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A Decision-Making Approach for Studying Fuzzy Relational Maps under Uncertainty

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Abstract

Every kid in the womb is initially a girl. It is over time and a series of changes that the kid turns into a boy or remains a girl. When these changes are incomplete, the kid becomes transgender. This model is more applicable when the data in the first place is an unsupervised one. To define FRM we need a domain space and range space, which are disjoint in the sense of concept. In this paper, we analyze the various problems of transgender in Chennai using Fuzzy Relational Maps (FRMs). This FRM method is best suited for this study. This method was introduced by Vasantha Kandaswamy and Sultana [1] in 2000. This paper contains five sections. The first section is introductory and deals with the basics of transgender issues. The second section deals with the preliminaries of the FRM Model. The third section lists the causes and causalities of the problems of transgender. These are arrived at through the linguistic questionnaire administered to 100 trans genders, 10 parents, and three NGO leaders who have been working for their rights and rehabilitations in Chennai City. In the fourth section, we analyze the interrelationship between the causes and causalities listed in the Domain and range spaces using the FRM Model. In the Final section we give the conclusion based on our studies and suggestions.

Keywords: FRM, Fixed point, Hidden pattern, Unsupervised, Transgender, Decision making and optimization.

1 | Introduction

Transgender is an Umbrella term for persons whose gender identity and gender expressions or behavior do not conform to that typically associated with the sex to which they were assigned at birth.

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Gender Identity refers to a person's internal sense of being male, female or something else. Gender expression refers to the way a person communicates gender identity to others through behavior, clothing, hairstyles, voice or body characteristics etc.

Gender identity or sexual orientation

Transgender people may be straight, lesbian, gay, and bisexual, just as transgender people can be. There are many types of trans-people, like lesbian, gay, bisexual and transgender, and in short, LGBT, due to some common concerns requiring intervention from the government through policy measures to resolve certain basic problems.

Lesbian or gay woman

A transgender woman or a person who is assigned male at birth and transitions to female, who is attracted to other women, would be identified as a lesbian or gay woman.

Gay man

A transgender man or a person who is assigned female at birth and transitions to male, who is attracted to other men, would be identified as a gay man.

Making fun of transgender has always been fun and since known history. Transgender is a gender given to the world by nature, and the recognition of such people by the people as well as the government is still chaotic. When a transgender is treated unequally or is humiliated by ordinary people, there are not a lot of redress mechanisms that are available to him. They face immense problems in society.

These people are hardly educated. Most of them are pushed into sex work and out of Illiteracy; they become vulnerable to deadly diseases like HIV/AIDS. Thus, in the long run, they lose hope, self-confidence and whatnot.

2 | Preliminaries of Fuzzy Relational Maps

2.1 | Previous Research Work

Vasantha Kandasamy and Sultana [2] introduced this method FRM to the analysis of employee and employer relationship model, and also in the year (2000) they made these calculations by the knowledge processing using fuzzy relational maps. Kandasamy et al. [3] used these methods to analyze of health hazards faced by rag pickers of Chennai city, using modified induced FRMs.

Divya and Uduman [4] concluded that the FRM model of the hypertension problem faced by adults in Tamilnadu. Kenneth and Monica [5] investigated the study of air pollution using FRMs. Rajkumar et al. [6] and GeethaLakshmi and Rajkumar [7] have studied miracles through the holy bible using modified induced FRMs.

Devadoss et al. [8] have used these methods to study the impact of malnutrition and fruits using FRMs. Arul et al. [9] studied these papers by the causes of school dropouts.

GeethaLakshmi and Rajkumar [7] presented these papers on the problems faced by experienced women IT professionals in Chennai using FRMs. Bivin et al. [10] concluded that the remedy for effective cure of diseases using combined Neutrosophic relational maps.

