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Living and Environmental Condition of Peripheral Bank Dwellers along Beliaghata Circular Canal, a Cross-Sectional Study at Kolkata Metropolis, India.

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Abstract:

Aim: *The present study aims to assess the satisfaction of the bank dwellers about their living circumstances and environmental vulnerabilities of their habitats.*

Methods: *This paper employs a comparative case study of the bank dwellers of Circular Beliaghata Canal in Ward 7 and Ward 14. A primary survey was conducted to construct Community Satisfaction Index for selected indicators. The study also estimated extent of pollution of canal water through water sample test.*

Results: *At aggregate level the Community Satisfaction Index for all indicators is higher in Ward 7 than in Ward 14. A Composite Satisfaction Index which includes the average of Overall Satisfaction Index of all selected indicators reveals that satisfaction of bank dwellers in Ward 7 (0.47) is marginally higher than in Ward 14 (0.44). Various water parameters are tested.*

Conclusion: *The satisfaction level of bank dwellers in both the Wards of Kolkata is below average on a scale of 0 to 1. The propagation of canals in the inner part of the city faces more pollution (Ward 14). The present findings may help to review the canal pollution and associated living condition of the bank dwellers. This can also become a baseline study about health issues of canal dwellers in future research.*

Keywords: *Bank, Canal, Circumstances, Dwellers, Satisfaction, Pollution, Vulnerabilities.*

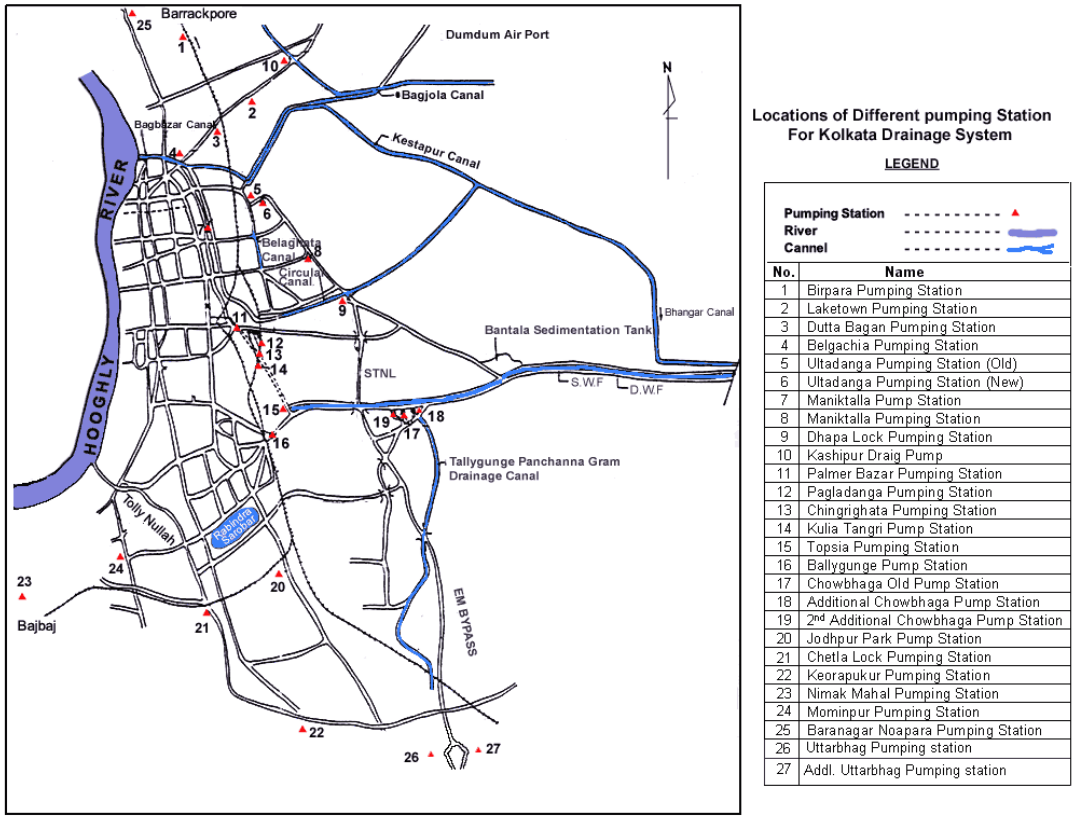
1. INTRODUCTION

Canals are bridges connecting civilization and commerce. Canals are man-constructed water routes particularly built with the purpose of navigation, connectivity within the cities, water supply for drinking, irrigation or even power generation. The evolution and growth of Calcutta now called Kolkata is not less than 300 years. Kolkata was a very prominent and promising capital for British Colonial Rule, one of the reasons being extensive possibility of inner-city canal network development. Fed by main rivers, Hugli, Bhagirathi, Adi-Ganga, canals like Bagjola Canal, Circular Canal, Beliaghata Canal, Tolly Nala, easter canals were excavated or dredged to provide navigation and defense to the British empire in Kolkata.

According to Census 2011 Kolkata situated on the banks of river Hooghly is crisscrossed by a number of canals. This city's estimated population is 4.5 million. 216 km long canal network is available in Kolkata [1]. KEIP report has noted that several canals in Kolkata are completely choked and silted and often leads to waterlogging during monsoon. The Asian Development Bank approved sanction for improvement of drainage system and sewerage dump in Canals [2]. Like Kolkata, in most metropolital cities like Madras the canal dwellers have encroaced the roads upto 40 feet and created informal settlements. These encroachment are often illegal and constructed to avoid Government taxes [3]. In Kolkata during the refugee influx from Bangladesh, the canal were the settling grounds for them. This led to shifting of canal waterways in Kolkata into stinking stagnant drains and the refugees settled in extreme vulnerable and marginal lands like "side of canals, large drains, garbage dumps, railway tracks and road" [4]. Often the informal settlers of the canal system work as helpers and cleaners in the households working as informal network of dependency of city dwellers for various odd jobs [5]. The canals of Kolkata has faced severe deterioration of its hydralic capacity of sewerage system and discharge due to heavy siltation. The encroachment of canal banks by squatter settlement minimizes the carrying capacity of canals [6]. Due to stagnation, water in the Beliaghata canal is absolutely polluted

and have become active source of harmful diseases. Due to lack of proper maintenance, all the canals have become out of use. If the canals are properly maintained, these water courses can be utilized for navigation purpose and as a result, dependence on road navigation may be minimized to a great extent [7]. However, the canal system is an ageing asset. With increasing societal needs and rapidly changing climate vulnerability redevelopment of canals is of dire need as the assets mainly developed in 20th century are almost defunct [8]. The Telegraph reported that the canals are dumping yards for rubbish, plastic bags, thermocols, dead animals etc. The areas left for some greenary along the bank of canal are significantly occupied by squatters. The canal breeds mosquitoes and can be a major health concern [9].

