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Factors Discriminating Entitlements to Water Supply: Empirical Evidence from Urban Household Survey in Cuddalore District, Tamil Nadu, India

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This paper explores the factors discriminating entitlements to water supply among the different type of urban regions at the household level through the multivariate linear discriminant function model. It presents three empirical evidences from the analysis as follows: (i) Institutional, access, personal and economic factors are principal to discriminating the entitlements to water supply among the urban regions of the study area. (ii) Particularly, institutional and access parameters play a vital role to discriminate slum region from developed and moderately developed regions. On the other hand, personal and economic parameter bifurcate the moderately developed region from the developed region. (iii) Among the different factors, the role of institutional and access factors are more significant to discriminate the entitlements to water-supply as compared to personal and economic factors. Thus, the study suggests that the relaxation in rules for piped water supply connection, introduction of new policies for controlling the market based water supply and managing ground water are indispensable to attain the equality in water access in urban regions.

Keywords: *Entitlements, Water supply, Discriminant, Urban regions*

I. INTRODUCTION

Water forms the lifeline of urban society and has pervasive links to most aspects of urbanisation and economic development. Thus, provision of safe drinking water to the urban households is a high agenda of the Government policy. In this context, the concept of water as a 'Human Right' emerged as a discourse at the national and international level. As a result, the Supreme Court of India has announced that the access to clean water is a fundamental right and enacted under Article 21 of the Constitution of India (Ramachandraiah, 2001: 619). United Nations Committee (2002:3) on economic, social and cultural rights has enforced the concept "right to water". It stresses the importance of water entitlements in terms of adequacy, protected, standardised, easy to access and cheaper water for individual and household uses.

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The concept of entitlements approach has a protracted history in the discipline of social science, starting from John Locke in the seventeenth century to the Libertarian American philosopher Robert Nozick and renowned economist A.K.Sen in the twentieth century (Pulin, 1989:PE2). Nozick employed a moral usage of 'entitlement' in his widely debated "Anarchy, State and Utopia" (Gasper, 1993: 689). Sen used the entitlements concept to focus his analysis on famines in West Bengal, where the failure of entitlements to cover up survival needs was put forth as the key cause of starvation and death (Sen, 1976: 1273-80). Though, the present study applied Sen's entitlements approach. A number of inter-related concepts were put forward by Sen in his analysis. An individual's resource possession includes physical, labour, societal representation, knowledge and skill. A person's effective legitimate command (i.e., the set of commodity bundles that can be legally attained by using one's set of resources and opportunities) is his/her entitlement. E-mapping refers to the relation that specifies the set of possible commodity bundles that are legally attainable from any given set of resources, through trade and/or production.

Thus, it reflects the rules, conditions, and processes, which affect how one's entitlements are derived from one's set of source. Types of possession/acquisition/claim that are deemed legitimate in a given case are determined by rules of entitlement such as legal rights concerning private ownership of goods and factors of production plus other social rights. Following Sen's formulation of entitlements in the context of famines, there are now several extensions to entitlement analysis applied to issues ranging from privatisation, households, and environment. There have also been a few attempts to apply Sen's entitlement approach to understand inequality in access to water supply in urban households (Webb and Iskandarani, 1998: 5, Anand, 2001: 5, 2004: 115-132, 2007: 47).

In India, urban governments are responsible for urban domestic water supply. The administration of local body follows institutional set up for water supply connection. This institutional arrangement follows some standard protocols which include authorisation of town planning, location of the household (planned and unplanned urban limit), ownership of house and plot (NIUA, 2000: 85). In addition, the slum households avert to own self taps due to huge amounts for connection deposit and connection charges. Similarly, the poor economic status of the households prevents in extracting ground water sources like hand pump and borewells. Further, overexploitation of ground water and contamination of ground water have paved the path for market sources of water supply and leads to a high price of water retailing practices which affect the poor urban households.

With this background, the present study analyses the entitlements to water supply and factors discriminating entitlements to water supply at the household level in sort of urban regions of the Cuddalore District, Tamil Nadu.

II. APPLICATION OF SEN'S ENTITLEMENTS APPROACH FOR ANALYSING INEQUALITY IN WATER ACCESS

The issue of inequality in water access is similar to Sen's entitlement approach. Sen's approach to "famine and starvation" states that "starvation is the characteristic of some people not having enough food to eat and it is not the characteristic of all not having enough food to eat" (Sen, 1981: 1). Similarly, the problem of water access and supply is that some people are not having enough water rather than all not having enough water (Anand, 2001: 3-5).

There are similarities between water insecurity and food insecurity. Some of the famines and highest level of malnutrition have taken place without any noticeable change in food supply (Sen, 1986: 18-19). For the same, the households face shortages of water, while the households of adjoining regions have enough water not only to meet their household needs but to keep their surroundings green, clean and their water tanks and sumps are filled up. In this context, Sen's entitlements approach is applied to analyse the entitlements to water supply in the study regions.

The entitlements approach explains the obvious paradox of hunger in the midst of plenty. Entitlements can be thought of as the set of alternative commodity bundles that can be acquired through the use of various legal channels. It refers to the ability of people to secure goods or service through a purchase (an exchange entitlement) or through a legally recognised and enforceable claim on a provider (a service entitlement) (UNDP, 2006: 80).

For a country like India, water supply is the prime duty of the state. At the same time, water access in urban regions is determined by a different type of water supply sources such as public, self and market and its combinations. Water is largely required item for daily needs. Thus, the households have to arrange through multiple sources within the limitations. This is considered as endowment portion as compared to exchange entitlements which decide the quantity of water that an individual accessed in the existing setup. In this situation, the application of endowment is more comprehensive than the concept of exchange entitlements for analysing entitlements to water supply in the urban regions. Thus, the present study analyses the entitlements to water supply by estimating water endowments per head (lpcd) (Anand, 2001: 20-25).

