



## **Mathematical Modelling for Sensitivity Analysis of HIV/AIDS in India**

Dhirendra Kumar Shukla<sup>1</sup>, Arvind Gupta<sup>2</sup>, Anil Goyal<sup>3</sup>

<sup>1</sup>Department of Applied Sciences

Corporate Institute of Science and Technology, Bhopal (M.P.), India

<sup>2</sup>Department of Mathematics

Govt. Motilal Vigyan Mahavidyalaya, Bhopal (M.P.), India

<sup>3</sup>Department of Applied Sciences

UIT-Rajiv Gandhi Proudhyogiki Vishwavidyalaya, Bhopal (M.P.), India

**Abstract:** In this note HIV/AIDS (Human Immunodeficiency Virus / Acquired Immuno Deficiency Syndrome) is explained especially in Indian Scenario. For the same statistical data is been unitized state wise. States are divided into 6 clusters where each cluster denotes a particular region of India. To find maximum and minimum infected region graphical presentation is utilized. Finally a mathematical model based on Fuzzy Cluster Means and Fuzzy Cognitive Maps is prepared and relation between clusters and causes of HIV/AIDS in India is established.

**Key words:** Mathematical Modelling, Fuzzy Cognitive Maps, Fuzzy Cluster Means, Graphical Presentation, Sensitivity Analysis.

### **I. Introduction about HIV/AIDS**

The human immunodeficiency virus (HIV) that causes AIDS has been isolated in 1983 in the United States and in the spring of 1981 first Acquired Immunodeficiency Syndrome (AIDS) has been reported. HIV virus in T-helper immune cells or genetic information that causes Acquired Immune Deficiency Syndrome the cellular RNA and acid is contained in the chromosome rather than a retrovirus. Antigen triggers the production of antibodies in humans. HIV-2 is largely confined to West Africa, while HIV-1 is the most common serotypes distribution. AIDS opportunistic infections and certain cancers strange reaction to the increased sensitivity appears that the retrovirus HIV causes an imbalance in the immune cell. This results to a severe immune disorder. The disease mainly infected body fluids, especially blood and semen and is transmitted by contact. HIV virus is in everyone's body, but not everybody is suffering with HIV. HIV in the United States during 1979-1981 has been found since the mid to late 1970s. A number of doctors in Los Angeles and New York have reported pneumonia, cancer, inflammation and other diseases for the rare type of men Patients who have sex with men. In 1982, AIDS opportunistic infections in previously healthy people described the appearance and formally track these cases in the United States and launched the term that was started in the 1983. Human cell or T-helper (PET lymphoid tissue) type virus that causes AIDS was later named by an international scientific committee III / lymphadenopathy-associated virus (HTLV-III/ LAV). Several theories about the basics of HIV and how it appeared in the population have been proposed. Most scientists recommended that HIV originated in other primates and gradually transferred to the human body. In 1999, an international team reported that HIV is one of the major diseases diagnosed in developed countries. The original source of the virus is the chimpanzee of West Tropical Africa has been identified as a kind of mother.

### **II. Fuzzy Cognitive Maps**

Fuzzy Cognitive Maps of researchers signed procedure may include different kinds of knowledge to draw and analyse complex operating system. An FCM is study about policy, events, concepts, etc., as well as a digraph of nodes and edges of the victims. The causal link between the terms, rise (or fall) is a concept, which is an increase (or decrease) on the other side, and then the value is 1. If there are problems, the ratio between these two concepts, the value is 0. Rise (or fall) in one victim decreases (or increases) in the second, then the value is -1.

### **III. Fuzzy Cluster Means**

In the fuzzy cluster analysis to measure the set of parameters based on a set of indicators is used to classify objects into categories based on the statistical method. Cluster analysis which is used in medical or clinical signs and symptoms of sub-groups based on pattern is used in the paper to identify HIV/AIDS infection in patients. The data of the same class is collected to make a similar type or group of process. Data is collected in the form of programs and articles from various sources. Nature of data and the collection of information used depends on the purpose of group's organization. Classification of the formation is the process of dividing data elements in a class or group to make a list on the same level. Some measures that can be used as a grouping including distance, connectivity, sensitivity and intensity.

In the fuzzy clustering, data elements can be in more than one group and each element is associated with a series of class members. They indicate the strength of the relationships between data elements and groups in particular. Fuzzy Grouping is the process of determining the level of these members and then use them to determine the composition of one or more than one group.

#### IV. Mathematical modeling by using Fuzzy Cluster Means

The paper tries to make a Mathematical Model to analyze sensitivity of HIV/AIDS in India. Few Indian states that satisfy the following five causes of HIV/AIDS transmission have been choosen.

**Table (1): Causes of HIV/AIDS in India.**

| S. No. | Causes         | Particulars         |
|--------|----------------|---------------------|
| 1      | C <sub>1</sub> | MTCT-HIV Prevalence |
| 2      | C <sub>2</sub> | STD-HIV prevalence  |
| 3      | C <sub>3</sub> | IDU-HIV prevalence  |
| 4      | C <sub>4</sub> | MSM-HIV prevalence  |
| 5      | C <sub>5</sub> | FSW-HIV prevalence  |

To define clusters and their elements (States of India) only those states are selected that contains information in all five categories (Causes of HIV/AIDS).

