.03	-0.03	-0.02

participatory processes and urban design and transit implementations. We can only state the whole package of participatory urban upgrading processes and transit interventions was successful.

The Medellin success strongly suggests that transit interventions, together with participatory processes, could more strongly improve equity and lift the fortunes of disadvantaged group than commonly realized. That raises the question why other municipalities have less success in implementing similar programs. Literature suggests that some projects have mixed goals that hamper adequate prioritization of social and cultural preferences (i.e. fostering economic growth, building a location brand or satisfying political interests) (Baumann & White, 2012; Boarnet & Compin, 1999; Certero, Ferell, & Murphy, 2002; Dorsey & Mulder, 2013; Turner, 2012). Traditionally narrow priorities based on utility-maximizing rational and physical and functional requirements present poor awareness of the nexus between TOD and place making (Baumann & White, 2012; Belzer & Autler, 2002; Chiu, Huang, & Ma, 2011; Ndebele & Ogra, 2014; Winston & Maheshri, 2007) and little integration of environmental values (Soria-Lara, Bertolini, & te Brömmelstroet, 2015) and social considerations such as travel patterns (Bailey, Grossardt, & Pridewells, 2007; De Vos, Van Acker, & Witlox, 2014). Intransigence of the target community on changes in lifestyles may also lead to unintended consequences. For example, the introduction of measures to avoid car usage (i.e. inner-city parking fees) may result in new suburban driving patterns, protests, and induced technological innovations that hamper social changes and, ultimately, sustainable development (Clark, 2005; Vallance, Perkins, & Dixon, 2011).

The design of appropriate interventions that take the social context into account increases the overall sustainability outcomes of TOD interventions. Specific to social capita, public participation in decision-making processes is commonly identified as a key factor of success (Bowling & Stafford, 2007; Grootaert, 1998; Grootaert & Bastelaer, 2001; Kamruzzaman et al., 2014; Masoud, Rastbin, & Ardahaey, 2011; Onyx & Bullen, 2000; Roche, 2004; The World Bank, 2011). These could generate synergies as the enhancement of social capita contributes to the development of sustainable development principles in the communities –e.g. fosters social equity and the preservation of natural ecosystems, among others - (Chen et al., 2015; Grootaert, 1998; Grootaert & Bastelaer, 2001; Putnam, 1993; The World Bank, 2011; Vallance et al., 2011). In the case of TOD project designs, participative interventions may foster eco-friendly behaviors related to urban mobility and shift social norms and perceptions related to active transport

and lifestyles preferences (e.g. car dependency and preference to live in low-density suburban areas).

## 7. Conclusion

Urban planning in general and TOD in particular will be fundamental in tackling the social and environmental challenges to come in cities due to climate change (Fernandez Milan & Creutzig, 2015). Place-based and inclusive interventions deserve more attention in the overall climate change mitigation, too often focused on technological options only (Creutzig, 2016; Creutzig et al., 2016). While TOD and participative urban planning emerges as an increasing popular urban measure, the potential of TOD interventions on social capita when citizen's participation takes place in the process remains underexploited. TOD often faces challenges related to inefficient public participation processes and unstructured stakeholder involvement which may lead to project designs at odds with local needs and suboptimal outcomes in social sustainability (Assefa & Frostell, 2007; Belzer & Autler, 2002; Dorsey & Mulder, 2013; Kathryn Scott, 2000; Soria-Lara et al., 2015). Participatory TOD planning could avoid such undesired outcome and further increase social and environmental positive effects. Besides the well-known TOD changes in transport emissions and land use mix, participatory approaches enhance the effects on social interactions in two ways. First, TOD itself improves the quality of public spaces and urban connectivity and accessibility. Diverse land use patterns, well-connected street networks and fast, frequent and well-connected TOD modes enhances citizen's urban mobility that in turn fosters social networks. Second, participation fosters transparency, trust, social inclusion, collective action and social networks. Third, social capita itself leads to sustainable behaviors in the community. For example, the feeling of ownership of the TOD makes usage of TOD more likely. The strengthening of democratic processes; and the empowerment of citizens in the design, implementation, handing over mechanisms and evaluation of TOD plans increases the public welfare and associated social benefit. Numerous methods have proved to be effective in communicating complex matters to citizens –e.g. visual and participative workshops aiming at identifying preferred TOD combinations for citizens (Bailey et al., 2007; Fernandez Milan, 2016). Hence, TOD and citizen's participation could be used as a catalyzer for local sustainability.