The metropolitan cities and urban agglomeration worldwide have witnessed significant upsurge in the population growth [10]. A major chunk of this population is pre-dominantly migrant in nature [11]. This excess population often settles in depreciated localities like the banks of canals, foothills, under the bridges, along rail tracks and beneath the flyovers. The canal dwellers mainly settle in these locations due to rural-urban migration, unemployment, poverty, limited scope for housing etc. The problems get aggravated due to societal stratification, lack of employment, poor land-man ratio, unplanned growth and poor administration. Poverty, discrimination, marginalization, segregation is constant source of deprivation in their lives [12]. From various literatures it is evident that the living condition of bank dwellers is immensely dilapidated and very unhygienic and insalubrious, with no access to toilet facilities and basic amenities [13].



No.	Name
1	Birpara Pumping Station
2	Laketown Pumping Station
3	Dutta Bagan Pumping Station
4	Belgachia Pumping Station
5	Ultadanga Pumping Station (Old)
6	Ultadanga Pumping Station (New)
7	Maniktalla Pump Station
8	Maniktalla Pumping Station
9	Dhapa Lock Pumping Station
10	Kashipur Draig Pump
11	Palmer Bazar Pumping Station
12	Pagladanga Pumping Station
13	Chingrighata Pumping Station
14	Kulia Tangri Pump Station
15	Topsia Pumping Station
16	Ballygunge Pump Station
17	Chowbhaga Old Pump Station
18	Additional Chowbhaga Pump Station
19	2nd Additional Chowbhaga Pump Station
20	Jodhpur Park Pump Station
21	Chetla Lock Pumping Station
22	Keorapukur Pumping Station
23	Nimak Mahal Pumping Station
24	Mominpur Pumping Station
25	Baranagar Noapara Pumping Station
26	Uttarbhag Pumping station
27	Addl. Uttarbhag Pumping station

Figure 1. *Map of Kolkata Drainage System*

Map Source: https://medium.com/@anjan.chatterjee/an-overview-of-Kolkatadrainage-system-major-outfallchannel-7fdff15d8aa2

Encroachment of settlements along the canal banks is however repetitive. Just off the banks of the canal they dwell, inhaling the stinking smell of the canal each time they breathe in, with thousands of mosquitoes breeding, congested narrow division between each unit of the dwelling sometimes not at all, establishing one of the most claustrophobic conditions to live in. Some places they are even barred behind the corporation boundary constructed along the canal. Thus develops a society within the recognized society of the city. Thus, the background lies here for the estimation of the satisfaction of these bank dwellers i.e., are they satisfied staying there in that vulnerable situation. Is it their choice or their fate framed by the socio political as well as economic structure of the society?

The extent of canal pollution is greatly due to the disposal of waste directly into the canal by the canal bank dwellers which is true for many countries of the world having large canal networks [14]. Although past literature reviews have pointed about the pollution and deterioration of water in the canals but investigation on quality of water is not much studied in various canals of Kolkata. Moreover, how the canal bank dwellers are impacting the pollution of canals in Kolkata is not much quantified. Compared to most of the previous works on canals in Kolkata, the inventiveness of this paper is that water quality of the selected Canal is investigated from the survey sights. In this study, hygiene and sanitation practices of canal bank dwellers is also evaluated to understand their role in canal pollution. We know that about a million people including children and women die in low- and middle-income countries due to water pollution, lack of sanitation and hygiene (WASH attributable deaths) [15] and discharging pollutants to canal will accelerate such vulnerabilities. Thus, this study will contribute towards an arduous challenge of policy makers towards providing a healthier environment to the people dwelling along the banks of the canals.

2. OBJECTIVE

- To identify the major habitat components of the bank dwellers though satisfaction index.
- To understand the extent of canal pollution along which they dwell and add to the pollution of the canal.

3. STUDY AREA

After the construction of Circular Canal, the main stream of Beliaghata Canal joined the Circular Canal (Fig1). The Beliaghata Canal has witnessed several covered areas, construction and blockage due to urban growth. In 18th century Beliaghata canal emerged as major trade centre of Bengal known as Rashmoni Bazaar. In early 20th century the banks of the canal witnessed slow growth of population settlement and few small-scale industries [16]

Slum population started cropping along the banks of Beliaghata canal. The negligence of the canal led to complete halt of navigation. Soon the canal transformed from navigation canal drainage to dumping ground of waste materials. The Government of West Bengal in 70s thought of filling up the canal completely but could not execute. The development of Salt Lake City, Beliaghata Canal drifted and lost connection with Bidhyadhari and Salt Lake. The Beliaghata Canal and Circular Canal drains in areas of Chitpur, Cossipore, Bagbazar, Ultadanga, Maniktala, Salt Lake and Beliaghata. During the Bangladesh War of Independence, the banks of the Canal transformed into Refugee camps. In recent years the Beliaghata Circular Canal has become extremely polluted. The last reformation of this canal was in 2002. The canal is heavily silted and polluted with the unplanned and haphazard settlement of migrants along its bank [17]. The population residing along the Circular Beliaghata Canal are mainly the international migrants and refugees from Bangladesh who crossed the borders of West Bengal during the partition of Bengal in 1947. Later on, migrants from Muzaffarnagar and Samastipur Districts of Bihar also settled along the banks in and around the Beliaghata stretch of the Circular Canal. However, these illegal settlements were burned and demolished in 2002 [18] .

Two Wards are selected from Kolkata Municipal Corporation. The selected Wards are 7 and 14 (fig2). The Circular Canal is to the north, Bagbazar to the east. Bidhan Sarani and Girish Avenue to the South and Hooghly River to the West. The study area in Ward 7 is restricted to Galiff Street of Bagbazar. The total population of Ward no & is 19180 of which 9924 are male and 9238 are female. In Ward no 14, Bidhannagar Road and Barin Ghosh Sarani are to the north, Eastern Railway line and Bagmari Road are to the south and Circular Canal to the west. The total population of the Ward no 14 is 53343 of which 27064 are males and 26279 are females [19].

3.1. Methodology

This research paper employs a comparative case study based on quantitative methods. Two Wards 7 and 14 of Kolkata Municipal Corporation are selected for the case study. Both the wards are situated on the banks of Circular Beliaghata Canal.

