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Economic Status of Indian States and its Impact on Covid 19 Management

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Abstract: *The present pandemic Covid 19 is playing havoc round the world. In such a situation where vaccination and medicine is not available, the prime responsibilities of national governments becomes the minimization of death rate and increase in recovery rate. This study aims to determine how a state's economic standing influences the management of Covid 19 in terms of the minimal death rate and maximum recovery rate. The economic status of the state is depicted by GDP per capita, number of isolation beds, ICU beds created, level of literacy, number o infected cases and its population size. These significant factors have been investigated on number of recoveries and deceased in the states. The response surface method using face centered composite design (FCCD) has been applied on the cumulative data (up to 15th may 2020) for training and optimization. The model accuracy is retrieved as co-efficient of determination is 99.9%. The best input variables for raising recovery rates and lowering fatality rates have been identified. A hybrid artificial neural network-multi objective genetic algorithm (ANN-MOGA) model with model accuracy of 99.9% has also been used to boost recovery rates and lower fatality rates. Further, a best fit curve of confirmed cases in Delhi (since lockdown to 15 June 2020) has been plotted and a prediction curve has been retrieved for coming months of 2020. It has been observed from the curve that confirmed cases rises up to mid-august and achieve the peak & then it continue to decline.*

Keywords*: GDP per capita, ANN-MOGA, FCCD.*

I. INTRODUCTION

Epidemics used to play havoc round the world in spite of advancement in the field of clinical sciences [1]. The current episode of outbreak of COVID 19 holds the center stage the world over. The pandemic began from China and from that point spread practically round the world in a short span of time. WHO had resisted utilizing the term pandemic regardless of COVID-19 arriving at all landmasses apart from Antarctica and a growing external scientific consensus that the outbreak was already a pandemic by March 11, 2020 [2]. The purposes behind this deferral incorporate past reactions, worry over instigating public panic and a dread of setting off a wrong change in way to deal with the flare-up. In any case, continued avoidance of the term has made its own issues [3]. The WHO says a pandemic is basically "the overall spread of new disease" to which we don't have immunity. It doesn't have a fixed definition with set standards, which leaves the suitable point to make pandemic revelation not entirely clear. The US Centers for Disease Control and Prevention (CDC) portrays three extensive measures that must be met for a pandemic: the virus is showing continued individual to-individual spread, is causing ailment and death, and has worldwide spread.

Regulation techniques are intended to end the spread of the virus and incorporate contact tracing, quarantine and isolation. Regardless of whether these are able to stop the episode, the decrease in the pace of spread is still critical, as it furnishes nations with an opportunity to get ready to deal with the pandemic. Generally, mitigation efforts signals that containment no longer appears possible and the aim is to minimize the severity and consequences of community spread. Techniques to stop community spread incorporates social distancing, cancelling mass gatherings, and closing social and business establishments. Many nations are already utilizing these strategies (CDC). Since World War II, no human catastrophe has been as serious as the one the world is currently facing, and the massive Corona virus epidemic (COVID-19) has affected practically every country on the planet [4]. Within a few months, Corona expanded from China to Europe to the United States following a flare-up that originated in China. Over 1.5 million people have been afflicted by COVID-19 to date, and 80,000 people have died as a result. Numerous billions of people have been affected indirectly by the COVID-19 global pandemic. The numbers appear to be low due to under-reporting, and may probably climb significantly in the upcoming weeks as asymptomatic people are present and testing is conducted at a higher rate. The pandemic-driven emergency is continuously posing a threat and nations are trying their level best to mitigate the effects [4].

Without a doubt, the world economy is in serious peril as a result of the Corona virus. Corona virus has had a tremendous impact on global financial institutions. It has been determined by observers whether this flare-up is the result of

hyper-globalization or the start of de-globalization. But the world will experience a downturn, and according to some commentators, the global catastrophes may be greater than the combined effects of World Wars I and II. Simultaneously, the falling cost of unrefined petroleum has aggravated further tensions. A few evaluations are presently accessible on the financial misfortune and post-COVID-19 development way, and the vast majority of the appraisals show that the world is as of now in an economic emergency [4]. Initially, in India the first corona virus case was found on Jan. 30, 2020. According to the Indian Ministry of Health and Family Welfare, there have been 39,980 confirmed infections across the nation, 10,633 cases that have been successfully treated, and 1301 fatalities, just in the first week of May. According to experts, contamination incidents may be significantly more common given that India has the lowest global death rate. The rate of infection in India is 1.7 which is altogether lower than any other country in the world [5].

In more than half of the states and union territories in India, the Epidemic Disease Act of 1897 has been used, forcing the closure of businesses and educational institutions. The Indian government has stopped all tourist visas because the bulk of confirmed cases were linked to other countries [6]. On March 22, 2020, a fourteen-hour public curfew was implemented in India at the request of the Prime Minister, Narendra Modi. The district administration then closed down 75 districts where there were confirmed instances of the Corona virus [7]. Additionally, on March 22, 2020, the PM issued a 21-day nationwide lockdown order that affected all of India. The prime minister of India extended the ongoing nationwide lockdown till May 3 on April 14 [8]. Since India is the second most populated country in the world, it will have a significant impact on the ability of the entire world to contain the corona virus, according to Michael Ryan, CEO of the World Health Organization's health emergency programme. Different experts stressed over the monetary pulverization brought about by the lockdown, which will be affecting casual laborers, smaller scale and micro enterprises, self-employed and farmers are left with no livelihood options in absence of transportation and access to business sectors [9].

According to observers, the spread rate of corona infection has been slowed down by the lockdown , which was getting doubled in six days by April 6 and came down doubling in eight days by April 18 [10]. According to the Oxford COVID 19 Government Response Tracker study, which is based on a survey of 73 countries, it was discovered that the Indian Government has responded to the pandemic more strictly than any other country. The government of India was one of the best at managing the pandemic thanks to its early action in establishing investments in healthcare, vaccine research, fiscal measures, and dynamic response to the situation. On April 27, Govt. of India declared seven Indian states as “Covid-19 Free" with zero dynamic cases. In a few weeks, additional states are anticipated to add their names to this list (11).

In India, the Covid 19 economic impact has been quite problematic. The Indian economy's projected growth rate for 2021, which is the lowest in the past thirty years since India's financial development in the 1990s, has been shrunk by the World Bank and credit rating agencies evaluation offices [12]. According to the former Chief Economic Advisor to the Government of India, the country needs a US$10 trillion boost to recover from the contraction and should prepare for a negative growth rate in FY21 [13]. However, Indian economic growth rate projections of 1.9 % for financial year 2021-22 by the International Monetary Fund, is the most noteworthy among G-20 nations [14]. Within a period of March 15 to April 19, due to lockdown unemployment rate rose from 6.7% to 26 %. During the lockdown, an expected 140 million individuals were unemployed. [15]. More than 45% of families reported drop in income when contrasted with the same period of earlier year. The Reserve Bank of India took several measures, which make available the funds in tune of Rs 374,000 Crore to the nation's budgetary framework. On April, 3 the central government released a grant of Rs 28,379 Crores to the states for handling the corona virus pandemic.

