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RESEARCH ARTICLE

LAND USE MIXING AND URBAN INFRASTRUCTURE

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ABSTRACT

Land use in urban areas are to date being regulated within the frame work of a development plan. One of the key components of the development plan is a proposed land use plan for a target year. Zoning is now a major tool for regulation of land use in urban area. Urban structure of the city is meant to provide facilities to the people. So, either the people go to the facilities or the facilities come to the people. The former part deals with zoning concept and zoning based urban structure is transport oriented. In Indian situation, where the infrastructure is poor and the funds are scare, the concept of bringing facilities to the people sounds promising and should work. Mixed land use is one of the ways to bring in facilities to people. Rapid urbanization with increasing mixed land use character has led to various serious problems in different parts of the city. To fight these problems heavy investments have been done in research to provide basic infrastructure at a minimum cost and with minimum environmental damage with optimum level of mixed land use. This paper, analyses the mixed land use intensity with its physical, social as well as environmental impact based on studies of Cuttack city, Orissa. Different infrastructural factors influencing the mixing of land uses are also found out and the empirical relationship between them is also established by Multiple Regression Analysis Method.

INTRODUCTION

Land is the medium on which all human settlements are established. Because, the land is the medium and city the product, all city planners largely concentrate on land use planning. Urban land use is the expression of exceedingly complex influences of demand and supply that have been interacted over a long period of settlement by man. Urban structure is meant to provide facilities to the people. Land use of a city is the product of various activities in the process of habitation. Overlapping of activities in a parcel of land is a universal phenomenon in India. Organic growth has resulted in mixing of spaces needed for various activities according to people's needs and convenience. Even in areas newly developed within the framework of development plans, it has been widely observed that mixing of land use pattern has emerged.

Can urban infrastructure for mixing of land uses be used as a tool in the whole process of developing an indigenous urban structure? If yes, how to do it?

This study, based on studies conducted by author in Cuttack city, Orissa indicates a little measure to accept inevitable phenomenon of mixing of different land uses.

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How far, the concept of compatible uses be evolved and applied, which will lead to a better physical environment and take cognizance of optimum utilization of land in context of urban infrastructure ?

Problem and purpose of study

Strict segregation of land uses have little relevance to the indigenous growth of Indian cities. Some amount of mixing of land uses is desirable and even beneficial as it suits the Indian way of life where people prefer the proximity of different activities. Non-compatible mixing has undesirable effects like environmental degradation, rapid depletion of natural resources, noise pollution and other associated evils on urban development. Unregulated mixing also affects traffic pattern, infrastructure and density. On the other hand, compatible mixing of land uses contributes immensely to the physical and socio-economic processes of a good living in the city. It enables the optimum utilization of site or building at all time of the day, helps to reduce journey to work and maximizes economic returns. Hence proper planning is necessary especially in the areas with mixing of land uses character in developing cities to provide basic urban infrastructure with minimum cost and with minimum environmental damage. An attempt has been made to analyze the growth of mixing of land uses in old areas as well as new planned areas in context of urban infrastructure and in the light of analysis some urban planning implications have been reflected.

Study Area

The study area for this paper is Cuttack city in Orissa as shown in Figure 1 below, mainly a commercial city located at the bifurcation of river Mahanadi and its main branch Kathajori. It is the center of eastern Orissa. Centralization of various urban activities such as trade, commerce, administration etc. due to its ideal location enhances the importance of Cuttack and makes it a prosperous metropolis of Orissa. Like most of the Indian cities, it has an old city center with mixed land use, out-come of organic growth and developments marked by cantonments, civil lines etc. adds to serve specific functions during 19th Century and post-independence development. The area of Cuttack city within the corporation boundary is 8145.88 hectare. Of the total area, 3801.97 hectares constitute 47% land portion and rest river beds of either Kathajori or Mahanadi.