3.2. Data

The data is based on primary survey of the bank dwellers of this canal, interviews, observations and documents. The primary survey was conducted with the help of questionnaires leading to door-to-door survey sampling method was random.

3.3. Sample Size

The sample size of the study was 300 (150 from each Ward) respondents were surveyed who live on the banks of this canal. Interview transcripts were analyzed using SPSS software.

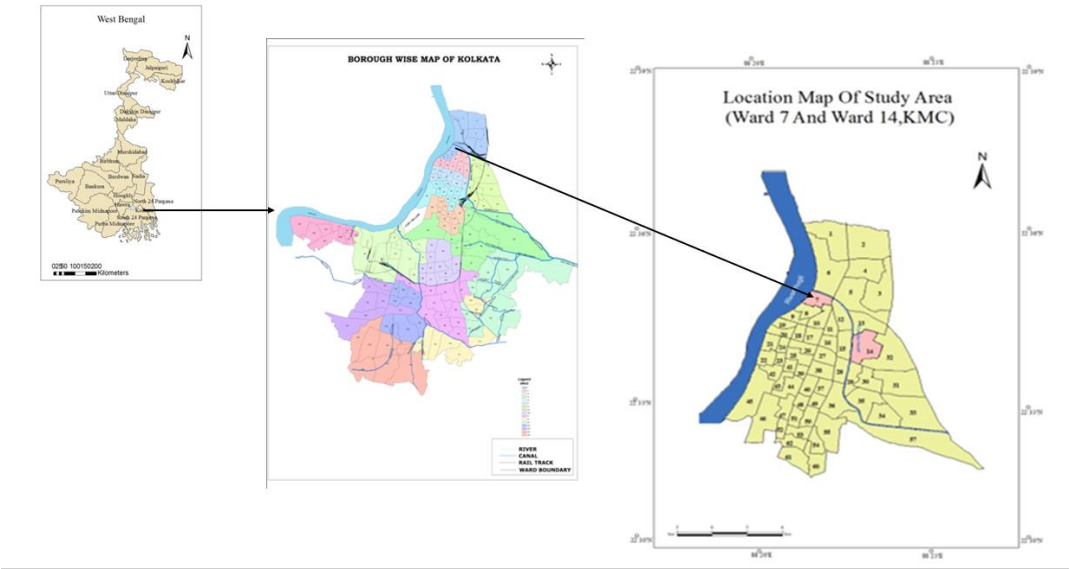
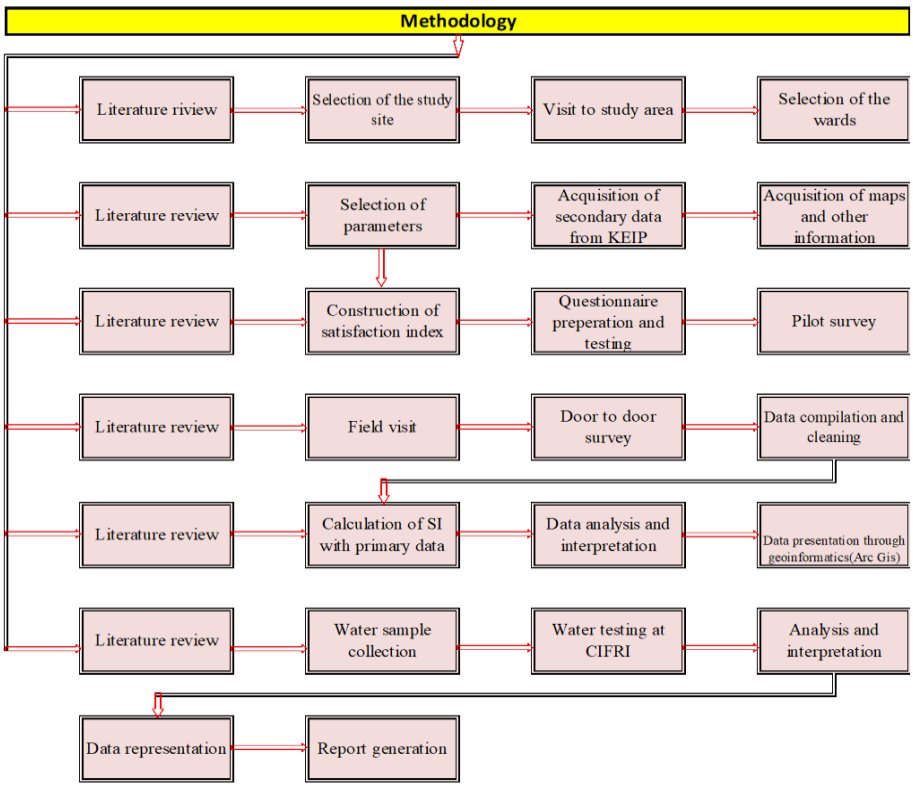


Figure 2. *Location Map showing Study Area*



4. METHODS

Community Satisfaction Index was constructed based on selected parameters to quantify the satisfaction of canal bank dwellers about their living condition. The Satisfaction Index in this study is a modified version of Customer Satisfaction Index. The Satisfaction Index used in this study is a quantitative technique to measure the level or degree of satisfaction of Canal Bank Dwellers about the basic physical infrastructure crucial for living. The satisfaction Index Scale ranges from 0 to 1, where 0 is no satisfaction and 1 is highly satisfied [20]. This index is determined based on primary survey. This

method brings into spotlight the contentment of the people staying along the banks of canals in Kolkata Metropolitan Area.

4.1. Satisfaction Index Scale

(1.0 Highly Satisfied) (0.75 Satisfied) (0.50 Partially Satisfied) (0.25 Sometimes Satisfied) (0 Not Satisfied)

Satisfaction Index- AWI = [fh (1.0) +fs (0.75) +fp (0.50) +fn (0.25)]/ (ni*N)

AWI= average weighted index, fh = frequency of high satisfied, fs = frequency of satisfied, fp =frequency of partially satisfied, fn =frequency of not satisfaction, ni =number of items, N = number of observations

Two locations were selected from Ward 7 and Ward 14 for test of sample water from the Canal. The sample location was about 30 cm below the canal water surface to test various physical and chemical properties of canal water like transparency, DO, BOD, COD, Specific conductivity, ph., alkalinity, chloride content and heavy metals. Samples were stored in sterile bags and stored with ice. All the samples were submitted in the Laboratory of Central Inland Fisheries Research Institute located at Barrackpore within 1 hour. The analysis was performed in the laboratory after incubation according to standard examination methods. The main purpose was to compare the water quality of canal water at the outlet of the river (Ward 7) and at sites as canal progresses inward into the city (Ward 14).

