The Covid 19 Pandemic and the Urban Vulnerable Communities: A Case Study of Coastal Underserved Dwellers of Jaffna Municipality, Sri Lanka

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Abstract

Environmental, socio-economical, cultural, psychological and political factors determine the deprivation of the community for the exposure to disasters and capacity to overcoming the hazard. Urban poor is considered more vulnerable due to their exposure to high risks easily and limited capacity to risk management. The vulnerability level of underserved dwellers of Jaffna Municipality to the COVID-19 pandemic is assessed based on the criteria of population density; economic status; house type; access to Water, Sanitation and Hygiene (WASH); land use; road density; and public gathering places. Primary data was gathered through six months field observation from October to December 2020 and April to June 2021, questionnaire survey with 278 dwellers of underserved communities who has been selected based on simple random sampling method and focus group discussion with community based organization members, health care workers, development officers while secondary data was obtained from the statistical handbook of Jaffna Divisional Secretariat Division and required base shape files were gained from the Survey Department of Sri Lanka . Multi criteria analysis was used to identify the underserved areas which are easily exposed to COVID 19 pandemic based on the criteria of population density; economic status; house type; access to Water, Sanitation and Hygiene (WASH); land use; road density; and public gathering places. Descriptive statistical methods and the SPSS statistical software were used to analyze the data collected through questionnaire survey while Arc GIS 10.4 mapping software was applied in preparing maps. Findings of the study identified risk areas, and revealed that the divisions with high population density, low economic status, high dense built-up land, high number of impoverished settlements, high road density and high number of population of poor accessibility to Water, Sanitation and Hygiene (WASH) practices and high number of public gathering places are considered having high risk for COVID 19 with lower capacity to manage the risk. In overall, Reclamation East and Reclamation West division were identified as very high risk area; Navanthurai North, Navanthurai South and Gurunagar West divisions are having high risk; Passaiyoor East, Passaiyoor West, Gurunagar East and Fort divisions are having moderate risk; whereas Nedunkulam, Columbuthurai East, Thirunagar and Small bazar having low risk and Koddady division has very low risk for the COVID 19 pandemic. The research is expected to be useful for the health authorities, developers, urban planners, and policy makers, academics to carry out their surveillance programmes, vaccination programmes, and livelihood development activities on the priority basis to control the transmission of disease and minimize the vulnerability level.

Keywords: Pandemic; Transmission; Vulnerability; Risk Management; Livelihood Development

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Introduction

In the 21st century 206 millions of population is affected by the unforeseen catastrophic disaster of COVID 19 and the cities with large share of population found to be worst affected by the deadly virus [1]. The COVID 19 pandemic has increased the level of socio economic deprivation of developing countries than previous times. Vulnerable groups are at disadvantage condition in terms of economic, social and health deprivations [2-4]. In Sri Lanka, the first confirmed case was diagnosed on the 27th of January 2020 and 13th August 2021 the country has 345 118 confirmed cases including 5620 deaths which presenting a pattern of rapid infection [5]. The pandemic is worsening the quality of life of entire communities and especially dwellers of underserved areas who already face multi-dimensional poverty are severely affected by the effects of COVID 19. There are 68,812 families living in 1499 underserved settlements of Colombo city which is lack in sufficient living space, healthy environment for human habitation, access to clean water and sanitation, secure tenure and durable housing conditions [6]. Bandaranayake Mawatha, Keselwatte, Panchikawatte, Mattakkuliya, Modara, Muttwal, Bloemendhal, Kotahena, Maradana, Grandpass, Foreshore Police area, Maligawatte, Dematagoda, Borella, Narehenpitiya, Kuppiyawatte, Wanathamulla and Wellampitiya have been identified as high risk areas of COVID 19 belongs to North and Central parts of Colombo which has the largest concentration of underserved settlements [7]. Obviously, the risks of communicable diseases are high in the underserved areas [2,8,9].

Underserved housing dwellers are unable to follow the recommended preventing measures due to their unplanned and unregularized housing arrangements [10]. Insufficient living space and the living conditions in underserved areas pose several challenging to practicing self-quarantine and social distancing in an overcrowded residence. Lack of access to water and sanitation facilities in slums makes it difficult to wash hands, clean and disinfect the home properly. Furthermore, transmission of the virus might be enhanced in high density areas [2,11]. The outbreak in Bandaranayake Mawatha, Colombo is an excellent example of how diseases spread in underserved settlements in urban areas. The cluster consisted of small living spaces, home to around 62 families on 20 perch land and lacking of basic amenities. Their placement makes social distancing an impossible task and in such neighbourhoods, residents tend to congregate in public spaces and visit neighbours.

Tracking and controlling socialising patterns in highly congested areas adds to the challenges making lockdowns and curfews redundant. Poor living conditions and insufficient health services reduce the ability to recover from COVID 19. Drinking unsafe water and being exposed to improper sewage disposal is highly correlated with the contraction of preventable diseases [2,11,12].

Furthermore, a majority of slum dwellers in urban areas are employed in self – managed, low wage jobs in the informal sector and earned daily wages. During the first wave of COVID 19 when the entire country was locked down for almost two months daily basis workers are the most vulnerable to pandemic shocks- they were left in a heavily shrunk informal urban economy from which they made a meagre living [13].The informal nature of their employment makes them vulnerable to sudden earning losses, access to food and other basic needs and this in turn exposes them to higher risks, when they are compelled to ignore precautionary measures in desperate attempts for survival. These marginalised groups violate the restrictions and isolation to earn an income for their basic livelihood.

