

Analysis on the Causes for Using Endosulfan in Agriculture by Induced Fuzzy Cognitive Maps (IFCM)

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Abstract: In this article we analyse the causes for using 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 remedial measures for the usage of 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.

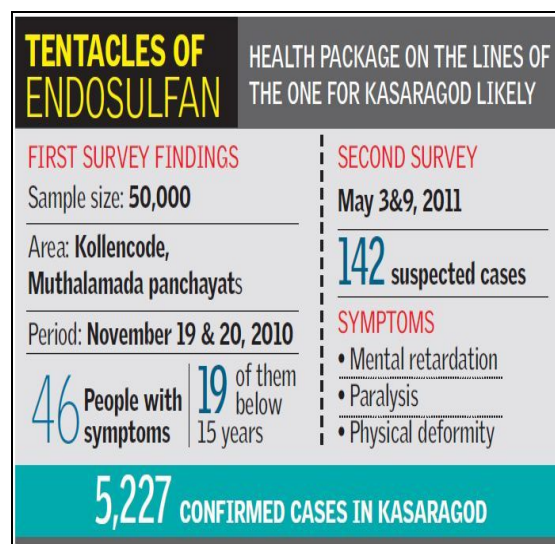
Key words: Fuzzy Cognitive Maps, Induced FCMs, Pesticide Endosulfan.

Introduction

Kerala, the southern state of India in the west coast is known as the “God's Own Country” and Kasargod, the northern district of this state has a village called 'Swarga' which literally means paradise. Around 1963-64, the Kerala Government brought cashew plantation to Kasargod district covering around 4600 hectares. In 1978, the Plantation Corporation of Kerala (PCK) took over the control of these cashew plantations. To prevent the pests, which affect trees during flushing, flowering and fruit set, PCK started aerially spraying Endosulfan thrice a year for almost two decades. Palakkad is another district in Kerala, where 300 land holders own big plantations of mango trees and use Endosulfan extremely during flowering season to kill pests, leaf miners and leaf hoppers. Endosulfan was introduced at a time when environmental awareness and knowledge about the toxicology of such chemicals were low and not mandatory

as per national laws. Then slowly farmers started using Endosulfan to control the pests in vegetables, fruits, and paddy, cotton, tea, coffee, tobacco and timber crops.

Endosulfan is an organo chlorine insecticide. Its chemical formula is $C_9H_6Cl_6O_3S$. Endosulfan exists as colourless crystals. Technically Endosulfan is a mixture of two isomers-alpha- Endosulfan and beta – Endosulfan in the ratio 7:3.



T. Sruthi in 2016 and 2006

T.Sruthi of Kasargod has been suffering from physical disability due to the after affects of insecticide sum-acaricide, Endosulfan. She has succeeded in getting admission into homeopathic medical college at Bengaluru. Chief Minister of Kerala declared to give 4 lakhs for her studies.

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.

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:

Causes for Using Endosulfan in Agriculture by Induced Fuzzy Cognitive Maps (IFCM)

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_2^1

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 1 to 7 for all the state vectors and find hidden pattern.

Selection of concepts as the causes for using Endosulfan

A sample survey of 101 people in Kerala (Palakkad and Kasargod) was conducted. They were interviewed using a questionnaire relevant to the topic. From the questionnaire the concepts for predicting the causes for using endosulfan in agriculture are determined.

The following are the eleven concepts:

C₁ –Population Increase

C₂ – Increase in food productivity

C₃ –Cheap cost of Endosulfan

C₄ –Easy availability of Endosulfan

C₅- Better yield

C₆ – Need for pest control

C₇ –Illiteracy

C₈-Un awareness on ill effects of Endosulfan

C₉-Less knowledge of any other non chemical alternative

C₁₀-Non involvement of social organizations

C₁₁- Indifference or negligence of Government with farmers

Justification for the concepts

A justification is given for the eleven concepts taken for the study

C₁: Population Increase

Food production capacity is facing a number of ever growing challenges, including world population which is expected to grow nearly 7.4 billion. As the world population continues to grow geometrically, great pressure is being placed on land, water , energy and biological resources. We provide an adequate supply of food while maintaining the integrity of our ecosystem. In order to maintain the balance between population and food production, chemicals such as pesticides, antibiotics, hormones etc are used to boost production and ensure adequate food supply.

