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Impact of COVID-19 on water and sanitation in Mumbai slums.

Impacto de COVID-19 en el agua y el saneamiento en los barrios marginales de Mumbai.

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ABSTRACT

Mumbai City (19.07° N, 72.87° E) is the true example of 'diversity in extreme level'. This well-known city is commonly known as the financial capital of India and is the 12th richest city in the world. Mumbai city (Municipal Corporation of Greater Mumbai or MCGM) spreads around 437.5 km^2, with 12.5 million population as per Census 2011, with a population density of 83,660 per km^2 and approximately 6.5 million are living in the slums without proper access to water, sanitation and hygiene (WASH). There is a debatable topic, 'water is a blessing or a curse?' We know water means life but in monsoon season these views might lead to conflicts. Mumbai alone has recorded 585.5 mm precipitation in July resulting in severe flooding across the city. The slum communities of Mumbai are at the receiving end of these erratic patterns due to inefficient drainage and lack of basic facilities. This pandemic situation has proved again the urgency of WASH. WHO has already listed the COVID-19 virus as one of the most contagious diseases which has been spreading exponentially due to the poor toilet facilities, lack of access to clean water and unhygienic activities in slums. The survey data from different slum communities configures their perception related to WASH and our study links it with the pandemic and the resultant adaptive capacity ranking. Although most of the Mumbai slum has a good literacy rate (69%) but lack of awareness among these slum communities lead to a vulnerable situation. The slum clusters of Mumbai have become COVID-19 hotspots and also resulted in losses of jobs and human lives. Through FCM (Fuzzy Cognitive Mapping) and SWOT analysis, the study discovers present social, technical, and economic aspects and perception of these slum communities to analyze their adaptive capacity towards COVID-19.

Keywords: WASH, COVID-19, Slum, Mumbai

RESUMEN

La ciudad de Mumbai (19,07 ° N, 72,87 ° E) es el verdadero ejemplo de "diversidad en un nivel extremo". Esta conocida ciudad es comúnmente conocida como la capital financiera de la India y es la duodécima ciudad más rica del mundo. La ciudad de Mumbai (Municipal Corporation of Greater Mumbai o MCGM) se extiende alrededor de 437,5 km2, con 12,5 millones de habitantes según el censo de 2011, con una densidad de población de 83,660 por km2 y aproximadamente 6,5 millones viven en barrios marginales sin acceso adecuado a agua, saneamiento y Higiene (LAVADO). Hay un tema debatible, "¿el agua es una bendición o una maldición?" Sabemos que el agua significa vida, pero en la temporada de monzones estos puntos de vista pueden generar conflictos. Mumbai por sí sola ha registrado una precipitación de 585,5 mm en julio, lo que ha provocado graves inundaciones en toda la ciudad. Las comunidades de tugurios de Mumbai se encuentran en el extremo receptor de estos patrones erráticos debido al drenaje ineficiente y la falta de instalaciones básicas. Esta situación de pandemia ha vuelto a demostrar la urgencia de WASH. La OMS ya ha incluido el virus COVID-19 como una de las enfermedades más contagiosas que se ha propagado exponencialmente debido a las malas instalaciones sanitarias, la falta de acceso a agua potable y las actividades antihigiénicas en los barrios marginales. Los datos de la encuesta de diferentes comunidades de tugurios configuran su percepción relacionada con WASH y nuestro estudio lo vincula con la pandemia y la clasificación de capacidad de adaptación resultante. Aunque la mayor parte de los barrios marginales de Mumbai tiene una buena tasa de alfabetización (69%), la falta de conciencia entre estas comunidades de barrios marginales conduce a una situación vulnerable. Los grupos de tugurios de Mumbai se han convertido en puntos críticos de COVID-19 y también han provocado la pérdida de puestos de trabajo y vidas humanas. A través de FCM (Fuzzy Cognitive Mapping) y análisis FODA, el estudio descubre aspectos sociales, técnicos y económicos actuales y la percepción de estas comunidades de tugurios para analizar su capacidad de adaptación hacia COVID-19.

Palabras clave: WASH, COVID-19, Slum, Mumbai

INTRODUCTION

Mumbai is the financial capital of India with a 12.48 million population as per Census 2011 [Chandramouli, 2014]. In the past few decades, the city has become highly developed industrial and the increased job prospects have resulted in unabated migration from all over India even from neighboring countries like Bangladesh, Nepal, Bhutan, etc. Almost half of the total population lives in the slums of Mumbai due to a lack of affordable housing. So, they are

forced to live in densely populated squatters even without basic facilities like proper toilets and access to clean water. The COVID-19 pandemic creates urgency for access to clean water and proper sanitation which is the first line of defense.

