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Causes of famers Suicides in Karnataka: A Fuzzy cognitive analysis

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ABSTRACT

The focus of this article is to determine the prominent causes of farmer suicides from the identified causes of a study by the Institute for Social and Economic Change, Bengaluru from selected districts of Karnataka. There are differences of opinions among the various experts on the causes for agrarian distress and farmer suicides. There has been an increase in the rate of farmers' suicides in India in general and Karnataka for the past twenty years and the reasons for this has been very widespread. In this research, an attempt was made to determine the hidden pattern for the listed causes and then find out the prominent cause leading to farmers' suicides through the implementation of Fuzzy Cognitive Maps. Results indicate that a few causes statistically affect farmer suicides in a smaller percentage, but cognitively these few causes can in turn play a role in influencing the causes which affect farmer suicides at a larger rate.

Key words: *Farmer suicides, Fuzzy cognitive analysis, Karnataka*

Introduction

The role of agriculture in India is indispensable. According to the projections given by Indian government census conducted in 2011 nearly 55% of population is engaged in agriculture and associated activities. This kind of involvement contributes to nearly 17.4% of country's Gross Value Added for the year 2016-17. These numbers clearly emphasize the importance agriculture in the country. Significant percentage of population is directly or indirectly are relying on farming (Shiva and Jalees, 2005). Indian government having realized this immense contribution from agriculture sector to the country's economy has always encouraged and appreciated its farmers participation in this sector by introducing various developmental schemes like PM FasalBima Yojana, PM Krishi Sinchai Yojana. Having discussed about the bright side of the issue let us look at the dark side as well (Ministry of Agriculture and Farmers Welfare, 2018).

The United Nations Commission on Sustainable Development (UNCSD) reported about one farmer committing suicide every 32 minutes between 1997 and 2005 in India. It is reported that fifteen farmers committed suicide every day in the country during 2014 and this went up to 21 in 2015. Many researches have been conducted to identify causes that are forcing these farmers to commit to such extreme measures. It ranges from increasing cost of cultivation to raise in costs for the households and climatic factors to market failures etc. There have been lot of studies conducted to link indebtedness to suicides (Manjunatha and Ramappa, 2018).

According to these studies conducted by experts from the Institute for Social and Economic Change,

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farmer's resolution to commit suicide cannot be due to single factor but due to effect of combinations to factors. Many observations have proven that farmers do not opt such sever measures due to one reason alone. Unexpectedly low returns from farming and the responsibility of taking care of family even though it is of the fact of providing basic needs force them to repeatedly borrow from the money lenders. Conditions are even worse if the farmer is dependent only on crop yields not involving in other source of incomes like dairy, fishery and other sources. Farmer faced with crop failure on which he had a huge hope bestowed on and also having an aged parent suffering from illness or a grown up daughter waiting to be married or a son whose education has to be taken care. All of these mental pressures forcing them to be addicted to factors like drugs, tobacco, and alcohol deteriorating their health as well. It is the cumulative effect of all the social responsibilities, farming related aspects and debts that might be forcing our farmers take these decisions. The causes of famer's suicides have be categorized under three main aspects (Manjunatha and Ramappa, 2017 b

a. Social causes
b. Farming related
c. Indebtedness related causes

According to the data collected from the victim families from major suicide prone districts in Karnataka that have been through this trauma many of the social causes listed were alcohol and drug abuse, Illness, family quarrel, daughter's marriage. Studies conducted on the data proved that degradation in social reputation may be was one of the causes for taking such extreme measures.

One cannot overlook the impacts the farming related aspects have on this issue. Farmer's financing for on- or off-agriculture ventures are very often insufficient. This vulnerable situation makes them to borrow from money lenders at very high rate of interests. To make things even more complicated after borrowing money if the farmers suffers from crop failure he is left with enormous amount of debts. Failure of crop due to many reasons like failure of monsoon, attack of pests, inadequate supply of water, spread of diseases and unanticipated natural or unnatural disasters. In many of the cases non realization of high yields was one of the predominant farm related causes.

