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Geospatial Distribution and Trend Analysis of Corona Pandemic (Covid-19) in West Bengal, India

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ABSTRACT

Novel Corona Virus or COVID-19 a highly infectious disease was originated in Wuhan city of Hubei province of China and rapidly spread across the world. This global pandemic creates a major challenge in respect to public health infrastructures around the world. This study has prepared on West Bengal, which is located in the eastern part of India. The aim of the study is to analyze the trends of outbreak and spatial distribution of COVID-19 pandemic with the help of spatial analysis tools of GIS software. Monitoring active ties using GIS spatial analysis is very important to control such as a COVID-19 virus spreading problem. Currently 2377 confirmed cases of COVID-19 have been reported in the state. Out of which 1394 are active patients, 768 patients have cured and discharged, 143 patients died and 72 patients died due to Comorbidity. There has been increasing trends found in all the attributes, i.e. confirmed cases, Cases load, recovery, death and test per million etc. of COVID-19 in last 8 weeks. Only the delta rates have declined over the last few weeks, which indicate that the cases of COVID-19 will be declined as compared to cured or recovered cases in near future. The prediction IDW maps of COVID-19 have shown that the area under extremely affected and dangerous lies in few districts namely Kolkata, Howrah, part of Hooghly, North and South 24 Parganas in case confirmed cases, active cases and deaths. These areas are also under the highly healing zone in respect to number of cured patients.

1. Introduction

WHO has declared Novel-Corona Virus as a global pandemic on 30th January (Eurosurveillance, 2020), which was first detected in Wuhan city of central Hubei province of China in early December, 2019 (Holshue et al., 2020). On 11 February 2020, WHO announced a name for the new coronavirus disease: COVID-19.As of 16th May 2020, about 4.5 million of COVID-19 confirmed cases across 213 countries and territories around the world and over 300000 deaths have been reported (WHO, 16th May, 2020). COVID-19 is a contagious disease and spread by human-to-human transmission through droplets, feco-oral, and direct contact and has a time period of 2-14 days (Backer, 2020). Novel-Coronavirus (COVID-19) infections are emerging respiratory viruses that are known to cause illness ranging from the common cold to severe acute respiratory syndrome (SARS) (Yin et al., 2018). COVID-19 is a zoonotic pathogen that can be transmitted via animal-to-human and then human-to-human interactions (Li et al., 2020). COVID-19 creates a major challenge in respect to health infrastructures in many countries. Especially in the developing country like India, where the presence of high density of the population, lack of health infrastructures, bad condition of public health sectors may cause a devastating scenario on spreading this pandemic. India reported its first confirmed COVID-19 case on 30th of January 2020 in the state of Kerala. As of now India cross China in case of total confirmed cases with more than 90 thousands cases (GOI, 17th may 2020). State like West Bengal where the population density is 2nd highest among the all states, it's clearly indicates a vulnerable situation would be occurred in the state in case of COVID-19 spread. The Capital of the state Kolkata, act as the epicenter of this pandemic spread. The first confirmed case of COVID-19 was reported on 18th march, when one male aged 18 years who had returned from UK on 15th March (GOW, 18th March, 2020).Till now almost every districts of the state have affected by this pandemic. The aim of this study is to analyze the spatial distribution of COVID-19 attributes (like spatial distribution of total confirmed cases, total active cases, cured or discharged and deaths due to COVID-19) and its trend to predict the spread of diseases over the state. Geographic Information Systems (GIS) and spatial mapping are emerging global health tools, but the degree to which they have been implemented in India for COVID-19 research is unclear (Murugesan et al., 2020). GIS and spatial analysis can also be important tools for acquiring knowledge, prevention, and treatment of any diseases. For example, GIS technology can be used as a visualization help to map the geographical distribution of the disease, the potential risk factors and the resources available for treatment and prevention. The spatial analysis of certain information, will help to evaluate the risks of disease, trends in outbreaks over time and space, and hotspots of infection (Lyseen et al., 2014;Kandwal et al., 2009).

2. Study Area

West Bengal is located in the eastern side of the country. (Figure1) The latitudinal and longitudinal extent of the state is 21°25´ N to 26°50´ N latitudes and 86°30´ E to 89°58´ E longitudes. It comprises of 23 districts. The state is surrounded by 5 neighboring states (i.e. Odisa in south-east boundary, Bihar and Jharkhand in western boundary, Sikkim in northern boundary and Assam in north-eastern boundary), and 3 neighboring countries (i.e. Nepal in north-western boundary, Bhutan in northern boundary and Bangladesh in eastern boundary). It occupies a geographical area of about 88, 752 sq.

km which is 2.70% of India's total geographical area and extending from the Himalayas in the north to the Bay of Bengal in the south. According to 2011 Census, its total population is 91,347,736 which is 7.55% of India's total population and population density is 1029 persons per sq. km. (in terms of population density West Bengal stood second after Bihar). According to 2011 Census west Bengal literacy rate is 77.08 percent and about 32% of population in West Bengal lives in urban areas and rest 68% lives in rural areas. The official language of the state is Bengali. The aged population of the state is 7742382 persons which is about 8.5% of total population of the state. These elderly peoples are more vulnerable to COVID-19 pandemic.

