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### Regenerative Mobility: Disruption and Urban Evolution

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#### Abstract

Mobility plays an important role in the cities by enabling people to carry out the most varied activities across the territory, as well as to ensure the city fully function. In addition, analogies to the human organism can be made by this urban dynamic, looking for solutions to specific issues. Moreover, this paper has been based by the premise that phenomena and urban elements could be conceptualized, explained and transformed from contemporary and innovative approaches applied in the medical field. For this reason, this paper aims to develop and present a new concept associated with urban mobility, based on the principles of regenerative medicine: the Regenerative Mobility, a concept with disruptive and evolutionary purposes. Furthermore, the structure of this paper is summarized by the introduction which contextualizes the theme, presents and characterizes the techniques used in the research. Additionally, the following chapters explore essential aspects of the city, explaining why it needs a mobility change and new concepts. Therefore, the concept of Regenerative Mobility is presented as a potential of mobility and cities improvement, followed by pragmatic cases, capable of illustrating some of its principles.

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#### Keywords

*Regenerative Mobility; Urban Mobility; Urban Evolution; Disruptive Concept; Medicine Regenerative*

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#### 1. Introduction

The dynamics and complexity that characterize the establishment of people in territories, the structuring of urban spaces and the analysis of transport systems are, on several occasions, compared to the processes that keep the human body alive (Odum, 1973; Ackroyd, 2000; Samaniego & Moses, 2008). Indeed, in the 19th century, the urban conception, according to Enlightenment, has considered the city something similar to the veins and arteries, with circulation principles that were based on the bloodstream and gradually applied to the urban centers (Sennet, 2008). Thus, as a complex and systemic organism, cities have their metabolism (Carta, 2017) and have the challenge of seeking a new urban metabolism (IAAC, 2012).

If innovation consists in transforming knowledge and ideas into values, urban innovation can be seen as a learning process acting on (and transforming) practices in urban collective environments (Concilio, 2016). Thus, the city is the best place where innovations could find necessary tangible/intangible resources, as long as it is able to recover its propensity for creativity and collective intelligence (Carta, 2017). Hence, the approach that has been used by this research starts from the premise that phenomena and urban elements could be conceptualized, explained and transformed from contemporary and innovative approaches applied in the medical field.

Moreover, the Brazilian urban growth is related to a displacement model based on individual motorization. Consequently, this model has degraded cities, making collectiveness unfeasible and also, causing incalculable social, environmental and economic damages. As a result, it affects the quality of urban life directly. However, even in concepts that have already been consolidated, such as sustainable urban mobility, it is clear that the need to change paradigms has been shown less sensitive to existing concepts and proposals.

Therefore, from the assimilation between the phenomena that manage cities and human body, and from the perception that concepts are dynamic and must evolve according to social construction of knowledge, this paper aims to develop and present an innovative, disruptive and revolutionary concept for urban mobility - associated with a paradigm shift - and supported by collectiveness. Indeed, its specific objectives are concentrated on: the identification of similar aspects between the dynamics of urban and human organisms; the development of relations between the concepts of Regenerative Medicine and Regenerative Mobility; and also, the development of first aspects which integrate this new concept of Regenerative Mobility.

Furthermore, the methodological procedure has adopted the format of bibliographic research. In this case, its development was based on works already developed by other authors such as those found in books and scientific papers. Moreover, regarding the goals, the research type is exploratory, since it is an initial study, which will promote further, more structured researches. Indeed, this type of research aims to develop, clarify and modify concepts and ideas; in addition to reveal a specific problem and also, to promote conceptual aspects capable of solving or minimizing it (Gil, 2008).

## **2. Collectivity: an essential factor of the city**

Cities are mainly made up of social connections. Otherwise, they are not only large portions of people but social links clusters. For instance, space, time, and infrastructure play a crucial role in enabling social interactions to create and persist, consequently, allowing them to become open to increased connectivity (Bettencourt, 2013). Because of its increased diversity, the city, a space of encounter and coexistence between "unknown" people, gives the urban environment an enriching and civilizing character.

In addition, in community life, a group cohesion does not leave space for appeals that touch only an individual. As a matter of fact, Kuster (2009) presents an enlightening metaphor. The author associates the conflicting relationship between the possibility of joining the maintenance of individuality to the dynamics of the puzzle. One piece, when connected to another, no longer exists as an isolated object, but as part of a set. Moreover, this is what allows to start the search for other pieces, which gives more meaning to the collective with each new piece added (Kuster, 2009). Thus, Glaeser (2011) emphasizes that the power of cities is not only linked to appropriate forms or extraordinary architectures, but rather to the collective way in which their inhabitants are organized, how they deal with their conflicts and cooperate with each other, exchanging ideas, artifacts, information, services, among others. Harvey (2008) considers that the city right goes beyond the individual freedom of access to urban resources, but consists of entitlement to change ourselves and thus change the city. However, this right is collective, since this transformation depends on a collective power to reformulate urbanization processes (Harvey, 2008).

It should also be noted that the city is made up of a complex and therefore plural society. Pluralism presupposes the coexistence of multiple voluntary and inclusive linkages, which reveals an openness to a multiple belonging awareness (Fleury *et al.*, 2008). Therefore, life in cities involves the collectivity, which requires its inhabitants a conscience and behavior consistent with this characteristic. Furthermore, Kuster (2009) warns that in order to live in society, it is necessary to balance doses of affection (desire) and responsibility. The city is collective by nature; however, when choices and actions of a public character are applied on individual interests' basis, there is a significant threat to the quality of urban life and can result in serious problems.

The absence of the notion of collectivity in the population, as well as in social, political or economic representatives, results in a distorted treatment and experience of urban life. Despite being challenging and involving rules that control individual impulses, city life requires paradigm shifts to become, in fact, collective cities. Lima (2015) associates useful transformations of public spaces with their limits and possibilities, also, the more open and intense the interactions in free areas, the more effective will be their transformation.

