

Chapter 13

Comprehending the Land Use Dynamics in Urban Regions by Conducting an Ex-post Master Plan Evaluation



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Abstract Comprehensive plans, known as ‘master plan’ or ‘blueprint’, are statutory tools to guide cities’ current and future land utilisation and zoning for 20–25 years. Urban master planning and land use plans are criticised for being costly, having rigid bylaws, and failing to control the development in a planned manner. Therefore, the research conducted an ex-post plan evaluation of urban land use plans prepared under master plans to determine if the proposed land uses conformed to subsequent existing land uses. Considering the rigidity of the planning process in India, the research adopted a conformance-based evaluation methodology and quantitative analysis for the case of five cities, viz. Indore, Ghaziabad, Lucknow, Jaipur and Surat to comprehend the urban land use dynamics. The results showed that the master plans of almost all the cities were considerably non-conforming. The non-conformance was evident in all land use categories and most significantly in commercial, recreational, circulation and overall developed/urbanised area. The research concludes that, given the lack of accountability for value-added outcomes and ex-post urban plan evaluation, proposed urban plans remain unevaluated, resulting in areas of non-conformance. The research recommends incorporating sustainable urban management strategies along with monitoring and ex-post plan evaluation to adhere to the planning proposals in order to use the land judiciously and provide a better quality of life.

Keywords Master/development plans · Urban planning · Land use · Ex-post plan evaluation · Conformance-based evaluation

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Introduction

Land as an essential natural resource is positioned at the basal ground in the composite structure of 'population-resource-environment-development' (Zhang et al. 2005). As a result, comprehensive and urban land use plans are essential for sustainable urban development and spatial planning (Bulti and Sori 2017). Even though its demise has been continually predicted, comprehensive plans remain operational and assist decision-makers in managing urbanisation and building community consensus on land use concerns (Kaiser and Godschalk 1995). The planning process is constantly criticised because governments spend a lot of time and resources making plans that, most of the time, 'sit on the shelf' for years without implementation (Berke et al. 2006; Norton 2005). Additionally, land use plans and planning are attacked for having excessively rigid bylaws and still failing to control the development in a planned manner. Hence, the demand for confirmatory value-added outcomes is increasing in the planning process (Kaiser and Godschalk 1995; Laurian et al. 2010; Newcomer 1997). Although five-year reviews of these plans are compulsory, the realities of planning practice reveal that monitoring and evaluation are frequently overlooked stages in the planning process (Seasons 2002). Without any attempt to determine the extent of goal implementation in a previous plan, planning agencies experience a 'new plan syndrome', where they produce an updated, revised or modified plan despite knowing that the actual developed urban land use substantially differs from the plan recommendations (Calkins 1979).

Plan evaluation is a rigorous but crucial exercise because it monitors the progress of planning proposals and supports efficient planning dynamics. Evaluation practices provide a valuable opportunity to suggest revisions or adjustments to planning products and procedures. Furthermore, it empowers the building of a planning system based on an ongoing learning practice and gives planning legitimacy in the eyes of the public (Oliveira and Pinho 2010a, b; Seasons 2002). Evaluation of a plan refers to examining the outputs and effects of current and previous actions and deciding whether these are consistent with the plan objectives (Minnery et al. 1993). There are three phases of plan evaluation in the planning process, which include ex-ante, ongoing and ex-post evaluations. Ex-ante evaluation takes place at the onset of the planning process, ongoing evaluation occurs during the plan implementation, and ex-post evaluation, concerned with the impacts of the plan, takes place after it has been implemented. The literature suggests that compared to ex-ante evaluations, the latter phases are studied to a lesser extent (Hoch 2002; Oliveira and Pinho 2010b). Moreover, rarely is the ex-post outcome evaluation of land use plans conducted, even though it is the final measure of the effectiveness of development management (Bulti and Sori 2017; Carmona and Sieh 2008). This crucial aspect of the urban plan implementation and evaluation gap has been criticised by academics in the United Kingdom (Gilg and Kelly 1997), the United States (Berke et al. 2006; Ryan and Gao 2019), New Zealand (Laurian et al. 2010; Laurian et al. 2004a, b), Israel (Rachelle and Morris 1978), Ethiopia (Bulti and Sori 2017), Australia (Minnery et al. 1993) and China (Hao et al. 2009; Shen et al. 2019; Tian and Shen 2011; Zhong et al. 2014).

To fill this gap for ex-post plan implementation evaluation, scholars generally follow two distinct approaches to ascertain whether and to what extent the goals and outcomes of the plans have been accomplished: conformance-based and performance-based (Oliveira and Pinho 2010b). The conformance-based approach, primarily concerned with the goal and outcome alignment of the plans, views the role of urban plans as a blueprint (Alfasi et al. 2012; Brody and Highfield 2005; Laurian et al. 2004a, b; Rachele and Morris 1978; Talen 1997). This method uses one or both standards to determine whether a planning exercise was successful or not. The first criterion is to what extent the ground realities conform to the plans or adhere to planning policy guidelines. Another one is if the instruments intended to implement a plan/policy, such as ordinances, detailed programs or projects, budgetary allowances, actually help accomplish its stated goals. Examples of conformance-based approaches include a comparison between proposed land use of comprehensive plans with consequent development efforts in Florida (Brody and Highfield 2005), comprehensive plans in Pueblo, Colorado (Talen 1996a), and local storm-water management and development permits in New Zealand (Laurian et al. 2004a, b). However, these analyses do not determine whether the observed outcomes result from planning activities or external influences (Laurian et al. 2010). The performance-based approach, conversely, views the plan as a guide and investigates how it affects the associated decision-making processes (Berke et al. 2006; Dalton 1989; Laurian et al. 2004a, b; Oliveira and Pinho 2009). A pioneering example of this approach is the Dutch school of planning evaluation (Alexander 2009; Driessen 1997; Mastop and Faludi 1997). Instead of focusing on how well a plan can lead to a particular goal, performance-based approaches analyse how the plan affects local discourse and the ongoing policy formulation and implementation process (Alexander and Faludi 1989; Driessen 1997; Ryan and Gao 2019).