Table 1. Land-use of Cuttack City

Sl. No.	Land-use type	% with Unbanishable Area, 2001	% with Unbanishable Area, 1961
1	Residential	46.78	31.33
2	Commercial	5.99	2.91
3	Industrial	5.92	2.18
4	Public / Semi-public	20.52	6.39
5	Major Roads	5.21	1.19
6	Railway Track	2.01	0.69
7	Open Spaces	13.57	55.31

Observation

During last few decades, most agricultural lands have been converted to urban uses. So the persons who are dependent on agricultural land have changed to non-agricultural occupation.

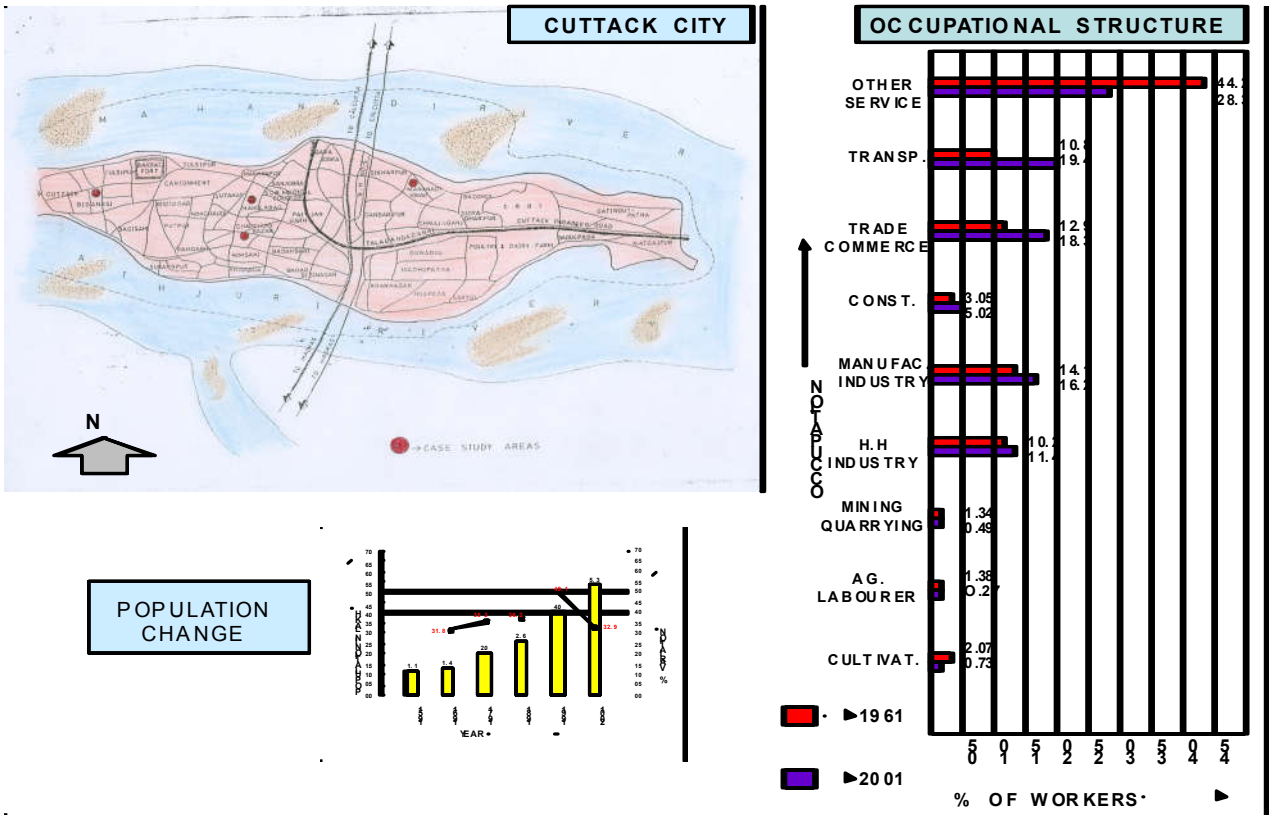
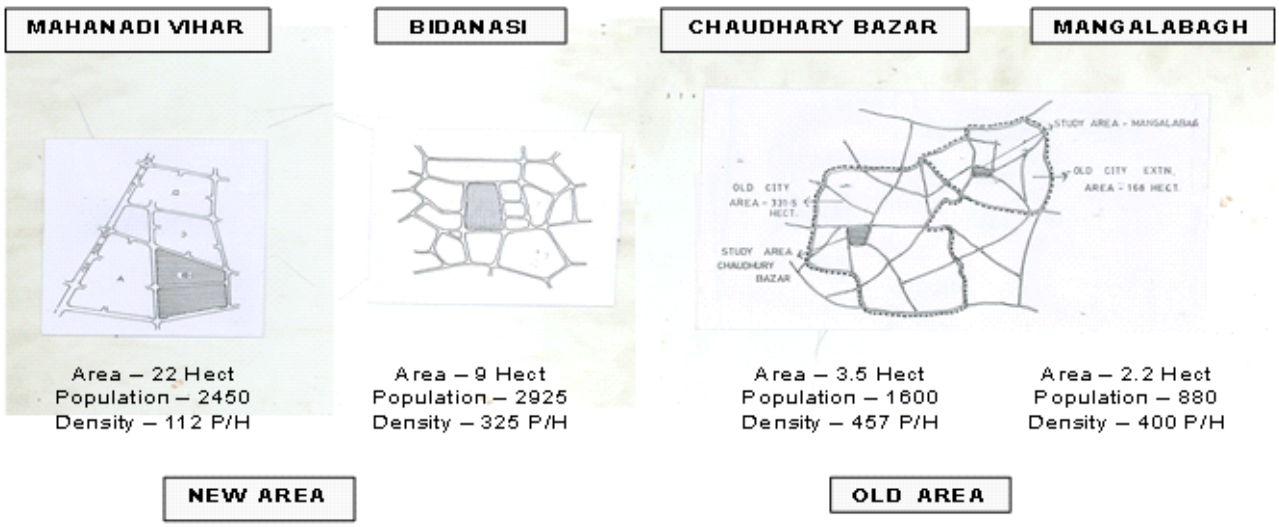


