

# A Systematic Literature on Application of Transit Oriented Development



Ar. Deepshikha Jain, Ekta Singh, Rashmi Ashtt

**Abstract:** *Transit oriented development (TOD) has quickly developed as a well-known urban developing approach all around the world to achieve a spatial economic transport interaction. TOD does not only relate to mass transit, but it is a strategy to decongest nodal, major points, arteries of the city by making people walk, use public transport, in order to make city environmentally sustainable. Indian cities are fronting major predicament under the sphere of mobility in urban development for which smart cities concept TOD in developing and big countries like India. Hence, this paper will be majorly focusing on presentation of a methodical literature assessment. Though, TOD as a policy is envisaged to have a significant positive impact in mitigating issues at urban scale but there are variety of attributes and indicators that impact the applicability of (SLR) that targets the consolidated knowledge on Transit Oriented Development, analyze the parameters for the successful TOD's all over the world and provide steps for further exploration in Indian context. The corpus analysis of 102 articles and reports leading to the most significant research offerings on TOD acting as the essential pillar in the development is researched such that these results could be utilized for further research.*

**Keywords:** *Transit oriented development, systematic literature review, TOD parameters, sustainable development, pedestrian connectivity, accessibility, public transport, NMT (Non-motorized transport), congestion, Indian cities, etc.*

## I. INTRODUCTION

Urbanization is a fundamental constituent of economic growth and rate of urbanization is rising universally. Modern urban time has formed an innovative environment that depends deeply on inadequate easily available resources. Due to increase in urbanization, a wide range of space is required for habitation which has challenged growing cities to become ecological. Since, conurbations are determined by its transportation system and almost all cities are developed on road based transport system. This has resulted side-effects like those of urban sprawl, increase in pollution levels, degradation at immune levels, etc. Hence, cities are required to take steps to make transport system. Similarly, Figure 2 explains the disastrous decrease in the interest of Indians authors since 2006 on the topic "Transit As Figure 1 explains the decrement in the interest of authors and practitioners all over the world starting from the year 2004 which declares the rationale of the study in the present years.

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Oriented Development" over the time. Thus, there is a lot need to study this topic in Indian context as this has been majorly worked by United States only. more sustainable such that reduction in pollution, energy consumption, and congestion could be achieved for which Transit Oriented Development (TOD) acting as the best tool aiming in developing the habit of using public transport by integrating land use and transport systems finally making cities more livable and sustainable.

Therefore, this paper strives to conduct a systematic literature evaluation on the application of Transit Oriented Development (TOD), such that to identify the lack of information of various aspects of TOD in growing cities. Gathering information from 102 papers and reports for the period of 1992 to 2017, a summary of the vital issues as well as the growth over time is identified and even assessment of the key indicators are employed.

The term Transit Oriented Development has been diversely discussed by several authors differently and thus universally accepted definition has not been accredited till yet. As Singh et. al in mentioned that understanding TOD varies with the deliberate intend of TOD vary whereas; evaluation and assessment of TOD are also varies. Extensively known 3D concept (Density, Diversity and Design) and measured as a vital feature in assessing TOD planning is given by Cervero in 1997. In the same way, Calthrope (1993) highlights the substantial characteristics particularly the walk able atmosphere and a set of six performance criteria e.g. location, efficiency, value recapture, livability, financial returns, choice of lifestyle and efficient land use pattern was given by Belzer in 2002 condemning a good number of TOD.

## II. INTEREST FOR TRANSIT ORIENTED DEVELOPMENT BY VARIOUS AUTHORS

According to the Google Trends, interest by various authors and practitioners is shown through the graphs below, by how often the topic is been searched by the people.

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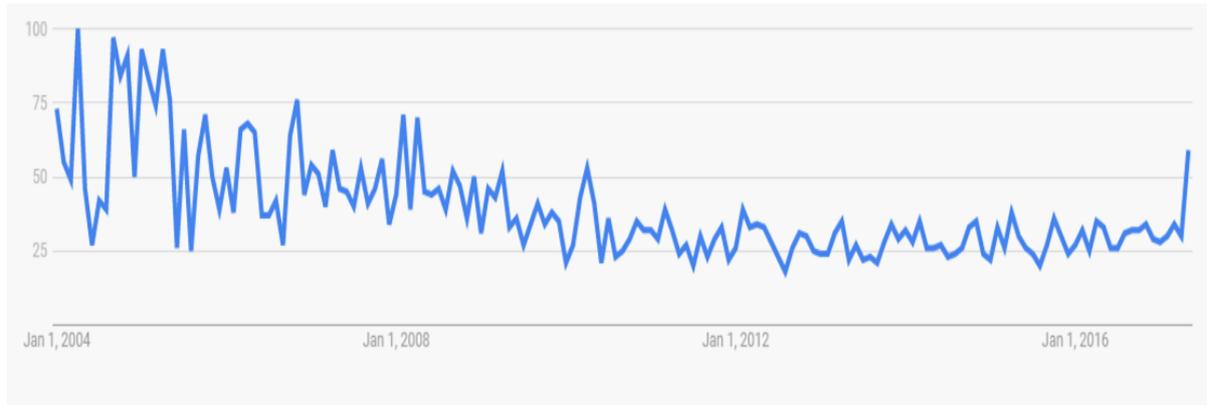


Figure 1. Worldwide interest on the topic “Transit Oriented Development” over time.