Most scholars usually adopt either of the approaches to conduct an ex-post plan evaluation as both are considered valid yet potentially conflicting (Laurian et al. 2004a, b; Loh 2011; Rachele and Morris 1978). Moreover, some scholars have attempted to integrate both approaches (Altes 2006; Berke et al. 2006). However, decisions regarding the adopted methodology get influenced by aspects like the nature of the plan, time and resource constraints, the decision regarding breadth versus depth of the research scope and the requirements of the identified research questions (Faludi 1989; Seasons 2002). Additionally, it is impractical and often unattainable to have an ideal plan monitoring and evaluation paradigm; hence, it is suggested that the notion and practice of plan evaluation must be progressively introduced in the planning process cycle and improved upon with time (Seasons 2002).

In the Indian context, for instance, a study attempted to delve into land use planning for a ward in Mumbai empirically by comparing existing land use to the envisioned use of the study area (Pethe et al. 2014). However, the author does not explore the study from the monitoring or ex-post plan implementation evaluation perspective. Instead, it presents it as a case of master plan failure and looks for new approaches towards urban planning in the global south cities. In India, master plans

(MPs) or development plans (DPs)¹ are considered a failure and have been criticised for decades (Bapat 1983; Bhan 2013; Meshram 2006; Nallathiga 2006; Pethe et al. 2014). Surprisingly, without even conducting a formal ex-post plan evaluation to conclude the success or failure of these plans.

India is rapidly urbanising, and the MPs are still the statutory tools to guide, control cities' growth and critically manage spatial sustainability (Raparathi 2015). The MP's scope is to provide broad proposals and specify land use allocation for primary land uses like residential, commercial, industrial, public and semi-public, recreational and circulation systems in Indian cities for a 20-year time horizon (Meshram 2006; Raparathi 2015). The urban maladies in Indian cities arise because of the disjunction between plan preparation and implementation, which creates a dichotomy between MP proposals and the existing ground realities (Meshram 2006).

Additionally, issues like urban sprawl, piecemeal constructions and interventions, environmental degradation, pollution and traffic congestion become the characteristics of a city in the absence or failure of MPs (Aayog 2021). But then the question arises: In the purview of lack of ex-post plan evaluation, how do we comprehend that an MP has failed to get implemented? These plans may successfully implement some land uses but may fail to do so in others. Theorists and urban planners may thus assume or hypothesise the success or failure of an MP. Therefore, the continuous process of plan implementation evaluations can help identify critical issues in different cities and specific land uses that need more attention.

As land use plans are the most common subject of monitoring and evaluation (Seasons 2002), the research has thus attempted an ex-post evaluation of land use plans proposed under the MPs. The research analyses the primary land uses in Indian cities at an aggregate MP level. Therefore, the research aims to assess the effectiveness of the proposed MPs in Indian cities by conducting an ex-post plan evaluation with the following research objectives (ROs).

1. RO1: To identify if the proposed MPs in the selected Indian cities were implemented, i.e. whether or not the proposed land use (PLU) under an MP conforms to the existing land use (ELU).
2. RO2: To identify in the selected Indian cities the land use categories which show conformance between the PLUs in MPs and the ELUs.
3. RO3: To determine the conformance variation shown by the individual land use categories in each MP of the selected Indian cities.

The research is focused primarily on conducting an ex-post plan evaluation, thereby establishing its need in the Indian planning scenario. However, it does not intend to identify the causal linkages or answer 'why' the MPs or land uses were not implemented. This research is instead centred around 'where', 'which' and 'how much' in the plan implementation evaluation, considering the Indian planning context and data availability. Following this introductory section, the second section of the

¹ As mentioned in URDPFI guidelines, master plan (MP) and development plan (DP) are identical terms and vary across the states in terminology only (MoUD 2014).

chapter is materials and methods, which presents the empirical evaluations complementary to the three research objectives. The third section presents the findings of the three analyses and discusses which MPs and land use categories were implemented and to what extent. The fourth section discusses the challenges/limitations of the study, and finally, the fifth section of the chapter ends with the conclusions.

Materials and Methods

Most former studies have dealt with plan implementation evaluation by considering individual case studies. On the contrary, this research followed a systematic and quantitative cross-sectional study of ex-post plan evaluation. Furthermore, quantitative analysis is relatively scarce for conducting plan implementation evaluation (Talen 1996a, b, 1997). This diverse dataset allows for the systematic ex-post plan evaluation, thereby bridging this knowledge gap in the planning literature. The research adopted the conformance-based ex-post evaluation methodology (Fig. 13.1), considering the blueprint nature of MPs and the rigidity of the planning process in India. The primary aim of the analysis was to comprehend the level of conformance between ELU and PLU as envisioned in the MP. This section of the chapter initially discusses the case study selection and the details of the land use data collected for the analysis. Next, the section moves forward with the conformance-based evaluation methods adopted to answer the three research objectives. The RO1 was first addressed by undertaking a master plan-wise analysis, followed by an urban land use category-wise analysis to address the RO2. Furthermore, RO1 and RO2 were answered using the statistical hypothesis testing technique, and finally, to address RO3, a conformance evaluation was carried out.

Case Study Selection

India is developing rapidly with high population, economic and urbanisation growth rates (Sudhira and Gururaja 2012). The level of urbanisation in the country is such that approximately 377 million inhabitants live in 7935 towns/cities, accounting for around 31.16% of the total population (Census of India 2011; Das 2013). Moreover, urbanisation is more prominent in the million-plus cities of India, which are the vital urban hubs accommodating 42.6% of the urban population (Chendrayudu and Chandrasekarayya 2020; Das 2013; Raparathi 2015; Sudhira and Gururaja 2012). In 1951, only five cities had a population above one million (m) in India. The same figure in 1981 increased to 12, whereas in 1991 this number rose to 23, and in 2001 the figure augmented to 35. The number of inhabitants of million-plus cities has rapidly increased in recent decades (Chendrayudu and Chandrasekarayya 2020). According to the Census of India (2011), 53 urban agglomerations (UAs) have a million or