Our results have to be understood in the larger context of Medellin's transformation since the early 2000s until now. During the study period

**Table 4**  
 Wilcoxon-Mann-Whitney test of TOD and non-TOD areas for zones, income, and gender. The test identifies whether distributions are significantly different in their mean value. Statistical results for the comparative groups for all variables: median (M) z and p values (\*significant at  $p < 0.01$ , grey coloured).

Variables/ Topic category	Values	Zones				Income				Gender			
		Change		Change in deviation		Change		Change in deviation		Change		Change in deviation	
		TOD	n-TOD	TOD	n-TOD	TOD	n-TOD	TOD	n-TOD	TOD	n-TOD	TOD	n-TOD
1 Housing	M	0.60	0.05	0.02	-0.03	0.35	-0.26	0.31	-0.25	0.91	-0.03	0.77	-0.12
	z; p	0.84; 0.40		1.01; 0.31		2.32; 0.02		2.32; 0.02		1.96; 0.05		1.96; 0.05	
2 Education	M	-0.05	-0.03	-0.01	-0.01	-0.04	-0.08	0.02	-0.02	-0.04	-0.07	0.02	-0.07
	z; p	-0.66; 0.51		-0.57; 0.57		1.03; 0.30		1.03; 0.30		1.09; 0.27		1.53; 0.13	
3 Income	M	0.02	0.00	0.00	-0.02	0.01	0.01	0.00	-0.01	0.01	0.03	0.00	0.01
	z; p	0.44; 0.66		1.06; 0.29		0.37; 0.71		0.98; 0.33		-0.31; 0.75		0.31; 0.75	
4 Education (satisfaction)	M	-0.05	-0.09	0.01	-0.04	-0.05	-0.05	0.01	0.01	-0.05	-0.06	0.01	-0.01
	z; p	1.96; 0.05		1.94; 0.05		0.00; 1.00		0.00; 1.00		1.00; 0.32		1.00; 0.31	
5 Environment	M	0.10	-0.01	0.06	-0.03	0.01	0.05	-0.02	0.05	0.03	0.02	0.01	0.00
	z; p	3.33; 0.00*		3.61; 0.00*		-1.38; 0.17		-3.63; 0.00*		0.41; 0.68		1.17; 0.25	
6 Health	M	-0.08	-0.09	-0.03	-0.04	-0.05	-0.04	0.00	0.00	-0.06	-0.05	0.00	-0.02
	z; p	0.49; 0.63		0.84; 0.40		0.26; 0.79		0.26; 0.80		-0.22; 0.83		0.65; 0.51	
7 Public Infrastructure	M	0.04	0.02	0.00	0.00	0.06	0.01	0.01	-0.01	0.03	0.04	0.01	0.00
	z; p	0.18; 0.85		0.64; 0.52		1.62; 0.10		3.62; 0.00*		0.85; 0.40		1.56; 0.12	
8 Public space	M	0.00	-0.02	0.05	-0.01	0.01	0.02	0.03	-0.01	-0.02	-0.01	0.02	0.00
	z; p	-0.01; 0.99		1.53; 0.12		-0.13; 0.90		0.78; 0.43		0.32; 0.75		0.99; 0.32	
9 Transit	M	0.02	-0.06	0.04	-0.03	0.02	-0.03	0.03	-0.01	-0.03	0.00	-0.01	0.01
	z; p	2.95; 0.00*		3.07; 0.00*		2.86; 0.00*		2.71; 0.00*		-1.47; 0.14		-2.83; 0.01	
10 Collective action	M	0.06	-0.08	0.09	-0.05	-0.04	-0.04	-0.02	-0.03	0.07	-0.06	0.06	-0.04
	z; p	2.75; 0.00*		3.04; 0.00*		0.00; 1.00		0.28; 0.78		1.92; 0.05		1.76; 0.07	
11 Groups and Network	M	0.15	-0.12	0.15	-0.14	0.31	0.15	0.15	0.12	0.08	-0.03	0.05	-0.12
	z; p	4.05; 0.00*		4.33; 0.00*		1.11; 0.27		0.92; 0.36		1.85; 0.06		3.77; 0.00*	
12 Inf & Communication	M	0.07	-0.02	0.03	-0.02	0.06	-0.03	0.05	-0.03	0.03	-0.04	0.02	-0.03
	z; p	1.50; 0.13		0.95; 0.34		3.06; 0.00*		2.94; 0.00*		1.14; 0.25		1.80; 0.07	