Kosko [11] has studied fuzzy cognitive maps by using the concepts of fish, shark and dolphin. Kannan et al. [12] studied of fuzzy Floyd Warshall algorithm and the fuzzy rectangular algorithm to find the shortest path. Broumi [13] made an efficient approach for solving time-dependent shortest path problem under Fermatean Neutrosophic environment. Vidhya and Saraswathi [14] proposed a novel method for finding the shortest path with two objectives under Trapezoidal Intuitionistic Fuzzy Arc Costs (TIFAC).

Prakash and Appasamy [15] presented an optimal solution for a fully spherical fuzzy linear programming problem. Saraswathi [16] developed a fuzzy-trapezoidal DEMATEL approach method for solving decision making problems under uncertainty.

Dharmaraj and Appasamy [17] have done an application of a modified Gauss elimination technique for separable fuzzy nonlinear programming problems. Vidhya and Saraswathi [14] investigated the A* search algorithm for the shortest path under an interval-valued Pythagorean fuzzy environment. Saraswathi and Mahalakshmi [18] solved a new approach for solving the minimal flow, shortest.

The route, maximal flow and the critical path using network. Saraswathi [19] used a triangular fuzzy clustering model under uncertainty. Prakash and Appasamy [20] studied a novel approach for a multi-objective linear programming model under a spherical fuzzy environment and its application. Karthick et al. [21] used a Neutrosophic linear fractional programming problem using the denominator objective restriction method. Nedumaran et al. [22] developed a comparative study for finding the critical path using triangular fuzzy numbers.

2.2 | Justification for Using FRM

This model is more applicable when the data in the first place is an unsupervised one. To define FRM we need a domain space and range space which are disjoint in the sense of concept.

The causes and causalities of the transgender problems form two disjoint spaces. By using this FRM model we can analyze the inter relation between doctor and patient, teacher and student, employee and employer methods as teaching and the behavioral outcomes etc. In this discussion the elements of domain space are problems and the range spaces are the causes/reasons.

We denote by R the set of nodes ($R_1 \ldots . \ldots R_m$) of the range space, where $R = x_1, \ldots . x_m / x_j = 0$ or 1 for j = 1, 2 ….m. If xj=1, it means the node R_i is in the 'on' state and $x_i = 0$ means that the node R_i is in the 'off' state. Similarly D denotes the nodes $D_1 D_2 \ldots D_n$ of the domain space where $D = x_1, \ldots x_n / x_j = 0$ or 1 for i =1, 2….n. It means the node D_i is on or off for xj=0 or 1 respectively.

2.2.1 | Fuzzy relational maps

An FRM is a directed graph or a map from domain space to range space with concepts like policies or events, etc., as nodes and causalities as edges. It represents casual relations between spaces D and R.

2.2.2 | Definition

The directed edge from D to R denotes the causality of D on R, called relations. Every edge in the FRM is weighted with a number in the set {0, 1}.

2.2.3 | Simple FRM

Let D_i and R_j denote the nodes of an FRM. Let e_{ij} be the weight of the edge $D_i R_j$, $e_{ij} = 0,1\}$. The weight of the edge $D_i R_j$ is positive if increase in D_i implies increase in R_j or decrease in D_i implies decrease in R_j. i.e., casuality of D_i on R_j is 1. If $e_{ij} = 0$ then D_i does not have any effect on R_j.

We do not discuss the cases when increase in D_i implies decrease in R_j or decrease in D_i implies increase in R_j. When the nodes of the FRM are fuzzy sets, then they are called fuzzy nodes, FRMs with edge weights {0, 1} are called simple FRMs. Let $D_1, D_2, \ldots D_n$ be the nodes of the domain space D of an FRM and $R_1, R_2, \ldots . R_m$ be the nodes of the range space R of an FRM.

2.2.4 | Relational matrix

Let the matrix E be defined as E = eij where eij = {0, 1} is the weight of the directed edge D_iR_j (or R_jD_i), E is called the relational matrix of the FRM. It is pertinent to mention here that unlike the FRMs, the FRMs can be a rectangular matrix; with rows corresponding to the domain space and columns corresponding to the range space.