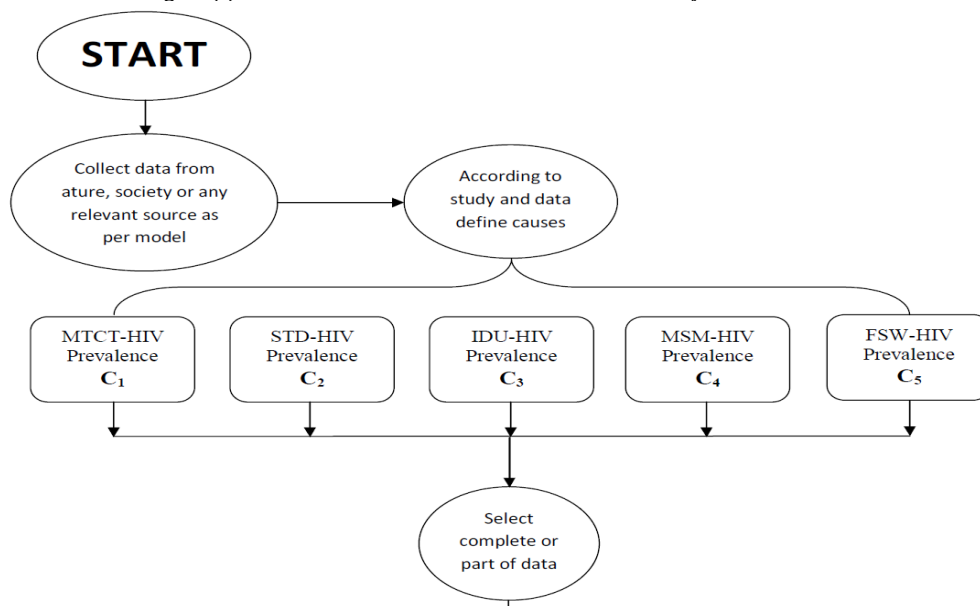
**Table (2): Clusters (States of India divided into 6 groups as per their zones).**

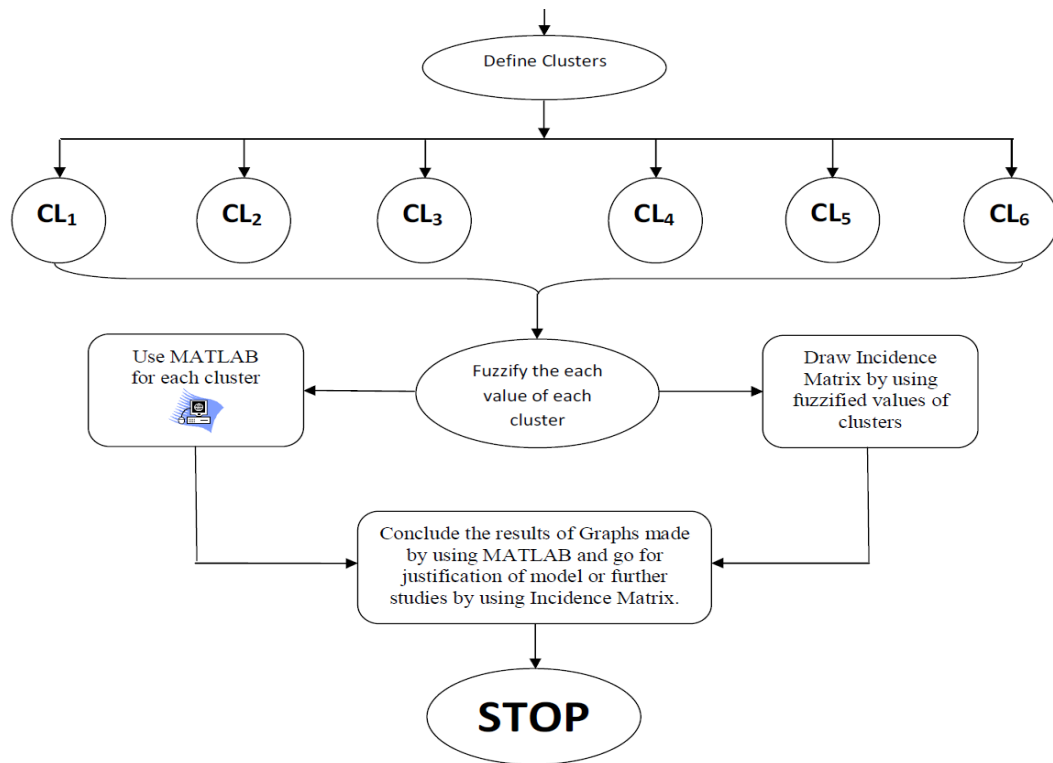
| S. No. | Clusters        | Particulars                                                                      |
|--------|-----------------|----------------------------------------------------------------------------------|
| 1      | CL <sub>1</sub> | Chattisgarh (CG) & Madhyapradesh (MP)                                            |
| 2      | CL <sub>2</sub> | Bihar (BR), Jharkhand (JH) & Odisha (OR)                                         |
| 3      | CL <sub>3</sub> | Delhi (DL), Haryana (HR), Himanchal Pradesh (HP), Punjab (PB) & Uttarpradesh(UP) |
| 4      | CL <sub>4</sub> | Assam (AS), Manipur (MN) & Nagaland (NL)                                         |
| 5      | CL <sub>5</sub> | Andhrapradesh (AP), Karnataka (KA) & Keral (KR)                                  |
| 6      | CL <sub>6</sub> | Gujrat (GJ), Maharashtra (MH) & West Bengal (WB)                                 |

#### V. Mathematical model based on Fuzzy Cluster Mean

This is the flow chart of proposed model to analyse sensitivity of HIV/AIDS in India by using Fuzzy Cluster Means and Fuzzy Cognitive Maps.

**Figure (1): Flow chart of Mathematical mode based on Fuzzy Cluster Means.**





## VI. Implementation of mathematical model

To start the process, first, collect the data from nature, society or any other relevant source as per the requirement of the model. For this paper, source of the data is [www.avert.org](http://www.avert.org). As per the requirement of model, following table mentioned the clusters and causes of HIV/AIDS with their associated values. Here, numerical values are population of infected people in each cluster due to a particular cause.