III. REVIEW OF LITERATURE

The research of entitlements to water supply is a recently emerged topic in the area of urban water to measure the inequality in water access. It is considered as a measuring road instead of regular tools for measuring status of water access. Hence, the studies of entitlements to water supply in urban households are meagre. The idea

of entitlements to the urban water supply was articulated and discussed by Webb and Iskandrani (1998:5) at the policy level in connection with slum households'. It recommends research on improved policy design and action. Anand (2001: 20-25) examines the inequality in water access at the metro city level by following Sen's entitlements approach. It concludes that the entitlements approach is the unique and suitable technique to study and measure the inequity in access and urban water supply mechanism.

Study on political economy of water scarcity and issues of inequality, entitlements and identities in Chennai and Cauvery delta area finds that various institutional forces and motivations are the major factors to influence the problem of water scarcity in southern India (Anand, 2004: 115-132). Further, the policy analysis of India's progress in drinking water supply in the context of Millennium Development Goals reveals that the introduction of entitlements based indicator is an alternative tool to assess the problem of inequality in access (Anand, 2007: 47-50).

The overview of the literature clarifies that studies have examined the entitlements to water supply at the theory and empirical level. These studies have failed to identify the factors discriminate the entitlements to water supply among the different sort of urban regions. Thus, the research gap opens the new scope to study the factors discriminating entitlements to water supply in urban regions at the household level.

IV. MATERIALS AND METHODS

In order to analyse the household's entitlements to water supply and factors discriminating entitlements to water supply in different sort of urban regions, the study adopts area sampling for district selection and disproportionate stratified random sampling for selecting the sample households.

At the first stage, Cuddalore district is selected for the following reason: the water supply performance of the municipalities in Cuddalore district is below the average at the state level according to the Tamil Nadu Water Supply and Drainage Board Assessment - 2009 (accessed from Tamil Nadu Water Supply and Drainage Board, Cuddalore Dt. Office). Therefore, Cuddalore district is selected for the study. At the second stage, all five Municipalities (Cuddalore, Chidambaram, Virudhachalam, Panruti and Nellikuppam) of the District are selected.

In the third stage, wards of the municipalities are classified into 'slum', 'moderately developed' and 'developed regions'. The slum region is identified according to the Slum Area Act - 1956. Areas where buildings are unfit for human habitation, overcrowding, narrowness of streets, lack of ventilation, and inadequacy in basic urban services are considered as a slum region. The expansion area of the municipality and recently developed residential areas are considered a moderately developed region. Regions

emerged from the beginning of municipality or regions in the central part of the urban area are considered developed region. In each municipality, 60 sample households are randomly selected from a slum (20 households), moderately developed (20 households) and developed regions (20 households). In total, 300 households are selected for the survey by using the pre-tested and structured interview schedule.

The interview schedule contains the information of personal and economic characteristics of the respondents, institutional and access to water supply parameters. In order to avoid bias, the data collection was completed during the normal season of 2015/16. The percentage analysis and table presentation are used to explain the water endowments from different water supply sources. The Multi-variate Linear Discriminant Function Model is adopted to find out the factors discriminating the entitlements to water supply among the different types of urban regions.

The total number of family members in the surveyed household population is 1486 (slum: 486; moderately developed region: 494 and developed region: 506) Average family size of the study area is five. The slum households are located in unplanned urban limits and the location of moderately developed and developed households comes under the planned urban limits. In the study area, there are three major sources of water supply namely self, public and market. The self-water supply sources refer to the water supply sources which are available within the premises of the households (own ground water sources and municipal piped water supply connection). The public borewells, public hand pumps and municipal taps are the major public water supply sources. The packed water and water supplied by tankers are the important mode of private or market water supply sources. However, households used different combinations of water supply sources which are availed in the study region.

V. WATER ENDOWMENT FROM VARIOUS WATER SUPPLY SOURCES

A water endowment from various water supply institutions is presented in Table 1. Here, the coefficient of variation is calculated to identify the variation in water endowments from various institutions and different regions. On average, the water endowment from self-institution is 130 litres, 49 litres in public institutions and 104 litres in a combination of various water supply institutions. In the study area, the coefficient of variation is huge in public institution (59.61) as compared to self (41.48) and combination of various water supply institutions (53.26). The users of self and combination of various water supply institutions are able to attain somewhat higher water endowments than the public source users. Therefore, there is a wide variation in water endowment from public institutions.

Table 1
Water Endowment (LPCD) from Various Water Supply Sources

Sl. No.	*Sources*	*Urban Regions*			*All*
		Slum	*Moderate*	*Developed*	
		(n=100)	*(n=100)*	*(n=100)*	*(N=300)*
1.	Self	49 (103.52)	154 (32.72)	123 (31.17)	130 (41.48)
2.	Public	44 (67.94)	65 (33.00)	67 (21.65)	49 (59.61)
3.	Combination	63 (64.96)	98 (45.76)	129 (43.56)	104 (53.26)
Total		51 (70.63)	107 (49.03)	126 (41.90)	95 (60.40)

Note: Figures in parentheses represent Coefficient of Variation

Source: Computed

In the slum region, the average water endowment accounts 49 litres from self, 44 litres form public and 63 litres from a combination of various water supply institutions. Among the different institutions, the coefficient of variation is more in self water endowment (103.52) than in public (67.94) and combination of various water supply institutions (64.96). The variation implies that the variation in ownership of self water supply sources. As a result, the households with more than one source enjoying the huge water endowment than that of single source users.