II. REVIEW OF LITERATURE

In a worldwide existence where there is an increasing public health threat from many rising and remerging diseases, having infectious potential, COVID 19 holds the possibility to be a quickly spreading and exceptionally pathogenic infection bringing about high mortality around the globe, particularly in developing nations whose scarce health resources are already stretched by existing health needs. The reaction of government toward the management of disaster relies on type of disasters [16]. The United Nation's (UN) Logistics Cluster categorizes the disaster into three type’s dependent on the kind of intercession: slow-beginning, unexpected beginning, and complex emergencies [17]. In disaster situations, the decision making is tough for associations and governments due to the need to handle the vulnerabilities while anticipating future necessities [17].

The idea of managing disaster on the basis of past evidences is based upon the idea of proof based medication which uses the most ideal proof so as to respond to a clinical inquiry. [18]. The significant level of vulnerability and limitation of resources, proof-based decision making is used to ensure effectiveness and accountability of humanitarian assistance [18]. While inoculation is one of the best ways to control irresistible episodes, antibodies stay illusive for huge numbers of these ailments.

For the episode like that of COVID 19, any improvement in an immunization would take months. Consequently, it is significant that exertion should be put on creating strategy for controlling COVID 19 at the community, local and national levels. The weight of catastrophic events falls most vigorously on developing countries where more than ninety-five percent of calamity related deaths happened (IFRC, 2001). A catastrophic event prompts annihilation of food yields and animals and in fact profoundly affects the personal quality of life of the individuals, as they are forced to dislocate. The cost of lives is among the most wrecking impacts [19].

Higher income empowers individual and nations to react to the natural disasters by utilizing extra exorbitant preparatory methods [20] Koi chiro Matsuura, highlighted the critical importance of training in improving the capacity of people and communities to lessen the danger of disasters. Envisioning, educating and illuminating are the keys to diminishing the fatal impact of such cataclysmic events (January 3, 2005, UNESCO Press Release). In this way, as a result of the solid link between the community and school, schools can be a perfect beginning point for the formulation and execution of calamity readiness arrangements, spread of disaster readiness data and setting up crisis techniques. The level of wealth in any economy plays a crucial role in how it responds to a catastrophic occurrence. A well off or more extravagant nation is considered as more secure nation [21].

Economic and social factors have been seen as the key determinants of a general public's reaction towards disasters, in addition to other factors, for example, climatic and geographical elements. His analysis of 2,791 occurrences during the years 1984 to 2004 revealed that economic growth plays a substantial role in determining a general public's vulnerability to ordinary dangers, with wealthier countries experiencing fewer fatalities from catastrophic catastrophes. However, institutional considerations, such as government stability and the investment climate, lessen the adverse effects of cataclysmic catastrophes on both the death toll and overall financial disasters [22].

The average household income in a nation is a good indicator of the level of security it experiences because as income rises, so does the need for protection. Additionally, a gain in income will not only provide for greater general security but, at sufficiently high income levels, disaster insurance is also available [23]. Income and the number of persons affected by typical catastrophes are found to be inversely correlated. The pan country regression results for the Eastern Caribbean Country, United Nations propose that the limit of nations to keep away from the human expense of debacles improves with increase in income levels [24]. In another analysis, it was discovered that an increase in income is associated with a decrease in the number of fatalities, injuries, deprived people, and relative material misfortunes. The degree of development of a nation is represented by per capita income and its distribution, the societal inclusion and level of economic diversification, investment environment, education and health [25].

The losses from disasters and economic development of a country are inversely related. A nation that has acquired high levels of educational achievement and increased trade openness is less susceptible to pandemics. Low disaster fatality rates are associated with strong economic sectors and small governments [26]. Noy (2008) found that countries with higher levels of government spending, better organisations, higher per capita income, greater levels of trade openness, and higher literacy rates are better able to withstand the initial shock of a catastrophe and prevent further spillover into the economy. Additionally, it is noted that countries with higher levels of domestic credit and foreign exchange reserves, but less open capital accounts, are more resilient and better able to handle natural calamities, with less detrimental spillover into domestic output. Raschky battles that economic development mostly decreases calamity fatalities and misfortunes; however expanding wealth reverses this relationship and along these lines causes moderately higher misfortunes in high-income countries.

III. RESEARCH OBJECTIVES

The increasing propagation and long term disruption, differentiates disasters caused by pandemics from other natural disasters. Such pandemic disasters if not controlled leads to severe disturbance in the supply chains and communities and thereby causes losses beyond repairs. The corona virus type of disasters occurs suddenly and their impact may increase in intensity within a short span of time. Normal functioning of society is hampered and causes loss of lives, economic downturn and environmental deterioration. [27]

To find out the significance of economic position of a state on recovery and death of patients.

To forecast the level of health infrastructural facilities required to improve recovery rate and zero death rate among COVID 19 patients.

To forecast the timings of peak of infection and decline stage.

IV. RESEARCH METHODOLOGY

The present study is descriptive in nature. It covers a period when first lockdown was announced in India till May 15, 2020. The study has taken data from all states across whole India where COVID 19 infected cases were reported. Economic condition of the states has been depicted by the proxy factors like GDP per capita, Number of isolation centers, ICU beds created, Level of literacy, area of the state and its population size. These significant proxy factors have been investigated on number of recoveries and deceased in the states. The response surface method using CCD has been applied on the cumulative data (up to 15th may 2020) for training and optimization. The model accuracy is 99.9%. The Ga-ANN modeling has also been applied to predict the level of significant factors that led to maximum recovery and minimum deaths.

A) Response Surface Modeling

With the help of a second order polynomial fitting model, a central composite design (CCD) based on RSM has been created to investigate the impact of the six state-level characteristics listed in Table 1 on the quantity of recoveries and deceased in each state. To keep the experimental run minimum ½(half) factorial 2k design was used. To include the same range of all input factors, maximum and minimum value of each factor was coded as high (+1) and low (-1) using equation (1). The axial points (high and low) and zero level (center points) of each factor were used apart from plus and minus level of each factor. By taking into account the value of alpha one, the face central composite design (FCCD) is employed to keep the number of layers to a minimum.

$$R = ¥_0 + \sum ¥_i y_i + \sum ¥_{ii} y_i{}^2 + \sum ¥_{ij} y_i y_j \quad \text{--------} (1)$$

(R = Predicted Outcome, ¥0 = Regression Constant, ¥i = Linear Coefficient ¥ii = Square Term of Each factor, ¥ij = First order Interaction effect).

B) Artificial Neural Network-MultiObjective enetic Algorithm (ANN-MOGA) Modeling

For the purpose of handling statistical data with sequential data training and data optimization, an ANN-MOGA hybrid technique has been devised. The six input components and two responses depicted in figure 1 have been trained using the artificial neural network (ANN) fitness tool. Ten hidden neurons have been used, with 70% of the data samples used for training, 15% for testing, and 15% for validation. The data has been trained using a feed-forward back propagation network and the Levenberg-Marquardt algorithm, which uses more memory but runs more quickly.

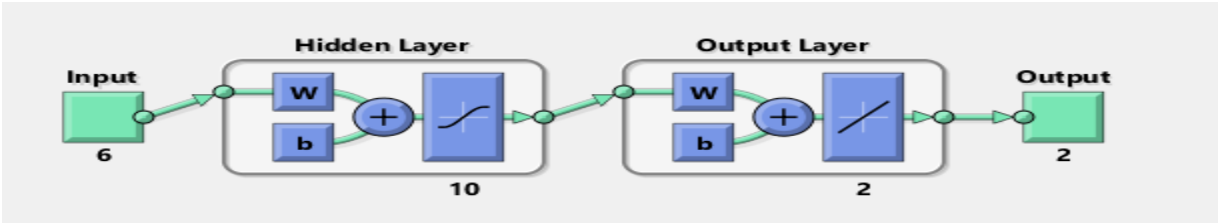


Figure 1: Neural Network Model

The trained neural network should be able to produce the response with predicted precision similar to an input pattern after being updated with the best weights. The neural fitting application can be helpful in selecting data, creating and training a network, and evaluating the network's performance using mean square error and regression analysis. When the mean square error of the validation samples starts to rise after reaching a minimum and the regression values are getting close to one, it means that the network's data training performance is adequate.