Source:

<https://trends.google.co.in/trends/explore?date=all&q=Transit%20oriented%20development>, 4 April, 2017 at 1:57 AM.

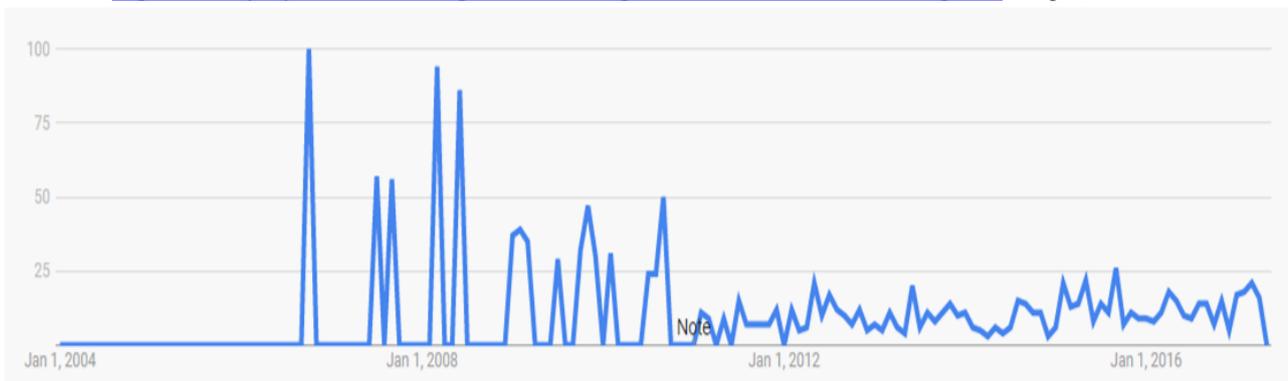


Figure 2. Interest on the topic “Transit Oriented Development” over time in India.

Source: <https://trends.google.co.in/trends/explore?date=all&q=Transit%20oriented%20development>, 4 April, 2017 at 1:57 AM.

### III. OBJECTIVES OF THE RESEARCH

It is the literature regarding application of transit oriented development, assessing the different focuses and different subjects of investigation. Some papers explicitly focused typically on the matter, whereas others are less focused and has discussed several topics at once. For illustration, Ghim Ping ONG *et. al* (2010) examined various options which can be used by transportation and urban development agencies for promoting sustainability. Monyrath KOV *et. al* (2011) developed analytical model for determining optimal frequency for urban bus transit and Nguyen Quang Minh *et. al* (2011) helped in enhancing the quality of life by protecting the living environment for the residents by developing a planning concept of new traffic- and- service. Since, no systematic analysis could be found for application TOD for growing cities, thus, the first research addressed in this paper is:

#### **Q1.To identify essential subjects related to Transit Oriented Development and how those topics evolved?**

The literature exposes exceptionally different methods of formulation and evolving solution for determining optimal frequency for urban bus transit by Hooke- Jeeves algorithm by Monyrath KOV *et. all* (2011) to classification of various levels of residential QOL indicators and socioeconomic groups in station and no station areas by Kazuki Akamura *et. all* (2016) to demonstrate the comparison of rail- based accessibility in urban areas to jobs concentrated around

railway network by Enrica Papa and Luca Bertolini (2015).While visiting some papers it came to notice that some papers have most suitable approaches and methodologies offering the complete coverage to the topic. Therefore, the second research question is:

#### **Q2.To identifies the methodology and parameters used for the application of TOD in urban areas all over the world.**

While giving the multiplicity of topics and a range of research methodologies, the objective to understand the parameters for the assessment of the application of TOD in an area even also to discover the best path. Thus, the third research question arrives as:

#### **Q3.To understands the literature pertaining to TOD in Indian cities.**

Further, identifying the planned TOD's in Indian cities and even to identify the places where the concept of transit oriented development tis proposed and executed in India, so, that the most practical guidelines for future research could be categorized. Finally, the fourth research question comes out as:

**Q4. To examine the papers that are instrumental in assessing the literature till now?**

To counter the above question, a SLR was elected with a specific focus on application of transit oriented development and methods by which these can be implemented. First, the SLR, procedure, the classification of the papers and the analysis that led to the answering of the questions are discussed. Subsequent, the chief conclusions from the collected body of papers are reported, bifurcating the essential areas mentioned and thus, development with time. Following, sprouting the methodologies and parameters and planned cities in India.