C₂: Increase in food productivity

In the current trend, arable land and population growth are inversely proportional and there in the necessity for higher food production from the limited arable land becomes inevitable. Pesticides are used for crop protection not only during the pre harvest stage but also post harvest stage as bugs, rodents, molds may harm the grains. The usage of pesticides at the post harvest

stage helps in prolonging the life time of the stored product thus making it consumable over a larger duration of time. Products such as herbicides, insecticides and fungicides reduce crop losses both before and after harvest which in term increases crop yields.

C₃: Cheap cost of Endosulfan

Endosulfan is a cheap pesticide costing around ₹ 220 per liter against imidachloprid (its substitute) which posts about ₹ 2000 per litre. The next cheapest alternative costs 10 times more. India is the world's largest manufacturer and user of Endosulfan. Even though Government of India agreed to wind down the use of Endosulfan in 5 year, it seems to continue its use until a safer cost effective alternative is found. If Endosulfan gets banned it is going to have a deep irreversible impact on the Indian economy as the poor farmers will not be able to afford the expensive substitute for Endosulfan which is cheap as well as effective. The highly toxic Endosulfan pesticide is banned in most of the countries, but still widely embraced by farmers in India. as the Govt. claims that there is no affordable alternative to this chemical, families are paying a high price.

C₄: Easy Availability of Endosulfan

The easy availability of Endosulfan from across the border has contributed to this problem in this agriculture dominated area. The continued availability of Endosulfan is desirable for the production of cotton and various other crops because of its particular suitability for use and resistance management strategies. Endosulfan is easily available in the Muthalamada area from across the borders; it is just 10 to 15 minutes journey to the neighbouring Tamilunadu. There is no proper mechanism to check smuggling of Endosulfan into Kerala.

C₅: Better yield

How the heck humans are going to grow enough food to feed our teeming masses without wrecking the planet? There are two assumptions embedded in this question:

1) We are going to have trouble in growing enough food.

2) We must race to keep food production to meet the requirements of the growing population. So the farmers and scientists are working to increase the yield.

C₆: Need for pest control

Pest control refers to the regulation or management of a species defined as a pest, usually because it is perceived to be detrimental to a person's health, the ecology or the economy.

C₇: Illiteracy

Due to illiteracy people are unaware about the dangerous side effects of Endosulfan. Farmers remain uneducated of the precautionary methods which have to be followed before the use of this pesticide. These workers are unaware of disaster spread by Endosulfan. They are also unaware of the alternative bio or herbal pesticides which could be used as an alternative for Endosulfan. They are unaware about the legal regulations against the use of this deadly Endosulfan. Due to illiteracy, the pesticides are sprayed on trees with the nozzles of the pump directed skywards. This immediately affects the person who is engaged in spraying this chemical pesticide.

C₈: Un awareness on ill effects of Endosulfan

Most of the people are unaware of the ill effects of endosulfan. The most likely way for people to be exposed to Endosulfan is by consuming the food contaminated with it. Endosulfan has been found in some food products such as oils, fats and fruits and vegetable products. They are also exposed to low levels of Endosulfan by skin contact with contaminated soil or by smoking cigarettes which made from tobacco that has endosulfan residues on it. Workers breathe in the chemical while spraying the pesticides on crops. Accidental spills and releases to the environment are also possible sources of exposure to endosulfan. The most likely exposure to endosulfan for people living near hazardous waste sites is through physical contact with soils containing it. Drinking water from the open well which is left uncovered during the aerial spraying of Endosulfan.

C₉: Less knowledge of any other non chemical alternative

Mostly farmers are not aware of the non chemical alternative methods like neem oil, chillies, garlic, cow urine and many other organic methods. The farmers are generally illiterates; they are not able to read about the latest technologies in organic farming. Only government should give them non chemical pesticides free of cost and encourage them. They must be motivated by radio and TV programmes to use organic manure and insecticides.