The households of the moderately developed region received 154 litres from self, 65 litres from public and 98 litres from a combination of various water supply institutions. Here, the coefficient of variation is greater in the combination of various water supply institutions (45.76) as compared to self (32.72) and public (33.00). The variation in the combination of various water supply institutions informs that the water endowment from a combination of various water supply institutions is determined by the number of water supply sources and the same trend could be noticed in the developed region.

As a whole, the average water endowment in the study regions is 95 litres and it is 51 litres in the slum region, 107 litres in the moderately developed region and 126 litres in the developed region. Among the different regions, the coefficient of variation is huge in the slum (70.63) as compared to moderately developed (49.03) and developed regions (41.90). The coefficient of variation shows that the variation in water endowment is higher in a slum than in moderately developed and developed regions. It explains the inequality in water endowment and the impact of institutional factors in the surveyed urban regions.

VI. HOUSEHOLD INCOME AND OVERALL WATER ENDOWMENTS

In order to explore the inequality in water access, the present venture analyses income and water endowments of the surveyed respondents. Based on the categorisation of Below Poverty Line (BPL) and taxable income, the income groups are classified as low (up to Rs. 60,000), middle (above Rs 60,000 and up to Rs 1, 50,000) and high (above

Rs 1, 50, 000). Water endowments in terms of litres per capita per day are classified as 0 - 30 lpcd, 31 - 60 lpcd, 61 - 90 lpcd, 91 - 120 lpcd, 121- 150 lpcd, 151 - 180 lpcd, 181 - 210 and above the 210 lpcd Per capita overall water endowment according to income groups is presented in Table 2.

In total, 12.67 per cent of the households are endowed between 0 - 30 lpcd and majority of them belong to low and middle income households of the slum and moderately developed regions. The same trend could be seen in the category of 31 - 60 lpcd. The households endowed 61 - 90 lpcd are found more in the middle income households. Water endowment between 91 - 120 lpcd is accessed by 13.67 per cent of the households and most of the beneficiaries are in the middle and high income groups of moderately developed and developed regions and a few in the slum. The same trend could be noticed in the categories of 121 - 150 lpcd and 151 - 180 lpcd. The water endowments of 181 - 210 lpcd and above 210 lpcd are enjoyed by the middle and high income households of moderately developed and developed regions. However, the beneficiaries of the developed region are high as compared to the moderately developed region.

Table 2
Income Groups and Overall Water Endowments (Lpcd)

Sl. No.	*Category of Lpcd*	*Urban Regions*								*All (N =300)*
		Slum (n=100)		*Moderately Developed (n=100)*			*Developed (n=100)*			
		Low Income	*Middle Income*	*Low Income*	*Middle Income*	*High Income*	*Low Income*	*Middle Income*	*High Income*	
1.	0 - 30	27	9	1	0	0	0	0	1	38
		(32.14)	(56.25)	(3.13)	(0)	(0)	(0)	(0)	(2.86)	(12.67)
2.	31 - 60	28	3	11	7	0	3	7	0	59
		(33.33)	(18.75)	(34.38)	(17.07)	(0)	(30.00)	(12.73)	(0)	(19.67)
3.	61 - 90	18	1	13	14	2	4	11	1	64
		(21.43)	(6.25)	(40.63)	(34.15)	(7.41)	(40.00)	(20.00)	(2.86)	(21.33)
4.	91 - 120	5	3	3	7	3	0	9	11	41
		(5.95)	(18.75)	(9.38)	(17.07)	(11.11)	(0)	(16.36)	(31.43)	(13.67)
5.	121 - 150	3	0	3	3	7	0	10	7	33
		(3.57)	(0)	(9.38)	(7.32)	(25.93)	(0)	(18.18)	(20.00)	(11.00)
6.	151 - 180	2	0	0	1	6	0	8	5	22
		(2.38)	(0)	(0)	(2.44)	(22.22)	(0)	(14.55)	(14.29)	(7.33)
7.	181 - 210	1	0	1	8	8	0	3	7	28
		(1.19)	(0)	(3.13)	(19.51)	(29.63)	(0)	(5.45)	(20.00)	(9.33)
8.	Above	0	0	0	1	1	3	7	3	15
	210	(0)	(0)	(0)	(2.44)	(3.70)	(30.00)	(12.73)	(8.57)	(5.00)
Total		84	16	32	41	27	10	55	35	300
		(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)

Note: Figures in parentheses represent percentage to respective column total.

Source: Computed

As a whole, most of the slum households accessed up to 61 - 90 lpcd water endowment and a few of them attained above the category of 61 - 90 lpcd. In moderately developed and developed regions, some of the low income and middle income households are scattered in various water endowments whereas the majority of high and middle income households are endowed with more water. The analysis of income and per capita water endowments of the surveyed respondents explains that the low income households accessed relatively lower water endowments as compared to middle and high income households of the urban regions. In particular, the low income households of the slum region are severely affected by lower levels of water endowments. The results imply that the economic and regional factors determine per capita water endowment in the study regions. Thus, inequality in the distribution of water supply sources exists in the study regions. The economic status of the households helps in attaining more water endowments through the ownership of self-water supply sources like taps, borewells and hand pump.

VII. MULTI-VARIATE LINEAR DISCRIMINANT FUNCTION

Assumptions and Analytical Framework

The Multi-variate Linear Discriminant Function assumes that the relationships are additive and linear of an independent variable, which has one effect on the dependent variable in one group and another or more on the dependent variables on the other groups. The discriminant function may not accurately describe the situation (George., Namasivayam and Ramachandriah, 1984:155). Another important assumption is that the discriminant function analysis could be used only when the samples within the groups are not too much part (Fisher, 1950: papers 32, 33 and 34).