**IV. THE RESEARCH METHOD**

The SLR method has been selected for this study because of the nature of the research questions aiming at the latest developments, changes and the existing gaps in the scientific literature. A review earns the adjective “systematic” when the questions are clearly formulated, studies are relevantly identified, quality is appraised and finally, methodology is summarized. It also provides a protocol with detailed documentation by L. Alexandra et. all (2016).

This SLR has adopted a four- step protocol to find out a valid procedure such that it can be replicated by other researchers also.

**Step 1: Insertion/ Omission Criteria**

In the start, a preliminary list of the keywords and insertion criteria were acknowledged, and the application of transit oriented development was devised by the various synonyms (for e.g. sustainable transport, green TOD) in the keywords, creating the research all-inclusive. Moreover, the study

focused on the documents published in journals and reports like transportation, urban planning, management and engineering science for the period 1992 to 2017. The starting year was selected because, however Peter Calthorpe in his publication “The New American Metropolis” in 1993, codified the concept of Transit-Oriented Development (TOD) and thus, the major push began around the year 1992. Conference proceedings and grey literature like technical report and works in progress is also included in corpus.

The exploration was started based on the criteria as per Table 1. Most of the publishers chosen for the research are Elsevier, Science Direct, Journal of Transport and Landuse, etc. were chosen for analysis. Whereas paper based on TOD and housing, property valuation, employment, economics, etc, are excluded. Each paper which leads to the disparity regarding insertion/ omission criteria was read completely until conformity was achieved. This lead to the final selection as accounted in Table 1 which resulted in the extraction of 65papers and reports. (Figure 3).

**Step 2: Selection based on title and omission criteria**

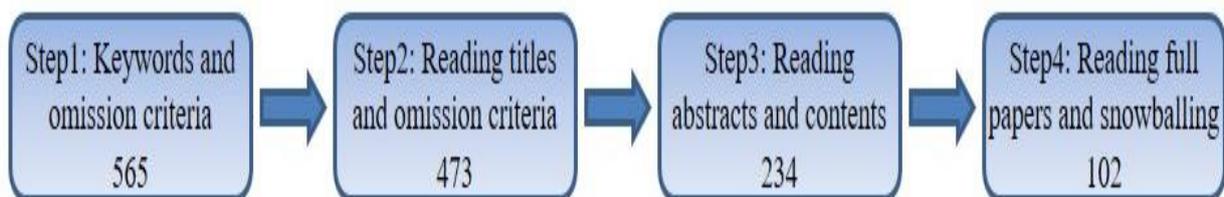
After reviewing the titles and omission of papers, 473 were selected to go for next step.

**Step 3: Selection based on reading abstracts/ contents**

Finally, after reading abstracts of papers and contents of reports 234 researches were selected, by removing the work out of the research scope from the corpus. Specifically, 239 researches that did not focus exactly on transit oriented development rather focusing on health, financial planning, economical planning, social aspects, traffic engineering and many more were excluded.

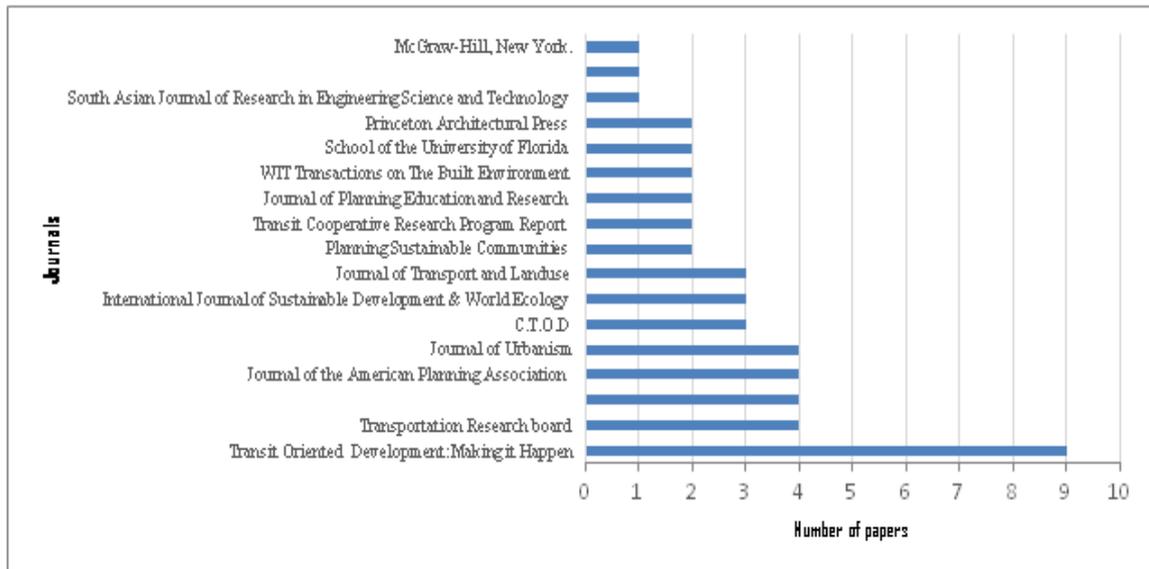
**Table 1. Insertion criteria for paper selection.**