In fields involving aspects like medicine, social issues and economic or political issues decision making impose numerous challenges as these systems are highly dynamic in nature. Interpreting these systems with the help of human knowledge and judgment is more preferred than using a traditional computational technique. Hence very often one finds the use of methods involving fuzzy theory in them for drawing decisions. Fuzzy Cognitive Maps (FCM) are one such approach which very efficiently acknowledges the experience and understanding of the expert gained over year. It is also the preferred method when understanding of a system rely on natural language. FCM incorporates human experts understanding of system that one has accumulated over years by observing the behaviour of the system when subjected to various circumstances. FCM typically consists of concepts or causes as nodes and causality as edges. The relation between causes and effects are conveyed as positive or negative weights. Each concept is assigned an initial value based on the expert's opinion and later FCM interacts through forward chaining until equilibrium is obtained. It can be an effective impact assessment tool (Victor Devadoss and Ajay, 2014).

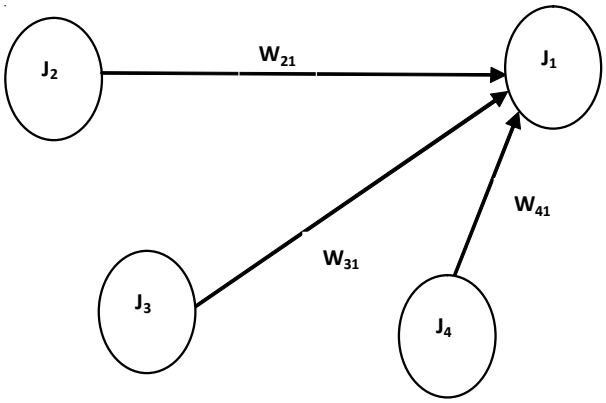

Fig. 1. A typical FCM.

Let J_1, J_2.....J_n be nodes of FCM indicating causes and W_{21}, W_{31}, W_{ik} represents the casual relation between i^{th} cause and k^{th} cause.

If $W_{ik} < 0$ the relation is treated to have positive causal relation wherein increase in i^{th} cause result in an increase in j^{th} cause.

If $W_{ik} < 0$ the relation is treated to have positive causal relation wherein increase in i^{th} cause result in an increase in j^{th} cause also.

If $W_{ik} = 0$ there is no causal relation i^{th} cause and j^{th} cause also.

W is a square matrix called the weight matrix

where number of rows and columns are equal to number causes indicated as nodes in the diagram above. If there are *n* number of nodes then the weight or connection matrix will be of *nXn* size. It basically indicates the causal relation existing between causes in the system.

$$W = \begin{bmatrix} W_{11} & W_{12} & W_{13} & W_{14} \\ W_{21} & W_{22} & W_{23} & W_{24} \\ W_{31} & W_{32} & W_{33} & W_{34} \\ W_{41} & W_{42} & W_{43} & W_{44} \end{bmatrix}$$

As we have already stated above FCM is a dynamic system which evolves over time. For each instant of time activation value of each cause is computed which indicates its activation value. This activation value a_i of every node will range in [01]. Each of these activation values for every causes or nodes is calculated to form the activation or event vector.

$A_t = (a_1 a_2 a_3 \ldots . a_n)$ of size $1X_n$. For the example given above the activation vector is of order 1X4. $A_t = (a_1 a_2 a_3 a_4)$. This connection matrix will be used in assessing the influence of each cause on other causes. The product of connection matrix and activation vector is computed at every instant of time resulting in an activation vector *A* for that instant of time until equilibrium is reached. The activation value of every node calculated gives the degree at the every node is influencing the overall system.

For analysing the impact of each node or cause on the overall system following steps can be performed:

a. Each node can be clamped to 'on' state keeping the other nodes to 'off' state in the activation vector.
b. Later the product of activation vector and the connection matrix $A_0 XE$ is performed.

$$[a_1 a_2 \ldots \ldots . a_n] X \begin{bmatrix} W_{11} & \ldots . & W_{1n} \\ \ldots . & \ldots . & \ldots . \\ W_{n1} & \ldots . & W_{nn} \end{bmatrix} \quad .. (1)$$

c. Each value of this resulting vector at time t is added with the previous activation vector computed at $t-1$ instant of time.
d. Each of these activation values are limited to a particular range by applying them individually to threshold functions like.
e. This multiplication is carried out until equilibrium is achieved i.e., when there is no dissimilarity between present state activation vector and previous activation vector computed at previous instant of time.

$$A_i^t = f\left(\sum_{i=1, i \neq k}^{n} A_k^{t-1} W_{ki} + A_i^{t-1} \right) \quad .. (2)$$

Where cause has a causal effect on the with the weight , is the activation value of at time , is the activation value at instant time and function is a threshold function.

