Sustainability of Water Management at Household Level in Tiruchirappalli City

[1]Dr. (Sr.) Sarguna Mary G.
[2]Dr. Jenitra. L.
[1] *Former Principal and Associate Professor of Commerce*
[2] *Associate Professor of Commerce*
Holy Cross College (Autonomous), Tiruchirappalli -2

Abstract
Water is a basic human need and a precious natural resource. Increase in population, change in climatic conditions and mismanagement of water sources have resulted in decrease in per capita availability of water for household and other uses. Hence, there is a need to manage water in a sustainable way to ensure availability of sufficient water for the present and future generations. This study on sustainability of household water management based on a newly developed model has assessed the sustainability of water management at household level on the basis of 29 indicators divided under four broad categories. The model will be useful to the Tiruchirappalli Corporation and other water suppliers. This study highlights that educational level and occupation of head of household and household income influence the level of sustainable water management.

Key words
Sustainability, Household, Water management.

Introduction
Among the basic necessities of life water assumes prime position, because life on earth is not possible without water. Realising the importance of water for life, Governments across the world and international organisations such as, The United Nations (UN), The World Health Organisation (WHO) and The World Bank have been playing major roles in water issues. Due to growing population, change in environment and mismanagement of water, there has been decrease in the per capita availability of water for various uses. Hence, managing water in a sustainable way is the need of the hour to ensure availability of sufficient water for the present and future generations. The word 'sustainability' refers to 'capacity to endure'. Sustainability management has three dimensions, environmental dimension, economic dimension and social dimension. Thus sustainability is a system running without depleting natural resources, maintaining economic viability and fulfilling the needs of the present and future generations. Sustainability of water use at household level can be measured by factors such as quantity of water used per capita per day, quality of water used, storage of water for future use, availability of water from different sources, etc.

Objectives
To provide a model for assessing sustainability of water management at household level To examine the sustainability of water management at household level among the sample households

Hypothesis
- There is a significant relationship or association between 'socio-economic variable' and 'sustainable water management at household level'. The socio economic variables compared are:
  i) Education status of head of household
  ii) Occupation of head of household
  iii) Level of household income
  iv) Number of members in the household and
  v) Age of head of household.

Methodology
After a pilot study, by adopting a stratified random sampling method, 410 households were contacted through interview schedule for collecting primary data.

Sample design
As per census of India 2001 there were 1,70,725 households in Tiruchirappalli in the then total 60 wards of four zones. The number of sample households selected from each zone was in proportion to the number of households in a zone to the total number of households in the city.

Sample size in each zone = Number of households in each zone × (410 ÷ 1,70,725)

Or

Sample size in each zone = Number of households in each zone x 0.0024

Limitations
1. This study is restricted to water management at household level and does not consider the supply aspects of water management.
2. The primary data collected covers only 60 wards as per census 2001 and it does not include other wards that were added afterwards.

Analysis and Interpretation
Sustainable management of water requires judicious management of various sources of water. Water like

other natural resources requires a wise management at present which will help the future generations also to satisfy their needs. Sustainability requires management of human consumption and management of environment. Sustainability of water use at household level can be measured by considering various indicators that have been identified based on the reports of various organisations such as Tamil Nadu Water Supply and Drainage (TWAD) Board, The Central Public Health and Environmental Engineering Organisation (CPHEEO), WHO, UN, etc. These indicators are broadly covered under four categories:

1. Accessibility indicators

These indicators cover the time taken to collect water, distance covered to collect water and cost involved. In Table No. 1 factors 1 to 7 relate to accessibility to water from various sources for drinking and food preparation and for other purposes.

2. Quantity indicators

The quantity of water used by households at present will have an impact on the availability of water at present as well as in future. In Table No. 1 indicators 8 to 14 relate to Quantity of water used and water conservation practices.

1. Quality indicators

Quality of water plays an important role in household water issues and the level of satisfaction. Indicators from 15 to 22 in Table 1 manifest quality related issues.