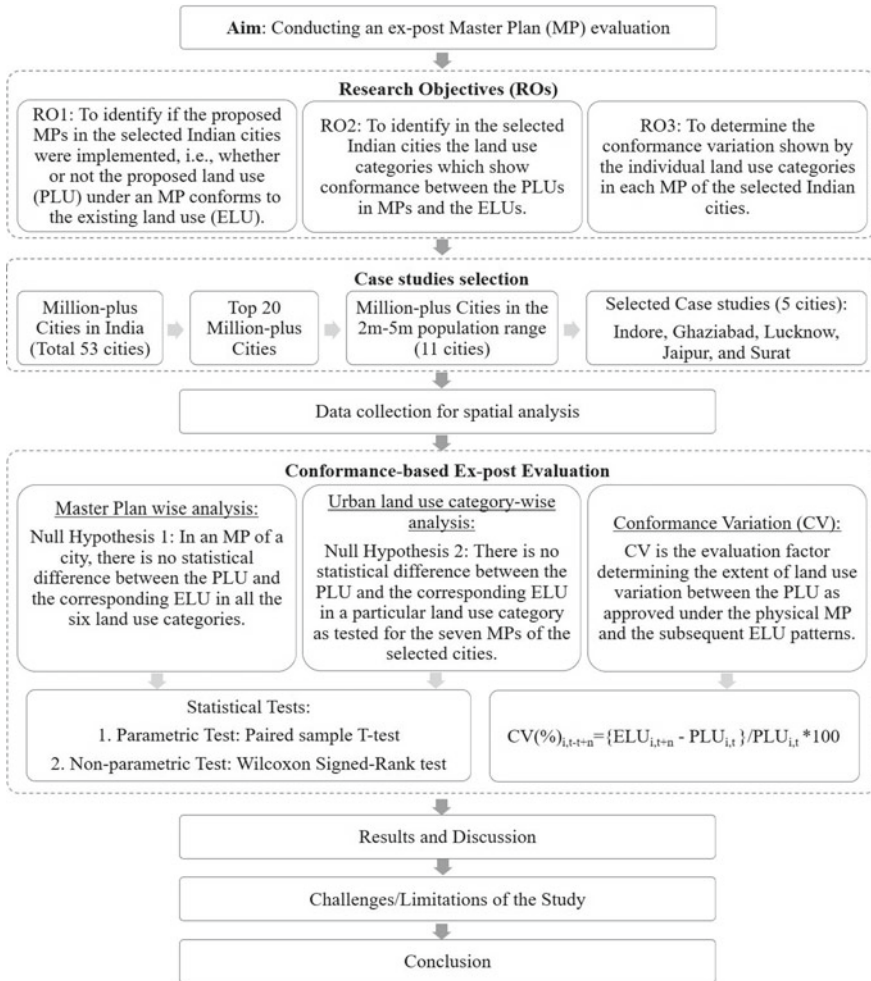


Fig. 13.1 Research methodology

above population (Ministry of Home Affairs, n.d.). Since the last census, 18 new UAs have been added to this list (Das 2013).

These statistics suggest that the million-plus cities are vital for the research to comprehend the urban land use dynamics. Additionally, these cities encounter issues like congestion, pollution, and social polarisation, and the urban growth in these cities impacts the overall regional development of the country (Chendrayudu and Chandrasekarayya 2020). Approximately 31% of the urban population resides in the top-20 most populated million-plus cities, according to the Census of India (2011) (Sudhira and Gururaja 2012).

This research selected the case studies from this list of the top-20 million-plus cities (Table 13.1). However, the cities with a population above five million were not chosen as their size was huge to comprehend the complex urban land use dynamics by undertaking only the conformance-based ex-post plan evaluation. Therefore, the research selected the case studies from the 2–5 m population range from the list of the top-20 million-plus cities to understand the ex-post plan evaluation scenario. An additional criterion for selecting these cities was that these UAs had a history of MPs preparation since independence. In this population range, there were 11 million-plus cities, and the collection of land use data of MPs from these 11 UAs was attempted for the research. However, land use data of seven MPs from five cities, namely Indore, Ghaziabad, Lucknow, Jaipur and Surat (Fig. 13.2), could be successfully obtained from various authorities. The following is a brief description of the selected case studies:

1. Indore in Madhya Pradesh has a population of 2.17 m. The city is an ancient settlement that dates back to the end of the fifteenth century. Patrick Geddes, a well-known architect and town planner, was invited to promote Indore's proper

Table 13.1 Top-20 most populated cities in India

S. No.	City/urban agglomeration	State/territory	Population (in million)
1.	Greater Mumbai	Maharashtra	18.41
2.	Delhi	Delhi	16.31
3.	Kolkata	West Bengal	14.11
4.	Chennai	Tamil Nadu	8.70
5.	Bangalore	Karnataka	8.50
6.	Hyderabad	Telangana	7.75
7.	Ahmedabad	Gujarat	6.35
8.	Pune	Maharashtra	5.05
9.	Surat	Gujarat	4.59
10.	Jaipur (M Corp.)	Rajasthan	3.07
11.	Kanpur	Uttar Pradesh	2.92
12.	Lucknow	Uttar Pradesh	2.90
13.	Nagpur	Maharashtra	2.50
14.	Ghaziabad	Uttar Pradesh	2.36
15.	Indore	Madhya Pradesh	2.17
16.	Coimbatore	Tamil Nadu	2.15
17.	Kochi	Kerala	2.12
18.	Patna	Bihar	2.05
19.	Kozhikode	Kerala	2.03
20.	Bhopal	Madhya Pradesh	1.88

Source Census of India (2011)



Fig. 13.2 Location of selected case studies

development in 1918. The Indore DP 1974–1991, adopted under the Town & Country Planning Organization Act, 1973, was the first post-independence planning intervention. The second DP was prepared for Indore in 2008 with the horizon year of 2021 (Indore Municipal Corporation 2018).