The objective of the study could be achieved by using either a multi-variate linear discriminant function or linear regression model. However, there is the principal difference between the two functions: the former model analyses the qualitative variable, whereas the latter analyses quantitative variable. Professor Fisher has suggested that the method of discriminant function is virtually meagre, if the qualitative dependent variable is quantitative by assigning dummy variable (George., Namasivayam and Ramachandriah, 1984:155).

Compared to the simple regression analysis, the multi-variate linear discriminant function approach is an effective tool to analyse discrimination between the respondents in urban regions in terms of institutional, access, personal and economic parameters.

The descriptive statistics and univariate test of significance provides the basic information on the distribution of parameters in the urban regions and helps to identify their differences. However, as the discriminant function analyses the parameters simultaneously, the researcher is able to incorporate some important information

(significant parameters) on their relationship. In the multi-variate linear discriminant function analysis, a linear contribution of the independent parameters is formed and serves as the basis for assigning cases to the urban region groups. Therefore, the information contained in the multiple independent variables is summarised in a 'single index'. In this analysis, the weights are estimated so that they result in the "best" separation among the urban regions.

The Model

In order to analyse the factors discriminating entailments to water supply among the urban regions, *twenty-nine* 29 variables which include institutional parameters, access to water supply parameters and personal and economics parameters are included in the analysis. Of the total variables, 19 variables viz. self-source, public source, combination of sources, regulation for tap connection, service area extension, supervision, service delivery, compliant clarence, self alone (quantity), public alone (quantity), combinations of institutions (quantity), total quantity, time spent on water access, increase in dependency of the number of water supply sources, ownership, total family members, housing area (sq.ft.), number of earners and total asset are removed by using the step-wise regression analysis. Therefore, only significant parameters of 10 are taken for further analysis.

To measure the net effect of each parameter in the analysis, all the other parameters are taken as constant by using the multi-variate linear discriminant function approach. The relative importance of the parameters with regard to their power to discriminant among the urban households, on the basis of institutions, access, personal and economic parameters could be understood with the help of this method. The general model used for the study is shown below:

Where X_1 to X_{10} are the scores at the parameters indicated and λ_1 to λ_{10} are the coefficient of the multi-variate linear discriminant function.

A "good" discriminant function is one that has much difference between the groups' variability when comparison is made within the groups' variability. In fact, the coefficients of multi-variate linear discriminant function are chosen, so that the ratio between the group sum of squares and within the group sum of squares is as large as possible. Therefore, the discriminant function is tested to find whether all the parameters considered together are sufficiently discriminant among the groups of urban households. Among the several methods available for selection of parameters, *Wilks' Lambda* method is employed in this study. This method is preferred as the researcher use to get an opportunity to extract maximum information from the given data set.

$$Z = \lambda_1 X_1 + \lambda_2 X_2 + \lambda_3 X_3 + \lambda_4 X_4 + \lambda_5 X_5 + \lambda_6 X_6 + \lambda_7 X_7 + \lambda_8 X_8 + \lambda_9 X_9 + \lambda_{10} X_{10}$$

Where, Z = total discriminant score among the urban regions viz., slum, moderatley developed and developed.

Institutional Parameters

X_1 = Location as a constraint for tap connection (yes = 1; No = 0)
X_2 = Connection deposit as a constraint for tap connection (yes = 1; No = 0)
X_3 = Regulation of market (Satisfied = 1; Not satisfied = 0)
X_4 = Ground water regulation (Satisfied = 1; Not satisfied = 0)
X_5 = Infrastructure maintenance (Satisfied = 1; Not satisfied = 0)

Access Parameters

X_6 = Number of persons involving water access (in numbers)
X_7 = Number of households per water supply source (in numbers)

Personal and Economic Parameters

X_8 = Education (Ill. =0; Primary = 1; Middle = 2; High = 3; H.sec. = 4; Coll. = 5)
X_9 = Ownership (Own = 1; Rental = 2)
X_{10} = Income (Actual in Rs.)

For this purpose, the Multi-variate Discriminant function analysis is used in three stages, namely, (1) Construction of Multi-variate Discriminant function (2) Classification of households into different urban regions and (3) interpretation of the functions.

To begin with, as a first step in the discriminant function analysis, group means and standard deviation for each of the institutional, access, entitlement, personal and economic parameters are calculated.

In the second step, to evaluate the implication of means of the households of different categories and respective independent parameters one-way ANOVA is applied. Prime target of this analysis is to identify the factors which powerfully discriminate the households among the urban area, the step-wise regression function is employed. Of the total, parameters which maximised Wilks' Lambda among the sets are permitted in the designed function. To find the efficient discriminating factor limiting the parameters in function is necessary. Therefore, a maximum 'F' statistics value fixed at 5 per cent level as eligible to enter parameters into the discriminant function equation.

The significance of the parameters of Wilks' Lambda is tested using the estimated 'F' value. Parameters included in the equation examined in each step to find possibility to eliminate from the function. Further, there are chances to eliminate the included parameters if there is high order multi-collinearity between independent parameters. Likewise, removal of criterion intention is also fixed at 10 per cent of 'F' value. This process of selection and inclusion of parameters for the institutional, access, entitlement, personal and economic parameters take the second step.

In the present study, the methods of Eigen value, canonical correlation, *Wilks' Lambda* and *Chi-square* statistics are employed. The method group '*Eigen value'* explains the ratio among within the groups and the group sum of square. The higher Eigen values are associated with *the "good discriminant function".*

The second method, viz., *canonical correlation* explains a measure of the degree of association of the discriminant score with the groups. It is simply the usual correlation co-efficient between the discriminant score and group parameters.

