Background:

The characteristics of an urban area greatly depend upon the history of its establishment and the age old changes that it has gone through over the years. Big cities are immensely complicated agglomerations of primary and secondary groups and networks, as well as an array of economic, political, religious, cultural, and many other institutions and structures, most of them organized hierarchically (Gans, 2009). In dynamic cities, there are often drawn lines separating different ethnic and religious groups from each other. These areas often develop out of exclusion from other residential locations, giving a sense of security. As new groups join new societies, ethnic identity and ethnicities are key variables in determining their position in those new, more so for the first generation than the second, which has taken acculturation, and perhaps eventually assimilated. A network of people of the same access to scarce resources, such as jobs, informal training, short, economic opportunities that migrants need so dearly disadvantaged position owing to their command of the lack of formal training within the educational system their incomplete understanding of the new value system, discrimination by the dominant group or groups (Bruijne and Schalkwijk, 2005). In India, the caste system initially classified people on the basis of the occupational categories which changed to inheritance through birth and ultimately determined social position in society. After independence, under the Indian constitution in 1950, the creation of the constitutional categories of Scheduled Castes (SC) and Scheduled Tribes (ST) were afforded with affirmative action in the form of reservation quotas in government jobs, higher education institutions and legislative seats (Vithayathil and Singh, 2012). Wealthier groups of local societies also try to separate themselves from disadvantaged people as much as possible. This induces a self-reinforcing spiral and continuously strengthens the spatial differences within a town (Farkas, et. al., 2017). Creation of fortified upper and middle-income residential and commercial enclaves excludes the poor and marginalized and private security companies fill the gap here in security and governance.

The Ecological Approach was the most dominant and popular approach in urban sociology from the 1920s to the 1950s. However, it failed to explain the situation in many cases, thus, was later modified to Factorial Ecology. Factorial ecology is an outgrowth of social area analysis (Berry and Rees, 1969).

Statement of Research:

Research Question: "How has residential pattern influenced the urban ecology in Kolkata?"

An attempt has been made in this paper to understand the changing urban ecology of the city of Kolkata from 1971 to 2011, using the Census of India data at the ward level. The year 1971 has been chosen keeping in account that Bangladesh, now a neighbouring country of India was liberated in this year and Kolkata (the then Calcutta) observed a huge mass of population migrating to the city. The paper aims to explain the systematic differentiation on the residential pattern at the zonal level using indicators of socio-economic, demographic and housing data for small intra-city census tracts (wards). The variance in all the Census information has been explained in terms of a few chosen variables which were obtained after combining several other variables.

Data:

The study uses Census of India data as published by the Office of Registrar General and Census Commissioner of India. The data is collected every 10 years. Data for the area under the Kolkata Municipal Corporation has been considered in this study for the years 1971-2011. The study uses the ward wise PCA tables and the District Census Handbook data for the years. In 2011, the Census provides detailed ward level data of houselisting and household, in the Houselisting tables that has also been used. The year of 1971 is the year of Bangladesh Independence which observed a huge mass of population

shifting to the city of Kolkata (the then Calcutta). The city ecology has vastly changed from that time till the present. To understand this transformation, a period of 50 years has been considered.

The number of wards (Census tracts) for the city of Kolkata has greatly changed since 1971. Initially there were 100 wards in 1971 and 1981. There was an increase in the number of wards to 141 in 1991 to 2011. However, there was administrative boundary change as well as identity change of the wards over the span of 50 years, especially between 1971 and 199. Thus, inter year factor scores were not compared. However, the area was demarcated by the researcher in concentric boundaries as city centre and so on and accordingly explained in the analysis.

The Census of India data over the years have introduced new sets of quantitative characteristics (variables) over the years, thus, the factors generated do not have the same composition.

Methodology:

Factor Analysis has been used for studying the urban ecology of Municipal Corporation of the city of Kolkata for 1971-2011. The analysis has been carried out in Stata 13. With the generation of the factor scores, choropleth maps of the study area have been prepared that gives a ward level outlook of the urban ecology for the city for the individual years. Arc GIS has been used to prepare these maps.

It is important to mention that all the tables and maps have not been included in the extended abstract due to shortage of space. However, they are included in the full paper.

Factor analysis with orthogonal rotation of all factors has been used to analyze a data matrix containing measurements on ***m*** variables for each ***n*** unit of observation (wards). The method aims to:

- isolate the fundamental patterns of identifying and summarizing the common patterns of variability of the ***m*** variables in a smaller number of independent dimensions ***r*** that additively reproduces the common variance and
- examine the patterns of scores of each of the ***n*** observational units on each of the ***r*** dimensions.