Insertion Criteria	Description
<b>Keywords</b>	Transit Oriented Development (TOD), Green TOD, Sustainable Transport, NMT, indicators of TOD, Design parameters for a successful TOD
<b>Language</b>	English
<b>Document Types</b>	Articles and Reports
<b>Source Types</b>	Journals and Reports
<b>Time Interval</b>	1992-2017



**Figure 3. Systematic literature review results according to the selection procedure.**

## Step 4: Selection based on full text and snow balling



**Figure 4. Papers bifurcated according to the period (year) of publication.**

The final step of the procedure included the distillation of the list of selected research works. After reading the full versions of papers and reports, 141 were not in the exact scope of the research work i.e. parameters for the application of transit oriented development and hence, were excluded. After listing down the focused research works, the references of selected were checked i.e. backwards snowballing, and spotted the most cited papers at least more than five times. Finally, missing works are added in the corpus, leading to a final corpus of 102 researches.

The outcomes in terms of number of works are programmed according to the selection criteria in Figure 3. Further for the answer of four research questions the main conclusion from the collected corpus of papers are accounted, distinguished according to the broad divisions of main topics addressed and their evolution over time were also accomplished to emphasize the strength of the progress of the SLR.

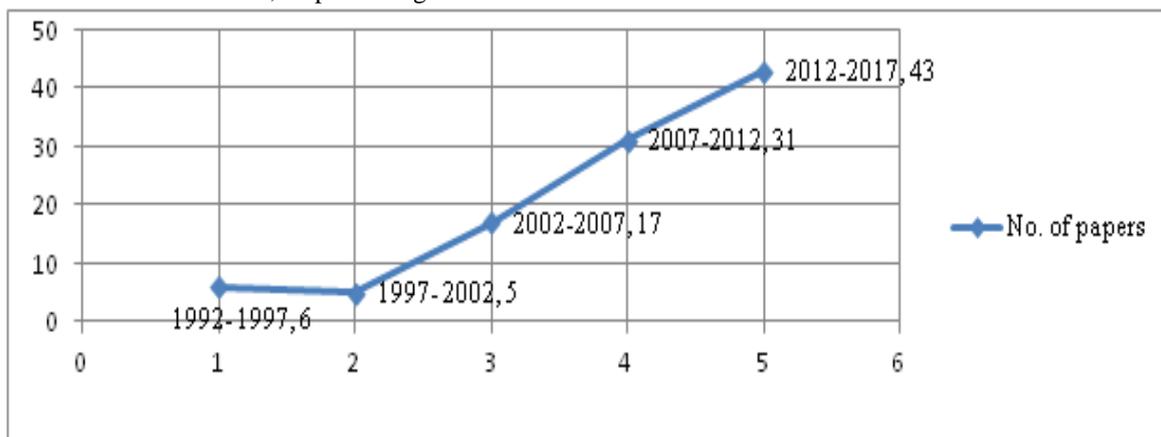
### V. ELOQUENT SCRUTINY OF THE CORPUS

Figure 4 explains the bifurcation according to the year of publishing and it can be seen that despite of some variations in the considered time interval, a positive growth in the

contributions regarding Transit oriented Development in the last ten years could be seen, finally authenticating the current significance of the subject.

The peak number of researches in this field can be seen in the last year i.e., 2016 partially due to the relevance and need of the subject in the present scenario and thus leading to the awareness regarding the concept of Transit Oriented Development among Planners, Demographers, Economists, etc. Since the scope of the topic ding a range of articles and report listed at the second stage, still a development can be analyzed where after 2 is very wide, thus, an extensive range of publications has been listed while going through the references. After exclu009 where 14 publications are found and with a growth of 12 publications in 2014 and of 2016 has hit the highest point in special case of Transit Oriented Development confirming the rising trend of the publications on the topic through the years.