This vector resulting after every thresholding operation is again operated on connection matrix. Repeating this process until the FCM converges or settles down or reaches a equilibrium state. The previously mentioned procedure might result in one of the following conditions:

a. The resulting vector after multiplication might settle down without any changes for many iterations. This state known as fixed point attractor.
b. The vector might keep changing with every iteration resulting in condition known as chaotic attractor.

Methodology

Initially, we acquire the relevant data from the study findings on farmer suicides by the Institute for Social and Economic Change, Bengaluru (Manjunatha and Ramappa, 2017). This data contains information about the various causes due to which farmers have committed suicide in major suicide prone districts of Karnataka.

The reasons for farmers' suicides are widespread, hence these causes are grouped into classes based on their inter-relations. This classification is made based on expert's advice. Hence the classification is subjective.In each of the classes,concepts that have a causal relation between each other are assigned a weight '1' and concepts that do not have causal relation between each other are assigned a weight '0'. Using the causes as nodes and weights as edges Fuzzy Cognitive Maps are plotted and their Adjacency matrices are formed. Hence FCMs for all the classes are obtained

The FCMs of all the classes are combined to form a COBFCM. This map consists of all the causes and gives the causal relations between each of the causes. To find the hidden pattern, COBFCM matrix is considered. An initial state vector with 'n' dimensions is taken, where 'n' is the number of causes that are used in the study. Each dimension in the initial state vector represents a cause and one state (cause) is kept high at a time(the cause is made '1'). This

vector is then operated with the COBFCM matrix until the resulting vector becomes constant. This constant vector is the hidden pattern.

This process is repeated for each of the causes (by keeping that cause high and rest all low in the initial state vector) and 'n' hidden patterns are obtained (Shiva and Jalees, 2005).

Process

Obtaining and identifying the data

The data required for our need was acquired from the Institute for Social and Economic Change, Bengaluru. Table 1 shows the most cited causes for farmers' suicides in a region where the study took place.

Classification of causes

These causes are grouped into different classes. This classification is done on the basis of inter-relatability (based on some basic features) of causes with the help of experts in the field.

Class A: Non-realization of higher output (C1), Failure of rainfall resulted in water scarcity (C2), Lack of access to adequate irrigation water resulted in water scarcity (C3),Non-realization of higher price (C4).

Class B:Non-realization of higher price (C4), Pest and disease attack resulted in reduced output (C5), Unable to take loans from institutional and non-institutional source as already loan taken (C6).

Class C: Due to loan recovery pressure from money lenders (C7), No institutional loan waiving from government (C8), Alcoholic addiction (C9), Gambling/Betting (C10).

Class D: Non-realization of higher output (C1), Gambling/Betting (C10), Well failure (C11), Due to significant expenditure on daughter's marriage (C12).

Assigning of weights

The causes in a class may affect one or more causes in the same class. We have represented this causal nature using the concept of Fuzzy Logic.

If a cause C_i affects a cause C_j in the class, then it is represented by a directed arrow from C_i to C_j. A weight of '1' is assigned to that relation. If a cause C_i does not affect a cause C_j, then it is not represented by arrows and implicitly a weight of '0' is assigned to it.

Here, we do not take into consideration the intermediate values between 0 and 1 to maintain simplicity in application.

iv. Construction of FCMs and its adjacency matrices

c1 c2 c3 c4

$$A = \begin{array}{c} \text{c1} \\ \text{c2} \\ \text{c3} \\ \text{c4} \end{array} \begin{pmatrix} 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 1 \\ 1 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

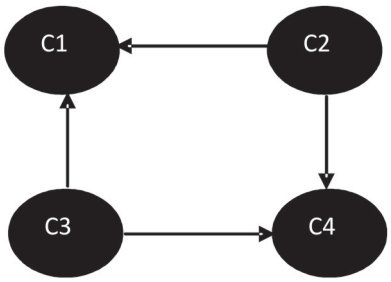

Fig. 2. FCM for Class A.