2. Ghaziabad in Uttar Pradesh, having a population of 2.36 m, started its planned development in 1958. On March 9, 1977, the Ghaziabad Development Authority (GDA) was constituted under the Urban Planning and Development Act, 1973. The primary objective of the GDA was to prepare MP for planned urban development. The city has had three MPs prepared since independence, namely MP1961–1981, MP1981–2001 and MP 2001–2021 (Nagar Nigam Ghaziabad, n.d.).
3. Lucknow, the capital of Uttar Pradesh, has a population of 2.90 m. Under the Uttar Pradesh Urban Planning and Development Act, 1975, Lucknow Development Authority (LDA) was established, which prepared the first MP for Lucknow

for 1970–2001. The second MP for Lucknow was formulated in 2001 with a perspective of 2021, and the current MP is for the horizon year 2031 (TCPO India 2020).

4. Jaipur, the capital of Rajasthan, also known as Pink City, has a population of 3.07 m. Jaipur was planned on a grid-iron pattern as a walled city in 1727. In 1976, the first MP for the horizon year 1991 was approved under Urban Improvement Trust (UIT) Act. In 1982, Jaipur Development Authority (JDA) was constituted to prepare the MP 1998–2011 and the current MP 2009–2025 (Bedi et al. 2019).
5. Surat, Gujarat, has a population of 4.59 m. In 1986, Surat Urban Development Authority (SUDA) was formed under the Gujarat Town Planning and Urban Development Act, 1976. SUDA is the concerned authority in preparing the Development Plans in Surat. The city has had three DPs since independence, namely DP 1986–2001, DP 2004–2011 and the current DP 2014–2035 (SUDA, n.d.).

Data Collection for Spatial Analysis

To conduct the conformance-based ex-post evaluation, the PLU data envisioned in the MP and the consequent ELU data pairs for the MPs of selected cities were collected. This data from secondary sources was mainly gathered from various government organisations, including development authorities and town planning departments (Table 13.2).

Master Plan-Wise Analysis

This section of the chapter addresses the RO1, which discusses the master plan-wise analysis. The null hypothesis shaped to answer the RO1 was:

Null Hypothesis 1: In an MP of a city, there is no statistical difference between the PLU and the corresponding ELU in all the six land use categories.

This analysis was carried out for seven MPs in five selected cities. The six land use categories considered under the MPs were residential, commercial, industrial, govt./public and semi-public, recreational and circulation. The null hypothesis was tested with a 95% confidence interval using parametric and nonparametric statistical tests on IBM SPSS Statistics 20 software. The analysis aimed to identify whether the MPs showed conformance between the PLU and ELU at an aggregate level.

Urban Land Use Category-Wise Analysis

This section focuses on the RO2, encompassing the urban land use category-wise analysis. The corresponding null hypothesis formed to answer the RO2 was:

Table 13.2 Details of the data collection process

Location on map	UAs/cities	Population in million (m)	Master plan (MP)/development plan (DP)	Source	Data collection
A	Indore	2.17	DP 1974–1991 ^a DP 2008–2021	DP, Directorate of Town and Country Planning, Madhya Pradesh	September 2021 to October 2021
B	Ghaziabad	2.36	MP1961–1981 MP1981–2001 ^a MP 2001–2021	MP section, GDA, Ghaziabad	
C	Lucknow	2.90	MP1970–2001 ^a MP 2001–2021 MP 2031	(TCPO India 2020)	
D	Jaipur	3.07	MP 1971–1991 ^a MP 1998–2011 ^a MP 2009–2025	MP section, (JDA), Jaipur	April 2020 to May 2020
E	Surat	4.59	DP 1986–2001 ^a DP 2004–2011 ^a DP 2014–2035	DP section, SUDA, Surat	

^aData was collected for these master plans for the research

Null Hypothesis 2: There is no statistical difference between the PLU and the corresponding ELU in a particular land use category as tested for the seven MPs of the selected cities.

Each land use category in the seven MPs of the five selected cities was examined for the research. For this analysis, seven urban land use categories were evaluated. The first six land use categories were residential, commercial, industrial, govt./public and semi-public, recreational and circulation. The sum of the aforementioned land use categories formed the last category, overall developed/urbanised area. The null hypothesis was tested on IBM SPSS Statistics 20 software with a 95% confidence interval using parametric and nonparametric statistical tests. The analysis aimed to identify whether the PLU categories conformed to the ELU at an aggregate level.

Conformance Variation (CV)

This section of the chapter focuses on quantifying the CV between the PLU and its corresponding ELU to comprehend to what extent the proposed plan was implemented. Conformance-based approaches generally use GIS-based spatial overlay analysis to identify the CV (Bulti and Sori 2017; Hao et al. 2009; Ryan and Gao

Table 13.3 Land use data of selected cities

Land use category (area in hectares)	Indore DP 1974–1991	Ghaziabad MP 1981–2001	Lucknow MP 1970–2001	Jaipur MP 1971–1991	Jaipur MP 1998–2011	Surat DP 1986–2001	Surat DP 2004–2011
Residential	5060 PLU	4287.51	15,924	6960	13,825	9806.18	20,400
Commercial	4660 ELU	4670	8945	6426.4	17,445	6189	10,249
	648 PLU	359.29	983	647.49	2064	415.72	765
Industrial	570 ELU	274	360	384.45	825	256	466
	1498 PLU	1987.62	731	1804.89	1862	3023.4	4394
Govt./public and semi-public	843 ELU	1710	990	1007.66	1888	2784	3889
	1417 PLU	557.56	379	1222.14	3843	579.82	6421
Recreational	1096 ELU	425.65	560	1015.75	1830	735	1360
	1417 PLU	1561.13	1869	404.68	3461	106.61	1236
Circulation	290 ELU	399.5	435	214.48	529	58	234
	2105 PLU	1133.59	2260	2436.2	4741	1561.41	4073
Overall developed/urbanised area	1370 ELU	752.85	1240	1177.63	3142	1661	3531
	12,145 PLU	10,039.2	23,682	13,557	30,830	17,043	37,289
	8829 ELU	8485	16,270	10,226.4	26,415	13,234	19,729

MP Master Plan; DP Development Plan; PLU Proposed Land Use; and ELU Existing Land Use

2019; Zhang et al. 2005). Moreover, most of these studies focus on a single city as a case study. This research, on the contrary, deals with multiple cities and their MPs. For this reason, it would be arduous to use spatial overlay analysis. Additionally, no standard method is prescribed in the literature to quantify the CV. Therefore, the research has adopted the basic formula to capture the percentage change and determine the mathematical expression for CV.