The third method, viz., Wilks' Lambda means the value (ratio) available within a set sum of squares and the aggregate sum of squares.

The lesser values of 'λ' are related to the functions that have far variation among the groups and tiny variation within the groups. For example, if the value of lambda is equal to '1', it implies that the mean discriminant score is equal to all the groups.

A test of the null hypothesis is that in the population from which the samples are drawn, there is no difference among the group means that is based on the Wilks' Lambda. The significance of Wilks' Lambda could be testified by Chi-square statistics. Therefore, the Chi-square statistics is used to understand if the group means are significantly different from each other. If the calculated Chi-square exceeds Chi-square with 'a' per cent level, then one can reject the null hypothesis. It means that the mean values differ significantly among the selected urban households of different urban regions.

Before testing the equality of mean differences, among the different households on the basis of the institutions, access, personal and economic parameters through the method of Wilks' Lambda and Chi-square statistics, one has to examine the "equality variance/covariance matrices" multivariate normal population (George, Namasivayam and Ramachandriah, 1984).

Testing the Equality of Variance Matrices of the Several Multivariate Normal Population

The hypothesis tested is:

$$\Sigma(1) = \Sigma(2) = \ldots = \Sigma(k)$$

The methodology is detailed below:

Let, Ni be the sample size from the i th population and $A^{(I)}$ be the corrected sum of squares and cross product matrix for the sample from the i th population.

$\overline{X}_a^{(i)}$ is the a^{th} sample observation vector from i th population.

$$\sum_{i-1}^{Ni}(X_a^{(i)} - \overline{X}^{(i)})(X_a^{(i)} - \overline{X})$$

Hence, $A^{(i)} = \overline{X}^{(i)} = \frac{1}{Ni}.\sum_{i=1}^{Ni}(X_a^{(i)}$

Where,

Let Vi =Ni – 1 where,

$$V=V1+V2+\ldots\ldots Vk$$

Then, the statistics 'B' is calculated as follows:

$$B = \frac{\prod_{i=1}^{k} |\hat{\Sigma}_{(i)}|^{Vi}}{|\hat{\Sigma}|^{V}}$$

with

$\hat{\sum}_{(i)} = 1/Vi.\ A^{(i)}$ and $\hat{\Sigma}\hat{\Sigma} = 1/V.\ \prod_{i=1}^{k} \prod_{\pi=1}^{k} A^{(i)}$

Computed T = $^{-}$P. In B

$$P = 1 - (\frac{1}{V} = V1 + V2 + \cdots Vk)\frac{2P^2 + 3P - 1}{6(P+1)(k+1)}$$

Where, P = number of parameters (10 parameters)

K= total population (3 urban regions)

The null hypothesis is

$\Sigma(1) = \Sigma(2) = \ldots = \Sigma(k)$. The test statistic 'T' is distributed as a Chi-square distribution with 'F' degrees of freedom.

$$where, f = \frac{(k-1)p(p+1)}{2}$$

Let, '$Z_{\alpha}^{2} Z_{\alpha}^{2}$' be the 'a' per cent point of '$Z^2\ Z^2$ ' distribution with 'f' degrees of freedom. If the calculated T> Chi-square, reject the null hypothesis that $\Sigma(1) = \Sigma(2) = \ldots = \Sigma(k)$.

Once the null hypothesis is acceptable to the pooled data analysis among the groups (i.e.,) urban households, then one can apply the multivariate discriminant function technique to test the stated objectives of the present study.

VIII. RESULTS AND DISCUSSION

To assess the equality of variance, co-variance matrices of the multivariate normal population is used for the pooled data of the groups on the basis of institution, access, personal and economic parameters. The parameters are considered homogenous with respect to their dispersion matrices. The compared value of Chi-square is 3.15, which is lower than the table value of Chi-square 18.75 at 5 per cent level. Therefore, the test result permits to apply the multi-variate discriminant function analysis.

From Table 3, one can understand the means and co-efficient variation of the significant institution, access, personal and economic parameters of the slum,

moderately developed and developed regions. Out of 30 parameters pooled from the individual section analyses of the present study, only 10 parameters are found to be statistically significant to discriminate the entitlements to water supply among the different urban households in different urban regions.

The *location restriction* for water supply connection is more affected by slum dwellers (0.78) than that of moderately developed (0.25) and developed (0.06) regions. It is an obvious fact that municipal water connection is given only to the approved plot and house. In the case of slum, 100 per cent of households are located in unapproved Government land (*porampoku*). Hence, slum dwellers are much affected by this parameter.

Second, the *connection deposit* also significantly discriminates the urban regions. By taking this parameter, the most affected households are in the slum (0.76) not in the moderately developed (0.24) and developed (0.34) regions. The inhabitant amount of deposit fixation by the municipal corporation is much affected to the slum dwellers. Since the slum dwellers are downtrodden and poverty groups, they are not capable of paying a huge deposit to the municipal corporation. Therefore, the parameter deprives the slum dwellers mostly.

The third significant parameter which discriminates the urban household is the *regulation over the market institution*. The mean score value of the parameter is relatively higher in the slum region (0.87) than in moderately developed (0.63) and developed (0.34) regions. The inefficiency in controlling market water supply institutions has failed to fix reasonable price, quality and quantity of the water. It adversely affects the urban household to afford the services of market water supply institution.

The fourth important parameter which discriminates with the urban regions is the *regulation of ground water management*. The most affected by the inefficiency of ground water management is the slum dwellers (0.43) than that of moderately developed (0.06) and developed regions (0.03). Inefficient ground water regulation has led to overexploitation of ground water and unfavourably affects the slum households.