13 Social Inclusion	M	0.09	-0.01	0.05	-0.04	0.12	0.00	0.07	-0.04	0.08	0.06	0.03	0.02
	z; p	4.73; 0.00*		5.60; 0.00*		3.94; 0.00*		5.74; 0.00*		1.49; 0.14		1.24; 0.22	
14 Trust	M	0.09	-0.01	0.03	-0.03	0.08	0.02	0.03	-0.01	0.08	0.07	0.01	0.01
	z; p	3.20; 0.00*		3.61; 0.00*		2.38; 0.01		3.27; 0.00*		0.28; 0.77		0.41; 0.68	
<b>Socioeconomic variables</b>	M	0.17	0.01	0.01	-0.02	0.12	-0.04	0.05	-0.04	0.21	-0.04	0.15	-0.08
	z; p	0.74; 0.46		0.76; 0.45		2.39; 0.02		3.37; 0.00*		1.89; 0.06		2.42; 0.02	
<b>Public Intervention</b>	M	0.03	0.00	0.02	-0.01	0.02	0.00	0.01	0.00	0.01	0.01	0.00	0.00
	z; p	2.53; 0.01		4.22; 0.00*		0.95; 0.34		1.77; 0.08		0.22; 0.83		0.8; 0.43	
<b>Social Capita</b>	M	0.09	-0.02	0.05	-0.04	0.11	0.00	0.06	-0.02	0.07	0.02	0.02	0.00
	z; p	7.13; 0.00*		7.50; 0.00*		5.07; 0.00*		6.07; 0.00*		2.96; 0.00*		3.98; 0.00*	
<b>Total</b>	M	0.05	-0.01	0.03	-0.02	0.07	0.00	0.04	-0.01	0.05	0.01	0.01	0.00
	z; p	6.93; 0.00*		8.46; 0.00*		4.71; 0.00*		6.64; 0.00*		2.82; 0.00*		4.05; 0.00*	

there were many interventions all around the city aiming at similar outcomes that certainly influenced all city areas. However, taking TOD modal changes as the grouping variable, we avoid looking at secondary effects (e.g. zone 2 is included in our TOD group regardless of the development of its upgrading program, not yet finished for the study period). In any case, despite the impressive positive effects of the PUIs, these cannot be considered as the only tool to enhance social and environmental objectives at the city level.

TOD is critical to the achievement of a wide range of social, economic and environmental objectives and, therefore, needs appropriate institutions to ensure its integration with the strategic management of the rest of urban development policy. In Medellín, local political leadership played a key role. An institutional strategy that comprises the processes of decision-making, design, construction and coordination of the multiple civil works, cable equipment procurement, installation and implementation, system operation, and financing of the whole package is fundamental for maximizing outcomes. This should be done by

aligning the divergent interests of the greater city, the project municipality, the regional authority and the national government to avoid individual structural intervention from the public transport authorities (Acevedo, 2012; Bahl, 2012; Creutzig, Thomas, Kammen, & Deakin, 2012; Dávila, 2014). In this way, the process also enhances local democracy, equality and social regulation and avoids confrontation with unaccepted structural interventions, ultimately maximizing the social results of the intervention (Brand, 2005).