Table 1. Causes for Farmers' Suicides

Notation	Cause	% of total
C1	Non-realization of higher output	51.47
C2	Failure of rainfall resulted in water scarcity	44.86
C3	Lack of access to adequate irrigation water resulted in water scarcity	41.12
C4	Non-realization of higher price	37.38
C5	Pest and disease attack resulted in reduced output	8.41
C6	Unable to take loans from institutional and non-institutional source as already loan taken	71.96
C7	Due to loan recovery pressure from money lenders	71.03
C8	No institutional loan waiving from government	67.29
C9	Alcoholic addiction	1.87
C10	Gambling/Betting	1.87
C11	Well failure	1.87
C12	Due to significant expenditure on daughter's marriage	15.89

In Figure 1 we can see that since C2 is Causing C1 and C4, a directed arrow is placed from C2 to C1, and C2 to C4. Similarly, C3 is causing C1 and C4 so a directed arrow is placed from C3 to C1 as well as C3 to C4.

This pictorial representation can be realised into an adjacency matrix by assigning a value of '1' at A21 (Since C2 is causing C1), A24, A31 and A34 positions in a 4 ' 4 matrix. Similarly, FCMs for class B, C and D are obtained.

Class B

$$B = \begin{pmatrix} 0 & 0 & 0 \\ 1 & 0 & 0 \\ 1 & 0 & 0 \end{pmatrix}$$

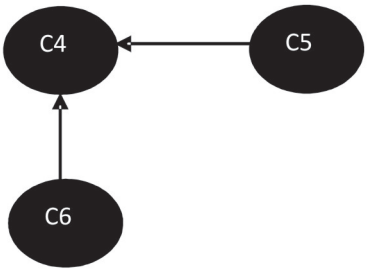

Fig. 3. FCM for Class B.

Class C

$$C = \begin{pmatrix} 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

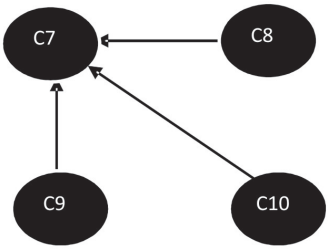

Fig. 4. FCM for Class C.

Class D

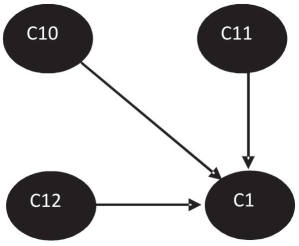

Fig. 5. FCM for Class D.

$$D = \begin{pmatrix} 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{pmatrix}$$

v. Construction of Combined Overlapping Block Fuzzy Cognitive Map(COBFCM)

The Adjacency matrices of Class A, B, C, and D are combined together to form a COBFCM matrix. This is a 12 × 12 Matrix. It gives the relations between all the 12 causes that are considered in the study.

The COBFCM and its Adjacency Matrix is Shown below:

F=

$$\begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

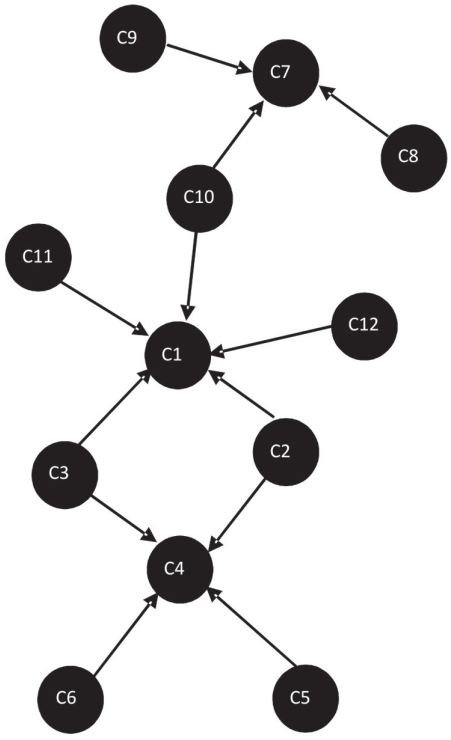

Fig. 6. COBFCM.

Finding hidden pattern

An initial state vector(Activation vector) 'I' is taken, which is a 1'12 matrix. which represents all the 12

causes as shown below.

t = (c1, c2, c3, c4, c5, c6, c7, c8, c9, c10, c11)

Each position in the vector represents a cause. Initiallywe make one of the causes high and rest all low (by making one position as '1' and rest all as '0'). This vector is then operated with the COBFCM matrix 'F' by using the activation function (equation 1).

$$I_i^t = f\left(\sum_{i=1, i\neq k}^{n} I_k^{t-1} F_{ki} + I_i^{t-1}\right) \quad \forall\, t \geq 0 \qquad .. (3)$$

In equation 1, (x) is the threshold function which is used to keep the output vector elements in range {0,1}. The threshold function is given by,

$$f(x) = \begin{cases} 0, & x < 1 \\ 1, & x \geq 1 \end{cases} \qquad .. (4)$$

The above operation is performed again and again until the two consecutive vector states of 'Vector I' become constant. This vector state represents the hidden state when the cause Ci is made active.

