



# Fuzzy Inference Model to Identify the Effects of Vaccination on Covid-19 Outbreak in Tamilnadu, India.

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## Abstract:

Coronavirus is a deadly disease that affects animals and birds. In most cases, this virus infects humans by causing aerial precipitation of certain fluid secreted by the infected animal or its bodily portion. This virus is more vital than other unintentional viruses. During December 2019, a new coronavirus family named Novel Coronavirus (Covid-19) was discovered in China, at the place called Wuhan. The number of people infected with this virus has quickly increased in Wuhan and other nations since January 23, 2020. This study proposes a system for classifying and analyzing COVID 19 confirmed cases, cured cases, and deceased as inputs and vaccinated people as outputs for the most populous twelve districts in Tamil Nadu, India, for the trimester tenure from July 2020 to September 2021. This research study can be analyzed using the Fuzzy Mamdani Inference study. This study clearly demonstrates the significance of vaccination in restoring the flourished glory of life, which we have been missing for the past two years.

**Key Words:** Fuzzy Mamdani Model, Covid 19, Inference system.

**DOI Number:** 10.14704/nq.2022.20.8.NQ44658

**NeuroQuantology 2022;20(8):6343-6355**

**Introduction :** Coronavirus infection in 2019 (COVID-19) [1,2,3] The pandemic spread rapidly around the world, killing over five million people and forcing many countries to enact costly restrictions that triggered multiple economic crises. Because of the rapid spread, huge mortality rate among at-risk groups, and lack of early therapies, social distancing measures, mandatory face masks, and public area closures were implemented.

While mass vaccination programmes have begun to bring the disease under control, many countries are still grappling with vaccination logistics, and dangerous new variants of

concern continue to emerge. Given the disease's ongoing threat, it's critical to understand how outbreaks form and how the virus behaves when it enters a new environment. Researchers looked into in a study published in Genome Medicine.

On January 21, 2020, the WHO proposed the possibility of continuous human-to-human transmission of Covid-19. Initially COVID-19 was found only in various places of China. Meanwhile, it started to spread in various Chinese-affiliated countries. In China alone 600 cases were confirmed when it started to spread and more than 4,24,000 humans are infected



worldwide in a shortest period of time. More number of patients died around the world, with a total death toll of 18,9002. According to WHO[4] tiredness, fever, and a dry cough are found to be the most common symptoms due to this virus. Individuals suffering from these mild symptoms can recover without the need for specialized treatment or medications. However, some patients reported additional symptoms such as nasal congestion, sore throat, body aches, foot pain, or diarrhea. Typically, eighty percent of the people were infected with COVID-19 have cold symptoms. Self-quarantine or self-isolation are considered as the effective strategy for reducing the virus transmission following the emergence of symptoms. In some instances, exhibited symptoms such as a high temperature and a persistent cough, according to National Health Service (NHS). Antibiotics are ineffective in treating patients who have viral pneumonia. Anyone suffering from these symptoms is advised to follow self-isolation for 7 to 14 days, according to the NHS. Patients should have a chest CT scan and RTPCR test to establish the severity of the condition [5,6,7,8].

The key contributions of this research Paper:

- We presented the study of the COVID-19 pandemic's growing impact in this paper.
- The fatality rate and danger level can be lowered if COVID-19 is discovered in early stages. As a result, we propose a COVID-19 risk level prediction model based on ANFIS.
- Based on the most recent suggestions from experts and the present circumstances, the COVID-19 dataset is analyzed and categorized. From July 2020 to September 2021, this study gives categorization findings based on criteria

for predicting Covid-19 risk variables for the key twelve districts in Tamilnadu, India.

– The fuzzy inference [14,15] classifiers are implemented for this dataset, the best classifier is chosen based on a machine learning classifier comparison.

– The results of the proposed system effectively recognizes that the vaccination is the only tool to control this pandemic.

The paper is structured as follows. Section 2 discusses the most recent work on COVID-19. Section 3 describes the proposed system for predicting COVID-19 based on classification models. Section 4 discusses the experimental and evaluation results, as well as the comparative analysis of the classification algorithms and in Section 5, the research paper is concluded.

## 2. ANALYSIS OF VARIOUS DISTRICTS IN TAMILNADU, INDIA INFECTED, CURED, DECEASED VACCINATED DOSE 1, DOSE 2 FROM APR 2021 TO SEP 2021

### Inference

In our analysis, it has been taken twelve major districts in Tamilnadu, India. The twelve major districts are Ariyalur,Chingleput,Chennai,Coimbatore, Dharmapuri, Dindugul, Kanchipuram, Nagapattinam, Nilgris, Salem, Trichy and Virudhunagar. The table shows how much persons infected, cured, Deceased, Vaccination dose1 , Vaccination dose 2 from three months data analysis during April 2021 to September 2021 of 6 months report. For the calculation purpose we have taken only six months from April 2021 to September 2021 in MATLAB using Mamdani Model.