Indeed, by assuming its collective character in various aspects, the city recognizes its essence and enhances its capacity to offer a quality of life to all. By associating collectivity with multiplicity in the offer of opportunities and possible activities, the city becomes more productive and also enhances the interactions between people and citizens with city spaces. Further, a key factor in order to occur such interactions is the displacements' needed around the city, which is also directly involved with the community. By driving solutions to urban displacements based on the priority of individualization, the municipality harms itself and, consequently, the people who live in it.

The following chapter explores the urban mobility issue under the collective bias. Moreover, it reveals how individualization problems in displacements have damaged life in cities and how it is possible to find ways, through the collectiveness, that enables cities to evolve.

### **3. Urban Mobility: transformation requires new concepts**

From the industrial revolution, cities began to experience explosive growth phenomena, which consequences have been perpetuated until nowadays. Further, the results significantly reached people's lifestyles by introducing new concepts of space use, particularly intending to the massive deployment of road space for automobiles. Besides, the extensive areas occupied by low densities also stimulate and are stimulated by the excessive use of cars (Girardet, 2010). Additionally, treatments like this contribute to the exhaustion of cities' capacity to provide quality services to people. As a result, the urban environment becomes deficient, susceptible to degradation and decay, thus compromising people's quality of life.

Urban mobility in Brazil has experienced a significant increase in displacements by individual motor vehicles. Furthermore, associated with this phenomenon, there are also substantial increases in travel times, energy consumption and road space, pollutant emissions and the number of traffic accidents (ANTP, 2010). These are some of the policy issues that have given priority to individual vehicles over collective modes of transportation. The collectiveness has been losing value, space, demand, and importance in the city and Brazilian society.

Notably, the paradigm shift has been sought for some time, targeting better cities. For instance, the term sustainability was officially presented in 1987 at the United Nations World Commission on Environment and Development (CMMAD, 2008). Moreover, the term was defined as the ability to meet the needs of the present without compromising the ability of future generations (CMMAD, 1988). In Brazil, this term was strengthened in 1992, at the event Rio-92, which concluded by the need to aggregate the economic, environmental and social components to guarantee sustainability (Senado Federal, 2017). In the early 2000s, the National Urban Mobility Policy was introduced and followed by the presentation of the term sustainable urban mobility, defined as a result of transportation and circulation policies sets aimed to provide democratic access to urban space through an effective, socially inclusive and in an ecologically sustainable way of prioritization collective and non-motorized transportation modes (Ministério das Cidades 2004). Subsequently, numerous other concepts and definitions have been developed at the national and international levels, combining mobility and sustainability, such as the World Bank Council for Sustainable Development (WBCSD, 2009), which according to them, sustainable mobility corresponds to the ability to know people's needs so that they can now move freely, gain easy access to places, communicate and establish relationships without sacrificing other essential human or ecological values (WBCSD, 2009).

Furthermore, regarding the concepts, Hjørland's (2009) approaches that concepts are dynamically constructed meanings, which classify the world according to particular interests and theories. As a matter of fact, concepts cannot be understood in isolation from the objectives and theories that motivated their construction (Hjørland, 2009). The author recognizes that the essential function of concepts is to fix reality parts in thought, language and other symbolic systems that enable their communication and reflection. Besides, Hjørland (2009) emphasizes that temporal context must be considered in the study concept since the meaning of a term cannot be something perennial or fixed definitively. The author also emphasizes that the concepts are dynamic and must evolve according to the social construction of knowledge.

Within the city, it is essential to highlight the concept of the system as an important attribute. According to Bertalanffy (1995), the system notion can be perceived in several contexts. Indeed, starting from a biological foundation, the author has developed the General Theory of Systems, which there is a general tendency to the integrate natural and

social sciences. Furthermore, the system is understood as a group of elements in interrelation with themselves and the environment. Davis (1974) reports the possibilities of systems classification, which stands out the open system concept, more appropriate to the urban context. Otherwise, it is about the existence of relationships in which there are information, materials and energy exchanges with the environment. Thus, an open system is the one that interacts with itself and also with other systems, in order to have exchange and communication. The author also highlights the concept of homeostasis to affirm that open systems tend to adapt. For this reason, open systems require to adapt to the changes which their environments are subjected as a fundamental factor to guarantee their existence.

In the field of medicine, Strand *et al.* (2004) have compared and evaluated complex adaptive systems (CAS) and human complexity. Moreover, the authors define human complexity as the result of higher mental capacities and human culture. Furthermore, the CAS concept is adopted by the same authors according to a variety of natural systems, such as the human central nervous system, the human immune system, ecosystems, economies, and cities. Therefore, the authors report that the analysis of human complexity is necessary to recognize the process towards the identification of the medical objective itself may be a significant challenge in medicine.

In addition, about the disruptive characteristic, it is evident in this paper the adopted terms, for example, references from Bower & Christensen (1995) and Christensen (1997), that refer to disruptive innovations. According to these authors, the disruptive term is associated with a paradigm shift and new trajectories for the improvement.

Besides, in a contemporary and future context and also, associated concepts, Adams (2006), has raised some questions about the world's landscape and possible future changes, and also some other questions regarding if sustainability-related concepts provide a coherent and sufficient basis in order to have a change. Moreover, Table 1 presents some concepts available in the literature that relate sustainability to the environment, transportation, and mobility.

Table 1. Relation between sustainability, environment, transports and mobility. Source: Authors.