In the context of ex-post land use plan evaluation, CV is the evaluation factor determining the extent of land use variation between the PLU as approved under the physical MP and the subsequent ELU patterns (Omollo 2019). The mathematical expression for CV(%) is given by:

$$CV(\%)_{i,t-t+n} = \{ELU_{i,t+n} - PLU_{i,t}\} / PLU_{i,t} * 100 \quad (13.1)$$

where $PLU_{i,t}$ = PLU for land use category 'i' at a time 't',

$ELU_{i,t+n}$ = ELU for land use category 'i' at the time 't + n',

n = MP/DP period,

i = land use categories, namely residential, commercial, industrial, govt./public and semi-public, recreational, circulation and overall developed/urbanised area,

$CV(\%)_{i,t-t+n}$ = CV in the land use category 'i' at the time 't + n' from time 't'.

Results and Discussion

The results of the three analyses mentioned earlier will be discussed sequentially in this section.

Master Plan-Wise Analysis

For the seven MPs, land use data was collected in pairs for the PLU and the consequent ELU. The difference between the collected pairs of land use data in most of the MPs was continuous, normally distributed and random. However, the difference between the collected pairs of land use data was not normal for the MP of Surat and Lucknow. Additionally, the outliers were present in the difference between the collected pairs of land use data of Surat DP 1986–2001, Jaipur MP 1998–2011, Lucknow MP 1970–2001 and Ghaziabad MP 1981–2001. Therefore, the analysis undertook both parametric and nonparametric tests to address non-normality and the presence of outliers. A paired sample t-test was conducted for the parametric test, and a Wilcoxon signed-rank test was used for the nonparametric test. The Wilcoxon signed-rank test is the nonparametric equivalent of the parametric paired sample t-test.

Table 13.4 Master plan-wise results of paired sample t-test

MP/DP	Pairs	Paired differences			<i>t</i>	df	Significance (p) value (two-tailed)
		mean	Std. deviation	Std. error mean			
Indore DP 1974–1991	ELU-PLU	–552.67	367.66	150.09	–3.68	5	0.01
Ghaziabad MP 1981–2001	ELU-PLU	–275.78	507.16	207.05	–1.33	5	0.24
Lucknow MP 1970–2001	ELU-PLU	–1602.67	2715.88	1108.75	–1.45	5	0.21
Jaipur MP 1971–1991	ELU-PLU	–541.50	422.59	172.52	–3.14	5	0.03
Jaipur MP 1998–2011	ELU-PLU	–689.50	2323.50	948.57	–0.73	5	0.50
Surat DP 1986–2001	ELU-PLU	–635.02	1468.58	599.55	–1.06	5	0.34
Surat DP 2004–2011	ELU-PLU	–2926.67	3972.57	1621.79	–1.81	5	0.13

MP Master Plan; *DP* Development Plan; *PLU* Proposed Land Use; and *ELU* Existing Land Use

Parametric Test: Paired Sample t-test

The parametric test was conducted using paired sample t-test to determine if the arithmetic means of the two pairs of observations were equal for the MP of selected cities. The two pairs tested were the arithmetic mean of six PLU areas (in hectares) against their consequent arithmetic mean of six ELU areas (in hectares). The test was conducted for seven MPs from five cities.

The test results found (Table 13.4) a statistically significant difference between the PLU in Indore DP 1974–1991 and the consequent ELU, as the significance (p) value is 0.01. Similarly, the test found a statistically significant difference between the PLU in Jaipur MP 1971–1991 and the consequent ELU, as the p-value is 0.03. Therefore, the null hypothesis was rejected with a 95% confidence level. The analysis indicates that, on average, plan conformance in Jaipur MP 1971–1991 and Indore DP 1974–1991 decreased by –541.51 and –552.67, respectively. The analysis suggests with 95% confidence that the PLUs and consequent ELUs in these two MPs were significantly non-conforming as the associated significance value was less than 0.05. However, for the rest of the five MPs, the results showed the conformance between PLUs and ELUs as the associated p-value was more than 0.05.

Nonparametric Test: Wilcoxon Signed-Rank Test

The nonparametric test was conducted using the Wilcoxon signed-rank test to determine if the median of the two pairs of observations was equal for an MP of selected

Table 13.5 Master plan-wise results of Wilcoxon signed-rank test

MP	Pairs	Z	Significance (<i>p</i>) value (two-tailed)
Indore DP 1974–1991	ELU-PLU	–2.20	0.03
Ghaziabad MP 1981–2001	ELU-PLU	–1.15	0.25
Lucknow MP 1970–2001	ELU-PLU	–1.57	0.12
Jaipur MP 1971–1991	ELU-PLU	–2.20	0.03
Jaipur MP 1998–2011	ELU-PLU	–0.73	0.46
Surat DP 1986–2001	ELU-PLU	–1.15	0.25
Surat DP 2004–2011	ELU-PLU	–2.20	0.03

PLU Proposed Land Use; *ELU* Existing Land Use; *MP* Master Plan; *DP* Development Plan

Note Based on negative ranks.

cities. The two pairs tested were the median of six PLU areas (in hectares) of an MP against their consequent median of six ELU areas (in hectares). The test was conducted for seven MPs from five cities.

Similar to the paired sample t-test results, Wilcoxon signed-rank test also found a significant difference between the PLU and the corresponding ELU in the Indore DP 1974–1991 and Jaipur MP 1971–1991, $n = 6$, $Z = -2.20$, $p < 0.03$ (Table 13.5). Furthermore, the test found a significant difference between the PLU and the corresponding ELU of Surat DP 2004–2011, $n = 6$, $Z = -2.20$, $p < 0.03$. The analysis suggests with 95% confidence that the PLUs and consequent ELUs in these three MPs were significantly non-conforming as the associated significance value was less than 0.05.

However, the rest of the four MPs showed conformance between PLUs and ELUs as the associated p-value was more than 0.05 (Table 13.5).