5. RESULTS

5.1. Housing Condition

It generally refers to home where people live and get shelter. Housing can be formal, semi-formal or informal in nature. It can be lodge, shelter, dwelling etc. The housing of the bank dwellers is informal in Ward & and Ward 14. The results of satisfaction index in both wards are calculated.

5.1.1. Ward 7

The satisfaction index of the necessary services to the housing like electricity and water supply is the highest (0.55), followed by that of the building material (0.425). Next ranks the satisfaction index of layout (0.35) and number of rooms respectively (0.335). Lastly comes the satisfaction levels of roof (0.32) and ventilation (0.27) making the least satisfaction index **(**Table 1). The water supply by the Talah pumping station makes the satisfaction level of the services like water supply comparatively higher than the other parameters. Presence of a concrete section of the government quarters of housing along the banks makes it the next ranking satisfaction level followed by layout of the housing as this section has the separate kitchen too unlike the majority of the tent dwellers. The numbers of rooms however remain in low satisfaction, as well as roof because of the material and lack of maintenance respectively in both tents and concrete houses respectively. Ventilation is equally least due to congested residing.

5.1.2. Ward 14

The number of rooms has the comparative highest satisfaction index (0.35) among the rest parameters. The necessary services of water supply and electricity supply (0.305), followed by those of layout facilities of separate kitchen (0.28). The satisfaction index of building material (0.255) and the roof (0.25) are same and finally the lowest satisfaction level is noticed in the ventilation (0.09). (Table1) Water supply by the Talah pumping station makes the bank dwellers more satisfied with the necessary services category. Here only a few residents, residing in the asbestos houses, a few among them have separate kitchen. The material in both cases for tent dwellers and asbestos dwellers is not satisfactory with both having non satisfactory roof performances as well as the ventilation is even poorer here.

5.1.3. Ward 7

The bank dwellers are more satisfied with the source of water (0.8) and almost at the verge of being highly satisfied about uses of water (0.98). But they are partially satisfied with the duration of supply (0.58). The bank dwellers are even partially satisfied with the low or almost nil water logging (0.53)

and therefore are near about of being satisfied with the drainage system (0.66). They are however not satisfied with the toilets (0.31) and garbage disposal system (0.39). The source and quality of the water is highly reliable being supplied by the Talah pumping station and the bank dwellers have no such complains of dissatisfaction with it.

5.1.4. Ward 14

The residential here are however not satisfied with the source of water supply (0.42), even much more not satisfied with the frequency of supply (0.21). But however, are satisfied with the quality of the water (0.87). They have quite good level of satisfaction for the water logging problem (0.7), satisfactory drainage (0.6), not satisfied to partially satisfied for toilets (0.28) and garbage disposal system (0.35) respectively.

The people are not so satisfied with the modes of water supply due to a smaller number of taps available and also with the frequency of supply as less taps and low duration or low frequency of supply both causes clamoring over water. The quality is as usual good due to the supply by the Talah pumping station. Due to the presence of canal, the good drainage system prevents any sort of water logging and the dwellers are satisfied with it. However, the toilets are all open and all are mostly common type. The garbage disposal system is very poor adding to their unhygienic condition.

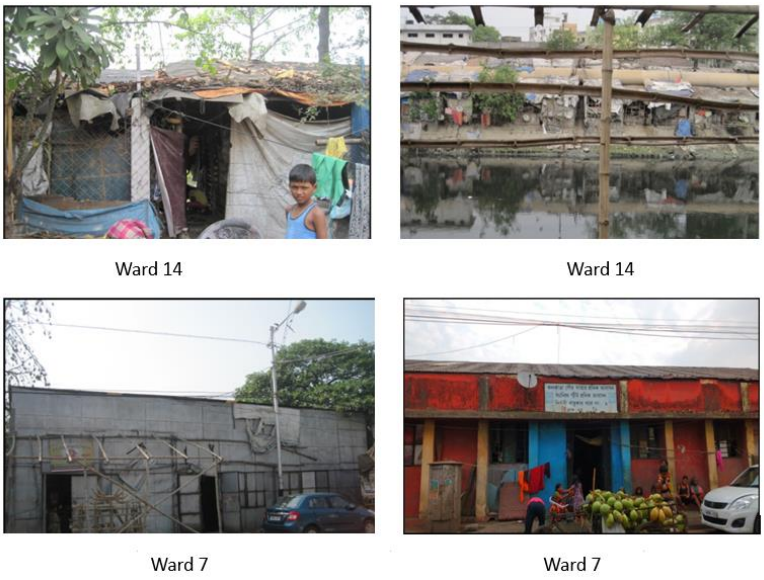


Figure 3. *Housing Condition of Ward 7 and Ward 14*

Figure 4. *Drinking Water and Sanitation in Ward 7 and Ward 14*

5.2. Transport Condition

5.2.1. Ward 7

The people here are satisfied with the modes of transport available (0.79). The nearest connector instance is also satisfactory (0.77). However, the vehicular movements (0.25) and frequency of road accidents are not satisfactory (0.25). Again, the accessibility to necessary institutions (school, college, hospitals, market) provides good satisfaction level (0.81) (Table 1). Being located near the Shyam bazar and Bagbazar connector on the either two ends of the locality people access the least connector distance as well as has the availability to all sorts of modes of transport. However,

5.2.2. Ward 14

In this ward also the satisfaction level is higher for the modes available (0.71) as well as high satisfaction level is noticed in the distance to nearest connectors (0.81). The vehicular movement (0.32) and probability to road accidents (0.3) are partially satisfied. Again, the level of satisfaction is higher (0.86) (Table 1) in the accessibility to necessary institutions like school, colleges, hospital, market etc. Being located in between the Ultodanga Gouri Bari and Manicktala Bagmari the area has good availability of transport modes, and these connectors being nearby along with another connector of Manicktala sahitya parishad.

Figure 5. *Major Bridges and Connectors in Ward7 and Ward 14*

Figure 6. Environmental Condition of Ward 7 and Ward 14

5.3. Environmental Conditions

5.3.1. Ward 7

Pollution due to emission from transport is higher here (0.32). The pollution due to emission from factories is lower and so the satisfaction index is higher (0.64). The noise pollution is also higher making low satisfaction level (0.32). The pest problems are intolerant providing non satisfaction (0.07) (Table 1). The bank dwellers are even dissatisfied (0.24) with the environmental programmes conducted by the corporation. Being one of the busy areas of north Kolkata the transportation pollution is higher which results in higher noise pollution as well. Any large factory being absent here industrial pollution is low resulting in high satisfaction against industrial pollution. The environmental programmes are not managed properly and regularly hence pests' problems are prevalent resulting in dissatisfaction in both the parameters.

