

Determining mode-priority on shared streets : A key solution for Pune city's Sustainable Mobility Development

Case analysis of Pune's core area

Aboli Mangire

Determining mode-priority on shared streets : A key solution for Pune city's Sustainable Mobility Development

Case analysis of Pune's core area.

Master Thesis M.Sc. International Cooperation in Urban Development

Aboli Jayadeo Mangire

Matriculation Number - 2853585

Supervisor

Prof. Dr.-Ing. Martin Knöll

Date of Submission

09 April 2021

The thesis was Completed as part of the requirements for the fulfilment of the M.Sc. Degree in International Cooperation in Urban Development at the TU Darmstadt



TECHNISCHE
UNIVERSITÄT
DARMSTADT

Dieses Dokument wird bereitgestellt von tprints, E-Publishing-Service der TU Darmstadt <http://tprints.ulb.tu-darmstadt.de> tprints@ulb.tu-darmstadt.de

Die Veröffentlichung steht unter folgender Creative Commons Lizenz: Namensnennung 4.0 International <https://creativecommons.org/licenses/by/4.0/>

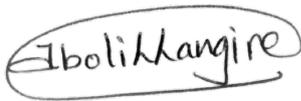
This work is licensed under a Creative Commons License: Attribution 4.0 International <https://creativecommons.org/licenses/by/4.0/>

CONFIRMATION OF AUTHORSHIP

I certify that this is my own work and that the materials have not been published before, or presented at any other module, or programme. The materials contained in this thesis are my own work, not a "duplicate" from others. Due acknowledgements have been given, where the knowledge, ideas and words of others have been drawn upon, whether published or unpublished. I understand that the normal consequence of cheating in any element of an examination or assessment, if proven, is that the thesis may be assessed as failed.

09 April, 2021. Darmstadt

Date, Place

A handwritten signature in black ink, enclosed in a hand-drawn oval. The signature reads "Aboli Mangire".

Signature of Author

ABSTRACT

Ranked as the most livable city in India and set to become a global urban center, Pune is currently at a high risk of reaching a deadlock over traffic congestion, traffic accidents and unbreathable air, threatening to cause unprecedented challenges in the city's fast-paced growing landscape (Bari, 2018; TOMTOM 2021). The city's Mobility Plan has actively planned, guided and monitored Pune's transportation facilities for over a decade. In 2018, the city set a goal of modal increase of Public Transport from 19% (in 2018) up to 50% (in 2038) (L&T Infra Engineering, 2018). However, the contradiction in the vision and the reality has been evident in this increasing gap of modal share and mobility inconvenience, presenting the need for research. This dissertation is an empirical research of Pune's core area, and Comprehensive Mobility Plan. Sustainable Urban Transport principles emphasized in the *avoid-shift-improve* approach are used to guide this research (GIZ, 2021a; Wilbur Smith, IL&FS, 2008). The literature review investigates the Mobility Plan Action Items, and provides a framework to analyze the street network of the study area based on two of the ten Sustainable Urban Transport principles: 1. Optimizing the road network and its use, and 2. Encouraging walking and cycling (GIZ, 2021a). Spatial mapping and street-network-analysis are carried out by using programs of QGIS and depthmapX respectively, based on Space Syntax street connectivity tools - Integration and NACH. Results of the spatial analysis have then been discussed through online interviews with local and international experts. This dissertation concludes that mode-priority on Pune's shared streets is an attainable solution to achieve its mobility vision. The conclusion is finalized in the design of a Route Map and Safe-Street-Guidelines, to ensure citizens' mobility-convenience, traffic safety, and to support Pune's long-term Mobility Development Planning.

ACKNOWLEDGEMENT

This dissertation would be incomplete without the acknowledgement of the people who have helped me overcome various challenges, and have showered me with their well wishes throughout this entire process. The very first expression of gratitude goes to Prof. Dr. Martin Knöll, supervisor of this dissertation, who carefully nurtured a growing researcher in me. With the conviction in the research potential of Space Syntax tools, we could align not only our mutual research interests, but also could attain greater breadth and depth to the earlier endeavors in this field. I am grateful of the association spanned throughout the academic year with him and his brilliant team of researchers at Urban Health Games, TU Darmstadt, in working on the ongoing Urban Mobility projects in Germany.

The Master of Science program - International Cooperation in Urban Development, a.k.a., Mundus Urbano, the launchpad of passionate urban professionals, was responsible for expanding my knowledge into the newer avenues of academic research and International Urban Development. I would like to thank all the teaching and administrative staff for making the wealth of valuable resources accessible. My special thanks to Prof. Dr. Nina Gribat, Dr. Donna J. Drucker, Yaşar Adanalı, Shanti Pillai, Dr. Anshika Suri, Dr. Nebojša Čamprag, for their encouragement in shaping a logical flow of my thought-process and its disposal through coherent written communication.

Gaining international training experience in one of the leading Urban Planning and mobility research practice, Space Syntax, London, which has formed a backbone of this academic work, was possible due to the combined efforts of the staff of TU Darmstadt and Space Syntax. I wish to express my gratitude to the organization team of Accessible Hubs Conference, and Ms. Juliane Hüge from TU Darmstadt's Erasmus Traineeship Abroad Scholarship. Space Syntax London office has an instrumental role in shaping the grounding knowledge in technological approaches to Urban Planning. I wish to thank its directors Anna Rose, Prof. Tim Stonor, Dr. Kayvan Karimi, Max Martinez, Godfrey Chikaviro, Susannah Williams, for creating an excellent environment of daily intellectual exchange. Especially Anna, Tim and Dr. Kayvan, who offered advice and support in making this work relevant and interesting. The empirical research of Pune's core city would have been difficult without the access to secondary data in the form of previously conducted field studies, surveys and reports. I wish to thank several members from various backgrounds, who have contributed to the freely accessible online database. I am especially grateful to Saga Wingård, a master student of Blekinge Institute of Technology, and Ar. Ravi Gadre for making their field study and street sketches accessible via the internet. I wish to sincerely thank members of Parisar NGO, Mr. Sujit Patwardhan, Mr. Suraj Jaipurkar and Ar. Aditya Chawande, for their continued interest and input about the close analysis of a local context. Along with this, I wish to thank for his the valuable inputs, Prof. Geoffrey Payne, an international adviser at World Bank, and a second expert of this dissertation, who enabled this dissertation to become closely integrated in local as well as international context. My study phase amidst the social isolation during the global pandemic COVID-19 was made comfortable by Ms. Elisabeth Gartner, the owner and manager of the beautiful shared house in Mühlthal, Germany. I wish to thank Elisabeth and my other housemates, Cansu Karakız, Mark Aguirre and Valencia Evelyn, for making the unprecedented

situation of restricted social contact a pleasurable and safe experience, while sharing the living and working spaces in the house. A special thanks to Mark Aguirre, also my classmate, who kindly accepted my idea to peer review each other's dissertation which became a regular, competitive yet very enriching experience.

Lastly, I wish to express my loving gratitude to my family and close friends. My parents, Seema and Jayadeo Mangire, my sister Sayali and nephew Arash Thokade, whose regular video calls used to fill long working hours with affection. Sarita Rupan, who is a close friend deserves a special thanks for reviewing the dissertation draft. Likewise many thanks to friends, Fatma Shalaby, Niharika Shukla, Rohini Sharma, Natasha Gill, Sabena Thomas, Gabriele Sabia, Anna Comas for their online and/or offline presence filled with love and support.

TABLE OF CONTENTS

Confirmation of authorship.....	2
Abstract	3
Acknowledgement.....	4
List of Figures.....	8
List of Tables.....	8
List of abbreviations.....	9
1. Introduction.....	10
1.1 Background.....	10
1.2 Research Focus.....	11
1.2.1 Urban Streets : An outcome of Urban Fabric and an actor in Sustainable Urban Transport	11
1.2.2 The Problem	13
1.2.3 The Research Potential : The Research Gap	15
1.3 Dissertation Structure	18
1.3.1 Research Objectives and Research Strategy.....	19
1.3.2 Data collection and Data Analysis.....	20
1.3.3 Text structure of the Dissertation.....	21
1.4 Value of the Dissertation.....	22
2 Pune City, the actors and their actions to achieve Non-Motorized Transport (NMT) vision for the city.....	24
2.1 Multiscale Street Network’s influence in development and Transport : Pune Metropolitan Area , Pune Municipal Area and Core Area.....	24
2.2 Investigation of Pune’s Mobility Plan for Core Area : Data Collection and Data Analysis.....	26
2.2.1 Focus on the Street-Network in Mobility Planning : 2008 Mobility Plan and 2018 Mobility Plan Review	27
2.2.2 Core Area Ring.....	31
2.2.3 Hope for traffic safety? : Guiding Instrument.....	33
2.3 Data Synthesis	35
2.3.1 Divergence on the issue of Safety of Non-Motorized Transport users.....	35
2.4 Recommendations	36
2.4.1 Area-based Development.....	36
2.4.2 Elements of Street-Network : For improved safety and avoiding accidents in mix traffic situations	37
2.5 Conclusion of the chapter	38

3	Street Network Analysis : A key driver in improving Non-Motorized Transport (NMT) movement inside Pune’s Core Area	40
3.1	Street Network : A key driver in shaping Core Area’s Urban fabric.....	40
3.1.1	Compact Urban Model : Quiet neighborhood life : The need for Street Element framework	41
3.2	Street Network Analysis : In optimizing the streets and their use for improving Non-Motorized Transport Movement inside the Core Area.....	45
3.2.1	Integration and Segment Angular Choice (NACH)	46
3.3	Street Analysis Maps 1	48
3.4	Modal Priority on Streets : Street Segregation for trip distance convenience	50
3.5	Conclusion of the chapter	52
4	Integration of views of local and international experts.....	55
4.1	Expert Interview 1	55
4.2	Analysis Findings 2.....	57
4.3	Expert Interview 2 : Recommendations	62
4.4	Conclusion of the chapter	63
5	Conclusion.....	66
5.1	Strength and Limitation of the Dissertation	68
5.2	Outlook.....	69
6	List of References.....	71

LIST OF FIGURES

Figure 1: 10 Principles of Sustainable Urban Transport.....	16
Figure 2: Modal-shift goal : A distant dream?.....	17
Figure 3: Pune City: A radial growth pattern.....	25
Figure 4 : Ring-Radial Pattern of Ring Rods and Mobility Corridors in Pune City.....	28
Figure 5: Urban typology of Pune.....	29
Figure 6: Mix transport-modes and modal-share in Pune's core area.....	30
Figure 7: Core area ring.....	31
Figure 8 : Traffic safety concerns inside Core Area.....	32
Figure 9 : Extract of Best Practices for Footpath Design and Standards in Pune City.....	33
Figure 10 : Proposed street typology for Pune Municipal Area.....	34
Figure 11 : Chronological growth of Pune's core area.....	42
Figure 12 : Pune's ageing core area. A sketch by Ar. Ravi Gadre, Pune, India.....	44
Figure 13 : An example of Street Network Analysis by using Space Syntax tools.....	47
Figure 14 : Space Syntax Analysis on Core Area's street-network : Radius 1200 m / 1.2 Km.....	48
Figure 15 : Space Syntax Analysis on Core Area's street-network : Radius = 5000 Meters / 5 Km....	49
Figure 16 : Space Syntax Analysis on Core Area's street-network : Radius = 10000 Meters / 10 Km.	49
Figure 17: Pune City Map with three scales of traffic radii.....	50
Figure 18 : Highly integrated streets for intermediate distance routes between 5-10 Km.....	51
Figure 19 : Highly integrated streets for short distance routes between 0-5 Km.....	51
Figure 20 : The market street along Shivaji road during weekend mornings.....	53
Figure 21 : The street-side market along Shivaji Road on weekdays.....	53
Figure 22: Traffic-safety Legend.....	58
Figure 23 : Safe Street Guidelines.....	59
Figure 24 The Route Map.....	60
Figure 25: Spatial Map for proposed routes superimposed on a satellite image.....	61
Figure 26: Play Street.....	67

LIST OF TABLES

Table 1 : Pune City and Metropolitan Region's Mobility Planning, Guiding and Monitoring instruments and their State of Research Summary.....	26
--	----

LIST OF ABBREVIATIONS

BRTS	Bus Rapid Transit System
CMP	Comprehensive Mobility Plan
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
NGO	Non-Governmental Organization
NMT	Non-Motorized Transport
NUTP	National Urban Transport Policy
PCMC	Pimpri-Chinchwad Municipal Corporation
PMC	Pune Municipal Corporation
PMRDA	Pune Metropolitan Region Development Authority
SPTM	Save Pune's Traffic Movement
STEP	Step Towards Empowering Pedestrians
SUTP	Sustainable Urban Transport Planning

1. INTRODUCTION

1.1 BACKGROUND

In the past 20 years, the field of International Development has seen several active engagements of joining hands in the resolution of acting against Climate Change. Paris Climate Agreement and New Urban Agenda by United Nations (both in 2016), Green Cities, 100 Resilient Cities, Smart Cities, C40 cities are some of the many international networks acting in response to Climate Change by promoting Sustainable Urban Development. Such growing networks among various cities around the world not only suggest a growing need for actions against negative impacts of climate change, but also indicate ‘cities’ as a vessel for such actions. The cities, as they grow with different urbanization patterns and trends, their governments also face multiple challenges to provide their citizens a good environment to live and thrive in. Their challenges get even more multiplied by natural disasters, or the infectious pandemic such as COVID-19 which is calling for an accelerated response and action. In this context, the city governments, along with the citizens are required to play an instrumental role in designing, developing and managing their cities together.

The two areas of study, the Climate Change Response, and Urban Transport have been under the same lens of investigation for a long time due to its very high contribution to the carbon emission levels (Hickman et al., 2013). In light of the urgent action indicated in international agreements, for reducing a city’s carbon footprint, the shift from car-friendly cities to pedestrian-friendly cities has become more important with the national governments seem to be adapting the new vision of pedestrian-friendly cities. Walkability Index adapted in Asian cities, Walkability Survey guidelines by the World Bank, Copenhagenize index for biking in cities are some examples with which the city governments and the citizens have been autonomously reviewing the city’s adaptability to Non-Motorized Transport (“NMT”) in relation to other cities in the world. This may have done the job of creating awareness and competition among cities to enhance their performance in these fields to a certain extent. Along with these developments, NMT is seen to have taken a center-stage in the narratives of experts in Transport Policies, Transport and Urban Planning, and Urban Design. (Cervero & Kockelman, 1997; Hickman et al., 2013; Millington, C., et.al. 2009; NUTP, 2008).

In this way, the Climate Change response and Urban Transport are interconnected between the national and international organizations, regulatory bodies, experts and researchers, and the city and its citizens.

1.2 RESEARCH FOCUS

The urban streets are an essential element of study when it comes to Urban Transport. Street networks and other modes of Public Transport when well-integrated with one another, serve as a good Transport System for the citizens. The Transport System that enables every citizen to travel to their place of work, education and recreation. Public health studies and research associated with cities believe that the Urban Transport System when designed and planned carefully, can improve public health by promoting active transport (Cervero & Kockelman, 1997; Hickman et al., 2013; Millington, C., et.al. 2009). Urban Street Design is believed to be a powerful tool in order to build public health resilience when they provide a safe environment in which citizens of all age groups enjoy walking and biking along the streets. This is also believed to improve quality of life (Webster, 2020). Urban Street Planning and Design is not only believed to be essential in promoting a city's employment opportunities and quality of life, but is also significant in promoting an equitable and socially just environment. The research and studies of Transport justice believe that equitable streets are needed for the balanced growth of all classes of the society. The major research themes are, but not limited to, current biased Planning which favors motorized vehicle users, and puts unequal burden distribution of travel time, pollution and stresses onto the sustainable mode users, who are pedestrians and bicyclists. These studies emphasize the need for negotiation among various users of the street for unbiased Planning and Design of streets (Goessling, 2016; Lau, 2012; Khayesi et al., 2010).