The dwellings in the coastal belt starting from Nedunkulam to Navanthurai are so badly underserved, poverty stricken and they have classified as slums [14]. Most of the areas indicate deprived living conditions and the basic amenities are either lacking or inadequate in these heavy congested areas. These dwellings do not confirm to the building regulations particularly with regard to lightning and ventilation, side space, rear space and frontage space of the settlements. The insufficient living conditions induce the people to encroach towards roads, drains, open spaces, marshy lands and sea. According to the study of UN Habitat Sustainable city programme, there is an urgent requirement to improve the living standards of the people in the coastal underserved areas nevertheless, this adverse living conditions lead to serious health problems to the entire city. In the past times, the outbreaks of epidemics have been recorded in the areas specially Cholera EI Tor [15]. The Jaffna peninsula has been experienced high incidence of dengue since the early part of 2010 and high number of cases reported in the coastal zone of Jaffna Municipality where the brackish water *aegypti larval* sites were found [16,17]. According to the statistics, total of 2157 dengue cases in Jaffna district for the year 2020 and 117 dengue cases were reported from January 2021 to up to present time [7]. The highest number of dengue cases was reported in the year of

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2019 as 8261 and one fourth is informed from the Jaffna Medical Officer of Health (MOH) areas [7]. During this COVID 19 pandemic, Jaffna Municipality has been clustered as one of the high risk MOH area and coastal zone has reported significant number of COVID 19 positive cases particularly in the second and third wave [7].

The vulnerability can be defined as the diminished capacity of an individual or group to anticipate, cope, resist and recover from the impact of any hazard [18]. Urban poor people are often found to be more vulnerable due to their exposure to high risks easily and limited capacity to risk management [18]. Physical, environmental, socio- economical, cultural, psychological and political factors determine the deprivation of the groups for the exposure to disasters and capacity to overcoming the hazard [18].

It is timely requirement to assess how the deprivational conditions of underserved settlements tend them prone to any hazard easily. So, these study focuses on the factors that are making underserved dwellers vulnerable due to COVID 19 and assess the impacts of COVID 19 on the livelihoods of the urban vulnerable communities.

Research Methodology

The Jaffna Municipality, the major cosmopolitan region in the Jaffna District with the total area of 20.26 square kilometres, was selected as the study area, due to the fact that high number of CO-VID cases have been reported as indicated in table 01. It is boarded by the Jaffna lagoon on its Western and Southern sides and the Nallur divisional secretariat division on the North and Eastern sides. The study sites cover the coastal areas of Jaffna Municipality which starts from Nedunkulam to Navanthurai. There are fourteen Grama Niladhari Divisions are included in the study area which comprise 94358 population [19]. The study location is depicted in figure 1.
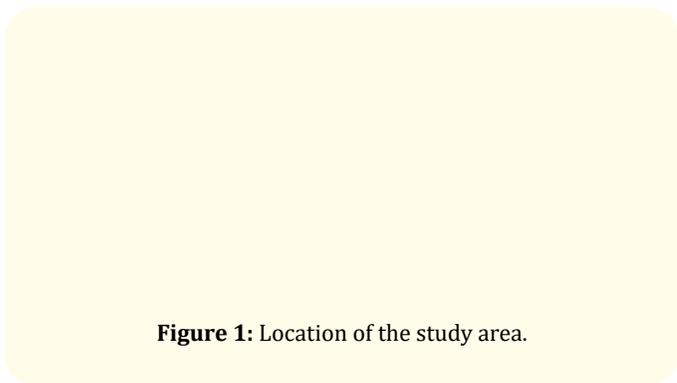
Figure 1: Location of the study area.

The coastal Grama Niladhari divisions of Jaffna Municipality has been selected for the present study. It has been recorded high number of COVID 19 positive cases and reported as one of the high risk MOH area of Jaffna district [7]. Table 1 and 2 represent the COVID 19 cases in MOH of Jaffna District and coastal areas of Jaffna Municipality respectively.

Division	Cases	Division	Cases	Division	Cases
Chankanai	219	Kayts	63	Sandilipay	547
Chavakachcheri	392	Kopay	243	Tellipalai	432
Jaffna	1831	Maruthankerny	26	Uduvil	575
Karainagar	121	Nallur	632	Velanai	138
Karaveddy	303	Point Pedro	547		

Table 1: Total number of COVID cases in MOH of Jaffna District as of 4th of August 2021.

Source: Epidemiology unit, Ministry of Health, 2021.

GND	Cases	GND	Cases
Nedunkulam	18	Gurunagar East	23
Columbuthurai East	51	Gurunagar West	88
Passaiyoor East	14	Small Bazar	12
Passaiyoor West	24	Fort	262
Thirunagar	39	Koddady	36
Reclamation East	26	Navanthurai South	40
Reclamation West	87	Navanthurai North	34

Table 2: COVID 19 positive cases in coastal areas of Jaffna Municipality as of 13th of August 2021.

Source: Jaffna Divisional Secretariat Division, 2021.

Based on the literature review, opinions of expert and availability of data, this study has selected the variables of population density; economic status; house type; access to Water, Sanitation and Hygiene (WASH); land use; road density; and public gathering places for assessing the vulnerability level of underserved areas to the COVID-19 pandemic. Conceptual framework and variables used to relate transmission of COVID- 19 are depicted in figure 02 and Table 03 respectively.

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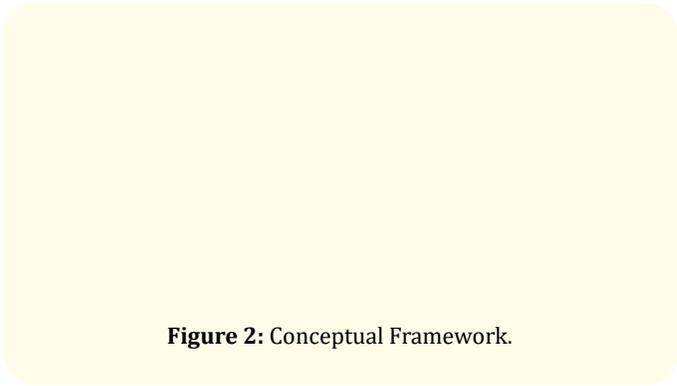
Figure 2: Conceptual Framework.