5.3.2. Ward 14

Here also the satisfaction level for transportational pollution is low (0.36) along with the noise pollution (0.34). The people are satisfied against the pollution from factories (0.81) i.e., almost nil. The satisfaction level for environmental programmes (0.37) and pest problem (0.14) is quite significantly low (Table 1). Again, one of the quite busy areas of Kolkata the pollution is quite high both transportational as well as noise. However, presences of no industries have made the industrial pollution lower and bank dwellers are satisfied with it. Here also the environmental programmes are not carried out properly and pest problem is highly dominating resulting in low satisfaction level.

Table 1. *Satisfaction Index of Respondents about Their Habitat Condition*

Housing							
Study Area	**No of rooms**	**Layout**	**Services**	**Building material**	**Roof**	**Ventilation**	
Ward 7	0.335	0.35	0.55	0.425	0.32	0.27	
Ward14	0.34	0.28	0.305	0.255	0.25	0.09	
Public Water and Sanitation							
	Source	**Supply Duration**	**Uses**	**Drainage**	**Toilets**	**Garbage Disposal**	**Water-logging**
Ward 7	0.8	0.58	0.98	0.66	0.31	0.39	0.53
Ward14	0.42	0.21	0.87	0.6	0.28	0.35	0.7
Transport Facilities							
	Modes Available	**Connector**	**Vehicle Movements**	**Accidents**	**Accessibility**		
Ward 7	0.79	0.77	0.25	0.24	0.81		
Ward14	0.71	0.81	0.32	0.3	0.86		
Environment							
	Transport Pollution	**Factory Pollution**	**Noise Pollution**	**Pests**	**Environmental Programmes**		
Ward 7	0.32	0.64	0.32	0.075	0.24		
Ward14	0.36	0.81	0.34	0.14	0.37		

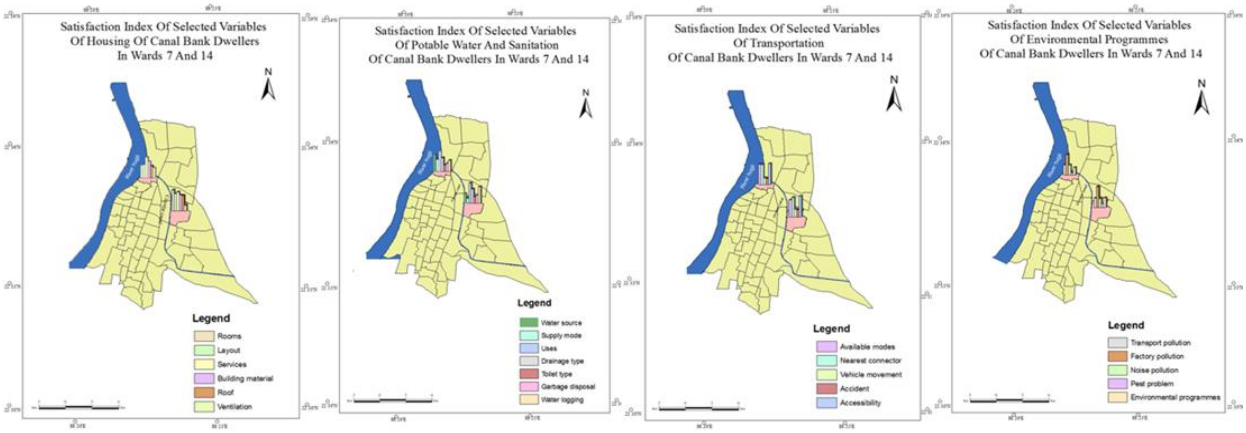


Figure 7. *Spatial Depiction of Satisfaction Index of Selected Variables*

Water quality was tested by collection of sample waters from Ward 7 (Site I) and Ward 14 (Site II). The collected water samples were tested in Central Inland Fisheries Research Institute, Barrackpore.

Table 2. *Water Samples for Analysis of Physical and Chemical Properties*

Sl. No.	Water parameters	Sampling Site I	Sampling Site II	Surface water criteria for trace elements in public water supplies (Kopp, 1970)
1	Colour	Greyish	Moderate black	
2	Transparency (cm)	12.0	4.0	
3	Temperature (oC)	27.0	27.5	
4	Dissolved Oxygen (DO)	1.2	0.0	
5	pH	7.6	8.2	
6	Sp. Conductivity (µS/cm)	544.0	605.0	
7	Total alkalinity (ppm)	184.0	208.0	
8	Total hardness (ppm)	156.0	172.0	
9	Calcium content (ppm)	61.0	67.3	
10	Chloride content (ppm)	50.0	58.0	
11	BOD (ppm)	5.2	21.5	
12	COD (ppm)	42.0	89.0	
13	Zinc (Zn, ppm)	2.2	4.0	5.00
14	Copper (Cu, ppm)	0.38	0.47	1.00
15	Cadmium (Cd, ppm)	Trace	0.007	0.01
16	Lead (Pb, ppm)	0.02	0.04	0.05

Sampling site I is near to river Hooghly and sampling site II is apart 3.5 km from the site I

Sampling Date 22.04.2025; Samplings time: 9.00 hrs

Air temperature: 39 °C

(Examined by CIFRI)

Figure 8. *Water sample Collection from Canal in Ward 7 and Ward 14*

Transparency is higher in Ward 7 than in Ward 14. The Ward 7 has 12cm transparency whereas Ward 14 has 4 cm transparency. The sewages have not yet contributed to the turbidity of water. But the water sample of Ward 14 is quite turbid, having transparency less than half of that of the Ward 7. (Table 2)

The BOD and COD levels both are higher in the ward 14 than ward 7. The BOD level at Ward 7 and 14 are 5.2(ppm) and 21.5 (ppm) respectively and the COD levels are 42(ppm) and 89(ppm) respectively. The lack of dissolved oxygen (DO) in Ward 7 and complete absence of it in Ward 14 indicates the difference between the BOD and COD levels of the water samples of the two sites. The more the DO the lesser should be the BOD and COD. (Table 2)

The sample of Ward 7 has 1.2-unit dissolved oxygen and sample of Ward 14 no dissolved oxygen contained in it. As at the Ward 7 water enters the canal and is yet to receive any sewerage outlet in it, thus still have oxygen in it but as the canal progresses the water receives sewerage outlets and sewages

gets into the water, the biological and chemical oxidation increases which takes up the available dissolved oxygen leaving behind no dissolved oxygen any further. (Table 2)

The pH level is also higher in the Ward 7 than Ward 14. Therefore, it can be said that the water of Ward 7 is more towards neutral with pH value of 7.6 than that of Ward 14 whose pH value is 8.2 thus being more basic. The total alkalinity has a higher value in sample 2 from Ward 14 than sample 1 from Ward 7. The Ward 7 has an alkalinity value of 184(ppm) and that of Ward 14 is 208(ppm). The higher ph. value in the Ward 14 indicates the higher alkalinity in this Ward than Ward 7 water sample.(Table 2)

The range of specific conductivity of the water samples collected from the segments of the canal from two Wards. The specific conductivity is higher in the Ward 14 than in Ward 7. The Ward 7 has a specific conductivity of 544µS/cm and Ward 14 has a specific conductivity of 605µS/cm.

