ESTIMATION OF THE MEASURES TO ELIMINATE THE USE OF ENDOSULFAN IN AGRICULTURE USING INDUCED FUZZY COGNITIVE MAPS (IFCM) MODEL

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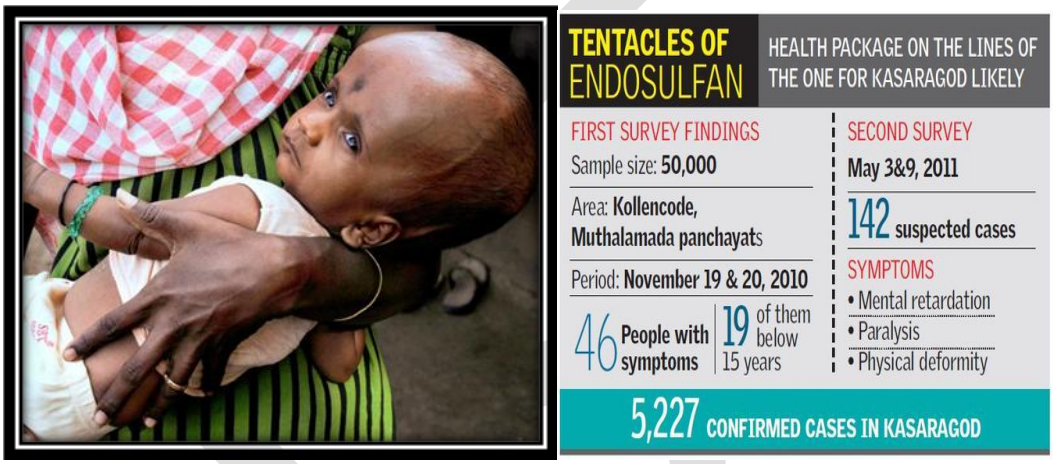
Abstract: *In this article we estimate the measures to eliminate the use of Endosulfan in agriculture which leads to most dangerous side effects in human beings faced by the people of South Indian State of Kerala, Kasargod and Palakkad Districts using Induced Fuzzy Cognitive Maps (IFCMs). We have interviewed 101 Endosulfan victims in the area of Palakkad and Kasargod Districts of Kerala. This research investigates the best measures to elimimate the use Endosulfan in agriculture by using IFCMs. IFCMs are a fuzzy graph modeling approach based on experts opinion. This is non statistical approach to study the problems with imprecise information.*

Key words: Fuzzy Cognitive Maps, Induced FCMs, Pesticide Endosulfan.

1. Introduction

Endosulfan is a pesticide which is a leading chemical used against a broad spectrum of insects and mites in agricultural products like fruits, vegetables, rice, grains, tea, coffee, cotton, rice and grains. But Endosulfan is acutely toxic and is readily absorbed by the stomach and lungs, through skin. Symptoms of acute Endosulfan exposure include central nervous system disorders such as dizzilings, vomiting, diarrhooea, breathing difficulties, convulsions, and loss of consciousness. In extreme cases, death can result. The Stockholm Convention, a global treaty to protect human health and environment from such compounds, has declared Endosulfan a persistent organic pollutant and 73 countries have banned its use. Endosulfan was banned in Kerala in 2005 after the Centre issued a gazette notification withholding the use of Endosulfan in the state, on the basis of reports of National Institute of Occupational Health and other

committees. But the ban has been ineffective. Nearly 300 landholders of Palakkad who own big plantations in the region use Endosulfan and other pesticides extensively during the flowering seasons to kill pests, leaf miners and leaf hoppers.The aerial spraying of Endosulfan over the cashew plantations in Kasargod district in Kerala was started in 1978.In this study we have interviewed 101 Enosulfan victims in Palakkad and Kasargod District Of Kerala. These people are affected with the diseases like skin diseases, mentally retardation, epilepsy, autism, etc. Our aim is to identify the cause of using Endosulfan in agriculture and find out the remedial measures for it.



2. FUZZY COGNITIVE MAPS

Fuzzy models are mathematical tools introduced by Zadeh (1965). Later Politician scientist Axelord (1976) used this fuzzy model Cognitive Map (CM) to study decision making in social and political systems. CM is signed digraph design to represent causal assertion and belief system of a person (or group experts) with respect to a specific domain, and use that statement in order to analyze the effect of a certain choice on a particular objective. Bart Kosko (1986) proposed some models which extend the idea of Cognitive Map by allowing the concept to be represented linguistically with an associated fuzzy set. This model are well suited to get a clear representation of the knowledge to support decision making process and assist in the area of computational intelligence, which involves the application of soft computing methodologies even though the given inputs are vague, uncertain and even contradictory in nature.

In order to explain what a fuzzy cognitive map (FCM) means we need to explain the three words it is composed of. The last two (Cognitive Maps) refer to the theory upon which

fuzzy cognitive mapping stems from. These two words on their own apparently define another discipline. The credit of the creation Cognitive Maps is quite rightly awarded to Edward Tolman back in 1948. Cognitive maps have been studied and used in various fields, such as psychology, education, archaeology, planning, geography, architecture, landscape architecture, urban planning and management. However, the theory of cognitive maps was fully developed from 1976 onwards. Thousands of articles and books have been written on this subject for the interested reader. Its main aim was and still is the representation of (causal) relationships among "concepts" also known as "factors" or "nodes". Concepts could be assigned values. Causal relationships between two concepts could be of three types: positive, negative or neutral. Increase in the value of a concept would yield a corresponding positive or negative increase at the concepts connected to it via relationships. The third word Fuzzy was introduced to cognitives maps in 1986 by Bart Kosko in a famous article in which he introduced the notion of fuzziness to cognitive maps and created the theory of Fuzzy Cognitive Maps (FCMs). More specifically Kosko introduced the notion of a "fuzzy weight" which in simple terms means that the relationship between two concepts, also called nodes, can take a value in the interval [-1,1]. Since then he is considered the "father" of cognitive mapping.