Data	Data sources
Population density	Statistical hand book of Jaffna Divisional secretariat division
Land use map	Survey department of Sri Lanka
Road network map	Survey department of Sri Lanka
Public gathering places	Google earth (2021)
Economic status	Statistical hand book of Jaffna Divisional secretariat division (2020)

Table 4: Secondary data and sources.

Source: Created by researcher, 2021.

Preliminary survey was conducted from August 2020 to September 2020 to identify the improvised houses and accessibility to WASH practices. Field observation was undertaken during two time slots covering of six months from October to December 2020 and April to June 2021. Focus group discussions were held with community based organization members, health care workers, development officers. A questionnaire survey was undertaken with involving 278 dwellers of underserved communities who has been selected based on simple random sampling method. The selected sample was indicated in table 5.

Variables	Variables used to relate transmission of COVID- 19
Population density	High population density > moderate population density > low population density
Economic status	Low economic status > moderate economic status > high economic status
House type	High number of improvised houses > moderate number of improvised houses > low number of improvised houses
Access to WASH	High number of poor accessibility population > moderate number of poor accessibility population > low number of poor accessibility population
Land use	High dense urban built-up areas > moderate or low dense urban built-up areas > non-built up areas
Road density	High road density > moderate road density > low road density
Public gathering	High number of public gathering places > moderate number of public gathering places > low number of public gathering places

Table 3: The variables used to relate transmission of COVID-19.

Source: Created by researcher based on literature surveys, 2021.

In order to achieve the objectives of the study, primary and secondary data were used. Secondary data were obtained from different sources and the list is tabulated in the table 4.

Primary data was gathered through preliminary survey, field observation, questionnaire survey and focus group discussions.

GND	Selected respondents	GND	Selected respondents
Nedunkulam	22	Gurunagar East	17
Columbuthurai East	20	Gurunagar West	14
Passaiyoor East	13	Small Bazar	8
Passaiyoor West	10	Fort	19
Thirunagar	10	Koddady	18
Reclamation East	42	Navanthurai South	23
Reclamation West	36	Navanthurai North	26

Table 5: Samples selected for the questionnaire survey.

Source: Created by researcher, 2021.

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Spatial multi criteria analysis of Arc GIS 10.4 software was used to identify the underserved areas which are easily exposed to COVID 19 pandemic. Structuring, standardizing, weighting and composition steps were undertaken to perform the analysis. Seven variables of population density; economic status; house type; access to Water, Sanitation and Hygiene (WASH); land use; road density; and public gathering places were identified as being relevant to COVID 19 transmission were based on literature review, opinions of expert and availability of data. These criteria were mapped in Geographic Information System using Grama Niladhari Division as a basic unit. In order to compare the variables with each other, all maps were standardized - value of three (3) is assigned for high vulnerability; value of two (2) is assigned for moderate vulnerability and value of one (1) is assigned for low vulnerability. Followed by standardization, a weight was assigned for each of the variable according to their importance for determining the vulnerability level of underserved areas to the COVID-19 pandemic in the study area context. Weight was provided for 100, as per the relative importance of each criterion while determining the vulnerability level. 20 percentages given to population density and economic status, 15 percentages given to house type and access to Water, Sanitation and Hygiene (WASH), 10 percentages given to land use, road density and public gathering places. Multi criteria analysis of Arc GIS 10.4 software was used to combine the weighted criteria and produce the composite vulnerability map. Finally, a vulnerable underserved area to the COVID-19 pandemic is identified and reclassified into five categories such as "very high risk area", "high risk area", "moderate risk area", "low risk area" and "very low risk area". Collected data through field observation, focus group discussion, and interview were analysed through descriptive statistical method, and the SPSS statistical software was used to analyse the data collected through questionnaire survey. Required maps were prepared by using Arc GIS 10.4 mapping software.

Results and Discussion

Contributing Factors for Vulnerability to COVID 19 Pandemic by Underserved Dwellers.

Population density and vulnerability to COVID 19 pandemic

Population density refers to the number of individuals per unit of geographical area which is an important consideration accelerating transmission of infectious diseases [20]. Several studies have shown significant relationships between density and the spread of

Figure 3: Flow chart for research methodology.
Source: Created by researcher, 2021.

the virus [21]. According to the study of Ren., et al. in 2020 [22], the very high risk zones of COVID 19 infection in Beijing and Guangzhou tend to occur in areas with larger population densities and the social distancing is more challenging in higher population density areas that feature more crowded space and higher transmission rate [23].

In this study, the population density more than 12568 persons per square kilometre (high population density) was considered as Passaiyoor West, Gurunagar East, Navanthurai North divisions have "moderate high favourable for COVID 19 transmission, population densities between 6248-12568 persons per square kilometre (moderate population density) and lower than 6248 persons per square kilometre (low population density) were considered as moderate and low risk for the transmission of COVID 19 infection respectively. Reclamation East, Reclamation West, Gurunagar West and Navanthurai South divisions have "high population density" ; population density" ; Nedunkulam, Columbuthurai East, Passaiyoor East, Thirunagar, Small Bazar, Koddady and Fort divisions have "low population density" and considered as, "high vulnerability", "Moderate vulnerability" and "low vulnerability" coastal underserved areas respectively for the transmission of COVID 19. Figure 4 depicts the relationship between the population density and vulnerability to COVID 19 of the coastal underserved areas.

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Figure 4: Population density and the level of vulnerability to COVID 19 in underserved areas.

Source: Created by researcher based on Survey department, 2021.

Economic status and vulnerability to COVID 19 pandemic

Socio economic status determines the level of vulnerability to COVID 19 and the people at the bottom of the socio economic condition suffer due to economic difficulties, more exposure to risks and limited access to services [18,21,24,25]. Underserved areas contribute immensely for the city's economic growth through supplying cheap labour force. Even though, national wide work place

closure and lockdown left a devastating impact on the livelihood of underserved dwellers which enhanced their job insecurity and inability to feed their family [26]. According to International Labour Organization in 2020 [26] casual labourers, self-employment workers and unprotected regular workers are the most vulnerable group to COVID 19 and WHO (2020) has highlight that 890 000 people in Sri Lanka would become newly poor and many of them from the poorest regions in Sri Lanka.