The MOGA programme uses the newly built ANN model to determine the best components for two different aims, namely raising recovery rates and lowering fatality rates. The MOGA is a method that uses biological evolution to solve optimisation issues based on natural selection that are both limited and unconstrained in nature. It simply functions as continuous population generation from the prior generation till the desired pattern is not obtained. Almost all real-world problems involve multiple, often conflicting objectives, are having set of Pareto optimal solutions. Pareto optimal set solutions carry non-dominating solutions in which no solution dominates the other (Deb, 2001). Constraints are predestined in any engineering optimization problem, including multi-objective optimization problems. Multiple objective and constraint handling with genetic algorithms are appropriate for a decision making perspective and characterized

C) Best Fit Curve:

The general logistic differential equation has been used to make the best fit curve of the infected cases of Delhi from 14th march to 15th june 2020 and then prediction has been done on this time series modelling for coming months. The equation used for time series modelling and prediction is as follows

$$y = \left(\frac{(b1*b2*np.exp(b1*x-b3))}{1+np.exp(b1*(x-b3))}\right)^2 \quad (1)$$

Table1: State/UT wise Data with respect to number of recoveries and deceased due to Covid 19

State /UT	Literacy Rate	Total No of isolation Beds	Total number of ICU beds	Confirmed	Population	GDP per capita	Recovered	Deceased
Maharashtra	82.91	231739	11587	59546	120837347	266805	18616	1982
Tamil Nadu	80.33	155375	7769	19372	76481545	273399	10548	148
Delhi	86.34	39455	1973	16281	18345784	466592	7495	316
Gujarat	79.31	64862	3243	15572	63907200	294959	8003	960
Rajasthan	67.06	93176	4659	8158	78230816	144828	4855	182
Madhya Pradesh	70.63	64939	3247	7453	82342793	116829	4050	321
Uttar Pradesh	69.72	281402	14070	7170	228959599	78223	4215	197
West Bengal	77.08	113535	5677	4536	97694960	150468	1668	295
Andhra Pradesh	67.66	83230	4162	3245	52883163	204413	2133	59
Bihar	63.82	30857	1543	3185	119461013	57425	1050	15
Karnataka	75.6	262109	13105	2711	66165886	272799	853	47
Punjab	76.68	60997	3050	2158	29611935	217480	1946	40
Telangana	66.46	99919	4996	2256	38472769	287996	1345	67
Jammu and Kashmir	68.72	7995	400	2036	13635010	101210	859	27
Odisha	73.45	25650	1282	1723	45429399	128771	887	7
Haryana	76.64	36141	1807	1504	27388008	343216	881	19
Kerala	94	99227	4961	1089	35330888	276812	555	8
Assam	73.18	24178	1209	881	34586234	118255	104	4
Uttarakhand	79.63	23843	1192	500	11090425	264192	79	4
Jharkhand	67.63	26496	1325	470	37329128	102601	191	4
Chhattisgarh	71.04	17430	871	398	28566990	126720	83	0
Chandigarh	86.43	5631	282	289	1126705	282239	189	4
Himachal Pradesh	83.78	16040	802	290	7316708	248746	73	6
Tripura	87.75	4667	233	244	4057847	113607	167	0
Goa	87.40	4584	229	69	1542750	500405	38	0
Puducherry	86.55	5172	259	53	1375592	260979	17	0
Manipur	79.85	1790	90	55	3008546	76781	4	0
Andaman and Nicobar Islands	86.27	1294	65	33	419978	157151	33	0
Meghalaya	75.48	5244	262	21	3276323	100723	12	1
Nagaland	79.60	2561	128	25	2249695	95569	0	0
Arunachal Pradesh	66.95	2624	131	3	1528296	153112	1	0
Mizoram	91.58	2496	125	1	1205974	145940	1	0
Sikkim	81.40	1952	98	1	690251	321622	0	0

V. RESULTS & DISCUSSIONS

A) RSM and Optimization

The proposed RSM model's analysis of variance for the quantity of recoveries has been shown to be significant, and the co-efficient of determination is 0.99. The model is suggested to be significant by the Model F-value of 1795.71.A "Model F-Value" this large might happen owing to noise only 0.01% of the time. When "Prob > F" is less than 0.0500, model terms are considered significant.

3D surface graphs have been plotted two factors on x-axis & y-axis respectively and response i.e number of recoveries on the z-axis. The normal plot of residuals for number of recoveries in the states has been shown in figure 2. The muti-regression equation of response1 i.e. number of recoveries has been retreived as

$$Number\ of\ Recoveries = 11351.72 - 272.79 * A - 251.54 * B + 5033.28 * C - 2.028 * D + 8.038 * D - 4.17 * E + 1.72A^2 - 2.13B^2 - 852.45C^2 - 1.34D^2 + 6.43E^2 + 1.36F^2 + 2.89 * \mathrm{A} * \mathrm{B} - 57.90 * \mathrm{A} * \mathrm{C} + .035 * \mathrm{A} * \mathrm{D} - 3.00 * \mathrm{A} * \mathrm{E} - 3.45 * \mathrm{A} * \mathrm{F} + 85.24 * \mathrm{B} * \mathrm{C} - .0125 * \mathrm{B} * \mathrm{D} + 3.46 * \mathrm{B} * \mathrm{E} - 1.37 * \mathrm{B} * \mathrm{F} + 0.25 * \mathrm{C} * \mathrm{D} - 6.93 * \mathrm{C} * \mathrm{E} + 2.73 * \mathrm{C} * \mathrm{F} + 1.44 * \mathrm{D} * \mathrm{E} - 1.01 * \mathrm{D} * \mathrm{F} + 5.57 * \mathrm{E} * \mathrm{F}$$

Figures3(a)-3(g) shows the effect of differnt factors on number of recoveries. It has been observed from the figures 3(a)-3(g), almost the surfaces are quadratic firstly increasing and then decreasing in nature, means number of recoveries are increasing as the input factors are increasing and then it is decreasing, if futher input factors have been increased. Therefore, optimal input factors have been evaluated to maximize the number of recoveries.

Similary, analysis of variance of the number of deceased in the states shows the RSM model is significant. The model is apparently important because the model F-value is 288.00. A "Model F-Value" this large might happen owing to noise only 0.01% of the time.