Altogether, the corpus includes a categorization of 55 different journals and reports (Figure 5) where there is no overriding publisher. Further, this bifurcation is categorized under broad divisions as seen in Figure 6.



**Figure 5. Quantity of papers from each journal in the corpus.**

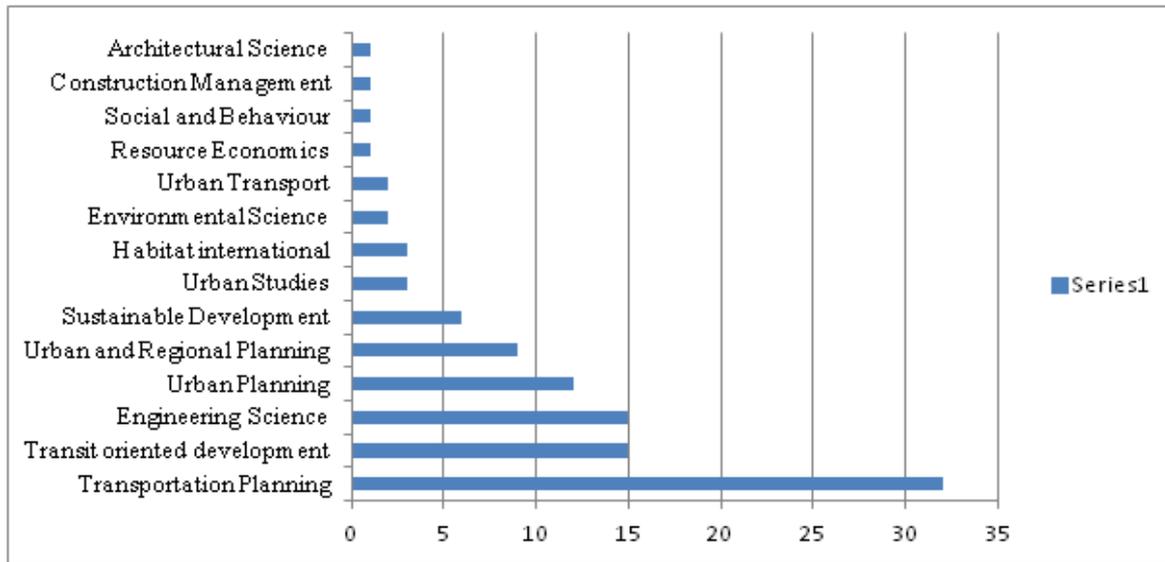


Figure 6. Number of papers for each area as per the journal in the corpus.

VI. CATALOGUING OF THE PAPERS

To answer to Q1, Q2 and Q3, an organization of the publications was conducted based on the main topics

addressed. During this process each paper was reviewed and inductively defines down list of topics. According to the topics defined, each paper was bifurcated which is reported in the Table 2.

Table 2. Bifurcation of the topics according to the own list in the paper corpus.