2.2.5 | Directed cycle

Let $D_1,D_2,\ldots D_n$ and $R_1,R_2,....R_m$ be the nodes of an FRM. Let D_iR_j (or R_jD_i) be the edges of an FRM, j=1,2,….,m, i=1,2,…n. The edges form a directed cycle if it possesses a directed cycle. An FRM is said to be acyclic if it does not possess any directed cycle.

2.2.6 | Dynamical system

An FRM with cycles is said to be an FRM with feedback. When the casual relations flow through a cycle in a revolutionary manner, the FRM is called a dynamical system.

2.2.7 | Hidden pattern

Let D_iR_j (or R_jD_i), $1<j<m,\ 1<i<n$. When R_j (or D_i) is switched on and if causality flows through edges of the cycle and if it again causes R_j (or D_i), we say that the dynamical system goes round and round. This is true for any node R_j (or D_i) for $1<i<n$, (or $1<j<m$).

The equilibrium state of this dynamical system is called the hidden pattern. If the equilibrium state of the dynamical system is a unique state vector, then it is called a fixed point. Consider an FRM with $R_1,R_2,....R_m$ and $D_1,D_2,\ldots D_n$ as nodes. For example let us start the dynamical system by switching on R1 or D1. Let us assume that the FRM settles down with R_1 and R_m (or D_1aA_1 and D_n) on i.e. 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 $A_2>\ldots>A_i>A_1$ or $(B_1>B_2\ldots B_i>B_1)$ then this equilibrium is called a limit cycle.

3 | Adaptation of FRM to the Relation between Problems and the Reasons of the Trans-Genders

By using a linguistic questionnaire, the expert's opinion was arrived at by administering the same to 100 Tran's genders, 10 parents and three NGO leaders. Here, we take the problems of the trans genders in the domain space added the causes for the problems in the range space as listed below:

3.1 | Some Survey Questions for the Transgender Respond

- *What does transgender mean?*
- *What is the difference between sex and gender?*
- *Why are some people transgenders?*
- *How prevalent are transgender people?*
- *What are some categories or types of transgender people?*
- *What is the relationship between transgender and sexual orientation?*
- *How do transgender people experience their transgender feelings?*
- *Is being transgender a mental disorder?*
- *What kinds of mental health problems do transgender people face?*
- *What kinds of discrimination do transgender people face?*
- *Where can I find more information about transgender issues?*

3.2 | Attributes Related to the Domain Space

I. D_1 – parents disown the trans genders after certain age.

II. D_2 – hormones disorder leading to unnatural behavior.

III. D_3 – poverty.

IV. D_4 – lack of education.

V. D_5 – unemployed.

VI. D_6 – no share in property.

VII. D_7 – lack of support from government and non-government organizations.

VIII. D_8 – forced to beg or uncertain prostitution for their livelihood.

IX. D_9 – unnatural slang in conversation.

X. D_{10} – prone to sexual diseases such as STD/HIV/AIDS.

4 | Attributes Related to the Range Space

I. R_1 – living with trans- people.

II. R_2 – lack of permanent shelter.

III. R_3 – forced to have illicit sex as marriage is not possible.

IV. R_4 – no sexual identity to be admitted in educational institutions or to register for employ mentor to exercise adult franchise.

V. R_5 - subject to teasing due to unnatural behavior.

VI. R_6 – no proper food/malnutrition.

VII. R_7 –living in depression and trauma.

The expert opinion is arrived at through the responses we received from the transgender themselves. The corresponding directed graph is given below. (see *Fig.1*)