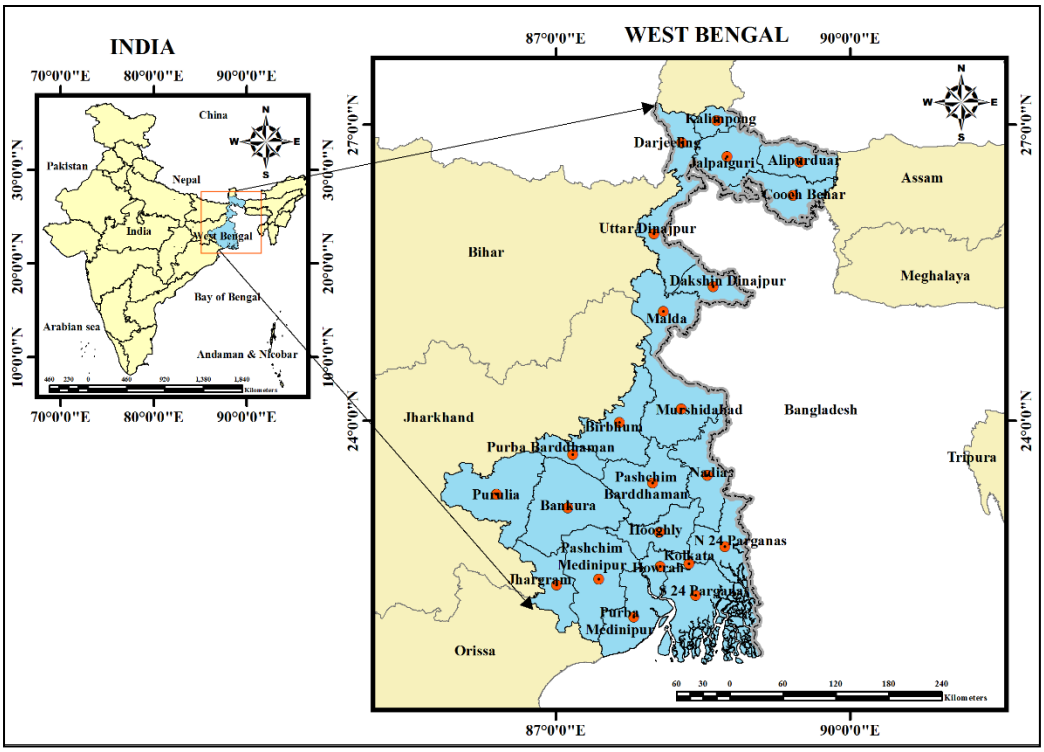


Figure 1 Location Map of the Study Area

3. Objectives

The main purpose of this paper is –

a. To assess the trend of the spread of COVID-19 from initial cases confirmed to 14th may in the state.
b. To analyze the geospatial distribution of COVID-19 within the state in the same period.
c. To estimate the trends of this pandemic in the state by using GIS and analysis tools.

4. Data and Methods

In this study various peer reviewed research papers based on COVID-19 in India and other countries have been reviewed with spatial assessment associated with GIS. For the purpose of this study, spatial analysis approaches and use of GIS were ambiguously specified to obtain a range of emerging activities i.e. studies were selected using special GIS tools or the specific use of spatial analysis techniques (Kawo and Shankar, 2018; Shankar and Kawo, 2019; Balamurugan *et al.,* 2020). The data used in this study is the number of COVID-19 disease patients in West Bengal since the inception of the COVID-19 case in the state to the next 8 weeks i.e. from 18th march to 14th may, 2020 obtained from Department of Health & Family Welfare, Govt. of West Bengal**.** The distribution pattern of disease transmission is demonstrated by GIS tools in the present study with the help of Inverse Distance Weighted (IDW) technique. Inverse Distance Weighted (IDW) is one of the most commonly recognized techniques of interpolation. It is used in the estimation of the forecast zone of neighboring areas to estimate values for every uncertain destination (Childs, 2004). It is based on two inferences: firstly, the impact of the unknown value of a point or location is specifically extended to the point of the range and secondly, the extent of the impact is directly related to the inverse of the range between the points. The following equation is used for the analysis (Bartier*et al.,* 1996; Huang *et al.,* 2011).