2. Motivation and Initiative indicators

These deal with participating in water issues, collecting information about water issues, etc. Indicators from 23 to 29 in Table 1 relate to the above factors. * *Refer to Table 1 page 13 and 14*

Each factor has been considered individually and assigned weighted scores. The maximum score that can be obtained is 100 for all the 29 factors taken together. Based on the maximum scores the households are classified as follows:

Scores	Category
81-100	Very good
61-80	Good
41-60	Fair
21-40	Poor
1-20	Very Poor

The factors and the corresponding scores allotted as given in table 1 are as follows:

Sources of water: Weighted scores have been given for various sources of water used by the households based on their safety for consumption as prescribed by Joint Monitoring Programme for Water Supply and Sanitation of the World Health Organisation and United Nations Children's Fund (JMP) (2006). Four scores are allotted for improved sources; three for public tanker; two for public PVC tank and one for unprotected dug well in-house and private tanker.

Distance walked for collecting water (in metres):

As per WHO norms, water source must be available within one kilometre from residence, if it is not available within premises. Hence, if distance is greater than one kilometre, no score is given. If water source is within premises (distance being zero), households get four scores which is the maximum allotted and for other distances in between these two.

Time spent for collecting water for one round trip (in minutes):

Time taken for a round trip includes number of minutes taken to get from the place of residence to the collection point, waiting time for obtaining water and to return to the place of residence. It does not include, time spent in socialising (outside of queuing). In case time taken is zero, four scores have been given and if the time taken is more than 30 minutes being the maximum prescribed by WHO, zero has been given and for others in between these two.**Cost of water incurred by the households:** If water cost is up to three per cent of household income (as recommended by United Nations Development Programme(UNDP), four scores have been allotted and gradually, reducing the score to zero, for cost greater than six per cent of household income.

Quantity of water used in Litres Per Capita Per Day (LPCD): If households use lesser than 70 lpcd being the basic minimum, zero is given and if they use between 135.1 and 200 lpcd being the optimum quantity, four scores are given and for others in between these two scores. For more than 200 lpcd, gradually scores are reduced.

Table 1 (Part –I)
Model for assessing sustainable water management at household level

Factors	Weighted scores				
	4	3	2	1	0
Accessibility related indicators					
1. Main source of water for drinking and food preparation	Tap in-house, public tap, bore well/ hand pump (in- house and public), protected dug well in-house, can water	Public tanker	Public PVC tank	Unprotected dug well in-house, private tanker	River
2. Main source of water for other purposes	Tap in-house, public tap, bore well/ hand pump (in- house and public), protected dug well in-house	Public tanker	Public PVC tank	Unprotected dug well in-house, private tanker	River
3. Distance walked for collecting water for drinking and food preparation from main source (in metres)	0	1-250	251-500	501-1000	> 1000
4. Distance walked for collecting water for other purposes from main source (in metres)	0	1-250	251-500	501-1000	> 1000
5. Time spent for collecting water for drinking and food preparation from main source for one round trip (in minutes)	0	1-10	11-20	21-30	> 30
6. Time spent for collecting water for other purposes from main source for one round trip (in minutes)	0	1-10	11-20	21-30	> 30
7. Cost of water to households (percentage of household income)	Up to 3 %	3.01-4%	4.01-5%	5.01-6%	> 6%
Quantity related indicators					
8. Quantity (litres) of water used per capita per day (lpcd)	135.1-200	110-135; 201-250	90-109.9; 251-300	70-89.9; > 300	< 70
9. Trend in quantity of ground water	Increasing	Remaining same	Not known	Not used	Decreasing
10. Sharing water	-	-	Yes	-	No
11.Storage of water (in days)	>3	>2 & up to 3	>1 & up to 2	Up to 1	Nil
12. Economic use of water	Yes	-	-	-	No
13. Avoiding wastage of water and using water saving measures	Yes	-	-	-	No
14. Harvesting rainwater	Yes	-	-	-	No

Table -1 (Part-II)