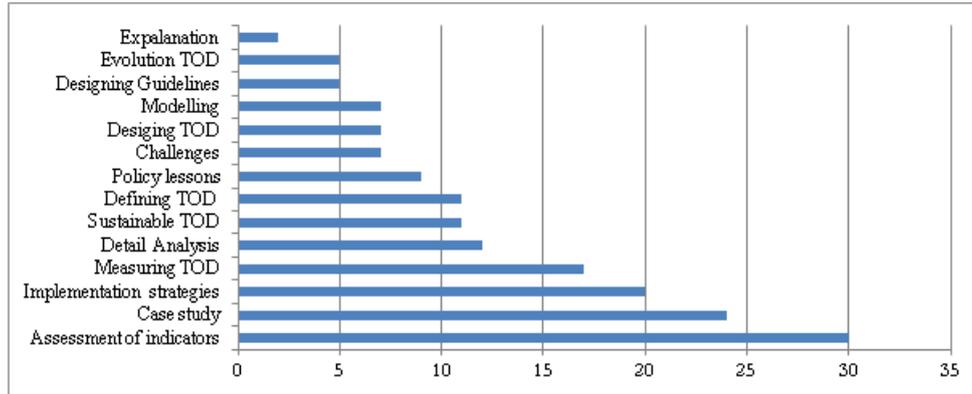
TOPICS	DESCRIPTION	PAPERS
<b>Evolution TOD</b>	Papers related to this topic discusses about the development of project in their particular 2egion according to the phases of growth.	1, 5, 7, 13, 27
<b>Detail Analysis</b>	In this authors have given the detailed analysis of the development of TOD between and after the execution of the project using various tools and measuring criteria.	2, 18, 40, 55, 58, 85, 86, 89, 94, 97, 99, 101
<b>Sustainable TOD</b>	This collection of papers includes the comparison of sustainability and Transit Oriented Development as both the topics go hand in hand.	3, 8, 21, 22, 41, 51, 52, 62, 72, 77, 99
<b>Challenges</b>	Various challenges faced during the execution and development of the TOD projects are discussed such that it could kept in mind while designing and TOD project.	6, 22, 23, 32, 44, 50, 91
<b>Defining TOD</b>	Every author has its own definition of TOD as there is no standard universal definition of TOD, therefore, it is very essential to understand various definitions and explanation discussed by the experts of TOD.	6, 34, 35, 51, 56, 89, 60, 78, 81, 82, 92
<b>Implementation strategies</b>	This topic includes various implementation strategies adopted by various authors and practitioners all over the world to make Transit Oriented Development a successful project.	8, 19, 25, 28, 29, 30, 34, 43, 47, 49, 51, 53, 61, 63, 71, 78, 87, 88, 94, 98
<b>Assessment of indicators</b>	To identify whether the TOD in any region is successful or not or make a TOD successful, some parameters are required for the justification which has been discussed in this section by various authors.	9, 12, 14, 17, 21, 37, 38, 39, 50, 52, 54, 58, 64, 66, 72, 73, 74, 77, 79, 84, 85, 86, 87, 88, 90, 91, 95, 96, 97, 101
<b>Measuring TOD</b>	In this collection authors have measured various TOD's using their own methodology and index to find out the reasons behind the success and failures.	9, 14, 37, 73, 74, 76, 79, 80, 82, 83, 84, 85, 86, 87, 88, 89, 90
<b>Case study</b>	A variety of case studies have been analyzed and studied to make the foundation more strong	10, 17, 18, 19, 20, 31, 32, 33, 34, 35, 37, 42, 44, 46, 49, 55, 56, 61, 65, 66, 68, 69, 81, 102
<b>Policy lessons</b>	In this authors have developed policy lessons for the successful execution of TOD	11, 47, 63, 71, 75, 81, 92, 93, 100
<b>Designing Guidelines</b>	Similarly, designing guidelines have been identified and developed by the authors required for their particular regions	15, 30, 31, 36, 43, 45, 65, 71, 75, 83, 100
<b>Explanation</b>	Theory behind the need of TOD in present scenario has been explained by various authors in this section.	16, 24
<b>Modeling</b>	Here authors have developed different models for the quantitative analysis for the execution and to check whether the TOD is successful or a failure.	39, 56, 59, 64, 66, 96, 101

Figure 7 exhibits the occurrence of the various topics as they appeared in the papers. The four most often concentrated topics are:



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1. Assessment of indicators: To identify whether the TOD in any region is successful or not or make a TOD successful, some parameters are required for the justification which has been discussed in this section by various authors.
2. Case study: A variety of case studies have been analyzed and studied to make the foundation more strong
3. Implementation strategies: This topic includes various implementation strategies adopted by various authors and practitioners all over the world to make Transit Oriented Development a successful project.
4. Measuring TOD: In this collection authors have measured various TOD's using their own methodology and index to find out the reasons behind the success and failures.



**Figure 7. Number of papers concentrating on each area.**

**Note:** Each paper may be listed to more than one topic

Table 3 give a detail analyses of methodologies and parameters for the application of transit oriented development studied in literature by various authors i.e., finally the answer of the Q2. Success or failure can be measured only when final step is known to us. Since stakeholders in this project might have different perspective, objectives as well as criteria for assessment, hence, this will also differ.

Whereas for the answer of Q3, no study has been found where TOD has been executed but TOD has been planned for many cities like Ahmadabad, Chennai and presently Delhi where criteria has been set by Delhi Development Authority and various other ones including the criteria of mixed use and compact development as per the typical which needs to be revised because as said by Kamruzzaman Md. Et. all (2014) that the reasons behind the failure of TOD are “development oriented transit” and “one – size fits all” .

**Table 3. TOD assessment by various authors**

References	Methodologies/ Parameters
<b>Renne (2009)</b>	Assessing the achievement of TOD relies upon the vision of the stakeholders. Thus, the Regional Performance Approach (RPA) and Community Performance Approach (CPA) were his suggestions.
<b>Renne and Wells (2005)</b>	Developed a strategy to measure TOD including 10 best indicators are identified that can monitor also. These are: Transit ridership; Density of development; Quantity of streetscape; Quantity of mixed use development; Pedestrian activity and safety; Increase in property value; Increase in tax revenue; Public perception; Number of mode connections at the station/ stop; and Parking.
<b>Nelson and Niles (2009)</b>	Acknowledged and counted 16 features that could conclude the attainment of TOD at both levels of local and regional. They developed a concept called ‘Back casting Delphi’ which can be utilized to know the perfect measure for preferred TOD result.
<b>Belzer and Autler (2002)</b>	Functional outcomes were desired in TOD in comparison to substantial characteristics. Six key criteria listed: Location efficiency; Choice; Value capture; Financial return; Livability; and Efficient land use patterns at regional level.
<b>Dittmar and Poticha (2004)</b>	Similar to the above mentioned “Belzer and Autler” criteria keeping in mind that these criteria require a lot of data for the scrutiny.
<b>Evans and Pratt (2007)</b>	Illustrated the TOD- ness of the projects through important indicators like: Centrally positioned transit; walker priority; High quality transportation; Mix of uses; Supportive density; and Parking management.