The examples mentioned above highlight the significance and urgency of cohesive Planning and Design of Urban Streets in several parts of the world for attaining sustainable and equitable Urban Transport.

1.2.1 Urban Streets : An outcome of Urban Fabric and an actor in Sustainable Urban Transport

Urban fabric refers to the physical urban environment such as elements, materials, form, scales, density and networks, and to its psychological, socio-cultural, ecological, managerial and economic structures (TU Delft, 2021). Urban Planning concepts such as Transit Oriented Design, NMT-oriented Planning, Walkable neighborhoods, Active Transport, and Public Health through Urban Design, not only serve the citizens with access to destinations but also promote public health through active lifestyle. These planning concepts are increasingly encouraged and being adopted by the advisory bodies, city governments in the development of city's old as well as new areas. What is common to both old and new area developments are the street connectors and the people who travel daily on these street networks.

10 principles of Sustainable Urban Transport by GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit) is an example which captures different aspects of urban fabric, and recommends their cohesive planning as an approach to sustainable Transport Planning. The empirical case study of this Dissertation is based on two of these ten principles, 'Optimize road network and its use', and, 'Encourage walking and cycling' (GIZ, 2021a).

Urban Data Analysis is an advanced method to inform the users about the urban services they use. Urban Data can be in numerous different formats and fields such as to pay tax, register a grievance about water supply issue and to seek help during disaster emergencies (PMC, Home Page, 2021). The data related to spatial maps of cities have been publicly accessible due to the open access programs such as Google Maps, Open Street Maps. Since last two decades, there have been an emergence of Digital Data Analysis companies which provide data and services related to Urban Traffic, such as:

- a. TOMTOM index - An index used to track the traffic congestion by street. The users can access it as easily as typing in the name of the city they wish to commute (TOMTOM, 2021)
- b. NUMBEO – A traffic predicting web-based application that is used by travelers to inform their daily travel, or for Urban Planners to assist their Traffic Demand Prediction Model (NUMBEO, 2021) among others. This Data Analysis paradigm is currently much advanced than it was 20 years ago. In near future, the automated driving is anticipated to be mainstream, and several countries will have Smart Cities including 100 Indian Smart Cities by 2050. It is predicted that the paradigm of Digital Data Analysis will be much more advanced and relevant in those times.

Space Syntax - Evidence-based Spatial Analysis as an aid to City Authorities, City Planners, Architects and Developers. It is identified as one of the highly digitally advanced and internationally used method of Mobility Analysis in Architecture, Urban Design, Urban Planning and Transport Policy making. The researchers from various backgrounds have integrated Space Syntax methods such as Street Connectivity tools in multitude of possibilities. The examples of such studies are not only limited to analyzing walking levels of residents in old city areas, or analyzing walking potentials of new developments, but also to develop a city's master plan by assemblage and analysis of large data about people's behavior, urban form, energy resources and environment (Kim, S., et.al., 2014 ; Moura, F., et.al. 2017 ; Millington, C., et.al. 2009; Space Syntax, 2021). The examples mentioned above are those of advanced technological data analysis in the context of Urban Transport and Traffic. These tools are increasingly becoming popular due to the ease in access, depiction of data through visualized maps, as we all as the evidence-based analysis. While they are

designed to aid the citizens to navigate through daily commute, they are also helpful to the decision makers while making long term Mobility Plans, and the traffic police while managing traffic at busy junctions.

We all are aware that the term **Smart** is widely used in the City Development paradigm in present times. The governments in Europe and Asia seem to be taking evident steps towards making cities Smart. In Indian context, Smart reintroduces key concepts of, retrofitting , reinforcing, adaptive reuse and reusing made easy with the help of advanced technological solutions (Ministry of Housing and Urban Affairs, Government of India., 2020). It is important to note that even though the focus is on improving urban life by means of smart tools, they are a technological aid and cannot replace the existing fabric of city and citizens. This clearly creates a niche for projects to improve *existing* street network with the help of advanced digital tools and advanced systems of Traffic Management. In such a way, this dissertation positions itself in the niche of reidentifying the potential of existing street-network to achieve Pune's Sustainable Mobility vision. It will use the methodology of Space Syntax in order to carry out empirical case study on Pune's core area, which will allow it to integrate advanced technology in optimizing the use of existing streets.

1.2.2 The Problem

A national survey, carried out by Ministry of Housing and Urban Development of India in 2015, which studied livability of 111 Indian cities, Pune city came first in the ranking (Bureau, 2018). This survey studied aspects of livability and attractiveness of rapidly growing cities in India. This survey highlighted Pune city in essential aspects, that makes life in a city attractive and enjoyable. These essential aspects, to name a few, were, Urban Services such as Solid Waste Management, Water and Sanitation, Digital Governance (Bureau, 2018). However, Interestingly, this is contrasted by an alarming number of growing slums or informal settlements. Over 30% of Pune's current population lives in such settlements where Urban Service provision is close to none (Sen S.,et al, 2003). The question that arises is, *if the city's essential Urban Services are ranked high, then why are they not distributed among city's 30% population?* (Benninger, 2018).The contrasting picture of shiny facades of shopping malls and hard tin roofed slums, existing in proximity of each other can be easily seen by people on Pune's streets.

The contradiction in Pune's urban service provision is not only visible in its urban fabric but it is also seen on its streets. A large population choses Public Transport and NMT for their daily commute to work and thereafter (L&T Infra Engineering, 2018). However, the Street Planning and Traffic Management authorities indicates a high level of neglect towards the users of these modes (STEP, 2020).

The attractiveness to live in the city has led to an increased migration from other cities in Maharashtra state. This is due to growing sectors of Information Technology, Automobile Manufacturing and Education. Second impetus for the draw towards Pune is that it is the second biggest and closest city to the megacity Mumbai. Not only it is the most livable and an attractive city for Indian citizens, it is also on the list of India's 100 potential Smart Cities with an agenda for smart and transparent governance.

When the rapid growth and the development is observed carefully, it can be seen that Pune is steadily moving towards becoming a good example of Urban Development in Indian context. It is a concern mentioned by one of city's Senior Town Planner *Ramchandra Gohad*, who extensively worked with the city in planning its 1987 Development Plan, that the high pace of growth could make city management difficult for the city government (Bari, 2018).

One of the most urgent problems for Pune is that it is set to become a global urban center, but has an alarming rise in air and noise pollution (NUMBEO, 2021; STEP, 2020). In 2018 it was ranked 5th city in traffic congestion in the world (TOMTOM, 2021). Although it is a potential global center of economic growth, it is currently at high risk of getting in the deadlock over traffic congestion, traffic casualties and unbreathable air. This poses a big question mark on its livability.

If the problem discussed above can be rephrased for more easier understanding,

Pune is set to become a global city of smart and fast economic and spatial growth but in this process it should not become the global city of traffic disaster.

Pune's Transport Planning and implementation of projects has been solely based on the Comprehensive Mobility Plan ("CMP") since 2008 till today. The vision of this Plan is - *Moving people safely and economically by emphasizing public transport and Non-Motorized Transport* (CMP, 2008; p.7-3). The methodology of this planning instrument is based on the study of the movement of motorized vehicles (Mangire, 2020).

As a result of this *contradiction* in the *vision* and the *methodology* of Pune's Transport Planning instrument, there can be seen a lack of cohesion in *what is imagined* and *what is under action*. What is envisioned is the pedestrian-friendly streets integrated with the efficient Public Transport network. However, the transport projects under action are those which are implemented by keeping the convenience of the motorized vehicles in mind. For instance, carriageway widening, frequent upgradation of interconnecting system of flyovers, bridges, to deliver smooth movement of motorized vehicles (Benninger, 2018; Patwardhan, 2021).

On the contrary, very slow progress and halted condition of proposed pedestrian facilities, Bus Rapid Transit System (“BRTS”), bicycle network are observed by the Civil Society Organizations (STEP, 2020). It is also important to highlight that all the three networks mentioned, pedestrian, BRTS and bicycle, are part of Pune’s Transport Plan (2008), but have been neglected, halted or have shown slow progress. It is important to mention that the city government has initiated a Street Program under which the national Urban Designers have been officially commissioned to turn major streets of Pune into Complete Streets or NMT-friendly streets (PMC, 2021). However, there are only two pilot streets that have been benefitted in the project so far.

1.2.3 The Research Potential : The Research Gap

Pune 2008 Mobility Plan highlights the need to Improve Street Network connectivity by using existing network more efficiently, with a focus on Public Transport and NMT. It is encouraging to observe the similarity between Pune’s vision and the international vision that is being heavily promoted by New Urban Agenda as well as Deutsche Gesellschaft für Internationale Zusammenarbeit or GIZ on behalf of German Government’s Federal Ministry for Economic Cooperation and Development. It consolidates 10 principles for Sustainable Urban Transport based on New Urban Agenda. This similarity in International guidelines, international research and Pune’s very own Mobility Plan is considered as this dissertations research potential. In the context of Indian cities, the GIZ currently supports initiatives such as Smart Cities, Clean India and Skill India. Indian partners seem to be taking advice and consultancy from GIZ to devise tailor-made, jointly-developed solutions to meet local needs and achieve sustainable and inclusive development (GIZ, 2021b).

Based on the approach *avoid-shift-improve* that the New Urban Agenda promotes, the GIZ Urban Mobility team has designed a poster on ten principles for sustainable urban transport (Fig.1). This dissertation refers this poster as a consolidated guideline of what has been promoted internationally in the context of Transportation challenges of developing cities around the world. These best practices guidelines have been created based on the GIZ’s work around the world with local partners and governments. It is anticipated by GIZ that the ten principles in this poster as well as the larger publication about Best Practices in Sustainable Transport for Developing Cities serve as a guideline. The ten principles consolidated in the following poster



Figure 1: 10 Principles of Sustainable Urban Transport.

Selected Transport Policies and measures from larger publication named – ‘Sustainable Urban Transport: A Sourcebook for Policy-makers in Developing Cities’. Data Source: (GIZ, 2021).

(Fig.1) are – 1. Planning dense and human scale cities, 2. Developing Transit-oriented cities, 3. Optimizing the road network and its use, 4. Encouraging walking and cycling, 5. Implementing transit improvements, 6. Controlling vehicle-use, 7. Managing parking, 8. Promoting clean vehicles, 9. Communicating solutions, 10. Approaching the challenges comprehensively. It is clear that all of the ten principles are interconnected. Therefore the progress in one principle will likely affect the progress of others principles. The major themes that can be identified are, – 1.Efficiency of Public Transport service provision, 2. Controlled management of Private Motorised vehicles, 3. New Clean, Green and sustainable transport modes , and , 4. Optimization of existing urban built environment, such as building density and street network. *This dissertation focuses on principles 3. And 4. This is due to their alignment with Pune’s Mobility Vision as per 2008 Mobility Plan.*

The previous research of Walkability in *Kasba Peth* by the same author, also located in this dissertation's case study area, emphasizes the absence of methods of NMT data analysis (Mangire, 2020). This previous research suggests how the street connectivity analysis especially focused on walking can help in understanding the neglect of NMT in current Transportation Planning. However, the previous study does not go into the action plan of the CMP. Therefore this dissertation attempts to bridge the gap by investigating the action plan items of 2008 CMP, and continue from there.

2008 Mobility Plan can be seen as successful in initiating, detailing and recording the sustainable Transport drive in Pune Mobility sector. Whereas, 2018 Mobility Report can be seen as a step towards internal critic and review to map the progress and to design a future road map based on this review. These two together are successful in Pune's continued journey to achieve its Mobility vision by 2038. However, the Mobility Vision is far from reaching its success. The following figure (Fig. 2) crystallizes the fact that the modal-shift from Private Motorized Transport to Public and Non-Motorized Transport (NMT) has proved to be extremely difficult in Pune since 2008.



The Problem ! A Distant Dream ?

Modal-shift Goal from Private Motorised to Public Transport and NMT

	2008	2018	2038 Goal
Public Transport	18%	19%	50%
Non-Motorised Transport	33%	28%	35%
Private Motorised Transport	45%	48%	10%

Figure 2: Modal-shift goal : A distant dream?

83% households own 2-wheeler / 2-wheeler & Car. Data Source: (L&T Infra Engineering, 2018)

In this way, this research positions itself in the study gap of Pune's current Transport Planning instrument. The study gap is wide and ranges from various aspects of street data analysis to negotiation and testing the solutions with the stakeholders. This research attempts to cover the aspects of the street network data collection, data assembling, data analysis and Route Planning proposal. The next steps of negotiating with the stakeholders and testing the solutions will require local institutional engagement and therefore cannot be covered in this dissertation's scope.

1.3 DISSERTATION STRUCTURE

This dissertation places its aim at suggesting refinement in the Pune's Mobility Plan Action Items by using Street-Network-Analysis. This is done by keeping two of the ten principles of Sustainable Urban Transport in focus, 1. Optimizing the road network and its use, and, 2. Encouraging walking and cycling (GIZ, 2021a)

These two principles are selected based on Pune's Mobility Vision and Strategy as stated below from the Comprehensive Mobility Plan , and emphasizes the three elements – Improving existing street network, Walking and Cycling (PMC b, 2008, pp.7-3 to 7-7).

The vision is –

Moving people safely and economically by emphasizing public transport and non-motorized transport (Walking and Cycling).

The strategy is –

Improve Street Network connectivity by using existing network more efficiently, with a focus on Public Transport and NMT.

The framework for suggestion of Spatial Planning refinements is based on the same framework used in Pune City's Comprehensive Mobility Plan, 2008.

To fulfil the research aim, the specific research question is necessary. This is because the Comprehensive Mobility Plan of Pune City consists of diverse proposals ranging from Spatial Planning, Traffic Management, Road Maintenance, Governance among others. And it is possible to suggest refinement in each of the proposal category by using Street Network Analysis. But due to the limited time frame of this dissertation, and author's expertise, the focused research question is framed in a following way –

-

IS URBAN STREET-NETWORK-ANALYSIS AN EFFECTIVE TOOL OF SPATIAL PLANNING IN ORDER TO ACHIEVE PUNE'S MOBILITY VISION?

-

The street Network Analysis methods that were used in CMP are focused on traffic studies and surveys. As discussed in the subchapter 1.2.3, this methodology was focused on motorized traffic and here can be seen as contradicting to the mobility vision and strategies.

1.3.1 Research Objectives and Research Strategy

The Research Objectives that are designed in order to reach the Research Aim and fulfil the Research Question are as following –

- RESEARCH OBJECTIVE ONE – TO INVESTIGATE STUDY AREA'S MOBILITY PLAN IN RELEVANCE TO THE STREET NETWORK.
- RESEARCH OBJECTIVE TWO – TO ANALYZE MOBILITY PLANNING ACTION ITEMS OF THE CASE STUDY AREA BY USING STREET-NETWORK-ANALYSIS.
- RESEARCH OBJECTIVE THREE – TO DISCUSS WITH THE LOCAL AND INTERNATIONAL EXPERTS FOR CONTEXTUALIZING THE FINDINGS.