World Commission on Environment and Development (CMMAD, 2008)	Environment	ability to meet the needs of the present without compromising the capacity of future generations to meet their own needs.
EMBARQ (2006)	Transport	set of transport activities associated with a relevant infrastructure that, collectively, leaves no problems or costs that future generations can not solve or support.
Ministério das Cidades (2004)	Mobility	a result of a transport and circulation policies set that aim to provide democratic access to urban space through an effective, socially inclusive and in an ecologically sustainable way of prioritization collective and non-motorized transportation modes.
Kayal <i>et al.</i> (2014)		refers to an alternative concept that seeks to understand the complex movement of people and goods in cities, as well as the link between transport and land use.
World Bank Council for Sustainable Development (WBCSD, 2009)		corresponds to the ability to know people's needs so that they can move freely today and in the future, in order to facilitate access to places, also to communicate and establishing relationships without sacrificing other essential human or ecological values.

Sustainability concepts and sustainable urban mobility have inspired various researches. Furthermore, they have been and continue to be very relevant for improving the planning and development of the cities. However, for Adams (2006), the sustainability concept, while being holistic, attractive and versatile, is also imprecise, since the idea of sustainability can unite people, but not necessarily make them seek consistent goals. Moreover, the sustainability concept has been widely used in different areas, by environmentalists, government officials, economists, planners and entrepreneurs, who express many different views using the same concept. For the author, a profound paradox surrounds this concept: on one side, everyone joined in this sustainability era (governments, civil society, and the

private sector), on the other side, global activities become less and less sustainable since rhetoric sustainability is ignored in practical decisions. Besides, Adams (2006) reinforces that sustainability concept is no longer sufficient for the necessary changes and he also questions whether such a concept provided a consistent basis for change.

The same is pointed out by Girardet (2015), who emphasizes that even for the planning of new cities, or for retrofit of existing cities, the concept related to sustainability is no longer sufficient.

In Brazil, there is a tendency to increase the degree of urban degradation provoked, among other reasons, by paradigms and behaviors detrimental to urban mobility. Therefore, mobility in Brazilian cities faces a crisis. As a consequence, it is still necessary, in the field of mobility, to find adequate answers to the new demands of this crisis.

According to the considerations expressed so far, which it can be concluded the rupture necessity, associated with a lack of sustainability sensitivity, the following questions are addressed:

- *How to change the existing scenario?*
- *Is the sustainability concept sufficient to guide this change?*
- *Should we work for urban mobility that (just) does not leave problems for future generations?*
- *Or should we desire urban mobility that can contribute to making future cities better than the present cities, so that they could really evolve?*

Adams (2006) reinforces that the attainment of favorable conditions for cities to be healthy organisms depends on positive transformations. On the other hand, the transformation requires new concepts, new ways of involving society in the search for solutions. Moreover, an effective strategy could be achieved by adopting an advanced or evolutionary approach, emphasizing the sense of future improvement not only to keep the organism supporting cities alive but also to correct and improve it (Adams, 2006).

Consequently, as an answer to the previously asked questions, the next chapter brings the Regenerative Mobility approach as a new potential path, expressed by a new concept.

## **4. Regenerative Mobility: new ways through the city**

In fact, considering the negative impacts of cities and the need to break concepts and behaviors related to urban mobility, it has been highlighted a possible connection between this scenario and a medical approach. Furthermore, the urban body has been degraded due to the practice of inadequate and incompatible actions allied with the balanced development of the environment where it is inserted. Indeed, the correction of the damage caused requires a significant change of concepts and behaviors.

### **4.1. Regenerative Medicine**

Additionally, in the medical field, due to the necessity to change the course of chronic diseases, the ways to evolutionary treatments have been sought in the principles of regeneration. The first reference to the term Regenerative Medicine was published in 1992, by Kaiser L. R., in an American article. According to the Austrian Society for Regenerative Medicine (2016), the Regenerative Medicine is evolving in its studies and research and develops an attempt to change the course of chronic diseases by regenerating condemned cells, tissues and organs, giving them superior conditions compared to the prior ones before the disease was acquired.

A good example is what has been done with hematopoietic cells, which make up the hematopoietic tissue, precursor of the red bone marrow and responsible for the production of blood cells and lymph (Amabis & Martho, 2004). Furthermore, the introduction of hematopoietic stem cells in cases where they used to manage fully functional organs made it possible to reconstitute all the hematopoietic cells of the patient. Thus, for the first time, the bone marrow could be slowly regenerated. The author warns about the existence of a crucial restrictive factor in medicine: there are not enough organs for all the transplants demand (Oliveira *et al.*, 2012). Moreover, this experience reveals that the emergence of Regenerative Medicine, characterized by the combination of tissue engineering, stem cell therapy, regeneration factors, extracellular matrices and therapeutic cloning, is intended to replace organ transplants. As a result of its restrictive factor, transplants have come to be seen as insufficient for medicine. From this deficiency,

Regenerative Medicine excels in offering pathways capable of advancing the treatment of diseases and achieving better results for patients.

Furthermore, among the approaches of regenerative medicine is the work of Professor Shinya Yamanaka of Kyoto University in Japan, who in 2007 transformed human cells into pluripotent cells (iPS), capable of transforming into various cell types (Hayden, 2011). Otherwise, the cells have proved to be a benefit of regenerative medicine, since by using the skin, blood or other cells of a person, it is possible to reprogram them into iPS cells and also use them to improve liver cells, neurons, or whatever is necessary to treat a disease. The work by Professor Yamanaka, along with Professor John Gurdon, has yielded the Medicine Nobel (Abbott, 2012). Further, regarding the applications, some studies show cases applied in the regeneration of retina, glaucoma and Alzheimer's (Scudellari, 2016); and also other studies on brain stimulation and research in Neuro-rehabilitation (Mayo Clinic, 2016).