The level of zinc in Ward 7 and 14 is 2.2(ppm) and 4(ppm) respectively [standard 5(ppm)].The level of copper in Ward 7 is 0.38(ppm) and that of Ward 14 is 0.47(ppm) [standard 1(ppm)].The level of cadmium in Ward 7 is almost nil but in the other is 0.007(ppm) [standard 0.01(ppm)] and the level of lead is 0.02(ppm) and 0.04(ppm) in Ward 7 and 14 respectively [standard 0.05(ppm)].(Table 2)

About the practices of canal bank dwellers that contributes to the canal pollution (Fig 9) several responses were documented from the settlers. Defecation of settlers along the canal banks particularly of children is a major cause of pollutant in canal water (Ward 7:39%, Ward 14: 55%). The practice of throwing raw sewage in canal is higher for both Wards, (Ward 7: 47%, Ward 14: 56%) due to absence of ways to dispose solid waste and it is easier to throw in canals. Throwing of polythene bags is another issue choking many outlets of canal water. This practice is less in Ward 7 but significant in Ward 14 (Ward7: 29%, Ward 14:67%). All temporary and public toilets in these Wards have outlet directly into the canal carrying sewage from the houses. The problem is aggravating in Ward 14 due to lack of soakage pits (Ward 7:42%, Ward14:87%). Usage of canal water is minimum in Ward 7 due to more public toilets but in Ward 14 bathing and washing clothes is higher due to fewer number of taps, dense population and lack of awareness (Ward 7: 12%, Ward 14:47%). Thus, the settlers of canal banks in Ward 14 are creating canal pollution at a higher rate than settlers of Ward 7 in all the indicators.

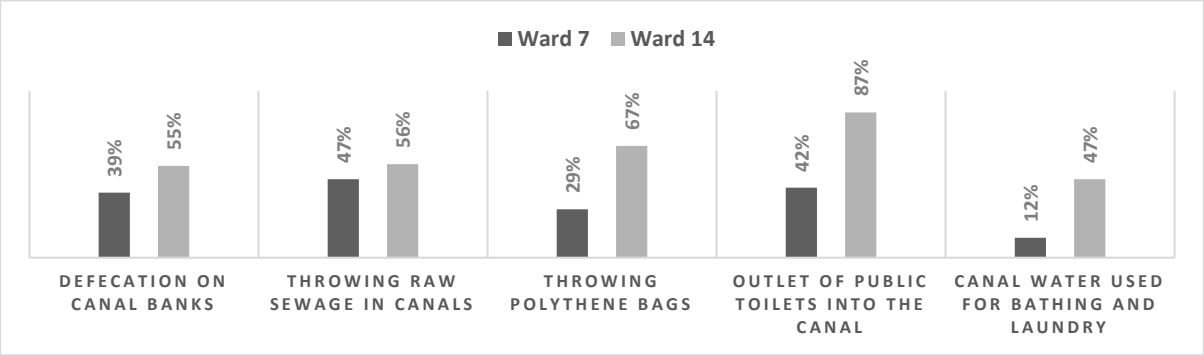


Figure 9. *Causes of Canal Pollution by Canal Bank Dwellers*

Ecological balance is of paramount importance to sustain habitable environment. The constant deterioration of quality of canals in cities automatically impacts the dwellers near it [21]. Primary survey revealed that the settlers of canal banks face living and health issues. Noise pollution affects the settlers more in Ward 14 than in Ward 7 (Ward7:23%, Ward14:57%). Houses are mostly non-permanent in nature built of tents, bamboos etc which is vulnerable during monsoon and cyclones (Ward 7:36%, Ward 14:74%). Lack of private toilets, shared public toilets and lack of privacy is a major deterrent towards personal hygiene, safety of females and cleanliness (Ward 7:34%, Ward 14: 61%), Both the settlers of Ward 7 and Ward 14 had no issues with waterlogging. (Fig 10)

In Ward 7 water logging may be experienced for 1 or 2 days which the dwellers are not very concerned about. The settlers of Ward 14 do not face waterlogging problem (Ward 7: 10%, Ward14:5%). Most of the settlers stay in stinking foul smell of the canal 24 hours. Sometimes they feel breathing trouble in such dilapidated environment (Ward 7:89%, Ward 14: 93%). Dermatological issues like skin disease, eczema, infection and rashes are faced by the settlers due to contact with canal water but it is more in Ward 14 (Ward7:47%, Ward14:58%). Cholera, dysentery and diarrhea affect the settlers particularly children to great extent (Ward7: 36%, Ward14:56%), Mosquito bite is another major issue for canal

bank dwellers and in Ward 14 it is very high. The dwellers here lack the consciousness about malaria and dengue and are reluctant in using mosquito nets (Ward7:21%, Ward14: 77%), Genital infection of women settlers is another health concern. Lack of private toilets, a smaller number of taps and use of canal water for washing clothes are causing such heath issues which is higher in Ward 14 (Ward7: 23%, Ward14:41%). (Fig 10)