The *research strategy* and the *methods* for this dissertation have been developed as a combination of learnings of previous walkability research performed by the author of this dissertation, and the secondary literature. The other part of combination in designing the Research Methods come from referring the literature on dissertation design, the fourth edition of the book by John Biggam called, '*Succeeding with your Master's Dissertation: A step-by-step handbook for building up the methods*'. The review discussions with the supervisor, spanned over three months, have helped in providing an evolved process of refinement in the dissertation design.

This dissertation is an *empirical research*, which includes its own data collection and data analysis (Biggam, 2017). The reason it requires its own data collection lies in the very nature of the subject of Urban Transportation. Urban Transportation is connected to various city actors and their actions. It is observed that Urban Transport in Pune city, the study area of this dissertation, is a product of such actions by the city government, citizens and the citizen organizations. It is also important to note that Pune City actors are creating, recording and publishing large collection of Urban Transport data every year, or even every month (PMC,2021; Parisar, 2021). Therefore it is necessary to collect the latest data for precise evaluation.

The *research strategy* chosen for this dissertation is a case study of area of 8 Sq.Km in the core area of Pune city. The research strategy has in its focal point, the case study based on the analysis of the secondary data

of field reports. This strategy is considered practical because of the international travel restrictions due to highly infectious COVID-19 pandemic situation. The other research strategies such as a field survey, primary data collection and field observation also have been ruled out because of the pandemic influence on the use of public spaces. On the other hand, the case study strategy allowed to explore the multiple potentials of digital technology, World-Wide-Web and the remote networking opportunities, which are considered to be having a large influence on the academia during and post pandemic times. The shortcomings that are brought upon by the absence of primary data and field observations have been acknowledged. They are attempted to be covered by using the reference of previous field studies that were carried out precisely in the study area. While the data of the previous field studies is considered valuable in keeping the suggestions field-relevant, on the other hand, the time gap of three to eight years between the previous studies and this dissertation is to be duly noted.

The nature of the research question, as well as the previous walkability research indicated the need for Exploratory Case Study. It is a type of case study that has the potential to offer reasonable findings to carry out further larger research (Biggam, 2017). The aim of this dissertation is threefold. Firstly, to *test* whether a certain type of analysis will be helpful in future planning, secondly, the research expectation is to *propose* to the city authorities about the idea of further research in this direction, and lastly, the flexible potentials of exploratory case study allows the third and last research objective of *discussing* the findings with the local and international experts. In this way, this dissertation positions itself in the intermediate stage before the future planning revision can take place.

1.3.2 Data collection and Data Analysis

For the first objective primary data is collected from the various departments of Pune Municipal Corporation (“PMC”), The departments of municipality that are studied for this are, Mobility and Spatial Planning, Governance and Data Communication, and a special division of Road Department called Street Planning and Design Guidelines for Construction. The data collection is complimented by the analysis of the secondary literature and studies that are particularly carried out in Indian cities and in their historic core areas in recent times.

For the second objective the spatial data is collected in the form of Transport Network, Base Maps, Development Plan Maps. This is collected from City website, OpenStreetMap, Google Earth and Master

Students field studies carried out in Pune's core area. For the third objective, the data has been collected by performing two video call interviews. First with three of the local Civil Society Organization experts in the field of Pune's Sustainable Urban Transport. The second video-call interview is with an International adviser at the World Bank in the field of Urban Development.

The *framework for data analysis* is based on the three themes for three objectives as follows – 1. Comparison of data obtained about the City Actors and their actions to achieve NMT vision of Pune's Transport Planning, particularly focused on the streets, 2. Space Syntax Analysis of Street Integration and Street Normalized Angular Choice (NACH), 3. Optimizing road network and its use to refine Pune's NMT-oriented Transport Planning vision.

1.3.3 Text structure of the Dissertation

In every chapter the text is arranged in the following sequence –

Subsection 1. Introduction

Subsection 2. Data Collection and Data Analysis

Subsection 3. Analysis Findings

Subsection 4. Recommendations, Suggestions / Synthesis

Subsection 5. Conclusion of the chapter

The following second chapter answers the first Research Objective. It investigates the Planning, Monitoring and Guiding instruments of Pune City's Mobility Plan. This chapter lays out the literature review essential for this dissertation's research aim. The outcome of this chapter is the street typology methodology. The third chapter answers the second Research Objective of Street Network Analysis by using Space Syntax tools. It follows the street-typology methodology that was concluded in the second chapter. The outcome of this chapter is the two core-area-maps with convenient routes for short and for medium distances. This is the first stage of map-analysis. The next or the fourth chapter follows the third Research Objective. It discusses the analyzed maps from the first Map-analysis stage with local experts, and integrates their views

into the second stage of map-analysis. The second stage of map-analysis is the more refined outcome that includes one final route-map and safety-legend that corresponds to the route-map. In the same chapter, the second stage of map-analysis, or the safety-route-map is discussed with the international adviser. The final outcome of this chapter is the synthesis of policy recommendations and strategies in order to bring the route-map closer to reality. This chapter at the end reflects on the accomplishments of this dissertations and critically reviews the research methods. The fifth or the final chapter discusses the final conclusions.

1.4 VALUE OF THE DISSERTATION

The important strength of this dissertation and its strategy is the integration of the views of experts early in the process of spatial planning, so much so that they are well integrated in the next analysis phase. In other words, the first stage of map-analysis-findings of this dissertation is discussed with the local experts. The discussion themes and suggestions of local experts have informed the second analysis findings. Finally the second stage of map-analysis-findings of this dissertation is presented to the international experts. This 2-step spatial planning process is believed to add the pillars of strength in the form of local and international knowledge. This is believed by the researcher of this dissertation as a strength due to the fact that the interventions are a joint output of map analysis and human knowledge. The sociological, technical and digital interfaces of the city can be brought together with this strategy. The digital analysis method such as Space Syntax can only be most effective by integrating the active knowledge in order to produce well-balanced proposals. Such proposals when successful on a neighborhood or an area scale can be implemented on urban scale, and finally can inform the more wider policy environment. This is also termed as scaling of projects (PMC & RMI, 2018). Currently the field of Transport Policy is largely the domain of social sciences such as political science and legal studies. This method presents a possibility to bring this expert domain closer to the city users. The active knowledge that takes place on local as well as international scale by human actors and citizens, when combined with the digital analysis methods can provide an effective social-digital-technical combination, which not only is relevant for neighborhood and the city level but also will improve the knowledge base of national level policy design.

CHAPTER 2.

PUNE CITY, THE ACTORS AND THEIR ACTIONS TO ACHIEVE NON-MOTORIZED TRANSPORT (NMT) VISION FOR THE CITY

2 PUNE CITY, THE ACTORS AND THEIR ACTIONS TO ACHIEVE NON-MOTORIZED TRANSPORT (NMT) VISION FOR THE CITY

This chapter will present the work carried out in order to fulfil the first Research Objective.

The Research Objective is to *investigate study area's Mobility Plan in relevance to the Street Network*. The city's 2008 Mobility Plan was a proposal document created by a private corporate company called Wilbur Smith on behalf of Pune Municipal Corporation. After the creation of this Plan document there have been many actions taken from the side of Municipal government, private actors on behalf of the city, the Citizens and Civil Society Organizations. The international Institute was also involved which promoted and implemented the international street design concepts such as Complete Street in a pilot project on J.M. Road, one of the core area ring roads. Along side of these various actors, the local Architects and Urban Designer have been actively contributing to studying the core area and proposing the sustainable solutions. The following subchapter will present the background of the Case Study area and emphasize on the role of streets in the development of Pune city.

2.1 MULTISCALE STREET NETWORK'S INFLUENCE IN DEVELOPMENT AND TRANSPORT : PUNE METROPOLITAN AREA , PUNE MUNICIPAL AREA AND CORE AREA

Streets in Indian urban and semi-urban context can be seen as growth generators. Indian cities and their hinterlands are fueled by industrial growth. The inter-state highways serve as the essential long-distance connectors to transport industrial goods among various Indian cities. Several Transportation and Urban Development studies carried out in Indian cities highlight the fact that the rapidly growing cities are a product of their location along major roads, such as national and state highways (Fazal, 2001). These highways often than not cut across the city centers where generally the primary commerce and markets are located, and sometimes the goods storage (Putter et al., 2005). For some cities, the goods storage can as well be seen as located in the hinterlands. However, the goods carrying vans need to transport them to the city center at a later time.

Pune's Transport Plan highlights the need to move the truck terminal which is currently located in the city center. Another category in Pune's city traffic is those trips which begin outside of the city limit and destined outside of city limit.

24 % trips among all trips surveyed are those destined to be outside the city (Wilbur Smith, IL&FS, 2008). Another survey indicates that 9% of all city traffic is for carrying long-distance goods and 7% for carrying long-distance passengers (L&T Infra Engineering, 2018).

In order to simplify the area considerations in this dissertation, the following area boundaries will be followed in the rest of the text when referring to the study area.

- Pune Metropolitan Region – Larger area than the Municipal city limits has influence on Pune’s traffic. Pune Metropolitan Region or PMR includes Pimpri Chinchwad and all surrounding villages, Pune Cantonment and Khadki Cantonment (Wilbur Smith, IL&FS, 2008).
- Pune Municipal Area – Pune City limits or Pune Municipal Area, measuring 243.84 Sq.Km. with a population of 3,115,431 (Voyants Solutions Pvt. Ltd., 2012).
- Case Study Area – Core Area as defined by the 2008 Mobility Plan - Comprehensive Mobility Plan (CMP). It is roughly of a pentagon shape measuring 8 Sq.Km. in area.

Following figure (Fig.3) shows the spatial arrangement and radii of three areas discussed above.



Figure 3: Pune City: A radial growth pattern.

The outermost ring represents larger Pune Metropolitan Region with a diameter of 30 Km (radius of 15 Km). The intermediate ring represents Pune Municipal area with diameter 20 Km (radius 10 Km). The innermost ring represents Core Area with diameter 4 Km (radius 2 Km).

Image and Information Source: (L&T Infra Engineering, 2018)

The street network cuts across these three areas is influential in shaping their Land Use Development and Transport. As a reciprocated effect, it can be seen that in the 2008 Mobility Plan, the streets were identified and assigned specific characters in order to improve the combined development of the region. For instance, the most connected streets among the three areas were assigned to be Mobility Corridors : More Capacity, More Speed and Mixed Traffic with on-street Parking prohibited (Wilbur Smith, IL&FS, 2008, pp. p.8-1). More details of the 2008 Mobility Plan relevant to this dissertation will be discussed in the following subchapter.

2.2 INVESTIGATION OF PUNE’S MOBILITY PLAN FOR CORE AREA : DATA COLLECTION AND DATA ANALYSIS

This subchapter presents the analysis findings from the 2008 Mobility Plan and various actions undertaken after that until this year. It was important to maintain the analysis focus on the street network and the Non-Motorized Mobility vision. The data collection had to be from various data sources ranging from Municipal Government Reports, Documents published on their website, the primary guidelines published on Street Design by the Street Planning and Road Department of Municipal Corporation and finally, the Grievance section of the website where the citizens regularly report traffic issues in their daily commute. The review of Planning, Guiding and Monitoring instruments can be summarized in the following table.

	PLANNING	GUIDING	MONITORING
	Comprehensive Mobility Plan 2008 + CMP Review 2018	Urban Street Design Guidelines 2016	Pune Municipal Website 2021
Highlights	Structured record of Vision, Strategy and Plan Action Items	Street Planning and Design Guidelines for Road Construction	Live, daily updated and managed data on governance, citizen participation, Public Policies.
Street Network	Abundant reference to long-distance roads used in Planning	Universal Design, Road Diet, Street Junction Improvement, Street edges.	Smart, Active and more recent than Mobility Plan, Ring Roads.
Non-Motorized Mobility Vision	Is realized by means of Mobility of Private Motorized vehicles and Public Transport	Mobility of people, Pedestrian and Bike safety.	Governance Transparency, Accountability, but digital forum accessed by limited user group
Core Area	Core Ring Roads for Restricting traffic entry by Bypassing core area	No specific data found	No specific data found

Table 1 : Pune City and Metropolitan Region’s Mobility Planning, Guiding and Monitoring instruments and their State of Research Summary.

Data Source : (Wilbur Smith, IL&FS, 2008), (PMC, 2021), (L&T Infra Engineering, 2018).

Table.1 summarizes Pune's Mobility Planning instruments which encompass all the efforts by City government in partnership with other forms of governments and partnerships with other city actors. This dissertation attempts to minimize data gaps by referring the data from 2008 to 2021. It also attempts to avoid misinformation by referring those data sources that are made transparent and are accountable by the Municipal government. All data sources in Table.1 are open to public.

It has been a challenging process to extract relevant data from above sources that are summarized in in Table.1. This was due to the expanse of information that is provided in the static reports, page numbers ranging from 50 to 150, as well as the daily informational addition in updated webpages and in public discussion forums. The information published on the websites of civil society organizations, even though in the public domain, is excluded in above study. That particular information is covered in the chapter 4 which integrates the discussion with NGO experts with the dissertation findings of street network analysis.

For this chapter, in order to investigate Pune's Mobility Plan, the major themes that are extracted from Planning, Guiding and Monitoring instruments are analyzed in detail in the following subsections. These major themes are in relation to the dissertation's study area or Core Area.

2.2.1 Focus on the Street-Network in Mobility Planning : 2008 Mobility Plan and 2018 Mobility Plan Review

Radial growth of the city : Ring-and-Radial Pattern of the streets

It is promising to see that the Planning instrument highly focuses on the Street Network of the city area and the metropolitan area. As discussed earlier in the subchapter 1.2b in the problem statement, the streets are the connectors of old areas with the new areas, the rich neighborhoods with the poor neighborhoods. The efforts by the city government to improve this street network as a whole brings a hope that the traffic challenges will be solved holistically without a bias or inequity. As also discussed in the problem statement, the time when these projects will see their fruition is still a question, even for the city authorities. The reasons behind the implementation delays are a result of multitudes of inefficiencies which are not the focus of this dissertation. This dissertation will assume that the planned projects will be implemented and will critic only about the functionality of spatial planning and design. It will not critic on the specific details about the functionality of governance and implementation.

The Street-Network focus can be seen on two large conceptual proposals. They are – 1. the Radial Mobility Corridors, 2. Ring Roads, 3. Ring-Radial Pattern (as a result of intersection of Mobility Corridors and Ring Roads, as seen in Fig.4). Mobility Corridors are connectors among large distances in Metropolitan Region. They are more capacity, more speed, planned especially to speed up the Public Transport. The identified roads have minimum 25 M in width and carry mixed traffic. Their width varies throughout the city. When it is more than 30 M, the dedicated Bus Rapid Transit System or BRTS is proposed (Wilbur Smith, IL&FS, 2008). The need for creating a safe passing route for vehicles from outer areas of Pune in a fast speed has given rise to the Ring Road proposal (Department, 2021).