Urban Land Use Category-Wise Analysis

For this analysis, seven urban land use categories were tested to identify whether the PLU categories got implemented on the ground at an aggregate level, considering the seven MPs. The primary land use categories analysed were residential, commercial, industrial, govt./public and semi-public, recreational, circulation and overall developed/urbanised area. For the seven land use categories of MPs, land use data was analysed in pairs of the PLU and the consequent ELU.

The difference between the collected pairs of land use data in each land use category was continuous, normally distributed and random. However, the difference between the paired land use data was not normally distributed in the commercial, govt./public and semi-public and overall developed/urbanised area land use categories. Additionally, the outliers were present in the difference between the paired land use data for the commercial land use, govt./public and semi-public land

use, recreational land use and overall developed/urbanised area. To address non-normality and the presence of outliers, the research performed both parametric and nonparametric statistical tests.

Parametric Test: Paired Sample t-test

The parametric test was conducted using paired sample t-test to determine if the arithmetic means of the two pairs of observations were equal for the land use categories under consideration. The two pairs tested were the arithmetic mean of the PLU areas (in hectares) against their consequent arithmetic mean of ELU areas (in hectares) in each land use category of seven MPs.

The test results found (Table 13.6) a statistically significant difference between the PLU and the consequent ELU in the commercial ($p = 0.04$), recreational ($p = 0.02$), circulation ($p = 0.01$) and overall developed/urbanised area ($p = 0.03$) land use categories. Therefore, the null hypothesis was rejected with a 95% confidence level for these four land use categories as the associated significance value was less than 0.05, indicating non-conformance between PLU and ELU. However, the results showed the conformance between PLUs and ELUs for the rest of the three land use categories, namely residential, industrial and govt./public and semi-public as the associated significance (p) value was more than 0.05.

Table 13.6 Urban land use category-wise results of paired sample t-test

Land use pairs	Paired differences			t	df	Significance (p) value (two-tailed)
	mean	Std. deviation	Std. error mean			
Residential ELU-PLU	-2525.47	4723.74	1785.40	-1.42	6	0.21
Commercial ELU-PLU	-392.43	416.86	157.56	-2.49	6	0.04
Industrial ELU-PLU	-312.75	373.51	141.17	-2.22	6	0.07
Govt./public and semi-public ELU-PLU	-1056.73	1917.85	724.88	-1.46	6	0.20
Recreational ELU-PLU	-1127.92	949.52	358.88	-3.14	6	0.02
Circulation ELU-PLU	-776.53	569.95	215.42	-3.61	6	0.01
Overall developed/urbanised area ELU-PLU	-5913.82	5431.12	2052.77	-2.88	6	0.03

PLU Proposed Land Use; ELU Existing Land Use

Nonparametric Test: Wilcoxon Signed-Rank Test

For the land use categories under consideration, the Wilcoxon signed-rank test was applied to identify whether the median of the two pairs of observations was equal. The two pairs tested were the median of the PLU areas (in hectares) versus their respective median of ELU areas (in hectares) in each land use category of seven MPs.

Wilcoxon signed-rank test found a significant difference between the PLU and the corresponding ELU in the commercial, recreational and overall developed/urbanised area land use categories, $n = 7$, $Z = -2.36$, $p < 0.02$ (Table 13.7). Moreover, the test found a significant difference between the PLU and the corresponding ELU in circulation land use, $n = 7$, $Z = -2.19$, $p < 0.03$. Therefore, the null hypothesis was rejected with a 95% confidence level for the commercial, recreational, circulation and overall developed/urbanised area land use categories.

On the other hand, the results showed the conformance between proposed and ELUs for the rest of the three land use categories, namely residential, industrial and govt./public and semi-public (Table 13.7). The associated significance (p) value for these land use categories was more than 0.05, suggesting that the null hypothesis failed to be rejected. Additionally, the parametric and nonparametric tests yielded similar results for the urban land use category-wise analysis.

Conformance Variation (CV)

To determine the extent of MP implementation, expression (13.1) was used to calculate the land use CV(%) in the seven land use categories of the seven MPs. A positive CV(%) indicates that ELU coverage for a given land use category surpassed the PLU, indicating higher land consumption. On the other hand, a negative CV(%) suggests that the ELU was less than the PLU under the MP. Likewise, if the CV(%) is zero, it would imply that the MP was implemented as the ELU matched the PLU.

Table 13.7 Urban land use category-wise results of Wilcoxon signed-rank test

Land use pairs	Z	Significance (two-tailed)
Residential ELU-PLU	-1.35	0.18
Commercial ELU-PLU	-2.37	0.02
Industrial ELU-PLU	-1.69	0.09
Govt./public and semi-public ELU-PLU	-1.52	0.13
Recreational ELU-PLU	-2.37	0.02
Circulation ELU-PLU	-2.20	0.03
Overall developed/urbanised area ELU-PLU	-2.37	0.02

PLU Proposed Land Use; ELU Existing Land Use.

Note Based on negative ranks.

The CV(%) analysis results suggest that all the MPs and all the land use categories considered in the seven MPs showed non-conformance (Table 13.8). Most MPs and land use categories had a negative CV(%), indicating that the ELU was less than the PLU and that the land use was not implemented as proposed in the MP. Alternatively, it could imply that the PLU was projected much higher than the actual requirement for the city. This section of the chapter further discusses the CV(%) results along the MPs and land use categories.

CV(%) Along the MPs

The CV(%) results along the MPs indicate a significant non-conformance in the overall developed/urbanised area in all the MPs (Table 13.8). The higher the CV(%) in the overall developed/urbanised area, the higher the non-conformance between ELU and the PLU, indicating that MPs were not implemented as proposed. In the case of Indore DP 1974–1991, there was a significant CV(%) of -27.30% in the overall developed/urbanised area. The highest CV(%) in Indore was observed in the recreational (-79.53%) and industrial (-43.72%) land use categories, whereas residential land use showed the lowest CV(%) of -7.91% . Ghaziabad MP 1981–2001 showed a CV(%) of -15.48% in the overall developed/urbanised area. The most deviated land use category in Ghaziabad is also recreational land use (-74.41%), followed by circulation land use (-33.59%). Lucknow MP 1970–2001 also showed a significant CV(%) of -31.30% in the overall developed/urbanised area. Additionally, all the land use categories showed a considerable CV(%) of more than $\pm 35\%$, which contrasts with the master plan-wise analysis results, which suggested that the PLUs in Lucknow MP 1970–2001 conformed with the consequent ELUs.