Medellin's experience could be used in urban development contexts to come. In Medellín itself, different governments repeated this scheme in other marginalized areas. They have developed an intervention methodology that is showing applicable in other contexts, provided there is commitment from the government to carry out such innovative urban planning (Cárdenas, 2008; Dávila, 2012b). In fact, this methodology has already been adapted to other cities in Colombia and Brazil, and is the bases for the development of the Growth Acceleration Program (Dávila, 2013; Farajado Valderrama et al., 2014). This is slightly

reminiscent of isomorphic development of urban administrations in China, coordinated partially by central governments, and by peer-based learning from frontrunners (Creutzig, Thomas et al., 2012). Network and learning processes should be leveraged to further upscale the positive experiences with TOD.

The increase in social capital and equity in Medellín is not just a result of the massive public transport investment, but also on the synergies between transport infrastructural interventions and the urban upgrading integration programs in the form of participatory TOD. With

Appendix A. Appendix

this study, we provide new evidence that citizen participation increases the environmental benefits of TOD, and augment the social capita of its participants.

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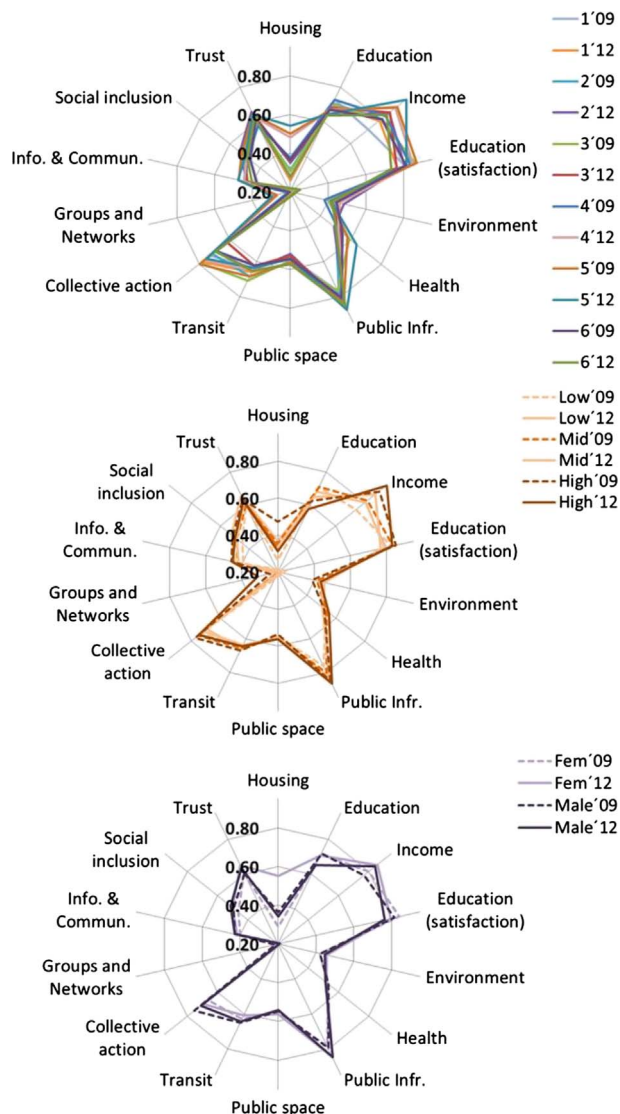


Fig. A.1. Scoring of the variables for the years 2009 and 2012 (“Change”) for all three comparison groups: zones, income level and gender (based on the numbers in Table 2).

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