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Mapping Causes and Implications of India's Skewed Sex Ratio and Poverty problem using Fuzzy & Neutrosophic Relational Maps

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Abstract. Numerous studies by different researchers have confirmed that skewed sex ratio is a critical social problem in India. This enduring problem of gender imbalance is the collective result of factors like sex selective abortion, gender discrimination, son preference for the preservation of tribe, emergence of new technologies in medical field and many more factors. Another severe problem to be addressed in India is poverty. Many factors contribute to the perpetuation of poverty such as illiteracy, bad governance, under employment and various other reasons. Despite of India's accelerated growth rate, poverty in India is still prevalent.

This paper employs a new soft computing based methodology for identifying and analyzing the relationships among the causes and implications of the two challenging problems in India: unbalanced sex ratio and poverty. The methodology proposed by authors is based on Linked Fuzzy Relational Maps which is a variation to Fuzzy Relational Maps and Linked Neutrosophic Relational Maps which is a variation to Neutrosophic Relational Maps. The relationships among the causes and consequences can be easily drawn through the given methodologies. The authors have implemented two models for the two social problems under study, one using Fuzzy Relational Maps and the other using Neutrosophic Relational Maps. Neutrosophic Relational Maps can support decision making on uncertain and indeterminate data. Authors have demonstrated that the model implemented using Neutrosophic Relational Maps presents more realistic and sensitive results as compared to the model using Fuzzy Relational Maps.

Keywords: Skewed Sex Ratio; Poverty; Fuzzy Relational Maps; Linked Fuzzy Relational Maps; Neutrosophic Relational Maps; Linked Neutrosophic Relational Maps.

1 Introduction

1.1 Sex ratio

India has significantly enhanced against multiple socio-economic indicators over the last few decades including level of economic growth, health related services, level of nutrition, level of education and status of women, but it has not been as victorious at achieving gender equality. One significant measure of this inequality in India is the country's sex ratio, defined as the number of females per 1000 males in the population, whereas internationally, sex ratio is defined as number of males per 100 females [4]. In this paper, authors follow the first definition.Son preference over daughter is an issue in many parts of the world. But with social and economic changes and rise in women's status, the preference for a son over daughter has declined in many countries. However it is still observed in some parts of the world mainly from East Asia to South Asia, particularly in China and India [12].

	CENSUS 2011		CENSUS 2001	
COUNTRY	SEX RATIO	CHILD SEX RATIO	SEX RATIO	CHILD SEX RATIO
India	943	919	933	927

Table 1 Sex Ratio of India, (Census data Sex ratio 2011)

The attributes associated with causes and consequences that result in deteriorating or improving the status of skewed sex ratio in India are described in Table 2.

Causes	Gender Equality in education and employment	This attribute helps in balancing the sex ratio as equal rights are given to boys as well as girls.	[5]
	Literacy rate	If parents are educated then there are minor chances of discrimination between a boy and a girl.	[27]
	Emergence of new technologies	With the emerging technology like ultrasound, there are more chances of sex abortions which leads to decline in sex ratio.	[9]
	Sons preferred, preservation of the clan	Parents always prefer a boy child as they think boys earn more, have more rights and carry the family name.	[2]
	Government and NGOs awareness campaigns	They conduct various awareness campaigns regarding no discrimination between male and female, equal rights to both male and female.	[19]
	Government support for girl child	They are taking some steps to decrease the sex ratio like beti bachao beti padhao yojana, ladli scheme etc.	[14]
	Female sex abuse	India is a male dominating country, every parent prefers a boy child which leads to sex selective abortions.	[13,15]
	Women trafficking	Due to decline in sex ratio, girls are more exploited and moved from one place to another for the purpose of forced labor, sexual slavery etc.	[22]
Consequences	Surplus men	Imbalance of sex ratio leads to more number of males than females.	[11]
	Geographical spread in marriage market.	The females are traveled from one part of country to another for the purpose of marriage.	[8]
	Inter-generational relationships	These are the relationships between persons of different generations.	[6]
	Polyandrous relationships	Due to shortage of brides, a female is married to number of males leading to polyandry.	[26]
	Homosexual relationships	These are the relationships between same sex of people due to decline in sex ratio.	[18]
	Cross class and cross caste marriages	Due to shortage of females, inter-caste marriages are encouraged in India.	[1]
	Economic condition of the country	The economic condition of the country is improved by providing equal opportunity in education and employment to both boys and girls.	[3]
	Women empowerment	Women are given equal rights and opportunities to increase their power so as to balance the sex ratio.	[16]

Table 2: Causes and consequences of sex ratio

1.2 Poverty

Poverty is multidimensional deprivation in income, illiteracy, malnutrition, mortality, morbidity and vulnerabil-

ity to economic shocks[17].Overcoming poverty in India is a key challenge; one third of the world's poor live in India. According to World Bank estimation,68% of the population live on less than $US\$\ 2$ a day [29]. UNICEF latest report shows that one in three Indian children is malnourished or underweight [30].