In the case of Jaipur city, Jaipur MP 1971–1991 showed a significant CV(%) of -24.57% in the overall developed/urbanised area. Circulation land use had the highest CV(%) of -51.66% in this MP, followed by recreational (-47.00%), industrial (-44.17%) and commercial (-40.60%). Residential land use showed the lowest CV(%) of -7.67% . In the Jaipur MP 1998–2011, however, the CV(%) in the overall developed/urbanised area was lowest (-14.32%) compared to other MPs. Interestingly, recreational land use deviated significantly with a CV(%) of -84.71% , whereas industrial land use showed the lowest CV(%) of 1.40% . These are the maximum and minimum CV(%) observed in all the MPs and all land use categories. The remaining land use categories in the Jaipur MP 1998–2011 also showed a considerable CV(%) including commercial (-60.02%), govt./public and semi-public (-52.38%), circulation (-33.72%) and residential (26.18%).

As observed in Surat city, Surat DP 1986–2001 showed a CV(%) of -22.35% in the overall developed/urbanised area. A significant CV(%) was observed in land use categories like recreational (-45.60%), commercial (-38.42%), residential (-36.89%) and govt./public and semi-public (26.76%). However, the industrial (-7.92%) and circulation (6.38%) land use categories showed the lowest CV(%) in the Surat DP 1986–2001. In the Surat DP 2004–2011, however, the CV(%) in the overall developed/urbanised area was highest (-47.10%) compared to other MPs.

Table 13.8 Land use CV(%) in master plans

MP/DP	Indore DP 1974–1991	Ghaziabad MP 1981–2001	Lucknow MP 1970–2001	Jaipur MP 1971–1991	Jaipur MP 1998–2011	Surat DP 1986–2001	Surat DP 2004–2011	Average land use CV(%)
Residential	-7.91	8.92	-43.83	-7.67	26.18	-36.89	-49.75	-15.85
Commercial	-12.04	-23.74	-63.38	-40.60	-60.02	-38.42	-39.08	-39.62
Industrial	-43.72	-13.97	35.43	-44.17	1.40	-7.92	-11.50	-12.06
Govt./public and semi-public	-22.65	-23.66	47.76	-16.88	-52.38	26.76	-78.82	-17.12
Recreational	-79.53	-74.41	-76.73	-47.00	-84.71	-45.60	-81.06	-69.86
Circulation	-34.92	-33.59	-45.13	-51.66	-33.72	6.38	-13.30	-29.42
Overall developed/urbanised area	-27.30	-15.48	-31.30	-24.57	-14.32	-22.35	-47.10	-26.06

The highest CV(%) in Surat DP 2004–2011 was observed in recreational (−81.06%) and govt./public and semi-public (−78.82%), followed by residential (−49.75%) and commercial (−39.08%) land use categories. Circulation (−13.30%) and industrial (−11.50%) land use categories showed less CV(%) as compared to other land use categories in this MP.

CV(%) Along the Land Use Categories

According to the CV(%) analysis results (Table 13.8), Surat DP 2004–2011 (−49.75%) and Lucknow MP 1970–2001 (−43.83%) showed maximum CV(%) in residential land use. However, in the same category, Jaipur MP 1998–2011 had a significant positive CV(%) of 26.18%, indicating higher land consumption than the proposed amount. In the commercial land use category, Jaipur MP 1998–2011 and Lucknow MP 1970–2001 observed a high CV(%) of up to −60%. The average CV(%) in commercial land use was as high as −40%, while Indore (−12%) comparatively showed a lower CV(%). In the case of industrial land use, Indore and Lucknow showed a CV(%) of −43.72% and 35.43%, respectively. Considering the case of Jaipur city, the CV(%) was as low as 1.40% for the Jaipur MP 1998–2011, whereas the highest CV(%) was −44.17% for the Jaipur MP 1971–1991. Surat (−11.50%) and Ghaziabad (−13.97%), on the other hand, showed a lower percentage of industrial land use CV(%). In the govt./public and semi-public land use findings, a high CV(%) of −78.82% was observed in the Surat DP 2004–2011, and the Surat DP 1986–2001 showed a CV(%) of 26.76%. In the same land use category, Jaipur city MP 1998–2011 showed more than −50% CV(%), followed by Lucknow (47.76%).

In the recreational land use, all the cities showed a significant amount of CV(%) of more than −45% and an average CV(%) of −69.86%, indicating that this particular land use had the highest non-conformance. In the recreational land use, Jaipur city showed the highest CV(%) of up to −84.71% in Jaipur MP 1998–2011, followed by Surat DP 2004–2011 (−81%), and cities like Indore, Lucknow and Ghaziabad had a CV(%) of more than 70%. In the circulation land use category, the highest CV(%) of −51.66% was observed in Jaipur MP 1971–1991, followed by Lucknow (−45.13%), Indore (−34.92%) and Ghaziabad (−33.59%). Surat city DPs (less than ± 14%) among the five cities show the lowest CV(%) in circulation land use. The findings suggest that the MPs have failed to get implemented in all the cities as the overall developed/urbanised area showed an average CV(%) of −26%, which is most remarkable in Surat, Jaipur, Lucknow and Indore. Among the five cities, Surat had the highest CV(%) of −47.10% in the Surat DP 2004–2011 and −22.35% in Surat DP 1986–2011. Lucknow city also showed a non-conformance of −31.30%, followed by Indore having a CV(%) of 27.30%. Jaipur city MP 1971–1991 showed a −24.57% CV(%). However, Jaipur MP 1998–2011 had the lowest CV(%) of −14.32%.