It is also important that how people are managing during this crucial pandemic period. People's perception and awareness play an important role in COVID-19 preparedness. The issues vary across slums from lack of awareness to lack of basic toilet and hygiene facilities. This study is based on the field survey conducted in 16 slum clusters across 24 wards under MCGM in August 2019 [Sherly et. al, 2019] and secondary data collection from around 2445 slum clusters. People's perception captured on WASH has been linked to the pandemic and their adaptive capacity ranking indicates the resilience of these slum communities. The attributes considered for the analysis can be divided into four main categories: 1) hazard; 2) vulnerability; 3) adaptive capacities and; 4) socio-economic and health-related risk. The perception also depends on the local authorities and how they are connected with the slum communities. Hence, we state that the perception of risk can be analyzed by considering socio-economic, political and technical aspects.

WHO has listed COVID-19 under the top seven contagious diseases which are directly or indirectly spread because of poor sanitation, hygiene facilities and lack of access to clean water. This literature also supports that good sanitation and hygiene facilities with access to clean water can control this virus. The slum communities are in a more risky and vulnerable situation in this pandemic because they do not have proper access to WASH facilities [WHO,2020].

Slums can be categorized as notified and non-notified. Baiganwadi, Dharavi, Janupada and Banganga are the four main slum belts located in Mumbai city and, Dharavi (2.1 km^2) is one of the largest slums in Asia. In those slums, many people are sharing (10 ft. X 15 ft.) rooms without much concern about their health [Deshmukh,2013]. Moreover, Mumbai being a severely flood-prone city [Sherly et.al, 2015], the majority of slums face the floods on annual basis. During this pandemic (COVID-19) situation, the basic needs are safe and clean water and also clean sanitation; however, but when we consider Mumbai slums, it appears to be 'Utopia'. A report says that for 6.5 million people in slums, World Bank funded a sanitation program from 2001 till 2017 and only 750 community toilets have been constructed and the total seats available in those toilets are 26,379 [Desai,2020]. There is a need to ensure that these public toilet facilities are functional and clean.

A survey result from Observer Research Foundation shows that only one toilet seat is available for 190 users which is against the WHO rules for sanitation uses and practices (one toilet per

50 people). Also, 58% of people do not have access to electricity, and 78 % of people with no direct access to clean water [Desai,2020].

Now in the pandemic situation, these slums are heavily affected due to the lack of basic facilities and Mumbai alone has recorded 60% positive cases in India, and out of which 40% of affected people are from these slums [Butler et al.,2020]. Therefore, this study will discover various perspectives on this issue and hopefully bring out a few fruitful suggestions which may be helpful for slum communities. Not only has this COVID-19 pandemic but before also, the world seen how these pandemic situations are aggravated due to the bad quality of water and poor sanitation systems. The microbial organisms become more contagious through the water. Here, we are focusing on access to clean and safe drinking water, with proper sanitation (system or process to treat the wastewater) [Butler et al.,2020].

It is observed that water tanks from the municipality are not providing water daily to the slums. This pandemic has shut down many industries which cause a decline in water demand by the industrial sector. As a result, revenue from the water was affected by the water supply chain. In Mumbai slums, sanitation comes under the Maharashtra Housing and Area Development Authority (MHADA). Almost all slum clusters have closed drainage systems but in terms of maintenance of these drains, there is yet to a functional system in place. Mumbai slums mostly depend on community toilets and COVID-19 led these public facilities to be contagious places. During our survey in 2019, we observed that due to the poor quality of construction and management, leakage of raw sewage from the septic tanks and closed drains is very common in slums. According to Census 2011, only 32% of households have individual toilets in the slums. This indicates the widespread of the pandemic in Mumbai slums and Mumbai alone has recorded 69% positive cases in Maharashtra [8] as indicated by (Fig. 1). (Considering last census report 2011, as next census report yet to come in 2021).

The pandemic also increases the biomedical waste generation in Mumbai. A recent BMC report says that biomedical waste generation increases by almost 1,104 kg/day [Times of India, 2020]. The literature also discovers the slum pockets like Dharavi-Mahim, Deonar-Govandi generating the excess amount of medical wastes. During the lockdown period, it has been difficult to collect medical waste with proper safety precautions. The medical waste from quarantined centers makes slums communities more vulnerable As many slums are located near Mithi, a highly polluted river in Mumbai.