**TABLE 1**

DISTRICTS	TENURE	INFECTED	CURED	DECEASED	VACCINATI ON DOSE 1	VACCINATIO N DOSE 2
ARIYALUR	APR 2021- JUNE 2021	10041	9395	162	96265	12957
	JULY 2021- SEP 2021	1782	2116	42	184681	49763
CHINGLEPUT	APR 2021-	100282	98250	1565	573644	94174

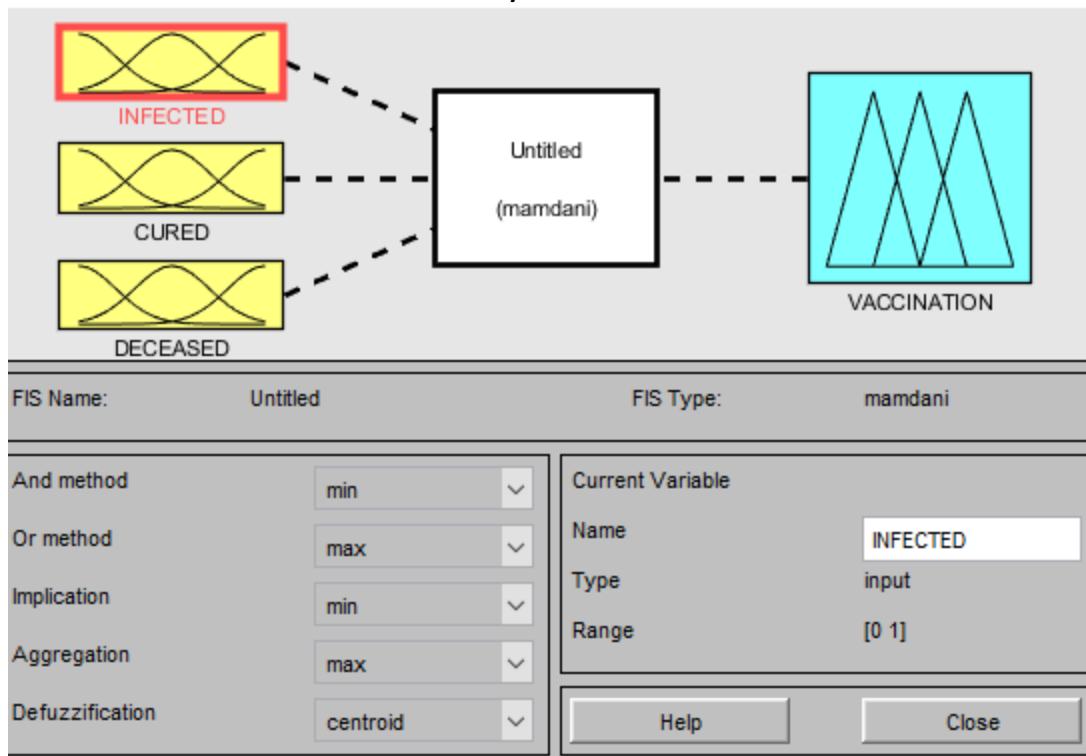


	JUNE 2021					
	JULY 2021- SEP 2021	11683	12373	111	642379	293814
CHENNAI	APR 2021- JUNE 2021	282529	282165	3941	1666102	650819
	JULY 2021- SEP 2021	17068	17738	291	1677696	1284889
COIMBATORE	APR 2021- JUNE 2021	160257	156391	1347	748987	144933
	JULY 2021- SEP 2021	22487	23965	289	1520851	593337
DHARMAPURI	APR 2021- JUNE 2021	17719	16789	153	176001	28083
	JULY 2021- SEP 2021	3073	3516	49	418576	104718
DINDUGUL	APR 2021- JUNE 2021	19709	19153	390	150739	27892
	JULY 2021- SEP 2021	1144	1330	46	388322	109420
KANCHIPURAM	APR 2021- JUNE 2021	39528	38685	716	151093	22468
	JULY 2021- SEP 2021	3609	65468	69	364328	119365
NAGAPATTINAM	APR 2021- JUNE 2021	8637	8567	126	183474	23627
	JULY 2021- SEP 2021	2624	2520	59	457470	119419
NILGRIS	APR 2021- JUNE 2021	19667	19016	114	173104	50919
	JULY 2021- SEP 2021	4297	4624	137	238151	133746
SALEM	APR 2021- JUNE 2021	54325	51786	1004	333973	81057
	JULY 2021- SEP 2021	9915	10650	188	756467	222407
TRICHY	APR 2021- JUNE 2021	53560	52070	725	398945	72499
	JULY 2021- SEP 2021	85714	7016	117	726320	270222
VIRUDHU NAGAR	APR 2021- JUNE 2021	27651	26822	296	128147	35564
	JULY 2021- SEP 2021	1440	1826	19	173447	79666

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**GRAPH 1 - INPUT/OUTPUT DECLARATION**



### 3. FUZZY INFERENCE SYSTEM-MAMDANI METHOD

Still, Fuzzy Inference Systems (FIS) use fuzzy logic, If you want to represent the moxie of professionals about positive issues in mortal-suchlike decision- timber. These structures use fuzzy sense modelling to give answers grounded on verbal expressions. They're most useful when mortal moxie is available but there are inadequate records to feed traditional fine model variables. The fuzzy conclusion device is composed of four major modules the fuzzification module, the understanding base, the conclusion machine, and the defuzzification module.