**Table (3): States of India divided into six clusters according to their zone.**

| S. No. | Clusters        | States of India | C <sub>1</sub> | C <sub>2</sub> | C <sub>3</sub> | C <sub>4</sub> | C <sub>5</sub> |
|--------|-----------------|-----------------|----------------|----------------|----------------|----------------|----------------|
| 1      | CL <sub>1</sub> | CG              | 0.43           | 3.33           | 0.42           | 14.98          | 2.73           |
|        |                 | MP              | 0.32           | 1.72           | 5.13           | 7.94           | 0.93           |
| 2      | CL <sub>2</sub> | BR              | 0.17           | 0.4            | 4.54           | 4.2            | 2.3            |
|        |                 | JH              | 0.25           | 0.4            | 2.02           | 0.4            | 0.82           |
|        |                 | OR              | 0.43           | 1.6            | 7.16           | 3.79           | 2.07           |
| 3      | CL <sub>3</sub> | DL              | 0.3            | 5.2            | 18.27          | 5.34           | 0.7            |
|        |                 | HR              | 0.19           | 0              | 0.8            | 3.05           | 0.48           |
|        |                 | HP              | 0.04           | 0              | 4.89           | 1.23           | 0.53           |
|        |                 | PB              | 0.26           | 1.6            | 21.1           | 2.18           | 0.85           |
|        |                 | UP              | 0.21           | 0.48           | 2.03           | 1.56           | 0.62           |
| 4      | CL <sub>4</sub> | AS              | 0.09           | 0.5            | 1.46           | 1.4            | 0.46           |
|        |                 | MN              | 0.78           | 4.08           | 12.89          | 10.53          | 2.8            |
|        |                 | NL              | 0.66           | 3.42           | 2.21           | 13.58          | 3.21           |
| 5      | CL <sub>5</sub> | AP              | 0.76           | 17.2           | 3.05           | 10.14          | 6.86           |
|        |                 | KA              | 0.69           | 8.4            | 0              | 5.36           | 5.1            |
|        |                 | KR              | 0.13           | 1.6            | 4.95           | 0.36           | 0.73           |
| 6      | CL <sub>6</sub> | GJ              | 0.46           | 2.4            | 1.6            | 3              | 1.62           |
|        |                 | MH              | 0.42           | 11.62          | 14.17          | 9.91           | 6.89           |
|        |                 | WB              | 0.13           | 0.8            | 2.72           | 5.09           | 2.04           |

Following formula is applied to convert the data up to or within hundred.

$$h_{11} = \left[ \frac{a_{11}}{\sum_{i=1, j=1}^{j=5} a_{ij}} \right] \times p \quad ; i=1, 1 \leq j \leq 5. \quad (1)$$

Here  $h_{11}$  shows the relation between  $CL_1$  and  $C_1$  (Table (4)),  $p = 100$  and  $i \in N$ .  $N$  is the set of all elements of clusters, which are states of India.  $a_{11}$  shows relation between  $CL_1$  and  $C_1$  (Table (3)). In the formula if we replace  $a_{11}$  by  $a_{12}$  then the result will be  $h_{12}$  and so on. To understand the model it is important to know that  $i=1$  indicates first element of  $N$ , which is a state; to find values of next element (or state of India) of cluster put  $i=2$  and so on. Here  $j$  indicates the causes of HIV/AIDS. Then finally we will get table (4) which can be written in matrix form as follows:

$$H = [h_{ij}] \quad ; 1 \leq i \leq 19, 1 \leq j \leq 5 \quad (2)$$

**Table (4): Converted data up to or within hundred.**

| S. No. | Clusters | States of India | $C_1$   | $C_2$    | $C_3$    | $C_4$    | $C_5$    |
|--------|----------|-----------------|---------|----------|----------|----------|----------|
| 1      | $CL_1$   | CG              | 1.96437 | 15.21243 | 1.91868  | 68.43307 | 12.47145 |
|        |          | MP              | 1.99501 | 10.72319 | 31.98254 | 49.50125 | 5.79800  |
| 2      | $CL_2$   | BR              | 1.46425 | 3.44531  | 39.10422 | 36.17571 | 19.81051 |
|        |          | JH              | 6.42674 | 10.28278 | 51.92802 | 10.28278 | 21.07969 |
|        |          | OR              | 2.85714 | 10.63123 | 47.57475 | 25.18272 | 13.75415 |
| 3      | $CL_3$   | DL              | 1.00637 | 17.44381 | 61.28816 | 17.91345 | 2.34821  |
|        |          | HR              | 4.20354 | 0        | 17.69912 | 67.47788 | 10.61947 |
|        |          | HP              | 0.59791 | 0        | 73.09417 | 18.38565 | 7.92227  |
|        |          | PB              | 1.00038 | 6.15621  | 81.18507 | 8.38784  | 3.27049  |
|        |          | UP              | 4.28571 | 9.79592  | 41.42857 | 31.83673 | 12.65306 |
| 4      | $CL_4$   | AS              | 2.30179 | 12.78772 | 37.34015 | 35.80563 | 11.76471 |
|        |          | MN              | 2.50965 | 13.12741 | 41.47362 | 33.88031 | 9.00901  |
|        |          | NL              | 2.85962 | 14.81802 | 9.57539  | 58.83882 | 13.90815 |
| 5      | $CL_5$   | AP              | 1.99947 | 45.25125 | 8.02420  | 26.67719 | 18.04788 |
|        |          | KA              | 3.52941 | 42.96675 | 0.00000  | 27.41688 | 26.08696 |
|        |          | KR              | 1.67310 | 20.59202 | 63.70656 | 4.63320  | 9.39511  |
| 6      | $CL_6$   | GJ              | 5.06608 | 26.43172 | 17.62115 | 33.03965 | 17.84141 |
|        |          | MH              | 0.97652 | 27.01697 | 32.94583 | 23.04115 | 16.01953 |
|        |          | WB              | 1.20594 | 7.42115  | 25.23191 | 47.21707 | 18.92393 |