## 4.2. Regeneration: from medicine to the city

Moreover, seeking significant advances in diseases solutions, the medicine has identified that organ transplant treatments were deficient and, therefore, insufficient. Similarly, in the context of urban mobility, it is possible to identify a similar situation. For cities, the challenge is to create more than sustainable cities, but cities that can regenerate, improve and evolve. Thus, they must guarantee future and present generations not only efficient but also low carbon resources, improvement of ecosystems which have been exploited beyond their limits (Girardet, 2010). In order for cities to achieve desirable scenarios capable of providing quality of life to all its inhabitants, under superior conditions to those they have already offered, the principles of regeneration emerge as a new paradigm capable of responding more adequately to the crisis so far faced, and that aims more than "sustain" their capability to offer urban life.

There is a significant lack of targeted medical treatments for healing or change that reaches the primary source of a disease, especially those that are subject to degeneration. Consequently, these have only palliative treatments, without favorable results. Moreover, this scenario ratifies how feasible is the field of Regenerative Medicine in the search for diseases cure of a different perspective. Accordingly, it becomes feasible to use treatments that act directly on the main and initial element of system change: the cell itself (Austrian Society, 2016).

The palliative treatments applied nowadays in urban mobility through many cities involve aspects of road infrastructure, usually in an attempt to increase the cars flow. As a consequence, actions such as the construction of overpasses, widening streets and avenues, increasing the speed limit, creating parking areas, among others, can give a momentary sensation of improved mobility. However, such actions end up encouraging, even more, the use of individual vehicles, provoking in cities the opposite effect: the degradation of the collective and also, an urban mobility crisis. Therefore, it is necessary to use treatments that act directly on the primary element of system change: the urban displacements.

Mulgan (2018) points out, regarding the human organism, that neurons only become useful when connected to billions of other neurons: the entire group becomes much more useful than the sum of its parts. A similar relationship happens in urban space: the collective, a fundamental characteristic of the city, is a factor which the quality of life depends. Furthermore, by associating the regeneration of medicine and urban mobility, the collectiveness could be understood as the treatment essence to be applied to urban displacements. Moreover, the roads that lead cities within reach of Regenerative Mobility are only possible if the treatment of urban displacements is based on the community. Under those circumstances, it is necessary to have a break from the individual to the collectiveness: collective cities as an answer to the mobility crisis.

Besides, Regenerative Medicine has the potential to solve the problem of donor organ shortage compared to the number of patients requiring organ transplantation (NIH, 2013). Further, transplants, still nowadays, are used as an alternative to curing diseases. However, Regenerative Medicine offers ways to overcome a significant barrier faced by those who need a transplant: the scarcity of donors. Indeed, realizing that this deficiency interferes directly and negatively in the success of the treatment of the diseases, Regenerative Medicine finds in the stem cells a way to overcome the paucity of donors and to reach more effective and efficient results, thus allowing unprecedented gains in medicine.

Regenerative Mobility, on the other hand, has the potential to contribute significantly to the solution of the problem related to urban displacements, nowadays excessively carried out by automobiles. In this case, the use of individual motor vehicles contributes to the scarcity of spaces for people, that is, spaces of leisure, nature, with safety and quality for pedestrians and cyclists. Additionally, cars are too much used as a model for urban displacements. However, Regenerative Mobility offers ways to overcome a significant barrier faced by those who need to move through cities: the excess of individual motor vehicles in transit. Besides, verifying that this condition is a decisive factor not only in the displacements but also in the quality of urban life, Regenerative Mobility finds in collective public transport and in the collective city the primary way to overcome problems such as congestion, aiming at reaching more efficient and effective conditions to enable people's displacement, thus allowing real gains to mobility and the city as well.

Thus, urban mobility will only reach evolutionary frames if there is a sufficient investment in actions based on the prioritization of modes such as collective public transportation, cycling, and walking; in parallel with the discouragement of car use. In addition, the rational urban land use is aiming to reduce the distances traveled and making it compatible with transport systems, also should contemplate a centralities' network. (Kneib, 2014 and 2016).

### 4.3. Regenerative Mobility and its potential for improving cities

The city is a complex and systemic organism. Hence, its regeneration depends on several factors, among which are the mobility, accessibility, land use, health, education, public safety, environment and others. In this context, urban mobility plays a fundamental role, by enabling people conditions to carry out the most varied activities across the territory. However, public transit, preferentially facilitating medium and long displacements, is the structuring mode, able to meet the principles of collectiveness and, therefore, is essential for Regenerative Mobility.

Therefore, Regenerative Mobility could be a great hope for cities that experience degradation scenarios of mobility and wish to break this process and evolve. Even for those cities that are already on the road to sustainability, Regenerative Mobility becomes essential, since sustaining alone may not be enough for mobility and cities to evolve. Hence, the concept and principles of Regenerative Mobility could be applied to any city.

In order to summarize and simplify the relationship approach between Regenerative Mobility and Regenerative Medicine, Figure 1 outlines the regeneration process developed on the treatment of "weakened organisms". In addition, in T1, the organism is in a healthy state, which constitutes a normal condition of its functioning. Subsequently, in T2 it could be observed the beginning of symptoms appearance that announces the arrival of a particular disease. Afterward, in T3, the disease progresses, and the debilitation caused by the damages to the organism make it doomed to saturation. Thus, In T4, after receiving expressive interventions based on regeneration, the organism recovers. Consequently, when it has regenerated, the organism does not return to its initial state (T1), but could also attain higher levels of health and conditions for its full and continuous development.