According to 2011 poverty Development Goals Report, around 320 million people in India and China are expected to be no more part of poverty in the next four years, with the estimation that India's poverty rate will fall from $51\%\ in\ 1990$ to about 22% in 2015 [28].

	Poverty Ratio (%)			Number of Poor (million)		
	Rural	Urban	Total	Rural	Urban	Total
1993-94	50.1	31.8	45.3	328.6	74.5	403.7
2004-05	41.8	25.7	37.2	326.3	80.8	407.1
2011-12	25.7	13.7	21.9	216.5	52.8	269.3
Annual Average Decline 1993-94 to 2004-05(percentage points per annum)	.75	.55	.74			
Annual Average Decline 2004-05 to 2011-12(percentage points per annum)	2.32	1.69	2.18			

Table 3:Percentage and number of poor estimated in India, (Census 2011)

The attributes associated with causes and consequences that result in deteriorating or improving the status of poverty in India are described in Table 4.

Causes	Literacy rate	Literacy rate directly affects poverty as with increased literacy, more opportunities of employment is available.	[7]
	Emergence of new technologies	Due to emergence of new technology millions of jobs have been created in private and public enterprises.	[9]
	Overpopulation	With limited jobs and resources overpopulation tends to increase poverty.	[21]
	Government support for girl child	Due to government support to the girl child, numerous job opportunities have been provided to female candidates.	[23]
Consequences	Female sex abuse	Poverty would lead to poor conditions for women and female sex abuse being one of them.	[13]
	Women trafficking	Poor jobless people will get drawn to unethical jobs and may be willing to do anything for money.	[22]
	Intergenerational relationships	Poverty will directly affect the living conditions of a family and will affect the mindset of	[6]

		all the generations in the family.	
	Economic condition of the country	With increase in poverty, the economic condition of a country would worsen.	[3]
	Mass emigration	People will tend to immigrate to other countries in search of jobs.	[10]
	Terrorism	Poverty will lead people to take steps in favor of terrorism when money will be promised to them in return for their services.	[20]
	Malnutrition	Due to poverty, a family will not be able to get adequate food or nutrition leading to malnutrition.	[24]

Table 4 : Causes and consequences of poverty

This paper uses the relational maps to map relations among different factors. Authors proposed two soft computing based methodologies Fuzzy relational maps (FRM) and Neutrosophic relational maps (NRM), for highlighting the causes and implications of skewed sex ratio and poverty problem pervasive in India. FRMs divides problem space into domain and range space, thereby represent the relationship between the elements of domain and range space. When the data under analysis is indeterminate, there is no definite relation between concepts but interrelation between concepts exists in a hidden way. In real life situations indeterminate relations can be seen everywhere i.e. Consider a situation where it is difficult to decide whether a relation between two concepts exists or not. The probability that a person wins an election is 35% true, 25% false and 40% indeterminate i.e. percentage of people giving a blank vote or not giving a vote.FRM cannot handle such data. NRM is an innovative technique for processing data uncertainty and indeterminacy while observing impacts among various factors to obtain more sensitive results.

The remaining of the paper is organized as follows. Section 2 presents Relational Maps. Section 3 presents basics of FRMs, Linked FRMs and gives a model based on FRM for studying India's skewed sex ratio and poverty problem. Section 4 introduces the NRM and Linked NRM methodology developed. This section gives a model based on NRM for studying India's skewed sex ratio and poverty problem. Section 5 details discussion of results. Finally, section 6 outlines the conclusion.

2 Relational Maps

A relational map is related to cognitive map, which is also known as mental map. It is a representation and reasoning model on causal knowledge [32].It is a labeled, directed and cyclic graph with disjoint set of nodes and edges represent causal relations between these set of nodes . A relational map represents knowledge (useful information) which further helps to find hidden patterns and support in decision making. Fuzzy Relational Maps are relational maps which use fuzzy values in domain $\{0, 1\}$. This represent the cases of existence and nonexistence of relations between nodes but indeterminacy between the relations are not represented. F. Smarandache proposed Neutrosophic Relational Maps which is an extension of fuzzy relational maps that can represent and handle indeterminate relations [31].

3 Fuzzy Relational Maps

W.B.Vasantha et.al(2000) introduced a new methodology called Fuzzy Relational Maps which is an extension of Fuzzy Cognitive Maps (FCM) and is used in applications like banking [33], IT expert systems [25] etc. In FRM, the problem space is divided into a domain space D and a range space R. There are relationships that exist between the domain space and range space concepts. No intermediate relations exist between the concepts within the domain or range space.

3.1 Basics of FRM

A FRM is a directed graph from Domain D(dimension *m*) to Range R (dimension *n*) such that $D \cap R = \varphi$, with concepts as nodes. The concepts represented as variables describe the behavior of system and the edges repre-

sent the relationships among the concepts which can be either positive or negative. The positive relationship shows that the effect variable undergoes a change in the same direction and negative relationship shows that the effect variable undergoes a change in the opposite direction [32].