Factors with Eigen values exceeding unity are considered only to be significant.

The variables for the study have been standardized to account the difference in population size among the urban units. These include: annual growth rate, population density, sex ratio, proportion of males and females below 6, percentage of SC population, percentage of ST population, percentage of slum population, literacy rate, work participation rate, and proportion of workers in sub-categories. The slum population has been introduced in 2001. The 1971 and 1991 Census of India data provides a 9 fold industrial classification of workers. The 1981, 2001 and 2011 Censuses provide a 4 fold classification of the workers, of which percentage of main workers as cultivators and agricultural labourers were combined because of their very less proportion in the urban areas. Along with the population characteristics the 2011 Census of India provide detailed characteristics of households in the ward level like, predominant material of wall, number of dwelling rooms, household size, ownership status, number of married couples living in the household, main source of drinking water, location of drinking water, main source of lighting, availability and type of latrine facility within premises, if bathroom facility available within premises, type of drainage, availability of kitchen, and assets possessed by the household and available banking facilities.

Findings:

The findings have been presented according to the Census year for the city of Kolkata. The number of wards has increased from 100 in 1971 and 1981 to 141 in 1991 to 2011. Choropleth maps showing the Factor score distribution in the city have been prepared but has not been included in this

extended abstract due to lack of space. The maps are included in the full paper. The factor scores generated at the ward level for the individual factors have been descriptively explained in the following section for each Census year. Instead of the individual wards, the scores have been explained according to location in the city.

Factorial Ecology of Kolkata (Calcutta), 1971:

The factor analysis for 1971 generated an output matrix for 4 factors that described the variables and explained 79 per cent of the total variance.

Factor	Variables significantly loaded
1	Sex Ratio (0.568)
	Proportion of SC Population (0.499)
	Proportion of Workers as Cultivators and Agricultural Labourers (0.411)
	Proportion of Workers in Construction (0.364)
	Proportion of Workers in Livestock (0.332)
	Proportion of ST Population (0.314)
	Proportion of Workers in Transport (0.156)
2	Work Participation Rate (0.989)
	Literacy Rate (0.970)
3	Proportion of Workers in Manufacturing other than in household industries (0.777)
	Annual Growth Rate of population (0.436)
	Proportion of Workers in Manufacturing in household industries (0.377)
	Population Density (0.252)
	Proportion of Workers in Mining (0.083)
4	Proportion of Workers in Other fields (0.361)
	Proportion of workers in Trade and Commerce (0.009)

The factor 1 explains a ***social groupism and workforce composition gradient***. The large peripheral wards extended towards the east, south and along the western side of the Fort William have high factor scores with more of SC and ST Population who are mainly engaged in the primary sector or as workers in transport and construction. It also shows a better female population. In this time period the city of Kolkata observed a huge influx of migrants and these peripheral wards had many refugee colonies. The core city extending from the northern stretch to the inner regions relatively housed lesser of these population thus the scores of factor 1 is relatively less in these areas.

The factor 2 is a ***literacy and work participation gradient*** which shows a high factor loading for both. The old core city has high factor 2 scores. However, ward 92 located on the south eastern part of the city estimated the highest score for factor 2. Considering that Kolkata (then Calcutta) to be an urban area there is a very high correlation between the literacy and work participation.

Factorial Ecology of Kolkata (Calcutta), 1981:

The factor output matrix of 1981generated 3 factors with significant eigen values and explained 93 percent of the cumulative variance.

Factor	Variables significantly loaded	
	Positive	Negative
1	Proportion of Workers as Cultivators and Agricultural Labourers (0.966)	Work Participation Rate (0.054)

	Proportion of ST Population (0.650)	
	Proportion of SC Population (0.649)	
	Annual Growth Rate (0.113)	
2	Sex Ratio (0.940)	Proportion of Workers in Other fields (0.011)
	Proportion of Marginal Workers (0.309)	
	Literacy Rate (0.295)	
3	Proportion of Workers in Manufacturing in household industries (0.994)	

The factor 1 explains a ***social groupism and primary workforce gradient.*** The peripheral wards in the east, south and along the western bank of river Hooghly in the city have a higher score for this factor. It can be assumed that with the inflow of more and more people in the city because of the independence of Bangladesh led to the occupancy in the peripheral ends of the city. There is a very strong correlation of the factor with proportion of cultivators and agricultural labourers. The trend shows that the SC and ST population may have been residentially segregated in the city towards the outskirts. A negative factor loading on Work Participation rate implies that these peripheral wards had a lower number of workers. The older part of the city towards the north and inner core area relatively scored less for this factor showing that relatively the proportion of SC, ST population as well as the proportions of people involved in farming are lower in these wards. The proportion of workers however is but the growth rate of population is less.