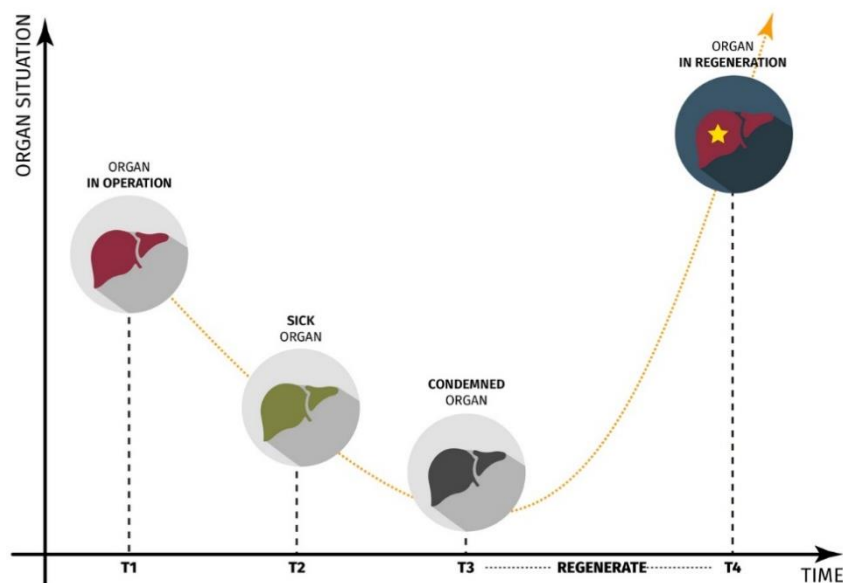


Figure 1. Regeneration process developed on the treatment of "weakened organisms". Source: Authors.

Similar to Regenerative Medicine procedure, it is also possible to observe the mobility transformation stages on the regenerative process. Moreover, it should be noted that Regenerative Mobility could be applied not only in cities with condemned mobility but also in those with fewer damages (sick mobility) and even in cities with mobility "in operation". Figure 2 outlines the procedure for Regenerative Mobility.

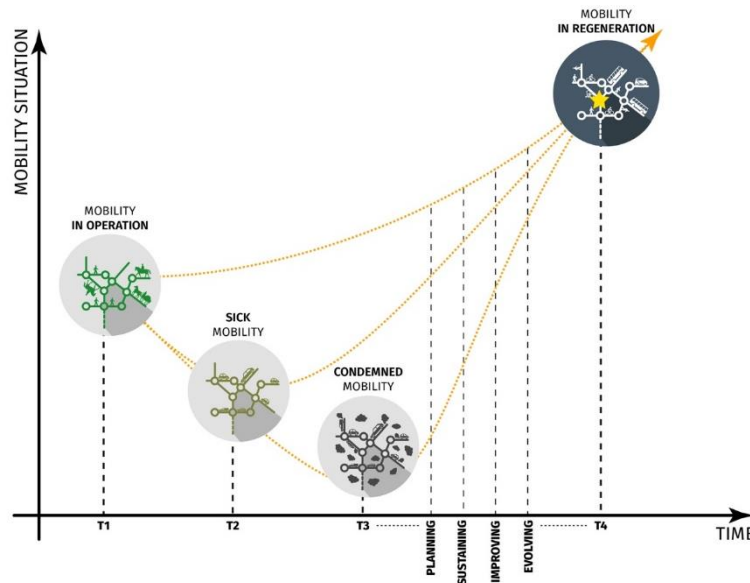


Figure 2. Regeneration process of "impaired mobility". Source: Authors.

Furthermore, in the cities' case, regeneration depends on several factors, with mobility being one of the basics. Additionally, obtained initially through the pillars of planning, sustaining, improving and evolving, public transportation is the structuring element of Regenerative Mobility. Therefore, Regenerative Mobility, based on the collectiveness, through public transportation, will be the basis of regenerating city process (Fig. 3).

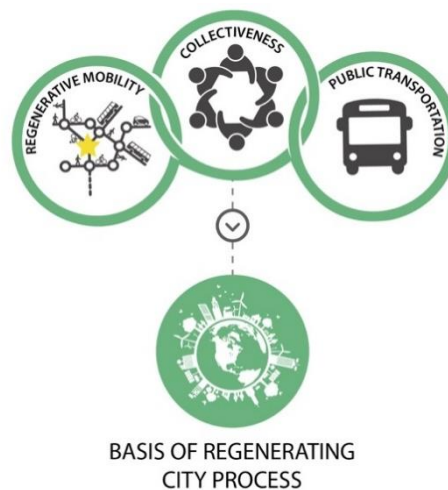


Figure 3 The basis of regenerating city process. Source: Authors

#### 4.4. Application of Regenerative Mobility principles

Since this is exploratory and initial research, as described earlier in this paper, which aims to develop, clarify, modify and innovate concepts and ideas, for this reason, it becomes crucial to understand the proposed concept - Regenerative Mobility - to illustrate some of its principles with practical examples.

Around the world, some cities already present actions and projects that reveal close relations to the principles of Regenerative Mobility. As an illustration for a reflection and beginning of construction of this concept, two European cities (London and Berlin) and another Latin American city (Bogotá) has been presented below.

– London, England



It has been clearly observed that the role of public transportation as a strategies focus, has complemented and articulated with several other elements. Moreover, according to the Mayor of London (2015, pg.1): "improving transport is central to most regeneration plans, and that plays a key role in regeneration in London".

London uses the concept of regeneration similar to urban (re)qualification (helping places to prosper). Decisions taken by TfL (Transport for London) play a central role in neighborhoods regeneration on the search for new investment and in promoting a high quality of life for its residents (Mayor of London, 2015). Table 2 presents a set of strategies and policies to support regeneration, which adopts the transport as the primary element.

Table 2.London: Strategies and policies to support regeneration. Source: Authors, based on Mayor of London (2015).