Factors	Weighted scores				
	4	3	2	1	0
Quality related indicators					
15. Quality of drinking water from main source (as perceived by households)	Very Good	Good	Moderate	Poor	Very poor
16. Quality of water used for other purposes from main source (as perceived by households)	Very Good	Good	Moderate	Poor	Very poor
17. Method of treating water to make it safer to drink	Boiling, using purifiers/filtering devices	-	-	Filtering with cloth	Not treating
18. Method of handling drinking water	Using safe method	-	-	-	Not using safe method
19. Testing quality of water before use	Yes	-	-	-	No
20. Method of waste water disposal	Underground (closed) drainage	Open drainage	-	-	No drainage
21. Awareness of water associated diseases (total number of diseases known)	>15	11-15	6-10	1-5	None
22. Family affected by water associated diseases	No	-	-	-	Yes
Motivation and initiative related indicators					
23. Existence of association to represent water issues	-	-	Yes	-	No
24. Awareness about water issues through different media	-	-	Yes	-	None
25. Counselling received or given for household water issues	-	-	Yes	-	No
26. Facing conflict for collecting water at household level	-	-	No	-	Yes
27. Participating at community level in household water related issues	-	-	Yes	-	No
28. Cooperating with public authorities in household water issues	-	-	Yes	-	No
29. Feeling insecure about future availability of water for household use	-	-	No	-	Yes

Trend in quantity of ground water obtainable for ten years (2001–2010):

If the quantity of water from any one of the ground water sources accessed by the household has been increasing, maximum score of four is given. If quantity has been remaining the same, three scores, if not known two scores and if decreasing the use is unsustainable and hence, zero is given. If ground water is not used then one score is given.

Sharing water with other households:

If the households share water with others then two scores have been allotted and if not, no score is given.

Percentage storage of water:

If more quantity of water in terms of number of days' requirement is stored, then more scores have been allotted to the households. If storage is more than three days' requirement, four scores have been given and gradually reducing scores for lesser storage. If there is no storage of water, then no score is given.

Economic use of water and avoiding wastages:

If the households use water in an economic way, four scores have been given and if not, no score has been given. If households take measures to avoid wastages or use water saving measures, then four scores and if not, no score has been given.

Rainwater harvesting:

If households adopt rain water harvesting, four scores and if not, no score has been given.

Quality of water as perceived by households:

If quality of drinking water is perceived to be very good, the maximum score of four is given and it is reduced gradually to zero if perceived to be very poor. For quality of water used for other purposes also, scores have been given similarly.

Treating water to make it safer to drink:

Boiling and using water purifiers or filtering devices are adequate methods for treating water for which four scores have been given. If water is just filtered with cloth, one score and if there is no water treatment at home, no score is given.

Method of handling drinking water:

If households use safe methods such as using purifiers or containers with tap, spout, etc. and using ladle with handle and similar methods, four scores have been given. If no safe method is used, then no score is given.

Testing quality of water before use:

If households have tested the quality of water for household use, then four scores have been allotted and if they have not tested then score is zero.

Method adopted for disposal of household waste water:

For safe disposal of household waste water, more scores and for unsafe methods, lesser scores have been given. Hence, if the households have underground drainage facility, then four scores, for open drainage facility three scores and finally if there is no drainage facility, then zero has been given.

Awareness of water associated diseases:

If the households are aware of more than 15 diseases out of a total of twenty five then four scores have been given. The scores are gradually reduced as the number of diseases aware of decreases and finally for no awareness, no score has been given.

Whether members of the household are affected by water associated diseases:

If any of the members of the household has been affected by water associated diseases then no score is given; if not affected then four scores have been given.

Existence of association to represent water issues:

A score of two has been given to the households who have association to represent household water issues.

Awareness about water issues through different media:

If households have received information about water issues from any one of the medium, then two scores have been given and if none of the medium has reached, then no score is given.

Other water associated issues at household level:

Two scores each have been given to the households, who have received or given some counselling concerning household water issues; who do not face any conflict at household level concerning household water issues; who participate at community level regarding household water issues; who cooperate with the public authorities concerning household water issues and who do not feel insecure about availability of water in future.