Figure 1. Cuttack City



Source-Cuttack Municipality

Figure 2. Study Areas of Cuttack

Manufacturing and house-hold industrial activities have increased. Number of persons engaged in industries have increased from 24.34% to 27.58%. The commercial activities of the city has increased owing to the emergence of Paradip as a big port. The % of workers in trade and commerce has increased from 12.86% to 18.28%. Cuttack is the district head-quarter and contains a number of educational and health institutions. In addition, there are some state level and central level Government offices. % of workers in occupations like public administration, health, education, recreational, legal and business etc. has decreased from 44.15% to 28.25%. In 1961, more than 55% of total land within Master Plan area was unbuilt and open in character, where as in 2001, only 13.57% constitute parks/open-spaces etc. Based upon the relation between type of residential activities and level of mixed land use activities, four areas have been selected for detailed study (Figure 2):

- Planned Plotted Scheme – Mahanadi Vihar
- Group-Housing / Apartment – Bidanasi
- Old City Center – Chaudhary Bazar
- Old City Extension – Mangalabagh

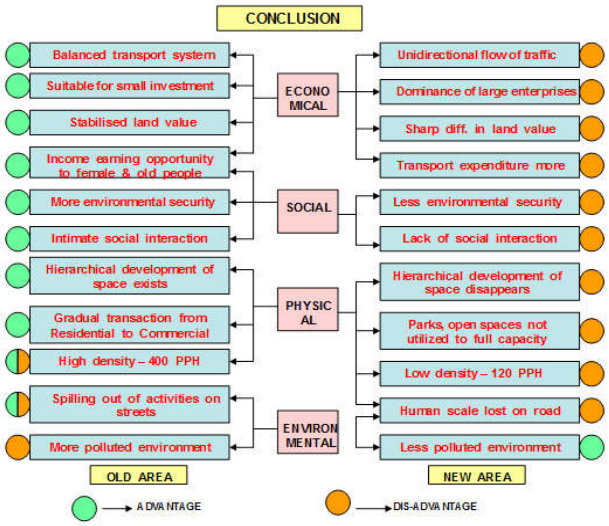
By primary and secondary survey, impact of mixed land use in certain aspects such as physical, social, economic and environmental has been found comparing the new areas i.e. group-housing and planned plotted developments with the old areas i.e. old city extension and old city centers. The following conclusions has been derived from the findings (Figure 3). Process of mixed land use development have taken place in residential colonies through conversions, gradually on internal main or peripheral roads connecting the existing major commercial node. Intensity of non-residential activities are more along transport corridors leading to market place. Lower category of non-residential uses like convenient shops are found much prevalent in low and middle income group areas. The traditional concept of organizing urban activities along pedestrian spines and the co-existence of complementary uses within proximity to each other have been validated in central area around bazaars and chowks. On street parking reducing the level of service of the network has also been developed. Social, economic, physical conditions in old area are somehow better than the new areas.

But, the environmental pollution is more in old areas, which can be controlled through proper enforcement of bye-laws, proper utilization of land and roads, establishing performance standards etc.

Analysis

The analysis pertains to four steps:

- Operationalizing the concept of infrastructure/services that is relevant to the areal unit of observation.
- Deriving significant infrastructure factors influencing land use mixing and formation of the generalized model.
- Validating the model with a new area not considered while building the model.
- Identifying the planning implications arising out of mixing of land uses in respect of infrastructure.



Source-Primary Survey

Figure 3. Impact of Mixed Land Use

Modelling Mixing of Land Uses with respect to Urban Infrastructure

The growth of mixing of land uses and infrastructure within a city are closely inter-related. It is well established that intensity of mixing is one of the major decisive factors for the infrastructural levels in a city. Though, these two are positively c0-related, the growth in infrastructure is rarely proportional to the growth of intensity of mixing. With the increasing mixing of land uses in developed cities, public agencies are not in a position to meet infrastructural requirements. As a consequence, the per capita availability of the entire range of urban services tends to decrease over time. Having analyzed the overall distribution of various kinds of urban facilities in the areas as a whole, an attempt is made to bring out the nature of the relationship between the distribution of services and intensity of mixing of land uses. Regression Analysis is the most widely used of all statistical techniques, in which, one variable is related to others so as to minimize the 'errors' between predicted and actual values of the dependent variables. The mixing of land uses is the net result of different infrastructural factors. Some are physical, some are social while others are environmental. The identification of variables is the most important step in the analytical process. There may be innumerable variables, but, only relevant ones which have considerable influence on the mixing process are taken into account. To estimate the relative influence of different factors by relative values of co-efficient, factors are graded as follows:

Physical Infrastructure Factors:

Centrality w.r.t to Rail-way Station (X_1)

Dist. from railway station (km)	Score
0 - 2	4
2 – 4	3
4 - 6	2
6 - 8	1

Road Width (X_2)

Road Width (m)	Score
0 – 5	1
5 – 10	2
10 – 15	3
Above 15	4

Time dist. from first order road (X_3)

Distance (m)	Score
0 – 200	4
200 – 500	3
500 – 1000	2
Above 1000	1

Water Supply Service (X_4)

Status	Score
Superior	4
Good	3
Satisfactory	2
Bad	1

Drainage Service (X_5)

Drain type	Score
Covered	4
Partially Covered	3
Open	2
Improper	1

Power Supply (X_6)

Supply Time (Hr)	Score
24	4
21	3
18	2
15	1

Traffic supporting infrastructure (X_7)

Status	Score
Superior	4
Good	3
Satisfactory	2
Bad	1

Solid waste management system (X_8)