The people of the area of Nedunkulam, Columbuthurai East, Passaiyoor East , Passaiyoor West, Gurunagar East, Gurunagar West, Reclamation East, Reclamation West , Small Bazar, Navanthurai North and Navanthurai South are predominantly fishermen. In the Thirunagar division, 82 percentages of the dwellers are engaged as sanitary labourers in Jaffna MC. Table 6 indicates the occupational composition of the underserved dwellers of the study area.

Informal sector workers involved in essential services including cleaning, street vending/ hawking, porter, home delivery, sewing shoes, domestic servant, casual labourer, sanitation worker, watchman, construction worker, industrial worker, food delivery to shop, repair works, drivers of three wheeler and so on. Divisions which have high number of fishing and informal sector population are experiencing high vulnerability and whereas divisions have high

GND	Fishermen (%)	Informal sector (%)	Formal sector (%)	GND	Fishermen (%)	Informal sector (%)	Formal sector (%)
J/61	13.83	70.52	15.65	J/70	17.28	43.34	39.38
J/62	9.55	58.15	32.3	J/71	52.32	14.24	33.44
J/64	70.06	18.32	11.62	J/72	42.66	21.55	35.79
J/65	64.20	23.96	11.84	J/81	17.36	58.42	24.22
J/67	3.68	12.88	83.44	J/83	0.25	17.87	81.88
J/68	55.12	40.86	4.02	J/84	38.86	50.06	11.08
J/69	65.40	30.59	4.01	J/85	67.84	23.92	8.24

Table 6: Occupational Composition of the Underserved Dwellers of the Coastal Area.

Source: Calculated by researcher based on Jaffna Divisional Secretariat Statistical Handbook, 2020.

number of formal sector population are experiencing low vulnerability during this pandemic situation. Relationship between occupational composition of the underserved dwellers and vulnerability level to COVID 19 pandemic is shown in the figure 5.

Approximately 83 percentages of the respondents stated immediately enforced lockdowns during the first and second waves of COVID 19 severely affected in their income generating activities and affect their livelihood which exacerbating their socio economic

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Figure 5: Occupation and the level of vulnerability to COVID 19 in underserved areas.

Source: Created by researcher based on Survey department, 2021.

condition into worst. Seventy five percentages of the fishermen said after the detection of COVID 19 positive cases in Passaiyoor fish market during the second wave period, it was temporarily closed and Passaiyoor and its adjoining areas isolated. By the latter part of 2020, all the markets in the Northern Province temporarily closed owing to COVID 19 outbreak in Maruthanarmadam market. At the same time, after reporting hundreds of positive cases, Reclamation and Gurunagar divisions were isolated in the latter part of June 2021 which has primarily fishermen population. These situations tend pushed them to a vulnerable situation. Many people erroneously believe the coronavirus can be transmitted through the fish. Due to the unreasonable fear among the public, vendors have to face numerous obstacles selling their catch. Forty seven

percentages of the fishermen said consequences of this pandemic situation leads them to quit their fishing activities and could not even afford diesel for their boats. Sixty percentages of the casual labourers said it is very difficult to find income generating sources in this pandemic; 40 percentages of the domestic workers and food suppliers to shop said they are forced to stay home upon their employers' requests with little hope for resuming their work soon; 30 percentage of the self-employment workers stated due to the supply shortage of raw materials, transportation restriction and shortage in consumer demands posed their job opportunities. Moreover, on an average 70 percentage of the urban households in the study area with a monthly income less than 5000 LKR. Besides, without employment security and medical benefits for such jobs, will force them to make out-of-pocket expenditures and further push them into debt if they catch infection. The rising level of anxiety and fear of getting infected among the citizens has impacted negatively on the resumption of most of the informal work as people have become too cautious of availing unregulated usual informal services even after the lockdown. So, the growing work irregularities, insecurity at job, and low income of slum dwellers have further increased their cost burden and intensified their vulnerability to resist Covid-19. Divisions which has high number of samurdhi recipients (monthly income < 5000 LKR) who are having a poor socio economic status were considered as exposed high risk for COVID 19 and divisions which has high number of non samurdhi recipients (monthly income >5000 LKR) who are having a medium or high socio economic status were considered as exposed moderate and low risk respectively. Table 07 shows the percentages of samurdhi recipients in the study area.

GND	Samurdhi recipients (%)	GND	Samurdhi recipients (%)	GND	Samurdhi recipients (%)
Nedunkulam	58	Reclamation East	75	Fort	70
Columbuthurai East	52	Reclamation West	66	Koddady	45
Passaiyoor East	77	Gurunagar East	62	Navanthurai South	80
Passaiyoor west	81	Gurunagar West	85	Navanthurai North	85
Thirunagar	49	Small Bazaar	52		

Table 7: Percentage of samurdhi recipients in the study area.

Source: Calculated by researcher based on Jaffna Divisional Secretariat Statistical Handbook, 2020.

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In this study area, the proportion of Samurdhi recipients more than 69 percentage was considered as high vulnerable for COVID 19, the proportion of Samurdhi recipients between 53-69 percentage and the proportion of Samurdhi recipients below 53 percentage were considered as moderate and low vulnerable for COVID 19 pandemic respectively. In this point of view, Reclamation East, Passaiyoor East, Passaiyoor West, Navanthurai South, Navanthurai North, Fort and Gurunagar West areas have considered as "High vulnerability", Nedunkulam, Reclamation West and Gurunagar East have considered as "Moderate vulnerability" and Columbuthurai East, Thirunagar, Small Bazar and Koddady have considered as "Low vulnerability" for COVID 19 in the aspect of economic status. Figure 06 depicts the relationship between the economic status and vulnerability to COVID 19 of the coastal underserved areas.