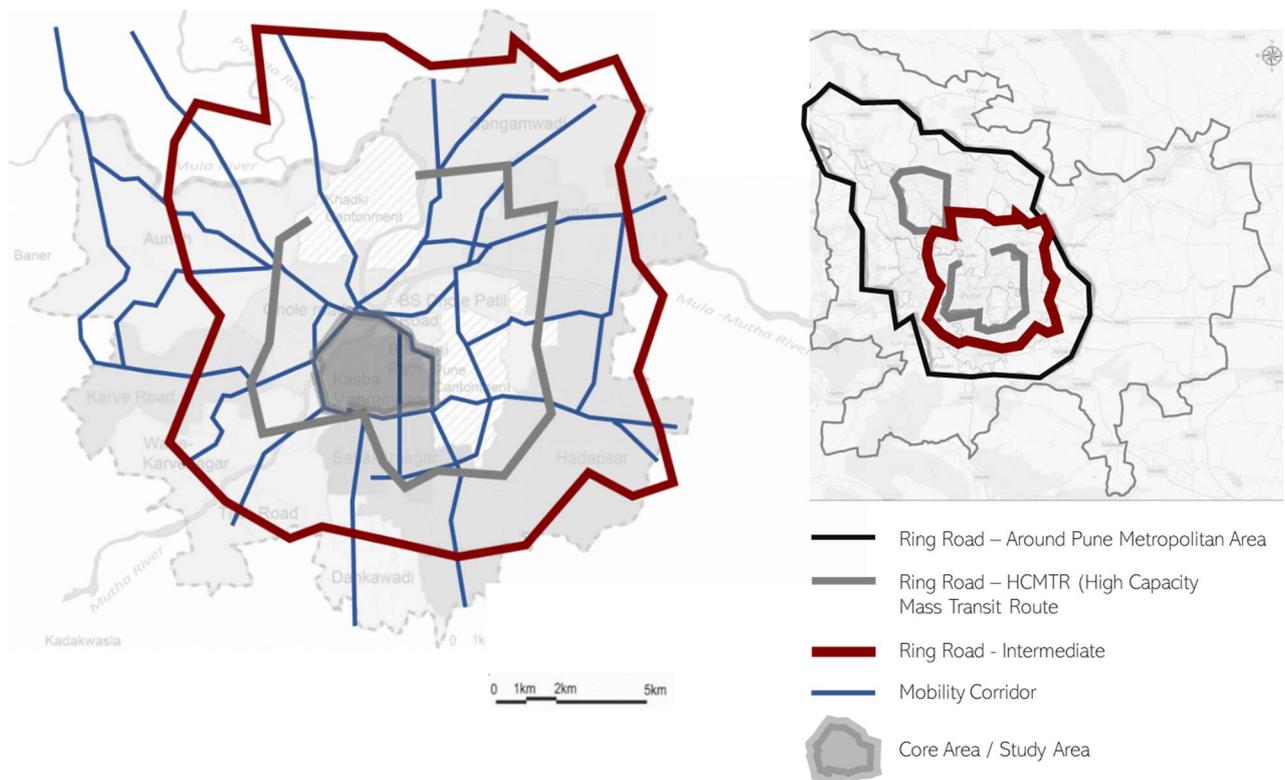


Figure 4 : Ring-Radial Pattern of Ring Rods and Mobility Corridors in Pune City.

Some of the streets have been identified and infrastructure provision is under construction.

Image : Author's Production. Information Source : 2008 Mobilty Plan, 2018 Mobilty Plan Review.

The large Street-Network in Pune Municipal as well as Metropolitan Area as seen in Fig. 4, contributes to a high amount of Transportation Planning and budget. Along with the financial investment, the large amount of time and management is involved in this planning proposal. For instance, the study of roads was carried out in 1978-1982 particularly for the Ring Road – HCMTR (Grey coloured ring in Fig.4). The complexities involved in the proposal could be the cause to a delay. The complexities can be but not limited to acquiring the permissions for the large areas of land to construct road-infrastructure. The reason for this large Planning Proposal of Ring Roads is because the majority of major high- traffic arterial roads are radial and they pass through the city center where the streets are narrow and building and population density is very high. The radial city growth pattern has influenced the development of major arterial roads. (Voyants Solutions Pvt. Ltd., 2012).

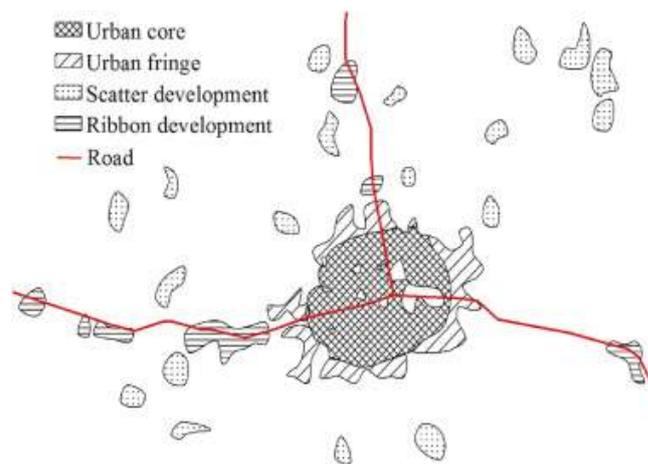


Figure 5: Urban typology of Pune.

Image Source: Kantakumar et al., 2015.

The urban expansion study of Pune city shows these different growth patterns in one image (Fig.5). The city growth as discussed before has been radial with an old and dense urban core at its center. The fringe and the ribbon development are taking shape in hinterlands and along the major roads due to the expanding industrial sector. From this study, the city can be expected to grow further as it has grown in the past decades, creating a need for robust and expanding ring and radial street- network.

This dissertation finds out some unclear aspects from this part of the Plan. According to the mobility vision, the Public Transport must have high speed and Private Transport must have low speeds. The mobility corridors will have a high speed limit. This may prove to be expensive and difficult to regulate Private cars passing through the same corridor and then entering the quieter zone. This means that if the cameras are not installed in all roads and if the automatic ticketing system which charges the speeding car-owner is not functioning, then speed control on private cars will not work. This makes the expensive electronic system of vigilance and ticketing necessary to relieve excess stress on the traffic police. Most importantly, it increases the risk speeding by private vehicles in NMT zones.

The mixed-traffic character of these corridors in Core Area is questionable. In one of the street of this area, the most used Transport Mode is two-wheelers, followed by walking (Fig.6). The mode-share differs with travel distances and purpose. For instance, the short-distance users who only want to visit the neighborhood shop, prefer to use two-wheelers. Those who are older, much younger or who cannot ride scooter easily, simply wave at auto-rickshaw to stop by, and ride in it. The auto-rickshaws can be stopped at the door of the shop and hence found to be a favored mode of transport among Core Area users or visitors.



Figure 6: Mix transport-modes and modal-share in Pune's core area.

Source: (Wingard, 2012).

These mode users can be seen at a vulnerable risk of high speeds at Mobility Corridor. Therefore the need for analyzing the streets with the variables of travel-distance, travel-purpose is essential before assigning the function to the streets. The second finding is that such a street network analysis of users' purpose, distance and mode differs for every area. This dissertation will only focus on the Core Area. It will attempt to highlight the fact that the special characteristics of this area highly influences how one travels in and out of this area.

2.2.2 Core area ring

2008 Mobility Plan has identified a circular ring made of streets that encircle the Core Area. This is proposed for all the streets that connect to each other and form a ring pattern. At present one of the streets, named J.M. Road has been successfully redesigned as an NMT-friendly street in a Pilot project. Apart from J.M. Road other Ring streets have not been redesigned. Inside this ring the majority of the neighborhood streets are proposed to have footpaths and cycling lanes, either grade-separated or painted. However, only one street inside the Core Area, named, Laxmi Road, is proposed to be fully pedestrianized (L&T Infra Engineering, 2018). All other neighborhood streets, according to this proposal, will have mixed traffic, including buses for Public Transport, 2-wheelers (Scooters), 3-wheelers (Autorickshaws), cars, vans, lorries and taxis. This dissertation would like to highlight the issues related to some of the Planning aspects mentioned above.



Figure 7: Core area ring.

Image Source : Dissertation Author's Production. Base map - Google Earth



The Core Area Ring is considered as a good proposal to limit the through traffic. This is expected to reduce the traffic stress on narrow neighborhood streets and allow shoppers to have a comfortable experience. However, the streets are not wide enough to allow all kinds of traffic without assigning priority. It causes

traffic congestion, delays and excess pollution. This area does not have open public spaces such as square, park to balance the traffic stress. The shopping streets have a very unique problem. The 2-wheelers are driven and parked in front of any shop because the on-street parking is almost always full. This takes large walking space away from the footpaths. As a result, pedestrians are often seen having to risk themselves by walking in the carriageway (NTNU students & SPA students, 2017; Wingard, 2012). The crossing junctions are very risky and do not provide enough pedestrian crossing time (STEP, 2020). The public Transport buses are frequently observed on all the major streets. The similar risks are shared by the cyclists on the street. It is a common sight that a cyclist riding next to the heavily loaded bus and other heavy vehicles. They face very high accident risks.

The ignored modes by the Planning instrument are not only walking and cycling but also the most favored modes of core area's residents and visitors- 2-wheelers and 3 wheelers (according to Fig.6) The irony is that the largest used modes are the most ignored ones , especially in the aspect of their safety.



8a: A common sight of drivers filling into pedestrian crossing area in Core Area Ring Road.

8b: Unsafe Autonomous Crossing : Pedestrians crossing street full of traffic inside Core Area.

Figure 8 : Traffic safety concerns inside Core Area.

Image Source : (Wingard, 2012)

In order to improve safety while walking and cycling, as well as to understand the road functions, it is important to design street infrastructure friendly to these mode-users. In order to do that in the existing narrow streets, the *road diet* or the optimum designing of streets is extremely crucial. In doing so, this dissertation highly supports the study of each individual street and its function in the network. Once the function of each street is studied, it will provide insight into what the street traffic should be composed of and which mode has the priority over the others. For instance the shared street with the highest priority to the pedestrians followed by the cyclist and lastly by two-wheelers.

At present Laxmi Road is the busiest and most popular shopping street among many citizens. But fully pedestrianizing this street will not be beneficial. Because it is the only longest connecting street in the East-to West direction, hence serves the function of East-West link street. On the other hand, a shared character with very restricted private traffic, limited to certain hours, and a smooth prioritized Bus Service can serve the traffic condition and the visitors in a more organized way.

2.2.3 Hope for traffic safety? : Guiding Instrument

4.1

PEDESTRIAN ROAD CROSSINGS

4.1.1 At grade pedestrian crossings

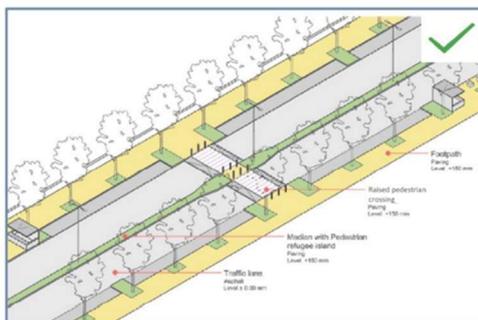
At grade pedestrian crossings are to be provided at all intersections as large number of pedestrians cross the street at intersections.

To ensure pedestrian safety and convenience, crossings should be designed so as to have direct and shorter route to the other side of street.

Safe pedestrian road crossings shall be provided also on streets with flyovers and underpasses.

Common formats of crossings

- Signalized crossings at junctions with refuge islands.
- Mid block crossings supported by traffic calming measures.



Ideal design for at grade crossing showing raised zebra crossing and refuge island



Zebra Crossings

➤ Pedestrian crossings should be provided at every 150m distance depending on the surrounding landuse and pedestrian footfall. (IRC: 103 - 2012, clause no. 6.7.2 Table 3) In no case should its width be less than 3m. Crossing width can be more as per pedestrian density.

➤ Zebra crossing is mandatory at all intersection crossings.

➤ The design and dimensions of zebra crossing should comply with IRC 35-1997 code of practices for road markings (with paints). Following are the recommendations in IRC 35-1997-

- The zebra marking of a pedestrian crossing consists of equally spaced white strips. Generally 0.3 m wide with a gap of 0.3 m in accordance with IRC 67-1977.
- Zebra crossings to be painted with thermoplastic paint of white color. Zebra crossings to be highlighted by reflective cats eye and should be easily visible with sufficient lighting. They should always be accompanied by stop line.
- Zebra crossings to be from edge to edge or footpath to footpath connecting refuge spaces in between.
- Tactile pavings should be embedded in zebra crossings to guide specially abled people.
- Medians, railings or any other obstructions should not be placed on zebra crossings.
- Distance between STOP line and edge of zebra crossing should be 2m (as per the 'Pedestrian policy of PMC').
- Traffic signal pole should be located midway between STOP line and edge of zebra crossing. (as per the 'Pedestrian policy of PMC').

Figure 9 : Extract of Best Practices for Footpath Design and Standards in Pune City.

The guiding Instrument provides ideals of street-design particularly aiming on Pedestrian's issues in Pune. Image Source : (Corporation, Urban Street Design Guidelines Pune, 2016).

NOTE: The text in the image is not is for information and not part of the text of this dissertation..

Guiding instrument of the Urban Street Design Guidelines (USDG) effective effort for setting up the street standards and introduce Pune's authorities as well as the users with the international universal design. This dissertation considered this as a good step towards recognizing that the street belongs as much to a walking or a cycling person as much it belongs to a person in the car or a bus. In a mixed traffic situation, which is on almost all Pune streets, this guiding instrument brings into a factor of Transport Justice, in the form of

just distribution of roads. In the aspect of road safety, this is considered as a hopeful step. Pune is one of the handful cities in India that has put forward a Pedestrian Policy which compliments with the slowly rising awareness among citizens about the pedestrian rights. The details of these guidelines and the policy are available on city government’s website. This policy largely focuses on safety and intends to guides all the future transport planning interventions (STEP, 2020).

The second useful proposal in guiding instrument is Street typology. The streets are assigned with specific typology such as Mobility Corridor, Mobility Corridor with NMT preference, Through traffic streets (carrying outside city traffic), Feeder Streets (which feed the traffic from neighborhoods into arterial streets) and neighborhood streets(narrow streets in calm residential areas). Following Fig. 10 shows illustrates spatial and visual arrangement of street typology of Pune. This street typology classification and design is based on mobility, activities and parking requirements.



Figure 10 : Proposed street typology for Pune Municipal Area.

Image : Dissertation Author's Production. Information Source: (PMC, 2016).

2.3 DATA SYNTHESIS

2.3.1 Divergence on the issue of Safety of Non-Motorized Transport users

Implementation issues

The study has shown that Pune city has a high modal share by walking and cycling, or NMT. This dissertation has highlighted convergences between current Mobility Planning and principles of sustainability based on avoid-shift-improve approach, as discussed above. The divergences are discussed below.

The core area ring is proposed in 2008 Mobility Plan. As discussed above, this intervention can prove to be protective for the safety of core area users. However, it is concerning to discover no mention of Core Area Ring in 2018 Mobility Plan progress report (L&T Infra Engineering, 2018) .

Other concerning factors are the planning divergences in road typology of mobility corridors between USDG 2016 and 2008 plan. It is understood that 2016 guiding instrument has studied the streets in more details for their activities, mobility and parking requirements. Depending on this study, the new mobility corridors do not include the core area ring, and the new implementation projects are based on this study. Therefore the implementation and advocacy of Core Area Ring is threatened.

Another concerning factor is the lack of progress. All streets are identified in typologies and some of them are also identified under the street program to be holistically developed as NMT-friendly streets.

According to the information provided by the Road Department on the city Corporation website, out of 100 km identified, 50 km will be carried out in first 2 phases. But the time-schedule of this project is not committed nor mentioned on the website. On the contrary to the promising claim of Pune Street Program, the progress report indicates footpath construction on 13 streets in Pune out of which 1 street is in core area. This is a very slow progress considering the dense network of streets without safe footpaths (STEP, 2020).

In this way, the major issues in achieving Sustainable Mobility Vision found in the Mobility Planning, Guiding and Monitoring instruments of Pune are : *Focus on mobility of Private Motorized Vehicles, extremely poor safety conditions for walking and cycling.*

The traffic studies are 10 to 30 years old. The Data Collection was done in the form of Traffic Volume Surveys in order to validate the Traffic Demand Model. They Need huge database, but provide results which are

outdated, and are based on the traditional planning methods of predicting traffic demand and providing the infrastructure (Kenworthy, 2019 b).