$$Zp = \frac{\Sigma_i^n=1\left(Z_i/d_i^p\right)}{\Sigma_i^n=1\left(1/d_i^p\right)} \qquad (1)$$

where, Zp refers to the interpolated value of the unknown point, the weighting function which controls the significance of the control point Zi and Zi is the value observed at the control point i which represents the nearest neighborhood of the interpolated point produced and ranges from 20 to 30, n is the nearest vicinity of the control points which is usually required to consume time, d_i^p refers to the interpolated point, p is a weighting absolute value that is an arbitrary positive real number, p is equal to 1 in inverse distance weighting (Guan and Wu, 2008). The trend analysis has been done with the help of Ms Excel and the GIS maps have been produced through ArcGIS 10.2.2. Formulas like recovery rate, Cases Load,, Cases Load Rate, Death Rate and Delta have been calculated for the estimation purpose in the present study (See Table2).

$$Recovery\ rate = \frac{Recovered\ cases}{Confirmed\ cases} \times 100 \qquad (2)$$

$$Cases\ load\ or\ Active\ Case = Confirmed\ cases - Recovered\ cases - Deaths \quad (3)$$

$$Cases\ load\ rate = \frac{Cases\ load}{Confirmed\ cases} \times 100 \quad (4)$$

$$Death\ rate = \frac{Death}{Confirmed\ cases} \times 100 \quad (5)$$

$$Delta = Cases\ load\ rate - Recovery\ rate \quad (6)$$

5. Result and Discussion

a. Current Status of COVID-19 in the State

The COVID-19 cases have crossed 2000 in West Bengal as of 14th May, 2020. The District wise confirmed COVID-19 cases in the state have shown in Table1. The first case was reported on 18th march when an 18 years old young guy returned to Kolkata to UK. Kolkata is the capital city of the state and it also the central hotspot for spread of this Covid pandemic. As of 14th May the highest numbers of confirmed cases of COVID-19 were reported in Kolkata with 1157 cases. Howrah the neighboring district of Kolkata is also badly affected by this pandemic. With 509 cases Howrah district stood 2nd position in respect to COVID-19 confirmed cases. On 4th May Ministry of Home Affairs published a press realized (dated 1st May) 3rd phase lockdown in the country and categorize all the districts of the country into 3 zones, i.e. Green, Orange and Red zone. Green zone is defined as districts with zero confirmed case till date or district with no confirmed cases in last 21 days. Red zone or hotspot districts are those districts where confirmed cases are found in last 21 days. Rest of the district whish are neither Green nor Red are categorized as Orange zone (GOI, 4th May 2020). On 1st May 10 districts (i.e. Kolkata, Howrah, North 24 Parganas, South 24 Parganas, East Medinipur, West Medinipur, Darjeeling, Jalpaiguri, Kalimpong and Maldah) of West Bengal are under Red Zone, 5 Districts (i.e. Hoogly, Pachim Bardhaman, Purba Bardhaman, Nadia and Murshidabad) are under Orange Zone and rest 8 districts (i.e. Uttar Dinajpur, Bankura, Bibhum, Coochbehar, Dakshin Dinajpur, Purulia, Alipurduar and Jhargram) are under Green zone. Recently in Uttar Dinajpur and Dakshin Dinajpur few positive cases have been reported. All the confirmed cases are the migrant laborers, who came from other parts of the country. Till now 142 patients of COVID-19 has reported death in the state. The highest death occurred in Kolkata with 94. The Comorbidity causality in the state is 72. A total of 768 patients have been cured from this pandemic in the state. Kolkata has the highest number of cured patients with 386 discharged. After that Howrah (135), North 24 Parganas (102), Hoogly (30), South 24 Parganas (27) and Purba Medinipur (26) etc. have cured patients (GOW, 14th May, 2020).

Table 1 District-wise breakdown of COVID-19 Cases in West Bengal

S. No	Districts	Total Cases	Total Active Cases	Total Discharged	Total COVID- 19 Deaths	Total Comorbidity Deaths
1	Alipurduar	0	0	0	0	0
2	Cooch Behar	0	0	0	0	0
3	Darjeeling	7	1	5	1	0
4	Kalimpong	7	0	6	1	0
5	Jalpaiguri	4	0	4	0	0
6	Uttar Dinajpur	4	4	0	0	0
7	Dakshin Dinajpur	0	0	0	0	0
8	Malda	19	19	0	0	0
9	Murshidabad	5	4	0	0	1
10	Nadia	12	4	8	0	0
11	Brigham	7	1	6	0	0
12	Purulia	0	0	0	0	0
13	Bankura	0	0	0	0	0
14	Jhargram	3	3	0	0	0
15	Paschim Medinipur	19	0	19	0	0
16	Purba Medinipur	49	22	26	0	1
17	Purba Bardhaman	10	7	3	0	0
18	Paschim Bardhaman	17	6	9	0	2
19	Howrah	509	347	135	22	5
20	Hooghly	135	101	30	1	3
21	North 24 Parganas	317	186	102	21	8
22	South 24 Parganas	79	50	27	2	0
23	Kolkata	1,157	625	386	94	52
24	Other State	17	14	2	1	0
Total		**2,377**	**1,394**	**768**	**143**	**72**

