

# Possibilities and challenges of creating a livable street with street tree: A literature review

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## ABSTRACT

Many cities are trying to reduce cars and create more human-centered environment to improve the urban life quality. A large body of research has been focused on urban street planning, particularly on livable street, while street tree as one of the key elements on building livable street has not been well studied and examined. This paper is a literature review of research that linked analyses of livable street with street tree. This paper provides a review of 36 relevant studies, examining: (i) the definition and discussion of livable street, and (ii) the role of street tree on creating livable street. This article discusses the definition of livable street and the relationship between livable street and residents, social inclusion, street traffic, infrastructure interactions, and stakeholders. More importantly, street tree as a very important element in livable street is examined from the perspective of its benefits, challenges and citizens' attitudes towards it. The results from the literature review indicate that a very limited number of studies have discussed the street tree's influence on street livability. Future studies could further investigate the interactions between street tree and residents and reveal the imperceptible effect of street tree on street livability.

**KEYWORDS:** Livable Street, complete street, street trees, interaction, urban trees, urban forest

## 1. Introduction

The intensive development of urban areas is destroying natural ecosystems of town and cities (Areas, 1997; Roy, Byrne, & Pickering, 2012). The invasion of city transportation system to urban street often creates environmental condition that does not support the existence of street trees (Roy et al., 2012). Because of the intensive urban land use and high pace of urbanization, neighborhoods are gradually taken over by car, which endangers the safety and comfort of pedestrians, their

physical activities and their enjoyment of outdoor living (Sauter & Huettenmoser, 2008). Except for the urban planning issues, many cities are also experiencing severe environmental problems, such as noise, carbon pollution, soil erosion, and species extirpation (Zipperer, Sisinni, Pouyat, & Foresman, 1997). Therefore, many scholars and policy-makers started to pay attention on building streets balancing the traffic and residential livability (Marshall & McAndrews, 2017).

There are several street concepts that have caught researcher's attention, and related policies have been implemented in practices, such as livable street, complete street, which have been widely discussed (Harvey & Aultman-Hall, 2016; Marshall & McAndrews, 2017). However, a comprehensive assessment of this research is lacking. Therefore, this paper aims to gain better insight of the concept of livable street or complete street concept by conducting a systematic literature review.

Moreover, when creating a livable street, street tree has been identified as a very important element (Roy et al., 2012). Planting trees and greeneries has been considered as beneficial solution among different alternatives to improve urban environment. Their benefits were discussed in many studies, such as improve air quality, reduce stress, promote outdoor activities, and so on (Roy et al., 2012; Tiwari & Curtis, 2012). However, planting street trees is also facing many different challenges in practices, such as tree mortality, causing damage and injury, healthy issues with pollen and insects from trees, invisible cost added-up to local commune and real-estate, etc. Because of the importance of planting street tree to create livable street, the paper also aim to find out how street tree influences the street livability, and two sub-topics will be discussed here: first, the benefits and issues of having street tree, and second, the social and economic impact of street tree.

This study is aimed at 1) finding out what is the livable street or complete street concept, and the relevant policies; 2) finding how street tree influences street livability, by investigating the benefits and issues of having street tree, and some social and economic impact of street tree.

The paper is a literature review of scholar literature, within the topics on livable street and street trees. This paper begins with an introduction of the literature review method used in this study. Results of the systematic literature review of relevant literature are then reported

and discussed, and some suggestions are then given for future research.

## 2. Methods

This paper applied a literature review method called systematic literature review, which is a method has been extensively used in the social sciences (Roy et al., 2012). This method involves a systematically searching and categorizing of the current relevant literature, which provide reliable assessments of the status of a field of research (Roy et al., 2012).

The literature is gathered by doing keyword searching from 'Web of Science'. Keywords used for the search included are divided into two groups: (1) street relevant keywords: 'living street(s), livable street(s)', 'liveable street(s)', and 'complete street(s)', and (2) tree relevant keywords: tree(s). Both keyword groups are included in the searching, for example: 'ts='living street\*' and 'tree\*'. Four pairs of keywords are used. There are 97 relevant articles (English Language) from database of Web of Science Core Collection. 31 articles were screened and kept as relevant to topic of urban design and/or street trees, and interactions between human and street tree. Except for these 31 articles, 5 additional articles and books from cross-reference were found from Google Scholar, NTNU Library searching service. In sum, there are 36 papers included in this literature review paper.

Four fundamental topics were looked for in these 36 articles. (1) Definition on livable street, living street, complete street; (2) discussion on keywords: livable street, living street, or complete street; (3) discussion on keywords: tree, greenery, plants; (4) discussion on keywords: human, people, citizen. The summary can be found in Appendix 1.

### 3. RESULTS

A total of 36 research papers were collected (Appendix1), and four fundamental topics are identified in these paper. The number of paper that discusses each topic reflects the research interest on these topics.

In general, the reviewed articles can be categorized with their various focus into two groups. One group is about the definition and similar concept of livable street, and discussions of livable street from several aspects. The other group is about discussion of the benefits and issues about street tree, discussion of street tree's influence from the social-economic perspective, and studies of local citizens' attitudes towards street tree.

In these 36 papers, 3 papers (8%) discusses the definition on livable street, living street, or complete street. 24 paper (63%) have the discussion on keywords: livable street, living street, complete street. 6 papers (16%) contain the discussion on tree, greenery, or plants. 6 papers (16%) discuss the perspective of human, people, citizen.

The results reveal that livable street has been a very popular research topic, however, there has been very limited discussion clarifying the definition of livable street. Moreover, tree as an important element for livable street has not been studied thoroughly, and there are very few articles studied the role of tree on creating livable street.