3. Estimating the measures to eliminate the use of Endosulfan In Agriculture By Induced Fuzzy Cognitive Maps (IFCM)

Even though IFCM is advancement of FCM it follows the foundation of FCM, it has a slight modification only in Algorithmic approaches. To derive an optimistic solution to the problem with an unsupervised data, the following steps to be followed:

3.1 Algorithmic Approach in IFCM

Step 1: For the given model (problem), collect the unsupervised data that is in determinant factors called nodes.

Step 2: According to the expert opinion, draw the directed graph.

Step 3: Obtain the connection matrix, *M*, from the directed graph (FCM). Here the number of rows in the given matrix = number of steps to be performed.

Step 4: Consider the state vector P_1^i by assigning the first component of the vector to be 1 and the rest of the components as 0. Find $P_1^i \times M$ and it is denoted by P_2

Step 5: Now each component in the P_2 vector is taken separately and product of the given Matrix is calculated. The vector which has maximum number of one's is found. The vector with maximum number of one's which occurs first is considered as Q_2.

Step 6: Product of Q_2 and M is calculated and it is modified by assigning 1 if the values of the entries are ≥ 1. Let the modified vector be $Q_2^{|}$

Step 7: Repeat step 5, till the same threshold value occurs twice. The value is considered as the fixed Point. The iteration gets terminated.

Step 8: Continue Step 1to 7 for all the state vectors and find hidden pattern.

Chemical pesticides have become a part of farming in India since the green revolution .With the growth of agrochemical industries in India, farmers have become dependent upon pesticides like endosulfan, which is cheap and easily available. Endosulfan is acutely toxic. It has been identified with the range of chronic effects and acute effects. From the sample survey taken the following 16 concepts as the measures to stop using Endosulfan are derived.

C_1 –Prohibition or restriction of production, use , import and export of Endosulfan

C_2 –Use lower risk alternative pest control practices.

C_3 –Strengthen agricultural chemical control act.

C_4 –Adopt organic, ecological and natural agriculture.

C_5- Voluntary cancellation and phase out of all existing Endosulfan

C_6 – Promote online information service on non chemical pest management.

C_7 -Use crop rotation, inter cropping, field sanitation and mechanical methods.

C_8 - Use insecticides derived from natural plant extracts, natural soaps, neem, lemon grass

C_9 - Give awareness about the ill effects of Endosulfan

C_{10} - Give severe punishment for using Endosulfan

C_{11} - Support of Govt. and research Institutions

C_{12} - Involve NGO organizations.

C_{13} - Educated younger generation to enter agriculture.

C_{14} - Give free organic pesticides to farmers.

C_{15} - Improve the status of farmers by giving incentives and loans by Govt.

C_{16} - Award the informer on Endosulfan.

4. Selection of concepts for the study

C_1 –Prohibition or restriction of production, use, import and export

Ultimately, the action most ably protecting human and environmental health would be the withdrawal from sale of Endosulfan. This requires the agrochemical industry to rapidly phase out production of Endosulfan and to dispose of all stockpiles safely.At the Stockholm Convention, India had agreed to phase out the use of Endosulfan by 2017. The farmers must consiciously stop using Endosulfan.

C_2 –Use lower risk alternative pest control practices

Alternative pest control practices reduce or eliminate the use of chemical pesticides. These ecological options improve the surrounding land and livelihood of farmers by eliminating the dependency on toxic insecticides, promoting local markets, and reducing food poverty by creating a long-term food source. These agroecological practices have shown to cost less for farmers than conventional practices, and in some cases, they cost nothing.

C_3 –Strengthen agricultural chemical control act

Our nation's main statute governing chemicals policy — The Toxic Substances Control Act (TSCA) — is seriously flawed and needs fundamental reform.Unlike every other major environmental law, the statute has never been significantly amended since it was adopted, from 1976.An Act to control and regulate the manufacture, storage, distribution and

trade in use, importation and exportation of agricultural chemicals and for other purposes connected therewith.

C_4 –Adopt organic, ecological and natural agriculture.

Organic agriculture is an ecological production management system that promotes and enhances biodiversity, biological cycles and soil biological activity. It is based on minimal use of off-farm inputs and on management practices that restore, maintain and enhance ecological harmony. Increasing environmental awareness in the general population in modern times has transformed the originally supply-driven organic movement to a demand-driven one. Premium prices and some government subsidies attracted farmers.

C_5- Voluntary cancellation and phase out of all existing endosulfan

At the Stockholm Convention, India had agreed to phase out the use of Endosulfan by 2017.The Conference of Parties to the Stockholm Convention on Persistent Organic Pollutants, meeting in Geneva, approved non-chemical as well as chemical alternatives to Endosulfan .The farmers should realize and come out voluntarily with existing Endosulfan and promise not to use it anymore.

C_6 – Promote online information service for non chemical pest management.

Online Information Service for non-chemical pest management in the Tropics (OISAT) offers easy to read web-based information, relevant for small scale farmers in the tropics on how to produce key crops using affordable preventive and curative non-chemical crop and pest management practices in a way that prevent pests and diseases by using non-chemical pest control measures. OISAT Partner Network is a platform for information dissemination, information sharing/exchange, and the integration of the online information into training and extension services. Thus an effective and efficient information flow from web to field will be ensured.

C_7 –Use crop rotation, inter cropping, field sanitation and mechanical methods

Crop rotation is one of the oldest and most effective cultural control strategies. It means the planned order of specific crops planted on the same field. It also means that the succeeding crop belongs to a different family than the previous one. The planned rotation may vary from 2

or 3 year or longer period. Advantages of crop rotation are Prevents soil depletion, Maintains soil fertilityReduces soil erosion, Controls insect/mite pests, Crop rotation as a means to control to insect pests is most effective when the pests are present before the crop is planted have no wide range of host crops; attack only annual/biennial crops; and do not have the ability to fly from one field to another, Reduces reliance on synthetic chemicals ,Reduces the pests' build-up and prevents diseases helps control weeds. Intercropping is the cultivation of two or more crops simultaneously on the same field.. Mechanical control methods are those that physically prevent the pest from attacking or injuring the crop. Hand weeding and use of fences to exclude deer and other wildlife are examples of mechanical, or physical controls. Mechanical controls such as vacuums, flaming, row covers, hand picking can all work but may have high cost. Sanitation involves the removal of material which allows pests to survive or be transported between plants or crops.