Source: Department of Health & Family Welfare, Govt. of West Bengal, 14th May 2020.

b. Trends of COVID-19 Cases in the State

i.Confirmed Cases and Cases Load

West Bengal experienced its first case of COVID-19 on 18th March. After that the numbers of confirmed cases and cases load have increased till now and continue to increase. Table2 and Figure2 reveal weekly confirmed cases and cases load of COVID-19 in the state from 18th March to 14th May. After the first week of first case detection, total confirmed cases and cases load have reached to 9 and 8 (with 88.89 cases load rate) respectively. In the next week i.e. in 1st April the confirmed and cases load have reached to 37 and 34 (with 91.89 cases load rate) respectively. In the 4th week (15th April) of COVID-19 pandemic the total confirmed and active cases in the state has reached 132 and 125 (with 94.70 cases load rate) respectively.

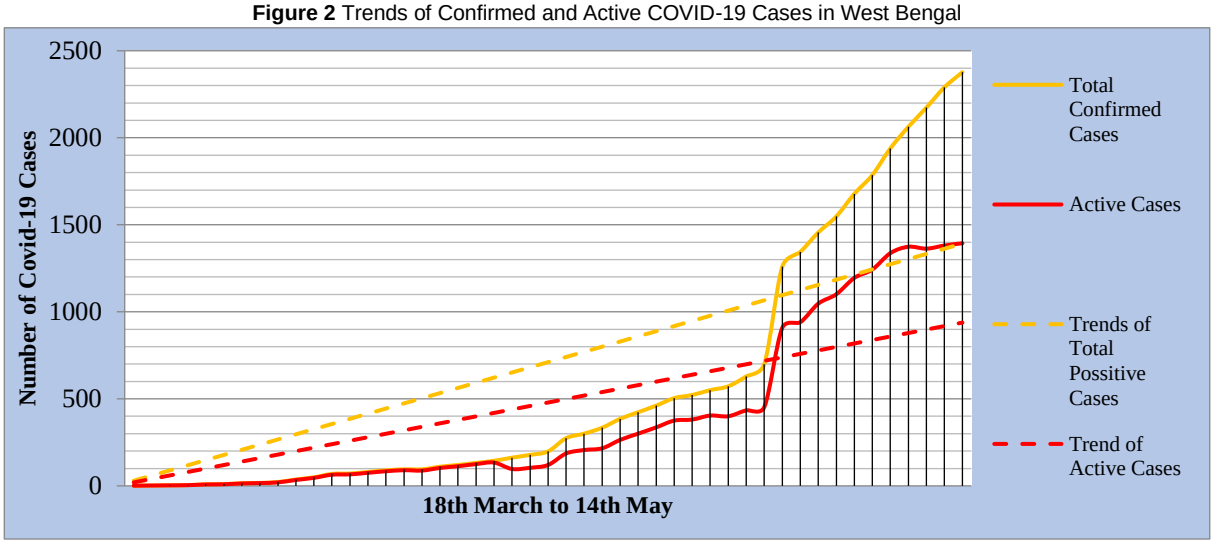
Table 2 WeeklyTrends of COVID-19 Pandemic in West Bengal (18th March to 14th May)

Days	Total Confirmed Cases	Cases Load	Cases Load Rate	Deaths	Death Rate	Recovery	Recovery Rate	Delta	Total Test	Test Per Million
18th Mar	1	1	100	0	-	0	0	100	77	1
25th Mar	9	8	88.89	1	11.11	0	0	88.89	242	3
1st Apr	37	34	91.89	3	8.11	0	0	91.89	605	7
8th Apr	71	66	92.96	5	7.04	0	0	92.96	1657	18
15th Apr	132	125	94.70	7	5.30	0	0	94.70	3470	38
22nd Apr	334	216	64.67	15	4.49	103	30.84	33.83	7037	77
29th Apr	550	404	73.45	22	4.00	124	22.55	50.90	14620	160
6th May	1456	1047	71.91	72	4.95	265	18.20	53.71	30141	330
14th May	2377	1394	58.65	143	6.02	768	32.31	26.34	62837	688

Source: Department of Health & Family Welfare, Govt. of West Bengal, 14th May 2020.
Complied by the Authors

In the 8th week (14th May) the total confirmed and active cases have reached to 2377 cases and 1394 (with 58.65 cases load rate) cases respectively. West Bengal is now in 9th week of this pandemic. Though the total number of confirmed cases is lower compared to other states in the country, but as per the expertise concern the number of COVID-19 cases will be increased in near future. The cases load rate has shown declined trend after 4th weeks of COVID-19 inception in the state.