Sustainability scores and rating of the sample households

Table 2 gives the range of scores obtained by the sample households on the basis of the sustainability indicators taken up for analysis and the corresponding rating.

Table 2

Rating of households with regard to sustainable household water management

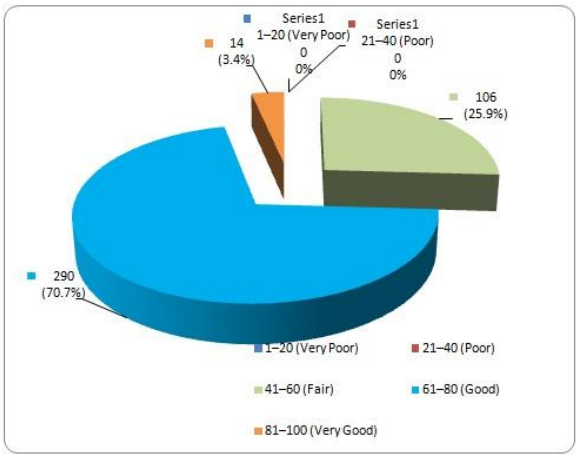
Sustainability scores and rating	Number of households	Percentage
1–20 (Very poor)	0	0.0
21–40 (Poor)	0	0.0
41–60 (Fair)	106	25.9
61–80 (Good)	290	70.7
81–100 (Very good)	14	3.4
Total	410	100.0

Source: Computed from primary data

The table shows that, 70.7 per cent of sample households fall under the category 'good' and 3.4 per cent 'very good' in sustainable water management practice, scoring 61–80 and 81–100 respectively. Remaining 25.9 per cent households are 'fair' in sustainability (scoring 41–60). There is no household under the category poor and very poor.

Figure 1

Rating of households with regard to sustainable household water management



Comparison of socio-economic variables and other factors with the sustainability rating will give an insight into sustainability rating of people belonging to different socio economic strata.

Table 3

Education status of head of household and sustainability rating

Education status of head of household	Sustainability scores			
	Fair 41–60	Good 61–80	Very good 81–100	Total
No schooling	7 (46.7%)	8 (53.3%)	0 (0.0%)	15 (100.0%)
Schooling (Up to Std. XII)	83 (33.1%)	163 (64.9%)	5 (2.0%)	251 (100.0%)
Diploma holder	4 (21.1%)	14 (73.7%)	1 (5.2%)	19 (100.0%)
Graduate	10 (9.5%)	87 (82.9%)	8 (7.6%)	105 (100.0%)
Professional	2 (10.0%)	18 (90.0%)	0 (0.0%)	20 (100.0%)
Total	106 (25.9%)	290 (70.7%)	14 (3.4%)	410 (100.0%)

Source: Computed from primary data

Table 3 shows that 90 per cent of households headed by professionally qualified persons are 'good' in sustainable water management followed by graduates (82.9 per cent) and diploma holders (73.7 per cent). As the educational qualification of head of household is higher, the percentage of households falling under the category 'good' is increasing. On the whole, for a maximum of all category of respondents the sustainability rating is 'good'.

Testing of hypothesis

Hypothesis (i)

Null hypothesis H_0: There is no significant relationship between 'education status of head of household' and 'sustainable water management at household level'.

Alternative hypothesis H_1: There is a significant relationship between 'education status of head of household' and 'sustainable water management at household level'.

Symmetric measures

	Value	Asymp Std. Error	Approx T	Approx. sig.
Ordinal by Ordinal Spearman Correlation	.268	.041	5.628	.000

Spearman correlation shows that significance value is 0.000 which is lesser than 0.05 (level of significance) ($p < 0.05$). Hence, null hypothesis is rejected and alternative hypothesis is accepted. It is therefore inferred that, there is a positive significant relationship between 'education status of head of household' and 'sustainable water management at household level'.