The Mamdani model [15,14] is most extensively used fuzzy conclusion fashion. Mamdani fuzzy conclusion fashion [18] has four stages Fuzzification, rule evaluation, rule affair

aggregation, and defuzzification. The fuzzification module converts the crisp entry figure into a degree of fuzzy unit class by utilizing fuzzification club characteristics. A class point yields a cost ranging from 0 (non-club) to 1 (for club) or (for full- club). The IF- Also rules handed by area professionals are stored in the Knowledge Base. The instructions are included in the form.

$F(A = \alpha 1) \text{ AND } (B = \alpha 2) \text{ AND } (C = \alpha 3)$  Also. Also  $(R \text{ equals to } \alpha m)$ , where A, B, and C are the input variables and  $\alpha 1, \alpha 2, \alpha 3$  are the corresponding verbal words (e.g., Yes, No), R is the rule of thumb for affair variable and  $\alpha m$  is the verbal time period (eg., high chance, medium chance, low threat). The conclusion machine's affair is converted into a precise affair price via the defuzzification module. The Centroid or Center of Graveness (COG)



approach is the most generally used defuzzification fashion, in which the crisp affair price is calculated using a weighted normal of the propinquity defined by the aggregated class point wind of the affair variable.

**MEMBERSHIP FUNCTION**

In Table 2 , Low first row represent the number of persons infected range between 8600 and 19,000 and second row its membership function definee as [0 0. 0.2]. Moderate represent infected persons range from 19000 to 100282 and its membership function defined as

[0.2,0.6 0.8]. In High, first row represent infected range between 100282 and 282259 and its membership function as [0.6 0.8 1]. Similarly Table 3, Table 4, Table 5 represent Cured, Deceased and Vaccinated persons range and its corresponding mapping membership values.

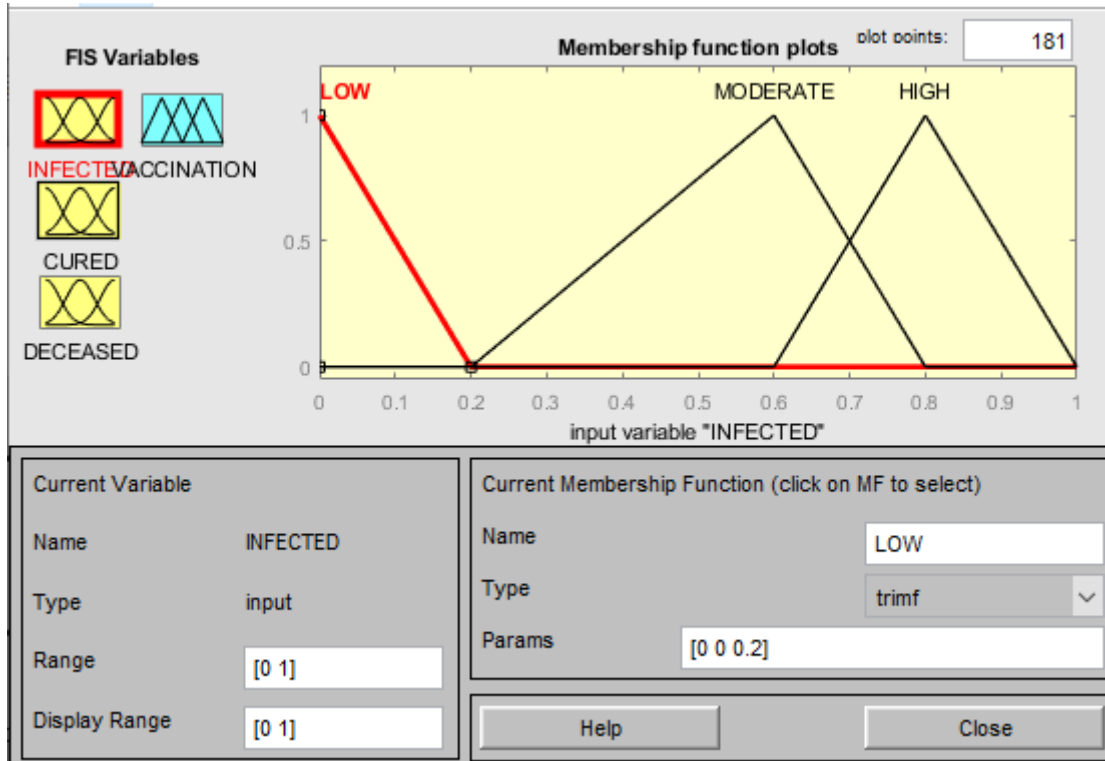
**RANGE FOR INFECTED**

LOW[0 0 0.2]  
 MODRATE [ 0.2 0.6 0.8]  
 HIGH[0.6 0.8 1]