C₁₀: Non involvement of social organization

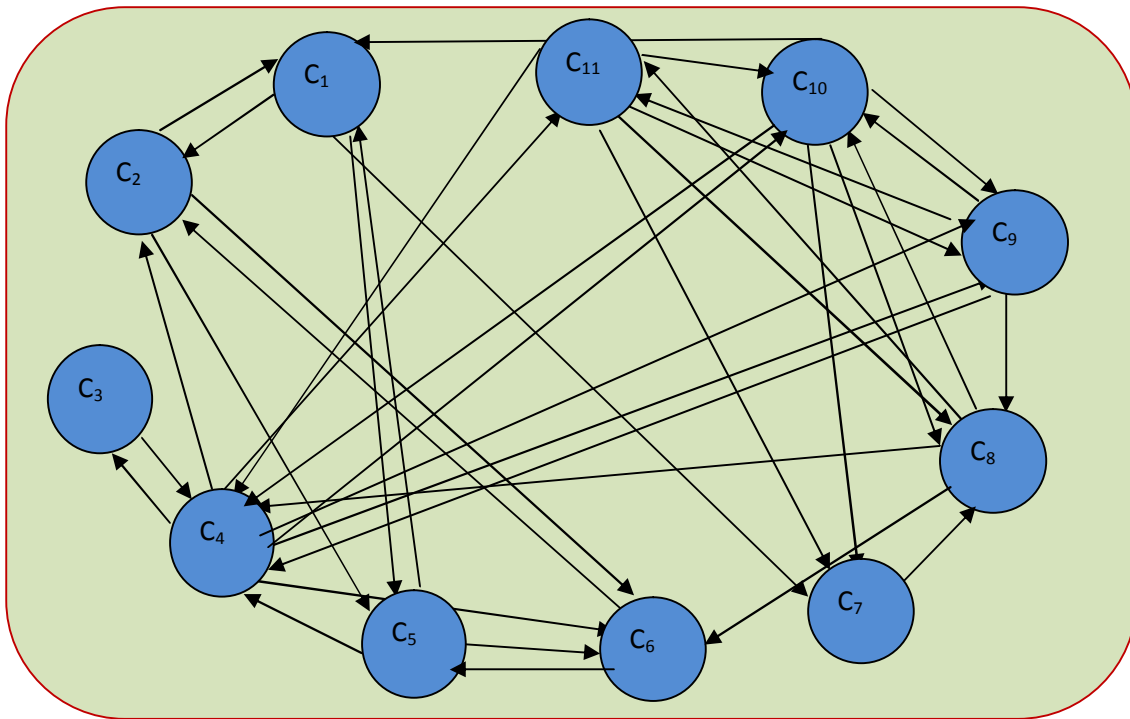
Initially the NGO's organized local and international compare to create awareness and the ban Endosulfan which later turned into an inactive one. Such organizations can give awareness about the alternative non chemical pesticides which are available in that region and other parts of the world thereby eliminating the use of endosulfan.

C₁₁: Indifference or negligence of Government with farmers

Government has to ban the production and use of Endosulfan but the Government has not yet done it. Actually Government is not taking that much interest to give awareness on farmers because most of these farmers are not their vote banks. The goal "Adopt Land and food without poisons" can be adopted for healthy survival. Pressure Govt. to ratify the Stockholm Convention if it has not already done so and press for addition of endosulfan to the Stockholm Conventions List.

5. Implementation of IFCM model to the study

The following represents the connection graph of the above eleven concepts and its connection matrix given below



$$M = \begin{matrix} & C_1 & C_2 & C_3 & C_4 & C_5 & C_6 & C_7 & C_8 & C_9 & C_{10} & C_{11} \\ \begin{matrix} C_1 \\ C_2 \\ C_3 \\ C_4 \\ C_5 \\ C_6 \\ C_7 \\ C_8 \\ C_9 \\ C_{10} \\ C_{11} \end{matrix} & \begin{pmatrix} 0 & 1 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 & 1 & 0 & 0 & 1 & 1 & 1 \\ 1 & 0 & 0 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 1 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 \\ 1 & 0 & 0 & 1 & 0 & 0 & 1 & 1 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 1 & 1 & 1 & 1 & 0 & 0 \end{pmatrix} \end{matrix}$$

As there are 11 concepts and IFCM model is very lengthy, only two trials are worked out manually. The rest are done using C++ computer program.