### 4. DISCUSSION

#### 4.1 Livable Street as an Ideal Street Form

In this session, the definition of livable street will be discussed first, and the similarity and diffidence between livable street and complete street will be discussed. Moreover, the session illustrates the

relationship between livable street and residents, social inclusion, street traffic, infrastructure interactions, and stakeholders. In end, the implementation of livable street will be discussed.

**Definition of livable street.** Livable street or living street, is a street concept that compares to conventional urban street concept, places more concern and focus on pedestrian and cyclist, so that the street can be equally used for all (D. Appleyard, Gerson, & Lintell, 1981). The concept of livable street is first introduce as '*Woonerf*' in Netherland, it can be translated as 'a road in which devices for reducing or slowing the flow of traffic have been installed'<sup>1</sup>. It was taken into design practices and widely implemented as features in country levels traffic codes early in 1970s (D. Appleyard et al., 1981). Donald Appleyard summarizes the features of the Dutch woonerf: 'You may walk anywhere on a road within a *woonerf* and children may play anywhere; [...] anyone who drives a car or rides a moped [...] must not impede pedestrians' (D. Appleyard et al., 1981, p. 306). This also means that street, together with the nearby neighborhoods should be a safe and comfortable environment. In livable street, pedestrians can walk comfortably, children can play safely, and disabled people are also able to use facilities and move around freely. Meanwhile, motorized vehicles can also use the street with restricted speed and less domination of street.

**Comparison with complete street concept.** The livable street is widely discussed in the past few decades. Meanwhile, similar concepts were brought up in several countries, such as complete street. A complete street is a road that is 'designed to be safe for drivers; bicyclists; transit vehicles and users; and pedestrians of all ages and abilities' (LaPlante & McCann, 2008, p. 24). The complete streets concept focuses on the decision-making and design process of the planning, designing, building and operating of all roadways (LaPlante & McCann, 2008). Therefore, it is relevant to policy and institutional change. In compete street, street

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<sup>1</sup> <https://en.oxforddictionaries.com/>

side greeneries, particular trees, street furniture and other street elements compose the protected street environment. The car speed is strictly restricted to pedestrian speed, while children can play on the same road. Complete street policies are implemented in several cities and many other urban area in the US (Kingsbury, Lowry, & Dixon, 2011).

The complete street has the same principle as the term of the livable street. Complete street is a design decision making approach and guidance that directs professionals to make streets safe and equal to *all* (Anderson et al., 2015; LaPlante & McCann, 2008). While livable street concept emphasizes residents who *live* in or nearby the street as the main focus, so livable street is a more human-centered concept. Human are seen as the center of a street, have interactions with other elements including street trees. Human' activities and various street elements have influences on each other, which further impact the street livability.

***Livable Street and residents.*** Livable Street emphasizes beyond safety and comfort. Street shall encourage residents to use the public space on street, give resident freedom to change the functions of the space, and reform the space with different need and creativity. To some extent, livable street is similar with the concept of democratic street, which emphasizes 'the access and needs of many different kinds of people, provides opportunities for discovery and challenge, and actively encourages user manipulation, appropriation, and transformation' (Francis, 2016, p.198). Therefore, people can see and interact with others in a public area without chaos, which presents some local and unique characters of the street, and city.

***Livable streets and social inclusion.*** Livable streets in urban neighborhoods can be great places for public life and social inclusion (Sauter & Huettenmoser, 2008). To create livable street, another important social factor to designers and engineers is that a street shall be a comfortable setting where people from different age,

knowledge and other groups can learn and perceive the nature and social connections in the neighborhood (Francis, 2016). Research shows that streets with slow moving traffic, limited space for parking and good environmental qualities offer a large potential for personal development, contentment and social integration, the contact in the neighborhood contacts in such streets are more frequent and more intensive (Sauter & Huettenmoser, 2008).

***Livable street and street traffic.*** The multi-mode traffic that the traffic flow consists not only private cars, but also public transportation, cyclists and pedestrians. It is demonstrated as a main emphasizing point of livable street in several studies. Donald Appleyard is one of the earlier researcher who brought up the term (D. Appleyard et al., 1981). In his book (D. Appleyard et al., 1981), he expounds the research that indicate the social impact on local community from different street traffic. He compared three streets in San Francisco which have similar morphology, but have different car traffic levels - 2,000 cars per day, 8,000 cars per day, and 16,000 cars per day. The empirical research demonstrates a result that local dwellers have more friends and acquaintances in street with lighter traffic flows, and as the heavier traffic is, the more shrinking home territory local dwellers perceive. Therefore, in his research, a livable street has light traffic and provide space for various activities beside traffic, and people's interaction is an important element in the urban street system.

Marshall & McAndrews (2017) examined influence on residential livability from nearby arterials. The arterials connected residential streets shall also be considered and evaluated in a network-level approach by designers and engineers. Simply push off traffic from residential streets to adjacent major road, and leave concentration only on local streets level will impact on the overall livability, and "improvements to the livability of the arterial road in lower-income neighborhoods could be as effective as and less costly than improvement of the livability on every residential street."

(Marshall & McAndrews, 2017). Therefore, it is necessary to have overview of connected streets, and the exploring of net-work level approaches might be helpful to analyze the street livability.

A balanced consideration of all road users is vital, and that does not mean to simply reduce the number of motorized vehicle or take motorized vehicle out of traffic. In fact, even with environmental concerns, people always choose the easiest transportation method. Research indicates that If close destinations are well connected by comfortable sidewalks and bicycle lanes, people would rather prefer walk and bicycle; If transit services are well designed and efficient among the long-distance destinations, people will prefer to take public transit than private cars (Holzer & Lockrem, 2011). Only when destinations are connected by roads that are car-oriented or high-ways, cars will be chosen by most of people. Therefore, to reduce heavy traffic flow and improve street livability, there could be more pathways that are well-designed and efficient for cyclists, pedestrian, and more public transit services built among the long-distance destinations.