Evaluated from Singh (2015)

**VII. CALCULATED ASSESSMENT PROCESS FOR EVALUATING SUCCESS OF TOD WITH CRITERIA AND INDICATORS**

A lot many studies have been acknowledged by numerous authors, categorizing the pointers to estimate the success of TOD in any area. Thus, rendering from the literature above, six main criteria and succeeding indicators have been computed which gives a supplementary meaning, to measure TOD such that they cover the different features of TOD. Thus, the lists of criteria are listed below which would

be used for quantifying the success of TOD in Indian studies.

- i. Institutional Support
- ii. Quality of Cityscape
- iii. Health, Safety and Environment
- iv. Economic Development
- v. Travel Behavior
- vi. Socio- Cultural Impact

Thus, the table below explains the validation behind the credentials of criteria as well as the indicators premeditated from the corpus of 102 papers.

**Table 4. Listing of criteria based on paper corpus**

ASSESSMENT INDICATORS	PAPERS													
	6	9	14	37	38	54	58	64	72	73	74	80	86	101
Institutional support	X	√	X	X	X	X	X	√	√	X	X	X	X	X
Quality of cityscape	√	√	√	√	√	√	√	√	X	√	√	√	√	√
Health safety and environment	√	√	√	√	X	√	√	√	√	√	√	√	√	√
Economic development	√	√	√	√	√	√	√	√	√	√	√	√	√	X
Travel behavior	√	X	√	√	√	√	√	√	√	√	√	√	√	√
Socio- cultural impact	X	X	X	X	√	X	X	√	√	√	X	X	X	X

**VIII. RESEARCH METHODOLOGIES EMPLOYED AND ITS CORRELATION**

To categorize the study methodologies, the scrutiny followed an inductive approach similar to the one previously discussed. Each paper is classified on own experiences. Then, a table was created by revising and grouping the various methodologies identified.

The resulting classification is reported in Figure8 and Table 5, where each paper could adopt more than one methodology. In this papers are characterized according to the methodologies used by the authors in their respective researches. It can be concluded that a systematic literature review is majorly utilized by the researchers to work for transit oriented development.

**Table 5. Division of the topics according to the methodology adopted**

Methods	Papers
Case Study/ Interview	9, 10, 12, 14, 15, 16, 17, 20, 22, 32, 33, 34, 35, 40, 41, 42, 43, 44, 46, 47, 52, 55, 72
Quantitative Modelling	8, 18, 19, 21, 27, 29, 40, 48, 72, 73, 84, 85, 86
Questionnaire/ Survey	5, 24, 25, 26, 27, 28, 37, 38, 39, 49, 50, 52, 56, 57, 58, 63, 65, 66, 67, 72, 74, 75, 78, 80, 81, 82, 84, 85, 86, 90
Experimental/ Piloting	1, 18, 30, 36
Literature/Systematic review	3, 4, 6, 7, 11, 13, 14, 16, 19, 23, 28, 29, 31, 32, 33, 34, 35, 37, 38, 39, 51, 54, 55, 60, 61, 62, 63, 64, 68, 69, 70, 71, 72, 76, 77, 78, 79, 80, 81, 83, 86, 88, 89, 90, 91, 92, 93, 94, 95, 100, 102
Simulation	2, 18, 37, 41, 45, 53, 69, 86, 87, 96, 97, 98, 99, 101

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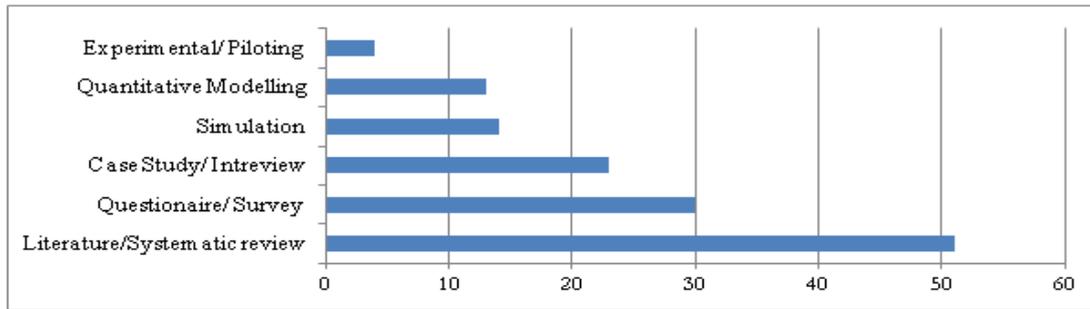


Figure 8. Number of papers according to the method in the corpus.