When "Prob > F" is less than 0.0500, model terms are considered significant. The normal plot of residuals for number of deceased in the states has been shown in figure 4. The muti-regression equation of response2 i.e. number of deceased has been retreived as

$$Number\ of\ deceased = -1791.83 + 41.032 * A + 89.73 * B - 1795.26 * C + 0.176 * D + 2.00 * E + 1.55 * F - .231A^2 - 0.49B^2 + 198.42C^2 + 1.10D^2 - 1.119E^2 + 5.16F^2 - 1.033 * A * B + 20.67 * A * C - 1.21 * A * D - 1.15 * A * E - 2.21 * A * F - 19.83 * B * C + 0.010 * B * D - 7.91 * B * E + 6.93 * B * F - 0.200C * D + 1.58 * C * E - 1.298 * C * F + 1.79 * D * E - 3.4.* D * F - 5.70 * E * F$$

Figures5(a)-5g) shows the effect of differnt factors on number of deceased. It has been observed from the figures 5(a)-5(g), that almost the surfaces are quadratic firstly decreasing and then increasing in nature means number of deceased decreasing as the input factors are increasing and then it is increasing, if futher input factors have been increased. Therefore, optimal input factors have been evaluated to maximize the number of recoveries and minimize the number of deceased. The input factors have been kept with in range (min-max) and output responses i.e. number of recoveries goal set to maximum & number of deceased goal set to zero as shown in table 2. It has been observed from table 1 and table 2 that the litracy rate is minimum in Bihar state which is 63.82% and maximum is 94% in Kerala state, thus, the literacy rate range is kept in between 63.84 to 94% for optimization. Similary, other factors like total number of isolation beds range is 1294-281402, number of ICU beds range is 65-14070, confirmed cases up to 5th may 2020 range is 1-59546, population range is 41998-22896E+08, GDP per capita is 57435-500405. The three optimal solution with desirablity 1, thus retreived with the RSM optimization have been shown in table 3. It has been observed from the table 3 that all the optimal solutions achieved the number of deceased near to zero. The number of confirmed cases depends on the size of populations, number of testings and literacy rate etc. The number of testings performed is not a part of this investegation. As the literacy rate increased, the number of recoveries in that state increased. For example, in optimal solution 1 the literacy rate in a state is 69.74%, then recovery percetage is 47.45; in optimal solution 3 the literacy rate in a state is 82.41%, then recovery percetage is 68.11 and in optimal solution 2 the literacy rate in a state is 91.74%, then recovery percetage is 82.57. Similarly, as GDP per capita increased, therecovery percentage of that states is increased. In table 3, the recovery percentage is 82.57% and GDP per capita is Rs. 193108.10 which is highest among the three optimal solutions. As the number of infected cases are very less as compared to number of isolation beds available in that state, so it does not affect the number of recoveries and deceased in that state.

Table 2: Input Factors' Range And Outputs' Targets

Name	Goal	Lower Limit	Upper Limit
Literacy	Is in Range	63.82	94
Total No. of Isolation Beds	Is in Range	1294	281402
Total No. of ICU Beds	Is in Range	65	14070
Confirmed Cases	Is in Range	1	59546
Population	Is in Range	419978	22896E+008
GDP per capita	Is in Range	57425	500405
Recovered	Maximize	0	18616
Deceased	is Target = 0	0	1982

Table 3: Optimal Solutions using RSM Optimization

No	Literacy Rate	Total no of Isolation Beds	Total No. of ICU Beds	Confirmed	Population	GDP per Capita	Recovered	Deceased	Desir-ability
1	69.74	61596.60	3080.36	40156.18	223073846.42	111365.15	19054.7	0.000641324	1.00
2	91.74	92042.01	4602.54	47999.73	222926105.33	193108.10	39637.6	0.0034797	1.00
3	82.41	135845.03	6782.61	27570.54	102605559.19	160989.27	18780.3	0.0109004	1.00

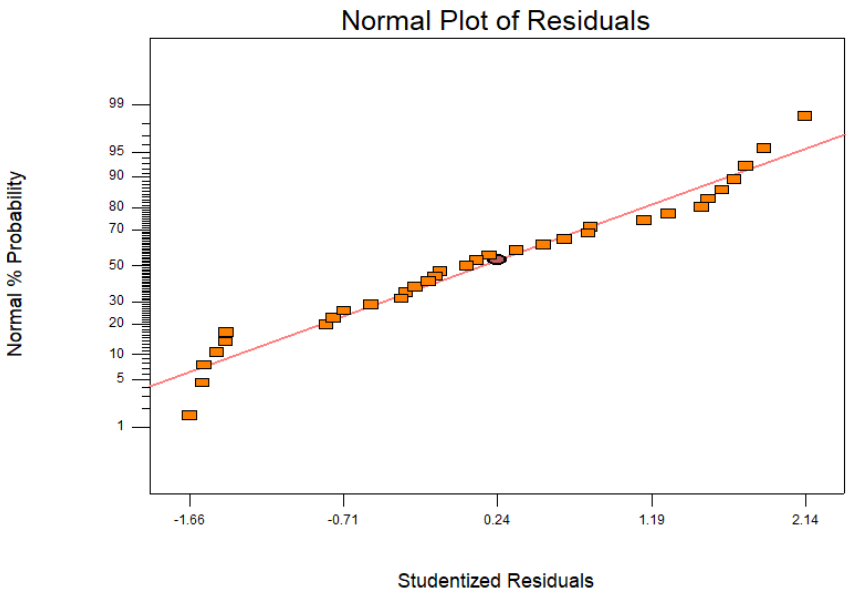
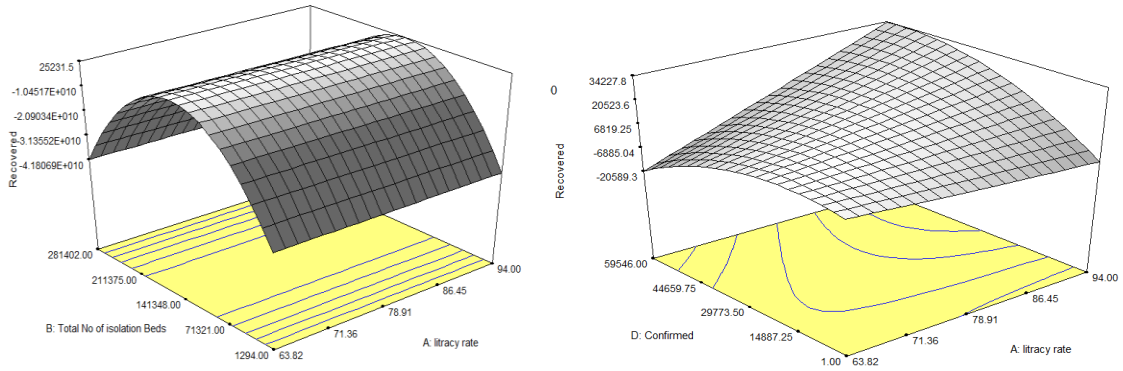
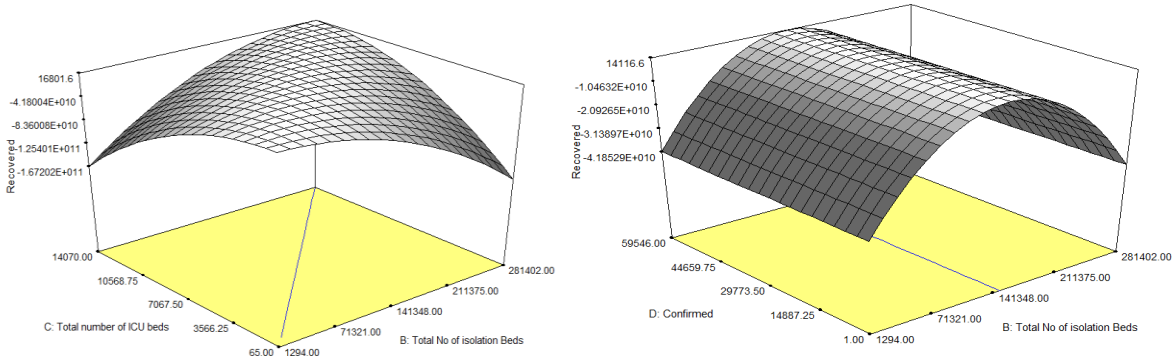