***Livable street and infrastructure interactions.*** The interactions between different infrastructure systems (transportation, water, building and forestry) shall be carefully considered as they can have both positive and negative impact on their performance. The argument from Holzer and Lockrem's research (2011) implicates that the service type of destination could influence the trip planning and decision on transportation decision. They find that by increasing density and completing street infrastructure, the existing locations can be reinforced into livable centers, increasing travel options and reducing auto dependence. Engel-Yan, Kennedy, Saiz, and Pressnail (2005) outlined a sustainable neighborhood design process. The paper concludes that it is difficult to achieve neighborhood sustainability objectives without infrastructure systems at the urban scale, and the interactions between local infrastructure systems can have a positive or negative impact on

infrastructure performance and environmental impacts.

***Livable Street and stakeholders.*** The progress of developing a livable street concept needs all different stakeholders' cooperation and involvement. With balance between the interests of different groups, organizations can lead to less conflicts, which makes the implementation progress might be smother. Sometimes, livable street policies sometimes might not be recognized as a better for all solution in practices. Several studies review the implementation challenges from local government practices (Dodson et al., 2014). A community case study interviewed key stakeholders involved in Complete street project in Topeka, Kansas, which is a successful case of policy implementation (Dodson et al., 2014). The project also encountered opposition during the process, which is from the patterned thinking and low level of trust. City planners, administrative departments had the patterned thinking that it took long time for them to switch the inertia of concentration. Community residents feared about the cost, and did not have the capability to see the preventive value. This study illustrates educating the public, advocates, building a strong and diverse network of supporters, and using stories and examples from other communities are effective methods to give people a clear image of how to implement livable street (Dodson et al., 2014).

***The implementation of livable street.*** At last, the implementation progress of livable street projects can be a slow process in many cases. Modi and McClain (2017) pointed out the stretched project period can kill the momentum of public excitement, which was generated in the project planning when projects had robust public engagement, and that can create higher public expectancy and push the projects to more innovative solutions. In their research, two case studies illustrated the "quick build" projects that applied interim design, such as installations with easy modified and adapted materials, helped local authorities to pilot and improve the design solutions, and maintain the public relations in

terms of the expectancy and trust. “Quick build process” can be taken as example to other cases (Modi & McClain, 2017).

## **4.2 Street Tree as an Element of Livable Street**

There are several elements compose a streetscape. Above street ground, there are driveway, pedestrian pavement, street trees and other plants, street furniture etc. Under street ground, there are city’s infrastructures including road base, water pipes, electricity cables, and roots of plants also take part of the space. In this chapter, papers will be examined with discussion about street tree’s benefits, social and economic influence. The issues and challenges about street tree are also discussed.

### **4.2.1 Benefits, social and economic influence of street tree**

Trees benefits were discussed in many studies, for example, trees can improve air quality, filter pollution particles, mitigate urban heat island effect, preserve storm water, and filter noise and wind for roadside buildings (Engel-Yan, Kennedy, Saiz, & Pressnail, 2005). In the study about street livability and quality evaluation, planting strips is perceived as the most important design element that would increase the satisfaction scores by pedestrians (Choi, Kim, Min, Lee, & Kim, 2016).

Tree can have psychological, esthetic or recreational benefits. People may also achieve enlightenment of life from trees (Jones, Davis, & Bradford, 2013). Different with other installed roadside features and constructions, street tree is the organic and alive body. Several studies demonstrate the benefits that trees bring to the human’s psychological health. Tree can reduce stress, promote outdoor activities. Trees integrated in a well-designed streetscape attract more people to go for walking and children playing around (Saumel, Weber, & Kowarik, 2016). On the other hand, because of the feeling of

solicitude, satisfaction, achievement and responsible raised by trees, this can also be part of the encouragement and reward for people to plant and maintain activities around trees (Jones et al., 2013).

From the perspective of social influence, trees in different streetscape can also influence the social interactions of local dwellers. Trees can be the carrier of history, memories and connections to past (Jones et al., 2013). People could remember their childhood playing with neighbors around the trees, the experiences, community development could also be attached with street trees rounded (Jones et al., 2013). Trees also have culture characters, and it can represent certain type of symbol and culture value in different culture background. Meanwhile, the social environment around trees has impact on tree (Nowak, McBride, & Beatty, 1990).

Another fact that cannot be ignored is, at many places, religious belief is one of the factors that influencing people’s perception of trees. In Christian culture, trees have unique symbolism as Tree of Life and the Tree of the Knowledge of Good and Evil (Josep, 2015).

Economically, trees can also influence roadside business that could lead people linger and shop for longer time at business surrounded by trees (caseytrees.org, 2017). Business will have higher productivity and employee will have higher satisfaction when the surrounding environment have tree as an ingredient. (Kathleen L Wolf, 1998). Several studies indicate that tree cover can contribute the local house price increasing (Jones et al., 2013; Sander, Polasky, & Haight, 2010). The dwellers in pricy residential area have more request on urban greenery in public streets that surround their properties (Kathleen L Wolf, 1998). However, the higher economic investment on the street tree cover lead to higher community taxes and fees to the residents, thus for some families living costs are increased. (Kathleen L Wolf, 1998).

#### **4.2.2 Issues and challenges about street tree**

While, there are some issues and challenges of street tree, which cannot be ignored, such as tree mortality, causing damage and injury, healthy issues with pollen and insects from trees, invisible cost added-up to local commune and real-estate, etc. Jones et al. (2013) point out the planning of urban street tree need to face various issues, including rapid urban growth and development, changing weather and climate patterns, invasive species, soil compaction, tree disease, and inadequate tree maintenance and protection. Inadequate programs and short-sighted public policies have also contributed to problems (Jones et al., 2013).