Status	Score
Superior	4
Good	3
Satisfactory	2
Bad	1

Street lighting (X_9)

Status	Score
Superior	4
Good	3
Satisfactory	2
Bad	1

Telephone service/Mobile tower (X_{10})

Status	Score
Superior	4
Good	3
Satisfactory	2
Bad	1

Primary/Secondary School Distance (X_{11})

Distance from residence (km)	Score
0 – 2	4
2 – 4	3
4 – 6	2
Above 6	1

Colleges/Institutions Distance (X_{12})

Distance from residence (km)	Score
0 – 2	4
2 – 4	3
4 – 6	2
Above 6	1

Dispensary/Hospital Distance (X_{13})

Distance from residence (km)	Score
0 – 2	4
2 – 4	3
4 – 6	2
Above 6	1

Post offices/Banks Distance (X_{14})

Distance from residence (km)	Score
0 – 2	4
2 – 4	3
4 – 6	2
Above 6	1

T - test : 1

S.N	Study Area	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}
1	Bidanasi	s	*	*	s	s	*	s	s	s	s	*	s	s	*
2	Mahanadi Vihar	s	s	*	*	s	*	s	s	*	*	*	s	s	*
3	Chaudhary Bazar	s	s	*	s	s	*	*	s	s	*	s	*	s	*
4	Mangalabag	s	*	s	*	s	*	*	s	*	s	s	*	s	s

Significance Level = 0.05 s = significant * = non-significant

T - test : 2

S.N	Study Area	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}
1	Bidanasi	s	s	*	s	s	*	*	s	s	s	s	*	s	s
2	Mahanadi Vihar	s	*	*	*	s	*	s	s	*	s	*	s	s	s
3	Chaudhary Bazar	s	*	*	s	s	*	s	s	s	*	s	*	s	*
4	Mangalabag	s	s	s	*	s	*	*	s	*	s	*	s	s	*

Significance Level = 0.15, s = significant, * = non-significant

Environmental Infrastructure Factor:

Open Parks/Play-grounds (X_{15})

Status	Score
Superior	1
Good	2
Satisfactory	3
Bad	4

In the four case study areas, a random stratified sample was chosen with single plots as each observation. The last fourteen variables (X2 to X15) were taken into consideration and scored for each observation. The reason for not including first variable viz. centrality w.r.t. railway station, being that within a particular case study area, it remained constant for all observations. Regression analysis was performed with fourteen variables and individual equations in the form '$Y = A_0 + A_1X_1 + A_2X_2 + \ldots\ldots\ldots\ldots\ldots\ldots + A_{15}X_{15}$ were framed for each area, where

Y (dependent variable) =

Then, the significance of the co-efficient of such regression equations was tested by t – test. The result of the t- tests on each of the co-efficient of the regression equations for each case-study area as follows:

By taking two levels of significance for ' t ' values, it is observed that, the variables which are significant in all the cases are X_2, X_6, X_9 and X_{14}. The next step was to take all the observations from the four case-study areas and work with those variables which were significant in at least one study area. Regression Analysis was performed only with the said variables plus the first variable X_1. After framing the composite regression equation, t – tests were performed on the co-efficients of the regression equation.

The variables, which became significant in the t – tests are:-

X_2 = Road width
X_3 = Time distance from first order road
X_6 = Power supply
X_8 = Solid waste management
X_9 = Street lighting
X_{15} = Open parks and play grounds

The co-efficients corresponding to the above mentioned significant variables are (Table 2):

Table 2. Variable – Co-efficient relationship

Variable	Co-efficient
X_2	0.295
X_3	-0.289
X_6	0.143
X_8	0.132
X_9	0.207
X_{15}	-0.114

Generalized Regression Equation is

$Y = -0.76 + 0.295\ X_2 - 0.289\ X_3 + 0.143\ X_6 + 0.132\ X_8 + 0.207\ X_9 - 0.114\ X_{15}$

Validation of Model

The variables in the generalized equation were scored based on observations made during field survey in each case-study area. By substituting the above scores in the equation, the Y values were calculated for at least five different observations in each case-study area. The average Y value was then calculated. The variation of the results obtained from final model and from zonal equations for each case-study area was found out (Table 3).