Figure 2 Trends of Confirmed and Active COVID-19 Cases in West Bengal

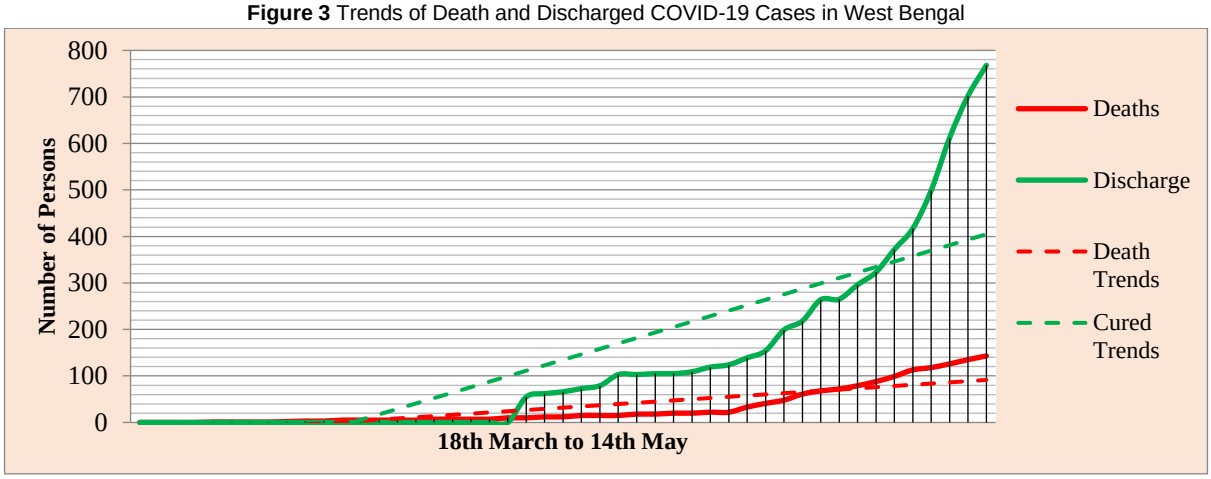


Source: Department of Health & Family Welfare, Govt. of West Bengal, 14th May 2020

ii. Death and Recovery Trends

First death due to COVID-19 in the state was reported on 25th March (Table2&Figure3) which is after one week of first confirmed case. After the 5th week the number of deaths reached 15 which is about 4.5% (death rate) of total confirmed cases. Presently (14th May) 143 patients died due to COVID-19 disease in the state which is over 6% (death rate) of total confirmed cases. The death rate of West Bengal due to this pandemic is higher (about 2.85% more) than the national percentage (i.e. 3.15%).

Figure 3 Trends of Death and Discharged COVID-19 Cases in West Bengal



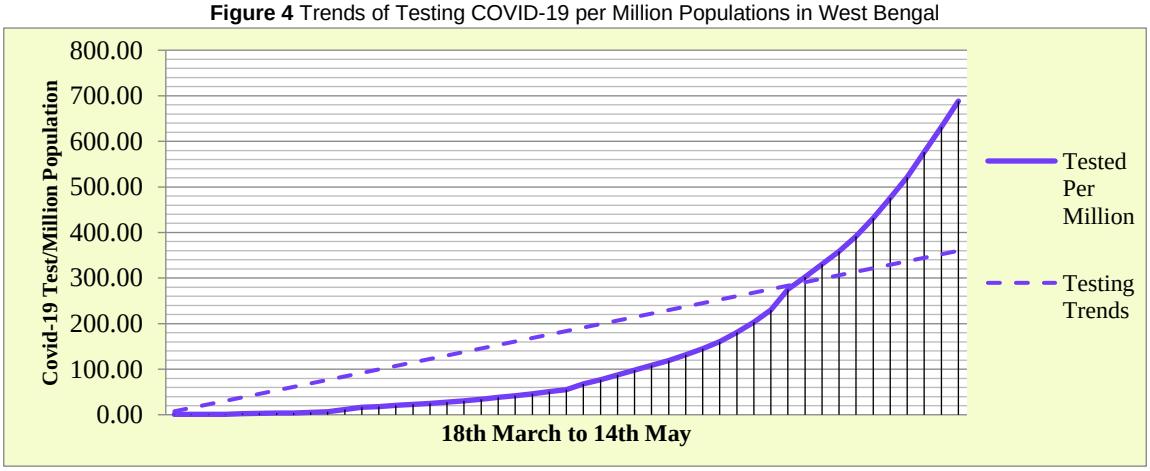
Source: Department of Health & Family Welfare, Govt. of West Bengal, 14th May 2020

55 patients were discharged (with 33.95% recovery rate) from COVID-19 hospitals, as they cured from this disease on 17th April, 2020, which is after one month of entry of this pandemic in the state. After that regularly patients were recovered from this disease in the state. After the 5th week of this pandemic, total 103 patients (Table2&Figure3) were discharged; this was almost 31% of recovery rate. As of 14th May total 768 patients were discharged from hospitals, with 32% recovery rate. But the discharge rate is lower than the national rate; i.e. 38.29%.

iii.Testing Trends in the State

Testing is one of the major tools to prevent the spread of COVID-19 disease. In the preliminary period of the spread of COVID-19, only few testing was done. In 18th March only 77 suspects weretested in the state. Even after 3 weeks of COVID-19 in the state the testing was only 1657 patients which was less than 20 persons per million (Table2&Figure4). As of 15th April on an average 105 patients were tested for coronavirus for every million in India. But in West Bengal the number is much lower (38 persons per million) than the national average. Presently 62837 patients are tested which is 688 persons per million population in the state.