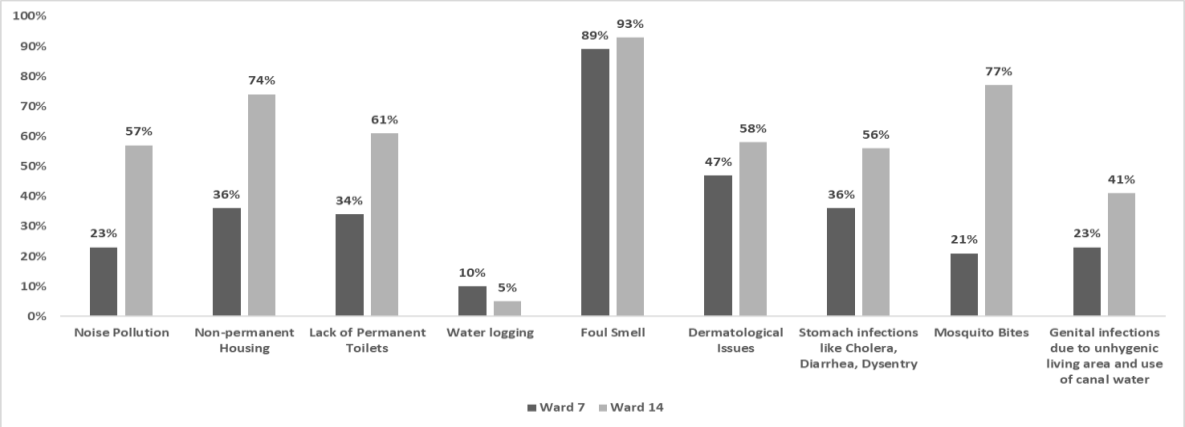


Figure 10. *Major Problems faced by Canal Bank Settlers*

6. DISCUSSION

In both Wards satisfaction level for the number of rooms (Ward7:0.34; Ward14:0.34) are same. The major difference is observed in the rest parameters of housing domain. The layout is much higher in the Ward 7 (0.35) due to the large section of government employees residential who have separate kitchen. In ward 14 the asbestos section also is made by government but here their proportion is less and with few having separate kitchen. Both receives water from Talah pumping station but the cost of electricity unit charges makes the difference making the satisfaction level higher in Ward 7 than in Ward 14. (Ward7:0.55, Ward14:0.34). In material (Ward7:0.43; Ward14:0.26) and roof performances (Ward7:0.32; Ward14:0.25) there is a significant difference mainly due to the concrete section in Ward 7 and asbestos section in Ward 14. Roof performance of concrete is way better than the claustrophobic asbestos part. The ventilation even has higher satisfaction index in Ward 7 than Ward 14 (Ward 7:0.27, Ward14: 0.09).

Regarding water and sanitation condition Ward no.7 has higher satisfaction levels in each parameters as compared to those of the Ward no.14.The vast difference is observed between the mode of supply(Ward7:0.8;Ward14:0.42) and duration of supply (Ward 7:0.58;Ward 14:0.21)for each wards as the Ward no.7 has good number of taps whereas the corporation built concrete sectors have their taps within their quarter premises, but the Ward 14 has few number of taps and all the residential depend on them. However, with the uses they have almost similar satisfaction level. The water logging is almost nil in the Ward 14 where as it is slightly higher (1 to 2 days) in Ward 7, thus the satisfaction level is higher in Ward 14(0.70) than that in ward 7(0.53). The drainage, toilets and garbage disposal systems have almost similar satisfaction level with negligible values of differences between the two wards. As they don't have any personal domestic supply lines thus a huge amount of population depends upon few numbers of taps where the frequency is twice to thrice a day. The presence of the canal prevents any sort of water logging as the dwellers claim. However, the toilets are majorly open with being shared by many people and if attached also they are common toilets deceasing their personal hygiene and increasing their dissatisfaction.

There is not much difference between the maximum parameters of this transport like modes available (Ward7:0.79; Ward14:0.71) and connector distance (Ward7:0.77; Ward14:0.81) between the two Wards. As the results of the satisfaction index which states the Ward number 14 are more satisfied with the vehicular movement (Ward7: 0.25; Ward 14: 0.32) and frequency of accidents (Ward 7: 0.24; Ward 14: 0.30). The accessibility to various institution also has slightly higher index in Ward 14 (0.86) than the Ward 7(0.81) due to the presence of two hospitals as well as two markets nearby.

In terms of environmental conditions satisfaction level due to transportational pollution has very low difference in their satisfaction index in both the Wards (Ward 7:0.32; Ward 14:0.36), as well as for the

noise pollution (Ward 7:0.32; Ward 14:0.34). The satisfaction index for factory pollution is much higher in ward 14(0.81) than Ward 7(0.64). However again the pest problem because of irregular environmental programmes is higher in Ward 7 resulting in significantly lower satisfaction level in this Ward than the Ward 14, where people are better satisfied with the environmental programmes and hence with the pest problem too.

The composite satisfaction index of each ward comprises of the average of overall satisfaction index of the domains of each ward. The composite satisfaction index is higher in the ward 7 portraying better satisfaction level than the ward 14 which has a lesser value of composite satisfaction index. The overall satisfaction index values of housing (Ward 7:0.38; Ward 14: 0.25) and potable water and sanitation (Ward 7:0.60; Ward 14:0.49) are higher in ward 7 where as those of transportation (Ward 7:0.57; Ward 14:0.60) and environment (Ward 7:0.32; Ward 14:0.40) are higher in Ward 14. Here the difference between the values of housing and water and sanitation are higher than the difference of the values of transport and environment for both the Wards thus averaging them we get the composite satisfaction index value for each ward in which the Ward 7 has slightly higher index than Ward 14, a difference of 0.03 unit in the composite index.

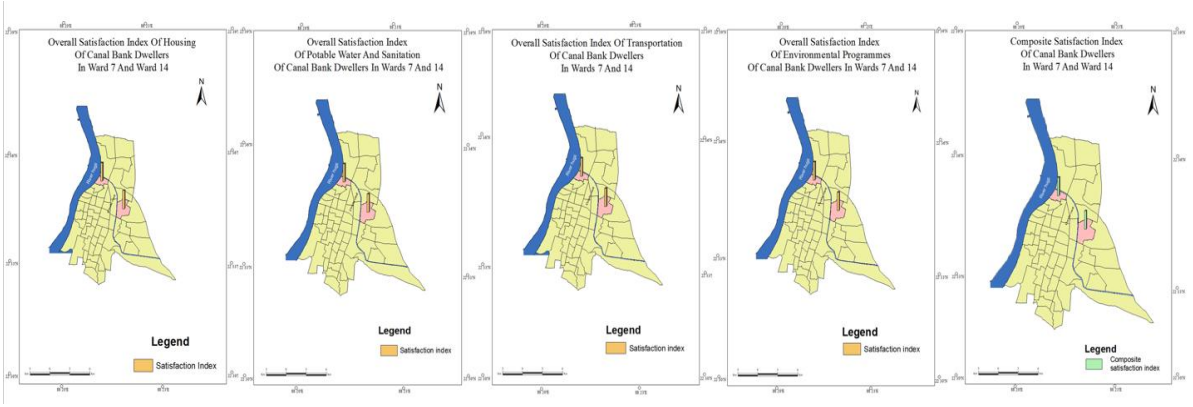


Figure 11. *Spatial depiction of Overall Satisfaction Index and Composite Satisfaction Index in ward 7 and ward 14*