**Table 2:**

<b>Low</b>	8600	9000	10000	11000	12000	13000	14000	15000	17000	19000
	0	0	0.04	0.08	0.1	0.12	0.14	0.16	0.18	0.2
<b>Moderate</b>	19000	25000	40000	60000	75000	80000	85000	90000	100000	100282
	0.2	0.2	0.25	0.3	0.4	0.5	0.6	0.7	0.75	0.8
<b>High</b>	100282	110000	150000	175000	185000	200000	225000	250000	275000	282259
	0.6	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1

**GRAPH 2 -INFECTED**



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**RANGE FOR CURED**

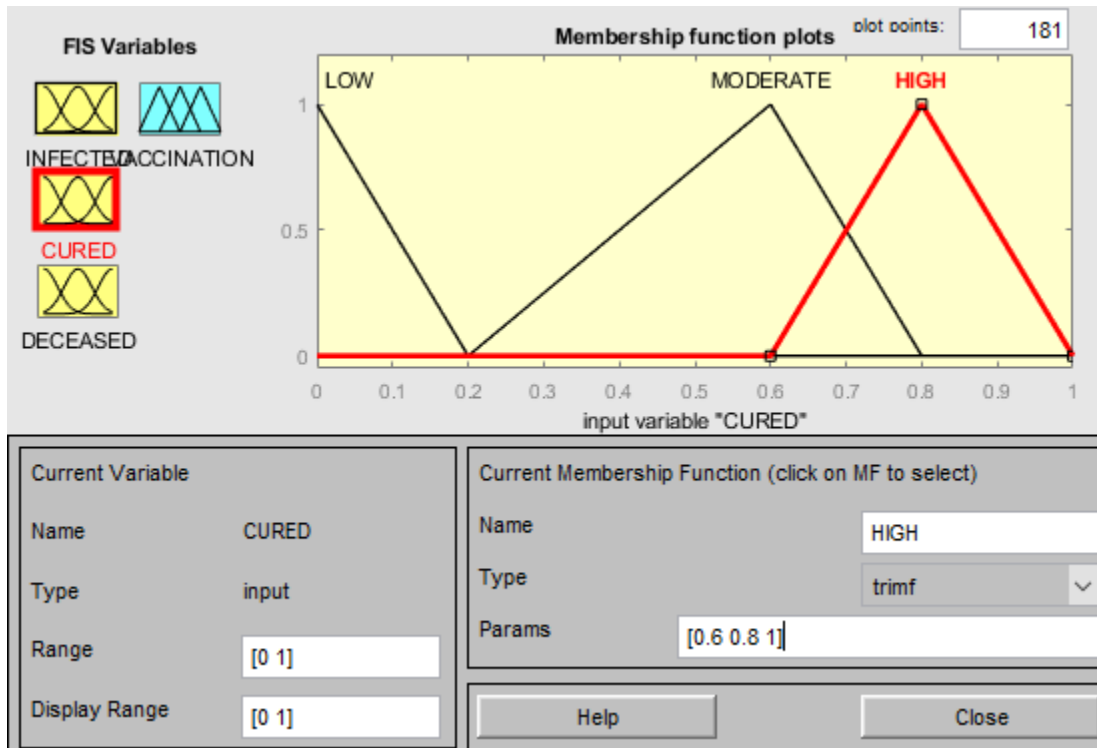


LOW[0 0 0.2]  
 MODRATE [ 0.2 0.6 0.8]  
 HIGH[0.6 0.8 1]

**TABLE 3**

<b>Low</b>	1000	10000	40000	45000	50000	60000	70000	80000	90000	100000
	0	0	0.04	0.08	0.1	0.12	0.14	0.16	0.18	0.2
<b>Moderate</b>	100000	110000	125000	130000	150000	160000	170000	180000	190000	200000
	0.2	0.2	0.25	0.3	0.4	0.5	0.6	0.7	0.75	0.8
<b>High</b>	200000	200500	225000	240000	260000	270000	275000	280000	281000	282165
	0.6	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1

**GRAPH 3 - CURED**



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**RANGE FOR DECEASED**

LOW[0 0 0.2]  
 MODRATE [ 0.2 0.6 0.8]  
 HIGH[0.6 0.8 1]