5.1. Trial 1

Consider P_1^8 in the trial 1, by setting the concept C_8 in ON state, that is the eighth component of the vector is set to be 1 and the rest are assigned to 0.

Then, $P_1^8 = (0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 1 \ 0 \ 0 \ 0)$

Product of P_1^8 and M is calculated.

$P_1^8 M = (0 \ 0 \ 0 \ 1 \ 0 \ 1 \ 0 \ 0 \ 0 \ 1 \ 1) = P_2$

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

$$P_2M \approx$$

$$(0\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0)M=(0\ 1\ 1\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1)=Q_2$$

$$(0\ 0\ 0\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0)M=(0\ 1\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0)$$

$$(0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 0)M=(1\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1\ 0\ 0)$$

$$(0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1)M=(0\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1\ 0\ 0)$$

$$Q_2=(0\ 1\ 1\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1) \neq P_2$$

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

1. Let the modified vector be Q_2^1

$$Q_2M=(0\ 1\ 1\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1)M=(2\ 2\ 1\ 4\ 2\ 2\ 2\ 3\ 3\ 2\ 2)$$

$$\Leftrightarrow(1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1)=Q_2^1$$

$$Q_2^1=(1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1)$$

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

$$Q_2^1M \approx$$

$$(1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0)M=(0\ 1\ 0\ 0\ 1\ 1\ 1\ 0\ 0\ 0\ 0)$$

$$(0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0)M=(1\ 0\ 0\ 0\ 1\ 1\ 0\ 0\ 0\ 0\ 0)$$

$$(0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0)M=(0\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0)$$

$$(0\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0)M=(0\ 1\ 1\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1)=R_3$$

$$(0\ 0\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0)M=(1\ 0\ 0\ 1\ 0\ 1\ 0\ 0\ 0\ 0\ 0)$$

$$(0\ 0\ 0\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0)M=(0\ 1\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0)$$

$$(0\ 0\ 0\ 0\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0)M=(0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 1\ 0\ 0)$$

$$(0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 0\ 0\ 0\ 0)M=(0\ 0\ 0\ 1\ 0\ 1\ 0\ 0\ 0\ 1\ 1)$$

$$(0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 0\ 0\ 0)M=(0\ 0\ 0\ 1\ 0\ 0\ 0\ 1\ 0\ 1\ 1)$$

$$(0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 0\ 0)M=(1\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1\ 0\ 0)$$

$$(0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 0)M=(0\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1\ 0\ 0)$$

$$R_3=(0\ 1\ 1\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1)=Q_2$$

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

The triggering pattern is $C_8 \rightarrow C_4 \rightarrow C_4$

5.2. Trial 2

The calculation for Trial 2 is performed similar to the Trial 1. Consider P_1^4 by setting C_4 in ON state that is, assigning the fourth component of the vector to be 1 and the rest of the components as 0.

$$\text{Let } P_1^4=(0\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0)$$

$$P_1^4M=(0\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0)M=(0\ 1\ 1\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1)=P_2$$

Each component in P_2 is taken separately and the product of the given matrix is calculated.

$$P_2M \approx$$

$$(0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0)M=(1\ 0\ 0\ 0\ 1\ 1\ 0\ 0\ 0\ 0\ 0)$$

$$(0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0)M=(0\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0)$$

$$(0\ 0\ 0\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0)M=(0\ 1\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0)$$

$$(0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 0\ 0)M=(0\ 0\ 0\ 1\ 0\ 0\ 0\ 1\ 0\ 1\ 1)$$

$$(0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 0)M=(1\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1\ 0\ 0)=Q_2$$

$$(0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1)M=(0\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1\ 0\ 0)$$

Now the vector with maximum number of 1's for the first time is Q_2 .