As we can see from the fig.-1 that from April till the end of October 2020, Mumbai’s total cases have increased rapidly. WHO report cited the reason as a highly dense population in Mumbai and the large proportion of slum population. to the option of maintaining social

distancing is practically not feasible in slums, while the numerous job losses during lock-down lead to challenges in controlling the pandemic. Till December 2020, Mumbai alone has recorded more than 4 lakh cases [Nicol,2020].

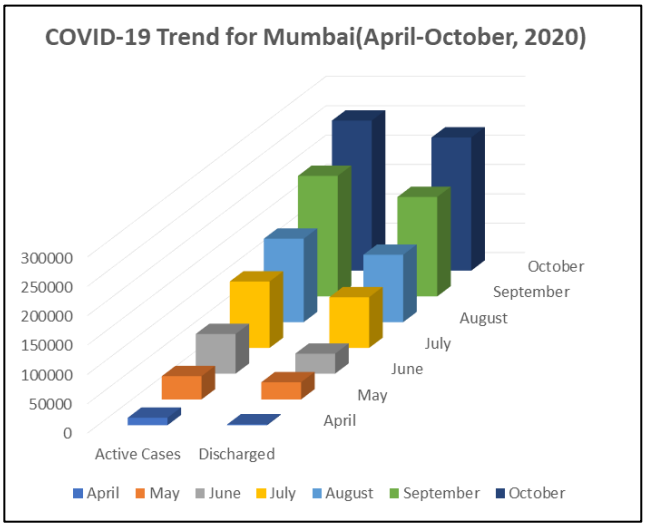

Fig. 1 COVID-19 cases in Mumbai (Apr-Oct, 2020)

Water and sanitation systems are also affected by this pandemic [Nicol, 2020]. Due to the COVID-19 pandemic, the water supply system in many slums has been disrupted. As per the latest report, slum communities are paying 135 rupees per 1000 liter on average. The maintenance of public toilets has stopped during the lockdown. In some slums, NGOs are maintaining some community toilets and also built bio-toilet facilities. The condition in non-notified slums is worse than the one notified in the suburban districts. Many migrant workers of the slums are trapped in vulnerable situations in this pandemic resulting in these slum clusters as hotspots for COVID-19.

The 18-km long Mithi River cuts across the city, originating in from the hilly regions of the Sanjay Gandhi National Park, flows through the residential and industrial areas like Powai, BKC and Asia's largest slum Dharavi, before emptying into the Arabian Sea. Almost 70% embankment of the Mithi River has been encroached by slum dwellers [Pallavi,2018]. All the domestic wastes, human wastes, open defecation are being discharged into this river. During this pandemic, the river has become more vulnerable because of the dumping of the used medical wastes from quarantined sites. There is a high likelihood that severe pollution in the Mithi River can create a suitable environment for the mutation of various deadliest contagious viruses. The study shows a detailed analytical process to capture people's perception through

FCM (Fuzzy Cognitive Mapping) along with statistical the construction of adaptive capacity ranking based on the perceptions and the existing WASH facilities in slums.

MATERIALS AND METHODS

This study was carried out on 18 slums (Fig. 2) which are both from island city and suburban districts of Mumbai. The questionnaire survey was conducted and also geospatial datasets were prepared using the ArcGIS platform. Further steps for data processing, visualization and analysis are discussed below following the work by Sherly et al. in 2019 [Sherly et. al, 2019].

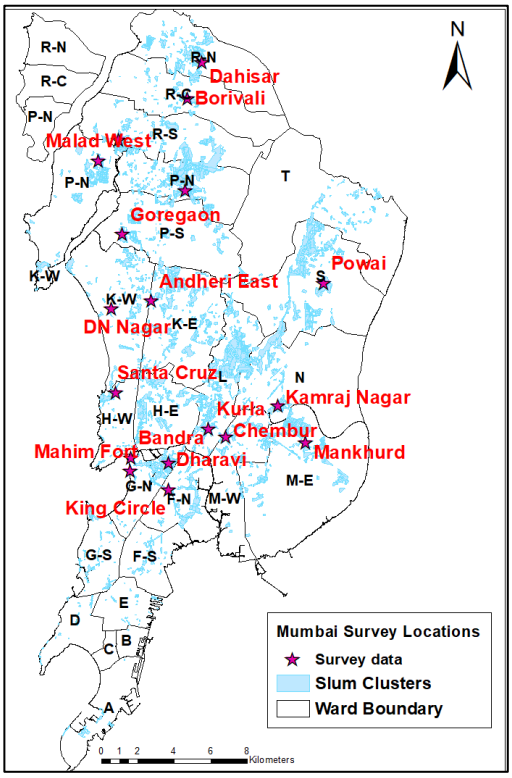

Fig. 2 Survey Locations and Ward boundary

The survey locations have been chosen based on slum clusters map, population density, landfill locations, COVID-19 outbreak and locality, etc.

