Application of Principal Component Analysis (PCA) to Determine the Catalysts and Hurdles for Efficacious Local Area Planning

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Abstract— **While variables of participatory approach to urban planning been studied since long, many planners and researchers have often deserted the preliminary study of the variables acting as catalysts and hurdles for the implementation of local area plans. This paper adopted the principal component analysis (PCA) to assess variables by finding out the level of redundancy among them from the correlation matrix and grouping indicators with higher similarities into the same factors. We then estimated the unrotated and rotated factor loadings with PCA method. Results from the PCA were acceptable since we obtained extreme loadings after the varimax rotation. The results identified factors in terms of important hurdles and catalysts responsible for successful local area planning.**

Keywords— Principal Component Analysis, Local Area Planning, Participatory Approach

I. INTRODUCTION

Irrespective of the discomforts, constraints, difficulty, and cost, particularly in intricate, heterogeneous and advanced 21st-century cities, participatory local level planning as an approach, keep on drawing our attention as a resolution. The major intent and relevance of public participation at local level is identification of needs and concerns at local level to facilitate the institutions that are important for effective decision-making and urban development (Nabatchi, 2012). There are various models of planning at local level practiced across the world on a time line (Kathlene, 1991). Besides, there are numerous studies that focus on different forms of participatory plans, factors stimulating and inhibiting stakeholder's initiatives, impact of stakeholder's participation on final decisions, thereby yielding plentiful indicators that may have direct or indirect impact on the formal decision making administrative machinery (Lane, 2005; Lowndes et al., 2001). This often raises a question on the relevance of these indicators in terms of real time local level planning for urban management. There is no research study on the determination of critical catalysts and hurdles in successful implementation of local area planning mechanisms. The purpose of this study is to apply principal component analysis (PCA) technique for identifying keys factors (Bryant & Yarnold, 1995) out of many that are identified through literature review, that are expected to have impact on the efficacious local area planning in the ward context. The study is based on perception of local people of one ward of Delhi. Hauz Khas, ward no. 164, is selected randomly for the purpose of conducting a pilot study.

To facilitate the study, PCA technique is used since it is considered to be one of the statistical multivariate methods based on eigenvector decomposition, which consolidates the variables in which there is interrelated smaller number of principal components (Jolliffe, 2002). These principal components are visualized, while holding the variation exhibited in the data set, as far as possible (Sratthaphut, et al., 2017). The subsequent section elaborates the methodology of the study.

II. METHODOLOGY

This study is based on the exploratory PCA of self-reported data. PCA was carried out to determine the strength of the correlation between variables pertaining to hurdles and catalysts for local area planning. As reported earlier, ward Hauz Khas, ward no. 164, is selected for the pilot study. Population of the selected ward is approximately 38000 (calculated based on electoral data, 2017, Election Commission of India). The sample size is calculated to be 380, with the confidence level of 95%. It is intended to constitute an unbiased sample of local people. The term "Local people", mentioned in the paper, refer to residents, shopkeepers (formal and informal), visitors and members of resident's welfare associations. The composition of the sample is illustrated in the Figure 1.

Figure 1: Composition of sample respondents in ward Hauz Khas.
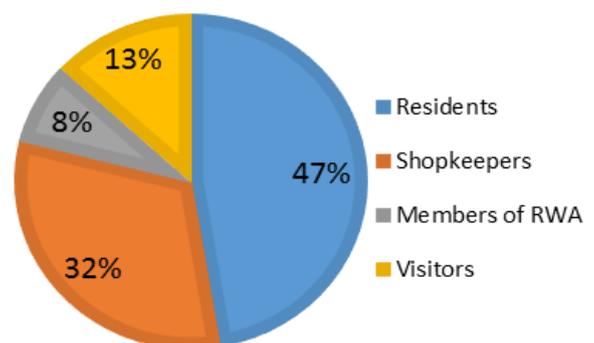
The ward houses one unauthorised colony, part of two urban villages and eight planned colonies, which have approved layout plans. The authors have attempted to make representation of samples from each of the typology of the

settlements. Besides, Figure 2 illustrate the characteristics of the sample in terms of gender, age structure and education level.