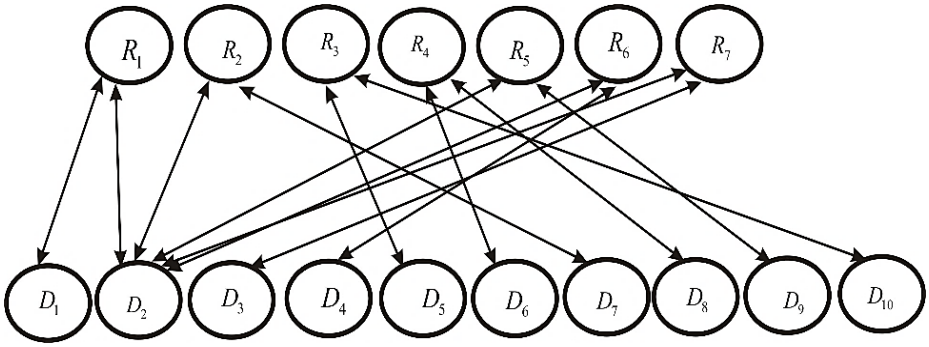

Fig. 1. The related matrix E_1 of the directed graph is given.

$$E_1 = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 \end{pmatrix}. \quad (1)$$

$$E_1^T = \begin{pmatrix} 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \end{pmatrix}.$$

4.1 | Method of Finding the Hidden Pattern

Let D2 be kept in "on state," i.e., "hormones disorder leading to unnatural behaviour" is in the 'on state'

Let the hidden pattern of the state vector X = (0 1 0 0 0 0) be obtained by the following method:

- *X=(0 1 0 0 0 0 0 0 0 0).*
- *XE1=(1 1 1 0 1 1 1)=Y.*

- *YE1T=(1 1 1 1 1 1 1 1 1 1)=X1.*
- *X1E1=(1 1 1 1 1 1 1)=Y1.*
- *Y1E1T=(1 1 1 1 1 1 1 1 1 1 1)=X2.*
- *X2E1=(1 1 1 1 1 1 1)=y2.*
- *Y1=Y2.*

When D2, "hormones disorder leading to unnatural behaviour" is the on state and all other states are off state. The fixed-point pair is {(1 1 1 1 1 1 1 1 1 1), (1 1 1 1 1 1 1)} that the corresponding hidden pattern is a fixed point.

4.2 | Display Results through Graphs

The matrix in previous section shows the following results (*Figs. 1-10*) through graphs.

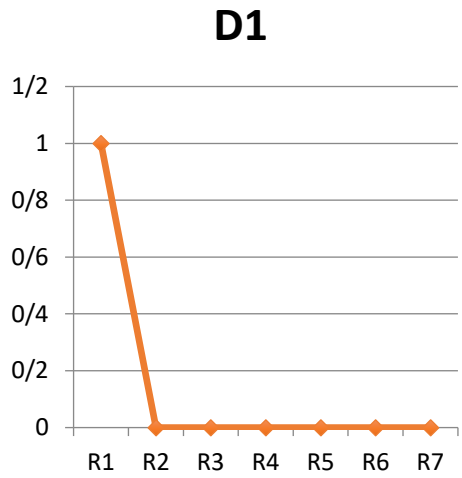

Fig. 1. Parents Vs reasons.

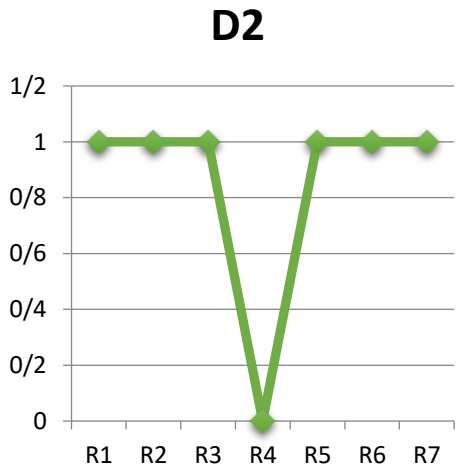

Fig. 2. Hormones Vs reasons.