In this way, the sustainability vision promotes avoid-shift-improve approach, however the Planning Methodologies are based on traditional predict-provide approach, which is contradicting in the their fundamental principles.

2.4 RECOMMENDATIONS

2.4.1 Area-based Development

The findings reveals that the 2008 Mobility Plan proposes the concepts largely for the Pune Municipal Area or the Pune City. It is not focused on any one area in detail. This is found to be one of the reasons why the long distance Street-Network is central to Planning.

This dissertation urges the attention of City Planners and Administrators to the fact that Core Area modal usage indicates high levels of Walking and Cycling. It also urges them to critically analyze the user needs who will be using the improved Bus System in the near future. If the users are not provided safe and functional footpaths and safe junction-crossings, and if the streets are highly polluted with high speed mix traffic, why will they be encouraged to change mode from private 2-wheeler and public 3-wheeler to the Bus System ?

In this way, the dissertation argues that the other public and sustainable modes such as walking and cycling can be and must be paid more attention on the Area Level. When the area level NMT network becomes strong and is integrated with the long distance Bus Service and other future Mass Transit Modes or Metro System on the Mobility Corridors , is only when the Mobility vision of drastic modal shift can be easier to achieve.

2.4.2 Elements of Street-Network : For improved safety and avoiding accidents in mix traffic situations

This is one more alarming subject stemming from rapidly growing pressure on Pune streets. Data on accidents reveal that the most affected user-groups by the traffic accidents in Pune are pedestrians (STEP, 2020). Recent news of the deadly accident of a motorbike rider sparked terror among Pune citizens that took place in the BRTS lane. At the same time it fueled the continued discontent from the user group of private motorized vehicles towards the public service such as BRTS (Abhyankar, 2020). The mixed use or shared character of any street is inevitable due to the favored modes of the two and three-wheelers among Pune users. It is recommended to keep the shared streets rather than pedestrian-only streets.

In the context of Pune's traffic and transportation challenges, this dissertation argues that if the users are provided a safe, harmonic transport network system, the same street network can serve as the guidelines for a harmonic movement. In doing so, it emphasizes two principles of Sustainable Transport as discussed in previous chapter, namely– 1. Optimizing road network and its use, and 2. Encouraging Walking and Cycling.

In order to make these principles more adaptive in Pune's Core Area, this dissertation recommends including following elements. These elements add the multiple dimensions of users and their needs which must be studied in cohesion.

1. **FUNCTION OF THE STREET** : The streets need to be given a function of use, such as, mobility corridor, ring road to bypass the core area, calm neighborhood street, safe connecting street.
2. **CHARACTER OF THE STREET** : According to the function of use, the streets need to be defined in their character. A mobility corridor's character is heavily motorized, heavily managed at the crossing junctions. Neighborhood road has the character of shared, safe, green environment with slow moving traffic. The street furniture, signage and greening can follow this character.
3. **PRIORITY OF MODES** : Street design and street monitoring systems to ensure priorities are provided, communicated and demonstrated.
4. **PURPOSE OF THE VISIT.**

In this way, this dissertation emphasizes the need of Street Analysis by paying attention to above elements in each area. It identifies two themes from existing mobility planning that are found to be beneficial are – a. Core Area Ring, and , b. Mix Traffic character of streets. The following chapter will study the Core Area in

detail by keeping above four elements central. The output of the next chapter is the street analysis and the Route Plan for the Core Area.

2.5 CONCLUSION OF THE CHAPTER

The extensive literature review including data collection and analysis guided this research to solidify the following conclusions.

The positive intention of the city government and ambitious vision of the national government to create a Sustainable Mobility System in Pune is reflected in the documents but not reflected in the speed of implementation. The slow implementation speeds threaten the modal-shift goals of 19% (in 2018) up to 50% (in 2038) for Public Transport and 45% (in 2018) down to 10% (2038) for Private Motorized Vehicles (Car and two-wheelers). The high emphasis on the urgency of improving Non-Motorized Transport in the Mobility Planning, Guiding and Monitoring documents must instead shift to critically review the progress of existing and new Public Transport (Bus and Metro System), and to effectively strategize the rise in ridership of existing Public Transport (Bus System). The emphasis on Non-Motorized Transport (Walking and Cycling) is important, but the current mode share of NMT (33%) is not very distant than the 20 year goal (35%). The real difficulty lies in the remaining 70% which is largely served by private vehicle industry. Therefore, the urgency must be first placed on the strategies to combat with people's urge for using the private vehicle and the mobility-convenience that they experience by using the private vehicles. Therefore, if the city wants to see the drastic transport-modal shift as a reality and not as a distant dream, then the urgency must be placed on drastically improving the mobility-convenience for NMT and Public Transport users.

This chapter concludes with the recommendations to include street elements of function, character, mode-priority and visit-purpose, into the planning process to fill the gap of *user-oriented design* which is currently missing Pune's large landscape of city and metropolitan level Mobility Planning. It further believes that this study will contribute in not only improving levels of walking and cycling, but will cater to the larger and more unattainable goal of making public transport more attractive than the currently favored mode of private motorized vehicle.

CHAPTER 3.

STREET NETWORK ANALYSIS : A KEY DRIVER IN IMPROVING NON-MOTORIZED TRANSPORT (NMT) MOVEMENT INSIDE PUNE'S CORE AREA

3 STREET NETWORK ANALYSIS : A KEY DRIVER IN IMPROVING NON-MOTORIZED TRANSPORT (NMT) MOVEMENT INSIDE PUNE'S CORE AREA

This chapter will present the research work carried out to fulfil the second Research Objective – *To analyze Mobility Planning Action Items of the Case Study area by using Street-Network-Analysis.*

The framework to analyze data of this empirical case study is based on the Space Syntax tools of street connectivity in the framework of Street Elements that is derived in the last chapter. The following subchapter will describe the case study area into more detail. For the data collection purposes, the field studies undertaken by Master Students from Sweden and Norway in collaboration with the local universities and / or architects and NGO from Pune have been referred. The studies belonged to the faculty of Architecture and Spatial Planning schools of respective students. A study of Spatial Planning and Transportation Design about the market street in Pune's Core Area, called Laxmi Road carried undertaken in collaboration with the NGO Parisar and Architect Prasanna Desai in 2012 is referred due to its relevance with the subject as well as geographical area selection. This study involved 2 months of field work and is focuses on pedestrian-friendly conceptual spatial planning of Core Area and the detailed planning of the Laxmi Road. The second study that is referred in this dissertation is of Ecological Planning of one ward (or a administrative spatial unit) in Pune's core area. This study proposes multipronged strategies in slum upgradation, participatory street and public space upgradation, heritage policy. Their methodology for this comprehensive planning is reflective of community and city actors participation during field study in Pune. For the data collection purposes of this dissertation, it is believed that above secondary sources will be valuable in bringing together multiple dimensions of core area including spatial and social structures.

3.1 STREET NETWORK : A KEY DRIVER IN SHAPING CORE AREA'S URBAN FABRIC

Ageing buildings, vibrant markets, narrow street network, and the pressure of Pune's growth.

Even today, the Core Area is one of city's most popular functional market for clothes, gold and silver Jewelry, food supplies such as spices, fruits and vegetables, and local craft business such as copper and clay articles. The bustling market streets dating back to 1700 become even more special among citizens and tourists during numerous festivals around the year. The presence of religious worship places create an added value

in this area. Not only during the festivals and religious times, but popularity of core city is spread across every household due to the individual shopping opportunities associated with marriage ceremonies (NTNU students & SPA students, 2017). A careful notice of Pune's Development Control Rules and the new building proposals reveal the future prospects of transformation of the ageing landscapes of this beautiful old village (NTNU students & SPA students, 2017; Voyants Solutions Pvt. Ltd., 2012). On the other side of such vibrant places of religious, cultural and public spaces, the ageing buildings, land plots are increasingly coming under the transformative development lens. More so because of the Development Control Rules (DCR) of higher buildable area also called as Floor Space Index (FSI) along the Metro corridor which will pass through this area. Many real estate developers are expressing interest in buying the old residential or commercial buildings, and developing higher density mix use building for profit. The soaring land value appraisal is a motivation for older population to sell their properties to such transformative development projects. The lack of maintenance to the old buildings is one of the causes of urban decay (Chawande, 2021). The urban decay can also be seen in the narrow alleys in between neighborhood streets, which are likely to vanish and merge into larger land plots for future development.

3.1.1 Compact Urban Model : Quiet neighborhood life : The need for Street Element framework

As defined by the 2008 Mobility Plan, Pune's Core is a group of several wards. A ward in Pune's context is an administrative unit whose Public Works are managed by an individual Ward Office. The report on the Existing Land Use Plan of Pune Municipal Area highlights the compact characteristics of the core area *pethas* or wards, in following statement

This area is the congested part of the city and consists of old pethas and the development taken place in this area is on the lines of gaothans, that is, the properties are adjoining to each other and there is no side margin in between two buildings (Waghmare, 2007, p. 4).

These different wards have different street patterns. More generally the pattern is grid-iron pattern (Waghmare, 2007). Fig. 11 shows the land that is divided by such grid-iron pattern. This grid pattern is not uniform in each grid. In some wards it is a narrow grid while in some wards it is wide. This also offers varying width to the streets. More generally, the neighborhood streets have narrow widths which were designed

for light movement. The most typical pattern of land use is as follows. The feeder or the main street is wide, and contains the permanent shops on ground floor and residences on upper two to three floors. The internal lanes or neighborhood streets are narrow, and they contain quiet residential buildings. The reason for such a compact urban model dates back to this area's initiation in 1300 and further development through 1789 by Maratha leaders. The map in Fig. 11 shows the chronological development of these different *pethas* or wards in the core city. These wards serve different purposes to collectively serve to the life of a large community. For instance, some wards are developed with a purpose of highly commercial use and some wards are highly for residential or religious purposes.

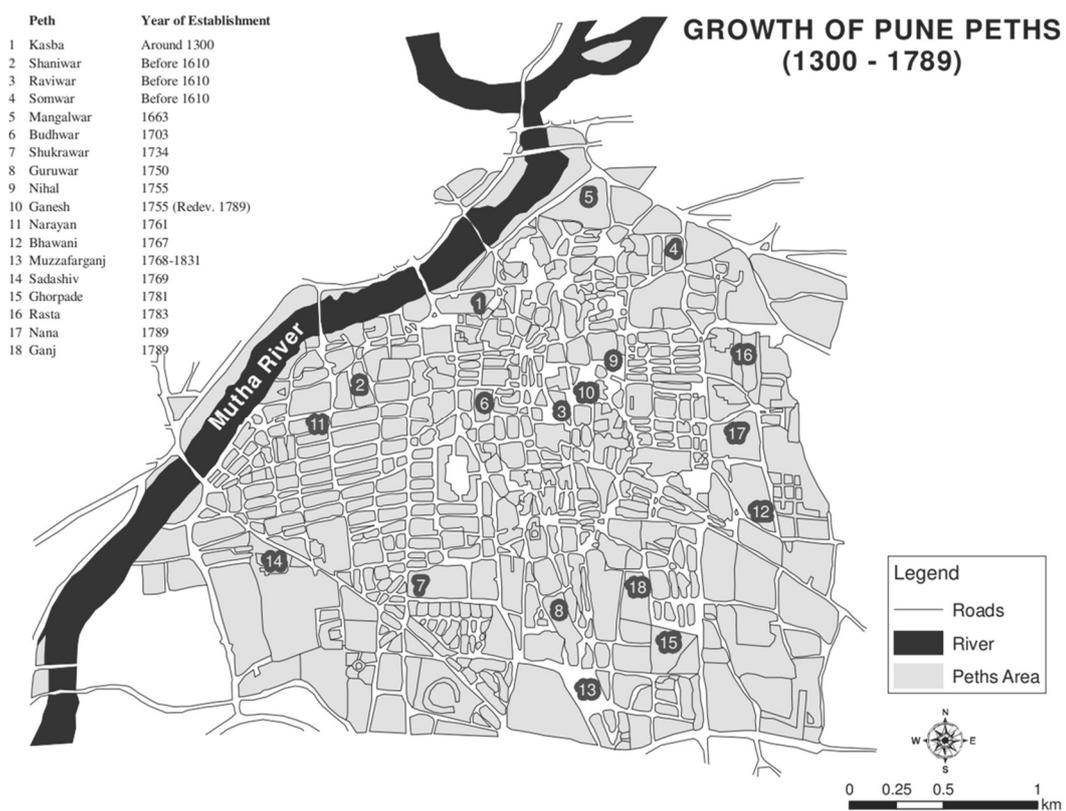


Figure 11 : Chronological growth of Pune's core area.

Image source : (Mundhe & Jaybhaye, 2017)

One of the literatures reviewed for this part of the dissertation is the case- study of three Indian historic city core areas that were measured for Pedestrian satisfaction. The historic core areas of particularly mix traffic in Varanasi (North-eastern India), Jaipur (Mid-western India), and Hyderabad (Mid-southern India), the pedestrian sense of safety was identified as most determining factor for satisfaction. For this measurement, the trip analysis was used as a main tool to capture the safety and satisfaction (Bhaduri et al., 2019). The trip analysis involved information about purpose of visit and nature of visit.

In addition to above literature, the analysis of the literature reviewed in the form of studies and surveys especially in the context of core areas in Indian cities , revealed the following method to be useful. These studies focused on the streets in core cities including the typology , the functions and the activities in relation to the street (Bhaduri et al., 2019; NTNU 2011; Wingard, 2012). This is partly complimented by the work of local Architecture Consultants in designing Street Design Guidelines for Pune’s streets. Their work involves setting up the road typologies for Pune Municipal Area. According to their report, Urban Street Design Guidelines, the street typologies define the function of the street and thereby inform the design elements required to make that street successful in the mobility (PMC, 2016).

Even today the quiet neighborhood life can be experienced when one walks through the narrow streets with a view of several traditional houses or *wadas* lined one after another. The clothes hanging in the courtyard of these houses, the pickles drying, and the members of the community bonding socially at the local sweet shop. The need to sustain the character of the old city particular to each ward is slowly rising. It is becoming more evident and more urgent with the rising age as well as dilapidated state of footpaths. In recent times, the sense of urgency can be observed among the city actors advocating for protection of heritage and ecological parts of river streams passing through this area, in light with the proposed Mass Rapid Transit routes and development. Bus Rapid Transit routes that cut across the center and the ring of the area as well as the underground metro line, although are welcomed for the mobility benefits, their adverse effect on the nature and heritage is not forgotten by some of the city actors. The two field-studies, literature review of Mobility Instruments and the state of the art study of the work by the local architects and NGOs in Pune’s core area has helped this dissertation in crystallizing the street network analysis which is experimented in the following subchapters.