The factor 2 scores are high for the northern and southern wards of the city.

Factor 3 is a gradient of ***household industry workers***. The score is higher for most of the western and central wards of the city for the year.

Factorial Ecology of Kolkata (Calcutta), 1991:

Factor analysis for the selected variables in the year 1991 generated 5 factors of significant eigen values and explained almost 80 percent of the total variance.

Factor	Variables significantly loaded
1	Proportion of SC Population (0.901)
	Proportion of females below 6 years (0.900)
	Proportion of Workers as Cultivators and Agricultural Labourers (0.845)
	Proportion of Workers in Livestock (0.716)
	Proportion of ST Population (0.471)
2	Proportion of Workers in Other fields (0.851)
	Literacy Rate (0.615)
	Work Participation Rate (0.467)
	Proportion of workers in Trade and Commerce (0.132)
3	Sex Ratio (0.863)
	Proportion of Workers in Mining (0.635)
	Proportion of Workers in Construction (0.516)
4	Proportion of Workers in Manufacturing other than in household industries (0.369)
	Proportion of males below 6 years (0.367)
	Proportion of Marginal Workers (0.268)
	Proportion of Workers in Transport (0.132)

5	Proportion of Workers in Manufacturing in household industries (0.401)
	Annual Growth Rate of population (0.245)
	Population Density (0.114)

The Factor 1 is the gradient for ***social groupism and work force gradient***. As the previous years, the factor score is higher for wards mostly lying in the eastern and southern periphery of the city, with a few wards in the western periphery of the city also. These wards are marked with higher proportion of female child below 6 years, higher proportion of SC and ST population, higher proportion of workers in farming and in livestock. The rest of the city does not show much regular pattern of decrease in the factor scores however.

The Factor 2 is a ***gradient of literacy and work participation***. Unlike the earlier years it shows a strong correlation between proportion of workers in other fields, literacy rate, work participation rate and proportion of workers in trade and commerce. The inner city wards have greater scores for Factor 2. With higher literacy rate, there is more work participation rate and more number of workers in the tertiary sector (others). There is also a high proportion of people involved in trade. On the other hand the Factor 2 scores are lower in the peripheral wards of the southern and eastern part of the city.

The Factor 3 and Factor 4 explain a ***gradient of workforce composition and sex ratio***. The Fcator 3 scores are higher for the southern and eastern peripheral wards whereas that for the city centre and northern part of the city (old city) has relatively lower Factor 3 scores. The Factor 4 scores are higher in a central middle zone that stretches in the wards lying from the extreme western part to the eastern part without extending to the southern part of the city.

Factorial Ecology of Kolkata, 2001:

Factor analysis for the selected variables generated 4 significant factors and explained 93 percent of the cumulative variance.

Factor	Variables significantly loaded	
	Positive	**Negative**
1	Proportion of Workers in Manufacturing in household industries (0.975)	
	Proportion of Marginal Workers (0.494)	
2	Proportion of females below 6 years (0.761)	
	Proportion of males below 6 years (0.719)	
	Proportion of Workers as Cultivators and Agricultural Labourers (0.639)	
	Proportion of slum population (0.606)	
	Population Density (0.108)	
3	Sex Ratio (0.911)	Work Participation Rate (0.041)
	Annual Growth Rate of population (0.615)	
	Literacy Rate (0.505)	
4	Proportion of SC Population (0.625)	Proportion of Workers in Other fields (0.002)
	Proportion of ST Population (0.444)	

The Factor 1 is a ***gradient of worker composition***. The scores are higher for wards located in the western and northern part of the city. The scores fall gradually for the wards towards the south of the city strating from the central part itself for Factor 1.

The Factor 2 is ***socio-economic gradient***. The scores are higher for some of the peripheral wards in the western and eastern parts of the city as well as the upper central wards of the city having a high proportion of slum population. higher population below 6 years of age, higher population density, a high slum population and larger population engaged in farming.

The Factor 3 is ***axiality of literacy gradient***. The scores are higher in the southern and eastern peripheral wards of the city. The central to northern wards record relatively lower scores for this factor in 2001.

The Factor 4 is a ***social groupism and worker composition gradient***. The scores for Factor 4 is higher in the eastern, southern and western peripheral wards of the city. These have relatively higher proportion of population belonging to SC and ST population with relatively lesser proportion of workers engaged in the 'other' work category (tertiary sector). The scores are lower for the northern part of the city

Factorial Ecology of Kolkata, 2011:

Factor analysis for the year was performed on the selected variables that generated 6 significant factors that explained 89 percent of the cumulative variance.