Now, with the help of table (4) make individual data sheet for each cluster. Find fuzzified values of each cluster in which each element (state of India) is associated with each cause of HIV/AIDS. Apply the following formulae to fuzzify the value:

for first cluster  $CL_1$ ,

$$f_{11} = \left( \frac{\sum_{i=1, j=1}^{i=2} j_{ij}}{2p} \right) \text{ where } p = 100, j = 1, 1 \leq i \leq 2 \quad (3)$$

Similarly to find values of  $f_{12}, f_{13}, f_{14}, f_{15}$ , put  $j = 2, 3, 4, 5$ .

for second cluster  $CL_2$ ,

$$f_{21} = \left( \frac{\sum_{i=1, j=1}^{i=3} k_{ij}}{3p} \right) \text{ where } p = 100, j = 1, 1 \leq i \leq 3 \quad (4)$$

Similarly to find values of  $f_{22}, f_{23}, f_{24}, f_{25}$ , put  $j = 2, 3, 4, 5$ .  
for third cluster  $CL_3$ ,

$$f_{31} = \left( \frac{\sum_{i=1, j=1}^{i=5} l_{ij}}{5p} \right) \text{ where } p = 100, j = 1, 1 \leq i \leq 5 \quad (5)$$

Similarly to find values of  $f_{32}, f_{33}, f_{34}, f_{35}$ , put  $j = 2, 3, 4, 5$ .  
for fourth cluster  $CL_4$ ,

$$f_{41} = \left( \frac{\sum_{i=1, j=1}^{i=3} m_{ij}}{3p} \right) \text{ where } p = 100, j = 1, 1 \leq i \leq 3 \quad (6)$$

Similarly to find values of  $f_{42}, f_{43}, f_{44}, f_{45}$ , put  $j = 2, 3, 4, 5$ .  
for fifth cluster  $CL_5$ ,

$$f_{51} = \left( \frac{\sum_{i=1, j=1}^{i=3} n_{ij}}{3p} \right) \text{ where } p = 100, j = 1, 1 \leq i \leq 3 \quad (7)$$

Similarly to find values of  $f_{52}, f_{53}, f_{54}, f_{55}$ , put  $j = 2, 3, 4, 5$ .  
for sixth cluster  $CL_6$ ,

$$f_{61} = \left( \frac{\sum_{i=1, j=1}^{i=3} o_{ij}}{3p} \right) \text{ where } p = 100, j = 1, 1 \leq i \leq 3 \quad (8)$$

Similarly to find values of  $f_{62}, f_{63}, f_{64}, f_{65}$ , put  $j = 2, 3, 4, 5$ .

Where  $J = [j_{ij}]$ ,  $K = [k_{ij}]$ ,  $L = [l_{ij}]$ ,  $M = [m_{ij}]$ ,  $N = [n_{ij}]$ ,  $O = [o_{ij}]$  represents matrix form of values  
for clusters  $CL_1, CL_2, CL_3, CL_4, CL_5, CL_6$ .

Finally we have  $F = [f_{ij}]$   $1 \leq i \leq 6, 1 \leq j \leq 5$ . i.e.

$$F = [f_{ij}] = \begin{bmatrix} f_{11} & f_{12} & f_{13} & f_{14} & f_{15} \\ f_{21} & f_{22} & f_{31} & f_{41} & f_{51} \\ f_{31} & f_{32} & f_{33} & f_{34} & f_{35} \\ f_{41} & f_{42} & f_{43} & f_{44} & f_{45} \\ f_{51} & f_{52} & f_{53} & f_{54} & f_{55} \\ f_{61} & f_{62} & f_{63} & f_{64} & f_{65} \end{bmatrix}$$

$$\Rightarrow F[f_{ij}] = \begin{bmatrix} 0.0 & 0.1 & 0.2 & 0.6 & 0.1 \\ 0.0 & 0.1 & 0.5 & 0.2 & 0.2 \\ 0.0 & 0.1 & 0.5 & 0.3 & 0.1 \\ 0.0 & 0.1 & 0.3 & 0.4 & 0.1 \\ 0.0 & 0.4 & 0.2 & 0.2 & 0.2 \\ 0.0 & 0.2 & 0.3 & 0.3 & 0.2 \end{bmatrix} \quad (9)$$

Now by taking transpose of matrix  $F$ . Suppose  $G = F^T$ ,  
Then,

$$G = F^T = \begin{bmatrix} 0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 \\ 0.1 & 0.1 & 0.1 & 0.1 & 0.4 & 0.2 \\ 0.2 & 0.5 & 0.5 & 0.3 & 0.2 & 0.3 \\ 0.6 & 0.2 & 0.3 & 0.4 & 0.2 & 0.3 \\ 0.1 & 0.2 & 0.1 & 0.1 & 0.2 & 0.2 \end{bmatrix} \quad (10)$$

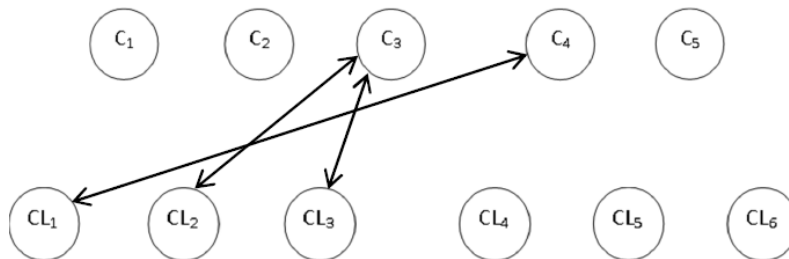
Finally, by using values of  $F^T$  table (5) is obtained which shows the relation between causes of HIV/AIDS and clusters. Here the values are between 0.00 to 1.00 which is degree or membership of any cluster with their associated cause of HIV/AIDS.