Let x denote concepts of the range space or the domain space, where $x = \{0 \text{ or } 1\}$

If $x = 1$, represents the on state of the node.

If $x = 0$, represents the off state of the node.

Let D_i and Rj denote the two concepts of FRM. The directed edge from D_i to R_j denote the relation or effect of D_i on R_j. The edge has the value which lies in the range $\{0, +1, -1\}$.

Let e_{ij} be the edge D_iR_j weight and $eij \in \{0, +1, -1\}$.

If $e_{ij} = 1$ decrease in D_i implies decrease in R_j or increase in Di implies increase in R_j.

If $e_{ij} = 0$, then there is no effect of D_i on R_j.

If $e_{ij} = -1$, then decrease in D_i infers increase in R_j or increase in D_i implies decrease in R_j.

3.2 Linked FRM methodology

W.B. Vasantha et.al [31] also introduced yet another new technique to help in decision making using FRMs called Linked FRMs which is not feasible in case of FCMs. This methodology is more adaptable in those cases of data where two or more systems are inter-related in some way but we are not in a position to inter-relate them directly. Assume we have 3 disjoint sets of concepts, say space P (m set of nodes), Q (n set of nodes) and R(r set of nodes). We can directly find FRMs relating P and Q, FRMs relating Q and R but we are not in a position to link or get a direct relation between P and R but in fact there exists a hidden link between them which cannot be easily weighted.

The linked FRM methodology developed uses FRMs connecting three distinct spaces P (m nodes),Q(n nodes) and R (r nodes) in such a way that by using the pairs of FRMs between P & Q and Q & R we obtain FRM relating P & R.

Let E_1 be the causal matrix between P and Q of order $m \times n$ and E_2 be the causal matrix between Q and R of order $n \times r$. Now cross product of E_1 & E_2 gives a matrix which is the causal matrix relating $P$and R.

3.3 Hidden pattern for FRM

Let $Di\ Rj(or\ RjDi)$ be an edge from D_i to Rj. D_i is the ith node in domain space and Rj is the *jth* node in range space where $1 \le j \le m$ and $1 \le i \le n$. When $Ri(or\ Dj)$ is switched on and if causality flows through edges of the cycle and if it again causes $Ri(orDj)$, we say that the dynamical system goes round and round. This is true for any node $Rj(or\ Di)$ for $1 \le I \le n$, or $(1 \le j \le m)$. The equilibrium state of this dynamical system is called the hidden pattern [30].

If the equilibrium state of a dynamical system is a unique state vector, then it is called a fixed point.

Consider an FRM with $(R1, R2, \dots, Rm)$ and $(D1, D2, \dots \dots, Dn)$ as nodes.

For example, let us start the dynamical system by switching on $R1\ (or\ D1)$.

If the FRM settles down with $R1$ and Rm(or $D1$ and Dn) on, eg. the state vector remains as $(1, 0, ., 0, 1)$ in R or $(1, 0, ., 0, 1)$ in D. This state vector is called the fixed point.

If the FRM settles down with a state vector repeating in the form

($A1 \to A2 \to A3 \to \cdots \to Ai \to A1$) Or ($B1 \to B2 \to B3 \to \cdots \to Bi \to B1$)this equilibrium is called a limit cycle.

3.4 MODEL: Implementation of linked FRM model in study of skewed sex ratio and poverty problem

The sex ratio and poverty problem in India are two of the major problems which are discussed in this section. There are three sets of conceptual nodes in three spaces. The spaces under study are P, Q and R where

P - The attributes associated with causes that result in deteriorating or improving the status of poverty and skewed sex ratio in India,

Q- Attributes representing the two problems, and

R- Attributes associated with resultant implications of the two problems under study.

The attributes / concepts used in the model are given below:

P - The attributes associated with various causes of poverty and unbalanced sex ratio. Though there could be many such attributes but here the authors have prominently categorized 7 important causes in P.

$P1$ – Gender Equality in education and employment

$P2$ – Literacy rate

$P3$ – Emergence of new technologies

$P4$ – Overpopulation

$P5$ – Sons preferred, preservation of the clan

$P6$ – Government and NGOs awareness campaigns, which aim to change the people's mindset and attitude towards girls

$P7$ – Government's support to families that have girl child for example direct subsidies at the time of birth, female quotas, scholarships and old age pensions

Q – The attributes representing the problems under study.

$Q1$ – Skewed sex ratio
$Q2$ – Poverty
R – The attributes associated with the various implications. Here the authors have basically taken 13 important possible such consequences. Though there could be many more.
$R1$ – Female sex abuse
$R2$ – Women trafficking
$R3$ – Surplus men, more unmarried men still in marriage market
$R4$ – Geographical spread in marriage market
$R5$ – Inter-generational relationships, young girls getting married with much older men
$R6$ – Polyandrous relationships, where one women is married to multiple men
$R7$ – Homosexual relationships
$R8$ – Cross class and cross caste marriages
$R9$ – Economic condition of the country
$R10$ – Women empowerment
$R11$ – Mass emigration
$R12$ – Terrorism
$R13$ – Malnutrition

Subsequent to the deliberations with the researchers working in this domain, the authors generated the relational directed graph of the model for spaces P & Q and Q & R as shown in Fig. 1a and 1b.