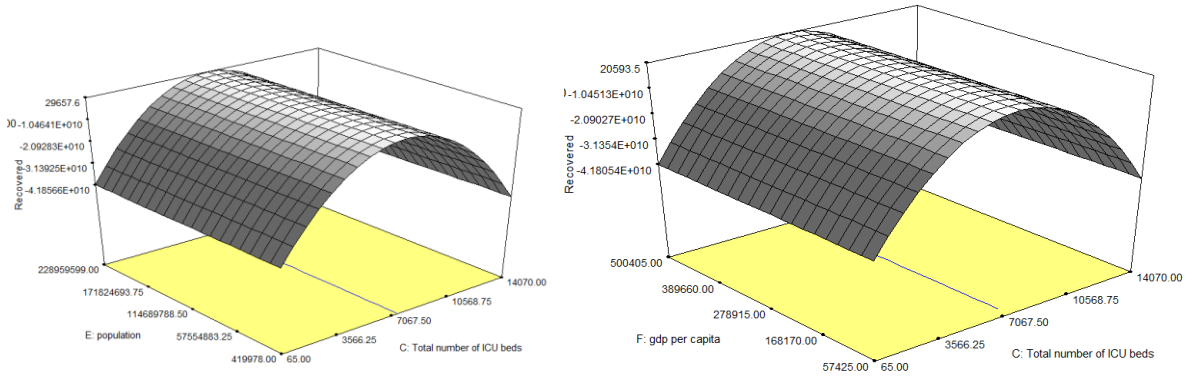
Figure2: Normal Plot of Residuals for Number of Recoveries



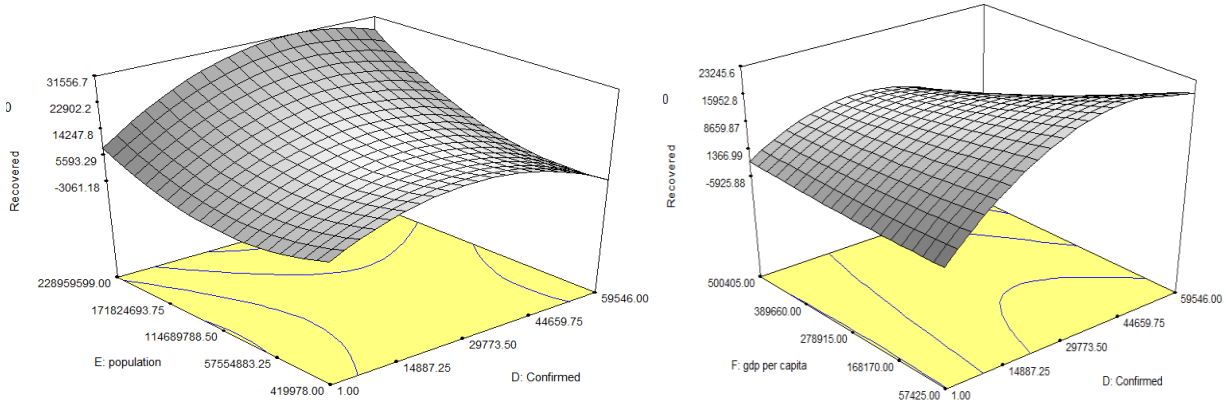
(a) No. of recoveries w.r.t Literacy rate & Isolation Beds (b) No. of recoveries w.r.t Literacy rate & Confirmed Cases



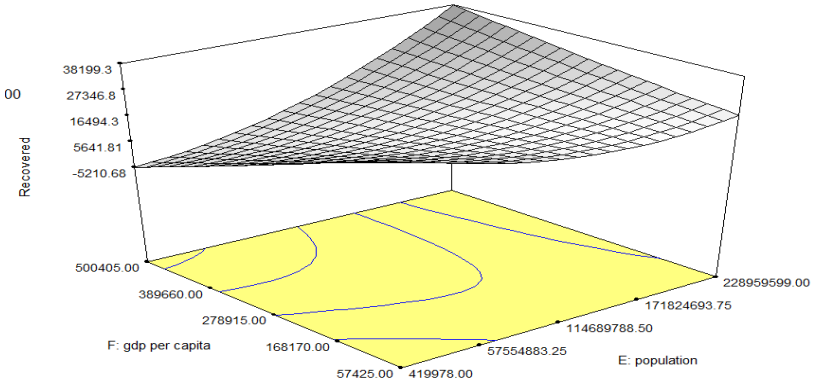
(c) No. of recoveries w.r.t ICU beds & Isolation Beds (d) No. of recoveries w.r.t Confirmed cases & Isolation Beds



(e) No. of recoveries w.r.t Population & ICU Beds (f) No. of recoveries w.r.t Literacy rate & Isolation Beds



(g) No. of recoveries w.r.t confirmed Cases & Population (h) No. of recoveries w.r.t GDP per capita & confirmed cases