Figure 4 Trends of Testing COVID-19 per Million Populations in West Bengal



Source: Department of Health & Family Welfare, Govt. of West Bengal, 14th May 2020

The delta signifies the difference between the rates of active cases or cases load and cured or recovered cases. From the Table2, a declining trend of delta can be found. It found that the value of delta was least on 14th May (i.e. 26.34); it means the difference between cases load rate and recovery rate was low. This indicates that in the near future the cases of COVID-19 will be declined as compared to cured or recovered cases.

c. Spatial Distribution and Prediction of COVID-19 Disease Spread in the State

In this work, interpolation using Inverse Distance Weighted (IDW) shows clearly how similar objects are more like each other than separate objects. For the estimation of each undetermined site, IDW uses the calculated values (cases) of the prediction site. The values determined closest to the forecast location have a higher impact than further away on the expected value. IDW assumes that the local effect of each measured point deteriorates in time. The IDW approach calculates the average value for non-sampled locations with values from nearby weighted locations. It was possible to determine the weight in proportion to the proximity of points to the un-sampled place and to specify an IDW power coefficient.

In order to predict the spread of disease in West Bengal, interpolation using IDW was obtained. The map shows the number of patients and the extended disease zone across West Bengal. Distributions of estimated confirmed cases in West Bengal as of 4th may and 14th may is classified into four

classes by IDW using standard deviation method (See Figure5).

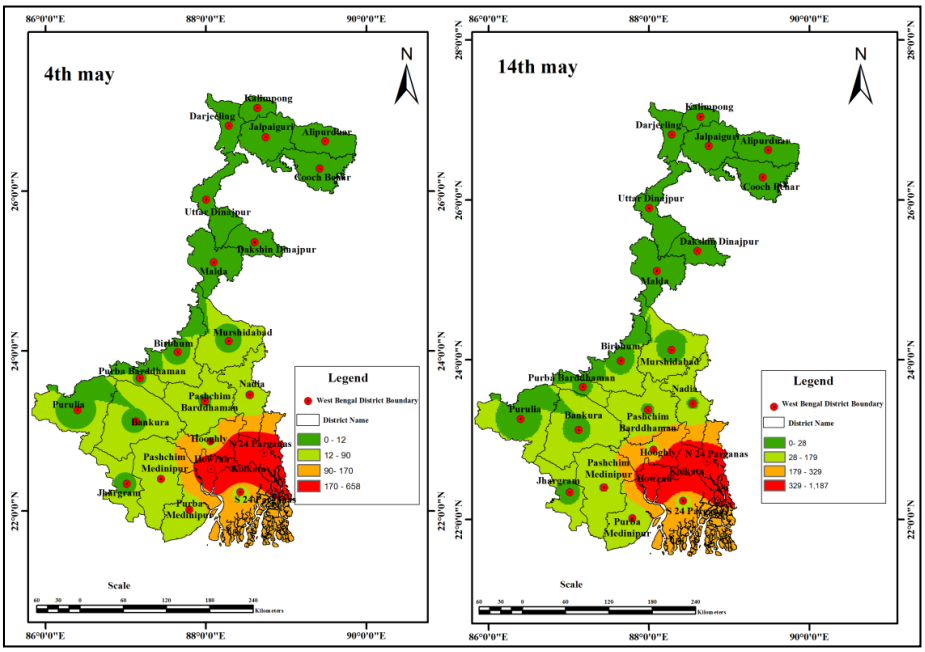


Figure 5 Distributions of Estimated Confirmed Cases

The classes are representing risk of exposing the spatial spread of the disease in relation to different districts of West Bengal, based on environmental factors and population factors that may control the distribution of the patient. The migrant labourers returning from Delhi, Kerala as well as other parts of the country are associated with carrying the COVID-19 cases in different districts of West Bengal. Population wise West Bengal is the 4th largest state and the population density is quite high here that is the main concern with high potential risk of COVID-19 cases here. Although within India West Bengal now has the 8th position by considering the number of confirmed COVID-19 cases. COVID-19 prediction IDW map (See Figure5) suggests that extreme cases will centered in around the state capital i.e. Kolkata, Mainly in Kolkata, Howrah, North and South 24 Parganas. On 4th may Kolkata having 659 (+24) confirmed cases while as of 14th may the confirmed cases increase to 1157. In case of Howrah on 14th may the confirmed cases are 509. Kolkata is the largest urbanization within the state which is associated with largest spread of infectious disease with COVID-19 cases has been increased daily.