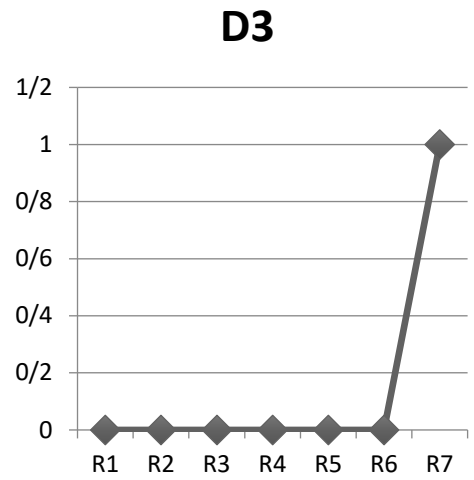

Fig. 3. Poverty Vs reasons.

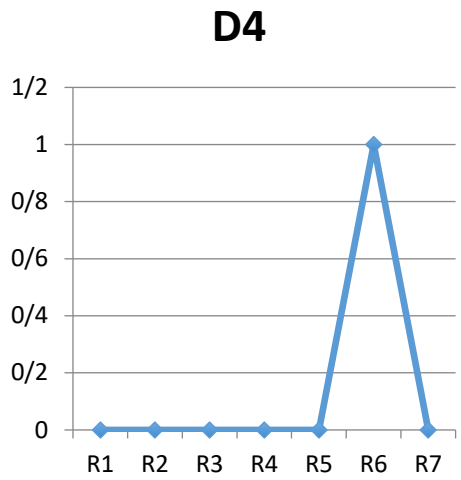

Fig. 4. Education Vs reasons.

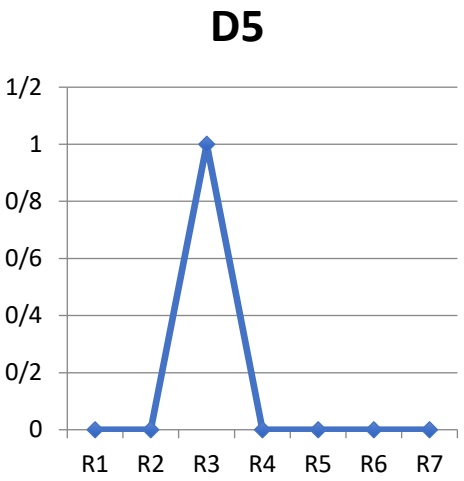

Fig. 5. Employers Vs Reasons.

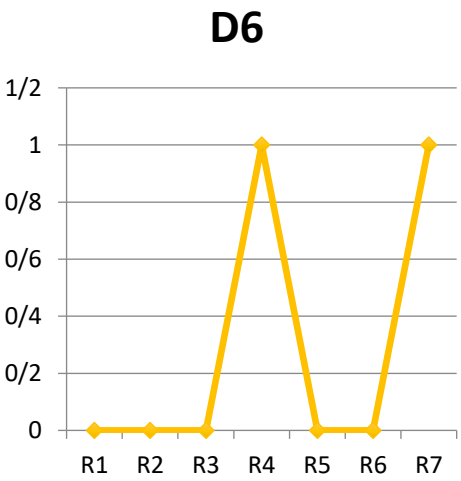

Fig. 6. No saving money Vs Reasons.

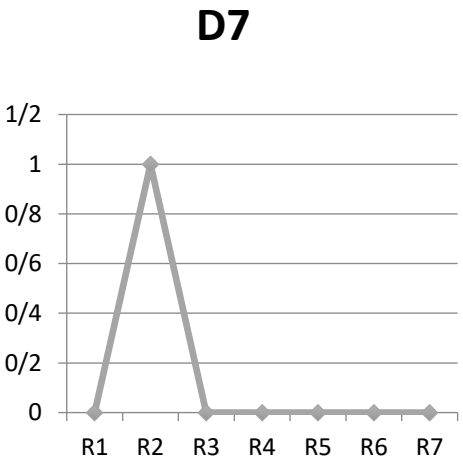

Fig. 7. Govt organizations Vs reasons.