C_8-Use insecticides derived from natural plants extracts, natural soaps, neem, lemon grass

Fortunately, there are a ton of effective techniques and natural products out there to help you deal with pests without chemicals. Nature has given us plant extracts that make very effective pesticides and insect repellents. For example, some organic pest control products such as Orange Guard use a citrus-fruit peel base, such as from lemons and oranges. Citrus oils kill many flying and crawling insects on contact by destroying the waxy coating of the insect's respiratory system.

Some products use garlic or hot peppers and essential oils of herbs such as cloves to repel insects and other pests. Neem is a plant from India that has natural abilities to repel common pests. Combined with soapy water, this neem-based insecticide is a powerful and safe form of pest control.

C_9-Give awareness about the ill effects of Endosulfan

Education to farmers about judicious use of chemical pesticides and adopting good agricultural practices & ill effects of indiscriminate use of chemical pesticides. Awareness about harmful effects of chemical pesticides, specially to farmers as they and their families will be exposed to it first. Use all medias to give awareness about ill effects of Endosulfan.They should

be taught how to protect them from the deadly poison, to have regular follow up to health centres.

C_{10}-Give severe punishment for using Endosulfan

Delhi Health Minister A. K. Walia has said that the State Government would be enforcing the new Food Safety and Standard Act-2006 within the next three months, thereby ensuring heavy fine and punishment of up to life imprisonment for adulteration. Increasing the punishment, besides fine, incorporate stringent provision of punishment to all offenders in the Food Safety and Standards Act, 2006 of food chain such as manufacturer/importer, dealer/retailer, farmer.

C_{11}-Support of Govt. and research Institutions

Endosulfan has been banned across 74 countries in all the continents after elaborate studies. In our own country Kerala and Karnataka have banned this chemical after finding health and environment damages. But it is not followed strictly in Kerala. Use of Bio-pesticides to be encouraged. To encourage the use of Bio-pesticides, farmers should be given assistance/subsidy by Government. Though alternatives to Endosulfan are available, support for such practices are very low.If Government and research institution can support such work, use of Endosulfan can be totally eliminated in agriculture and other sectors. Government should build canals, pumps and also provide electricity at low cost for watering. They should also make aware to the farmers about new good technologies for watering. Government is providing loan to farmers but for that in some of the areas they have to pay bribe, for example a loan of 50,000 they pay bribe as 5000. So the government should take strong action against this.

C_{12}-Involve NGO organizations.

Below is a detailed chronology of CSE's campaign against Endosulfan and the tactics the pesticides industries used to suppress information, distort truth and discredit the whistle blowersGovernment started taking note after 2000. From then committees of various departments, Non Governmental Organizations, Indian Council of Medical Research and other agencies conducted visits to the area, conducted studies and surveys to understand the relation between aerial spraying of endosulfan and the sudden spurt of health problems in the village.

All studies recommended banning of aerial spray of Endosulfan in the area, accepted the evident lapses in precautionary measures followed by the PCK and acknowledged the fact that there were indeed a large number of people health abnormalities.

C_{13}-Educated younger generation to enter agriculture

Engaging youth in agriculture has been a prominent topic recently and has risen up the development agenda, as there is growing concern worldwide that young people have become disenchanted with agricultureAdd Agriculture to the Curriculum.Offer Young Farmers a Voice Farming offers the young generation a chance to make a difference by growing enough food to feed the world.Those who become farmers now have the opportunity to be the generation that end world hunger and alleviate malnutrition, as well as helping the sector adapt to climate change. As we look to find solutions to feeding a world of nine billion people by 2050, it is this new generation that – working together – can help to achieve global development.

C_{14}- Give free organic pesticides to farmers

Organic foods are defined as those foods that are grown without the use of synthetic fertilizers or pesticides. Pesticides are chemical or control agents made to kill insects, weeds and fungal pests that damage crops. In large amounts these have been found to cause different illnesses including cancer.

C_{15}- Improve the status of farmers by giving incentives and loans by Govt

In order to improve farmer's conditions Government must know their problems which are as follows:

1. Fear of loss due to either drought or storm
2. Lack of proper knowledge about modern farming among the farmers.
3. Lack of knowledge about the facilities provided by government
4. For some segments essential commodities act is becoming a big pain.

5. Lack of man power

6. Lack of water resource

Government should provide proper subsidy for seed and fertilizer Farmers are still using old model tractors and other machines. Some advance model machines are also available but they are costly. So government should provide subsidy on such machinery.The government should buy directly from farmers at a proper rate without middle manGovernment should send agriculture scientists in each village panchyat and educate the farmers about which type of crop they should grow in which type of soil.