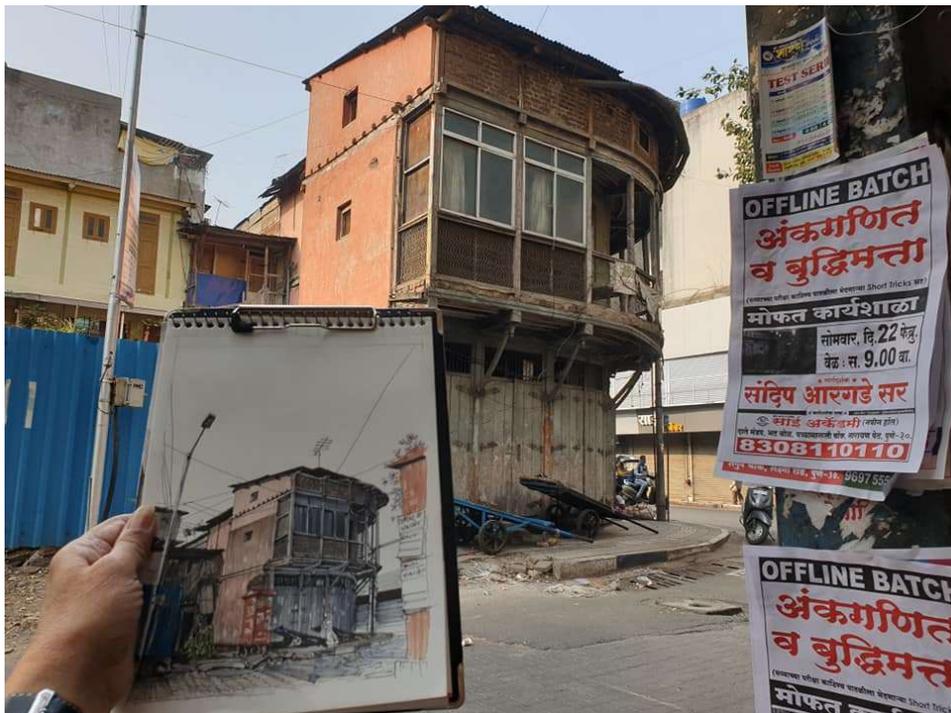


Figure 12 : Pune's ageing core area. A sketch by Ar. Ravi Gadre, Pune, India.

(included with the permission of an artist).

In this photo, which showcases the lively urban sketch by Pune's renowned architect with the physical backdrop, not only captures the ageing beauty of the core city, but also highlights the urgent need of repurposing neighborhood streets and buildings.

3.2 STREET NETWORK ANALYSIS : IN OPTIMIZING THE STREETS AND THEIR USE FOR IMPROVING NON-MOTORIZED TRANSPORT MOVEMENT INSIDE THE CORE AREA.

This subchapter will present the work carried out in Street Network Analysis. Space Syntax Theoretical background emphasizes the significance of street pattern or street network in shaping the urban fabric. The theory highlights that the streets influence how the land-use is shaped and how one travels through the city. (Hillier et al., 1993). The theory is being developed since over 30 years, is currently being used in practice as a basis for street network analysis, as well as, being experimented for further research directions (Kim, S., et.al., 2014 ; Moura, F., et.al. 2017 ; Millington, C., et.al. 2009; Space Syntax, 2021).

The author of this dissertation integrates the theoretical knowledge and software operational competences that were acquired during her 3 months internship experience at Space Syntax office in London.

As discussed in chapter 2, the focus of this research is in optimizing the streets for improving NMT movement inside the core area. In doing so, this dissertation needed the tool that can integrate the following Street Elements to analyze the Core Area streets–

1. *Street Function*
2. *Street Character*
3. *Mode Priority*
4. *Purpose of Visit*

The most important character of this analysis that is most applicable to this dissertation is found to be Segment Analysis. This analysis type is based on the Radius or the distance of the Journey. The radius of journey can be chosen in Meters and the streets that are most convenient can be determined for each specific distance. This is done by carrying out the Segment Analysis for two types – Integration and Normalized Angular Choice. The benefits of these tools as illustrated by one of the studies emphasized on the area level as well as city level study potential. This study was a comparative analysis of 20 cities around the world. (Hillier et al., 2012).

This dissertation selected 3 types of radii or 3 types distances – 1200 Meters (1.2 Km), 5000 Meters (5 Km) and 10000 Meters (10 Km). These radii are based on the literature of Space Syntax studies and is compared with Pune’s travel pattern. This comparison is used to finalize the distance with the Transport Modes-

1200 Meters (1.2 Km) = Walking

5000 Meters (5 Km) = Cycling, 2-wheeler, 3-wheeler

10000 Meters (10 Km) = Bus, 2-Wheelers, 3-Wheelers, Cars

30000 Meters (30 Km) = Long distance travel by Bus, Car, Trucks, Vans.

The radius 30 Km is not included in the analysis of this dissertation, because it required long distance route mapping, which is not in line with the dissertation timescale. However this is compensated by the Core Ring in 2008 Mobility Plan. Core Ring is suggested in this plan on the basis of its long distance route connectivity and to limit the long distance traffic by bypassing the Core Area.

3.2.1 Integration and Segment Angular Choice (NACH)

SEGMENT ANGULAR INTEGRATION - The founding theory for all techniques is based on the assumption that the spatial configuration of a space is responsible for the users movement in that space. In the integration measure, The linear space such as urban streets are represented with axial lines. These axial lines are the longest straight lines which follow the spatial configuration of buildings, boundaries etc. Each street is one line segment and the Segment Integration Analysis gives it a color code by using its integration value. In other words, the integration value is determined by the degree of how well or poorly the street is integrated in the system. By definition the integration is a measure of how each street is connected with every other street in the system (Hillier et al., 1993).

In urban scale, this technique combines three elements - 1. Spatial configuration of the study area, 2. Movement accessibility of each street and, 3. To-movement potential of the street. High integration means high to-movement potential, or, The red streets in Fig. 13a show high to-movement potential as opposed to the (deep) blue streets which have low to-movement potential. (UCL Space Syntax, 2020).

SEGMENT ANGULAR CHOICE (NACH) – Segment angular choice measures the *through-movement potential* of linear structures (eg. streets and corridors). The layout is coloured according to segment angular choice values. Red denotes a high through movement potential and blue indicates a low through movement potential. This enables us to understand the foreground network, highlighted in red and orange, and background network highlighted in the other colours (Fig. 13b). The foreground network highlights the shops and cafés of a place. The background network highlights the residential areas of a place (UCL Space Syntax, 2020).



13a : Segment Angular Integration Analysis.



13b : Segment Angular Choice Analysis.

Figure 13 : An example of Street Network Analysis by using Space Syntax tools.

Source : UCL Space Syntax online training platform

3.3 Street Analysis Maps 1

The following Fig.14 show Segment Angular Integration and Segment Angular Choice for the Radii - 1200 Meters (1.2 Km) = Walking. The Case Study Area or Core Area is 8 Sq.Km, roughly measures 3 Km from East to West edge. It is marked in dotted grey red border in the following Figures.

Important Note : The following 6 maps are of raw analysis. There are presented here only for the purpose of introducing the reader to the nature of raw analysis maps. The final analysis map in large size is provided in the next subchapter 3.4

STREET CONNECTIVITY SCALE



0 1Km 2Km



14a : Segment Angular Integration Analysis..



14b : Segment Angular Choice Analysis

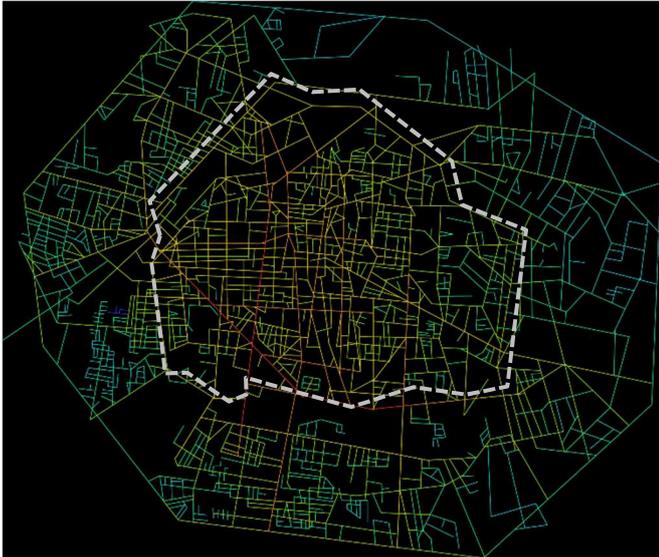
Figure 14 : Space Syntax Analysis on Core Area's street-network : Radius 1200 m / 1.2 Km

Source : Dissertation Author's production

Fig.15 = Radius 5000 Meters (5 Km) = Cycling, 2-wheeler, 3-wheeler

Fig.16 = Radius 10000 Meters (10 Km) = Bus, 2-Wheelers, 3-Wheelers, Cars

The Case Study Area or Core Area is 8 Sq.Km, roughly measures 3 Km from East to West edge. It is marked in thick dark red border in the Figures.



15a : Segment Angular Integration Analysis.



15b : Segment Angular Choice Analysis.

Figure 15 : Space Syntax Analysis on Core Area's street-network : Radius = 5000 Meters / 5 Km.



16a : Segment Angular Integration Analysis.



16b : Segment Angular Choice Analysis.

Figure 16 : Space Syntax Analysis on Core Area's street-network : Radius = 10000 Meters / 10 Km.

3.4 MODAL PRIORITY ON STREETS : STREET SEGREGATION FOR TRIP DISTANCE CONVENIENCE

ANALYSIS FINDINGS 1

The analysis of 1200, 5000 and 10000 Metric offered output in the form of street segregation. The streets could be divided by their To-Movement (Integration) and Through-Movement (Choice) potential. This offered insight into which streets are most convenient for intermediate and short distances. This in turn also offered the division of the streets based on which modes to be prioritized in which streets. Following figure shows the representation of these findings. The Green colour indicates short distance connectivity which allows efficient prioritization of walking and cycling, Orange colour indicates intermediate distance connectivity which allows effective conditions if the Bus Service, cycling, 2-wheelers and Auto-rickshaws are prioritized. The circles of colors red, orange and green indicate the distances corresponding to long distance, medium distance and short distance travel.

Fig. 17 shows analysis findings on city level .

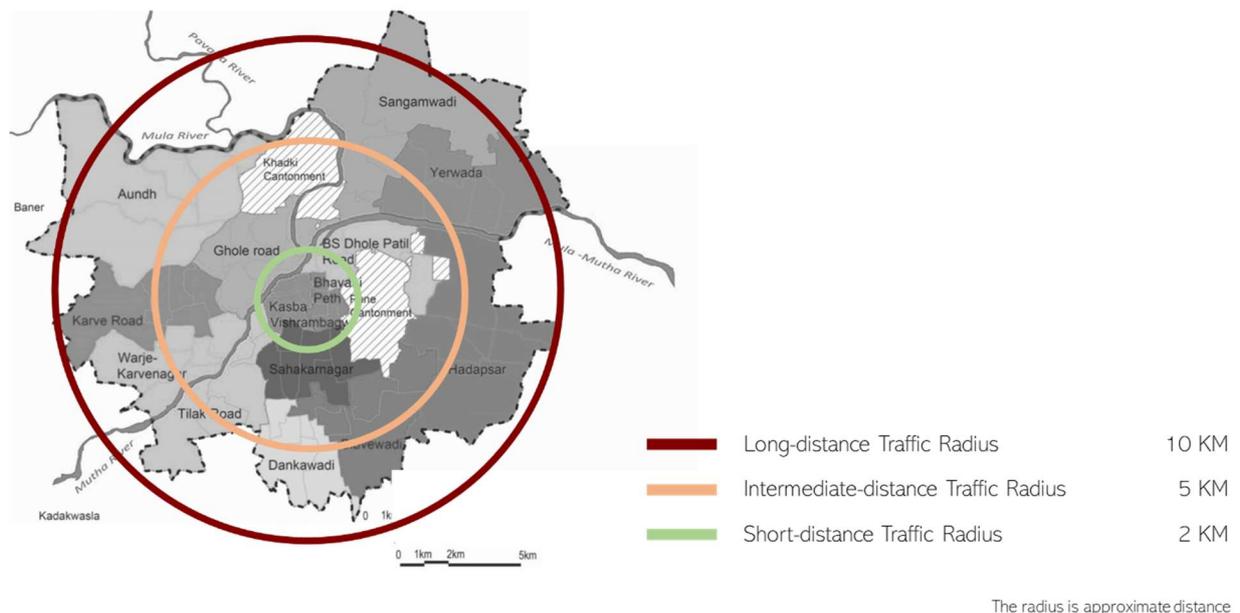


Figure 17: Pune City Map with three scales of traffic radii.

The radii are referred from Pune Mobility Plan Traffic Surveys,

The Base Map source - - (Voyants Solution Private Limited, 2012).

The analysis reconfirms that the tools proved to be beneficial for this dissertation because they aligned with the framework of street elements.

The framework of Street Elements derived in previous chapter is -

1. *Street Function*
2. *Street Character*
3. *Mode Priority*
4. *Purpose of Visit*

This dissertation recommends the primary data on elements 3 and 4. Character of the street will be best designed when these findings will be opened up for public scrutiny in presence of local architects. Purpose of the visit needs to be verified with case studies of all wards in core area.

Fig. 18 and 19 shows analysis findings on core area level .



Figure 19 : Highly integrated streets for short distance routes between 0-5 Km

Source : Dissertation Author's production.

Base Map Source - (Wingard, 2012)



Figure 18 : Highly integrated streets for intermediate distance routes between 5-10 Km

Source : Dissertation Author's production.

Base Map Source - (Wingard, 2012)

	Long-distance Traffic Radius	10 KM
	Intermediate-distance Traffic Radius	5 KM
	Short-distance Traffic Radius	2 KM

The radius is approximate distance

3.5 CONCLUSION OF THE CHAPTER

Street analysis leads to mode-prioritization detailed for user-oriented elements.

The division of streets achieved in the Analysis Findings 1 were found to be a helpful aid in predicting and bettering the traffic movement. The same existing width of the street can serve for better movement when the modes are prioritized and the speed of each are monitored. For instance, the street where cycling is prioritized, the speed of that street is recommended to be regulated to be the desired speed for cycling. This must be enforced for other less prioritized modes on that street. In other words, Laxmi Road which is both orange (motorized) and green (cycling), needs to regulate speeds as per the cycling mode. Therefore the Bus Service which is the second priority, must follow the low speeds which are comfortable to cycling speeds. This analysis however could not offer detailed insight into which street serves which function. According to earlier research, it is useful in taking the next step in planning which is in alignment with the on-ground surveys. This information is expected to be found in the local traffic management. This department of the City government could not be contacted during the research period of this dissertation. Therefore the street functions are excluded in this stage. However, the field study about Laxmi Road (Wingard, 2012) was found to be helpful in determining the function of Laxmi Road in the Network system of the area.

Calmer Streets present opportunities for Social, Environmental and Commercial cohesion

The second outcome of the Analysis Finding 1, is found to be in the streets that are not well connected in any of the radius measured. In other words, the streets that are colorless, are excluded from short as well as intermediate distance convenience routes. The lack of connectivity can be seen as an opportunity to develop spaces for public activities. The activities can be based and designed on the local social cohesion where people can gather and spend quality time with much restricted traffic. This is considered an outcome of optimized street network. Where the streets identified as less needed in the traffic movement can then act as the pilot projects for social and environmental cohesion. Some examples could be creating public square, green areas and allowing more street vendors. 2008 Mobility Plan highlights that the Core Area has a very high number of street vendors. Some areas can be allowed for parking vehicles where visitors can park, and enjoy the social space. The same Mobility Plan emphasizes in the need for large number of easy parking places for convenience of shoppers.



Figure 21 : The street-side market along Shivaji Road on weekdays.

Image Source : (Wingard, 2012)

Traffic-oriented space in heavy mix-traffic street situation



Figure 20 : The market street along Shivaji road during weekend mornings.

Source : (Wingard, 2012).

User-oriented space in light mix-traffic street situation

CHAPTER 4.