Opportunity and Intensification Areas	38 Opportunity Zones have been allocated, such as areas of industrial occupations abandoned, with significant capacity to develop through residential and commercial activities. Besides, 7 Intensification Zones have been designated, which can accommodate work activities and residences.
London Enterprise Panel - LEP	It contributes to the Economic Development Strategies distribution that the mayor designates through the programs' action between local partners. Investment in public transport for qualification is a key feature of London Growth Fund. LEP also has guaranteed 20 million euros for roads and workplaces.
Economic Development Strategy	It actively refers to the public transit role on qualification. Transportation links should support regeneration in the Opportunity Zones. It also includes a commitment to consider the best ways to make local transport and environmental improvements contribute to development.
Financing of roads and urban centers re-qualification	Since 2011 the City of London has invested resources in roads requalification. Improvements in transportation configure some of the various consolidated projects as part of the city's duties.
Transport strategies	TfL and the City of London affirms that some actions need special attention. For example: Support of economic development; Improvement in quality of life; Support to urban renovation and fight against deprivation.

– *Berlin, Germany*

Indeed, searching for new mobility and concerning the importance that the urban transport policies influence on population's choices for new transportation modes, for instance, it has been analyzed the case of Berlin. Furthermore, this is a case where traditional motoring patterns are not significant for its mobility, especially regarding the growing number of adepts to other modes such as bicycle, walking and shared vehicles, for example, to the detriment to the individual cars. Moreover, following the technology advances and its potential for smarter mobility, in particular, it has been recognized in Berlin that smartphone applications have also been embedded as tools that help people make their displacements decisions.

The Berlin Metropolitan Region (BMR) has been made up by the city of Berlin and 18 other local authorities close to the capital. In 2013, the BMR added 4.4 million people, within 80% of this total living in Berlin. Although it is a more evolved context concerning the investments and the quality of public transport services, the suburbanization impact on displacement has been through increasing travel distances. Furthermore, faced with such a challenge, the investments have concentrated in the road network, as well as in the public transportation of the region. Therefore, the increase of the railway capacity in and through Berlin has been noted, due to the strategies performance based on the so-called "mushroom concept" (Pilzkonzzept), which is the intersection of two basic planning concepts: axis and ring concepts which includes four stations of main lines decentralized in the ring line (Ringbahn) around the city center. Moreover, the new concept consists of the central station - Berlin Hauptbahnhof - which enabled more extensive services and a new connection between the east-west and north-south directions; and five other stations, some old and

some new ones. Besides, it has created a new high capacity rail branch in the south and a north tangential connection (LSE Cities, 2015).

Furthermore, implications of the strategies implementation based on the mushroom concept in Berlin were significant: they widened regional connectivity and increased transport flows by increasing service levels. Hence, after its inauguration, regional suburban train services grew more than triple, with travel times being reduced by up to 35 minutes (LSE Cities, 2015).

Additionally, the demand increase for public transport between 2001 and 2011 was over 20%, from 1.14 to 1.38 million passengers. On the other hand, the relative participation of cycling and walking has been highlighted. Consequently, the most significant gain was the decrease in car use. In order to reduce pollution in Berlin, a low emission zone (Umweltzone) has been established in 2008, which settled restrictions on specific neighborhoods, focusing on the adoption of low pollution certified vehicles (LSE Cities, 2015).

The transport policy that has been applied in Berlin also prioritizes walking and cycling as a transportation mode. Further, with the construction of more than 1,000 km of cycling infrastructure, the number of cyclists has increased by more than 40% between 2004 and 2012. For this reason, this investment impact has been reflected by the active participation of cycling in all displacements in Berlin. Despite the advances, travels by cars still occur in higher numbers than the others (37%). Subsequently, there are trips by public transport (30%) and by bicycle (17%) (LSE Cities, 2015).

Moreover, individual vehicle availability rates are high in Berlin. However, 27% of households do not own a car. A survey by the LSE Cities (2015) found that among the reasons why inhabitants do not own a car, 53% is due to the high cost of owning and using the car, and also 47% said it was unnecessary to own a car in Berlin. Furthermore, shared cars have also been an increasing option among the population (LSE Cities, 2015).

The development of new information and communication technologies has caused significant and increasing impacts on the travel behavior in Berlin, with an emphasis on public transport. According to the research, 37% have smartphones with Internet access, and displacement applications often used (LSE Cities, 2015).

Thus, advances in the quality of urban life had fundamental strategies based on public transportation. Moreover, connectivity increase has not only been provided through actions such as the "mushroom concept", which had as its main purpose the rail region network, but also a combined action of the various transportation modes. Although the car use is still significant, it is evident that Berlin's transport policy, based on public transport prioritization, has achieved better results in its organization and conflicts solution. Therefore, this is a case in which there are indications of the application of consistent actions related with Regenerative Mobility and, as this concept emphasizes, there is always the need to seek new advances, innovations, and improvements.

– *Bogotá, Colombia*

Bogotá has had public transportation as a crucial element in its urban transformation. In this case, Transmilenio, the Bogotá Bus Rapid Transit (BRT) system, was a determining change factor of the chaotic urban development scenario in a dense city marked by social segregation with more than 7.5 million inhabitants (Bocarejo & Tafur, 2013).

The first phase of the TransMilenio system was inaugurated in December 2000. Inspired by Curitiba BRT system and created as a key element of a mobility strategy to reduce the use of individual vehicles, prioritizing public transportation and non-motorized modes. Further, the main goal of TranMilenio was to create an economic system, capable of improving productivity and quality of life in Bogotá. Besides, TransMilenio has provided comfort, speed and safety displacements to citizens. As a result, the challenges caused by severe social problems related to the absence of excellent public transportation and also the constant congestion have been transformed by Transmilenio implementation.

Bocarejo & Tafur (2013) have recognized that Transmilenio was able to change the perception of Bogotá: from bankrupt to a sustainable and promising city example. Further, TransMilenio has constituted the most visible change, but also it has effectively influenced aspects of Bogotá's urban structure and citizens' lives, such as land use, productivity, road accidents and even crime and public health.