**Table (5): Relation between causes of HIV/AIDS and clusters with their degree or membership.**

| Causes         | Clusters        |                 |                 |                 |                 |                 |
|----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                | CL <sub>1</sub> | CL <sub>2</sub> | CL <sub>3</sub> | CL <sub>4</sub> | CL <sub>5</sub> | CL <sub>6</sub> |
| C <sub>1</sub> | 0               | 0               | 0               | 0               | 0               | 0               |
| C <sub>2</sub> | 0.1             | 0.1             | 0.1             | 0.1             | 0.4             | 0.2             |
| C <sub>3</sub> | 0.2             | 0.5             | 0.5             | 0.3             | 0.2             | 0.3             |
| C <sub>4</sub> | 0.6             | 0.2             | 0.3             | 0.4             | 0.2             | 0.3             |
| C <sub>5</sub> | 0.1             | 0.2             | 0.1             | 0.1             | 0.2             | 0.2             |

## VII. Development of digraph and incidence matrix

**Figure (2): Digraph based on fuzzified values from table (5).**



On the basis of fuzzified values from table (5) in which values are between 0.00 to 1.00 above digraph can be formed. Then, an incidence matrix is made as given below:

$$D = [d_{ij}] \quad ; 1 \leq i \leq 5, 1 \leq j \leq 6 \quad (11)$$

In which,  $d_{ij} = 0$ , if degree or membership value is less than 0.5 and  $d_{ij} = 1$ , if degree or membership value is equal or greater than 0.5.

$$D = [d_{ij}] = \begin{matrix} & \begin{matrix} CL_1 & CL_2 & CL_3 & CL_4 & CL_5 & CL_6 \end{matrix} \\ \begin{matrix} C_1 \\ C_2 \\ C_3 \\ C_4 \\ C_5 \end{matrix} & \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \end{matrix} \quad (12)$$

After that, Fuzzy Cognitive Maps will be applied on the incidence matrix to conclude the result obtained by the model based on Fuzzy Cluster Means.

### VIII. Implementation of Fuzzy Cognitive Maps

According to the mathematical model based on fuzzy cluster means mentioned above corresponding relation between causes of HIV/AIDS and clusters (In which elements are states of India) is found in the form of an incidence matrix  $D = [d_{ij}]$ .

The iteration begins by using incidence matrix (12) where  $C_3$  and  $C_4$  are ON and others are OFF as they are the major problems.

$$\text{Then, } I_1 = (0 \ 0 \ 1 \ 1 \ 0) \quad (13)$$

Multiply  $I_1$  with matrix 'D',

$$I_1 D = (0 \ 0 \ 1 \ 1 \ 0) \sim (1 \ 1 \ 1 \ 0 \ 0 \ 0) \\ \text{i.e., } I_1^1 D = (1 \ 1 \ 1 \ 0 \ 0 \ 0) \quad (14)$$

In the calculated value, zero (0) in third place is replaced by one because of hypothesis:  $C_3$  and  $C_4$  states are ON and others are OFF. As it is known that threshold value is calculated by assuming one (1) for the values greater than one and zero (0) for the values less than zero. Now, to calculate threshold values by iteration method, we suppose ON one by one all  $C_i$ 's. So,

$$I_1^1 D \sim (1 \ 0 \ 0 \ 0 \ 0) D \rightarrow (0 \ 0 \ 0 \ 0 \ 0 \ 0) \quad (15)$$

$$I_1^1 D \sim (0 \ 1 \ 0 \ 0 \ 0) D \rightarrow (0 \ 0 \ 0 \ 0 \ 0 \ 0) \quad (16)$$

$$I_1^1 D \sim (0 \ 0 \ 1 \ 0 \ 0) D \rightarrow (0 \ 1 \ 1 \ 0 \ 0 \ 0) \quad (17)$$

$$I_1^1 D \sim (0 \ 0 \ 0 \ 1 \ 0) D \rightarrow (1 \ 0 \ 0 \ 0 \ 0 \ 0) \quad (18)$$