The methodology is based on the Fuzzy Cognitive Mapping (FCM), Adaptive Capacity Ranking and SWOT analysis based on different factors from survey datasets (Fig. 3).

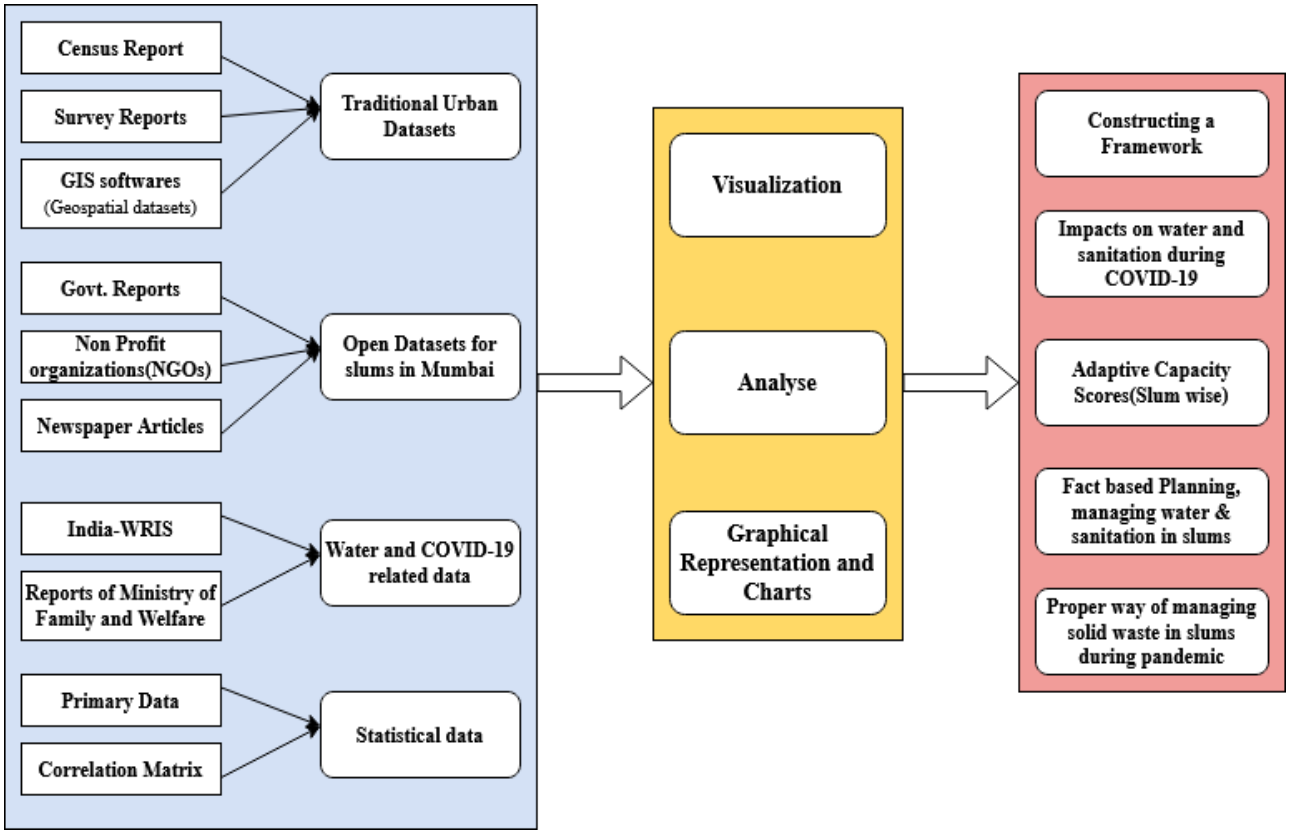

Fig. 3 Data processing and representation

A. Slum Prioritisation

In the prioritization process, layers of ward boundary, slums and surveyed location were marked. For this, datasets for literacy rate, ward wise Census report and community toilets were used.

B. Questionnaire Survey data Collection

The questionnaire surveying for data collection was conducted in 18 slum clusters under 15 slum dominant wards of Mumbai. This survey was conducted on random samples in these clusters until similar responses were found from the majority of the people (Fig. 4).