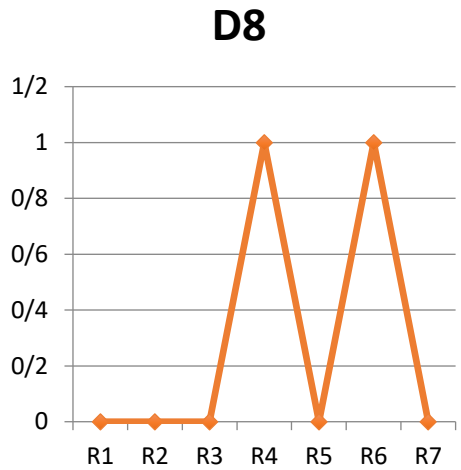

Fig. 8. Beg Vs reasons.

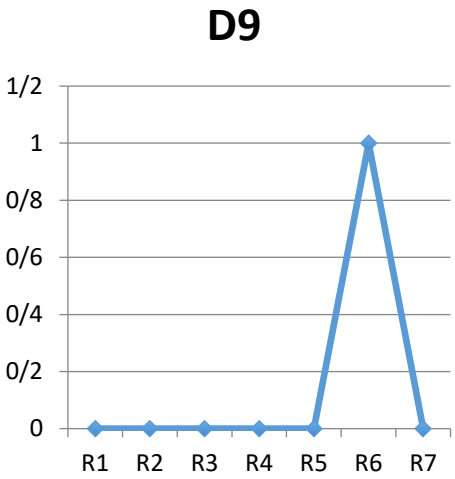

Fig. 9. Language Vs reasons.

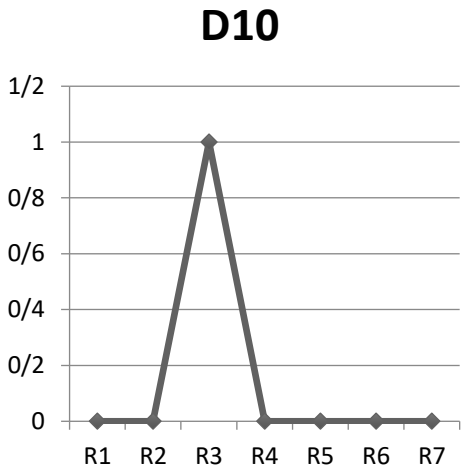

Fig. 10. HIV/AIDS Vs reasons.

5 | Results

Based on the calculations, when D2" Hormones disorder leading to unnatural behaviour" is on state, all the nodes in domain and range spaces come up to on state. This clearly shows that the problem of transgender is due to hormone disorders only.

According to the analysis considered, D2 (hormones) has been in the on state and all other nodes changed in appearance. But people in the family, as well as the society, do not take up this scientific reason for having been born transgender.

They take it as a 'curse of god' and will treat them by pushing them out of the family, which forces them to become shelter beg or enter into prostitution to live. Looking at the graph, it is evident that D2 (hormone disorder) is followed by D6" no share in the property) and D8 (forces to beg) along with the problem are the major only for their depressed status. Hence, hormone disorders leading to unnatural behaviour are the main causes of all the problems.

Based on the graph, no share in property and forces to beg leads to problems for transgender. From the study, it is seen that while using FRM, hormone disorders leading to unnatural behaviour are the main causes of Transgender.

5.1 | Conclusion

The governments need to make special efforts to include trans persons in all the development programs in important areas such as education and employment. As persons with disabilities are to be provided with free facilities in common places, transgender too, need such provisions.

For instance, there need to be special toilets for Tran's people; the right to marriage, too, should be protected. It is the responsibility of the government to ensure wide publicity through the print and visual Media of the fact that caravans are entitled to get registered in electoral rolls and that transgender persons are.

Individuals could choose either 'male' or 'female' as their gender when applying for official identity documents. The state's education department issued a G.O. creating a "third gender category" for admission to educational institutions. As per this order, educational institutions have to issue an application form for undergraduate courses that will include transgender as a separate category.