As a fixed feature in street urban design, street tree has the body and root involved in space up-ground and underground. This feature should be taken into consideration from early stage of progress in design and construction, otherwise, a series of challenges will come along from the planting to maintenance of street tree (Jones et al., 2013). Hauer, Miller, and Ouimet (1994) assess the damage on trees' roots from the perspective of road reconstruction and further impact on survival condition and economic value. They find that larger lawn width can cause less damage. However, tree roots can grow to a more expanded area in the underground than the tree canopy when the space is unlimited (Hauer et al., 1994). Therefore, in urban environment trees are typically grown in box-framed volume where soil is compact, however, if not designed properly, this method can lead to street trees decline and cause sidewalk pavement cracked and heaving. A nonprofit organization named Casey trees illustrates the importance of designing enough soil volume for tree roots to make urban tree live longer (caseytrees.org, 2008). Planting larger trees and proper staking techniques may also improve the survival rate of street trees (Nowak, McBride et al. 1990).

Nevertheless, the planting and maintenance of the street tree needs to follow the guidelines

thoroughly. The study on Urban Forestry in Europe indicates that even though there are existing standards and guidance for urban tree planting, engineers and planners often do not thoroughly comply with them in practices (Forrest, Konijnendijk et al. 1999). More qualified and professional staff are needed at all levels in daily practices. A survey conducted by Pauleit (2003) reaches similar results, and it suggests a guidance model that adapting local context for tree selection and establishment shall be implemented thoroughly and further studied. This study also suggests close cooperation between different disciplined experts is in strong demand. Comprehensive concepts for sustainable urban forests and specifically for street tree plantings shall be developed and applied (Pauleit 2003).

In addition, Nowak et al.(1990) demonstrate in their paper that lower socio-economic areas had greater tree mortality. The lower income indicates less funds available for tree care. Increased unemployment correlates with more street vandalism which is one of the reasons caused trees' damage. Lower sense of ownership also implies lack of care to street trees.

In sum, tree can bring street more livability and quality, and its benefits range from socially, culturally, to economically. While, there are also some challenges relevant to street tree planning and maintenance. The pros and cons of street tree are listed in Appendix 2.

#### **4.2.3 Residents' attitudes towards street tree**

Local residents tend to have various attitudes towards street tree, and their attitude can be very influential for street tree planning and maintenance. In the research on residents' attitudes toward street trees, the street trees' intangible benefits are found to be very important for local citizens, because they can provide more satisfaction than their physical benefits to local (Schroeder, Flannigan, & Coles, 2006).

Residents' attitude of street tree can be variant on their locations. The research conducted by Schroeder et al. (2006) compares residents' opinions of street trees, perceptions of the benefits and annoyances trees provide, and preferences for tree size, shape, and growth rate between three communities in the United States and the United Kingdom. In general, citizens in the UK prefer less shade of the tree, and rated annoyances as more serious, and physical benefits as more significant than did the US residents. This research also pointed out that different culture background of community can contribute the variation of valuing the benefits and annoyances (Schroeder et al., 2006).

The attitudes of residents towards street tree can also variant on residents' demographical features. The study by Hitchmough and Bonugli (1997) in Scotland find that, firstly, most respondents did not see trees as important in improving the quality of their street. Secondly, trees were seen as most important in the two affluent streets, and least important in a low-income street with large amount of elderly residents. Thirdly, male respondents were significantly more likely to favor street tree planting than females. While a study by Jones et al. (2013) shows that women and democrats are also more supportive. They also find that homeowners who have stronger pro-tree attitudes, have greater environmental concerns, place more importance on trees when looking for a new place to live, attribute symbolic value and meaning to them are more supportive (Jones et al., 2013).

Those above mentioned studies indicates that residents generally like trees, and they normally know the benefits of trees. However, when it comes to the locations of trees, they would rather prefer trees are not planted close to their buildings, as the reasons are various and mentioned by many studies, such as "trees' shading issues" (Hitchmough & Bonugli, 1997; Schroeder et al., 2006).

In sum, residents tend to have different attitude toward street tree. While, those who have more

sense of ownership towards street trees usually have a more positive attitude on tree (Jones et al., 2013). The sense of ownership can be build through more activities on street that in front of doorstep, such as casual chatting between neighbors, children playing, and people sitting on bench beside street. Therefore, in order to protect street tree and building livable street, the residents sense of ownership and involvement of street trees should be strengthened.

### **4.3 Street Tree and Livable Street**

The results from the literature review indicate that a very limited number of studies have discussed the street tree's influence on street livability. Few studies have discussed if there are any interactions between people and street tree, and the interactions with livable street or any other ideal street concept as context (Jones et al., 2013).

By doing a literature review on livable street and street tree, this paper illustrates that the livable street or similar term of street form all have some same principles: human-centered thinking and emphasize the equality between car and residents on using street. However, there has not been a specific model or pattern that can be applied in local environment to build livable street, which is needed by urban designer and engineers when creating livable street or reform existed street to a more livable street.

Street tree has many long-term benefits such as improve air quality, filter pollution particles, mitigate urban heat island effect, preserve storm water, and filter noise and wind for roadside buildings (Engel-Yan et al., 2005). Street tree can increase the residents' perceived satisfaction (Choi et al., 2016) and enlightenment of life (Jones et al., 2013). Trees can be the carrier of history, memories and connections to past (Jones et al., 2013). Therefore, tree can be seen as an emotional carrier of local dwellers'. Therefore, tree is a very important element of creating livable street.



Even though street tree is an essential ingredient can influence street livability, its benefits can be undervalued when it come across with some political and economic issues. Such as the limited land use for public space and large cost expenditure for tree maintenance, and sometimes these issues may be taken more priority, which may lead street tree excluded from streetscape.