This process is followed for all the causes and their respective hidden patterns are obtained. The below table shows the hidden pattern.

Table 2. Hidden Pattern

Active Cause	Initial state vector	Hidden Pattern
C1	(1 0 0 0 0 0 0 0 0 0 0 0)	(1 0 0 0 0 0 0 0 0 0 0)
C2	(0 1 0 0 0 0 0 0 0 0 0 0)	(1 1 0 0 0 0 0 0 0 0 0)
C3	(0 0 1 0 0 0 0 0 0 0 0 0)	(0 0 0 0 0 0 0 0 0 0 0)
C4	(0 0 0 1 0 0 0 0 0 0 0 0)	(1 0 1 1 0 0 0 0 0 0 0)
C5	(0 0 0 0 1 0 0 0 0 0 0 0)	(0 0 0 1 1 0 0 0 0 0 0)
C6	(0 0 0 0 0 1 0 0 0 0 0 0)	(0 0 0 1 0 1 0 0 0 0 0)
C7	(0 0 0 0 0 0 1 0 0 0 0 0)	(1 0 0 0 0 0 0 0 0 0 0)
C8	(0 0 0 0 0 0 0 1 0 0 0 0)	(1 0 0 0 1 0 0 0 0 0 0)
C9	(0 0 0 0 0 0 0 0 1 0 0 0)	(1 0 0 0 1 1 0 0 0 0 0)
C10	(0 0 0 0 0 0 0 0 0 1 0 0)	(1 0 0 0 0 0 1 0 0 0 0)
C11	(0 0 0 0 0 0 0 0 0 0 1 0 0)	(1 0 0 0 0 0 0 0 1 0)
C12	(0 0 0 0 0 0 0 0 0 0 0 1)	(1 0 0 0 0 0 0 0 1 0)

Illustration

Let's consider that cause C3 (Lack of access to adequate irrigation water resulted in water scarcity) is active. Therefore, its initial state vector becomes,

I_o = (0 0 1 0 0 0 0 0 0 0 0 0)

This initial state vector and matrix 'F' is given as input to the activation function (equation 1). The following iterations are obtained

$I_o F$ = 1 0 0 1 0 0 0 0 0 0 0 0

I_1 = 1 0 1 1 0 0 0 0 0 0 0 0

$I_1 F$ = 2 0 0 2 0 0 0 0 0 0 0 0

I_2 = 1 0 1 1 0 0 0 0 0 0 0 0

Since the two consecutive vectors I_1 and I_2 are constant. The vector I_2 is the hidden pattern when C3 is active.

Analysis of hidden pattern

Each hidden pattern for cause, Ci represents the effect of Ci on other causes. It tells which other causes are activated when cause, Ci is activated. Hence by counting the number of 1s in each of the hidden pattern, we can find the strength of the cause Ci. The cause Ci whose hidden pattern has maximum number of 1s is considered to be the most prominent cause.

Therefore, on analysing the hidden pattern and counting the number of 1s in the hidden pattern we can see the following result.

Table 3. Table showing the count of '1s'in Hidden pattern for each cause

Cause	Strength (number of 1s in hidden pattern)
C1	1
C2	3
C3	3
C4	1
C5	2
C6	2
C7	1
C8	2
C9	2
C10	3
C11	2
C12	2

It can be seen from the table 3 that cause C2(Failure of rainfall resulted in water scarcity), C3(Lack of access to adequate irrigation water resulted in water scarcity) and C10(Gambling/Betting) are the prominent causes

Conclusion

Results of the FCM analysis indicate that causes such as *Failure of rainfall resulted in water scarcity*, *Lack of access to adequate irrigation water resulted in water scarcity* and *Gambling/Betting* are the most prominent in the major suicide prone districts of Karnataka.

While the first two causes are reported at a higher

percentage as compared to the third, we are undertaking a cognitive approach rather than a statistical one.

Hence, with our model, we can determine the underlying causes which may lead to other causes having a higher percentage.

Therefore, we can target these underlying causes as well as the other prominent causes by providing methods to counteract the effect of these causes and reduce the incidents of farmer suicides.

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