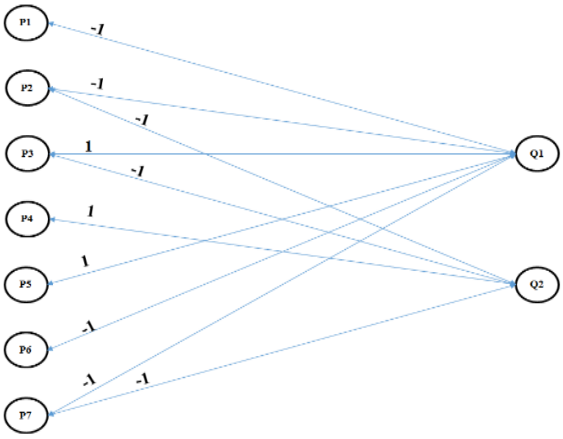

Figure. 1a FRM for spaces P and Q

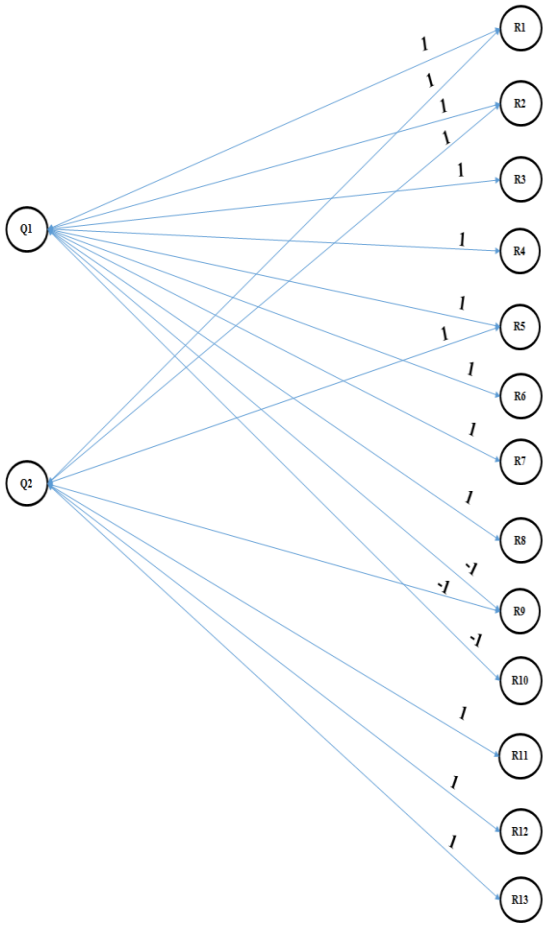

Figure. 1b FRM for spaces Q and R

The relational or connection matrix for spaces P & Q and Q & R can be constructed as given by table 5a and table 5b.

CAUSES	Q1	Q2
P1	-1	0
P2	-1	-1
P3	1	-1
P4	0	1
P5	1	0
P6	-1	0
P7	-1	-1

Table 5a FRM Matrix (E1) for P and Q

IM-PLICATIONS	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13
Q1	1	1	1	1	1	1	1	1	-1	-1	0	0	0
Q2	1	1	0	0	1	0	0	0	-1	0	1	1	1

Table 5b FRM Matrix (E2) for Q and R

Thus E1 is a 7×2 matrix and E2 is a 2×13 matrix. $E1 \times E2$ gives the relational matrix which is a 7×13 matrix say E, known as the hidden connection matrix, as shown in Table 6.

Causes\Implications	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13
P1	-1	-1	-1	-1	-1	-1	-1	-1	1	1	0	0	0
P2	-1	-1	-1	-1	-1	-1	-1	-1	1	1	-1	-1	-1
P3	0	0	1	1	0	1	1	1	0	-1	-1	-1	-1
P4	1	1	0	0	1	0	0	0	-1	0	1	1	1
P5	1	1	1	1	1	1	1	1	-1	-1	0	0	0
P6	-1	-1	-1	-1	-1	-1	-1	-1	1	1	0	0	0
P7	-1	-1	-1	-1	-1	-1	-1	-1	1	1	-1	-1	-1

Table 6 Hidden FRM Matrix (E) for P and R

Thus, by this method even if the authors were not in a position to get directed graph, authors could indirectly obtain the FRMs relating them. Now using these three FRMs and their related matrices, conclusion is derived by studying the effect of each state vector.

For the given model,

First take initial vector $A1$ by keeping $P2$ i.e. literacy rate in ON state.