C. Fuzzy Cognitive Mapping

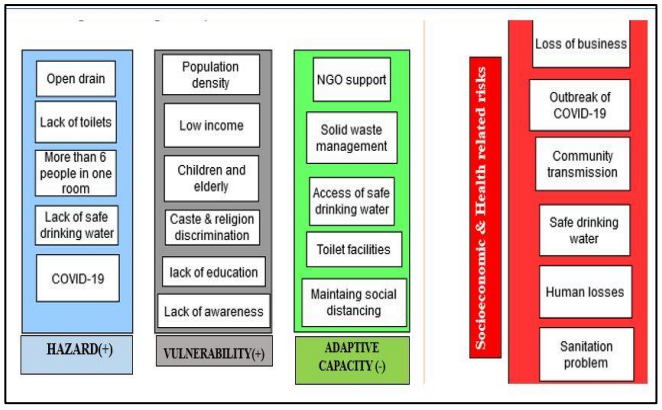

Fig. 4 Supportive Factors of Risk Included in the Survey

A correlation matrix was prepared using the relevant attributes collected during the survey that has a direct linkage to COVID-19. This is followed by FCM that elucidates the linkages among various factors and their impact on these slums. The final score has been calculated as the fractional difference from the worst-case scenario which has then been rescaled to 10.

Based on survey reports, we constructed linkages through FCM among various indicators and factors related to health risks. The size of each vertex in FCM depends on the survey data and indicates the significance of each indicator. Therefore, this mapping can give us a clear picture of the people's perceptions, activity during the COVID-19 outbreak in the slums of Mumbai [Sherly et. al, 2019].

D. Statistical analysis of slum attributes

Based on our survey report, we have prepared a statistical representation of adaptive capacity that indicates the relevant issues and coping factors in Mumbai slums. These attributes depend on socioeconomic, political and governance aspects [Sherly et. al, 2019].

E. Adaptive Capacity Ranking of Slum Clusters

To prepare the adaptive capacity ranking for each surveyed slum cluster, we combined up the results of the Fuzzy Cognitive Method and Statistical analysis of slum attributes with a total score out of 40. Now, based on these steps, we set a maximum score and each slum was assigned scores according to their responses and higher scores indicated higher adaptive capacity [Sherly et. al, 2019].

F. SWOT Analysis

This pandemic has introduced us to the new normal. The pandemic has caused distress to human lives; however, it has also shown us new ways of living. Especially, the small scale business based on mainly homemade products is emerging. Therefore, we can analyze the situation through strengths, weaknesses, opportunities and threats. Thus, we attempt at exploring the impacts of COVID-19 through various perspectives.

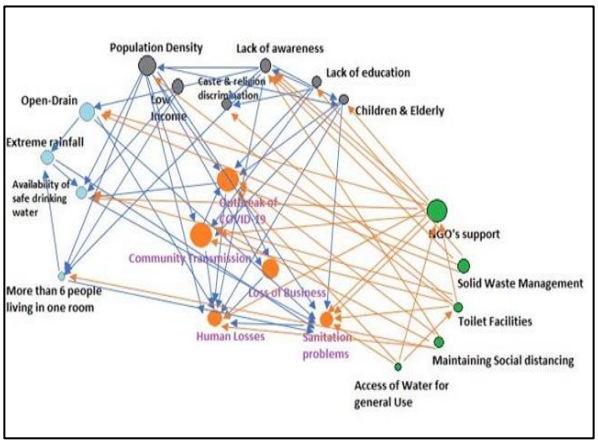

Fig. 5 Linkages among chosen indicators for Water & Sanitation

RESULTS AND DISCUSSIONS

Based on survey data and general observations, multiple challenges are being faced by slum dwellers that make them vulnerable during this pandemic. Almost all the slum clusters are facing poor sanitation facilities, lack of access to clean water, poor drainage system and discharging medical wastes like masks and PPE kits into the open drains and the river. For each slum, FCM has been performed with indegree, outdegree and centrality based on their perceptions. The adaptive capacity ranking of each slum has been calculated by considering the best case and worst-case scenarios.

G. Fuzzy Cognitive Mapping

Fuzzy Cognitive Mapping has been processed through the FC mapper tool which is openly available (FCMapper v2.0). The ranking for each slum is calculated by the fractional difference between the best-case scenario and the worst-case scenario. According to the ranking each slum was rescaled out of 10. The Adaptive capacity has been calculated by their risk perceptions, preparedness and other general observations (Table I).