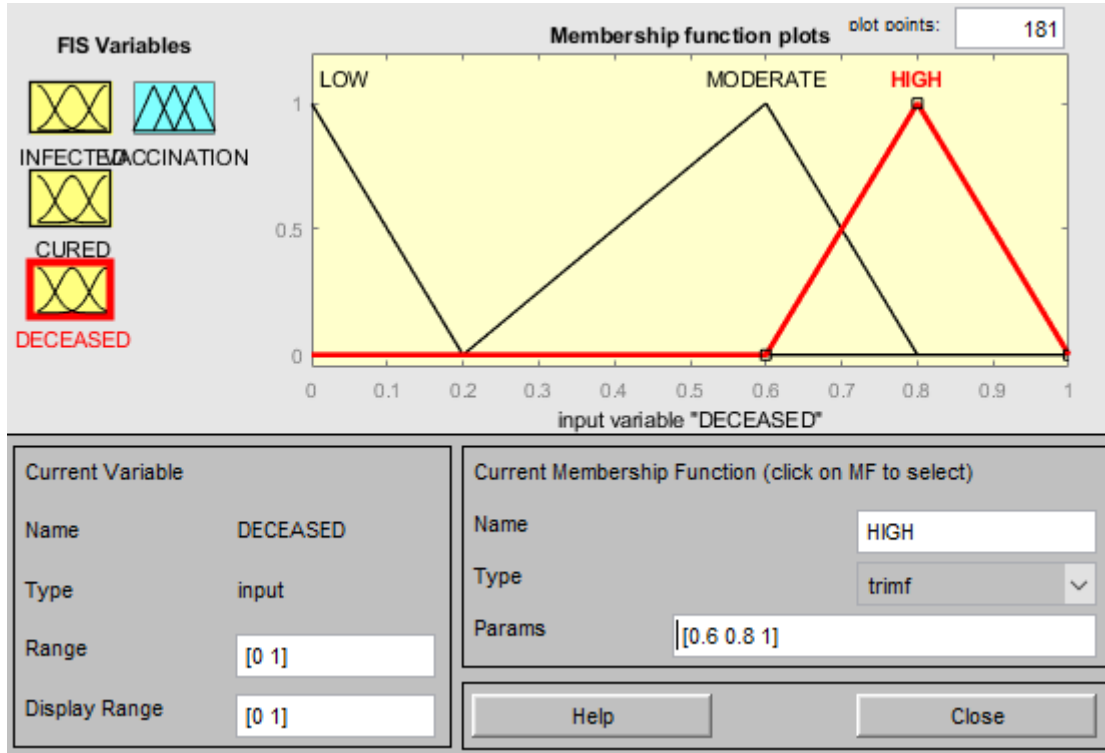
**TABLE 4 :**

<b>Low</b>	0	50	150	200	250	300	350	400	450	500
	0	0	0.04	0.08	0.1	0.12	0.14	0.16	0.18	0.2
<b>Moderate</b>	500	800	1000	1200	1400	1600	1700	1800	1900	2000



	0.2	0.2	0.25	0.3	0.4	0.5	0.6	0.7	0.75	0.8
High	2000	2400	2800	3000	3200	3400	3500	3600	3800	4000
	0.6	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1

GRAPH 4 - DECEASED



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The following equation is used to calculate the final defuzzified affair price using the centroid system or centre of graveness [13]

$$d_{COG}(\alpha) = \frac{\int_{-\alpha}^{\alpha} \alpha(\theta) \theta d\theta}{\int_{-\alpha}^{\alpha} \alpha(\theta) d\theta}$$

We analyzed data to identify the maximum affected districts in COVID-19 disease by combining the six various input factors such as infected, cured, and deceased, along with one output factor vaccinated. The input factors which has been further divided into three linguistic categories Low, Moderate, High of the specific districts. The output factor vaccination has two subdivisions such as low vaccinated and high vaccinated. For the elements that are

included, we had developed membership functions. We propose a framework for a fuzzy inference system based on fuzzy inference rules in this research.

#### 4. Structure of fuzzy inference system with three inputs and one output

As shown in Table I, each input variable have three membership functions. The Mamdani Rules Inference is as follows



**TABLE 5**

Inputs				Output
S.No	Infected	Cured	Deceased	vaccination
1	High	Low	High	Low
2	High	High	Low	High
3	Low	High	Low	High
4	Low	Low	High	Low
5	Moderate	Low	Low	Low
6	Moderate	High	Low	High
7	Low	Moderate	High	Low
8	Low	Moderate	Low	High
9	Low	High	Moderate	High
10	Moderate	Low	Moderate	Low

1. If (INFECTED is HIGH) and (CURED is LOW) and (DECEASED is HIGH) then (VACCINATION is LOW) (1)
2. If (INFECTED is HIGH) and (CURED is HIGH) and (DECEASED is LOW) then (VACCINATION is HIGH) (1)
3. If (INFECTED is LOW) and (CURED is HIGH) and (DECEASED is LOW) then (VACCINATION is HIGH) (1)
4. If (INFECTED is LOW) and (CURED is LOW) and (DECEASED is HIGH) then (VACCINATION is LOW) (1)
5. If (INFECTED is MODERATE) and (CURED is LOW) and (DECEASED is LOW) then (VACCINATION is LOW) (1)
6. If (INFECTED is MODERATE) and (CURED is HIGH) and (DECEASED is LOW) then (VACCINATION is HIGH) (1)
7. If (INFECTED is LOW) and (CURED is MODERATE) and (DECEASED is HIGH) then (VACCINATION is LOW) (1)
8. If (INFECTED is LOW) and (CURED is MODERATE) and (DECEASED is LOW) then (VACCINATION is HIGH) (1)
9. If (INFECTED is LOW) and (CURED is HIGH) and (DECEASED is MODERATE) then (VACCINATION is HIGH) (1)
10. If (INFECTED is MODERATE) and (CURED is LOW) and (DECEASED is MODERATE) then (VACCINATION is LOW) (1)