Let E =Hidden connection matrix for P and R

Initial state vector $A1$ should pass through the relational matrix E.

This is done by multiplying $A1$ with the relational matrix E.

Let $A1E = (r1, r2, \ldots . rm)$

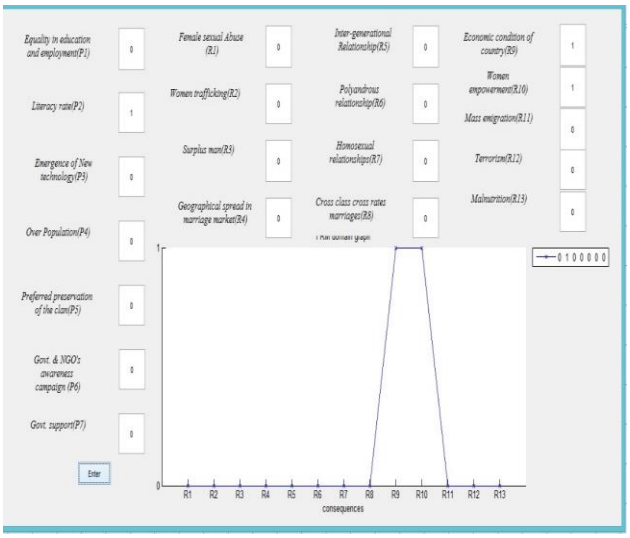

Figure. 2 Problem simulation using MATLAB for FRM when 'Literacy Rate' is ON

After thresholding and updating the resultant vector we get $A2 = A1E \in R$. Now pass $A2$ into ET and calculate $A2ET$.

Update and threshold the vector $A2ET$ such that vector $A3$ is obtained and $A3 \in D$.

This procedure is repeated till we get a limit cycle or a fixed point.

$A1 = (0\ 1\ 0\ 0\ 0\ 0\ 0)$
$A1E = (0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 1\ 0\ 0\ 0) = A_2$
$A2E = (1\ 1\ 0\ 0\ 0\ 1\ 1) = A_3$
$A3E = (0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 1\ 0\ 0\ 0) = A_4$
Hence, $A4 = A2$ we got a fixed point.

Problem simulation using MATLAB

The authors have created a graphical user interface using MATLAB as shown in Fig. 2

The GUI takes input from the user which can be either 0 or 1 , where 1 represents the concept is in ON state and 0 represents the OFF state. The GUI contains a graph which shows the impact on various concepts based on the initial state vector taken as input.

Resultant vector can have two outputs:

'1' represents the existence of relation among the concepts , whereas '0' represents that there is no causal relationship.

3.5 Limitations of FRM

The concepts for which the experts are not in a position to draw any relations, i.e. concepts may or may not have causal effects, cannot be associated in FRMs. The edges can take either of the values $0,1$ or -1 as shown in Table 5a and Table 6 . An expert may not always be able to make certain decisions on the relation between two nodes. This drawback can be overcome by using Neutrosophic Relational Maps which support decision-making under uncertainty in dynamic systems as shown in Table 7 and Table 8.

In FRMs, either a relation exists or do not exist, but this will not always be true in case of real world problems. When the data under analysis is unsupervised data, the relation can be indeterminate like considering a relation where skewed sex ratio may or may not lead to homosexual relations as it depends upon the mindset of the individuals. In such cases only NRMs are better applied than FRMs. Thus NRMs play a better role and give a sensitive result than the FRMs as shown in Table 10.

Fuzzy world is about fuzzy data and fuzzy membership but it has no capacity to deal with indeterminate concepts.

Thus with the help of NRM, whenever in the resultant data indeterminacy is observed i.e. the symbol I, the person who analyze the data can deal with more caution thereby getting sensitive results rather than treating the nonexistence or associating 0 to that co-ordinate.

4 Neutrosophic Relational Maps

NRM is an extension of FRM where indeterminacy is included [32]. The concept of fuzzy relational maps fails to deal with the indeterminate relation. Neutrosophic logic is the soft computing technique which is able to support incomplete information i.e. it deals with the notions of indeterminacy.

The input state vectors are always taken as the real state vectors i.e. the node or the concept is in the on state or in the off state but when we are indeterminate about any concept then it is represented as indeterminate, with the symbol *I*.

4.1 Basics of NRM

Let D be the domain space with nodes $D1, \dots, Di$ and R be the range space with the conceptual nodes $R1, \dots, Rj$, $i \in 1 \dots n$ and $j \in 1 \dots m$ such that they form a disjoint class i.e. $D \cap R = \varphi$. Suppose there is a FRM relating D and R and if any edge relating $Di\ Rj$ is indeterminate then we call the FRM as the Neutrosophic Relational Maps (NRMs).

Every edge in the NRM is weighted with a number in the set $\{0, +1, -1, I\}$.

Let e_{ij} be the edge D_iR_j weight and $eij \in \{0, +1, -1, I\}$.

