Chapter 3: Barriers to the Adoption and Growth of Food Banks in India

3.1. Introduction

Food banks in impoverished nations encounter a wide range of obstacles. Limited infrastructure, insufficient funds, and logistical limitations often impede their capacity to properly collect, store, and distribute food. Food banks offers a sustainable solution to reduce food wastage by redistributing the surplus or leftovers which is in edible condition. These foods might end up in landfills increasing the carbon footprint if not re-distributed. Due to its pivotal role in alleviating hunger, food insecurity and reducing food wastage, food banks are gaining momentum and attaining wide popularity among industries, philanthropists, researchers and practitioners. Despite, its significant contribution in ensuring food security, food banks operations are often hindered by its limitations and associated challenges. These challenges not only limit food banks effectiveness, it also effects the growth and ability to expand the operations of food banks. Therefore, it becomes necessary to study and address these challenges for its perpetual effect on food banks operations. Modelling these challenges is crucial for identifying the severity of each of the issues for the growth and adoption of food banks.

This chapter aims to study the Indian food banks to identify the challenges ahead of them and barriers to their growth in the Indian context. In particular, we introduce the food banks operating in India. To the best of our knowledge, this is one of the pioneering studies related to Indian food banks. We tried to identify the challenges that are hindering the growth of food banks by literature surveys and performing qualitative interviews of experts from academia

and executives of some major food banks. We identified the critical barriers to the adoption and growth of food banks in India by performing interviews, brainstorming sessions, etc. Food banks are an emerging phenomenon in India but still there is dearth of contributions, particularly in identification of barriers to food banks. We evaluate barriers using the DEMATEL (Decision-Making Trial and Evaluation Laboratory) methodology. This method prioritizes barriers and establishes cause and effect relationship among the barriers for the adoption and growth of food banks in India. We further use the DEMATEL-based Analytic Network Process (ANP) (Tang, 2018) methodology to model this complex system by formulating a network of inter-relationships among the identified critical barriers.

In the literature review section, we have enlisted most of the key challenges pertaining to food banks across the globe found during the literature survey. These challenges along with their encodings is given in the following Table 3.1.

Table 3.1: Encodings of identified barriers

Sr. No.	Code	Main Barrier Criteria	Sub-code	Sub-barrier criteria
1.	**(B1)**	Policy	**A**	Low penetration of policies & regulations for donation
2	**B2**	Financial	**B**	Limited funds /commodities raised from the donation
3			**C**	Limited financial support from the government
4	**B3**	Infrastructure and Human resources	**D**	Lack of storage
5			**E**	Lack of transportation facilities
6			**F**	Lack of collection and distribution facilities, handling & operations
7			**G**	Lack of manpower
8	**B4**	Planning & Coordination	**H**	Lack of strategic/tactical level planning & Decision Support System (DSS)

Sr. No.	Code	Main Barrier Criteria	Sub-code	Sub-barrier criteria
9			**I**	Lack of coordination among food banks
10	**B5**	Knowledge	**J**	Lack of awareness about food bank
11	**B6**	Uncertainty	**K**	Uncertainty in demand
12	**B7**	Characteristics of donated food	**L**	Low nutritional value in donated food
13			**M**	Perishability and limited shelf life of food items
14			**N**	Uncertainty in supply

To assess their applicability in the Indian context, we conducted qualitative interviews with executives and volunteers affiliated with various food banks in India to learn about their objectives, vision and mission, methods of operation, strengths, and, most importantly, the challenges they face in order to gain a ground-level understanding of Indian food banks. The necessary information is received from the Indian Food Sharing Alliance (Indian Food Sharing Alliance, n.d.), a government entity that monitors and delivers directives to all food banks operating in India. We first approached 79 such food banks to learn about the issues they confront and received responses from 32 of them.