TABLE I FCM analysis for each slum and their adaptive capacity scores

Slum	Deviation			Average Deviation	Score out of 10
	OutDegree	*InDegree*	*Centrality*		
Andheri East	7	5	9	7	9
Bandra	12	11	18	14	8
Dahisar	6	5	9	7	9
Dharavi	14	11	22	15	7
Malad West	17	16	27	20	6
Borivali	11	12	20	14	8
Chembur	13	14	23	17	7
DN Nagar	13	11	20	15	7
Goregaon	14	11	21	16	7
Kamraj Nagar	13	10	19	14	8
Kandivali West	13	10	19	14	8
King circle	12	11	19	14	7
Kurla	10	8	14	11	8
Mahim Fort	14	13	23	17	7
Malad East	9	8	13	10	9
Mankhurd	12	12	21	15	7
Powai	12	10	18	13	8
Santa Cruz	13	11	20	15	8

The final scores out of 40 were calculated considering both the perception and existing WASH facilities. Dahisar (9.0), Andheri East (8.5), Malad East (8.3) scored well because each of these areas has a higher literacy rate, whereas Dharavi suffered because of a lack of awareness and disposal of medical wastes in the open drains. Malad West (6.1) scored the lowest because of poor drainage management, and people are neglecting safety measures and hygiene practices.

H. Slum Wise Adaptive Capacity Ranking

Slum wise adaptive capacity ranking has been calculated by adding up all the risk perceptions & impacts of COVID-19 on WASH facilities in the surveyed slum clusters. Each slum cluster has been assigned a score out of 40 according to their risk perceptions and activities towards containing the outbreak of COVID-19.

Surprisingly, Dharavi, one of the largest slums could control the rate of active cases in the last three months. Govt. and different NGOs have come together and started campaigning "Testing, Tracing and Isolation" and built awareness in Dharavi. Therefore, Dharavi scored 28.3 out of 40. Borivali (30.1) scored highest because of well management of medical wastes from quarantined centers, maintaining community toilets weekly, building bio-toilets. Goregaon scored lowest (14.0) because of poor drainage management, improper handling of medical wastes along with lack of access to the free water supply. Bandra (19.6), Malad West (16) and Kamraj Nagar (19) also scored below 20 because of lack of awareness, open drains and unhygienic community toilets.

I. SWOT Analysis

- Strength

The impacts of this pandemic cannot be defined from one perspective. People's perceptions and their behavior towards these new normal vary across slums. Now, the strengths can be defined as the preparedness of local Govt., health facilities and also risk perception of slum dwellers. For, example Govt. has started a campaign "Testing, Tracing and Isolation". A COVID-19 affected person can be traced by her/his smartphone location. Moreover, a higher literacy rate, access to WASH facilities can be included as strengths.

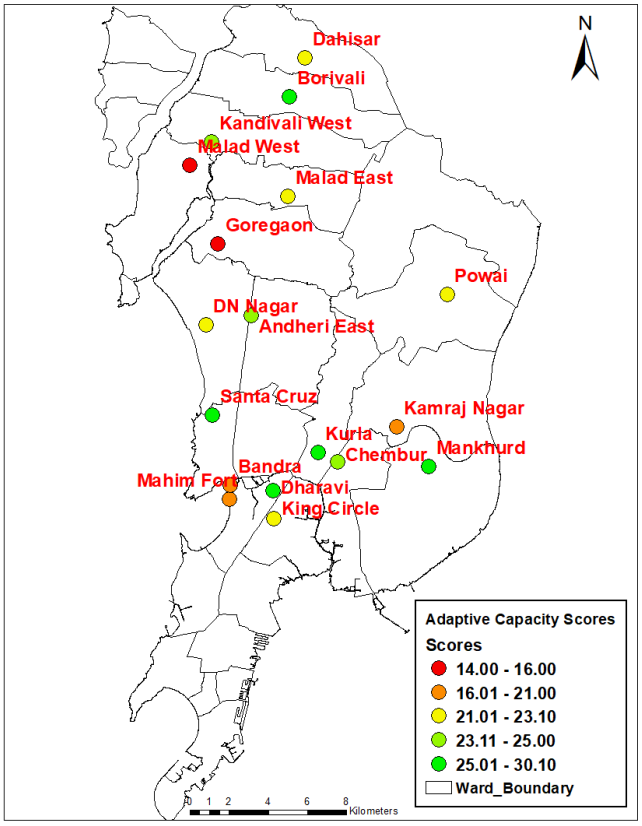

Fig. 6 Adaptive Capacity scores - slum wise

- Weaknesses

Strengths and weaknesses are the two sides of one coin. Through the survey and news reports, it has been found that slum dwellers are not well aware of hygiene practices. Also, poor sanitation facilities and the non-availability of clean water make it

vulnerable. However, job losses in the lockdown period are one of the main weaknesses.

- Opportunities

The impacts of the pandemic have thrown multiple challenges to the poor people of slums but have also opened opportunities for many small-scale businesses that are mainly based on homemade products like masks.