Moreover, in terms of planting and maintaining street tree in livable street, authorities need to have a comprehensive evaluation of neighborhoods' attitude towards street tree and the social structure of residents. However, timing in urban design can also be a tricky issue. Sometimes, spending too long period of time on doing an 'thorough' evaluation and finding a 'perfect' solution could kill the momentum and diminish the public excitement (Modi & McClain, 2017). Therefore, in order to have a comprehensive evaluation and, at the same time, keep the momentum, some temporary installations and easy adapted materials are need when designing and planting street trees to get efficient feedback.

## 5. CONCLUSIONS

This article of literature review was performed to gain an overview and better understanding of what are the livable street concept and its similar concepts, and how street tree influences the street livability. Since the urban development lead to limited public space, streets often having less space for pedestrian and street trees. Therefore, there are more demand on creating livable street, as street tree is seen as essential element.

The extensive literature review indicates that livable street can provide citizens comfortable urban and social environment, and street tree could contribute street livability. However, there need more studies on the interactions between human and street tree, and study on how these interactions could influence street livability.

Practically, street reform tends to be a long process, and it need different stakeholder groups to participate in. Government and organizations shall put more effort on supporting public education and disseminating knowledge of healthy, livable street concept, and the importance of integrating street tree in the actions. It is important to let public know about the complicity of process of street reformation, and that need closed cooperation between different stakeholder groups from society. Understanding on policies, regulations can also maintain and improve street livability, thus lead to rational protection and intervention.

Through appropriate knowledge disseminating among communities, and educational activities on different age group, people can achieve better understanding of the relationship between tree and social environment. More community level public activities related to street tree can also help to make better neighborhood's connections.

## 6. FUTURE WORKS

Future studies could further investigate the interactions between street tree and pedestrian, explicitly demonstrate the influence and impact from social and behavioral perspectives, and further reveal how these imperceptible effects of street tree could influence street livability.

In addition, there can be more local studies on citizens' attitudes towards street tree. Research can be performed on methods and theories of improving public service, such participatory design and co-creation can be applied in to the service process.

Also, innovative solutions can be explored, there could be tools to improve management about street tree, and tools to provide citizens access to using public resources better.

At last, future studies could also further investigate the policies about street tree, and the

rules and regulations that guide professionals about how tree should be included in street design and engineering practice.

## REFERENCES

- Anderson, G., Searfoss, L., Cox, A., Schilling, E., Seskin, S., & Zimmerman, C. (2015). Safer Streets, Stronger Economies: Complete Streets Project Outcomes From Across the United States. *Ite Journal-Institute of Transportation Engineers*, 85(6), 29-36.
- Appleyard, B. (2017). The meaning of livable streets to schoolchildren: An image mapping study of the effects of traffic on children's cognitive development of spatial knowledge. *Journal of Transport & Health*, 5, 27-41. doi:10.1016/j.jth.2016.08.002
- Appleyard, D., Gerson, M. S., & Lintell, M. (1981). *Livable streets*. Berkeley: University of California Press.
- Areas, E. (1997). Ecosystem appropriation by cities. *Ambio*, 26(3), 167-172.
- Bosselmann, P., Macdonald, E., & Kronemeyer, T. (1999). Livable streets revisited. *Journal of the American Planning Association*, 65(2), 168-180. doi:10.1080/01944369908976045
- Brown, B. B., Smith, K. R., Tharp, D., Werner, C. M., Tribby, C. P., Miller, H. J., & Jensen, W. (2016). A Complete Street Intervention for Walking to Transit, Nontransit Walking, and Bicycling: A Quasi-Experimental Demonstration of Increased Use. *Journal of Physical Activity & Health*, 13(11), 1210-1219. doi:10.1123/jpah.2016-0066
- caseytrees.org (Producer). (2008). Tree Space Design - Growing the Tree Out of the Box. Retrieved from [www.caseytrees.org](http://www.caseytrees.org)
- caseytrees.org (Producer). (2017). CITIZEN ADVOCATE HANDBOOK. Retrieved from [www.caseytrees.org/advocate](http://www.caseytrees.org/advocate)
- Choi, J., Kim, S., Min, D., Lee, D., & Kim, S. (2016). Human-centered designs, characteristics of urban streets, and pedestrian perceptions. *Journal of Advanced Transportation*, 50(1), 120-137.
- Conteh, F. M., & Oktay, D. (2016). MEASURING LIVEABILITY BY EXPLORING URBAN QUALITIES OF KISSY STREET, FREETOWN, SIERRA LEONE. *Open House International*, 41(2), 23-30.
- Dodson, E. A., Langston, M., Cardick, L. C., Johnson, N., Clayton, P., & Brownson, R. C. (2014). "Everyone Should Be Able to Choose How They Get Around": How Topeka, Kansas, Passed a Complete Streets Resolution. *Preventing Chronic Disease*, 11. doi:10.5888/pcd11.130292
- Donovan, G. H., & Butry, D. T. (2010). Trees in the city: Valuing street trees in Portland, Oregon. *Landscape and Urban Planning*, 94(2), 77-83.
- Dumbaugh, E., & Trb. (2006). Design of safe urban roadsides - An empirical analysis *Geometric Design and the Effects on Traffic Operations 2006* (pp. 74-82).
- Engel-Yan, J., Kennedy, C., Saiz, S., & Pressnail, K. (2005). Toward sustainable neighbourhoods: the need to consider infrastructure interactions. *Canadian Journal of Civil Engineering*, 32(1), 45-57. doi:10.1139/l04-116
- EPA, U. S. E. P. A. (2008). Managing Wet Weather with Green Infrastructure, Municipal Handbook, Green Streets
- Francis, M. (2016). The making of democratic streets. *Contesti. Città, territori, progetti*(1-2), 192-213.
- Galenieks, A. (2017). Importance of urban street tree policies: A Comparison of neighbouring Southern California cities. *Urban Forestry & Urban Greening*, 22, 105-110. doi:10.1016/j.ufug.2017.02.004