To understand more, the type of data collected and used in the study is also bifurcated. Therefore, the analysis distinguished between qualitative, quantitative data and the papers using both techniques. Quantitative data can be quantified and verified and are amendable to statistical

manipulation whereas qualitative data is achieved from the case studies and interviews, which cannot be measured directly. The results of the classification of data are reported in Figure 9.

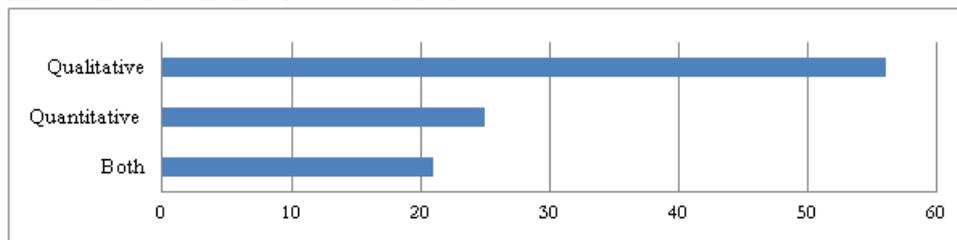


Figure 9. Variety of data utilized in the corpus.

## IX. RESULT ANALYSIS: ISSUES, GAPS AND FUTURE LINES OF RESEARCH

In addition to answering the four research questions, the scrutiny of the literature on application of transit oriented development permitted us to classify some guidelines for research that deserve further exploration by both academics and practitioners.

Likewise, from above discussion it is clear that TOD has been defined diversely by various authors which explain that there is no standard definition of TOD. It is expected that the main idea of TOD is the integration land use and transit to encouraged to use public transport more and avoid using personal vehicles, they are even encouraged to be pedestrianism or use non- motorized transport to make environment more sustainable. Stakeholders and involved parties have different criteria for developing TOD and hence have different aims and definitions.

Since, all authors define TOD diversely but there is not much difference in their definitions. Therefore, majorly the benefits expected to be out of each TOD are:

1. Increased use of public transport, thus bringing more prospects.
2. Increasing property values and healthy market competition leading to financial and economic development.
3. Making people pedestrianism or use non-motorized transport, to create healthy environment.
4. Avoid congestion on roads and create a healthy lifestyle, safer vicinity and active societies.
5. Utilization of land in a more organized and systematic order.
6. Increase transit ridership and diminish traffic pollution, utilization of non renewable resources.

Detail analysis of the aforementioned, it is quite clear that Transit Oriented Development concept cannot only be

achieved by creating a area with higher densities with mixed land use or by pedestrianizing them alone. Regions including all these characteristics with appropriate access to a good transit system still require integration of land use and transit system.

Whereas Singh (2015) declared that public reserves in facilities such as for TOD are made often without knowing present circumstances and probable results of the proposals. A deficiency of inclusive tools to evaluate TOD or TOD-ness of any area is identified in Wells and Renne in 2005. Whereas there are many indicators to measure TOD, but in no case indicators are used to quantify TOD jointly but the case studies were mainly qualitative discussions by authors. Assessment of TOD- ness will add in evaluating TOD projects also (Evans and Pratt, 2007).

## X. CONCLUSION

The intention was to provide a systematic analysis of the scientific literature that addresses the importance of the concept of Transit Oriented Development which is degrading day by day. There is significant confirmation that enthusiasm for transit oriented development is on the ascent in the United States. Transit Oriented-Development moves the concentration from diffuse, car sited development to denser, blended utilizes neighborhoods revolved around travel station. TOD can have a heap of social, natural and financial advantages for individuals and groups, from lessened expenses of living, better access to employments, and financial development, to more beneficial ways of life and, through diminished car utilize that defines the rationale of TOD in India.

Therefore, the objective of this literature review is to be aware of the genesis of the literature and put forward idea regarding the best steps for further research. Furthermore, a lot many methodologies have been adopted to study these topics where year wise bifurcation, methodological investigation, etc have applied. Hopefully, this research will help the academics and practitioners to know TOD concept and help them to get used to their efforts in a way that is consistent with past progress and future point of view.

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### FURTHER READING

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