(i) No. of recoveries w.r.t GDP per capita & population

Figure 3 (a-i): Input factors versus no of recoveries 3D surface plots

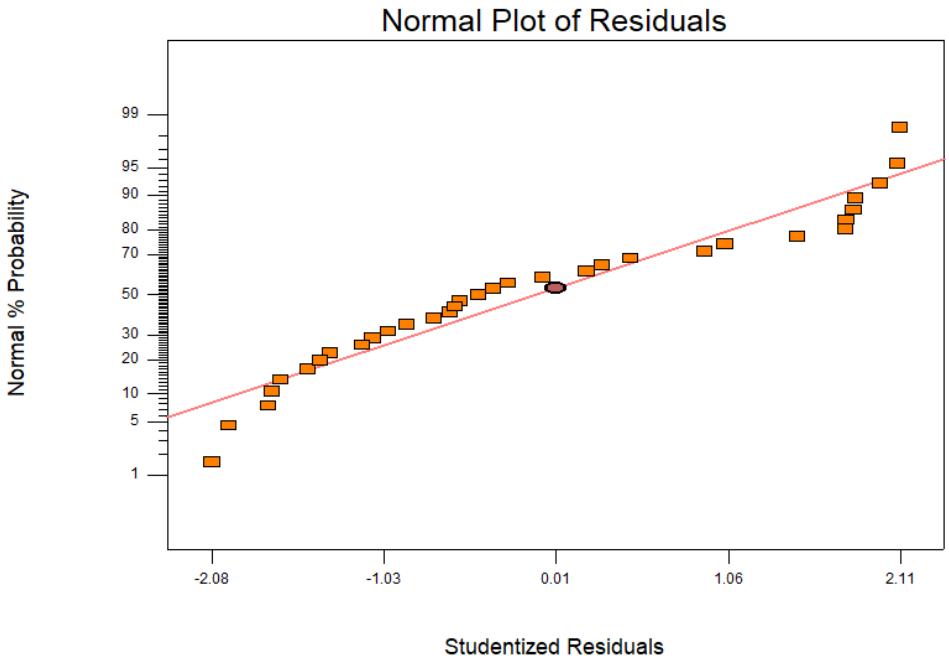
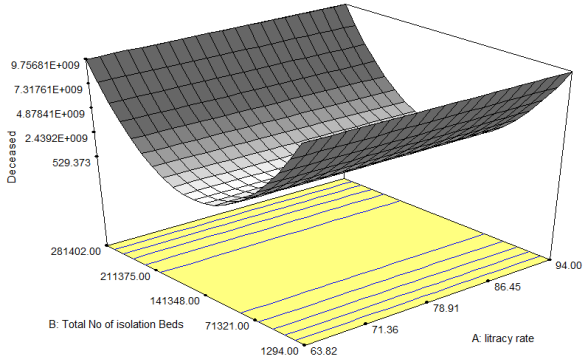
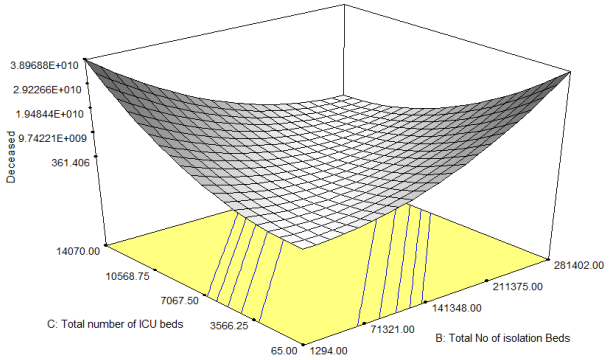
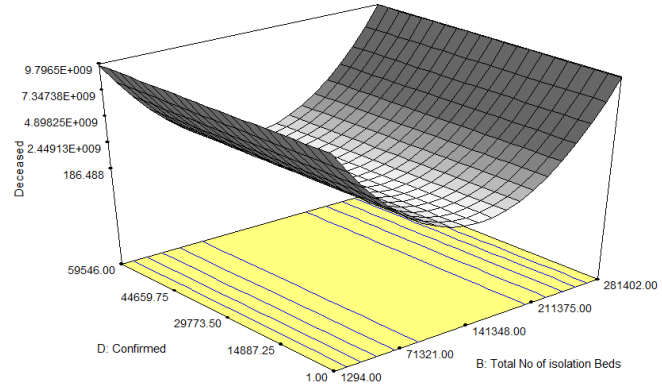


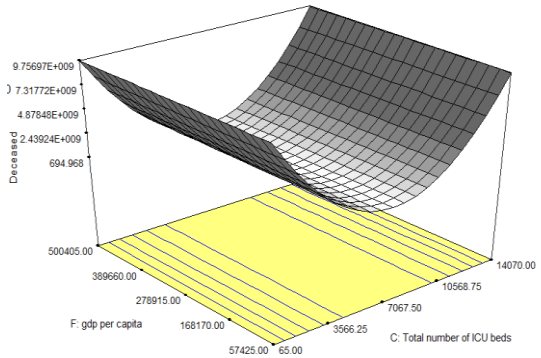
Figure 4: Normal Plot Of Residuals For Number Of Deceased



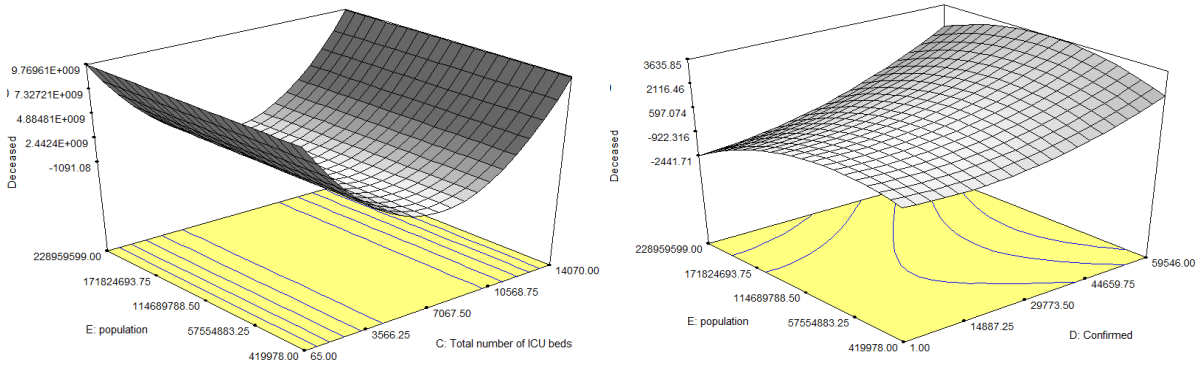


(a) No. of deceased w.r.t Literacy rates & isolation beds (b)No. of deceased w.r.t ICU beds & isolation beds

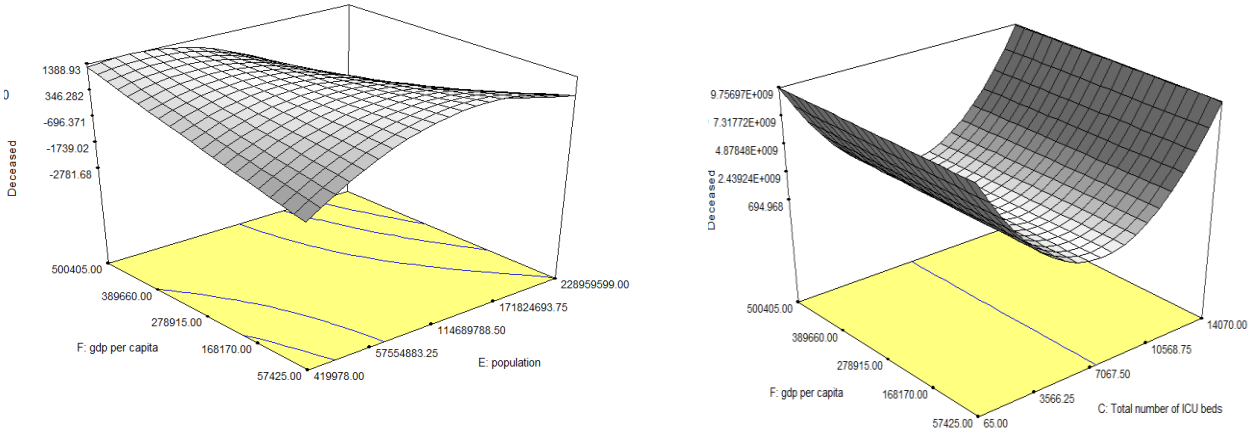




(c) No. of deceased w.r.t Confirmed & isolation beds (d) No. of deceased w.r.t Literacy rates & isolation beds



(e) No. of deceased w.r.t population & ICU beds (f) No. of deceased w.r.t Population & confirmed cases



(g) No. of deceased w.r.t GDP per capita & population (h) No. of deceased w.r.t GDP per capita & ICU beds
Figure 5(a-h): Input factors versus no. of deceased