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**Defuzzification of the Output**

**Membership functions for the factors**

The inference system implemented here, initiates a set of fuzzy rules based on the patient symptoms which is given as input, with each rule producing an output [18]. By using the fuzzy operator, the output fuzzy set was generated "min" by taking into account of every rule that satisfies the AND operational logic for a given set of input values. After that, the aggregation procedure of each rule's output fuzzy set into a single fuzzy set. The single fuzzy set was defuzzified into a single numeric output value using the Centroid technique to assess the % risk level of being COVID-19 infected.

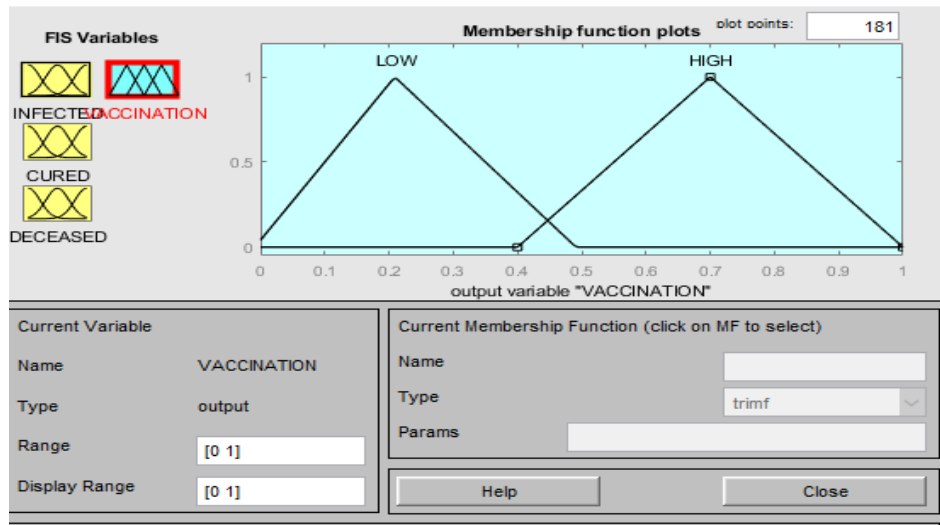
**VACCINATED**

LOW [0 0.2 0.5]  
 HIGH [0.4 0.7 1]

**TABLE 6 :  
 GRAPH 5 - VACCINATED OUTPUT**

Low	10000	50000	100000	150000	200000	250000	300000	350000	375000	400000
	0	0	0.05	0.1	0.12	0.25	0.3	0.4	0.45	0.5
High	400000	450000	500000	600000	650000	800000	1000000	1100000	1200000	1284889
	0.5	0.6	0.7	0.75	0.8	0.85	0.9	0.93	0.95	1