Discussion

The findings of the three analyses broadly align with each other. The master plan-wise analysis indicated with 95% confidence that the Jaipur MP 1971–1991, the Indore DP 1974–1991 and the Surat DP 2004–2011 showed non-conformance on the ground. Similar results were obtained from the CV(%) evaluation also. In the overall developed/urbanised area of the Jaipur MP 1971–1991, Indore DP 1974–1991 and Surat DP 2004–2011, a CV(%) of -24.57% , -27.30% and -47.10% , respectively, was observed. Additionally, Lucknow MP 1970–2001 (-31.30%), Surat DP 1986–2001 (-22.35%), Ghaziabad MP 1981–2001 (-15.48%) and Jaipur MP 1998–2011 (-14.32%) showed a significant CV(%) in the overall developed/urbanised area, which was not captured in the statistical analyses.

Simultaneously, urban land use category-wise analysis suggested with a 95% confidence that the commercial, recreational, circulation and overall developed/urbanised area land use categories were not implemented as proposed. Likewise, it was observed that the recreational, commercial, circulation and overall developed/urbanised area land use categories showed an average CV(%) of up to -69.86% , -39.62% , -29.42% and -26.06% , respectively (Fig. 13.3). However, the statistical analyses showed conformity in the rest of the land uses. Nevertheless, the CV(%) results suggested that a significant amount of non-conformity was present in almost all land use categories.

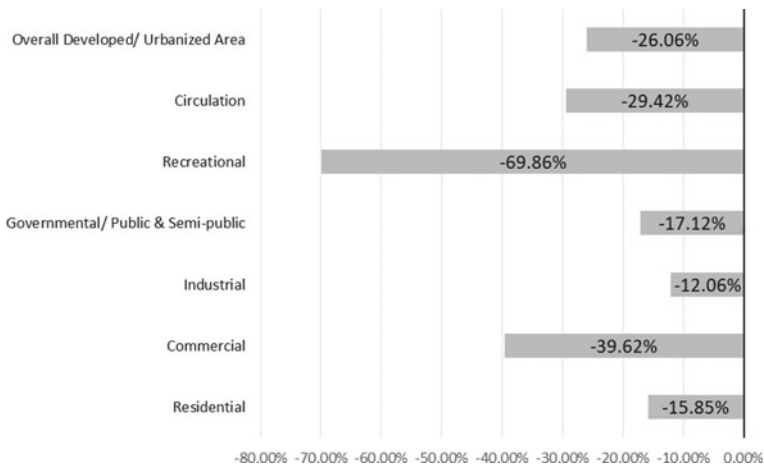


Fig. 13.3 Average CV(%) in the land use categories

Challenges/Limitations of the Study

Land use data from only five of the 11 cities in the 2–5 m population range could be collected due to the data non-availability and restrictions to provide the data from the concerned development authorities and other related departments. The willingness to make available the land use data across the cities also varied. For instance, in Indore, the land use data was simply available on the development authority website. On the contrary, in other million-plus cities, authorities were unwilling to share the data even after visiting the concerned departments. Additionally, acquiring the data for previous MPs was challenging due to the lack of ex-post plan evaluation practice. Also, it was difficult to collect data by personally visiting these departments in different cities considering the pandemic situation. However, this data limitation was handled by evaluating a sample of seven MPs from the selected five cities. Moreover, the same methodology can be applied in future with larger sample size, and statistical analysis can be performed using a paired sample t-test or z-test, depending on the sample size.

The analysis was conducted using a conformance-based evaluation, which has the limitation of not addressing attribution and causal linkages. To address this limitation, further research can be undertaken by combining performance-based and conformance-based evaluations to carry out a detailed ex-post plan evaluation.

Conclusion

The ex-post urban plan evaluation seems remarkably needful considering the amount of non-conformance identified in the land use plans. Surprisingly, MPs have been continuously prepared over the decades to guide cities' urban development and land use management without accountability for value-added outcomes. Furthermore, how do we know what happened to the plans after the exhaustive exercise of the master planning process? The research attempted to look into the answers by understanding the urban land use dynamics after the plan implementation. Land use data from seven MPs for cities with populations ranging from 2 to 5 m was collected to test the research hypothesis. The research aimed to comprehend whether or not the proposed MPs were conforming with the ground realities, which land use categories showed conformance or otherwise, and to what extent.

The findings of the research analysis were intriguing because all the MPs showed significant non-conformance, remarkably in Indore, Lucknow, Jaipur and Surat. According to the land use category-wise analysis results, the highest non-conformance was observed in recreational, commercial, circulation and overall developed/urbanised area land use categories with an average CV(%) of -69.86% , -39.62% , -29.42% and -26.06% , respectively.

Furthermore, the research findings indicate that recreational land use is poorly implemented in all cities and, as a result, requires special attention to understand the

underlying issues with implementation. Considering the increasing urbanisation, land as a limited resource must be used wisely and sustainably. Thus, by incorporating sustainable urban management strategies, we can help to provide a better quality of life and green spaces. The research findings highlight the need for ex-post urban plan evaluation and establish the presence of non-conformance between the planning proposals and the consequent ELUs. The results indicate that even with detailed land use guidelines and planning experience, concerned authorities/departments fail to implement the MPs, and the final step of the planning process, i.e. plan evaluation, remains untouched.

Overall, the results of CV(%) showed a range of (−84.71%, 47.76%), which are significant, but how substantial is a CV(%) of, say, $\pm 15\%$. So, how do we determine whether the amount of CV(%) indicates that the plan was successfully implemented or not? As there is no established definition of a successful plan, the extent of CV(%) is an important aspect that should be investigated further. The research provides a methodology to evaluate MPs by bridging a gap by introducing a statistical approach and simultaneously witnessing a noticeable amount of CV(%). Further research can be conducted on ex-post plan evaluation using multiple methods, including conformance and performance-based approaches. Moreover, the performance-based techniques would help to identify the causal linkages. To ensure that planning proposals are implemented, the role of urban planners can be expanded to monitor the development persistently and conduct ex-post plan evaluations to identify CVs(%) at various scales. The severity of non-conformance, for example, may differ at the city and local area planning levels. This will further help the urban planners to understand the areas where the development control needs to be strengthened, and the plans can be updated effectively, thereby completing the planning process cycle.

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