The fifth important parameter which discriminates the urban region is the *infrastructure maintenance*. The infrastructure maintenance is more effective in developed (0.77) and moderately (0.67) developed than in the slum region (0.3). The effectiveness of infrastructure maintenance in moderately developed and developed regions is mainly due to higher level of educational attainment, affluent groups of Government employees, business people, somewhat middle and high income profile groups, which possess control over the municipal officials.

Another important significant parameter, which discriminates the urban regions is the *number of persons involved in water access*. The number of persons involved in

water access is higher in the slum region (2.16) than in moderately developed (1.62) and developed regions (1.39). This is mainly due to the fact that the water access of the slum dwellers is greater from the public water supply sources. The water supply in the public tap is given at particular times. Therefore, the supply of water from the public tap is to be obtained by involving the maximum number of family members during the water supply. But in the case of moderately developed and developed regions, the water supply from the corporation is available within their premises. The water is stored in the sump and overhead tanks, which can be used whenever they require by operating motor for pumping the water.

Table 3
Comparison of Means, Co-efficient of Variations of Institutions, Access, Personal and Economic Parameters

Sl. No.	*Name of the Significant Indicators*	*Urban Region*						*Pooled Data*	
		Slum		*Moderate*		*Developed*			
		Mean	*C.V.*	*Mean*	*C.V.*	*Mean*	*C.V.*	*Mean*	*C.V.*
1.	Location	0.78	0.42 (53.85)	0.25	0.44 (176.00)	0.06	0.24 (400.00)	0.36	0.48 (133.33)
2.	Connection deposit	0.76	0.43 (56.58)	0.24	0.42 (175.00)	0.34	0.48 (141.18)	0.44	0.49 (111.36)
3.	Regulation of market	0.87	0.34 (39.08)	0.63	0.49 (77.78)	0.34	0.48 (141.18)	0.61	0.48 (78.69)
4.	Ground water regulation	0.43	0.5 (116.28)	0.06	0.24 (400.00)	0.03	0.17 (566.67)	0.17	0.38 (223.53)
5.	Infrastructure Maintenance	0.3	0.46 (153.33)	0.67	0.47 (70.15)	0.77	0.43 (55.84)	0.58	0.49 (84.48)
6.	No. of persons for access	2.16	0.79 (36.57)	1.62	0.38 (23.46)	1.39	0.55 (39.57)	1.85	0.68 (36.76)
7.	No. of household per source	10.07	8.8 (87.39)	3.02	1.92 (63.58)	2.67	1.34 (50.19)	5.25	6.25 (119.05)
8.	Education	1.39	1.14 (82.01)	2.74	1.46 (53.28)	2.63	1.32 (50.19)	2.25	1.45 (64.44)
9.	Ownership	0.96	0.2 (20.83)	1.89	0.32 (16.93)	1.87	0.34 (18.18)	1.9	0.29 (15.26)
10.	Total Income	3.71	19.83 (534.50)	11.21	86.47 (771.36)	19.13	20.94 (109.46)	11.35	14.52 (127.93)

Note: Figures in parentheses represents co-efficient of variation.

Source: Computed

The *number of households per water supply source* is another important parameter which discriminates among the urban regions. The number of households per water supply source is higher in slum region (10 households) followed by the moderately

developed region (3 households) and it is least for the developed region (2 households). This parameter explains that the households of developed and moderately developed regions are highly self-dependent by owning borewell or self-tap. But this is not possible in the case of slum region.

Only three parameters are found to be statistically significant under the personal and economic indicators of the urban households, which discriminate among the urban regions in the study area. The parameter *education* is significant for doing discrimination among the urban regions. It means that the education level is higher in the developed region (2.63), followed by moderately developed region (2.74) and it is least in slum region (1.39). It clearly indicates that the respondents of the slum households attained a lower level of education, whereas, moderately developed and developed region households achieved educational attainment up to colligate level. The level of education is also important to understand the institutional arrangements for water supply and approaching the municipal authorities for solving the issues related to water supply and other problems. But in the case of slum region, the level of education always keeps the distance between the slum households and municipal officials.

Another significant parameter is the *ownership of the house*. This is classified into two ways: rented and owned. The ownership of the house is relatively higher in the developed region (1.87) and moderately developed region (1.89) as compared to slum region (0.96). The ownership of a house is important to get water supply connection from the municipal corporations. Another economic parameter is *household income*, which is relatively higher in the developed region (1.91 lakhs) and moderately developed region (1.12 lakhs) and it is least for the slum region (Rs.37,000). It shows that the developed and moderately developed regions have relatively higher average income than the slum households.

The co-efficient of variation is used to analyse the variation in each of the institutional, access, personal and economic parameters for different regions and pooled data analysis. The results of various regions and polled data analysis indicate that the variation between the regions and factors is wide in the parameters of location, connection deposit, ground water regulation, number of households per water supply source, total income, regulation of the market, infrastructure maintenance and education. On the other hand, the level of variation is meagre in the number of persons involved for water access and house ownership. It explains the role of the institution, access, entitlement, personal and economic to discriminate the households according to regions.

The results from Table 4 provide the overall step-wise discriminant results after all the significant parameters results included in the discriminant function. At the first

level, 29 parameters (institutional, access, entitlement, personal and economic factors) are taken into account for the analysis. At the next level, only 10 parameters are selected based on the level of significance. The significance of discriminating parameters is tested using Wilk's lambda and its 'F' statistics.