Figure 2: Characteristics of Samples in Ward Hauz Khas
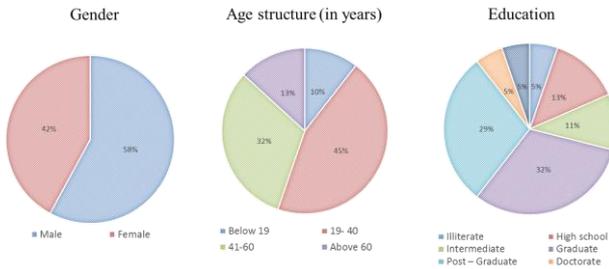
Since this is a perception based study; a questionnaire based study was conducted to evaluate the perception, attitude and feedback of the respondents. The questionnaire was constructed based on identified indicators through literature review (Fraenkel & Wallen, 2006) that affect local area planning mechanisms (Alan Walks, 2011, Amado M.P, Amado et al. 2009, Castelloe, P. et al. 2002, Chado, J., & Johar, F. B. 2016, Chado, J. et al. 2016, Frediani, A. A. 2015, Garcia-Zamor, J. C. 2012 Healey, P. 1992, Kathlene, L., & Martin, J. A. 1991, Marzuki, A. 2015, Poplin, A. 2012, Stewart, T. R. et al. 1984 and Wilson K, et al. 2015) as shown in Table 1. Subsequently, the questionnaire was divided in 3 sections, namely, Section 1- Role of Government, Section 2- Willingness of stakeholders, Section 3- Role of technology. All the sections were further divided under the two categories – Hurdles and Catalyst. A five-point adjectival ordinal scale was used to measure the responses (Strongly Disagree = 1, disagree = 2, Neutral=3, Agree =4, Strongly Agree = 5).

After created the survey instrument, the validity and reliability was tested. Validity and reliability are interwoven as until a measure is reliable, it cannot be said to be valid. Cronbach's alpha is used to assess the reliability, or internal consistency. Cronbach's alpha is computed by correlating the score for each scale item with the total score for each observation (usually individual survey respondents or test takers), and then comparing that to the variance for all individual item scores.

III. RESULTS AND DISCUSSION

A list of 22 indicators is shown in Table 1. These were divided in three categories. Section 1 included behavioural indicators, section 2 encompassed of policy related indicators and section 3 comprised of technological indicators. The indicators under each section are further divided as hurdles and catalysts, as identified from Literature. In the table 1, Section is denoted by "S", Hurdles are denoted by "H" and Catalysts are denoted by "C".

Table 1: List of Identified indicators of Local Area Planning.

S. No	Code	Indicator
1	S1_H_1	MCD initiatives for development at local level are not satisfactory.
2	S1_H_2	Local People are not given opportunity to share their viewpoint with respect to development of your locality in any case.
3	S1_H_3	MCD is biased towards rich and influential.
4	S1_C_1	Core function of MCD is Planning and monitoring of local areas
5	S1_C_2	The prime focus of MCD should be Service delivery
6	S1_C_3	MCD should act as a link between people and state.
7	S2_C_1	Local residents wish to participate in decision making at local level.
8	S2_H_1	Illiteracy is the reason for reluctance for participation in decision making.
9	S2_H_2	People do not participate in plan making due to lack of awareness
10	S2_H_3	People think it to be waste of time and energy
11	S2_H_4	People believe that their inputs will not be incorporated in the plan.
12	S2_H_5	People have lost trust on local authorities
13	S2_C_2	People are bothered about the development of their locality.
14	S2_C_3	Local people are ready to pay minimum amount for development of local areas, beyond taxes.
15	S3_C_1	Consumerist method is the most adopted means of public consultation (complaints and suggestions).
16	S3_C_2	People are more comfortable with conventional methods of participation.
17	S3_C_3	Technology is more widely accessible to citizens through internet, smartphone applications, and social media.
18	S3_H_1	IT illiteracy of the government officials is the reason for reluctance in adopting technology.
19	S3_H_2	IT illiteracy of the masses is the reason for reluctance in adopting technology.
20	S3_C_4	Cost of adopting technology for public participation is not high.
21	S3_C_5	Access to technology facilitates adoption of technology for participation.
22	S3_H_3	Technology is not adopted for decision making due to Behavioural issues