Figure 6: Economic status and the level of vulnerability to COVID 19 in underserved areas.
Source: Created by researcher based on Survey department, 2021.
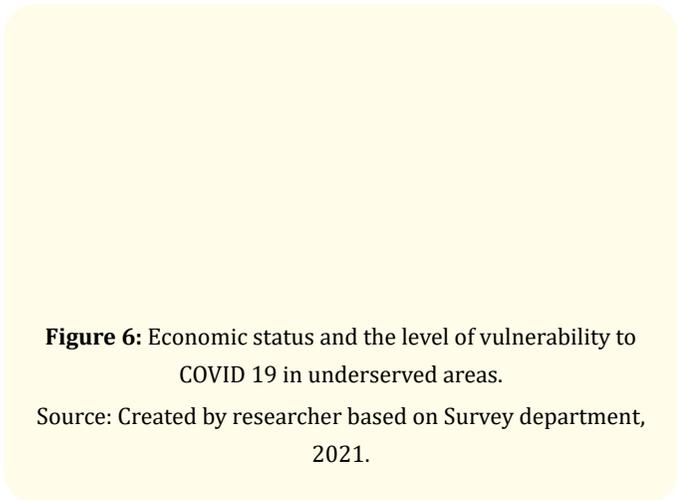
House type and vulnerability to COVID 19

"Stay home save life" is the theme emphasised by WHO to minimize the spreading rate of COVID 19. Even though, dilapidated residential condition in the underserved areas induce the risk of infectious disease transmission and insufficient facility for isolation and social distancing [18,20]. Poor housing conditions had the higher incidence of positive COVID 19 cases and mortality [27]. Overcrowded in a single settlement has been associated with spread of respiratory diseases transmitting through aerosol and droplet which are potential modes of transmission for COVID 19 [27]. High number of improvised housing units was considered having high risk for transmitting the COVID 19, whereas moderate number and

low number of improvised housing units has very low risk to transmit infectious diseases respectively [18,20]. The number of impoverished housing units of the study area is highlighted in the table 8.

Division	Housing units	Division	Housing units
Nedunkulam	62	Gurunagar East	31
Columbuthurai East	48	Gurunagar West	8
Passaiyoor East	10	Small Bazaar	25
Passaiyoor west	43	Fort	70
Thirunagar	86	Koddady	18
Reclamation East	819	Navanthurai South	45
Reclamation West	353	Navanthurai North	130

Table 8: Number of impoverished housing units in the study area.
Sources: Preliminary survey, 2020.

There are 5942 settlements are evolved along the coastal areas of Jaffna Municipal Council area. Among that, 1765 settlements have the impoverished housing condition - insufficient living area, don't cope up with building regulations, un-durable building material, and face threat of eviction (Field observation, 2020). A typical impoverished household characterized with 5 to 7 people squeezed into a makeshift arrangement of 25-35 square meters [18,28]. In the study area, 20 percentages of the impoverished settlements hold the size of lower than 25 square meters, 70 percentage hold the size between 25 – 35 square meters and 10 percentage hold the size of higher than 35 square meters. About 45 percentages of the impoverished households manage themselves in to one single room and 10 percentages have no exclusive room – they used tin, cardboard, asbestos sheet to divide their house into two parts. Approximately 75 percentages of the settlements don't cope up with the building regulations regarding the plot size, room size, door and window size, roof height, building material, distance between well and latrine pit, side space of toilet, pre space and recessive space and space between two settlements. Poor indoor air quality due to insufficient ventilation and natural light and dependency on firewood make them vulnerable to communicable diseases. Physi-

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cal distancing keeping at least 2 metres away from the nearest person is an important measure to prevent the spread of COVID 19 pandemic [10]. Because of this congestion dwellers cannot maintain physical distancing properly. 85 percentage of the respondents stated it is incapable of adhering to 2 metres of physical distancing in this lack of spacious settlement. Home quarantine for those who have been exposed to corona virus is crucial to prevent community transmission and people must stay in the separate room during the quarantine [10]. Even though, seventy five percentages of the respondents stressed that the impoverished housing condition prevents them from practicing self-quarantine in the area. Divisions which have more than 100 improvised housing units was considered having high risk for transmitting the COVID 19, whereas 50-100 housing units and lower than 50 improvised housing units has very low risk to transmit infectious diseases respectively. Figure 7 depicts the relationship between the level of vulnerability to COVID 19 pandemic and the impoverished housing units of the study area.

Figure 7: Impoverished housing units and the level of vulnerability to COVID 19.
Source: Created by researcher based on Survey department, 2021.
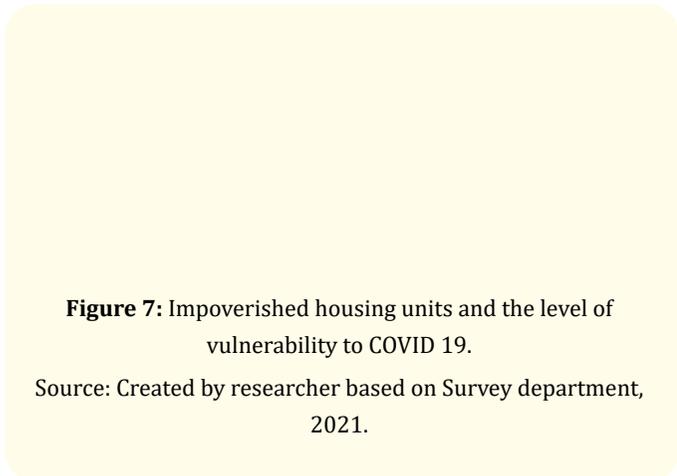
Access to safe water, sanitation and hygienic practices (WASH) and vulnerability to COVID 19

Access to safe water and sanitation is a critical safeguard against Covid-19, has exacerbated in informal settlements owing to overloaded public sanitation and water supply facilities [18]. Accessibility of Water, Sanitation and Hygiene (WASH) is determined based on access to improved water which is measured through water collection method, number of people rely on a water collecting point, quality and quantity of water, distance from home, spending time; access to improved sanitation which is measured through toilet type, number of people share a single toilet, toilet structure, toilet waste disposal method and awareness of hygienic practice which is measured through awareness programmes for hygienic practices, knowledge of good hygienic behaviour [29]. The community living in specific geographical area with poor accessibility to WASH practices is denoted by the term of underserved population [28]. The number of underserved population of the study area is highlighted in the table 9.