If $e_{ij} = 1$ decrease in D_i implies decrease in R_j or increase in Di implies increase in R_j.

If $e_{ij} = 0$, then there is no effect of D_i on R_j.

If $e_{ij} = -1$, then decrease in D_i infers increase in R_j or increase in D_i implies decrease in R_j.

If $e_{ij} = I$ it implies that the effect of D_i on R_j is indeterminate so we denote it by I.

4.2 NRM hidden patterns

Let $Di\ Rj\ (or\ Rj\ Di) 1 \le j \le m$, $1 \le i \le n$, when $Rj\ (or\ Di)$ is switched on and if causality flows through edges of a cycle and if it again causes $Rj\ (or\ Di)$ we say that the Neutrosophical dynamical system goes round and round. This is true for any node $Rj(\ or\ Di)$ for $1 \le j \le$ m $(or\ 1 \le i \le n)$. The equilibrium state of this Neutrosophical dynamical system is called the Neutrosophic hidden pattern.

Fixed point and Limit cycle in an NRM

If the equilibrium state of a Neutrosophical dynamical system is a unique Neutrosophic state vector, then it is called the fixed point.

Consider an NRM with $R1, R2, \dots, Rm$ and $D1, D2, \dots, Dn$ as nodes.

For example let us start the dynamical system by switching on $R1\ (or\ D1)$. Let us assume that the NRM settles down with $R1$ and $Rm(or\ D1\ and\ Dn)$ on, or indeterminate, eg. the Neutrosophic state vector remains as $(1,0,0,\dots,1)$ or $(1,0,0,\dots I)$ in R or $(1,0,0,\dots 1)$or

$(1,0,0,\dots I)$ in D, this state vector is called the fixed point.

If the NRM settles down with a state vector repeating in the form

$(A1 \to A2 \to A3 \to \cdots \to Ai \to A1)$ or $(B1 \to B2 \to B3 \to \cdots \to Bi \to B1)$ then this equilibrium is called a limit cycle.

Now we proceed on to define the notion of linked NRM as in the case of FRM.

This methodology is more adaptable in those cases of data where two or more systems are inter-related in some way but we are not in a position to inter-relate them directly i.e. cases where related conceptual nodes can be parti-

tioned into disjoint sets. Such study is possible only by using linked NRMs.

Assume we have 3 disjoint sets of concepts, say spaces P (m set of nodes), Q(n set of nodes) and R(r set of nodes). We can directly find NRMs relating P and Q, NRMs relating Q and R but we are not in a position to link or get a direct relation between P and R but in fact there exists a hidden link between them which cannot be easily weighted; in such cases we use linked NRMs where using the pair of NRMs we obtain a resultant NRM.

4.3 Linked NRM Methodology

The methodology developed uses NRMs connecting three distinct spaces namely, P(m nodes), Q(n nodes) and R(r nodes) in such a way that using the pairs of FRMs between P & Q and Q & R we obtain FRM relating P & R (VasanthaKandasamy & Sultana, 2000).

If $E1$ is the connection matrix relating P and Q then $E1$ is a $m \times n$ matrix and $E2$ is the connection matrix relating Q and R which is a $n \times r$ matrix. Now $E1E2$ is a $m \times r$ matrix which is the connection matrix relating P and R and $E2T$ $E1T$ matrix relating R and P, when we have such a situation we call it the pair wise linked NRMs.

4.4 MODEL: Implementation of linked NRM model in study of skewed sex ratio and poverty problem

Recall the model in section 3.4 where the study of sex ratio and poverty is carried out using linked FRM where no indeterminacy is considered.

Now instead of FRM we instruct the expert that they need not always state the presence or absence of relation between any two concepts but they can also spell out the missing relations between two concepts, with these additional instruction to the expert, the opinions are taken.

In order to implement our model using linked NRM, we take the same three sets of conceptual nodes in three spaces as taken in section 3.4 i.e. the spaces under study are P, Q and R.

The attributes / concepts used in the model can be referred from section 3.4.

In our model the relations where indeterminacy can be represented are:

$P1$ (Gender Equality in education and employment) $\rightarrow Q2$(Poverty)

If there is equality in education and employment i.e. women are given equal opportunity to study and earn for their families then there may be a possibility that there might be a decline in poverty, but we cannot conclude this for sure(refer Table 5a).

Q1(Skewed sex ratio)→ *R7*(homosexual relationships)

If there exists imbalance in male to female ratio then there would be surplus men. There is a possibility that the situation would lead to more homosexual relations in shortage of women(refer Table 5b).

Other indeterminacies between nodes introduced in this model are highlighted in the Table 7 and Table 8.

Taking the expert opinion, the authors give the Neutrosophic Relational maps as shown in Fig. 3a and Fig. 3b.