Next, Cronbach's alpha is calculated to measure the reliability of the variables in the questionnaire. It is recommend to have a minimum α coefficient between 0.65 and 0.8 (or higher in many cases); α coefficients that are less than 0.5 are usually unacceptable (Cortina J., 1993). The literature suggests that in case based heterogeneous questions, alpha should be calculated for each case, for efficacious results (Cohen, 2010). Therefore, Cronbach's alpha value is calculated for each section of the questionnaire to check the consistency. The results are as below in Table 2:-

Table 2: Results of Cronbach's alpha

Abbreviation	Sections of Questionnaire	Cronbach's Alpha
S1_H	Section 1: Hurdles	0.751
S1_C	Section 1: Catalysts	0.814
S2_H	Section 2: Hurdles	0.691
S2_C	Section 2: Catalysts	0.706
S3_H	Section 3: Hurdles	0.717
S3_C	Section 3: Catalysts	0.703

Cronbach's alpha values showed fair to good internal consistency in all the three sections. This means that the questionnaire is reliable and good to proceed for PCA.

As a first stage to PCA, the sampling adequacy can be assessed by examining The Kaiser-Meyer-Olkin (KMO) (Kaiser 1970). KMO varies between 0 and 1. The values closer to 1 are better and the value of 0.6 is the suggested minimum. This test provides the minimum standard to proceed for Factor Analysis. Normally, $0 < KMO < 1$. If, $KMO > 0.5$, the sample is considered to be adequate (Hair, Anderson et al. 1995a). Section 1 and 2 show, $KMO > 0.5$, which indicates that the sample is adequate and we may proceed with the Factor Analysis. Bartlett's Test of Sphericity was also applied. Bartlett's test of Sphericity provides a chi-square output that must be significant (Bartlett 1950). Taking a 95% level of Significance, the results are 0.05. The p-value (Sig.) of .000 < 0.05, therefore the Factor Analysis is valid. Since the results of section 3 shows that the matrix is not positive definite, the KMO and Bartlett's Test table was not showing in Statistical Package for the Social Sciences (SPSS) software. The PCA results are nevertheless valid (Ulanowicz, 1986). Therefore, Factor Analysis is considered as an appropriate technique for further analysis of the data. Details of 1 section are elaborated and similarly results for other two sections are obtained.

Table 3 shows Eigen values of section 1. This is one of most fundamental and most useful concepts in linear algebra. To explain further, if n × n matrix is called A, then A scalar λ is said to be a eigenvalue of A. The vector x is called an eigenvector corresponding to λ. Eigen Values >= 1 were only selected in the SPSS.

Table 3: Eigen values of Section 1

Total Variance Explained

| Comp	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.596	43.265	43.265	2.596	43.265	43.265	2.576	42.935	42.935
2	1.983	33.044	76.309	1.983	33.044	76.309	2.002	33.375	76.309
3	.712	11.865	88.174						
4	.326	5.433	93.606						
5	.229	3.822	97.428						
6	.154	2.572	100.000						

Extraction Method: Principal Component Analysis.

In the present section, only the 2 factors were extracted by combining the relevant variables. The Eigen values are the variances of the factors. The total column contains the Eigenvalue. 2 factors are extracted by combining the relevant variables. The first factor always accounts for the most variance and hence has the highest Eigen values. The next factor will account for as much of the left over variance. Each factor is constituted of all those variables that have factor loadings greater than 0.5. The percentage of variance represents the percent of total variance accounted by each factor and the cumulative percentage gives the cumulative percentage of variance account by the present. In this section, the first 2 factors explain 76.309% of variance.