$$Q_2=(1\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1\ 0\ 0)\neq P_2$$

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

$$Q_2M=(0\ 2\ 1\ 2\ 1\ 2\ 1\ 2\ 2\ 3\ 3\ 3)\leftrightarrow(0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1)=Q_2^1$$

$$Q_2^1=(0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1)$$

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

$$Q_2^1M \approx$$

$$(0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0)M=(1\ 0\ 0\ 0\ 1\ 1\ 0\ 0\ 0\ 0\ 0\ 0)$$

$$(0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0)M=(0\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0)$$

$$(0\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0)M=(0\ 1\ 1\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1)=R_3.$$

$$(0\ 0\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0)M=(1\ 0\ 0\ 1\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0)$$

$$(0\ 0\ 0\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0)M=(0\ 1\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0)$$

$$(0\ 0\ 0\ 0\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0)M=(0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 1\ 0\ 0)$$

$$(0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 0\ 0\ 0\ 0)M=(0\ 0\ 0\ 1\ 0\ 1\ 0\ 0\ 0\ 1\ 1)$$

$$(0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 0\ 0\ 0)M=(0\ 0\ 0\ 1\ 0\ 0\ 0\ 1\ 0\ 1\ 1)$$

$$(0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 0\ 0)M=(1\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1\ 0\ 0)$$

$$((0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1)M=(0\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1\ 0\ 0))$$

$$R_3=(0\ 1\ 1\ 0\ 0\ 1\ 0\ 0\ 1\ 1\ 1)$$

Here $R_3 \neq Q_2$. 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^{\downarrow}

$$R_3M = (2 \ 1 \ 0 \ 4 \ 2 \ 1 \ 2 \ 3 \ 2 \ 1 \ 1) \hookrightarrow (1 \ 1 \ 0 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1) = R_3^{\downarrow}$$

$$R_3^{\downarrow} = (1 \ 1 \ 0 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1)$$

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

$$R_3^{\downarrow}M \approx$$

$$(1 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0)M = (0 \ 1 \ 0 \ 0 \ 1 \ 1 \ 1 \ 0 \ 0 \ 0)$$

$$(0 \ 1 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0)M = (1 \ 0 \ 0 \ 0 \ 1 \ 1 \ 0 \ 0 \ 0 \ 0)$$

$$(0 \ 0 \ 0 \ 1 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0)M = (0 \ 1 \ 1 \ 0 \ 0 \ 1 \ 0 \ 0 \ 1 \ 1) = S_4$$

$$(0 \ 0 \ 0 \ 0 \ 1 \ 0 \ 0 \ 0 \ 0 \ 0)M = (1 \ 0 \ 0 \ 1 \ 0 \ 1 \ 0 \ 0 \ 0 \ 0)$$

$$(0 \ 0 \ 0 \ 0 \ 0 \ 1 \ 0 \ 0 \ 0 \ 0)M = (0 \ 1 \ 0 \ 0 \ 1 \ 0 \ 0 \ 0 \ 0 \ 0)$$

$$(0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 1 \ 0 \ 0 \ 0)M = (0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 1 \ 1 \ 0 \ 0)$$

$$(0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 1 \ 0 \ 0)M = (0 \ 0 \ 0 \ 1 \ 0 \ 1 \ 0 \ 0 \ 0 \ 1)$$

$$(0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 1 \ 0 \ 0)M = (0 \ 0 \ 0 \ 1 \ 0 \ 0 \ 0 \ 1 \ 0 \ 1)$$

$$(0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 1 \ 0)M = (1 \ 0 \ 0 \ 1 \ 0 \ 0 \ 1 \ 1 \ 1 \ 0)$$

$$(0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 1)M = (0 \ 0 \ 0 \ 1 \ 0 \ 0 \ 1 \ 1 \ 1 \ 0)$$

$$\text{Here } S_4 = R_3 = (0 \ 1 \ 1 \ 0 \ 0 \ 1 \ 0 \ 0 \ 1 \ 1)$$

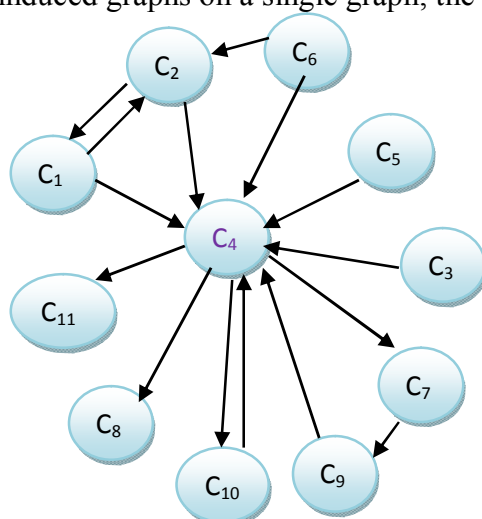
Hence the fixed point $(0 \ 1 \ 1 \ 0 \ 0 \ 1 \ 0 \ 0 \ 1 \ 1)$ is obtained when the same threshold value occurs twice. The iteration gets terminated.