- Geraghty, A. B., Seifert, W., Preston, T., Holm, C. V., Duarte, T. H., & Farrar, S. M. (2009). Partnership Moves Community Toward Complete Streets. *American Journal of Preventive Medicine*, 37(6), S420-S427. doi:10.1016/j.amepre.2009.09.009
- Hartman, L. M., & Prytherch, D. (2015). Streets to Live In: Justice, Space, and Sharing the Road. *Environmental Ethics*, 37(1), 21-44.
- Harvey, C., & Aultman-Hall, L. (2016). Measuring Urban Streetscapes for Livability: A Review of Approaches. *Professional Geographer*, 68(1), 149-158. doi:10.1080/00330124.2015.1065546
- Hauer, R. J., Miller, R. W., & Ouimet, D. M. (1994). Street tree decline and construction damage. *Journal of Arboriculture*, 20, 94-94.
- Hitchmough, J. D., & Bonugli, A. M. (1997). Attitudes of residents of a medium sized town in South West Scotland to street trees. *Landscape Research*, 22(3), 327-337. doi:10.1080/01426399708706518
- Holzer, R., & Lockrem, Z. (2011). COMPLETE STREETS & LIVABLE CENTERS Why Location Matters. *Journal of Green Building*, 6(3), 21-32.
- Jones, R. E., Davis, K. L., & Bradford, J. (2013). The Value of Trees: Factors Influencing Homeowner Support for Protecting Local Urban Trees. *Environment and Behavior*, 45(5), 650-676. doi:10.1177/0013916512439409
- Josep, G. S. M.-M., B. B. (2015). The symbolism of trees. Retrieved from <https://metode.org/issues/article-revistas/the-symbolism-of-trees.html>
- Kingsbury, K. T., Lowry, M. B., & Dixon, M. P. (2011). What Makes a "Complete Street" Complete? A Robust Definition, Given Context and Public Input. *Transportation Research Record*(2245), 103-110. doi:10.3141/2245-13
- LaPlante, J., & McCann, B. (2008). Complete Streets: We Can Get There from Here. *Ite Journal-Institute of Transportation Engineers*, 78(5), 24-28.
- Litt, J. S., Reed, H. L., Tabak, R. G., Zieff, S. G., Eyler, A. A., Lyn, R., . . . Tompkins, N. O. (2013). Active Living Collaboratives in the United States: Understanding Characteristics, Activities, and Achievement of Environmental and Policy Change. *Preventing Chronic Disease*, 10. doi:10.5888/pcd10.120162
- Maco, S. E., & McPherson, E. G. (2003). A practical approach to assessing structure, function, and value of street tree populations in small communities. *Journal of Arboriculture*, 29(2), 84-97.
- Mahmoudi, M., & Ahmad, F. (2015). Determinants of livable streets in Malaysia: A study of physical attributes of two streets in Kuala Lumpur. *Urban Design International*, 20(2), 158-174. doi:10.1057/udi.2015.3
- Mahmoudi, M., Ahmad, F., & Abbasi, B. (2015). Livable streets: The effects of physical problems on the quality and livability of Kuala Lumpur streets. *Cities*, 43, 104-114. doi:10.1016/j.cities.2014.11.016
- Mansfield, C., Pattanayak, S. K., McDow, W., McDonald, R., & Halpin, P. (2005). Shades of Green: Measuring the value of urban forests in the housing market. *Journal of Forest Economics*, 11(3), 177-199. doi:10.1016/j.jfe.2005.08.002
- Marshall, W. E., & McAndrews, C. (2017). Understanding livable streets in the context of the arterials that surround them. *Transportation Research Record: Journal of the Transportation Research Board*(2605), 1-17.
- Modi, C. N., & McClain, R. (2017). Building on Complete Streets Momentum From Studies to On-the-Ground Solutions. *Ite Journal-Institute of Transportation Engineers*, 87(5), 31-35.
- Moreland-Russell, S., Eyler, A., Barbero, C., Hipp, J. A., & Walsh, H. (2013). Diffusion of Complete Streets Policies Across US Communities. *Journal of Public Health Management and Practice*, 19, S89-S96. doi:10.1097/PHH.0b013e3182849ec2
- Nowak, D. J., McBride, J. R., & Beatty, R. A. (1990). Newly planted street tree growth and mortality.
- Riggs, W., & Gilderbloom, J. I. (2017). How multi-lane, one-way street design shapes neighbourhood life: collisions, crime and community. *Local Environment*, 22(8), 917-933. doi:10.1080/13549839.2017.1303666