In case of active cases or cases load similar scenario like confirmed cases has been found in the state. Spatial mapping (IDW) for active cases of COVID-19 (See Figure6) for 4th May and 14th May in the state has shown that the Kolkata, Howrah, part of North and South 24 Parganas and Hoogly have extremely affected as the number of active cases are higher in these districts. In these districts the active cases zone ranging from 182 to 463 in 4th May and 273 to 605 in 14th May. Areas like Nadia, Hoogly, Pachim Bardhaman, Pachim Medinipur, Purba Medinipur and central & south part of South 24 Parganas lies in moderately affected. All the districts of North Bengal are less affected in respect to active cases.

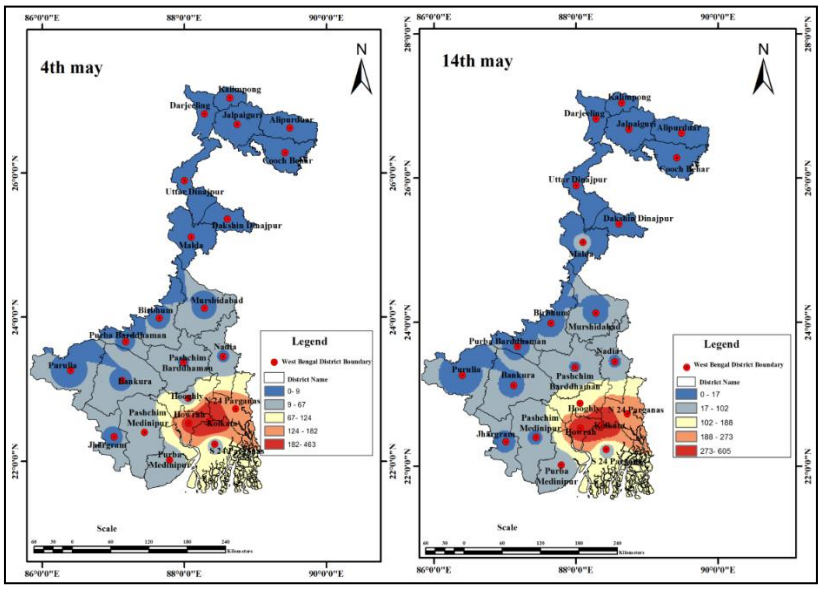


Figure 6 Distributions of Estimated Active Cases

The death and cured prediction distribution of the COVID-19 map of West Bengal as shown in Figure 7 and 8, respectively. In case death districts like Kolkata, Howrah and North 24 Parganas are highly dangerous in 4th May as the death zone ranging from 10 to 35 patients. Pachim and Purba Medinipur, Pachim Bardhaman, Nadia, Part of Murshidabad, and Hoogly are moderately dangerous as the death zone ranging from 1 to 5 patients. Whole North Bengal along with Purulia, Bankura, Purba Bardhaman and Birbhum districts are in zone of less dangerous in 4th May. Again in 14th May the extremely dangerous zone lies in Kolkata, Part of Howrah, Hoogly, North and South 24 Parganas with the value ranging from 33 to 100 deaths. Except Purulia, Birbhum and Purba Bardhaman whole South Bengal is under the moderately dangerous zone with the value ranging from 11 to 22 deaths. Till 14th May whole North Bengal along with Purulia, Birbhum and Purba Bardhaman is under less dangerous zone.