INTEGRATION OF VIEWS OF LOCAL AND INTERNATIONAL EXPERTS.

4 INTEGRATION OF VIEWS OF LOCAL AND INTERNATIONAL EXPERTS.

This chapter will further consolidate the findings of the dissertation mainly focusing on the third Research Objective, and its data analysis from the previous chapter. This will be done with the help of the primary data collection through expert interviews. The themes that emerged from the interviews are integrated to produce next stage of conclusions. The final set of conclusions, therefore are formulated as a synthesis of map-analysis (Street Network), qualitative primary data (Expert interviews) and secondary literature (based on the emerging themes from interviews).

4.1 EXPERT INTERVIEW 1

Validation of the results with the local NGO experts in the field of Sustainable Urban Transport

The third outcome of the Analysis Finding 1 was achieved by discussing the intermediate findings with the local Non-Governmental Organization or NGO Named *Parisar* via the channel of online interview. *Parisar* is a leading NGO in the city currently working on the issues surrounding Sustainable Urban Transport , Pedestrian's Rights, Road Safety and Air Quality. It has been active since 1980 (*Parisar*, 2021). The author of this dissertation first got in touch with the *Parisar* team when she participated in the 2-day online workshop about the rights of the pedestrians in Indian context. This workshop was held in October 2020 which not only informed the author about the current situation of pedestrian-related development in India, but also introduced the plethora of active work done by *Parisar* in this regard. The maps and findings (Fig. 18 and Fig. 19) were discussed with three experts in an online meeting in January 2021. The meeting duration was over two hours. The experience of the three experts is spread across the fields – Collaborative Activism, Founder and Trustee, Architecture-Urban Design and Campaign Manager-People Based Pedestrian Campaign. Their experience ranges from 10 to 40 years.

This discussion strengthened some of the findings with the current situations as well as threw light on relevant challenges that may come in as obstacles that may prevent a new planning proposal from its fruition. Street prioritization with regulated speed is received very well by the experts. This proposal complimented by safe walking and cycling conditions along the streets as well as at the junction crossings are considered to be a step forward to reach the vision.

The first of the concerns that were highlighted by the experts lie in the transformative development of Pune, especially the ageing core area, that is on the horizon. This is because the old buildings and the narrow plots will soon be converted in the larger developments. In that case the street planning will need to be adaptive and must serve the changing land use and the transforming character of this area. For instance the small alleys with historical residences are already being converted in mid-rise apartment buildings. When more such apartment buildings or group of buildings appear and the underground metro line is completed, there are proposals for mix-use retail and commercial buildings along the mass transit route. This character change from low rise traditional housing to the Central Business and Market District will need to be complemented by the adaptive use of the street network. This may also mean to design new street pattern that is more efficient. For attaining a drastic shift, a strong political will is extremely important. And lastly, the residents, commerce owners and the city leaders together must compromise a cohesive plan that is suitable for each actor of the street (Chawande, Interview with Parisar, 2021)

The second theme that emerged from discussion, is the need to reimagine a safe, green and clean future of the core area. To do this, one needs to not only think of the development as a transportation development, but also needs to strongly believe that the old Pune can be reimaged without losing its old charm. The neglected river streams can be revived for greening the open spaces and host markets around them. The forgotten part of the history can be brought back by repurposing the heritage with the help of public events such as exhibitions, and more such innovative land development rules. This vision is possible in the form of power of policy, transport action plan and the good intentions of the local authority due to the new sustainable mobility drive of Pune city (Patwardhan, Interview with Parisar, 2021).

The third very important outcome of this discussion is reverification of some of the dissertation's recommendations. Mix-traffic streets and walkable core area protected by a Core Area Ring are reconfirmed by the experts. The mix traffic is favored especially by the residents because of the daily commute-convenience. Mix-traffic is also favored by the retail (commerce) owners because the allowance of different modes means more diverse clientele. The walkable areas are not only favored by street and market vendors, but are also beneficial for active and healthy life of citizens. And to bring down the excessive stress on pollution levels.

Moving forward, this dissertation recommends integration of the dimensions of density, land use and real time footpath and parking infrastructure for best results. This could be either done with the help of secondary data available on field studies or primary data collected on site. This integration with the street analysis is expected to create the maps that can act as a multidimensional base maps for stakeholder discussions. However, it is not integrated in this dissertation due to the timescale and the restrictions on international travel due to COVID-19 Pandemic.

This discussion was beneficial in advancing the analysis process. The emerging issues summarized above helped in understanding the development challenges of area. This was named to be the reason for a halted progress of Transportation projects, specific to this area. According to one of the experts, the other areas in Pune are witnessing a good drive among residents. This is due to the positive effects of J.M. Road's recent conversion into a widened pedestrian and cycling-oriented Complete Street. The positive response to this project encouraged many citizens to enjoy the street as a public space. And the second positive effect is seen in the increased demand by the residents to the ward authorities for such streets in their individual neighborhoods (Jaipurkar, Interview with Parisar, 2021). This two together helped in maturing the knowledge about the functions , characters and challenges of some of the streets in the Core Area. The following subchapter will present the next round of refined analysis findings and recommendations that was based on the outcome of this discussion.

4.2 ANALYSIS FINDINGS 2

The most important advancement that is integrated in this version of analysis findings is the traffic-safety of the street. In Analysis Findings 1, the streets were divided by the priority of modes. The literature study indicates that the streets in Pune lack pedestrian and cyclist safety in general. Especially in the Core Area, during peak hours, the streets become a congested mess. The footpaths occupied by the illegal 2-wheeler parking and the vendors' presence whenever the footpath space is available causes the pedestrians to walk on the streets (Wingard, 2012). This also puts tremendous pressure on the drivers of the Bus Service who are juggling between the time schedules, congestion, car honking and the pedestrians jaywalking.

Safety is believed to have further improved after segregating traffic by purpose. The routes have been formed which can also be communicated to the users with the help of appropriate friendly signage design and web based applications. For instance, the 2-wheeler traffic originating from Core Area and destined to go in the surrounding area and vice versa is included in the low speed and safer route. This safe route does not coincide with the medium speed and less safe route serving as a prioritized route for Public Buses. The following figures will illustrate this.

In this step of analysis the scale of priority and safety in relation to traffic speed is created as follows. The most prioritized mode is shown first and the least in the last as a linear representation

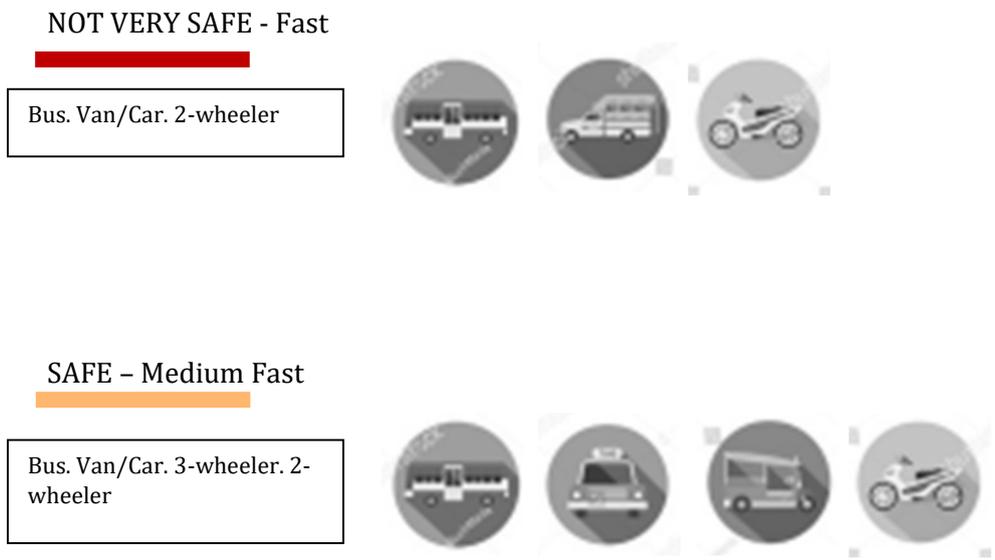


Figure 22: Traffic-safety Legend

Part of Safe-Street Guidelines (Continued on the next page)

Source : Dissertation Author's production. Image icons : Google

SAFE – Slow



Cycle. 2-wheeler. 3-wheeler.
Pedestrian



VERY SAFE – Very slow



Pedestrian. Cycle. Cycle-
rickshaw.



	NOT VERY SAFE 	SAFE  	VERY SAFE 
SMART USERS			
FUNCTION	Priority for Long distance motorised traffic	Priority for intermediate distance public transport	Priority for short distance 2 and 3-wheelers
DISTANCE	20 – 30 Km	15-20 Km	5 – 15 Km
CHARACTER	Heavily Motorised	Shared	Shared, Core Auto-Rikshaws allowed
WHO	Goods, Passengers	Workers, Tourists, Visitors.	Residents (Core Area and neighbourhoods)
PURPOSE	Whose Origins and Destinations are in Pune Metropolitan area	Whose origins are in Pune Municipal Area and Destinations in Core Area	Whose origins are in Core and destinations in neighbourhoods, and vice versa
MUST HAVE			

Figure 23 : Safe Street Guidelines.

Source : Dissertation Author's production.

The following Route Map (Fig. 24) is to be referred in conjunction with the Safe Street Guidelines provided in the previous page. The Route Map is believed to be an advanced step that followed the street analysis, because it not only integrates the experts comments and views which were gained during the discussion but also incorporates some of the most challenging issues in Pune’s Traffic.

	Not Very Safe – Fast	Bus.Van/Car.2-Wheeler
	Safe – Medium fast	Bus.Van/Car.3-wheeler.2-wheeler
	Safe – Slow	Cycle.2-wheeler-3.wheeler.Pedestrian
	Very safe – Very slow	Pedestrian.Cycle.Cycle-rickshaw



Figure 24 The Route Map.
 Spatial Map for proposed routes.
 Source : Dissertation Author’s production. Basemap source: (Wingard, 2012).



Figure 25: Spatial Map for proposed routes superimposed on a satellite image.
Source : Dissertation Author's production, Google Earth.

The roadmap of the research outcome is - 1. Space Syntax Street Analysis, 2. Discussion on the analysis maps with local experts, 3. Route Legend and Route Maps. This roadmap is found to be the strength of this dissertation. This is because, it allowed to integrate data from multiple dimensions into spatial information that is understood by many of us. It is believed to be an amalgamation of diverse fields and expertise that are involved in the process of City and Mobility Planning. It is acknowledged that this dissertation cannot fulfil all the steps in the advancement of the Route Map to reality. The steps that need negotiations with stakeholders, integration of the land use with the changing patterns of development among others. However, it exemplifies how could an autonomous process of improving existing streets by using digitally advanced tools be initiated and integrated in Pune's active environment of Sustainable Transport Planning and Development. The same advanced tools that are internationally applicable and been proven to be

successful in shaping cities like London, Nur- Sultan, Beijing among others . The author of this dissertation finds this work as a valuable contribution in Pune’s journey towards becoming a Smart City with safe, active and enjoyable streets.

4.3 EXPERT INTERVIEW 2 : RECOMMENDATIONS

Conversation on the final results with the international expert

The online conversation with the international expert, Professor Geoffrey Payne, the international adviser at the World Bank, generated creative policy design directions. This is considered an essential as well as complimenting addition to the local perspective in the first interview. Two creative Policy directions that are generated in this discussion are –

Using Transport Policy as a means of Environmental Policy :

Leveraging Smart City and Clean Air drive to speed up and fund the Sustainable and clean Public Transport

As urban pollution levels in Indian cities are breaking record high levels, unfortunately Pune is joining New Delhi in this race. The pressure for action that this episode has brought upon the local as well as state authorities can be seen as a potential to use rigorous Environmental Policy as an opportunity to solve Pune’s mobility conundrum. Example of policy intervention given by the expert is declaring Pune’s Core Area as a congestion zone. This means through traffic modes such as cars, vans, lorries, two-wheelers private buses will need to pay the tax electronically before entering the area. It is monitored by electronic cameras at the entering junctions. This model has been successfully implemented in city of London and has been effectively drawing away large amount of peak time traffic by having them to bypass the core area. For older vehicles the tax is more due to their high emission levels.

The funding for the clean-efficient Public Transport to be generated from private motorized users crossing through the Core Area.

Congestion charges, Parking charges to be efficiently recovered and used to improve public transportation system of Buses. In addition to this form of funding, the partnerships with private actors of the city can be an effective way to operate a successful system. The example of the Curitiba's Public Transport System (Brazil) is noted during the discussion. The BRTS or the Bus Rapid Transport System of this Brazilian city is one of the well-known longest running system in the world. The Bus fleets are operated by different private companies. While this is considered efficient in operation, the regularization of ticketing system at the junctions is found to be challenging.

4.4 CONCLUSION OF THE CHAPTER

Through this experience, the author of this dissertation believes that the qualitative knowledge-base attained in the expert interviews has been valuable. It helped to contextualize the research aim and outcomes both locally and internationally. This dissertation supports certain themes discussed during the interviews and it further adds its remarks as follows -

Vision for Core Area is attainable through a collaborative and negotiated actions

The actors and the users of the city must work through a cohesive vision of the core area's sustainable future. The term 'sustainable' is used in various contexts, however in this context, it refers to having the existing street network efficiently identified, recognized for its potential in creating safe spaces to walk and to cycle. It is acknowledged that this study is limited to core area. It does not represent the case for other parts of the city. While it's case-specificity is understood and the findings are taken in the context, it opens door to the act of imagining planning of other parts of the city. City's core area, especially when holds a historic, cultural and religious significance, if developed as an outstanding example of sustainability, has the potential to inspire other parts of the city to follow the footsteps of sustainability. This is considered to due to the symbolic leadership and the civic sense of responsibility. Examples – Manhattan of New York, Central area of Barcelona among other European cities (Kenworthy, 2019a).

In the case of Pune city, the core area along with historic, cultural and religious significance, also holds strong commercial, residential and multimodal transit value. Therefore, the city's collaborative actors need to take it as the highest priority. The convergence found in the city government's recent action and in the international expert interview is the preparation of the city for advanced private partnerships in the

Sustainable Mobility sector (PMC & RMI, 2018). The ideation in this expert interview suggested to encourage public partnerships which in Pune's existing scenario of strong private sector is attainable. At present, Pune and New Delhi are first two cities that are selected , studied and discussed for need-analysis, scaling and presenting for private partnership opportunities under the intervention called – Urban Mobility Lab (PMC & RMI, 2018).

It is recommended to integrate the contribution of this dissertation along with the present opportunities and actions. It is also suggested that this contribution highly supports the idea of retrofitting or improving the existing infrastructure by means of adding new elements. This aspect can be introduced to one of the India's *Smart Cities* aims according to Smart City Council, India, which is– 'Retrofitting' or addition of new infrastructural development to facilitate greater connectivity in the city. The author urges to add new elements to the old streets, instead of proposing a new street altogether. And, to do so, using open-source advanced digital tools to help the process. It is extremely important to be aware that constructing new roads will not assure to ease the traffic congestion problem. However, this dissertation believes in the world-wide claim that providing more roads instead of improving traffic flow, worsens it by attracting more private vehicle users.

CHAPTER 5.

CONCLUSION

5 CONCLUSION

This dissertation has illuminated the elements that can substantially aid in the process of Pune's Sustainable Mobility Planning. The various gaps have been identified in the Mobility Plan and its implementation, which are responsible for creating a contradiction in Pune's Mobility vision and the ground reality. These gaps concerning each of the research objectives have been indicated in previous chapters. This chapter will highlight the elements that have been consolidated from the previous findings of this dissertation, and which are expected to significantly contribute in the process of Pune's Mobility Planning, interventions and pilot projects in the future.