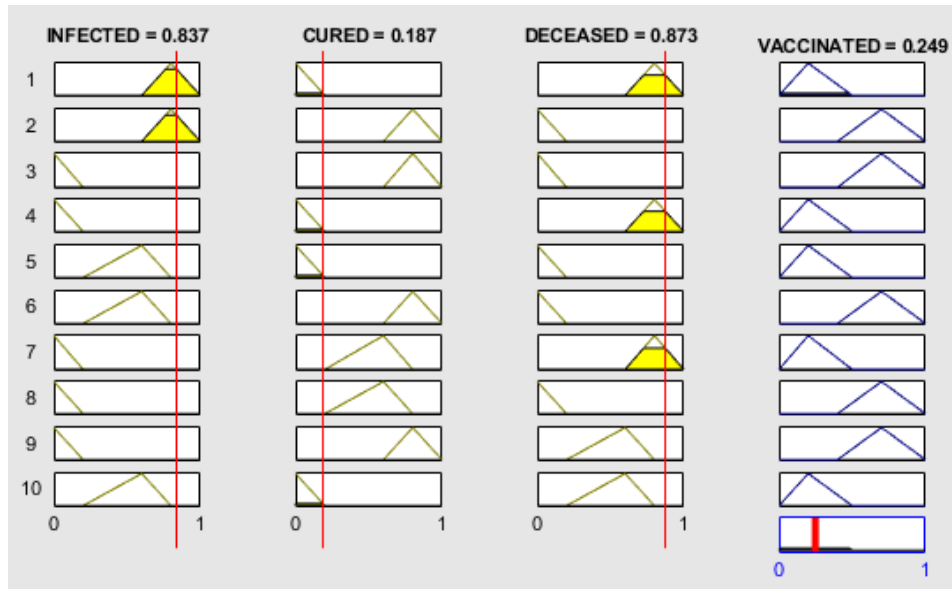




**OUTPUT DECLARATION USING MAMDANI INFERENCE MODEL**

**Output Graph for Condition 1**

If infected is HIGH cured is LOW and deceased is HIGH then vaccination is LOW

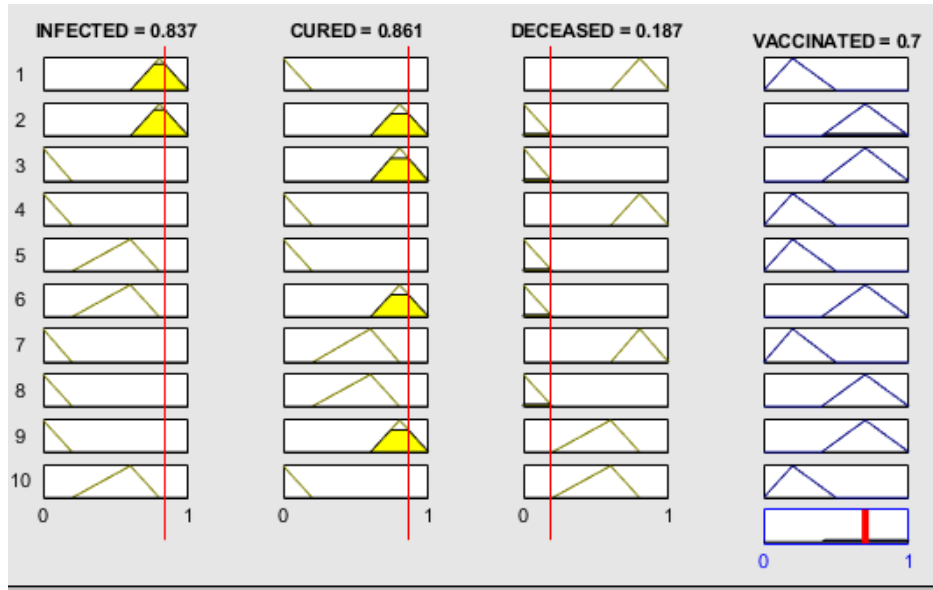


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**Output Graph for condition 2**