Table 3. Y-value Calculation

S.N	Case-study Area	Y (zonal equation)	Y (final model)	Variation
1	Bidanasi	0.226	0.251	9.9%
2	Mahanadi Vihar	0.228	0.252	9.5%
3	Chaudhary Bazar	0.314	0.351	10.5%
4	Mangala Bagh	0.303	0.339	10.6%

The maximum of the results obtained from the final model and that from the zonal equation is 10.6%. This is sufficiently low variation in built in the model. A new area, other than the areas considered for formulation of the model, was chosen for field survey and subsequent analysis. The area chosen was Tulsipur area of North Cuttack, which is an essentially residential locality with considerable non-residential activity. The variables in the generalized equation were scores based on observations made during field survey. By substituting the above scores in the equation, the Y values were calculated for at least five different observations. The average of Y value was then calculated. The Y values were noted simultaneously from each observation during field survey and their average was calculated, yielding to result as follows:-

Y (zonal equation) = 0.219
Y (final model) = 0.244
Variation = 10.2%

Since the variation is less than 10.6%, the validity of model is indicated. Thus, the generalized equation or the overall model may be used with reasonable confidence to estimate the mixing of non-residential activity with residential land use in a particular location with respect to different infrastructural facilities provided the scoring values of the variables are known for that location.

Planning Proposals

Proposals regarding mixing of land uses in context of infrastructure may be suggested based on the relationship between dependent and independent variables in varying degrees of importance such as:

Road Width: Greater road width causes more mixing up to a certain limit due to its accessibility to the area and its contact opportunities. Road width may be increased or decreased depending on the intensity of mixed land uses desired within the residential area.

Time Distance from First Order Road: Nearer is the area to the first order arterial road, more is the mixing of land uses. So, in order to enhance the establishment of non-residential activities, the inner residential areas may be connected to the first order road. Similarly, to curb the undesirable non-residential activities from the area, the access of the area to first order road may be restricted.

Power Supply: Uninterrupted or continuous power supply initiates different types of activities which can be organized one after another leading to mixing of land uses. So, in order to regulate the amount of non-residential activities in a particular area, the power supply can be intermittent or uninterrupted as desired.

Solid-Waste Management: Solid waste management system which includes collection, segregation, transportation, processing and disposal of waste, greatly affects the mixing of land uses. So, to effectively control certain activities, solid waste management system can be encouraged or discharged with a proper limited boundary line.

Street Lighting: Street lighting with street furniture, footpath treatment and safe road crossings provide a safe and convivial urban realm for all users. Successful mixed use areas can be achieved through ensuring sufficient street lighting which will also give rise to stronger neighborhood character and create suitable environment for small investments which does not find place in specialized zones.

Open Parks & Playgrounds: From the generalized model, it is apparent that open parks and playgrounds has a guiding influence on land use mixing. Generally, the intensity of mixing is low with high amenity open space and recreation areas especially for children, which is a measure of level of urbanity. Though it may be difficult to visualize the changes in the income level of residents that may occur in a period of time, it however may be possible to identify the income group persons, who are likely to settle in some planned area by planning through the provisions of different roads, capacity and networks, community, open spaces and playgrounds, formal and informal space organization, utilities, zoning ordinances etc.

Conclusion

Mixed land use is being increasingly recognized as a development necessity. Compatible mixing contributes immensely to the physical and socio-economic processes in the urban areas. Sustainable infrastructure development serves as a rallying point for creating greater concern about the urban built environment and its long term viability. The above analysis despite various lacunae would tend to provide a suitable pattern of mixed land use development with suitable infrastructure facility which can be useful to curb excessive mixing in order to minimize the negative consequences of such mixing and to forecast possible changes in land use mixes for the future.

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