Table 4
Summary of the selected (significant) Parameters

Sl. No.	*Indicators*	*Wilks' Lambda (λ)*	*'F' Statistics*
1.	Location (X_1)	0.59	99.52 *
2.	No. of persons for water access (X_2)	0.46	69.50 *
3.	No. of household per source (X_3)	0.40	56.06 *
4.	Regulation of market (X_4)	0.36	49.28 *
5.	Ground water regulation (X_5)	0.30	48.37 *
6.	Total Income (X_6)	0.27	44.87 *
7.	Education (X_7)	0.26	40.78 *
8.	Ownership (X_8)	0.24	37.28 *
9.	Maintenance (X_9)	0.23	34.19 *
10.	Connection deposit (X_{10})	0.22	31.87 *

Note: * Significance of 'F' value at 5 per cent level

Source: Computed

From the results, the case of significant mean differences among the urban regions in each of the institutional, access, personal and economic parameters on the basis of their power of discrimination among the urban regions are location (0.59), number of persons involved for water access (0.46), number of households per water supply source (0.40), regulation of market (0.36), ground water regulation (0.30), total income (0.27), education (0.26), ownership of house (0.24), infrastructure maintenance (0.23) and connection deposit (0.22). Since their 'F' ratio are found to be higher than the 'F' statistics at 5 per cent level.

Another interesting aspect of the present section is to examine the significance of pair-wise comparison of means in each of the significant parameters through the measure of 'F' test. Findings of the analysis are given in Table 5.

It is observed from the results that there is a significant mean difference in each of the parameters between slum and moderately developed regions, between slum and developed regions and between moderately developed and developed regions. The 'F' values in each of the parameters are highly significant between slum and developed

regions followed by slum and moderately developed regions and it is least significant between moderately developed and developed regions.

Table 5
Summary of Pair-wise Comparison of Significant Parameters of the Analysis

Sl. No.	*Indicators*	*'F' Statistics*		
		Slum Vs Moderate	*Slum Vs Developed*	*Moderate Vs Developed*
1.	Location	100.39 *	185.27 *	12.90 *
2.	No. of persons for water access	53.90 *	149.62 *	37.78 *
3.	No. of household per source	40.68 *	126.63 *	34.18 *
4.	Regulation of market	43.90 *	106.89 *	25.58 *
5.	Ground water regulation	51.24 *	107. 05 *	20.80 *
6.	Total Income	52.25 *	95.34 *	17.51 *
7.	Education	44.97 *	86.89 *	18.71 *
8.	Ownership	42.33 *	76.64 *	16.49 *
9.	Maintenance	39.80 *	68.98 *	14.83 *
10.	Connection deposit	38.06 *	65.01 *	13.35 *

Note: ** Significance of 'F' value at 5 per cent level

Source: Computed

The result of Table 6 indicates the multi-variate aspect of the model given under the canonical discriminant function. The two discriminant functions are used in this analysis. These two discriminant functions are 0.84 and 0.45. By squaring them, one gets 0.71 and 0.20. Hence, the values may be interpreted as 71 per cent of variations in the dependent variable of parameters depending on the urban water supply and the first function is explained by the selected parameters. Similarly, the variation with dependent variables of parameters determining urban water supply by the second canonical function is explained by 20 per cent. It implies that more variation in the discrimination of urban water supply system is attributed by the first canonical function i.e., 71 per cent, followed by the second function to the tune of 20 per cent.

Table 6
Summary of Canonical Discriminant Functions

Function	*Eigen value*	*Percentage of Variance*	*Cumulative %*	*Canonical Correlation*	*Wilks' Lambda (λ)*	*Chi-square value*
1.	2.48	88.8	88.8	0.84	0.22	442.96 *
2.	0.31	11.2	100.0	0.45	0.76	79.39 *

Note: * Significance at 5 per cent level

Source: Computed

Similar results are explained by the Eigen values that are associated with the good discriminant function in the determination of urban water supply systems, on the basis of institutions, access entitlement, personal and economic parameters to the tune of 88.8 per cent by the first function and 11.2 per cent by the second function. The significance of Wilk's lambda is tested through the Chi-square statistics. There is a higher mean difference between the urban regions on the basis of the institution, access, entitlement, personal and economic parameters. That exists among the urban households in the first function through the Chi-square value of 462.96, which is found to be statistically significant Chi-square statistics at 5 per cent level. It is followed by the significance of the second function at 79.39.

The co-efficient of discriminating *Institutional, Access, Personal and Economic Parameters* (IAPEP) are derived from the two different discriminant functions which are stated in Table 7. The associated un-standardised canonical discriminants function co-efficient exhibited the parameters, which discriminate among the urban regions, on the basis of IAPEP. The intensity of co-efficient with a positive sign in the first function is higher for ground water regulation (1.34), ownership of house (0.97), connection deposit (0.67), regulation of market water supply institutions (0.62) and it is the least for the parameters of location (0.32), and the number of households per water supply source (0.09). On the other hand, four parameters viz., infrastructure maintenance (-0.60), education (-0.17) and the number of persons involved in water access (-0.85) among the urban households to the water supply system depend negatively in the first function.

Table 7
Un Standardised Canonical Discriminant Functions Co-efficient for Significant Variables

Sl. No.	*Parameters*	*Function 1*	*Function 2*
1.	Location	0.32	-0.73
2.	Connection Deposit	0.67	-0.03
3.	Regulation of Market	0.62	-1.07
4.	Ground Water Regulation	1.34	-0.85
5.	Maintenance	-0.60	-0.21
6.	Number of Persons Involving Water Access	-0.85	0.93
7.	Number of Household per Water Supply Source	0.09	-0.09
8.	Education	-0.09	-0.29
9.	Ownership	0.97	1.04
10.	Total Income	-0.17	0.35

Source: Computed

In IAPEP parameters such as ownership of the house (1.04), total income (0.35) and the number of persons involving water access (0.93) are positively discriminated among the urban regions to the water supply system in the second function, whereas the other parameters having negative co-efficient of discrimination among the urban regions in the second function.