- Roy, S., Byrne, J., & Pickering, C. (2012). A systematic quantitative review of urban tree benefits, costs, and assessment methods across cities in different climatic zones. *Urban Forestry & Urban Greening*, 11(4), 351-363.
- Sander, H., Polasky, S., & Haight, R. G. (2010). The value of urban tree cover: A hedonic property price model in Ramsey and Dakota Counties, Minnesota, USA. *Ecological Economics*, 69(8), 1646-1656. doi:10.1016/j.ecolecon.2010.03.011
- Saumel, I., Weber, F., & Kowarik, I. (2016). Toward livable and healthy urban streets: Roadside vegetation provides ecosystem services where people live and move. *Environmental Science & Policy*, 62, 24-33. doi:10.1016/j.envsci.2015.11.012
- Sauter, D., & Huettenmoser, M. (2008). Liveable streets and social inclusion. *Urban Design International*, 13(2), 67-79. doi:10.1057/udi.2008.15
- Schroeder, H., Flannigan, J., & Coles, R. (2006). Residents' attitudes toward street trees in the UK and US communities. *Arboriculture and Urban Forestry*, 32(5), 236.
- Shapard, J., & Cole, M. (2013). Do Complete Streets Cost More Than Incomplete Streets? *Transportation Research Record*(2393), 134-138. doi:10.3141/2393-15
- Tiwari, R., & Curtis, C. (2012). A three-pronged approach to urban arterial design: A functional plus physical plus social classification. *Urban Design International*, 17(2), 129-143. doi:10.1057/udi.2012.7
- Wolf, K. L. (1998). *Enterprising landscapes: Business districts and the urban forest*. Paper presented at the Cities by Nature's Design: Proceedings of the 8th National Urban Forest Conference. American Forests, Washington, DC.
- Wolf, K. L. (2008). Community Context and Strip Mail Retail Public Response to the Roadside Landscape. *Transportation Research Record*(2060), 95-103. doi:10.3141/2060-11
- Zipperer, W. C., Sisinni, S. M., Pouyat, R. V., & Foresman, T. W. (1997). Urban tree cover: an ecological perspective. *Urban Ecosystems*, 1(4), 229-246.

## Appendix 1: Results from literature review

Topic 1: Definition of livable street, living street, complete street

Topic 2: Discussion of keywords: livable street, living street, complete street

Topic 3: Discussion of keywords: tree, greenery, plants

Topic 4: Discussion of keywords: human, people, citizen

	AUTHOR(S) (YEAR)	TOPIC				DISCUSSION
		1	2	3	4	
1.	(Riggs & Gilderbloom, 2017)		*			Two way streets better support multi-modal travel than one-way multi-lane streets
2.	(Marshall & McAndrews, 2017)		*			Using network level approach and thinking, and understanding the context on urban street design
3.	(Modi & McClain, 2017)		*			“Quick build” projects, or so called interim design, use low cost materials (paint/plastic based, planters, public art) to implement innovative urban design or solution, which are effective and can maintain the momentum of public excitement and provide evaluation opportunities before permanent features are installed onsite.
4.	(Galenieks, 2017)			*		A local culture favoring tree protection and reflective policies can result better urban forest management
5.	(B. Appleyard, 2017)		*			children allowed to have higher levels of interaction with the environment, through independent, active travel modes improve their spatial knowledge development
6.	(Francis, 2016)		*			Introduce democratic streets and the ingredients. The street should be a comfortable setting where learning by children, teens, and the elderly alike can take place naturally. The experience and interpretation of the street by all age groups is critical to the continued education and development of an urban society
7.	(Conteh & Oktay, 2016)		*		*	*. The paper contends that lively streets are not necessarily livable streets. Livability is defined by other criteria that take cognizance of human comfort and capabilities within living environments. 2. Observations suggest an uneasy relationship between a crowded public space and the private residential spaces that sit next to them. The paper's focus measures the livability of a lively but overcrowded street and how its everyday use affects the physical characteristics of buildings, the activities, and the wellbeing of residents. The findings suggest that an overcrowded street space has a negative effect on the livability and quality of living of residents and other users but that this is tempered by intra dependency amongst the users and the negotiation of the rights accruing to all as individuals and as groups.
8.	(Saumel et al., 2016)			*	*	*. The study synthesis illustrates management options that can support planning and governance approaches toward more livable streetscapes by fostering ecosystem services and counteracting disservices. Further study can be the contribution of biodiversity to ecosystem services and on the valuation of green street components by different sociocultural groups. 2. Different society groups' participation benefits the process of developing concept for roadside greening, reconcile conflicts, arouse awareness about multifunctional ecosystem services.

9.	(Harvey & Aultman-Hall, 2016)				
10.	(Brown et al., 2016)		*		Living near the complete street intervention supported more pedestrian use and possibly bicycling, suggesting complete streets are also public health interventions.
11.	(Hartman & Prytherch, 2015)		*		The fairness and ethical thinking of street using
12.	(Mahmoudi, Ahmad, & Abbasi, 2015)		*		users' perception on the identified problems and their effects on livability of the studied areas were found and defined. The result revealed that physical problems like improper walkway paving, inadequate public services and maintenance, besides traffic congestion, are deteriorating the livability of streets.
13.	(Mahmoudi & Ahmad, 2015)		*		Findings show that provision of facilities like paving, maintenance, parking space and traffic calming techniques contribute to street livability in Kuala Lumpur streetscapes.
14.	(Anderson et al., 2015)	*	*		*. complete streets as a transportation decision making approach, directs professionals to plan, design, construct, operate and maintain a community transportation network to support travel by foot, assistive device, bicycle, public transportation vehicle, car and truck. 2. The study found from economic measures that many projects can support employment, new businesses, and property values. (redesign, retail shop). Most of complete street projects are much more affordable than average arterial road.
15.	(Dodson et al., 2014)		*		From successful example of town Topeka, Kansas, Education to public and Stakeholders on CS is important, the interviews show reason of resistance to CS,
16.	(Shapard & Cole, 2013)		*		Complete street construction cost is relatively being not as expensive as traditional street
17.	(Jones et al., 2013)			*	A series of multiple regression analysis tested an Integrated Model of Urban Tree Support that combines measures of attitudes, beliefs, values, and sociodemographic variables to predict homeowner support for local urban tree protection. The findings lend support to many features of the model and revealed that homeowners who have stronger protree attitudes, have greater environmental concerns, place more importance on trees when looking for a new place to live, attribute symbolic value and meaning to them are more supportive. Women and Democrats are also more supportive.
18.	(Litt et al., 2013)		*		Complete Streets policy and zoning ordinances were the most frequently cited policy types. Engaging in media activities and the policy-making process in addition to engaging stakeholders appear to influence success in achieving change.
19.	(Moreland-Russell, Eyler, Barbero, Hipp, & Walsh, 2013)		*		Policies implementation varied in geographic and sociodemographic factors.
20.	(Tiwari & Curtis, 2012)		*		Their research indicates lack of public participation and understanding is one of the barriers in the implementation of livable street approach
21.	(Donovan & Butry, 2010)			*	estimate the effects of street trees on the sales price and the time-on-market (TOM) of houses in Portland, Oregon that if the provision of street trees is left solely to homeowners, then there will be too few street trees from a societal perspective. Tree benefits neighborhoods, but provision of trees shall be from government
22.	(Sander et al., 2010)			*	To recognize the economic benefits that street trees bring to local communities At certain level (..), tree cover can contribute to the house price
23.	(Geraghty et al., 2009)		*		The partnership delivered more than *50 project reviews to city planners, architects, and developers with recommendations for improved