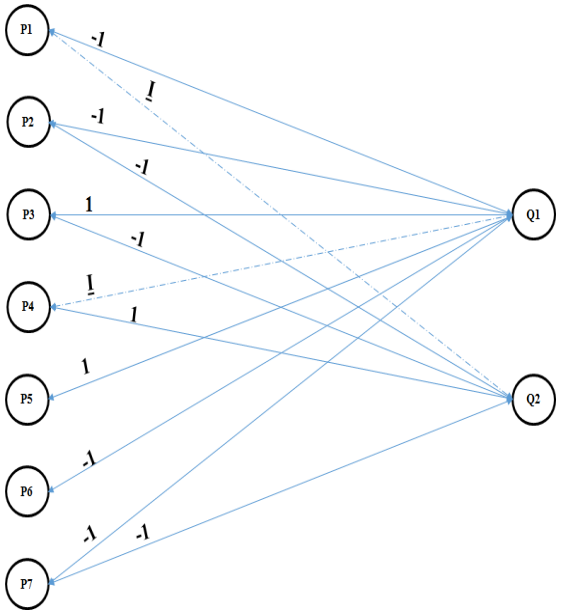

Figure. 3a NRM for spaces P and Q

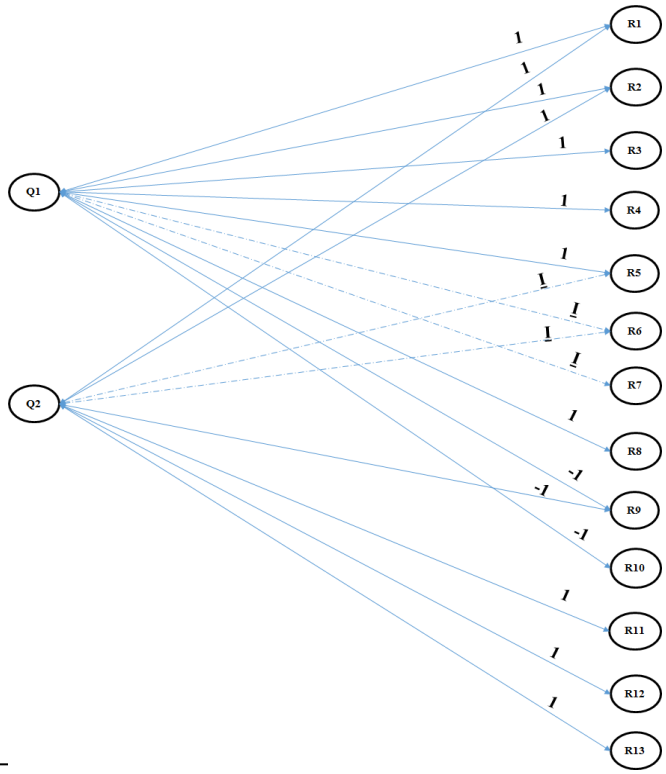

Figure. 3b NRM for spaces Q and R

The matrices for the three NRMs formulated which can contain the values from set $\{0, 1, -1, I\}$ are given by:

CAUSES	Q1	Q2
P1	-1	I
P2	-1	-1
P3	1	-1
P4	I	1
P5	1	0
P6	-1	0
P7	-1	-1

Table 7 NRM Matrix for P and Q

IMPLI-CATI-ONS	R 1	R 2	R 3	R 4	R 5	R 6	R 7	R 8	R 9	R 10	R 11	R 12	R 13
Q1	1	1	1	1	1	I	I	1	-1	-1	0	0	0
Q2	1	1	0	0	I	I	0	0	-1	0	1	1	1

Table 8 NRM Matrix for Q and R

Causes/Implications	R 1	R 2	R 3	R 4	R 5	R 6	R 7	R 8	R 9	R 10	R 11	R 12	R 13
P1	-1	-1	-1	-1	-1	0	I	-1	1	1	I	I	I
P2	-1	-1	-1	-1	-1	I	I	-1	1	1	-1	-1	-1
P3	0	0	1	1	1	0	I	1	0	-1	-1	-1	-1
P4	1	1	I	I	I	I	I	I	-1	I	1	1	1
P5	1	1	1	1	1	I	I	1	-1	-1	0	0	0
P6	-1	-1	-1	-1	-1	I	I	-1	1	1	0	0	0
P7	-1	-1	-1	-1	-1	I	I	-1	1	1	-1	-1	-1

Table 9 Hidden NRM Matrix for P and R

The 'I' factor was introduced in the NRM matrix. The hidden pattern using Linked NRM was calculated as,

$N(E)$ Hidden connection matrix with indeterminacy added. (Table 9)

I =Indeterminacy

The hidden pattern for Linked NRM is calculated as follows:

We first take same initial vector (as in section 3.4) $A1$ by keeping $P2$, literacy rate in ON state

If $A1 = (0\ 1\ 0\ 0\ 0\ 0\ 0)$,

$$A1N(E) = (0\ 0\ 0\ 0\ 0\ I\ I\ 0\ 1\ 1\ 0\ 0\ 0) = A2$$
$$A2N(E) = (1\ 1\ 0\ 0\ 0\ 1\ 1) = A3$$
$$A3N(E) = (0\ 0\ 0\ 0\ 0\ I\ I\ 0\ 1\ 1\ 0\ 0\ 0) = A4$$

Problem simulation using MATLAB

The authors have created a graphical user interface using MATLAB as shown in Fig. 4.