Table 4

Occupation of head of household and sustainability rating

Occupation of head of household	Sustainability scores			
	Fair 41–60	Good 61–80	Very good 81–100	Total
Business	5 (10.6%)	39 (83.0%)	3 (6.4%)	47 (100.0%)
Professional	0 (0.0%)	18 (100.0%)	0 (0.0%)	18 (100.0%)
Salaried-government employee	6 (9.2%)	56 (86.2%)	3 (4.6%)	65 (100.0%)
Salaried-private employee	17 (23.6%)	53 (73.6%)	2 (2.8%)	72 (100.0%)
Self employed	25 (43.1%)	31 (53.4%)	2 (3.5%)	58 (100.0%)
Wage employed	47 (43.5%)	60 (55.6%)	1 (0.9%)	108 (100.0%)
Others	6 (14.3%)	33 (78.6%)	3 (7.1%)	42 (100.0%)
Total	106 (25.9%)	290 (70.7%)	14 (3.4%)	410 (100.0%)

Source: Computed from primary data

Table 4 discloses that all households headed by professionals are 'good' (100 per cent) in sustainable water management followed by households headed by government salaried employees (86.2 per cent are rated 'good') and business persons (83 per cent are rated 'good'). On the whole, for a maximum of all categories of respondents the sustainability score is 'good'.

Testing of hypothesis

Hypothesis (ii)

Null hypothesis H_0: There is no significant association between the 'occupation of head of household' and 'sustainable water management at household level'.

Alternative hypothesis H_1: There is a significant association between the 'occupation of head of household' and 'sustainable water management at household level'.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	55.227	12	.000

Chi square test shows that significance value is 0.000 which is lesser than 0.05 (level of significance) ($p < 0.05$). Hence, null hypothesis is rejected and alternative hypothesis is accepted. It is therefore inferred that there is a significant association between the 'occupation of head of household' and 'sustainable water management at household level'.

Table 5

Monthly income of household and sustainability rating

Monthly income (₹)	Sustainability scores			
	Fair 41–60	Good 61–80	Very good 81–100	Total
Up to 10,000	89 (39.4%)	133 (58.8%)	4 (1.8%)	226 (100.0%)
10,001–20,000	12 (14.1%)	69 (81.2%)	4 (4.7%)	85 (100.0%)
20,001–30,000	2 (3.8%)	48 (92.3%)	2 (3.9%)	52 (100.0%)
30,001–50,000	2 (7.4%)	24 (88.9%)	1 (3.7%)	27 (100.0%)
Above 50,000	1 (5.0%)	16 (80.0%)	3 (15.0%)	20 (100.0%)
Total	106 (25.9%)	290 (70.7%)	14 (3.4%)	410 (100.0%)

Source: Computed from primary data

Table 5 shows that combining ratings 'good' and 'very good' sustainable water management practice is the best among households earning between ₹20,001 and 30,000 as the highest percentage are rated 'good' and 'very good' (96.2 percent) and 95 per cent of households earning above ₹50,000 are rated 'good' and 'very good'.

Testing of hypothesis

Hypothesis (iii)

Null hypothesis H_0: There is no significant relationship between the 'level of household income' and 'sustainable water management at household level'.

Alternative hypothesis H_1: There is a significant relationship between the 'level of household income' and 'sustainable water management at household level'.

Symmetric measures

	Value	Asymp Std. Error	Approx T	Approx. sig.
Ordinal by Ordinal Spearman Correlation	.351	.039	7.576	.000

Spearman correlation shows that significance value is 0.000 which is lesser than 0.05 (level of significance) ($p < 0.05$). Hence, null hypothesis is rejected and alternative hypothesis is accepted. It is therefore inferred that there is a positive significant relationship between the 'level of household income' and 'sustainable water management at household level'.