Several detailed yet unstructured interviews were conducted with the stakeholders majorly through telephonic talk and social media applications. After several detailed interviews, multiple rounds of discussions, brainstorming sessions, most of the participants agreed on a total of 19 barriers that are hindering food banks to sustain, operate efficiently, and reach to a maximum number of donors, beneficiaries, volunteers in India. To review the list of barriers and for its categorization, we communicated the entire list of barriers to the food banks in India and academic experts via email and asked for their opinion. A series of in-depth yet unstructured interviews with key stakeholders, mostly done over the telephone and on various social media platforms, were used to conduct a thorough analysis of the issues encountered by

food banks in India. Following several lengthy interviews, multiple rounds of discussions, and collaborative brainstorming sessions, the majority of participants identified 19 issues to the long-term operation and efficient outreach of Indian food banks. The gathered list was distributed to food banks across India as well as academic experts to ensure a thorough examination and classification of these impediments. Their feedback was sought through a systematic procedure incorporating email communication, thereby increasing the comprehensiveness and validity of the evaluation.

Throughout the course of interviews, individuals from food banks highlighted that, policies and regulations governing donations have lower penetration and it acts as a major impediment in growth of Indian food banks. Until 2018, there were no codified formal policies or directives from Indian regarding the daily operations of the food banks involving recovery and distribution of surplus or leftover food. Furthermore, due to absence of regulatory framework, donors and distributing agencies was held responsible for any untowardly event happened during donation and distribution. These situations rendered food banks less enticing to the potential donors, thereby limiting its growth. Regarding the financial barrier, a bifurcation has been made into two sub-barriers: limited funds or commodities derived from donations and restricted financial backing from the government. In Indian context, certain food banks receive donations not only in the form of food, but also non-consumable items such as vehicles, refrigerators, and utensils, as well as direct monetary contributions from corporate entities, government bodies, and individuals. Despite these diversified sources of aid, most of the food banks stated, lack of financial assistance as a substantial hindrance, which causes poor functioning of food banks.

Insights gathered during the interviews demonstrated that food banks phenomena in India were not a result of concrete planning, rather it emerged out manually on the go basis and thus possess a myopic view. This results in inadequate planning and coordination, thus posing a significant challenge for their sustenance. During one of our interviews, we asked question pertaining to capacities and resources and how do they deal with storage and manpower when huge donation request is made. The following response is received which suggests that limited resources and funds are potential challenge to food bank operations.

"Our volunteer base is incredibly strong, with individuals who are genuinely dedicated to the cause. These volunteers are not politically affiliated; they're motivated by a shared purpose. For example, if we receive a food donation request from a locality, say SCB, we can quickly rally nearby volunteers. In some cases, we have up to fifty to a hundred volunteers in the vicinity who can execute a drive on the same day. This enables us to efficiently handle the received food while prioritizing food safety. We can store excess food for the next day or even the next week, depending on the location. Currently, we don't have dedicated storage facilities or office premises as we are entirely funded by donations."

Similarly, when we asked questions pertaining to transportation aspect of the food bank the following response is received which suggest huge reliance on volunteers –

"We primarily use volunteers' vehicles for transportation, and we have a variety of vehicles at our disposal, including bikes and cars. Volunteers are quite versatile in this regard."

This should be noted that food banks are relatively in their nascent stage of development and have limited recognition among donors and beneficiaries, thus causing limitations to its expansion and widespread adoption. Therefore, the insubstantial awareness acts a significant challenge for Indian food banks. One of the recurrent themes during the sessions are

uncertainty in donations. Most of the executives have reported limited and uncertain donations as an intrinsic characteristic of the system which compounds their problem, thus we clustered this uncertainty in donations as one of the sub-barriers of 'characteristics of donated food'. Moreover, overall performance of food banks is associated with the characteristics of donated food. Challenges such as cultural and nutritious appropriateness, dietary differences were considered under the characteristics of donated and has a significant impact on the performance of food banks. For example, in India, freshly cooked food has more preference over the packaged food. Mostly food banks operate as the front-end model i.e., collect and distribute food immediately due to this characteristic of the donated food. This enables food banks to deal with challenges associated with perishability and shorter shelf-life. During our discussions, it emanated that some food banks, sometimes collect and distribute only *chapati* (Indian bread) and cooked rice to provide support to the unfortunate section and thus, nutritional challenges in the donated food, poses a challenge for the food banks. During the course of discussions, it emerged that among all those 19 issues identified earlier, some can be clustered due its similar nature and some can be removed from the list due to their insignificant effect. For example, we have eliminated "food preferences" from the list based on consensus. We refined and recoded all these feedbacks and reported the updated list that contains 7 parent-barriers and 14 sub-barriers as summarized in Table 3.1.