C_{16}-Award the informer on endosulfan

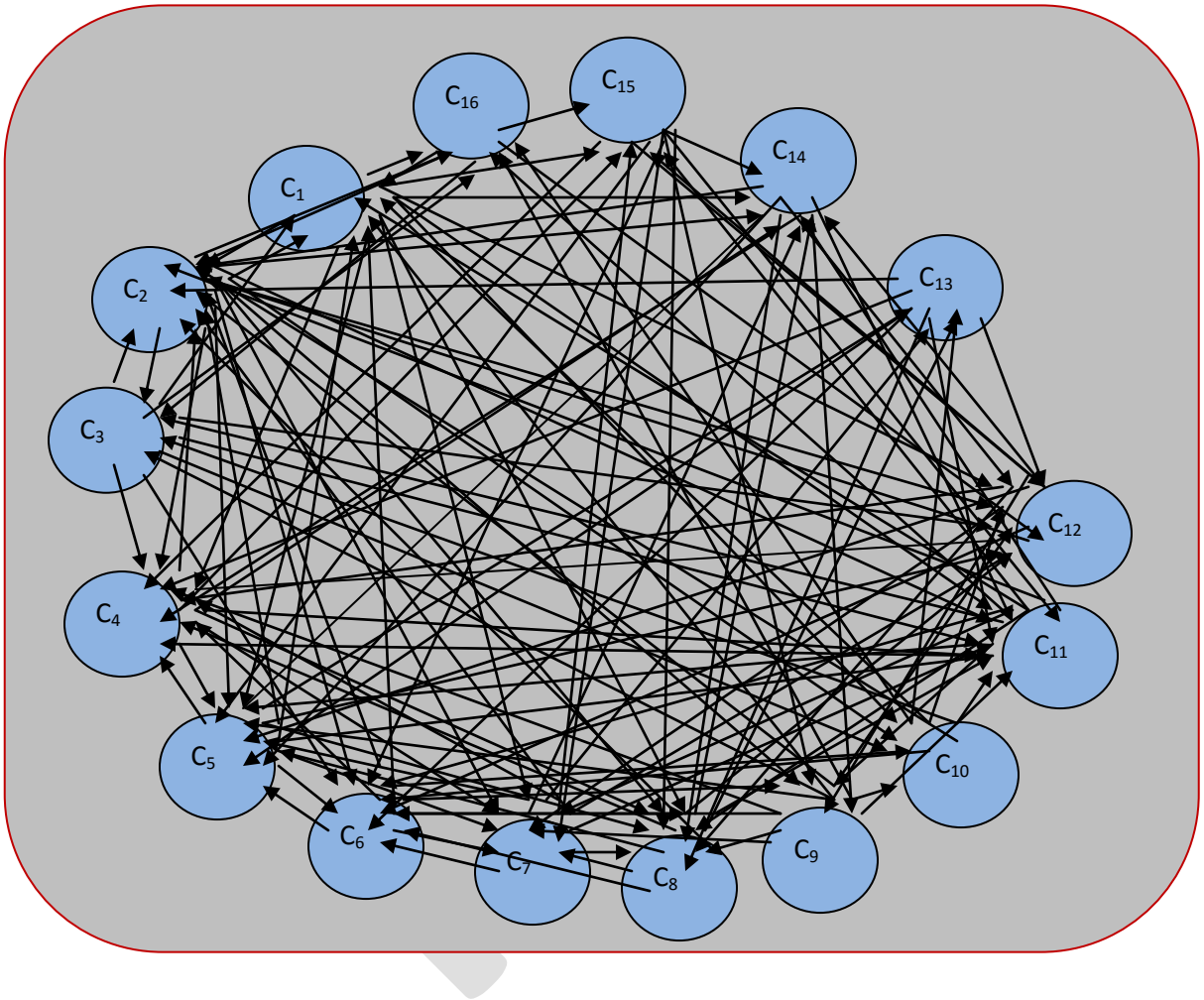
Give some award to the informer who tells about the usage of Endosulfan after the ban. Also give that news to media and newspapers. Such a propaganda can reduce the usage of Endosulfan .Slowly we can stop the usage completely using herbal pesticides.

5. Implementation of IFCM model to the study

Induced Fuzzy Cognitive Maps (IFCM) is an advancement of FCM .The method is same as that of FCM until P_2 is calculated. Each component in P_2 vector is taken separately and multiplied with matrix M. Among these vectors, the vector which has the maximum number of 1's for the first time is considered as Q_2.Then the same procedure is repeated as done for P_2 until a fixed point is obtained.

5.1 Implementation of IFCM model to the study

Now taking the above 16 concepts as fuzzy node we proceed to give the directed graph using an expert's opinion.



$$M = \begin{array}{c} \\ C_1 \\ C_2 \\ C_3 \\ C_4 \\ C_5 \\ C_6 \\ C_7 \\ C_8 \\ C_9 \\ C_{10} \\ C_{11} \\ C_{12} \\ C_{13} \\ C_{14} \\ C_{15} \\ C_{16} \end{array} \begin{array}{c} \begin{array}{cccccccccccccccc} C_1 & C_2 & C_3 & C_4 & C_5 & C_6 & C_7 & C_8 & C_9 & C_{10} & C_{11} & C_{12} & C_{13} & C_{14} & C_{15} & C_{16} \end{array} \\ \begin{bmatrix} 0 & 1 & 0 & 1 & 1 & 0 & 1 & 1 & 0 & 1 & 1 & 1 & 0 & 1 & 1 & 1 \\ 1 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 & 0 & 1 \\ 1 & 1 & 0 & 1 & 0 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 & 1 & 0 & 1 & 1 & 0 & 0 & 1 & 1 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 1 & 0 & 1 & 1 & 1 & 0 & 0 & 1 & 1 & 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 1 & 1 & 0 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 1 & 1 & 0 & 1 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 0 \\ 0 & 1 & 0 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 0 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 1 \\ 1 & 1 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 1 & 1 & 1 \\ 0 & 1 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 1 & 1 & 1 & 0 & 1 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 1 & 0 & 0 & 1 & 1 & 0 & 1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 & 1 & 0 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 \end{bmatrix} \end{array}$$

5.2 Trial 1

Consider P_1^1 in the trial 1, by setting the concept C_1 to ON state, that is the first component of the vector is set to be 1 and the rest are assigned to be 0.

Then ,P_1^1 = (1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0)

Product of P_1^1 and M is calculated.

P_1^1M=(0 1 0 1 1 0 1 1 0 1 1 1 0 1 1 1) =P_2

Now as per Induced Fuzzy Cognitive Map methodology, each component in the P_2 vector is taken separately and product of the given matrix is calculated. The vector which has the maximum number of one's which occurs first is considered as Q_2

$P_2M \approx$

(0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0)M= (1 0 1 1 1 1 1 1 1 1 1 0 1 0 1)= Q_2

(0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0)M= (0 1 0 0 1 0 1 1 0 0 1 1 0 1 1 0)

(0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0)M= (0 1 0 1 1 1 1=0 1 0 0 1 1 1 1 1 0)

(0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0)M= (0 1 0 1 1 1 1 0 0 0 1 1 1 1 0 0)

(0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0)M= (1 1 1 0 0 1 0 0 0 0 1 1 1 0 0 1)

(0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0)M= (1 1 1 1 1 1 1 1 1 0 0 0 0 1 1 1)

(0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0)M= (0 1 0 1 1 1 1 1 1 0 0 0 0 1 1 0)

(0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0)M= (0 1 0 1 1 0 0 1 1 0 1 1 0 0 0 0)

(0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1)M= (0 0 0 1 1 1 1 1 1 0 1 1 0 1 0 0)

(0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0)M= (1 1 1 0 0 0 0 0 0 0 0 1 0 0 1 0)

Q_2=(1 0 1 1 1 1 1 1 1 1 1 1 0 1 0 1) ≠P_2, so the iteration continues

Product of Q_2 and M is calculated and modified by assigning 1 if the values of the entries are ≥1

Let the modified vector be $Q_2^{|}$

Q_2M= (6 13 6 12 11 10 11 6 6 11 11 5 8 7 6 5) ↪(1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1)= $Q_2^{|}$.