- Threats

We all know that once this pandemic situation will be over and we will be out of danger. However, we should be concerned and be prepared to face various threats that can cause troubles in the future. The pollution in the Mithi River is increasing day by day which can create a suitable environment for the mutation of many contagious micro-organisms. Open drains, unhygienic surroundings and poor management system for medical wastes may result in new disease outbreaks massively.

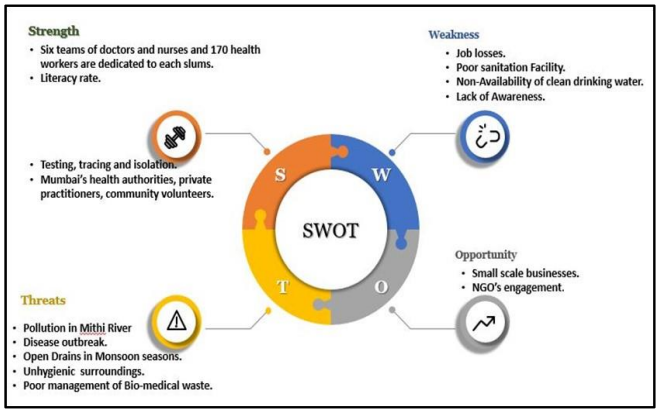

Fig. 7 SWOT Analysis of Mumbai slums

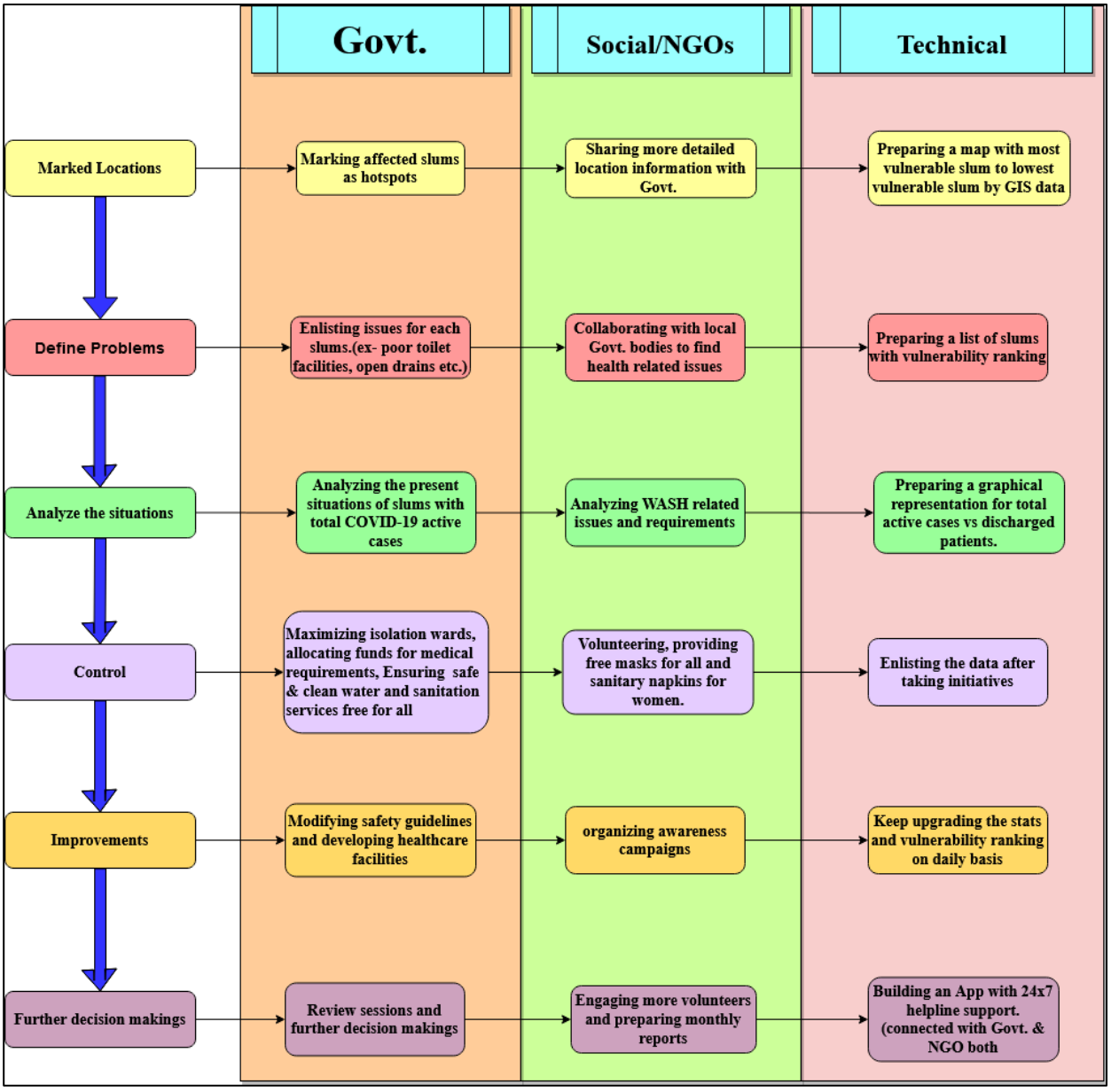

Fig. 8 Framework to Mitigate Pandemic Risks

J. Proposed Policy Framework

This pandemic situation hits the backbone of our society. Even in the twentieth century we still do not have a clear solution to handle this. The main problem lies between our policies and interventions. It is high time that we considered this pandemic as a warning. We should reform our disaster and health-related policies and interventions. Hence, based on the perceptions survey data this study suggests a framework, especially for slums. The framework consists of six steps which are: Selection of areas, Define problems, Analyze the present situation, Control the situation, followed by Improvements and further decisions (Fig. 8).

Firstly, Govt. and NGOs should divide the slums into different zones based on the total active cases. The map will be prepared through geospatial datasets. NGOs should share the ground data with Govt. which can reduce the errors in the data processing. The GIS datasets will be used for preparing a map with the most vulnerable slum cluster to the least affected slum cluster.

Secondly, according to the hotspots identified Govt. and NGOs should conduct field visits or surveys. Based on this survey, Govt. can determine the key issues which are influencing this pandemic situation. Every slum should be assigned a vulnerability score. In Fig. 6 slum wise adaptive capacity scoring method already has been discussed that every slum is suffering from different issues; water & sanitation is the most common problems in those slums. So, according to the survey reports from NGOs, Govt. can determine the vulnerability of each slum with their existing issues.

Thirdly, Govt. should continuously monitor the situation for each hotspot zone. The database should be up to date with the total number of active cases and discharged patients with graphical representation also. NGOs should share their field report with the local Govt. body. Also, NGOs can arrange campaigns for WASH-related guidelines and safety measures. Moreover, Govt. should look into the issues related to the community toilets, open drains and medical wastes.