After finalizing the list of barriers and sub-barriers, we investigated the cause-effect relationship among those barriers and sub-barriers. Further, we prioritized them to analyze the relative importance of one on other. This study was categorized into three sections. The first phase is identification of the barriers using extant literature and expert's inputs. Subsequently, we applied DEMATEL technique to the barriers to visualize the cause-effect relationship

among them in phase II. In Phase III, we applied DEMATEL-based ANP to prioritize the critical barriers. A summarized overview of these phases is depicted in Figure 3.1. In the subsequent section, we present the methodology to prioritization.

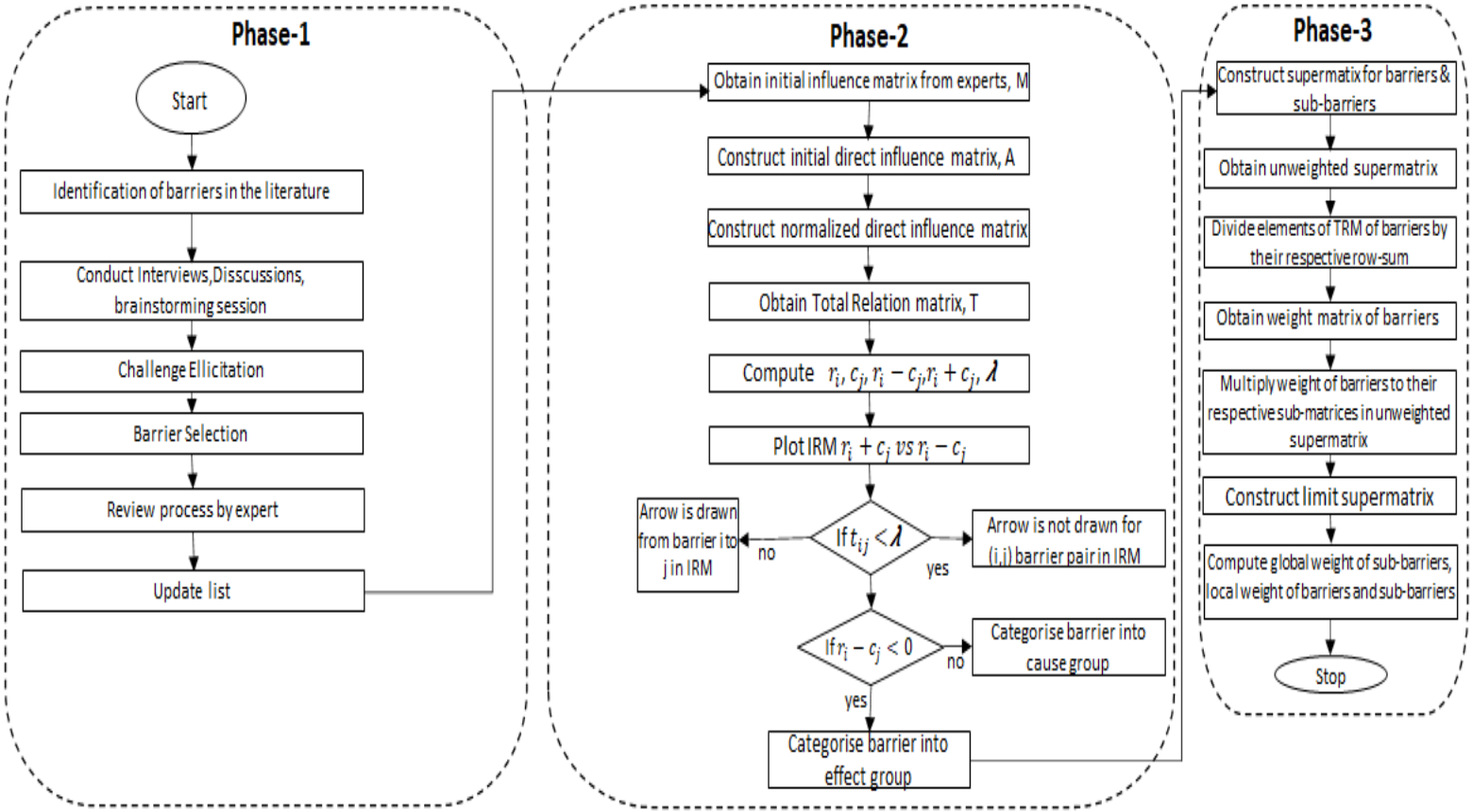

Figure 3.1: Flowchart of hybridized DEMATEL-based ANP

3.2. Methodology

This research uses a multi-criteria decision-making technique - DEMATEL to structure the problem into cause-and-effect relationships among barriers as well as DEMATEL-based ANP to prioritize the critical barriers. The stimulus behind the selection of DEMATEL methodology for our study is multifold. Firstly, the identified barriers are highly interrelated and interdependent with each other and exhibit inherent complexity. Secondly, the barriers are subjective in nature and it is quite an assiduous task to quantify them and use any other quantitative methodology. Thirdly, DEMATEL enables us to quantify the measure of the influence of one barrier on others on a 5-point scale (0-4) for pair-wise comparison among the barriers. DEMATEL uses graphs and matrices to visualize the inter-dependencies of barriers and their sub-barriers using the Impact-Relation Map. The implementation of the DEMATEL technique for prioritizing the critical barriers in our study is shown in Figure 3.1 and briefly explained in the following text.

3.2.1. Procedure for constructing Impact relation map [IRM] using DEMATEL

***Step* 1:** *Obtaining the initial pair-wise comparison matrix from experts' ratings*

$M^k = [m_{ij}^k], \qquad i = 1,2,3 \ldots \ldots \text{n};\ j = 1,2,3 \ldots . . \text{n};\ k = 1,2 \ldots . \text{N}$