Now each component in the vector $Q_2^{|}$ is taken separately and product of it with the given matrix is calculated.The vector which has maximum number of one's is found and is called R_3

$Q_2^{|}$M ≈

(1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0)M =(0 1 0 1 1 0 1 1 0 1 1 1 0 1 1 1)

(0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0)M= (1 0 1 1 1 1 1 1 1 1 1 1 0 1 0 1)= R_3

(0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0)M= (1 1 0 1 0 1 0 0 0 1 1 1 0 0 0 1)

(0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0)M= (0 1 0 0 1 0 1 1 0 0 1 1 0 1 1 0)

(0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0)M= (0 1 0 1 0 1 1 1 0 0 1 1 1 1 0 0)

(0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0)M= (1 1 0 1 1 0 1 1 1 1 0 0 0 0 0 0)

(0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0)M= (0 1 0 1 1 1 0 1 0 0 1 1 1 1 1 0)

(0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0)M= (0 1 0 1 1 1 1 0 0 0 1 1 1 1 0 0)

(0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0)M= (1 1 1 1 1 1 1 1 0 1 1 1 0 0 0 1)

(0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0)M= (1 1 1 0 0 1 0 0 0 0 1 1 1 0 0 1)

(0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0)M= (1 1 1 1 1 1 1 1 1 0 0 0 0 1 1 1)

(0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0)M= (0 1 0 1 1 1 1 1 1 0 0 0 0 1 1 0)

(0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0)M= (0 1 0 1 1 1 0 1 0 0 1 1 0 0 0 0)

(0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0)M= (0 1 0 1 1 0 0 1 1 0 1 1 0 0 0 0)

(0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0)M= (0 0 0 1 1 1 1 1 1 0 1 1 0 1 0 0)

(0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1)M↪=(1 1 1 0 0 0 0 0 0 0 0 1 0 0 1 0)

Here R_3=(1 0 1 1 1 1 1 1 1 1 1 1 0 1 0 1)=Q_2. Hence the fixed point is (1 0 1 1 1 1 1 1 1 1 1 1 0 1 0 1).

The triggering pattern is $C_1 \rightarrow C_2 \rightarrow C_2$

5.3 Trial 2

The calculation for Trial 2 is performed similar to the Trial 1,. Consider P_1^2 by setting C_2 in ON state that is, assigning the second component of the vector to be 1 and the rest of the component as 0.

Let P_1^2=(0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0)

Product of P_1^2 and M is calculated.

P_1^2M= (0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0)M =(1 0 1 1 1 1 1 1 1 1 1 1 0 1 0 1)=P_2

Now each component in the P_2 vector is taken separately and product of it with the given matrix is calculated. The vector which has the maximum number of one's which occurs first is considered as Q_2

P_2M ≈

(1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0)M= (0 1 0 1 1 0 1 1 0 1 1 1 0 1 1 1)

(0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0)M= (1 1 0 1 0 1 0 0 0 1 1 1 0 0 0 1)

(0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0)M= (0 1 0 0 1 0 1 1 0 0 1 1 0 1 1 0)

(0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0)M= (0 1 0 1 0 1 1 1 0 0 1 1 1 1 0 0)

(0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0)M= (1 1 0 1 1 0 1 1 1 1 0 0 0 0 0 0)

(0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0)M= (0 1 0 1 1 1 0 1 0 0 1 1 1 1 1 0)

(0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0)M= (0 1 0 1 1 1 1 0 0 0 1 1 1 1 0 0)

(0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0)M= (0 1 0 1 1 1 1 0 0 0 1 1 1 1 0 0)

(0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0)M= (1 1 1 1 1 1 1 1 0 1 1 1 0 0 0 1)= Q_2

(0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0)M= (1 1 1 0 0 1 0 0 0 0 1 1 1 0 0 1)

(0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0)M= (1 1 1 1 1 1 1 1 0 0 0 0 1 1 1)

(0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0)M= (0 1 0 1 1 1 1 1 0 0 0 0 1 1 0)

(0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0)M= (0 1 0 1 1 0 0 1 1 0 1 1 0 0 0 0)

(0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1)M= (1 1 1 0 0 0 0 0 0 0 0 1 0 0 1 0)

That is, Q_2 =(1 1 1 1 1 1 1 1 0 1 1 1 0 0 0 1) $\neq P_2$, So the iteration continues

Then Q_2M is calculated and modified by assigning 1 if the values of the entries are ≥ 1. Let the modified vector be $Q_2^{|}$

Q_2M = (5 11 4 9 8 8 8 8 4 4 4 9 3 8 6 5) $\hookrightarrow$ (1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1) = $Q_2^{|}$

Now each component in the vector $Q_2^{|}$ is taken separately and product of it with given matrix is calculated. The vector which has maximum number of 1s is found and is called R_3.