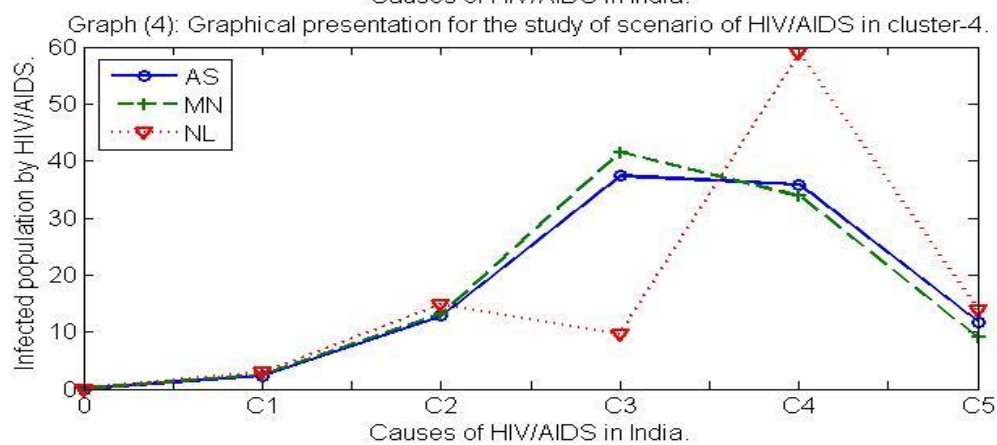
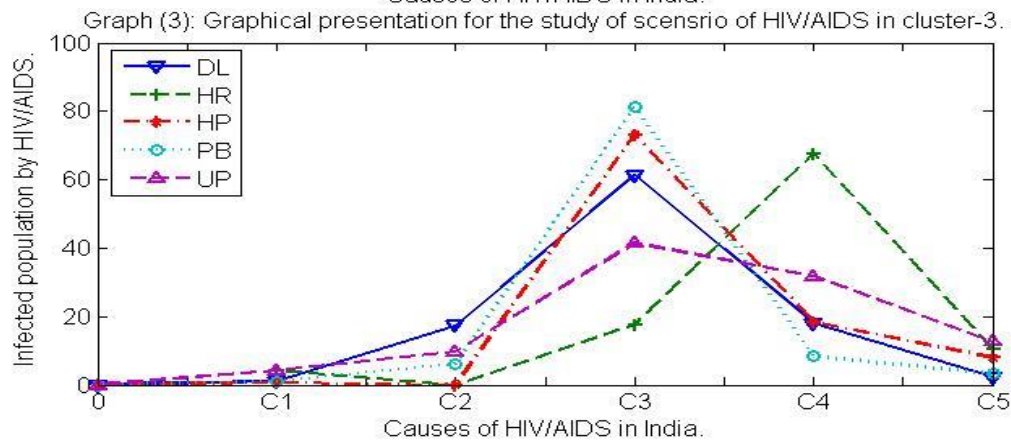
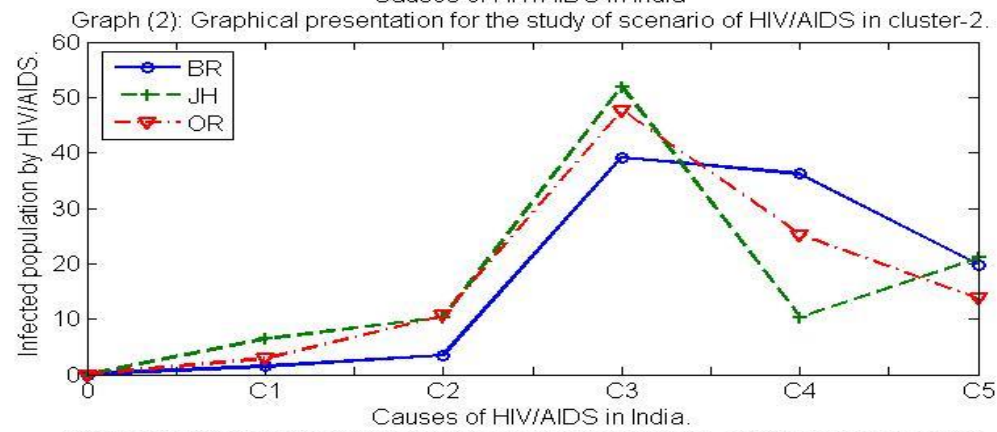
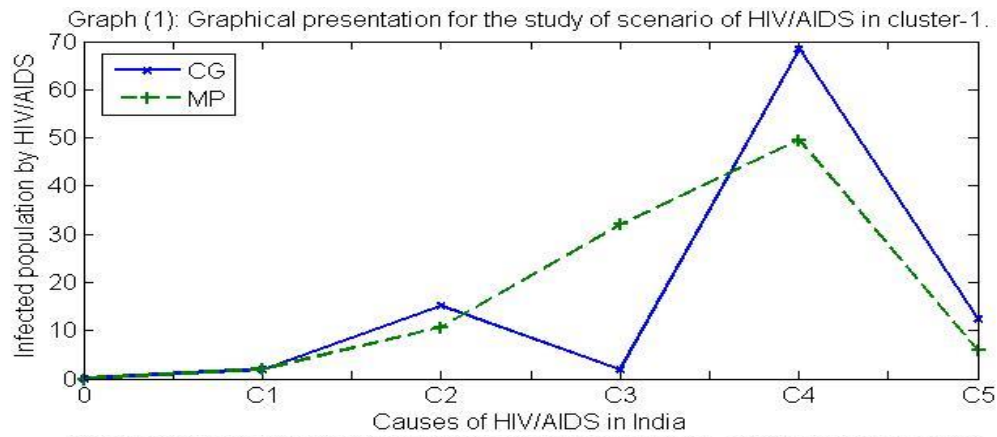
$$I_1^1 D \sim (0 \ 0 \ 0 \ 0 \ 1) D \rightarrow (0 \ 0 \ 0 \ 0 \ 0 \ 0) \quad (19)$$