Table 6
Number of members in the household and sustainability rating

Number of members	Sustainability scores			
	Fair 41–60	Good 61–80	Very Good 81–100	Total
1	7 (50.0%)	7 (50.0%)	0 (0.0%)	14 (100.0%)
2–4	64 (23.3%)	200 (72.7%)	11 (4.0%)	275 (100.0%)
5–7	29 (30.5%)	63 (66.3%)	3 (3.2%)	95 (100.0%)
Above 7	6 (23.1%)	20 (76.9%)	0 (0.0%)	26 (100.0%)
Total	106 (25.9%)	290 (70.7%)	14 (3.4%)	410 (100.0%)

Source: Computed from primary data

From table 6 it is inferred that **s**ustainable water management is comparatively better among households having number of members above seven (76.9 per cent rated 'good') followed by households having number of members between 2 and 4 (72.7 per cent rated 'good' and 4 per cent 'very good').

Testing of hypothesis

Hypothesis (iv)

Null hypothesis H_0: There is no significant relationship between the 'number of members in the household' and 'sustainable water management at household level'.

Alternative hypothesis H_1: There is a significant relationship between the 'number of members in the household' and 'sustainable water management at household level'.

Symmetric Measures

Ordinal by Ordinal Spearman Correlation	Value	Asymp. Std. Error	Approx. T	Approx. Sig.
	-.016	.051	-.323	.747

Spearman correlation shows that significance value is 0.747 which is greater than 0.05 (level of significance) ($p > 0.05$). Hence, null hypothesis is accepted and alternative hypothesis is rejected.

Table 7

Age of head of household and sustainability rating

Age of head of household	Sustainability scores			
	Fair 41–60	Good 61–80	Very good 81–100	Total
21–40	36 (25.9%)	98 (70.5%)	5 (3.6%)	139 (100.0%)
41–60	59 (26.6%)	157 (70.7%)	6 (2.7%)	222 (100.0%)
Above 60	11 (22.4%)	35 (71.4%)	3 (6.2%)	49 (100.0%)
Total	106 (25.9%)	290 (70.7%)	14 (3.4%)	410 (100.0%)

Source: Computed from primary data

Table 7 indicates that sustainable water management is good for a maximum of households headed by persons belonging to all age group categories. Around 71 per cent are rated 'good' in all the age groups.

Testing of hypothesis

Hypothesis (v)

Null hypothesis H_0: There is no significant relationship between the 'age group of head of household' and 'sustainable water management at household level'.

Alternative hypothesis H_1: There is a significant relationship between the 'age group of head of household' and 'sustainable water management at household level'.

Symmetric Measures

Ordinal by Ordinal Spearman Correlation	Value	Asymp. Std. Error	Approx. T	Approx. Sig.
	.017	.050	.334	.738

Spearman correlation shows that significance value is 0.738 which is greater than 0.05 (level of significance) ($p > 0.05$). Hence, null hypothesis is accepted and alternative hypothesis is rejected.

Results

1. In total, 70.7 per cent of sample households fall under the category 'good' and 3.4 per cent 'very good' in sustainable water management practice.
2. As the educational qualification of head of household is higher, the percentage of households falling under the category 'good' is increasing.
3. Considering occupation, all the households headed by professionals are rated 'good' in sustainable water management, followed by government salaried employees (86.2 per cent).
4. Sustainable water management practice is the best among households earning between ₹20,001 and 30,000 (96.2 per cent are rated 'good' and 'very good').
5. The testing of hypothesis reveals that education, occupation and income of the respondents influence sustainable management of water at household level. Number of members in the household and age of head of household do not influence sustainable water management at household level.

Conclusion

There are certain best practices followed by the households concerning household water management such as using multiple sources based on quality and quantity requirements for different household needs, using water in a conservative way, rain water harvesting, cooperating with public authorities, etc. which contribute to sustainable water management at household level. The testing of hypothesis reveals that education,

occupation and income of the respondents influence sustainable household management of water. The 29 factors studied under accessibility to water sources, quantity of water used, quality of water used and motivational factors for sustainable household water management reveal that there is sustainable water management at household level in Tiruchirappalli city. Household members must understand the enormity of water challenges in India, posed due to huge population, varied topography, growth rate prevailing in the country, climatic changes and lifestyle changes and must willingly come forward to participate in water related issues at their level and adapt to such changes which will enhance the quality of life of all the citizens.

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