Division	Population	Division	Population
Nedunkulam	265	Gurunagar East	110
Columbuthurai East	210	Gurunagar West	113
Passaiyoor East	44	Small Bazaar	115
Passaiyoor West	168	Fort	320
Thirunagar	423	Koddady	67
Reclamation East	4294	Navanthurai South	225
Reclamation West	3654	Navanthurai North	564

Table 9: The number of underserved population of the study area.
Sources: Preliminary survey, 2020.

The division which has more than 500 underserved populations were considered as exposed high risk, between 100-500 underserved populations was considered as exposed medium risk and below 100 underserved populations was considered as exposed low risk for COVID 19. Figure 8 depicts the relationship between the level of vulnerability to COVID 19 pandemic and the number of underserved population of the study area.

In terms of accessibility to WASH practices, Reclamation East, Reclamation West, Navanthurai North divisions have high number of population who are in the condition of poor accessibility to WASH practices, Nedunkulam, Columbuthurai East, Passaiyoor West, Thirunagar, Gurunagar East, Gurunagar West, Small bazar, Fort, Navanthurai South divisions have moderate number of population who are in the condition of poor accessibility to WASH practices Passaiyoor East and Koddady divisions have low number of population who are in the condition of poor accessibility to WASH practices respectively.

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Figure 8: Number of underserved population and the level of vulnerability to COVID 19.
Source: Created by researcher based on Survey department, 2021.

Access to water for drinking purpose is a major challenge in this coastal area due to high salinity of ground water. More than 80 percentages of the households depends on shared public water collection points where water is provided one or two hours per day and remain households fetch water from either temple well or common well. Generally ten or more households share a single stand post but in the overcrowded settlements of Reclamation East and West, more than fifteen households need to share a single stand post. More than 85 percentages of the dwellers of Reclamation East stated, particularly in the dry season people need to stay in a queue for long time to fetch limited amount of water which is inadequate for their drinking and cooking purpose and the dwellers of flat complex encountered challenges to carry the fetching water to their apartments. The water service provision of Municipal council is limited to the dwellers of underserved settlements who encroached the state, temple and private lands. Particularly encroached underserved dwellers of Nedunkulam, Columbuthurai East, Passaiyoor West, Reclamation East and West, Small Bazar, Fort, Navanthurai North and South face extreme drinking water scarcity problem where per capita per day allocation of water is scanty under normal situation and there is a risk to collect water during the emergency time. Initiation of the unlock period has worsened seclusion of a slum when the residents are getting exposed to the larger crowd and presently people agglomerate in the water collection points without wearing mask and maintain social distancing to collect water in the limited provision time. This has intensified the risk of spreading Covid-19 infection.

Poor sanitation is linked to transmission of communicable diseases and exacerbates stunting [12]. Access to individual toilet facility is highly recommended to maintain hygienic practices in this COVID situation. Even though in the study area more than 190 settlements do not have individual toilet facility and share public or neighbour toilets. Among that, 28 percentages of the households who live in Vasanthapuram, Nithiya Oli and Sabinagar of Navanthurai North utilize public toilet or neighbour toilet. At the same time, 21 percentages of the households of Reclamation East, 13 percentages of the households of Nedunkulam and 12 percentages of the households of Fort share toilet facility with their neighbourhoods. Significant number of latrines in the coastal belt starting from Nedunkulam to Navanthurai North not cope up with the building regulations and not maintain hygienically where the distance between well and latrine pit below 50 feet and the latrine pits located on the road, sea and inside the house. In the flat complex of Reclamation East due to the ineffective septic system, toilet waste is disposed into sea directly through the drainage canal without proper management. These dilapidated conditions push the coastal areas easily prone to communicable diseases. Figure 9 showed the dilapidated condition of the underserved settlements in the study area.

Figure 9: Dilapidated condition of the underserved settlements.
Source: Filed observation (2021).

Over 98 percentages of the participants has the knowledge of COVID 19 and they are receiving the information from wide variety of sources including TV, radio, newspaper and social media, even though their attitudes and hygienic practices against COVID 19 is in inadequate level. Hand washing with soap or sanitizer, wearing mask are another important measures to prevent the spread of COVID 19 virus and these practices are less in slums than non-slum settlements [10]. Seventy five (75) percentage of the household said that they wear facemask, 20 percentage of the households said that they have the practices of both wearing face mask and hand washing with soap or sanitizer. It is observed that more than 60 percentages of the people cover their nose and mouth in unprotected way by using unprotected face masks or handkerchief.

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They gather in the public places without maintaining physical distancing and they remove the masks while talking with nearest person. Since the early part of this year, the percentage of wearing face mask is reduced and people neglect the preventing measures for COVID 19. This irresponsible attitudes and practices of people induced the risk for transmission of COVID 19 through the emitted droplets. As the same time two thirds of households are economically vulnerable and 40 percentages of them stated that it is very difficult to maintain social distancing and hygienic practices in the daily wage jobs, 30 percentages of them said that continually purchasing sanitizers, soaps, tissue papers, masks are un-adorable for their income.

Type of land use and vulnerability to COVID 19 pandemic

Food and Agriculture Organization states in 1993 [30] that "land use concerns the function or purpose for which the land is used by the local human population and can be defined as the human activities which are directly related to land, making use of its resources or having an impact on them". In the study area, land is utilized for different purposes including built-up land, agricultural land, water bodies, marshy land, scrubs, grassland and bare land. High dense urban built-up areas were considered as having a high risk for transmission of COVID 19, whereas low dense urban built-up areas and non-built-up areas were considered as having moderate and low risk respectively [21]. The relationship between the land use types and level of vulnerability (risk) to COVID 19 is depicted in figure 10.