$Q_2^{|}M \approx$

(1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0)M =(0 1 0 1 1 0 1 1 0 1 1 1 0 1 1 1)

(0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0)M= (1 0 1 1 1 1 1 1 1 1 1 0 1 0 1)= R_3

(0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0)M= (1 1 0 1 0 1 0 0 0 1 1 1 0 0 0 1)

(0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0)M =(0 1 0 0 1 0 1 1 0 0 1 1 0 1 1 0)

(0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0)M =(0 1 0 1 0 1 1 1 0 0 1 1 1 1 0 0)

(0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0)M= (1 1 0 1 1 0 1 1 1 1 0 0 0 0 0 0)

(0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0)M= (0 1 0 1 1 1 0 1 0 0 1 1 1 1 1 0)

(0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0)M= (0 1 0 1 1 1 1 0 0 0 1 1 1 1 0 0)

(0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0)M= (1 1 1 1 1 1 1 1 0 1 1 1 0 0 0 1)

(0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0)M= (1 1 1 0 0 1 0 0 0 0 1 1 1 0 0 1)

(0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0)M =(1 1 1 1 1 1 1 1 0 0 0 0 1 1 1)

(0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0)M=(0 1 0 1 1 1 1 1 1 0 0 0 0 1 1 0)

(0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0)M =(0 1 0 1 1 1 0 1 0 0 1 1 0 0 0 0)

(0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0)M= (0 1 0 1 1 0 0 1 1 0 1 1 0 0 0 0)

(0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0)M= (0 0 0 1 1 1 1 1 1 0 1 1 0 1 0 0)

(0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1)M= (1 1 1 0 0 0 0 0 0 0 0 1 0 0 1 0)

Now the vector with maximum number of 1's be R_3.

R_3.=(1 0 1 1 1 1 1 1 1 1 1 1 0 1 0 1) $\neq$ Q_2.So the iteration continues.

Then R_3M is calculated and modified by assigning 1 if the values of the entries are ≥ 1. Let the modified vector be $R_3^{|}$

R_3M=(6 11 4 9 8 8 8 8 3 4 8 9 3 7 5 5))↪(1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1)= $R_3^{|}$

Now each component in the vector $R_3^{|}$ is taken separately and product of it with the given matrix is calculated. The vector which has maximum number of 1s is found and is called S_4.

$R_3^{|}M \approx$

(1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0)M =(0 1 0 1 1 0 1 1 0 1 1 1 0 1 1 1)

(0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0)M=(1 0 1 1 1 1 1 1 1 1 1 1 0 1 0 1)= S_4

(0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0)M= (1 1 0 1 0 1 0 0 0 1 1 1 0 0 0 1)

(0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0)M=(0 1 0 0 1 0 1 1 0 0 1 1 0 1 1 0)

(0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0)M= (0 1 0 1 0 1 1 1 0 0 1 1 1 1 0 0)

(0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0)M= (1 1 0 1 1 0 1 1 1 1 0 0 0 0 0 0)

(0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0)M= (0 1 0 1 1 1 0 1 0 0 1 1 1 1 1 0)

(0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0)M= (0 1 0 1 1 1 1 0 0 0 1 1 1 1 0 0)

(0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0)M= (1 1 1 1 1 1 1 1 0 1 1 1 0 0 0 1)

(0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0)M= (1 1 1 0 0 1 0 0 0 0 1 1 1 0 0 1)

(0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0)M =(1 1 1 1 1 1 1 1 1 0 0 0 0 1 1 1)

(0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0)M=(0 1 0 1 1 1 1 1 1 0 0 0 0 1 1 0)

(0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0)M =(0 1 0 1 1 1 0 1 0 0 1 1 0 0 0 0)

(0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0)M= (0 1 0 1 1 0 0 1 1 0 1 1 0 0 0 0)

(0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0)M= (0 0 0 1 1 1 1 1 1 0 1 1 0 1 0 0)

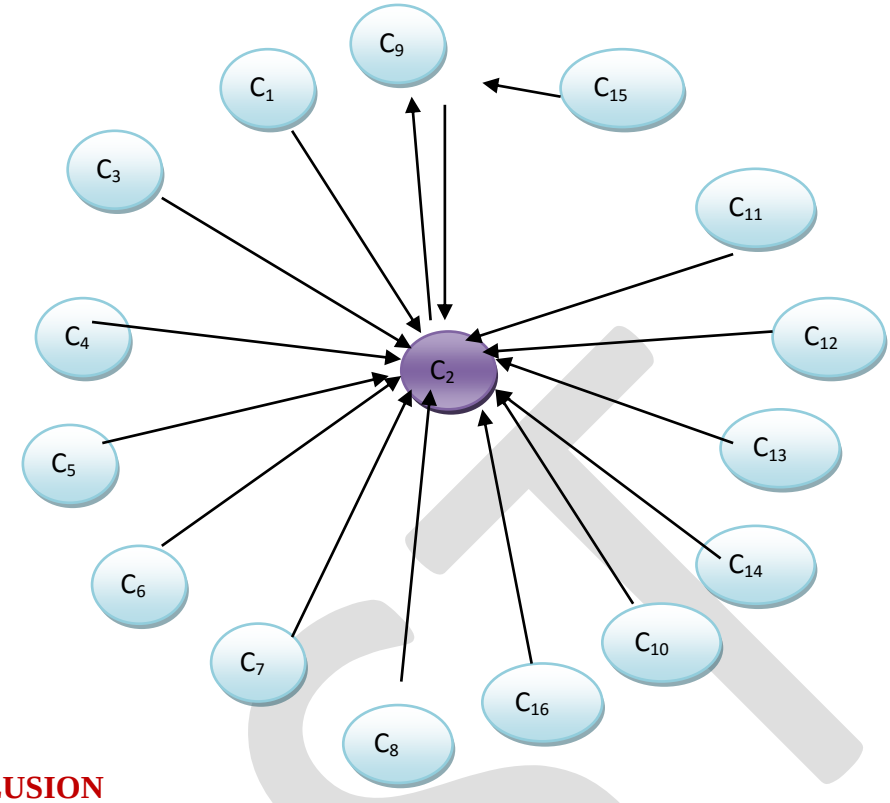
(0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1)M= (1 1 1 0 0 0 0 0 0 0 0 1 0 0 1 0)

Here R_3=(1 0 1 1 1 1 1 1 1 1 1 1 0 1 0 1)= S_4 . Hence the fixed point is =(1 0 1 1 1 1 1 1 1 1 1 1 0 1 0 1) . Here the triggering pattern is $C_2 \rightarrow C_9 \rightarrow C_2 \rightarrow C_2$.

A C++ Computer Program (Appendix 1) is used to find out the triggering patterns when other attributes are kept in ON state. The following table gives the triggering patterns for each concept.