B) ANN-MOGA

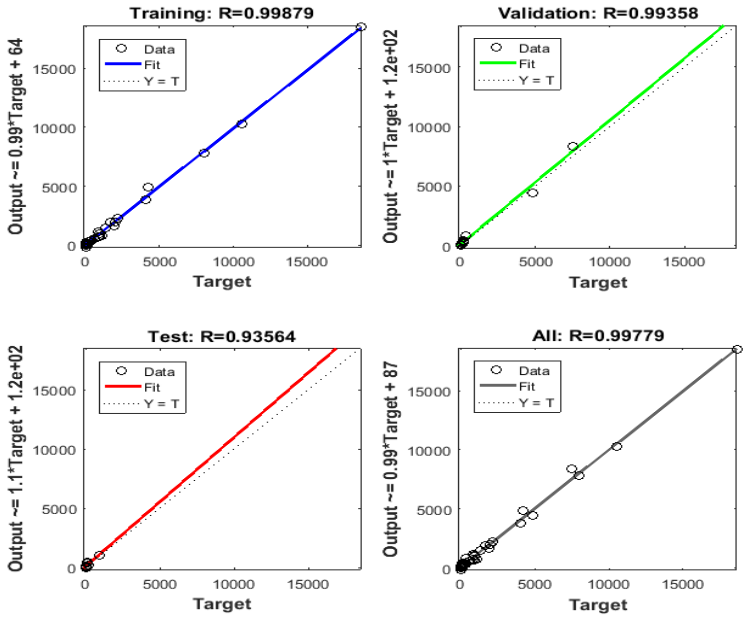


Figure 6: Regression Plot retrieved using Artificial Neural Network

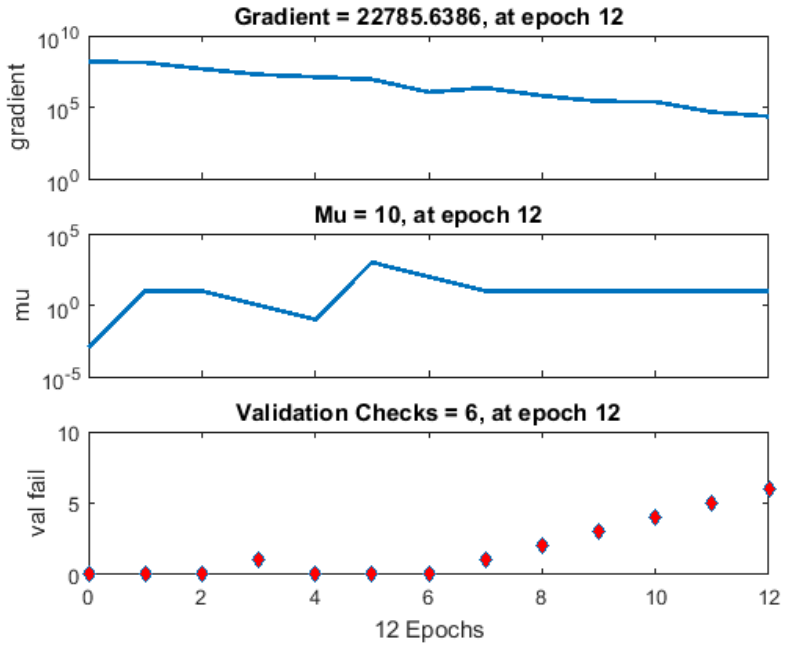


Figure 7: Gradient, mu and validation check for Covid 19 data

Figure 6 depicts the regression plot produced by an artificial neural network with a tangent sigmoid activation function. Figure 6 shows that the proposed modelling produced an overall R value of 0.99779, or 99.78% accuracy, and that other R values, such as training, testing, and validation, are adequate. Figure 7 illustrates the gradient, mu, and validation tests and demonstrates that the iterations halt after 12 epochs.

The resulting ANN model is fed into MOGA in order to determine the best input variables in order to raise the number of recoveries and lower the number of fatalities. The crucial criteria for MOGA have been established as

Population Type=Double Vector
Creation Function=Custom
Crossover Function=Crossover two point
Mutation Function=Mutation uniform,
Crossover Fraction=0.8
Elite Count=2,
Population Size=100
Generations=10
Plot Function=gaplotpareto

Table 4 displays the pareto non-dominant optimal solutions obtained from the ANN-MOGA. It is observed from the table 4 that percentage recovery achieved in solution1 is 71.4, in solution 2 is 60 and in solution 3 is 54.51. As the literacy rate and GDP per capita in solution 1 is highest among the three solutions, thus, the recovery percent in solution 1 is the highest.

Table 4: Optimal solutions retrieved using ANN-MOGA

Litracy Rate	Total No of isolation Beds	Total number of ICU beds	Confirmed	Population	GDP per capita	Recovered	Deceased
81.17116	112298.3	1453.72	35508.28685	181041501.9	405762.1	25356.81	0
78.56622	163343.5	231.6885	29168.92	220523867.8	299649	17532.03	0
78.56622	163343.5	593.5328	32204.73	209142203.5	299649	17557.97	1.88288

C) Best Fit Curve:

The confirmed cases data of Delhi state have been plotted form 14th march 2020 to 15 june 2020 as shown in figure 8. The best fit curve has been plotted based on logistic differential equation according to the data has been plotted in figure 9. On the basis of the same, prediction curve has been plotted of COVID 19 infected cases month wise of Delhi in figure 10. Figure

11 shows the bell shape overall curve of infected cases in Delhi. The data of predicted positive cases and actual positive cases from 3rd june to 21st june 2020 is shown in table 5. The percentage error has also been calculated and shown in table 5. It has been observed from the table that the percentage error is up t o 20% with proposed modeling. The infected case reaches the peak from mid-july to mid-August and then it starts declining.