Figure 10: Land use types and level of vulnerability (risk) to COVID 19.
Source: Created by researcher based on Survey department, 2021.

Road density and vulnerability to COVID 19

Road density is one of the risk factor that may contribute to increasing transport connectivity and diffuse infectious diseases [21,31]. High road density areas are considered as having "high risk", Moderate road density areas are considered as having "moderate risk", and low road density areas are considered as having "low risk" for transmitting COVID 19 infection. In terms of road density, Gurunagar West division has high road density; Reclamation East, Reclamation West, Navanthurai North, Navanthurai South, Passaiyoor East, Passaiyoor West, Thirunagar, Gurunagar East, Small bazar have moderate road density; Nedunkulam, Columbuthurai East, Fort and Koddady have low road density. Figure 11 depicts the relationship between the level of vulnerability to COVID 19 pandemic and the road density of the study area.

Figure 11: Road density and the vulnerability to COVID 19 in the study area.
Source: Created by researcher based on Survey department, 2021.

Public gathering places and vulnerability level to COVID 19

Anthropogenic factors increase the infection risk through contact with contaminated surfaces or person to person contact in public spaces [32]. Relationship between the distance of public gathering places and the risk for the transmission of communicable diseases was investigated in previous literatures [31-34]. Study by Pourghasemi., et al. in 2020 [32] considered the variables of bus stations, hospitals, bakeries, mosques, banks and automated teller machines for the risk mapping of COVID 19 in Iran.

Public gathering places in each division of the study area were identified based on Google earth and hot spots were marked through field observation. Table 10 indicates the public gathering

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places and figure 12 displays the identified hot spots – high number of public gathering places of each division which has the probability to easily transmit communicable diseases.

Division	Public gathering place
Nedunkulam	07 worship centres, community centre
Columbuthurai East	Columbuthurai Fish market, 03 worship centres, 02 schools, playground, 02 community centres
Passaiyoor East	Passaiyoor market, worship centre, 02 schools, sub post office, 02 play grounds, community centre
Passaiyoor West	Private hospital, ayulvedic dispensary and maternity home, 03 worship centres, sea food processing centre
Thirunagar	Advance technical college, net factory, worship centre, police station, school, playground, 02 community centres
Reclamation East	Eight five storey Flat complex with 160 houses, playground, 04 community centres, Divisional hospital, sea food processing centre
Reclamation West	Playground, community centre, school, ice factory, fish market
Gurunagar East	Worship centre, community centre
Gurunagar West	02 worship centres, 02 community centres, sub post office
Small Bazaar	School, 05 worship centres, Small Bazaar market, Ocean university
Fort	02 schools, 03 community centres, TB hospital, police station, 03 playgrounds, Samurdhi bank, fuel station, court complex, 02 urban parks, Fort, fish market, prison, Sri Lanka telecom
Koddady	05 worship centres, 06 community centres, school
Navanthurai South	02 worship centres, 07 community centres, 02 schools, 02 play grounds, Navanthurai market, sub post office
Navanthurai North	03 community centres, play ground, sea food processing centre

Table 10: Public gathering places in the study area.

Source: Google earth, 2021& Jaffna Divisional Secretariat Statistical Handbook, 2020.

Figure 12: Identified hot spots of each division.

Source: Field observation, 2021.

Particularly high number of public gathering is observed in markets, higher education centres, hospitals, post offices, factories, sea food processing centres, police stations, court complex, prison, attraction sites, parks, fuel stations and flat complex.

The relationship between the levels of vulnerability to COVID 19 pandemic and number of public gathering hotspots in the study area is depicted in figure 13.

Figure 13: The levels of vulnerability to COVID 19 pandemic and number of public gathering hotspots in the study area.

Source: Created by researcher based on Survey department, 2021.

Miserable life of the underserved dwellers has been further jeopardized by the COVID 19 pandemic. Seventy five percentage of the health care workers stated that the coastal underserved ar-

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eas have reported more frequency of vector borne diseases, water borne diseases, malnutrition problems and the COVID 19 added burden on their health risk. Eighty five percentage of the development officers said the location and the infrastructure of the underserved areas make them increasingly vulnerable to the extreme weather conditions and natural disasters. Another form of vulnerability – violence targeted to adolescent girls and women in the underserved areas [35]. Sixty percentage of the members of women Rural Development Society (WRDS) stated during the lockdown period there are number of domestic violence occurred in the area but there are no complaints registered yet. Staying home is deemed safe against Covid-19, but not to prevent domestic violence. Sixty five percentage of the dwellers said they always apprehensive from the threat of eviction while they encroach the lands which are belonged to state, temple and private owners. Eighty percentage of the dwellers stated due to their inhabitable area they face social exclusion and discrimination.

Vulnerability mapping of underserved areas

The vulnerability of underserved settlements to the COVID 19 pandemic is assessed in terms of the criteria of population density, economic status, land use, transport connectivity, housing condition, access to WASH and public places. The divisions with high population density, low economic status, high dense of built-up land, high number of improvised houses, high number of population who are in the condition of poor accessibility to WASH practices, high transport connectivity and high number of public gathering places are considered having high risk for COVID 19 with lower capacity to manage the risk. Multidimensional Vulnerability of Slums due to Covid-19 is summarized in table 11.