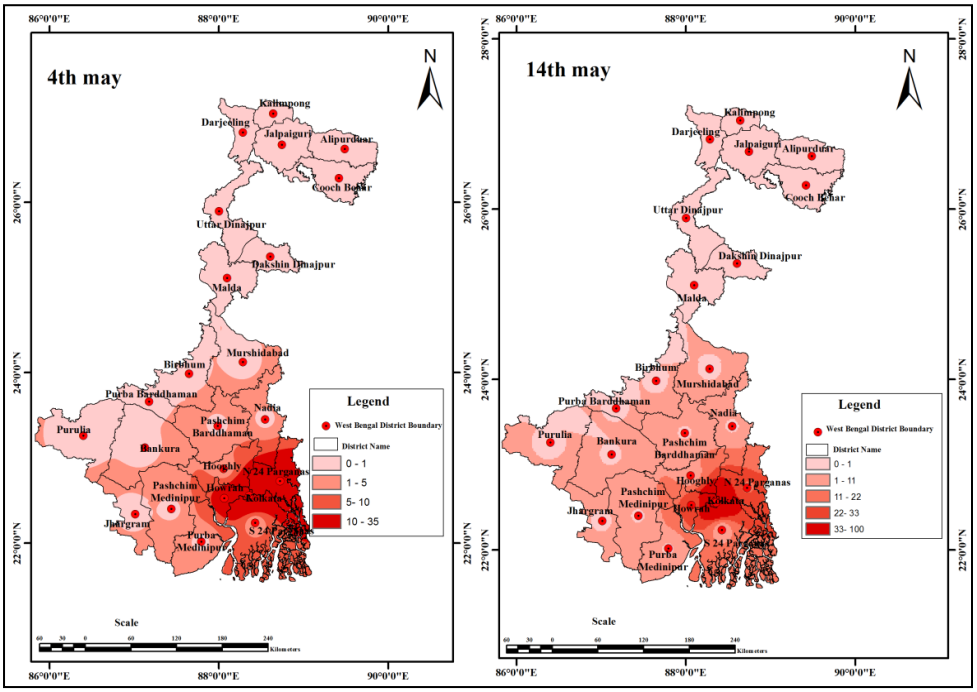


Figure 7 Distributions of Estimated Deaths due to COVID-19

In case of Cured prediction COVID-19 map (See Figure8) districts like Kolkata, North and South 24 Parganas, Howrah and part of Hooghly is under highly healing zone as the number of cured patients are also higher in this zone in 4th May and 14th May.

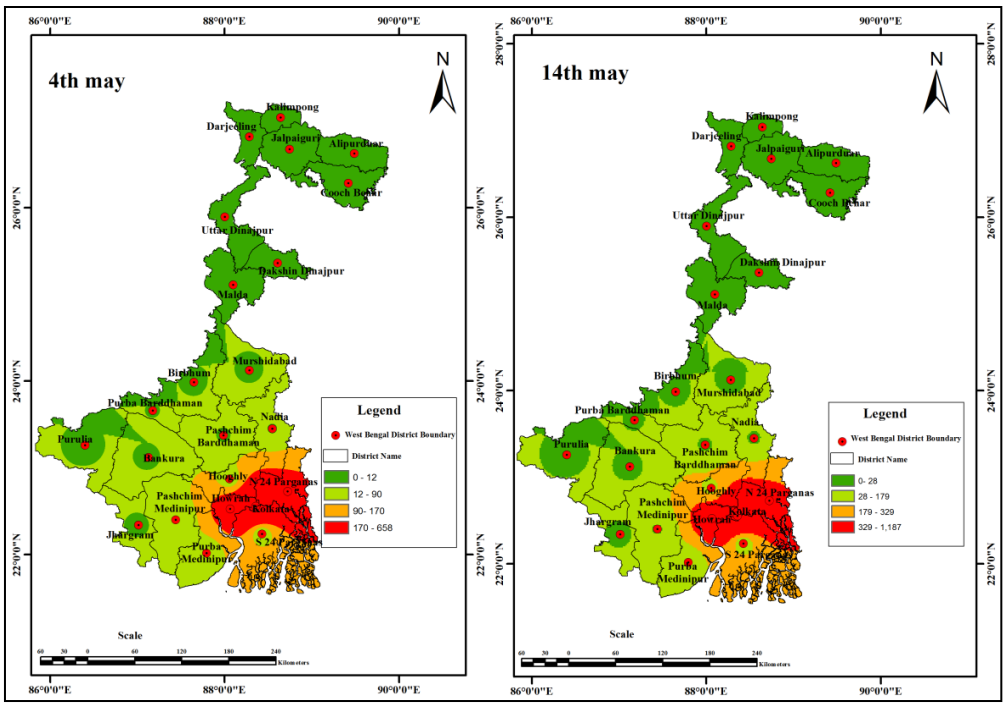


Figure 8 Distributions of Estimated Cured / Discharged Patients

The moderately high healing zone lies upon Hoogly, part of Nadia, Pachim and Purba Medinipur, South and North 24 Parganas. PachimBardhaman, Bankura, part of Pachim and Purba Medinipur, Nadia, Purba Bardhaman, Birbhum and Murshidabad lies under the moderately healing zone in both time period. As the confirmed cases are much lower in North Bengal, therefore the cured cases also lower. So this zone is under low healing zone in case of cured cases.

6. Conclusion

The study has shown the trends of spread and spatial distribution pattern of COVID-19 pandemic in West Bengal. All the attributes of COVID-19 (i.e. confirmed cases, active cases, recovery and death etc.) have been presented in simple line graph with trend line to understand the outbreak of novel-coronavirus in the state in last 8 weeks. GIS based spatial techniques have provided a perspective for measuring the degree of outbreak of this pandemic. Analysis of spatial distribution patterns may provide valuable information to support government monitoring and the predicting spread of the virus across small and large areas in the state. As a result, a GIS-based spatial distribution using the IDW method was performed in this article to identify potential disease risk assessments in West Bengal. The results of this study may be appropriate for the associated agencies to carry out a comprehensive assessment of the spread of the virus and environmental control in the study area.

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