Table 3. *Ward-wise Overall Satisfaction Index and Composite Index of Selected Domains*

Ward	Housing (H)	Potable Water and Sanitation(P)	Transport(T)	Environmental (Programmes E)	Composite Index (H+P+T+E)/4
7	0.375	0.6	0.57	0.32	0.47
14	0.253	0.49	0.6	0.40	0.44

From the water sample test, it is evident that the canal in Ward 7 is not polluted due to its proximity to River Hugli. The hydrology of the canal at Ward 7 is impacted by tides, fluctuations in water level and hydraulic regimes. However, the canal becomes more polluted as the canal progresses inwards to the city which is evident from water test results of Ward 14. In terms of transparency of canal water, the water being clearer in Ward 7 than in Ward 14 is mainly due to its just entrance in the canal channel from the river Hugli. Ward 14 has canal receiving sewage outlets at various points. Thus, it may also indicate more polluted water in the Ward 14 than Ward 7. Again, as more and more sewerage and other chemical compounds are added to the canal water as it progresses through its channel biological and chemical decomposition of these substances increases leading to higher BOD and COD. Thus, both the levels are desired to be higher in Ward 14 than Ward 7. DO in surface water is very important for thriving of aquatic life. If the DO is low, it indicated that the water's self-cleaning ability is poor. The DO is 0 in Ward 14 which indicates anaerobic situation with higher death, decomposition and lower aquatic organism activities indicating polluted water and foul odour [22]. The more sewage inclusion indicates more specific conductivity of water. The sewage intrusion increases as the canal progresses so also the specific conductivity of the canal water in Ward 14. The Ward 7 has canal water less affected by heavy metals than that of Ward 14. The water of Ward 14 is more vulnerable to pollution limits as when compared to the Ward 7 though the values remaining within the standard limits in both cases (Table 2). The canal being majorly a sewerage canal and not a sludge or effluent canal is likely to have fewer amounts of heavy metals as they are predominantly the components of industrial waste.

7. Conclusion and Recommendation

The study reveals that the banks of canal are occupied with migrants from other States who aspired to settle in Kolkata city for better work. However, over saturation of this city has pushed them to settle way beyond the slums and shanties and along the banks of canals. Their housing sometimes is obstructing the path of canals making maintenance and cleaning even more difficult. This informal occupant of canal banks lacks security of tenure and, with this, lacks ready or reliable access to civic amenities (potable water, electricity and gas supply, sanitation and waste collection) as well. Due to the informal nature of occupancy, the state will typically be unable to extract rent or land taxes that may lead to sluggish development of basic amenities and physical infrastructure in these spots. If these households lack the economic resilience to repurchase in the same area or relocate to a place that offers similar economic opportunity, they are prime candidates for informal housing. Most of the respondents in this study are reluctant in relocating to other areas. Therefore, along with relocation of these family's on-site upgradation has to be initiated. The canal in the studied area has become the dumping area of sewage and pollutants from streets, septic tanks, industries and other households. The waste water, garbage, plastics, raw sewage, chemicals has converted the canals into degraded "anaerobic ponds". The drinking water supply is from Tallah Pumping station hence the water is potable however the few inadequate taps cannot supply sufficient water to the canal bank dwellers. The major issue however is the sanitation. Lack of toilets forces the dwellers for open defecation into the canal banks. The canal water is also the breeding ground of mosquitos. Even if there are few public toilets constructed by Kolkata Metropolitan Development Authority but those toilets have no septic tank, discharging the sewage directly into the canal. Government should allow standpipes closer to this community, septic tanks, sewerage pits have to be constructed along with public toilets. Liquid wastes like bathing water, laundry water, industrial chemicals free flow to the canal has to be restricted.

For the canal bank dwellers in Ward 7, being between two busy junctions the vehicular movement is high and rash at times leading to higher probability of accidents frequently. But the hospitals like R.G. Kar hospital, Shyam bazar market area, different schools and colleges are very nearby rendering good services. The vehicular movements are smooth giving partial satisfaction level along with seldom occurrence of accidents at time but in general frequency is low. Similarly in Ward 14 the accessibility to hospitals like R.G. Kar Hospital, E.S.I Hospital, markets like Muchi Bazar of Ultodanga, Manicktala Bazar and several schools and colleges leads to higher satisfaction level. Since transport network is better in this part, the low-income communities of canal banks can get engaged in transport sector for their source of income. The environmental pollution and degradation are linked and related to sanitation condition of the bank dwellers to a great extent. The canals are the channels collecting storm waters, chemicals from industries, puddles in monsoon and all other dirty waters from the city. The open defecation and sewage disposal along with waste disposal has led to environmental pollution of the canals. Although the dissatisfaction of the canal dwellers is on industrial pollution but they are unaware of the water pollution that is caused by open defecation, shared public toilets on the banks of the canal and throwing of wastes in the canal water. Interestingly, the water sample analysis revealed that heavy metals in the studied Wards are within permissible limits but DO, COD, BOD indicated sewage pollution.

The aspect of social well-being of canal bank dwellers is extremely critical as it needs better living condition of the people, improved sanitation and sustainable environment. The relocation of bank dwellers in various Govt projects have failed as the dwellers are reluctant to leave the place and shift to government housing. Forced evacuation will be unjust from humanitarian ground hence the on-site upgradation needs to be robust. Participation of canal bank dwellers in various cleanliness programmes, awareness generation of local stake holders, regular EIA of the areas, alternative location for dumping of solid wastes, water collection and analysis of risk assessment, fencing of the banks, specific bathing slots, placing covered bins, quick transit of the bins once full, spacing of houses in row, frequent removal of sludge from emptier, more water supply through taps, regular health checkups and health awareness campaign, and skill development of the community to use these on-site measures can be executed in-situ for addressing the critical issues of canal sustainability.

This study brings out the psychological satisfaction of the settlers in terms of socio-environmental domains on one hand and the extent of ecological vulnerability they are facing while settling in such locations on the other. This study also highlights the physical and chemical quality of canal water which

can throw light on extent of canal pollution. Health issue has been addressed in this paper but not in details which can be a further area of research in future. This study very potently has addressed the intricacies of the importance of location of settlers along the canal. The socio-environmental condition of canal bank dwellers is not same in all places is a significant outcome for policy makers in terms of canal pollution, hygiene, health and other amenities. The propagation of canals inward and the canal bank settlers inside the city are facing greater issues and concerns. Limitation of this study however is its coverage of only two Wards.

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CONFLICT OF INTEREST

There is no conflict of interest.

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