Where m_{ij}^k represents the direct influence of barrier *i* on barrier *j* given by the k^{th} expert. The values of m_{ij}^k could be 0, 1, 2, 3 and 4 that represent no, low, medium, high and very high influence of barrier *i* on barrier *j*, respectively.

***Step* 2:** *Creating the initial direct influence matrix* (**A**) by averaging judgments of all the experts

$$\boldsymbol{A} = [aij] \tag{1}$$

where $a_{ij} = \frac{1}{N}\left(\sum_{k=1}^{N} m_{ij}^{k}\right) \forall\, i, j$ (2)

Step* 3*: *Construct the normalized direct influence matrix* (**X**) with the help of direct influence matrix (**A**) and normalised weight factor (α)

$$\mathbf{X} = \mathbf{A} * \alpha \tag{3}$$

where $\alpha = \frac{1}{\max\limits_{1 \le i \le n} \sum_{j=1}^{n} a_{ij}}$ $, i, j = 1,2,..,n$ (4)

Step* 4*: *Compute Total Relation Matrix* (***T***) or full direct/indirect influence matrix to encompass the indirect effects of each barrier. The value in ***T*** for each pair of barriers represents the relative importance of the relation of each pair of barriers is calculated as

$$\boldsymbol{T} = \left[t_{ij}\right], \qquad \forall i = 1,2, \ldots . \text{n};\ j = 1,2, \ldots . \text{n} \tag{5}$$

$$\boldsymbol{T} = X + X^2 + X^3 + \cdots \ldots \ldots + X^{\infty} = \sum_{i=1}^{\infty} X^i = X * (I - X)^{-1} \text{ when } \lim_{i \to \infty} X^i = \tag{6}$$

$[0]_{n \times n}$

where ***I*** is the identity matrix

After this, we perform row summation (r_i) and column summation (c_j) on matrix **T** as given in Equations (7) and (8), respectively.

$$r_i = \left[\sum_{j=1}^{n} t_{ij}\right] \tag{7}$$

$$c_j = \left[\sum_{i=1}^{n} t_{ij}\right] \tag{8}$$

Here, r_i represents the degree with which barrier/sub-barrier i influences the overall system and thus called as the *degree of influence*. Similarly, c_j represents the degree by which barrier/sub-barrier j is being affected by other barriers/sub-barriers and thus named as the *degree of affected*.