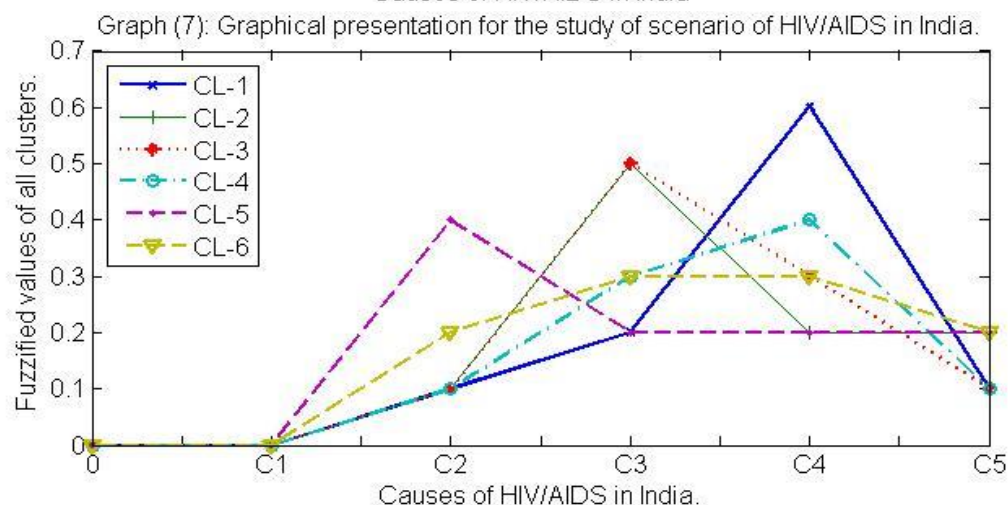
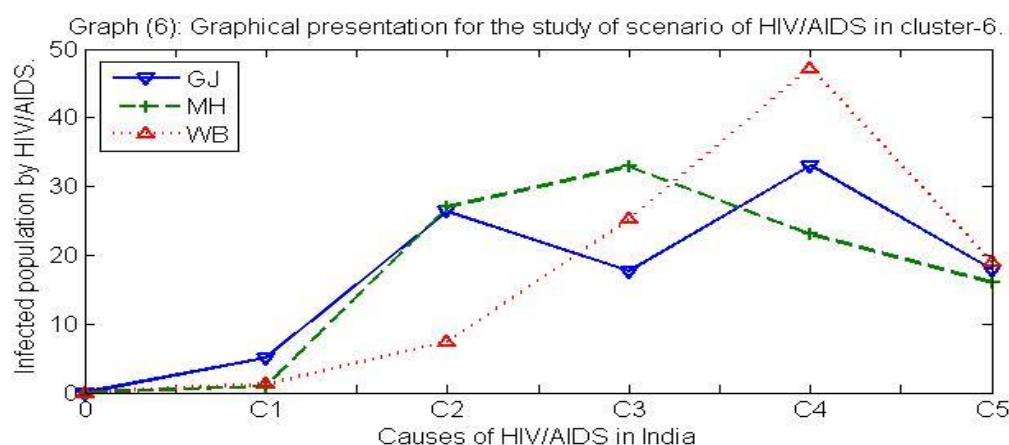
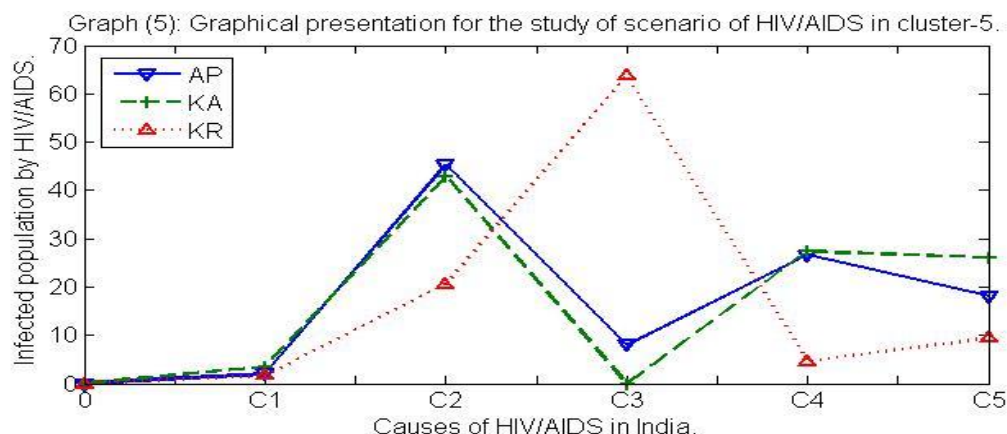
$$\text{Let } I = (0 \ 1 \ 1 \ 0 \ 0 \ 0) \quad (20)$$

Now the result of the iteration is equation (20) where the third iteration have maximum 1's in equation (17). Here it can be seen that  $CL_2$  and  $CL_3$  are associated with the third cause ( $C_3$ ). On the basis of results found by both ways now the result of Model is concluded.

### IX. Graphical presentations

Graphical presentation for the study of scenario of HIV/AIDS in clusters according to their causes to analyse sensitivity of disease in India.





## X. Conclusion

As mentioned above the paper used the process of fuzzy cluster means to prepare a mathematical model to analyze the data and after that implemented concept of fuzzy cognitive maps to establish the result. Following are the conclusions:-

- Graph (1) shows that in cluster-1(CL<sub>1</sub>) reason of HIV/AIDS infection is C<sub>4</sub> and it is maximum in CG(Chattisgarh) with 68.4% and minimum with 1.9% in same state due to Causes C<sub>3</sub>.
- Graph (2) shows that in cluster-2(CL<sub>2</sub>) reason of HIV/AIDS infection is C<sub>3</sub> and it is maximum in OR(Odisha) with 47.5% and minimum in BR(Bihar) with 1.46% due to Cause C<sub>1</sub>.
- Graph (3) shows that in cluster-3(CL<sub>3</sub>) reasons of HIV/AIDS infection is C<sub>3</sub> and it is maximum in PB(Punjab) with 81.1% and minimum in DL(Delhi) & PB(Punjab) with 1% but individually in HR(hariyana) the major problem is cause C<sub>4</sub>.
- Graph (4) shows that in cluster-4(CL<sub>4</sub>) reasons of HIV/AIDS infection are C<sub>3</sub>& C<sub>4</sub>but maximum in NL(Nagaland) with 58.8% due to cause C<sub>4</sub> and minimum in AS(Assam) with 2.3% due to Cause C<sub>1</sub>. While cause C<sub>3</sub> is highly effecting AS(Assam) and MN(Manipur).