Criteria	Risk of getting infected by COVID 19	Incapacity to manage the risk
Population density	Very high population density	Social distancing is more challenging
Economic Status	Low paid casual jobs and irregular income	Low savings and a high burden of cost
	Hazardous, unhealthy and congested work place	Insufficient provision for personal protection measures
	Exposure to large population at work	No provision for paid leave and No social security/ medical insurance
	Malnutrition as a result of Poverty	Low income & quality of life
Land use	High dense built-up areas	High mobility
Transport	High road density and transport connectivity	High probability for diffusion of infectious diseases
	Use of over-crowded public transport	High transport cost due to increased fuel price during unlock period
Access to WASH	Shared Public Facilities (Toilet and Tap water)	Minimal government initiative to improve in water supply or toilets in congested settlements
	Incidences of vector and water-borne diseases	Dependency on existing health infrastructure
Public spaces	High public gathering places	Increase the infection risk through contact with contaminated surfaces or person to person contact
Housing condition	Overcrowded in a single settlement	Transmit through droplets
		Insufficient facility for isolation
	Higher risk of Covid-19 infection	Lower capacity to cope against Covid-19
Upsurge of vulnerability		

Table 11: Mapping of Multidimensional Vulnerability of Slums due to Covid-19.

Source: Created by researcher based on literature surveys, 2021.

Based on the multi criteria analysis, risk areas were identified. In this regard, Reclamation East and Reclamation West division were identified as very high risk area, Navanthurai North, Navanthurai South and Gurunagar West divisions are having high risk, Passaiyoor East, Passaiyoor West, Gurunagar East and Fort divisions are having moderate risk, whereas Nedunkulam, Columbuthurai East, Thirunagar and Small bazar having low risk and Koddady division has very low risk for the COVID 19 pandemic. Risk level of the coastal areas of Jaffna Municipality for the COVID 19 pandemic based on the multi criteria analysis is shown in the figure 14.

Figure 14: Risk level of the coastal areas of Jaffna Municipality for the COVID 19 pandemic.
Source: Created by researcher based on Survey department, 2021.

Based on the statistical records of Jaffna Divisional Secretariat Division, the divisions of Fort, Reclamation West and Gurunagar West were recorded with significantly high number of positive cases. The number of positive cases reported in the coastal areas of Jaffna Municipality from 1st of January 2021 to 13th of August 2021 is shown in figure 15. The factors of number of Polymerase Chain Reaction (PCR) test and antigen test were undertaken in the division, accuracy of the results and reliability of the records are highly influenced on the reported positive cases in the divisions [1].

Conclusion and Recommendations

It is timely significant to integrate the epidemiological, economic and social strategies to preserving the lives, livelihoods and human capital of urban environment especially the underserved areas which are the main labour force supply areas. Prioritize the

Figure 15: The number of positive cases reported in the coastal areas of Jaffna Municipality.
Source: Created by researcher based on Survey department, 2021.

wellbeing of the poorest and most vulnerable people in the society help in order to minimize the impact of epidemiological and economic externalities as well as political risks. Social care should be better integrated into health care for vulnerable populations to connect them with needed social and economic services.

Responding to the pandemic situation, government hastily imposed fully and partially lockdown which created turmoil across the economically disadvantaged groups. It requires maintaining essential flow of income and food delivery for the low income populations who are in the quarantine areas and at risk of food insecurity as an urgent action. Small scale fishing community in the study area severely impacted not only during the first and second wave but also in the third wave due to the increased risk of spread of the disease, reduced fish consumption, low demand and falling incomes. The government should exonerate the myth that the COVID 19 virus doesn't transmit through fish. As the same time encourage the community to diverse their income generating activities including coir industry, net mending, ornamental fisheries, fish net dying, agriculture, animal husbandry, tourism activities (guides, fishing tours in lagoons), boutiques to earn supplementary income.

COVID 19 is compounding the severe health vulnerabilities and inequalities facing the urban poor, prompting a re-evaluation of the contemporary approach to settlement upgrading. The most basic COVID 19 preventing measures such as hand washing, social

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distancing, working from home and online learning are not possible for underserved settlement dwellers. The pandemic has also starkly highlighted the interconnectedness of the health of all urban residents, bringing into consciousness the plight of urban poor who are disproportionately suffering. There is a necessity to upgrade the underserved houses according to the housing regulation, ensuring supply of adequate water by increasing frequency or running time to every household is highly encouraged, so that crowd cannot assemble, empower the divisional hospitals, paving streets, improving storm water drainage, formalizing electricity and solid waste collection, land tenure regularization delivered through a community based approach in the medium or long term action. Inequities further exacerbate the impact of COVID-19 on vulnerable populations. Providing phone, internet, broadband which are essential for the distance learning with the collaboration of public and private partnerships; offer a phone hotline for the community to report the violence against vulnerable population; disseminating the knowledge culturally and linguistically concordant regarding the significance of preventing measures including wearing masks, hand washing, physical distancing to reduce the rate of transmission should strengthen their capacity to manage the risk.

The research is expected to be useful for the health authorities, developers, urban planners, and policy makers, academics to carry out their surveillance programmes, vaccination programmes, and livelihood development activities on the priority basis to control the transmission of disease and minimize the vulnerability level. Leveraging and employing current technologies such as geospatial mapping and predictive modelling at the zip code level to determine COVID 19 hotspots to target for intervention and better understanding at risk populations. Lessons learned from this pandemic will require us to rethink public health responses and urban planning practices that could better prepare our cities for future pandemics.

Emphasise the concept of cities of resilience which is inextricably linked to sustainable development is timely requirement. The concept of cities of resilience refers to complex urban forms arising out of functional integration of several aspects that play specific roles in the spatial heterogeneity in both ecological and social function of the urban areas [36]. It indicates how cities can endeavour across different sectors and creates situations enabling cities to bounce back and recover swiftly from sudden shocks or from slow onset disasters. Urban future is depending on the mechanisms for risk management and vulnerability reduction which can create resilient cities. Mainstream public health and health service delivery in the urban development agenda; planning and designing urban living and working environment with open and green spaces, efficient waste management and service provision; developing eco cities - a human settlement modelled on the self-sustaining resilient structure and function of natural ecosystems which provides healthy abundance to its inhabitants without consuming more resources than it produces, without producing more waste than it can assimilate, and without being toxic to itself or neighbouring ecosystems; enhancing digital technologies for building community resilience will make Urban areas of Sri Lanka more resilient by making cities smarter, greener, more inclusive, resilient and livable.

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