As project focus has been the vast capacity of public transportation, the TransMilenio system has as differential measures that complement and support public transportation use. Indeed, this system has included 300 kilometers of new cycle paths, improvements in public space, and also the dominical closing of 120 kilometers of highways to private motor vehicles, among other resources. Thus, the success of this project and the effective priority of collectiveness, measures have been implemented to discourage the car use, through parking restrictions and also a restricted use program by the license plate number (Ministério das Cidades, 2008).

Indeed, with new cycle routes, improvements in the public space and also the TransMilenio system, citizens could notice a transformation that had been expanding through the city. Among the urban improvements that have been mentioned, such as connection, development of areas, the material of Brazilian Ministério das Cidades (2008) has emphasized that TransMilenio represent an example of a high-quality urban regeneration mix with BRT system, mainly in roads where there is exclusive access to public transport.

Therefore, according to Bocarejo & Tafur (2013), in the last decades, Bogotá has developed a consistent policy based on principles that give priority to public transportation and non-motorized modes, revealing the objective of consolidating a dense city with a development-oriented to public transportation. Furthermore, the authors affirm that TransMilenio has corroborated to the fact that mobility changes have a direct impact on urban development. However, even in success, the city still faces some challenges, such as the increase in motorization rates, loss of service quality, segregated areas with fairness lack of service, showing a city that has transformed itself for the better but still has much more to evolve.

## **4.5. Regenerative Mobility and its basic attributes**

The practical cases presented converge with the regenerative mobility concept, in which public transportation is a fundamental element for positive and structuring changes in cities. Moreover, this regeneration depends on several factors, in which the mobility is one of the basilar. Consequently, regenerative mobility, guided by the collectiveness, focusing on public transportation, will be the basis of the regenerating city process.

The paper has developed the following specific objectives: first, to identify similar aspects between the human and urban organism; secondly, to strengthen relations between the concepts of Regenerative Medicine and Regenerative Mobility. Subsequently, the third specific objective, which deals with the initial development of Regenerative Mobility characteristics, could be illustrated through a concepts synthesis and the case studies addressed. Further, from the conceptual approach developed, as well as from the case studies carried out and with the pillars of planning, sustaining, improving and evolving, it is possible to highlight seven essential attributes of Regenerative Mobility:

### **4.5.1. Systemic Approach**

The first attribute portrays a significant analogy between medicine (human body) and urban mobility: the pieces interfere in how the whole system works. Hence, the systemic approach is necessary for Regenerative Mobility to be feasible. Therefore, it is essential to consider the interrelationship between urban mobility and the spheres in which it is inserted and interacted. Thus, public policies need to be transversal and integrated; otherwise, mobility will not be regenerative.

### **4.5.2. Recognition of city's metabolism**

The second attribute refers to the notion that each city works as a complex and systemic organism, as well as singular and particular. Thus, before applying any strategy of urban planning, first, it must be known the territory in which intends to intervene. Furthermore, the particularities of each city - as well as the particularities of each human organism - must be taken into account before going through a particular treatment. If this is not a condition for defining intervention strategies in a city or a person, there are risks that, contrary to what is intended, cause other problems.

### **4.5.3. Collectivity focus**

Despite its peculiarities, a characteristic, however, is common to all cities: the collectivity. Moreover, in this context, the third attribute has been justified, and the same presupposes respect for the city's collective essence. Further, as

discussed in this paper, the city is, by its nature, multiple and diverse, these characteristics making it prosperous and civilized. Indeed, it is evident that choices arising from individual interests threaten the quality of urban life. Therefore, in the urban mobility context, this can have a substantial and negative impact on the conditions of people displacements through the urban territory, which contributes to degrading any city.

#### 4.5.4. Disruptive Innovation

The fourth attribute considers something that is at the core of Regenerative Mobility: the notion of a necessary disruption process to give space for a paradigm shift and, thus, open the way for new paths. Furthermore, this notion must be accompanied by the awareness that time is part of the urban organism, which causes this continuous changes. Hence, the treatment given to the city can not perpetuate without it being under the constant changes and consequent new necessities.

#### 4.5.5. Identification, evolution, and improvement of existing urban elements

This attribute is also an essential step for the development of Regenerative Mobility since there is the understanding that a configuration or treatment given to the city no longer meets their needs and, therefore, hinders or even prevents it from evolving. Hence, by identifying such elements, it is possible to transform and thus improve them, achieving evolution.

#### 4.5.6. Direct action on urban displacements

Although it is contradictory, it is also common to find actions that sake urban mobility and, erroneously, do not consider their due importance urban displacements. However, these must also be accompanied by the notion that the city is collective by its essence. The sixth attribute refers to the treatment given to this characteristic in front of urban mobility interventions. Therefore, collectiveness is expressed in this attribute based on the preference given to pedestrians, cyclists and public transportation to the detriment of individual vehicles use.

#### 4.5.7. Recognition of public transport as a structuring element

Since the city is the space of multiplicity, diversity, and collectivity, public transport is a fundamental mobility element. The seventh attribute of Regenerative Mobility observes the structural character of this modal and considers that it should be at the core of the urban displacement improvements actions, as well as must act in a harmonious and integrated way with other transportation modes. Lastly, this connection must have people as protagonists, with public transport as the collective structure of the cities in function of meeting the needs that the population presents regarding the displacements through the territory.

Moreover, this paper is a result of initial studies on the Regenerative Mobility concept, and it should also be highlighted that the attributes presented here have been derived from the concepts discussed so far. Therefore, these are essential characteristics of Regenerative Mobility, which in the deepening researches development, it will function as a basis for the next shreds of evidence about this concept. Table 3 presents a synthesis of these attributes and their presence in each of the case studies.

Table 3. Synthesis of Regenerative Mobility Attributes. Source: Authors.