STREET EQUITY BY STREET REDISTRIBUTION

Street space for *quiet* NMT user-groups such as pedestrians, cyclists, vendors, cycle rikshaw, is needed to be carved out of existing urban fabric and to be claimed for equitable use. These user-groups are particularly mentioned as '*quiet*' to emphasize their *weak* representation in the public participation platforms, which are accessible through online traffic-grievance forums. The inequitable access to public participation is clearly reflected in the inequitable distribution of street space, as well as in the infrastructure investment. The findings of this dissertation have shown how the financing for large-scale infrastructure projects is provided based on a highly biased attitude towards motorized traffic, and which contradicts with the national transport vision of promoting NMT. This has been further supported by the views of the local experts, who expressed serious concern about the lack of political will in reimagining the status quo. In this regard, a ***three-rights-formula*** – 'right attitude', 'right redistribution' and 'right language' is essential. This formula can be effectively demonstrated with the following example of a 'Play Street' in Germany. It is a traffic concept which can be frequently seen at the start of the quieter streets, where schools and residences are located. The sign displays the icons of a child playing with an adult, alongside of a house in the foreground, and a car in the background. The highest priority for pedestrians is observed by all the street users when this signage is displayed. This attitude ensures highest degree of traffic-safety of the children and the residents, by keeping the high speed traffic away. The right attitude by all the users of the street, right redistribution by carving out available space, and right language communicated via effective signage, are a key that can potentially solve large part of Pune's traffic issues.



Figure 26: *Play Street*

(Left image) Boundary of a motorized street and a 'Play Street' in Mühlthal, a town situated 45 km from Frankfurt, Germany. Source : Aboli Mangire.

(Right image) A typical road signage on a 'Play Street' to indicate pedestrian-priority over motorised traffic. Source : Driving in Germany, Road Signs.

LARGE INVESTMENTS WILL NOT BRING ABOUT A NECESSARY CHANGE

Pune city is heavily pouring money into the large-scale mobility projects such as Metro Train Service, Ring Roads on state and national routes, BRTS, and multiple flyovers. However, there is a severe lack of basic street services on almost every street in the city. The municipality's survey indicates lack of footpaths, street signage, adequate drainage, lighting (L&T Infra Engineering, 2018). Moreover, the surveys by NGOs and individual researchers further highlight the extreme lack of pedestrians' traffic-safety at the crossings and the street junctions. This dissertation emphasizes that the concern of the city authority and Transport Planners should be focused on the redistribution infrastructural investment, that will serve the basic needs of a daily commuter, rather than adding more traffic in these unsafe streets. The example of a 'Play Street' must be recalled to highlight that a relatively smaller investment is needed to underpin a necessary change in the current neglected condition of pedestrians and cyclists on Pune's streets.

5.1 STRENGTH AND LIMITATION OF THE DISSERTATION

This dissertation believes to have acquired qualities of being evidence-based, user-oriented and contextualized. Evidence-based by means of a street-network-analysis, user-oriented due to Space Syntax's proven tools of pedestrians and cyclists' mobility, and contextualized in a local and international frame of relevance due to the experts' engagement. This chapter will elucidate the details of how each of the three objectives, the methods used in them, have added to the strength of the final outcome. The limitations of these methods have then been discussed at the end of this subchapter. The first objective – To investigate Pune city's Mobility Plan, has offered a decade-long view of adequacy as well as inadequacy of the mobility planning process. Moreover, the knowledge of local needs, planning measures and their results found in the municipality documents, acted as a rich database in every step of the research. The second objective - To spatially analyze the street network by using Space Syntax tools, brought out the multiscale potential of this method. Three scales of street-network-systems, long-distance (between 2 cities), medium-distance (within the city) and short-distance (within an area), could be collectively analyzed. In other words, a multiscale perspective has discovered changing purpose of the major streets, according to their position in each of the three network systems. This insight has been crucial in determining which modes must be prioritized on these major shared streets, to regulate their undisciplined mix-traffic, and in optimization of their spatial network . As a result of this, the planning measure of '*mode-prioritization*' that this dissertation has recommended, had the benefit of a complex background study of various spatial scales, which has not been practiced in city's current planning process. The third objective – To discuss findings with the local and international experts, brought in social, economic and environmental cohesion by integrating local, national and international interests. These discussions, one with the local leading NGO, and the second with the international adviser at the World Bank, allowed the alignment of topics that are relevant both in the local and in the international context.

In the similar manner, as the strengths of the methodology have contributed in the process of Mobility Planning, the limitations of this methodology have illuminated the uncovered directions. The intricacies hidden in the governance system of Pune City and Indian National government, that are largely responsible for the adequacies and inadequacies of the Mobility Planning, have not been studied in this dissertation. In many parts of the world it has been observed that the strong political and administrative systems have been successful in bringing about the systemic changes. This dissertation, even though has studied the City Corporation's databases, could not reach to the depths of its systemic failures. Similarly, the failure in the

BRTS which has negatively influenced Pune's mobility system, has not been studied in the scope of this dissertation. However, the future research may benefit largely from the inclusion and integration of BRTS analysis with the NMT Analysis. During the data collection phase, the highly infectious COVID-19 pandemic had highly influenced how everyone communicates in the public spaces. In India, at first the lockdown measures shaped the new ways of economic activities and public space usage by prohibiting or minimizing the social interactions. The traffic data that has been included in this dissertation reflects the public space usage prior to the pandemic times. It could not be updated with the new forms of public activities. While the lack of updated data can be seen as a limitation of this study, this dissertation would like to emphasize the non-perpetual nature of the COVID-19 pandemic.

5.2 OUTLOOK

This dissertation expects its contribution in preparing Pune city for upcoming major transformational changes. Transformative development that is observed in the Metropolitan Region or the hinterland villages outside Pune Municipal Area is inevitable. As advanced, shiny, clean and organized as it seems, it will have negative impacts on the existing, ageing, and decaying urban areas. Especially the 400-year-old Core Area. This dissertation believes that it has been successful in communicating the concerns of the local actors about the core area. It would like to re-emphasize the inevitable development pressure that this area will soon face. When the proposed underground metro line will pass under busy Shivaji road, and above the ground, the shiny buildings with ample side margins will replace the old *Gaathan* style urban development (with no side margins), it will be essential for Pune residents to be prepared for these changes. This dissertation highlights that if the streets are prioritized and designed for walking and cycling, and other dominant modes which favor public mobility are organized with better efficiency, it will be easier to face the pressure of the new development. In other words, instead of surviving the pressure that the metro line and shopping malls bring, it is recommended to creatively prepare and welcome these changes.

This dissertation recommends the street management on the basis of mode-priority, not only for the smaller areas and for walking and cycling, but it also recommends for larger radii such as 30 Km for Pune Metropolitan Region for high-speed, long distance public and private transport. This dissertation does not attempt to defy the new development promoted by Pune Metropolitan Region Development Authority or PMRDA. However, it urges to bring to the city authorities' attention towards the interdependent benefits that the prioritized, safe street network combined with the *Smart City* street management can bring to

both old Pune and the new Pune. In other words, old and New Pune have the opportunity to become *smart* together by using the interdependent transportation needs of each other. If people can walk and cycle safely, they will be more likely to use the Public Transport. Therefore, the safe, calm neighborhood streets with prioritized walking and cycling, will benefit the safe, fast mobility corridors prioritized for high speed public transport. This dissertation offers insight into how can the steps be taken by using advanced digital tools, which, without any political bias deliver the crisp clear analytical colored lines, combined with local surveys by students and expert actors who witness these streets on daily basis, breathe into the pollution , hear the noisy honking and undertake the dangerous act of street crossing in busy hours.

In this way, this dissertation concludes that determining and implementing mode-priority on Pune's shared streets, is an attainable solution which can ensure long-term success of the city's old as well as new mobility development efforts.

6 LIST OF REFERENCES

- Abhyankar, H. (2020, October 11). Traffic Katta by Save Pune Traffic Movement (SPTM) - Webinar. Pune, India.
- Bari, P. (2018, March). *PMC lacks proper and effective administration, says town planner Ramchandra Gohad*. Hindustan Times.
- Benninger, Christopher. 2018. "Pune Metropolis: Unlivable Cities Within a Livable Metropolis." In *Livable Cities from a Global Perspective*, edited by Roger W. Caves, Fritz Wagner, pp. 113-128. Routledge, New York.
- Biggam, J. (2017). *Succeeding with Your Masters Dissertation : A step-by-step handbook* (Fourth ed.). London: Open University Press.
- Bureau, E. (2018, August). *News : Pune most livable followed by Navi Mumbai, Rampur in UP is the worst*. From The Economic Times : Politics : <https://economictimes.indiatimes.com/news/politics-and-nation/pune-most-livable-followed-by-navi-mumbai-rampur-in-up-is-the-worst/articleshow/65387097.cms?from=mdr>
- Bhaduri E, BS M, Sen J, Maitra B, Goswami A. (2019). Measuring User Satisfaction of Pedestrian Facilities and its Heterogeneity in Urban India - A Tale of three cities. *Journal of the Eastern Asia Society for Transportation Studies*. 13
- Cervero, R., & Kockelman, K. (1997). Travel demand and the 3Ds: Density, diversity, and design. *Transportation research. Part D, Transport and environment*, 2(3), 199-219.
- Driving in Germany, Road Signs. Retrieved February, 2021 from <https://routetogermany.com/drivinggermany/road-signs>
- Fazal, S. (2001). Land re-organisation in relation to roads in an Indian city. *Land Use Policy*, 18(2), 191-199.
- GIZ. (2021a). *Sustainable Urban Transport Project*. Retrieved February, 2021 from <https://www.sutp.org/publications/10-principles-for-sustainable-urban-transport/>
- GIZ. (2021b, February). *giz Worldwide*. Retrieved February, 2021 from <https://www.giz.de/en/worldwide/368.html>
- Goessling, S. (2016). Urban Transport Justice. *Journal of Transport Geography Elsevier*. 54. 1-9.
- Hickman R, Hall P, Banister D. (2013). Planning more for sustainable mobility. *Journal of Transport Geography*. 33.210-219.
- Hillier, B, Penn A, Hanson J, Grajewski T, Xu J (1993). Natural Movement: or, configuration and attraction in urban pedestrian movement. *Environment and Planning B: Planning and Design*. 20. 29-66

- Hillier B, Yang Tao, Turner Alasdair. (2012). Normalising least angle choice in Depthmap. *The Journal of Space Syntax*. 3(2), 155-193.
- Kantakumar L, Kumar S, Schneider K. (2015). Spatiotemporal urban expansion in Pune metropolis, Indis using remote sensing. *Elsevier Habitat International*, 51(11-22).
- Kenworthy, J. (2019a). The Central City: Planning in People, Planning out Cars. (Presentation in Master in Urban Agglomeration). Frankfurt University of Applied Sciences
- Kenworthy, J. (2019b, December). Traditional Transport Planning : Why it no longer works (Presentation in Master in Urban Agglomeration). Frankfurt University of Applied Sciences.
- Khayesi M, Monheim H, Nebe J. (2010). Negotiating “Streets for All” in Urban Transport Planning: The Case for Pedestrians, Cyclists and Street Vendors in Nairobi, Kenya. *Antipode*. 42. 103-126.
- L&T Infra Engineering. (2018). *Presentation on Comprehensive Mobility Plan (CMP) for Pune Metropolitan Region*. Pune: Pune Metropolitan Region Development Authority.
- Lau, J. (2012). Sustainable urban transport planning and the commuting patterns of poor workers in a historic inner city in Guangzhou, China. *Habitat International*. 39. 119-127.
- Mangire, A. (2020). Walkability in Pune’s city center- A proposal to analyse walkability using Space Syntax tools in the context of Pune's central neighbourhood. Darmstadt: Medium Munuds Urbano Blog.
- Millington, C., Thompson, C. W., Rowe, D., Aspinall, P., Fitzsimons, C., Nelson, N., ... & SPARColl—the Scottish Physical Activity Research Collaboration. (2009). Development of the Scottish walkability assessment tool (SWAT). *Health & place*, 15(2), 474-481.
- Ministry of Housing and Urban Affairs, Government of India. (2020, December). *Smart City Mission*. From Smart City: <https://smartcities.gov.in/#block-habikon-content>
- Mundhe N and Jaybhaye R. (2017). CHRONOLOGICAL DEVELOPMENT OF PUNE FROM 758-2014 AD. *International Journal of Environment, Ecology, Family and Urban Studies*. 7(5). 33-50.
- NTNU students & SPA studens. (2017). *Kasba Peth Urban Ecological Planning*. Trondheim: Norwegian University of Science and Technology.
- NUMBEO. (2021, April). *Traffic In Pune*. From NUMBEO: <https://www.numbeo.com/traffic/in/Pune>
- OECD. (2018). *Ownership and Governance of State-Owned Enterprise*. OECD.
- Patwardhan S, Chawande, A Jaipurkar, S. (2021, January 28). Pune Core Area Transportation Development. Interview with Parisar.
- PMC (2016). *Urban Street Design Guidelines Pune*. Pune: Pune Municipal Corporation.
- PMC (2021). *Road Department*. Retrieved February, 2021 from <https://pmc.gov.in/en>
- PMC & RMI. (2018). *Transforming Mobility in Indian Cities*. Pune: Urban Mobility Lab Report. PMC, Rocky Mountain Institute.

- Parisar. (2021). *Home Page*. Retrieved February, 2021 from <https://www.parisar.org/>
- Putcher, J., Korattyswaropam, N., Mittal N., Ittyerah N. (2005). Urban transport crisis in India. *Transport Policy*. 185-198.
- Road Diet definition retrieved from :
<https://www.completecommunitiesde.org/planning/complete-streets/road-diets/>
- Sen S., Hobson J, Joshi P (2003). The Pune Slum Census: creating a socio-economic and spatial information base on a GIS for integrated and inclusive city development. *Habitat International*.
- STEP. (2020, October 23). Pedestrianization: Become a Pedestrian Champion. Parisar. *Online Crash Course - Zoom*
- TOMTOM. (2021, April). *Pune Traffic*. From TOMTOM: https://www.tomtom.com/en_gb/traffic-index/pune-traffic/
- TU Delft. (2021). *Design of the Urban Fabric*. Retrieved April 02, 2021 from Faculty of Architecture and the Built Environment: <https://www.tudelft.nl/en/architecture-and-the-built-environment/research/research-at-bk-bouwkunde/urbanism/design-of-the-urban-fabric#:~:text=Urban%20fabric%20refers%20to%20the,ecological%2C%20managerial%20and%20economic%20structures.>
- Voyants Solutions Pvt. Ltd. (2012). *Revising / Updating the City Development Plan (CDP) of Pune City - 2041 Under JNNURM*. Pune: Pune Municipal Corporation.
- Waghmare, S. P. (2007). *Existing Land Use Plan of Old City Limit in Pune Municipal Corporation sanctioned in revised DP of Jan 1987*. Pune: Pune Municipal Corporation.
- Webster, C. (2020). Viewpoint How high can we go? Urban density, infectious versus chronic diseases, and the adaptive resilience of cities. *Cloud Publish*.
- Wilbur Smith, IL&FS. (2008). *Comprehensive Mobility Plan for Pune City. Final Report*. Pune: Pune Municipal Corporation.
- Wingard, S. (2012). Planning with focus on pedestrians and sustainable transport in Pune, India. Master's Program of Spatial Planning at Blekinge Institute of Technology (BTH).