Here the triggering pattern is $C_4 \rightarrow C_{10} \rightarrow C_4 \rightarrow C_4$

Using a C++ Computer Program used to find out the triggering patterns when other attributes are kept in ON state are found out. 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)	C ₁ →C ₂ →C ₄ →C ₄
Concept 2	C ₂ : (0 1 0 0 0 0 0 0 0 0 0)	C ₂ →C ₁ →C ₄ →C ₄
Concept 3	C ₃ : (0 0 1 0 0 0 0 0 0 0 0)	C ₃ →C ₄ →C ₄
Concept 4	C ₄ : (0 0 0 1 0 0 0 0 0 0 0)	C ₄ →C ₁₀ →C ₄ →C ₄
Concept 5	C ₅ : (0 0 0 0 1 0 0 0 0 0 0)	C ₅ →C ₄ →C ₄
Concept 6	C ₆ : (0 0 0 0 0 1 0 0 0 0 0)	C ₆ →C ₂ →C ₄ →C ₄
Concept 7	C ₇ : (0 0 0 0 0 0 1 0 0 0 0)	C ₇ →C ₉ →C ₄ →C ₄
Concept 8	C ₈ : (0 0 0 0 0 0 0 1 0 0 0)	C ₈ →C ₄ →C ₄
Concept 9	C ₉ : (0 0 0 0 0 0 0 0 1 0 0)	C ₉ →C ₄ →C ₄
Concept 10	C ₁₀ : (0 0 0 0 0 0 0 0 0 1 0)	C ₁₀ →C ₄ →C ₄
Concept 11	C ₁₁ : (0 0 0 0 0 0 0 0 0 0 1)	C ₁₁ →C ₄ →C ₄

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



Conclusion

From the results the conclusions arrived are:

1. All the concepts get the same fixed point (0 1 1 0 0 1 0 0 1 1 1) which is the vector corresponding to the concept C_4 . The triggering pattern of all the concepts in the above table and graph also reveal that C_4 – *easy availability of Endosulfan* is the terminal node. If any one of causes is switched on to ON state, C_4 goes ON State. Hence “*easy availability of Endosulfan* is the cause related to all the causes.

2. The limit point corresponding to C_4 (0 1 1 0 0 1 0 0 1 1 1) highlights that attribute C_2 , C_3 , C_6 , C_9 , C_{10} , and C_{11} (i.e the concepts corresponding to 1 in the vector C_4). Which seem to be the major causes for using Endosulfan in agriculture. Hence the conclusion arrived in this model is that the major causes for using Endosulfan are:

C_2 – Increase in food productivity

C_3 – Cheap cost of endosulfan

C_6 – Need for pest control

C_9 -Less knowledge of any other non chemical alternative

C_{10} -Non involvement of social organizations

C_{11} - Government indifference or negligence with farmers

3. The triggering pattern shows that:

- i. C_1 & C_2 are related i.e population increase gives rise to increase in food productivity.
- ii. $C_4 \rightarrow C_{10} \rightarrow C_4 \rightarrow C_4$. reveals that C_{10} - *non involvement of social organization* plays the role of intermediary node.
- iii. The relation of C_6 & C_2 implies that pest control is needed to improve the food productivity.
- iv. C_7 & C_9 are connected i.e illiteracy is the major cause for having poor knowledge of any other non chemical alternatives

The following **remedial measures** are suggested:

- i. Population increase must be controlled
- ii. To increase food productivity, alternative, preventive, and curative non chemical pest controlled methods should be applied
- iii. Integrated Pest Management (IPM) strategies are to be followed
- iv. As illiteracy plays an important role in using Endosulfan, farmers must be educated to adopt alternative non chemical pesticides and organic farming.
- v. Educated younger generation has to enter into agriculture to make a co operative farming with the latest methods of agriculture along with using insecticides derived from natural plant extracts

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