					pedestrian and bicycle infrastructure, and many positive changes resulted. The partnership's communications plan linked partners with diverse interests to produce a powerful advocacy network to influence adoption of Complete Streets policies. Project development reviews were most Successful in Communities that allowed comments at a conceptual stage in the process
24.	(EPA, 2008)			*	A series of techniques and solution to solve the arrangement issue of tree root box underground
25.	(K. L. Wolf, 2008)			*	Prior studies indicated that consumer behavior is positively associated with city trees on multiple cognitive and behavioral dimensions. In mail surveys depicting varied roadside treatments, residents were asked to indicate preferences and perceptions about proposed changes.
26.	(LaPlante & McCann, 2008)	*	*		*. a complete street is a road that is designed to be safe for drivers, bicyclists, transit vehicles and users and pedestrians of all ages and abilities. 2. The complete streets concepts focus not just on individual roads but on changing the decision-making and design process so that all users are routinely considered during the planning, designing, building and operating of all roadways. It is about policy and institutional change.
27.	(Sauter & Huettnermoser, 2008)			*	The research result indicates House price and rent were not higher in traffic calmed streets than non-calmed streets. Reason may be balanced mixture of different apartment sizes and types, which in some degree prevent gentrification. Streets are great place for social integration.
28.	(Dumbaugh & Trb, 2006)			*	this study used negative binomial regression models to examine the safety effects of three roadside design strategies: widening paved shoulders, widening fixed-object offsets and providing livable-street treatments. The model results indicated that of the three strategies, only the livable-streets variable was consistently and negatively associated with reductions in roadside and midblock crashes. Wider shoulders were found to increase roadside and midblock crashes, while unpaved fixed-object offsets had a mixed safety effect by decreasing roadside crashes but having a slightly positive effect on midblock crashes.
29.	(Schroeder et al., 2006)			*	street trees' intangible benefits can provide more satisfaction than their physical benefits and annoyance to local dwellers
30.	(Engel-Yan et al., 2005)			*	interactions between local infrastructure systems can have a positive or negative impact on infrastructure performance and environmental impacts. Careful consideration of these relationships during neighborhood design could yield significant improvements in infrastructure resource efficiency as well as reductions in pollutant emissions and overall costs.
31.	(Mansfield, Pattanayak, McDow, McDonald, & Halpin, 2005)			*	Each type of forest cover provides different amenities to the homeowner and to society at large. While trees on a parcel of land or in a neighborhood may add value for homeowners, the ecological value of these trees as habitat is far less than large, unbroken parcels of forest.
32.	Dumbaugh and Gattis (2005)			*	prove livable street concept enhance road safety, trace the evolution of conventional safety philosophy that neglect relationships between driver behavior and safety. Propose an alternative to illustrate the dynamic relationship between driver behavior, safety and road design
33.	(Maco & McPherson, 2003)			*	to determine the existence of empirical evidence that human-centered design increases pedestrian satisfaction levels and enhances community

					walkability to determine the existence of empirical evidence that human-centered design increases pedestrian satisfaction levels and enhances community walkability
34.	(Bosselmann, Macdonald, & Kronemeyer, 1999)		*		The study concludes that boulevards with a side median design successfully mitigate the adverse impacts of heavy traffic. The research methods used for this study were based on *969 "Livable Streets" project by Donald Appleyard and Mark Lintell. The new study shows trends similar to those found in the original one and adds information about boulevards.
35.	(Kathleen L Wolf, 1998)			*	Business have higher productivity and employee have higher satisfaction when surrounding environment have tree as ingredient
36.	(D. Appleyard et al., 1981)	*			Livable street, case study of three streets comparison (D. Appleyard et al., 1981)



## Appendix 2: Pros and cons of street tree

### Pros

- Filter pollution, converting CO<sub>2</sub> and O<sub>2</sub>
- Screen noise ultraviolet light and wind
- Reduce soil erosion, storm water runoff, flooding
- Provide habitat for wildlife
- Heritage value, historical properties
- Increase property value
- Well-maintained street trees appeal customer and investments, can increase business productivity
- Educational service
- Provide culture, historical, aesthetic and symbolic value
- Mitigate stress, and mental fatigue, improve streetscape, have aesthetics value
- Contribute to healthy community and more using of common area
- Residents' participation of maintenance bring sense of ownership and responsibility

### Cons

- Carbon emission caused by maintenance service
- Block wind and interfere city ventilation
- Reduce view and create unwanted shading
- Root can damage pavement, underground pipes and cables
- Provide habitat for unwanted wildlife species
- Allergic problems caused by some tree species
- Tree cover can reduce shop's appearance to customer
- Trunk can be fixed obstacle, and reduce space of passage way
- Cause injury and damage by felling branches
- Create unpleasant feeling in the dark