The GUI takes input from the user which can be either 0 or 1 where 1 represents the concept is in ON state and 0 represents is in OFF state. The GUI contains a graph which shows the impact on various concepts based on the initial state vector taken as input.

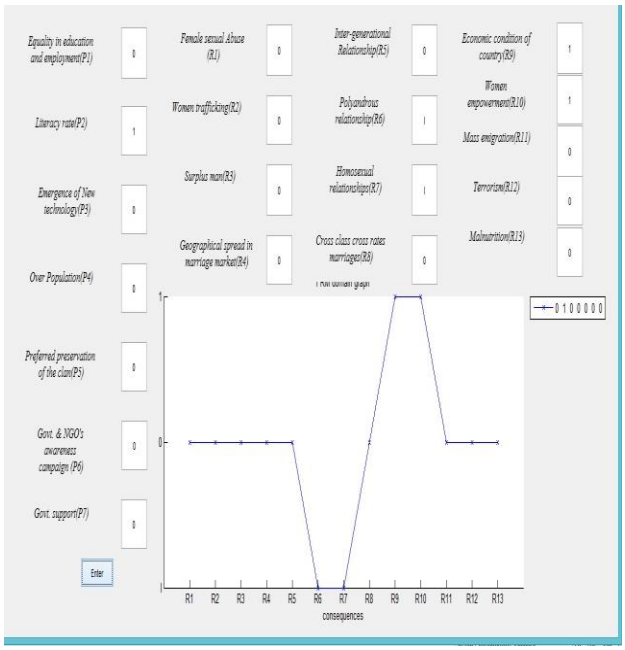

Figure. 4 Problem simulation using MATLAB for NRM when 'Literacy Rate' is ON

Resultant vector can have three outputs: '1' represents the existence of relation among the concepts ,

'0' represents that there is no causal relationship, whereas

'I' represents that there might be a causal relationship among the concepts i.e. the existence of the relationship is indeterminate.

5 Discussion of results

The development of the models to support decision making in this research is to identify and analyze the indirect relations among the factors responsible in the distorted sex ratio and poverty of India and their implications, have been proved as reliable and valid.

Values achieved in the Fig. 2 and Fig. 4 shows impacts of various causes and their consequences. FRMs and NRMs are modeled in section 3.4 and 4.4 to show how the various spaces are related.

The perceptions of the expert could not be 100% accurate. In addition, different experts may have different perceptions working with the same data, which will lead to different conclusions.

The results show that due to emergence of new technologies available in medical field like ultrasound, the factors like female abuse, crime rate, surplus men in marriage market, geographical marriage spread and women trafficking are indirectly influenced. However, the author is not in a position to surely say anything about the implications like polyandrous relationships and homosexual relationships because these depend on the mindset of the individuals. There is one positive outcome; greater acceptance towards inter-caste and inter religious marriages. Problems such as terrorism, mass emigration and malnutrition are a result of poverty pervasive in India which in turn is a result of overpopulation.

6 Conclusion

This paper discusses two major problems existing in India-namely, skewed sex ratio and poverty. The authors use the methodologies which help in decision-making when the information is incomplete and dynamic in nature. The paper highlights the various factors leading to these problems in India and show in what ways these causes relate to their positive as well as negative implications. The data concludes the explanation that due to the sources contributing in female deficit in India, there is a tremendous impact on the country's economic growth and the status of women in society. Authors also show that prevalence of the problems discussed in the paper depends heavily on the literacy rate of the population.

The model used here is NRM which has significant advantages over FRM. As discussed in the cases above, in the FRM model, the literacy rate has effect only on two factors but the NRM model along with two previous factors has drawn our attention to two other factors which may have indeterminate effect on polyandrous and homosexual relation hence depicting that increase in literacy rate may or may not lead to polyandrous or homosexual relation. The other factor discussed using both the models is the effect of sons preferred preservation of clan and its effect on other factors, here the NRM model suggests that affect on polyandrous and homosexual relations is indeterminate.

Literacy has a direct impact in the growth of a country eradicating problems like mass emigration of labor by providing employment opportunities in the country, directly or indirectly affecting poverty. Also, literacy has a direct relation with the attitude of the society towards females. There is a need for enlightened mindset towards females.

In India, different schemes encouraging the parents to have a girl child have been launched by the National and State Governments. Some of the schemes are the Ladli Scheme in Delhi and Haryana, the Rajlakshmi Scheme in Rajasthan, Rakshak Yojna in Punjab, Bhagyalakshmi Scheme in Karnataka. As discussed by the authors, if such schemes are put in place females will no longer be considered as economic burden on their families.

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