Fourth, Govt. should allocate funds to mitigate the situation. Ensuring the strict rules on public gatherings, free service of safe water for slum communities and proper maintenance of community toilets on daily basis is crucial in containing the COVID outbreak. NGOs should provide masks, hand sanitizers and sanitary napkins free of cost for the slum communities with the help of local Govt. Govt. and NGOs both should enlist the important data(demands and further requirements) after taking initiatives.

Finally, Govt. and NGO can improve the following process according to the situation and can build advanced digital initiatives like an app with a 24x7 helpline service facility. Govt. and NGOs should share their recorded data to review the initiatives which have been taken by them. Govt. should maintain the records about funding from the different private organizations with transparency. NGOs can engage more volunteers and deploy them into sensitive zones with proper safety equipment.

The backbone or main supporting factor is the participation of industry experts. The participation of industry experts can suggest advanced technologies, recommend policies and interventions. The whole project needs an industrial expert who can manage all the requirements of this project and ensure the security of the people. For example, they can use

their advanced recycling techniques for the Bio-medical waste management process, allocate funds for building community toilets, construct water-related infrastructure for the people.

CONCLUSIONS

COVID-19 pandemic has indeed created a buzz about 'the new normal' but it is also a fact that we were not concerned enough about hygienic practices till the outbreak of COVID-19. However, this situation also changes the old perceptions about health & hygiene.

This manuscript discussed SWOT analysis which has which showed the present condition of the Dharavi slum. Also, how the small financed industries created opportunities. Mithi River needs to restore its original condition otherwise in the future it can be the source of many diseases.

Participation of industry experts in the proposed framework with the Govt. and NGOs is must needed. They are the main drivers for this framework. Allocating funds and giving important suggestions to Govt. will secure the livelihood of the slum dwellers.

The risk perception varies with different slums and is connected to their mindsets, impacts on water and sanitation services and economic conditions. This risk perception helps us to understand the adaptive capacity of each slum against COVID-19. The adaptive capacity ranking shows that Borivali scores highest because of their literacy rate, well drainage management system and awareness whereas Goregaon and Malad West score low because they do not have a proper management system for collecting medical waste and have a lower literacy rate.

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