The scree plot graphs the Eigenvalue against the each factor. The graph shows that after factor 2 there is a sharp change in the curvature of the scree plot. This shows that after factor 2 the total variance accounts for smaller and smaller amounts. (Reference Figure 3)

Figure 3: Scree Plot- Section 1
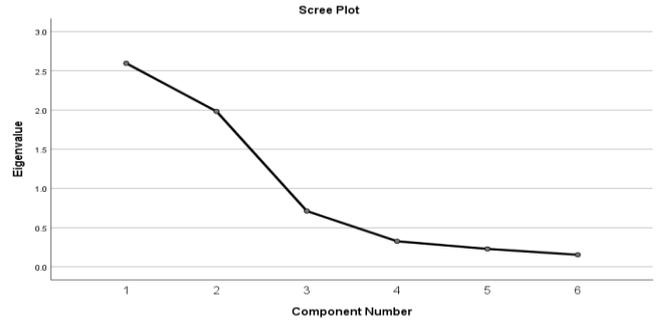
Identification of the Core Factors

The Rotated Factor Matrix characterises the rotated factor loadings demonstrating correlations between the variables and the factors as shown in Table 4. The factor column denotes the rotated factors that have been mined out of the total factor. These are the core factors, which have been used as the final factor after data reduction.

Table 4: Rotated Component Matrix- Section 1

Codes	Rotated Component Matrix^a	Component	
		1	2
S1_H_1	MCD initiatives for development at local level are not satisfactory.	-.130	**.879**
S1_H_2	Local People are not given opportunity to share their viewpoint with respect to development of your locality in any case.	.016	**.873**
S1_H_3	MCD is biased towards rich and influential.	.051	.683
S1_C_1	Core function of MCD is Planning and monitoring of local areas	.904	-.005
S1_C_2	The prime focus of MCD should be Service delivery	.932	-.034
S1_C_3	MCD should act as a link between people and state.	.933	-.007

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

The factors are grouped and each group of factors is named which is the representation of the grouped factor. Two factors explain the variance in performance of the variables in section 1. Similarly, factors in section 2 and 3 were also identified. Results of Principal Components Analysis (PCA) of Section1, 2 and 3 are showed below in Table 5.

Table 5: Identified Significant Factors in Section1, 2 and 3- Catalysts and Hurdles

S.no	Factors	Description of the factor
POLICY FRAMEWORK INDICATORS		
1	S1_H1	People at local level are not satisfied with the MCD services and feel deprived of opportunity to participate in the decision making for development of their locality.
2	S1_C1	MCD should be dedicated to deliver and monitor services, thereby realizing the needs/problems of the people at local level and extending them to state for prompt resolutions.

BEHAVIOURAL INDICATORS

3	S2_C1	Literate local residents are willing to participate in the decision-making for development of the locality.
4	S2_H1	Lack of awareness is the reason for non- participation of people at local level.
5	S2_H2	People perceive public participation to be waste of time and energy, since their inputs are not considered while planning for local areas.
6	S2_H3	People are concerned about development of their locality but have lost trust on ULBs, because of their past experiences.

TECHNOLOGY INDICATORS

7	S3_C1	People are comfortable with conventional methods of participation but are ready to adopt the technology through various means.
8	S3_H1	IT Illiteracy and reluctance of the officials to adopt the new means of participation strategy are the reason for not adopting technology.
9	S3_C2	People are ready to adopt technology as it is cheap and accessible.

IV. CONCLUSION

This paper aimed to investigate into various attributes related to local area planning. PCA technique is the powerful choice for the determination of most significant factors which acts are hurdles and catalyst for implementation of Local Area Plans. 22 indicators as shown in Table 1 were identified from literature. 11 indicators were pertaining to hurdles and 11 refer to the catalysts to local area planning mechanism. Subsequently, the number reduced drastically to 9, where 5 indicators point to hurdles and 4 point toward catalysts for successful implementation for local area planning mechanisms in the ward context. In addition, this conclusion is also useful for policy makers and practitioners in highlighting these attributes to refine adaptable local area planning framework in order to achieve sustainable solution to urban development at local level. This work can be extended to investigate whether these indicators are correlated with the characteristics of different wards in Delhi and its adjoining cities.

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