Number	Attribute on State	Triggering Pattern
Concept 1	C_1: (1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0)	$C_1 \rightarrow C_2 \rightarrow C_2$
Concept 2	C_2: (0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0)	$C_2 \rightarrow C_9 \rightarrow C_2 \rightarrow C_2$
Concept 3	C_3: (0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0)	$C_3 \rightarrow C_2 \rightarrow C_2$
Concept 4	C_4: (0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0)	$C_4 \rightarrow C_2 \rightarrow C_2$
Concept 5	C_5: (0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0)	$C_5 \rightarrow C_2 \rightarrow C_2$
Concept 6	C_6: (0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0)	$C_6 \rightarrow C_2 \rightarrow C_2$
Concept 7	C_7: (0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0)	$C_7 \rightarrow C_2 \rightarrow C_2$
Concept 8	C_8: (0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0)	$C_8 \rightarrow C_2 \rightarrow C_2$
Concept 9	C_9: (0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0)	$C_9 \rightarrow C_2 \rightarrow C_2$
Concept 10	C_{10}: (0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0)	$C_{10} \rightarrow C_2 \rightarrow C_2$
Concept 11	C_{11}: (0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0)	$C_{11} \rightarrow C_2 \rightarrow C_2$
Concept 12	C_{12}: (0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0)	$C_{12} \rightarrow C_2 \rightarrow C_2$
Concept 13	C_{13}: (0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0)	$C_{13} \rightarrow C_2 \rightarrow C_2$
Concept 14	C_{14}: (0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0)	$C_{14} \rightarrow C_2 \rightarrow C_2$
Concept 15	C_{15}: (0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0)	$C_{15} \rightarrow C_9 \rightarrow C_2 \rightarrow C_2$
Concept 16	C_{16}: (0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1)	$C_{16} \rightarrow C_2 \rightarrow C_2$

Merging of all these graphs on a single graph , the following graph is obtained.



6. CONCLUSION

All the concepts except C_{15} have direct impact to the same fixed point. **(1 0 1 1 1 1 1 1 1 1 1 0 1 0 1)** which is the vector corresponding to the concept C_2. Hence, the interrelationships between the attributes reveal that C_2-*"Use lower risk alternative pest control practices.*" is the terminal node.The triggering pattern $C_2 \rightarrow C_9 \rightarrow C_2 \rightarrow C_2$ implies that C_9-*Give awareness about the ill effects of Endosulfan* plays the role of intermediary node. The limiting point corresponding to C_2(1 0 1 1 1 1 1 1 1 1 1 0 1 0 1) highlights that attribute C_1, C_3, C_4, C_5, C_6, C_7, C_8, C_9, C_{10}, C_{11}, C_{12}, C_{14}, C_{16} which seem to be the major measures to stop the usage of Endosulfan in agriculture.Hence the conclusion arrived in this model is that the major measures to stop the usage of Endosulfan are:

C_1 –Prohibition or restriction of production, use, import and export

C_2 – Ues lower risk alternative pest control practices

C_3 –strengthen agricultural chemical control act.

C_4 –Adopt organic, ecological and natural agriculture.

C_5- Voluntary cancellation and phase out of all existing Endosulfan

C_6 – Provide online information service for non chemical pest management.

C_7 –Use crop rotation, inter cropping, field sanitation and mechanical methods.

C_8-Use insecticides derived from natural plants extracts, natural soaps, neem, lemon grass

C_9-Give awareness about the ill effects of Endosulfan

C_{10}-Give severe punishment for using Endosulfan

C_{11}-Support of Govt. and research Institutions

C_{12}-Involve NGO organizations.

C_{14}- Give free organic pesticides to farmers.

C_{16}-Award the informer on Endosulfan.

2. The triggering pattern shows that C_2 and C_9 are related. ie, Giving awareness about the ill effects of Endosulfan to the farmers will result in the usage of lower risk alternative pest control practices.