This Will permit transgender students to join any college of their choice, whether co-educational, men's or Women's colleges.

Further, the government has issued guidelines for schools to provide counselling for transgender students, counselling for families of transgender students to ensure they don't disown them, and ensuring disciplinary action against schools and colleges who refused to admit Aravani. There needs to be a policy of reservation in education and employment measures in proportion to their population. Only then their rights and rehabilitation will be protected and promoted.

5.2 | Suggestions

People must be made aware through awareness programs of the real cause problem of being born as a trans person. Then, the family members, as well as the society around them, will be treated with special care and development. The government needs to make a special effort to include trans persons in all development programs in important areas such as education and employment.

As persons with disabilities are to be provided with free facilities in common places, transgender too, need such provisions. For instance, there need to be special toilets for Tran's people; the right to marriage too, should be protected. There needs to be a policy of reservation in education and employment measures in proportion to their population. Only then their rights and rehabilitation will be protected and promoted.

There is a need for their social acceptance. They should be provided separate wards in all government hospitals. The authorities do not admit them in women's wards because women do not feel comfortable or free in their presence, and in men's wards, they face sexual abuse. Besides, there are no separate toilet facilities for them.

5.3 | Solutions

I. Transgender persons must be properly documented in the census.

II. Extend financial support for community-based organizations run by transgender communities.

III. They need to be considered for statutory reservation in educational institutions and job opportunities in public and private sectors.

IV. They need to be empowered with a high degree of educational and vocational training to upgrade their earning and status in society.

V. Support of civil society organizations to advocate for their cause and efforts. For example, advocate for land/ shelter, creation of separate public toilets, hospital wards, and recognition.

VI. Right to vote as citizens, reservation seats in elections, etc.

VII. Since they are prone to health setbacks, they need proper medical facilities, including insurance in the health sector.

VIII. To generate awareness so that the transgender is viewed and understood as a culture, community and a movement.

IX. The government has created a database on transgender that would help to deal with their problems and demands, such as housing ration cards, voter identity, patta, health facilities, etc.

X. The government has also issued a government order for the admission of transgender.

5.4 | Hopes for the Future

I. The right to be treated fairly with compassion & free from unjust treatment, cruelty, discrimination& exploitation in all private & government institutions & other entities.

II. The right to be recognized as a marginalized group; thus, appropriate representation should be afforded to us in all government instrumentalities & all other groups & organizations, whether local or international.

III. The right to be given equal opportunities in employment as transgender.

IV. The right to participate in all social-economic, political & cultural activities, programs & services that directly concern and affect us.

V. The right to build a family and home without prejudices and biases.

Author Contributions

The authors collectively contributed to the research and development of this study in a collaborative effort. A. Saraswathi, Seyed Ahmad Edalatpanah, and Sanaz Hami Hassan Kiyadeh equally participated in the conceptualization of the study, formulation of the methodology, data analysis, and writing of the manuscript.

A. Saraswathi was primarily responsible for conducting detailed research on transgender issues, including the collection and interpretation of qualitative data from linguistic questionnaires administered to transgender individuals, their families, and NGO representatives. This foundational work provided the contextual framework for the study.

Seyed Ahmad Edalatpanah and Sanaz Hami Hassan Kiyadeh focused on the mathematical modeling aspects of the research, specifically the formulation and application of Fuzzy Relational Maps (FRMs) to analyze the interrelations between the identified causes and effects of the issues faced by transgender individuals. They worked extensively on adapting FRM methodologies to suit the complexity of the collected data, ensuring accurate representation and insightful outcomes.

Together, the authors integrated their respective contributions to create a comprehensive study that highlights both the societal and mathematical dimensions of the research problem. Their collaboration ensured a balanced approach, combining qualitative insights with rigorous quantitative analysis.

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Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflicts of interest.

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