All the selected parameters mentioned above are discriminant among the urban regions in terms of dependent variables in the two functions even though the percentage of variation in urban water supply system is explained by IAPEP parameters by both the Eigen values and the canonical discriminant functions.

It is obvious that the location, connection deposit, regulation of market water supply institutions, ground water regulation, number of households per water supply source and ownership of house have increased among the urban regions in terms of water supply systems. They are found to be statistically significant to discriminate the urban regions, through the 'F' statistics in the first function. In addition to that, the parameter like total income is also added in the second function. The other parameters have shown negative co-efficient among the urban regions and they are found to be statistically significant as 'F' statistics in the functions performed. In the second function, the parameters which have shown negative discrimination of the urban water supply system among the urban regions are infrastructure maintenance and education.

Fisher's Multi-variate Linear Discriminant function co-efficient of the parameters derived by each of the urban regions is furnished in Table 6. The estimated co-efficients of the parameters show that the location, connection deposit, regulation of market water supply institutions, ground water regulation, number of persons involved for water access, number of households per water supply source and ownership of house are positive to the slum dwellers. Other parameters viz., infrastructure maintenance, education and household income give the least positive in the slum region and remaining parameters are found to be negative. In the case of moderately developed and developed regions, the majority of the parameters are positive (except infrastructure maintenance, education and income). However, the parameters such as the number of persons involved for water access and the number of household per water supply source show a negative sign in the moderately developed and developed regions. It means that the households of the moderately developed and developed regions utilise the least number of persons in water access and availability of a large number of sources to the households.

The canonical discriminant function evaluated the group means of different urban regions and the results are shown in Table 9. Individual's discriminant value

is estimated through using discriminant function co-efficient available in Table 8 which represents the discriminating parameters of the analysis. The average values for each group are compared with the other groups, which are called 'group centroids'.

Table 8
Fisher's Linear Discriminant Function Coefficient of the Significant Parameters in the surveyed urban regions

`	*Parameters*	*Urban Region*		
		Slum	*Moderately Developed*	*Developed*
1.	Location	1.99	1.84	0.54
2.	Connection Deposit	8.61	5.83	6.48
3.	Regulation of Market	1.17	-0.56	-1.50
4.	Ground Water Regulation	9.68	5.27	4.98
5.	Infrastructure Maintenance	-1.85	-0.04	0.30
6.	No. of persons for water access	7.31	-5.95	-3.84
7.	No. of household per source	0.71	-0.40	-0.43
8.	Education	-1.38	1.89	1.60
9.	Ownership	-28.07	24.45	24.81
10.	Income	-3.76	3.56	5.19
Constant		-47.56	-35.68	-32.80

Source: Computed

It is an interesting fact to note that the canonical function-1 is fully explored by the slum region, which indicates a positive sign. Therefore, the function-1 of the discriminant function is fully concentrated in the slum region, which indicates discrimination with the other urban regions. This function has influenced the slum region in terms of high unfavorable impact of location, connection deposit, high unfavorable impact of inefficient regulation of market water supply institutions, high unfavorable impact of inefficient ground water regulations, number of persons involved for water access and less unfavorable impact of ownership of house.

Table 9
Canonical Discriminant Functions Evaluated at Group Means

Sl. No.	*Region*	*Function 1*	*Function 2*
1.	Slum	2.12	0.22
2.	Moderately Developed	-0.53	-0.76
3.	Developed	-1.59	0.54

Source: Computed

The second function is concentrated for the developed and moderately developed regions, which shows the discrimination with the other groups. This function is much influenced by the parameters like high infrastructure maintenance, high education, high concentration of ownership of house, and high income.

The derived classification analysis gives the details of the number of respondents; those are correctly classified in the respective regions or groups and the overall correct significance parameters. The accuracy of the classification in the different urban regions is exhibited in Table 10. It is found from the discriminant function that 95 per cent of slum households, 80 per cent of the moderately developed households and 78 per cent of the developed households and the study area worked out to be 81 per cent are correctly classified by the discriminant functions. It means that the classification of urban dwellers is correct by more than 78 per cent in the case of the slum, moderately developed, developed regions and study area.

Table 10
Classification of Discriminant Functions
(Derived Classification Analysis)

Sl. No.	*Region*	*Functions*		
		Actual	*Predicted*	*Predicted %*
1.	Slum	100	95	95
2.	Moderately Developed	100	80	80
3.	Developed	100	78	78
Total		300	243	81

Source: Computed

IX. CONCLUSION

The foregoing multivariate linear discriminant function exhibits that the location of the household, no. of persons involved for water access, no. of household per water supply source, inefficiency in regulating market related water supply sources, inefficiency in regulating the ground water management, total household income, education, house and plot ownership, maintenance of urban water supply infrastructure and high connection deposit for municipal water supply connection are the predominant factors discriminating the entitlements to water supply among the urban regions of the study area.

On the other hand, location of the household, connection deposit, regulation of market water supply institutions, ground water regulation, huge number of persons involving for water access, huge number of households per water supply source and rented houses are the important functions of slum dwellers. These parameters discriminate slum region from the moderately developed and developed

regions. On the other hand, the moderately developed and developed dwellers are mostly influenced by the parameters like infrastructure maintenance, higher level of education, ownership of house and total households income. These parameters significantly discriminate the developed and moderately developed regions from the slum region.

Factor-wise comparison reveals that the role of institutional and access factors are more significant to discriminate the entitlements to water supply as compared to personal, housing and economic factors. Therefore, the process of relaxation in regulation for municipal water supply connection, introduction of new policies for controlling the market based water supply sources and managing ground water table are indispensable for urban authorities to attain the equality in water access.

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