- Graph (5) shows that in cluster-5( $CL_5$ ) reasons of HIV/AIDS infection are  $C_2$  &  $C_3$  but maximum in KR(Keral) with 63.7% due to cause  $C_3$  and minimum with 1.67% in same state due to Cause  $C_1$ . While cause  $C_2$  is highly effecting AP(Andhra prdesh) and KA(Karnataka).
- Graph (6) shows that in cluster-6( $CL_6$ ) reasons of HIV/AIDS infection are  $C_2$  &  $C_4$  but maximum in WB(west Bengal) with 47.2% due to cause  $C_4$  and minimum in MH(Maharashtra) with 0.97% due to Cause  $C_1$ . While cause  $C_2$  is highly effecting MH(Maharashtra) & GJ(Gujrat) and individually GJ(Gujrat) is suffering from cause  $C_3$ .
- Finally, using fuzzified values of all clusters, Graph (7) shows that in India the major problems are  $C_3$  &  $C_4$  where Cluster-2( $CL_2$ ) & Cluster-3( $CL_3$ ) suffering from  $C_3$  and Cluster-4( $CL_4$ ) from  $C_4$ .

As it is known that  $C_3$  is IDU-HIV prevalence- Transmission of HIV among injecting drug users in a direct way by injecting drug use as the virus is identified and  $C_4$  is MSM-HIV prevalence- Men who have sex with men. A very diverse group not only in India but all over in the world.

Above mentioned conclusions are based on Fuzzy Cluster Means. After that to establish our result we have used concept of Fuzzy Cognitive Maps and implepented this on Incidence Matrix  $D = [d_{ij}]$ . Then we have the following conclusion:

- Here the third iteration [equation (17)] shows that major problem is with Cluster-2( $CL_2$ ) and Cluster-3( $CL_3$ ) due to Cause  $C_3$ .

Hence in this paper analysed sensitivity of HIV/AIDS in India in which graphical presentation shows approx value of maximum and minimum infected population in each cluster due to any particular cause. By using Fuzzy Cluster Means method we have established that the result shown in graphs resembles with our result obtained by Fuzzy Cognitive Maps.

## XI. Future scope of the research

The research provides a deep insight to the sensitivity analysis of HIV/AIDS infection in different states of India with their probable causes of spread. The research will also help in finding out the basic problem of HIV/AIDS infection in India and its area of spread along with symptoms. So that Government agencies or Non-Government agencies can prepare a proper strategy to prevent people from such hazard disease. The study can also be used as an important asset for agencies to prepare a precise public health policy for the treatment of infected people thereby providing adequate medicines in infected area as per the prevailing causes and symptoms of HIV/AIDS in clusters.

## XII. References

- [1] A. A. Imianvan, U. F. Anosike and J. C. Obi., "An Expert System for the Intelligent Diagnosis of HIV using Fuzzy Cluster Means Algorithm", Global Journal of Computer Science and Technology, Volume 11, Issue 12, Version 1.0, 2011.
- [2] Bart Kosko, "Fuzzy Cognitive Maps", International Journal of Man-Machine Studies, Volume 24, Pp. 65-75, 1986.
- [3] C. Ramkumar, R. Ravanani and S. Narayanamoorthy, "A Fuzzy Mathematical Modeling to Analyze the Major Problems Faced by Gypsies in Tamilnadu India", International Journal of Mathematical, Archive-4(10), Pp. 101-105, 2013.
- [4] M. B. Eisen, P. T. Spellman, P. O. Brown and D. Botstein, "Cluster Analysis and Display of Genomewide Expression Pattern", Department of Genetics, Stanford University School of Medicine, United Kingdom, 1998.
- [5] R. Bharati, Jipkate and V. V. Gohokar. "A Comparative Analysis of Fuzzy C-Means Clustering and K-Means Clustering Algorithms", International Journal of Computational Engineering, Vol. 2, Issue 3, Pp. 737-739, 2012.
- [6] S. Narayanamoorthy and S. Kalaiselvan, "Adaptation of Induced Fuzzy Cognitive Maps to the Problems Faced by the Power Loom Workers", International Journal Intelligent Systems and Applications, 9, Pp.75-80, 2012.
- [7] T. Pathinathan and M. Peter, "sAdaptation of Induced Fuzzy Cognitive Maps to the Problems Faced by the Farmers in Sriperumbudur Taluk Kanchi District", International Journal of Computing Algorithm, Volume 03, Pp. 578-582, 2014.
- [8] Tb Ai Munandar, "The use of Certainty Factor with Multiple Rules for Diagnosing Internal Disease", International Journal of Application or Innovation in Engineering & Management (IAIEM), Volume 1, Issue 1, Pp. 58-64, 2012.
- [9] Victor Devadoss, D. Mary Jiny, "A Study on Finding the Key Motive of Happiness using Fuzzy Cognitive Maps (FCMs)", Indo-Bhutan International Conference on Gross National Happiness, Volume 02, Pp. 225-230, 2013.
- [10] W. R. Taber, "Fuzzy Cognitive Maps Model Social Systems", AI Expert, Volume 9, Pp. 18-23, 1994.
- [11] W. R. Taber, "Knowledge Processing with Fuzzy Cognitive Maps", Expert Systems with Applications, Volume 2, Pp. 83-87, 1991.
- [12] [www.avert.org/india-hiv-aids-statistics.htm](http://www.avert.org/india-hiv-aids-statistics.htm)