<b>Regenerative Mobility Attributes</b>	<b>London</b>	<b>Berlin</b>	<b>Bogotá</b>
<i>1. Systemic Approach:</i> the pieces interfere in how the whole system works	X	X	X
<i>2. Recognition of city's metabolism:</i> each city works as a complex and systemic organism, as well as singular and particular	X	X	X
<i>3. Collectivity focus:</i> respect for the city's collective essence	X	X	X
<i>4. Disruptive Innovation:</i> necessary disruption process to give space for a paradigm shift		X	X

Table 3 continued

5. <i>Identification, evolution, and improvement of existing urban elements</i> : certain elements no longer meet the needs and therefore hinders or even prevents the city from evolving. By identifying these elements, it is possible to transform and thus improve them, achieving evolution		X	X
6. <i>Direct action on urban displacements</i> : urban mobility interventions based on collectiveness, from the preference given to pedestrians, cyclists and public transportation to the detriment of individual vehicles use	X	X	X
7. <i>Recognition of public transport as a structuring element</i> : should be at the core of the urban displacement improvements actions, as well as must act in a harmonious and integrated way with other transportation modes	X	X	X

Hence, the attributes listed in Table 3 are initial properties that seek to translate the first steps of the developed concept in an applied method. Moreover, they are extremely important in the research scope of this subject, since they are primary and initial elements to understand the related phenomena, as well as for the development of qualitative and quantitative research on the theme, including the development of indicators, which could help the mobility characterization and how it could become a regenerative mobility - allied with the pillars to plan, sustain, improve and evolve.

## 5. Final considerations

The approach that has been presented by this paper has raised questions that are challenging and also fundamental to the cities. Moreover, it is essential to recapture Adams's (2006) position, which asserts that challenges require vision and daring, and the sustainability concept may no longer be sufficient to induce necessary changes.

In order to change the existing scenario, that cities face a mobility crisis, this article supports Adams's (2006) vision and presents the concept of Regenerative Mobility, which seeks an approach beyond sustainability, a concept that is capable of contributing to making the cities of the future better than those of the present.

London uses a regeneration definition for its projects, however, associated with urban requalification. Girardet (2010 and 2015) uses a term more robustly, in what he calls a regenerative city, relating to its ecosystems, surroundings, resources, and landscape, mentioning a restorative relationship, and comparing the urban regeneration concept with the eco-regeneration. The author also mentions initiatives of urban regeneration, focusing on the health and well-being of inhabitants, in Great Britain, Germany, and the United States. However, in this paper, the regenerative is not just a term associated with mobility, but also provided as a new concept, with specific disruptive and evolutionary purposes.

Furthermore, cities can offer the ability to establish better conditions of quality of life, always seeking to avoid new problems, overcome old problems and repair damages already caused. Thus, the essence of such solutions lies at the heart of every city: the collectiveness.

Besides the urban mobility context, the regeneration concept derivation, brought from the medicine, relates the promising of stem cells with the potential of public transport. Furthermore, this is the way through which cities could achieve significant evolution. Additionally, it is on this purpose that the Regenerative Mobility contribution is found. Moreover, it is necessary to reverse roles from the individual to the collectiveness. Also, it is indispensable to consider the systemic character that manages the cities and also applies to urban mobility. Based on Bertalanffy's (1995) Theory of General Systems, as in the medical field and also in urban mobility, the interactions between the pieces and the whole system are impermanent. Therefore, in order to Regenerative Mobility be feasible, the system requires that it is essential to consider the interrelationship between urban mobility and the spheres in which it is inserted and interacted.

In addition, it has emphasized that its conception does not rule out the sustainability importance and its potential in offering improvements to mobility, cities and, consequently, people. However, Regenerative Mobility includes sustainability in its principles but warns: just sustaining is not enough. Therefore, going beyond that is necessary.

Urban mobility will only reach evolutionary frames if there is adequate investment in actions based on the prioritization of public transportation, complemented by cycling and walking; parallel to the rational use of the car and the adequacy of the activities disposition in the territory. Eventually, it is fundamental to recover and articulate existing concepts and proposals, such as the Compact City and Transport Oriented Development principles, which aim to stimulate the mixed land use and the compact occupation, thus reducing the displacements distances and bringing people closer to the available high capacity transport infrastructures (ITDP, 2017). Thus, when dealing with innovation in urban systems, it is also necessary to consider as a critical approach the principles of the Living Labs concept (Concilio, 2016), which will allow a deeper understanding of future works.

In order to give a clue to practical cases that converge with the regenerative mobility concept, three examples in which public transportation is a fundamental element for positive and structure changes. Moreover, this regeneration depends on several factors, being the mobility one of the basilar. Consequently, regenerative mobility, based on the collectiveness, through the pillars of planning, sustaining, improving and evolving, has public transportation as the basis of the regenerating city process.

Moreover, it is noteworthy that this paper achieved its general objective in developing and presenting a disruptive concept of Regenerative Mobility. Besides, by pointing out similarities between the dynamics of urban and human organisms and thus developing relationships between the concepts of Regenerative Medicine and Regenerative Mobility, it is emphasized that this work also reached its specific objectives. Indeed, it is a concept launched in its initial bases, and that seeks to aggregate researches, knowledge and involve society in order to pursue solutions. Under those circumstances, it is expected that this article could contribute to the first steps of Regenerative Mobility and also instigate the reflection of researchers, managers, planners, and society itself.

In conclusion, the development of this work had some limitation due to this new concept, for instance, the small number of references associated even related to the regenerative city. On the other hand, this characteristic can also be a stimulus for other works to be developed in order to continue the development and consolidate the Regenerative Mobility concept. Hence, potential future work is expected to develop practical methods applicable to cities, including classifications, characterizations and also quantitative and qualitative tools for diagnosis, planning, and evaluation, to consolidate Regenerative Mobility and contribute to driving cities to the desired evolutionary process.

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