**Condition 4.** If infected is HIGH, cured is HIGH, Deceased is LOW then the Vaccination is HIGH

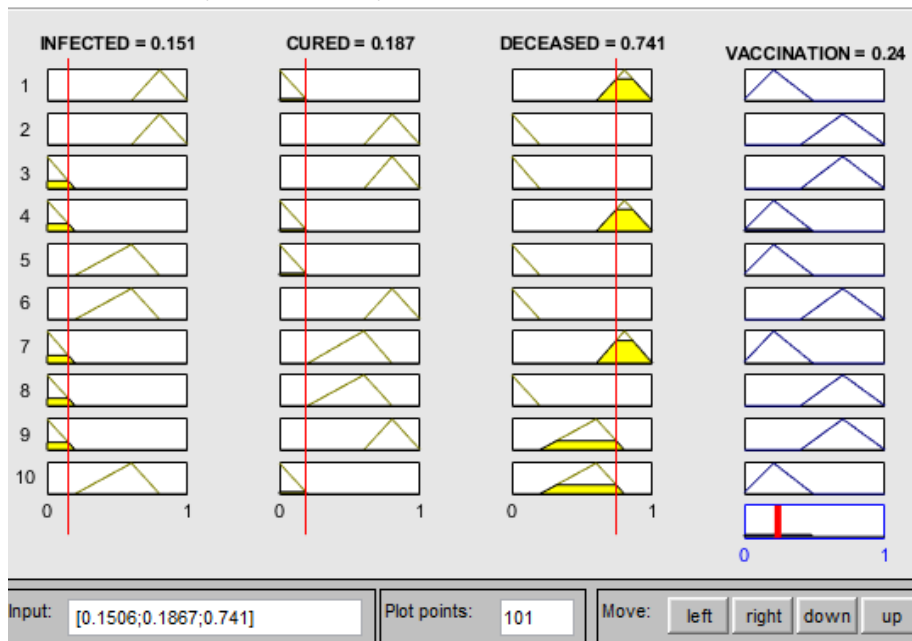




**Output Graph for condition 4**

**Condition 4.** If infected is LOW, cured is LOW, Deceased is HIGH then the Vaccination is LOW

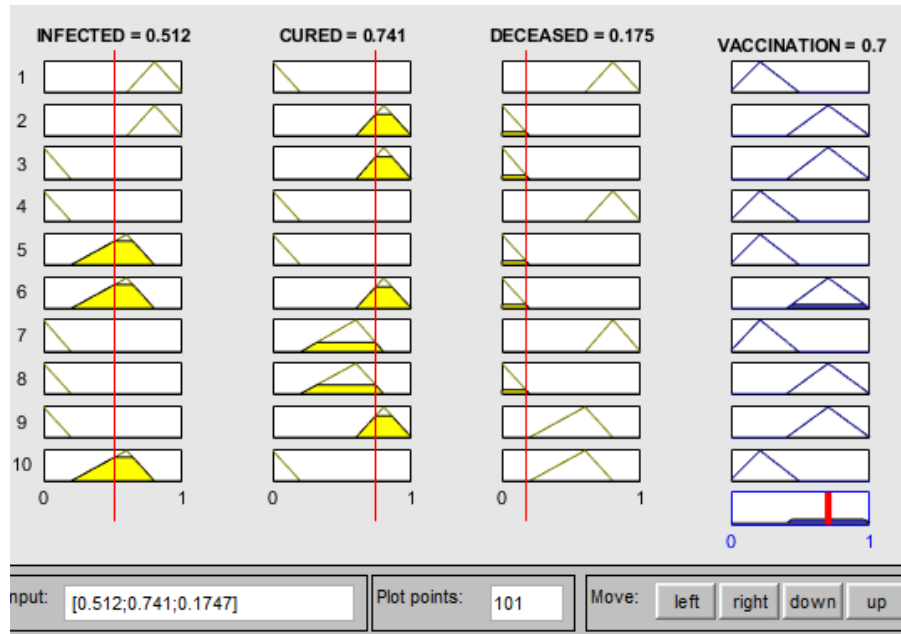
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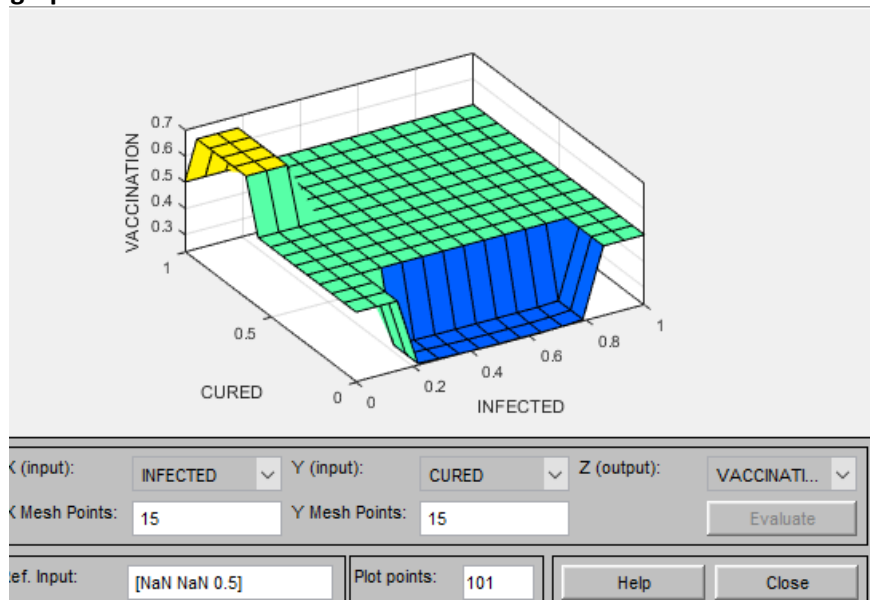
**Output graph for Condition 6**

If infected is MODERATE, cured is HIGH and deceased is LOW then vaccination is HIGH





### Surface Viewer graph



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### 5. CONCLUSIONS AND FUTURE DIRECTIONS

We have proposed a smart fuzzy inference system in this research with the analysis of various districts in Tamil Nadu, India, that were infected, cured, deceased, vaccinated dose 1 and vaccinated dose 2 with COVID-19. Based on the symptoms that patients present, the system infers the risk level of COVID-19 infection.

Fever, exhaustion, and a dry cough are all considered symptoms, as are diarrhea, sore throat, headache, and conjunctivitis, loss of taste or smell, and breathing problems. This inference study aids in determining how the districts level infected, cured, and deceased rates occurred in a three-month analysis in major districts of Tamilnadu, India, from April



2021 to September 2021. Based on this analysis, we strongly predicted that the infection and death rate would increase significantly from April 2021 to June 2021, when vaccination was not yet widely known among the general public in Tamilnadu. After June 2021, when the government and public health department raised awareness among the general public, the infection and death rate would gradually decline and become very low by September 2021. For this analysis, complete data from various districts was obtained from the ICMR report and genuine Google.Mamdani rules of inference clearly visualize the importance of vaccination as it really correlated with the infected cured and deceased data. As a result, vaccination is the only tool available to reduce our mortality rate in this Pandemic situation. In the future, the work can be expanded to include the next type variant omicron among the same districts, as well as other patients with chronic diseases, blood pressure, and so on.

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