Factor	Variables significantly loaded	
	Positive	**Negative**
1	Proportion of Dwelling Rooms 2 and Above (0.939)	
	Proportion using LPG/PNG as cooking fuel (0.886)	
	Proportion with own Kitchen (0.871)	
	Proportion with Assets (0.853)	
	Literacy Rate (0.842)	
	Proportion of Self owned Residential Houses (0.775)	
	Proportion with own bathroom facility (0.690)	
2	Sex Ratio (0.702)	Proportion with improved Drinking water sources (0.033)
	Proportion of males below 6 years (0.678)	
	Proportion of Slum Population (0.343)	
	Proportion of females below 6 years (0.325)	
	Proportion of Workers in Manufacturing in household industries (0.155)	
	Proportion using Kerosene as cooking fuel (0.123)	
3	Proportion with Semi Permanent structured Census Houses (0.922)	
	Proportion with Kutcha House Wall (0.878)	
	Proportion of SC Population (0.673)	

	Annual Growth Rate of population (0.492)	
	Proportion of ST Population (0.342)	
	Proportion with dilapidated residential houses (0.325)	
	Proportion with no Latrine (0.157)	
	Work Participation Rate (0.136)	
4	Proportion of Workers in Other fields (0.890)	
	Proportion with Closed Drainage (0.341)	
	Proportion with No Couples (0.301)	
5	Population Density (0.601)	
	Proportion with lighting with Electricity (0.564)	
	Proportion with Drinking Water facility within the premises (0.436)	
	Proportion of Couples 2 and more (0.341)	
	Proportion of Household Size 5 and above (0.167)	
6	Proportion of Workers as Cultivators and Agricultural Labourers (0.859)	
	Proportion of Marginal Workers (0.496)	

The Factor 1 is a ***gradient of housing and owned assets***. The wards in the southern, eastern and western periphery of the city have higher scores. This refers to the areas which initially saw a lot of migrants settling some 40 years before. The scores remain lower in the wards located in the central to northern part of the city.

The Factor 2 is a ***socio-economic gradient***. The municipal wards in the southern and western parts of the city have higher sex ratio, more children below 6 years of age (both sexes), higher proprotion of slum population, more workers manufacturing in household industries and more population using Kerosene as fuel for cooking. The scores are relatively lower for the extreme northern areas and the inner central wards.

The Factor 3 is ***axiality of social groupism and housing gradient***. The eastern, southern and the central wards of the city have more semi-permanent houses, more of kutcha house walls (made of mud, bamboo, polythene, wood, stone etc.), more proportion of the minority population of SC and ST, more of dilapidated houses, higher annual growth rate than general population, with no latrine and more work participation. The scores lower out towards the northern and north eastern wards of the city.

The Factor 4 is a ***gradient of familism and work-force composition.*** The upper central and northern wards of the city have highest scores for this factor. These are the oldest parts of the city. Most of the households have no couples i.e. bachelors working in the tertiary sectors. The scores are lowest for the wards in the western periphery of the city.

The Factor 5 is a ***gradient of familism and housing***. The scores are highest for wards located in the older part of the city i.e. upper central portion of the city. The scores decrease as one move southwards.

The Factor 6 is a ***workforce composition gradient.*** The wards in the peripheral west and lower central parts of the city have higher proportion of people engaged in farming, thus, having greater share of marginal workers (workers working less than 6 months a year). The scores are less in the peripheral northern wards of the city.

Discussion and Conclusion:

The urban ecology of Kolkata over the years has changed. The historical event of the Bangladesh Independence influenced a lot of cross border migration to the city. The migrated population generally settled in the southern, eastern and western parts of the city. The central and northern parts of the city are the older parts of Kolkata. The changing urban ecology from 1971-2011 show a change in the type of workforce composition. People initially engaged in primary activities like agriculture has shifted to manufacturing or tertiary activities (others). Also, there has been significant improvement in literacy and after 2001 the southern and eastern parts of the city have higher literacy rates than the inner core city. But, it is evident from the analysis that residential segregation prevails in the city of Kolkata more in terms of social classification as on the basis of caste (SC and ST) than in terms of economic quintile (slums). The southern, western and eastern parts of the city have higher proportion of SC and ST that affects many aspects. According to the factorial ecology of 2011, better housing conditions prevail in the northern part of the city, but assets owned and housing conditions are better in the southern and eastern parts. Occupation, education, social status, type of household and family composition, household conditions and assets owned are found to be responsible for the urban ecological classification of the city.

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