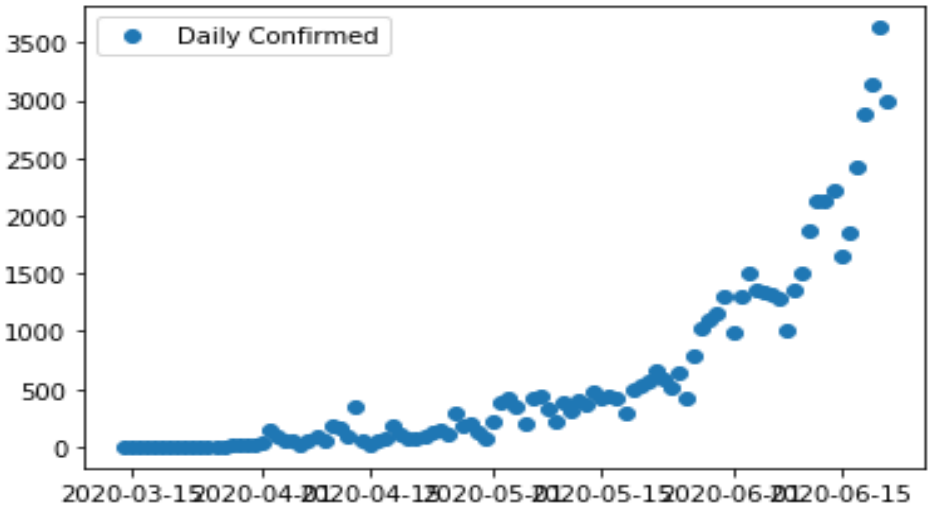


Figure 8: Confirmed cases data of Delhi up to 15 June 2020

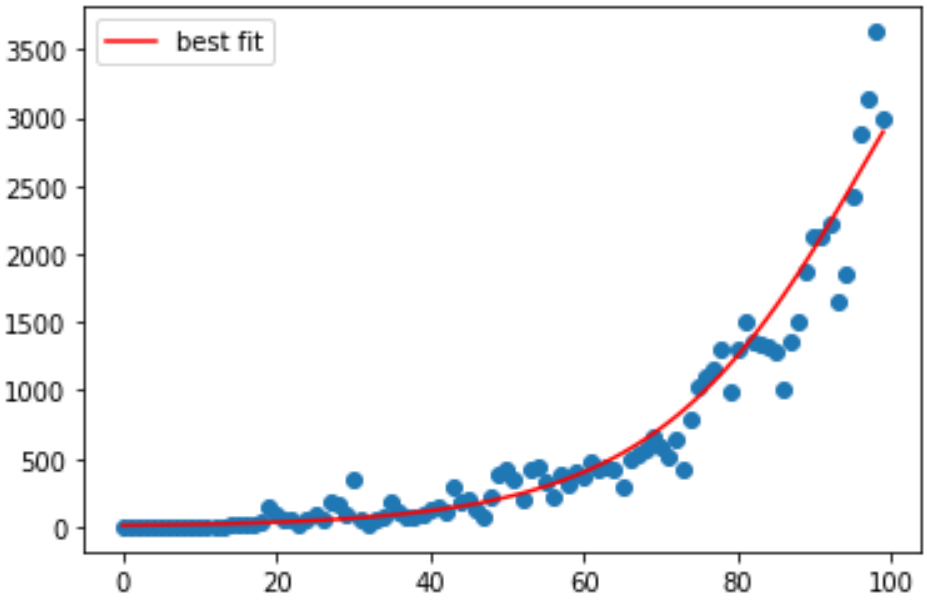


Figure 9: Best fit curve on the basis of exponential algorithm

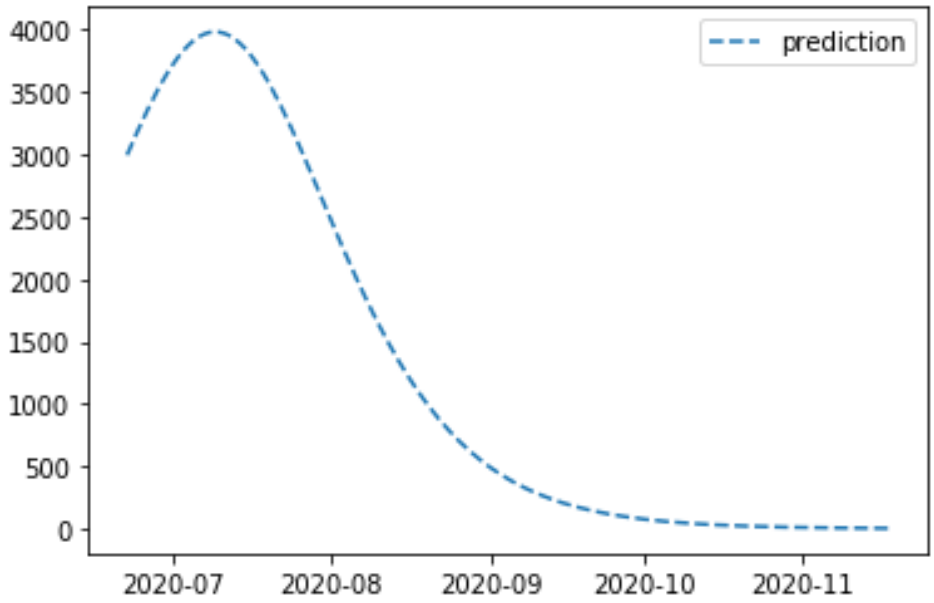


Figure 10: Prediction of COVID 19 infected cases month wise of Delhi

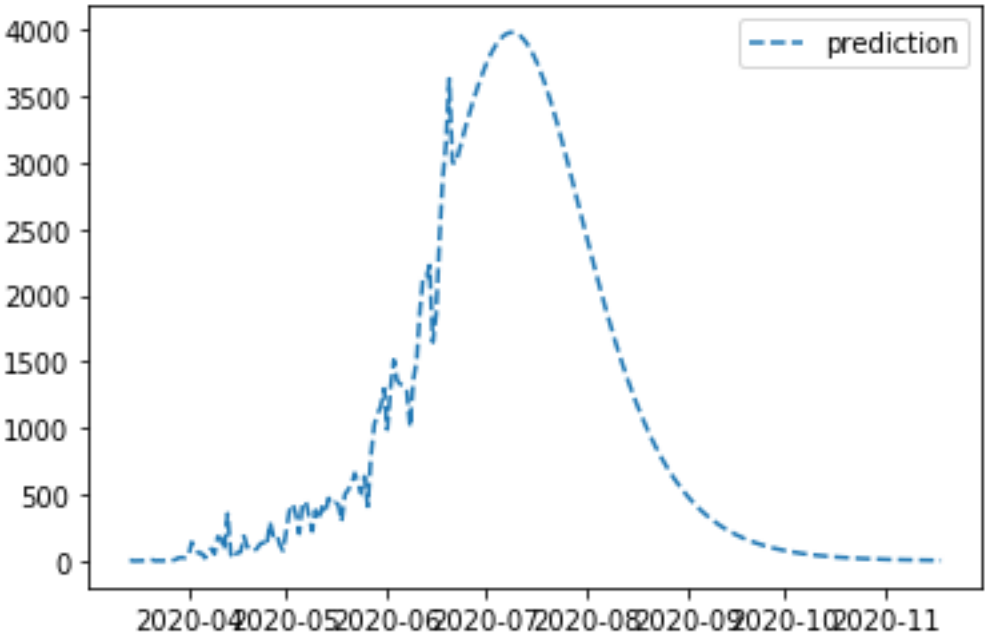


Figure 11: Bell Shape overall curve of infected cases in Delhi

Date	Confirmed	Status	Date	Prediction	Actual	Error
2020-03-14	7	data	2020-06-03	1224.889	1513	
2020-03-15	0	data	2020-06-04	1290.367	1359	
2020-03-16	0	data	2020-06-05	1359.345	1330	
2020-03-17	1	data	2020-06-06	1432.009	1320	
2020-03-18	2	data	2020-06-07	1508.556	1282	
2020-03-19	4	data	2020-06-08	1589.195	1007	
2020-03-20	6	data	2020-06-09	1674.143	1366	
----------	-------	--------	2020-06-10	1763.632	1501	
2020-05-29	1105	data	2020-06-11	1857.902	1877	
2020-05-30	1163	data	2020-06-12	1957.21	2137	

2020-05-31	1295	data	2020-06-13	2061.825	2134	
2020-06-01	990	data	2020-06-14	2172.031	2224	
2020-06-02	1298	data	2020-06-15	2288.125	1647	

VI. CONCLUSION

The aim of study is to determine whether economic position of a state helps the minimization of death rate and maximization of recovery rate. From the study it is found that rich states are in better position in achieving their aim as compared to less effluent states. The present study confirms the findings of Ghesquiere Francis, Mahul Olivier [26] where they found that rich nations are better off in managing the natural disasters as compared to less affluent states. Furthermore, the number of isolation beds in the states is not impacting the recovery and deceased rate as the number of patients is less than the number of isolation beds. As the number of infected crosses the no of isolation beds then it may impact both rates. The level of GDP and literacy rate in the state is directly impacting recovery and deceased rate. The states having high GDP and literacy rate have higher recovery and minimum death rates. The present study also forecasted the level of health infrastructure which would bring death rate to zero and recovery rate to highest. As per the study specifically for the state of Delhi the infection rate would be at peak from Mid July to end of August and thereafter it would start declining.

In summary, it can be said that rich states managed COVID 19, in terms of recovery and death rate, in a better way than their poor counterparts.

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