7. C++ program for IFCM

(Appendix 1)

```
#include<stdio.h>
#include<conio.h>
void main()
{
 int M[16][16]={

{0,1,0,1,1,0,1,1,0,1,1,1,0,1,1,1},

{1,0,1,1,1,1,1,1,1,1,1,1,0,1,0,1},

{1,1,0,1,0,1,0,0,0,1,1,1,0,0,0,1},

{0,1,0,0,1,0,1,1,0,0,1,1,0,1,1,0},

{0,1,0,1,0,1,1,1,0,0,1,1,1,1,0,0},

{1,1,0,1,1,0,1,1,1,1,0,0,0,0,0,0},

{0,1,0,1,1,1,0,1,0,0,1,1,1,1,1,0},

{0,1,0,1,1,1,1,0,0,0,1,1,1,1,0,0},

{1,1,1,1,1,1,1,1,0,1,1,1,0,0,0,1},

{1,1,1,0,0,1,0,0,0,0,1,1,1,0,0,1},

{1,1,1,1,1,1,1,1,1,0,0,0,1,1,1,1},

{0,1,0,1,1,1,1,1,1,0,0,0,0,1,1,0},

{0,1,0,1,1,1,0,1,1,0,0,1,0,1,0,0},

{1,1,1,0,1,1,1,1,1,0,1,1,0,0,0,0},

{0,0,0,1,1,1,1,1,1,0,1,1,0,1,0,0},

{1,1,1,0,0,0,0,0,0,0,1,0,0,1,0}}
;
  int
X1[1][16]={{1,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,0}};
 int
X2[1][16]={{0,1,0,0,0,0,0,0,0,0,
0,0,0,0,0,0}};
 int
X3[1][16]={{0,0,1,0,0,0,0,0,0,0,
0,0,0,0,0,0}};
 int
X4[1][16]={{0,0,0,1,0,0,0,0,0,0,
0,0,0,0,0,0}};
 int
X5[1][16]={{0,0,0,0,1,0,0,0,0,0,
0,0,0,0,0,0}};
 int
X6[1][16]={{0,0,0,0,0,1,0,0,0,0,
0,0,0,0,0,0}};
 int
X7[1][16]={{0,0,0,0,0,0,1,0,0,0,
0,0,0,0,0,0}};
 int
X8[1][16]={{0,0,0,0,0,0,0,1,0,0,
0,0,0,0,0,0}};
 int
X9[1][16]={{0,0,0,0,0,0,0,0,1,0,
0,0,0,0,0,0}};
```

```
 int
X10[1][16]={{0,0,0,0,0,0,0,0,0,0,
1,0,0,0,0,0,0,0}};
 int
X11[1][16]={{0,0,0,0,0,0,0,0,0,0,
0,1,0,0,0,0,0,0}};
 int
X12[1][16]={{0,0,0,0,0,0,0,0,0,0,
0,0,1,0,0,0,0,0}};
 int
X13[1][16]={{0,0,0,0,0,0,0,0,0,0,
0,0,0,1,0,0,0,0}};
 int
X14[1][16]={{0,0,0,0,0,0,0,0,0,0,
0,0,0,0,1,0,0,0}};
 int
X15[1][16]={{0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,1,0,0}};
 int
X16[1][16]={{0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,0,1,0}};
  int
X[1][16],R[1][16],nX[1][16],nR
[1][16],max_nR[1][16],pre_X[1
][16];
 int
i,j,s,k,m,r,prnt,rep=0,lmt,count,p
os,ones,ones2,max_ones2,eql=1,
ones_pos=1,onspos;
 clrscr();
 printf("IFCM_C4\n");

printf("==================
=======================
=======================
=====");

 main_repeate:

 for(j=0;j<16;j++)
 {
  if(ones_pos==1)
    X[0][j]=X1[0][j];
  else if(ones_pos==2)
    X[0][j]=X2[0][j];
  else if(ones_pos==3)
    X[0][j]=X3[0][j];
  else if(ones_pos==4)
    X[0][j]=X4[0][j];
  else if(ones_pos==5)
    X[0][j]=X5[0][j];
  else if(ones_pos==6)
    X[0][j]=X6[0][j];
  else if(ones_pos==7)
    X[0][j]=X7[0][j];
  else if(ones_pos==8)
    X[0][j]=X8[0][j];
  else if(ones_pos==9)
    X[0][j]=X9[0][j];
  else if(ones_pos==10)
    X[0][j]=X10[0][j];
  else if(ones_pos==11)
    X[0][j]=X11[0][j];
  else if(ones_pos==12)
    X[0][j]=X12[0][j];
  else if(ones_pos==13)
    X[0][j]=X13[0][j];
  else if(ones_pos==14)
    X[0][j]=X14[0][j];
  else if(ones_pos==15)
    X[0][j]=X15[0][j];
  else if(ones_pos==16)
    X[0][j]=X16[0][j];

 }
  printf("\nA * ");
 for(j=0;j<16;j++)
 {
   printf("%d ",X[0][j]);
 }
 printf(" = ");
 repeate:
 /**************Multiply the
Matrix M with Matrix
X***************/

 for(j=0;j<16;j++)
 {
  s=0;
  for(k=0;k<16;k++)
  {
    m=X[0][k]*M[k][j];
    s=s+m;
  }
  R[0][j]=s;
 }

 /***convert all numbers except
zero into
one********************/
 for(j=0;j<16;j++)
 {
   if(R[0][j]==0)
              X[0][j]=0;
   else
              X[0][j]=1;
   onspos=ones_pos-1;

   /*** change the value to one at
ones location****************/
   if(X[0][onspos]==0)
          X[0][onspos]=1;
 }
 /********** Check previous
result is equal to current result
*****/

  if(rep!=0)
  {
    eql=0;
    for(j=0;j<16;j++)
    {
     if(X[0][j]!=pre_X[0][j])
     {
      eql=eql+1;
     }
    }
    if(eql==0)
      goto finish;
  }

    /***************** Store X
matrix into pre_X ***********/

  for(j=0;j<16;j++)
  {
    pre_X[0][j]=X[0][j];
  }


 /********** Count Total ones
*****/

  ones=0;
  for(j=0;j<16;j++)
  {
   if(X[0][j]==1)
    ones=ones+1;
  }

  max_ones2=0;
  count=1;

  mult:
  /******* Find 1's position
********/

  for(j=0;j<16;j++)
  {
   if(X[0][j]==1)
   {
     pos=j;
     X[0][j]=0;
     break;
```

```
  }
 }

 /******* Create new matrix
********/

 for(j=0;j<16;j++)
 {
  nX[0][j]=0;
  if(j==pos)
    nX[0][j]=1;

 }


 /********* Multiply new
matrix with M **********/


 for(j=0;j<16;j++)
 {
  s=0;
  for(k=0;k<16;k++)
  {
          m=nX[0][k]*M[k][j];
          s=s+m;
  }
  nR[0][j]=s;
 }

 /*******change the value of
ones position into one if it is
zero********/

 if(nR[0][pos]==0)
          nR[0][pos]=1;

 /********** Find maximum
ones matrix **********/

 ones2=0;
 for(j=0;j<16;j++)
 {
  if(nR[0][j]==1)
   ones2=ones2+1;
 }
 if(max_ones2<ones2)
 {
   max_ones2=ones2;
     for(j=0;j<16;j++)
          {

          max_nR[0][j]=nR[0][j]
;
          }
 }
 /********** Repeat
multiplication with next 1s
position *********/

 if(count<ones)
 {
  count=count+1;
  goto mult;



 }
 if(max_nR[0][j]==X[0][j])
 {
   goto finish;
  }

 /***************** Store
maximum ones matrix to X
**********/

 for(j=0;j<16;j++)
 {
    X[0][j]=max_nR[0][j];
  }

 /***************** Repeat the
process **********/

 rep=rep+1;
 if(rep<=10)
 {
  goto repeate;
 }


 finish:
 /****** Print result
**************************
**/

  for(j=0;j<16;j++)
  {
   printf("%d ",max_nR[0][j]);
  }
  printf("\n----------------------
--------------------------------
----");
  ones_pos=ones_pos+1;
  if(ones_pos<=16)



  {
    rep=0;
    goto main_repeate;
  }
 getch();
}

#include<stdio.h>
```

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