Step* 5*: *Setting up a threshold and obtain an impact-relation map* [IRM]

The arithmetic mean of all the elements in total relation matrix **T** can be used as threshold λ that will be used to obtain the *reachability matrix* **K** as given in Equation (9).

$$\mathbf{K} = \left[k_{ij}\right]_{n\times n} \tag{9}$$

$$k_{ij} = \begin{cases} 1, \ if\ t_{ij} \geq \lambda \\ 0, if\ t_{ij} < \lambda \end{cases}, \forall i,j \tag{10}$$

The reachability matrix highlights the important relation between barriers and ignores the lesser important relationships. It simplifies the complex web of inter-relationships and very helpful in visualizing and understanding the complex system of barriers. We can plot an impact-relation map from the reachability matrix **K** as follows. If the barrier/sub-barrier pair (*i*, *j*) is significant (that is, its value is 1 in the reachability matrix **K)** then a direct link will be shown between them in the impact-relationship map. Otherwise, such a link will be excluded. Moreover, the vector $r_i + c_j$ where $i = j$ is also known as 'prominence' which represents the total amount of effect attained and contributed by the barrier/sub-barrier *i*. The value of vector $r_i + c_j$ exhibits the level of inter-relatedness that a barrier/sub-barrier i has with other barriers/sub-barriers. is Higher the value of $r_i + c_j$, higher the relation of barrier/sub-barrier *i* with other barriers/sub-barriers. For exploring the nature of barrier/sub-barriers, we compute the values of vector $r_i - c_j$ where *i=j*, known as 'cause-degree' that plays a very crucial role

in distinguishing barriers/sub-barriers into cause-and-effect groups. If the value of $r_i - c_j$ is positive, the particular barrier/sub-barrier '*i*' is categorized into cause group (also known as 'dispatcher') and if the value of $r_i - c_j$ is negative, then barrier/sub-barrier '*i*' is categorized into effect group (also known as 'receiver').

The overall procedure of DEMATEL can be summarized as follows. The procedure begins with obtaining an initial matrix from each expert. These inputs are then translated into the direct influence matrix considering the average of the expert's inputs which is further normalized to render aggregation of criteria with quantitative and commensurable data. Then the total relation matrix is obtained for both barriers and sub-barriers to evaluate the interrelationships and indirect relationships. Total relation matrix is then used to find out the cause-barriers and effect-barriers by setting up a threshold and plotting the Impact-Relationship Map.

It can be noted that DEMATEL helps to categorize the barriers into cause-and-effect group but it cannot yield the weights of individual criteria and individual weights are essential for retrieving out the most critical barrier of the underlying structure of problem. By using ANP after applying DEMATEL, we try to incorporate both sub-barriers and barriers in IRM into a super matrix for factor prioritization and aiding effective decision making. The motivation behind selecting DEMATEL-based ANP is listed below.

I. This hybrid MCDM methodology enables us to model the underlying complex food banking system by devising a network of inter-relationship among the identified barriers.

II. DEMATEL alone is not sufficient to combine the weight of inter-dependent and hierarchical barriers to their sub-barrier in order to determine the global ranking, and that's

why we chose to apply ANP after the implementation of DEMATEL to get a global ranking of the sub-barriers and barriers.

III. Literature suggests that the technique of factor prioritization in DEMATEL has inconsistencies associated with them (Büyüközkan & Güleryüz, 2016). This effect reflects in IRM developed from DEMATEL.

In what follows, the implementation of ANP is explained.

3.2.2. Obtaining priority weights of barriers and sub-barriers using Analytic Network Process

***Step* 6:** *Obtain unweighted super matrix* $\boldsymbol{Z_S}$ for barriers and sub-barriers using their Total relation matrices denoted by $\boldsymbol{T_B}$ and $\boldsymbol{T_s}$, respectively, and following equation (11). Here sub-barriers are denoted as s_{ij}, where *i* is the barrier and *j* represent the sub-barrier number.

$$U_S = \begin{array}{c} \\ B1 \\ \\ \\ \\ B2 \\ \\ \vdots \\ Bn \\ \\ \end{array} \begin{array}{c} \begin{array}{cccccccccccc} B1 & & & & B2 & & & \cdots & Bn & & & \\ s_{11} & s_{12} & \cdots & s_{1m_1} & s_{21} & s_{22} & \cdots & s_{2m_2} & \cdots & s_{n1} & s_{n2} & \cdots & s_{nm_n} \end{array} \\ \begin{bmatrix} U_s^{11} & & U_s^{12} & & \cdots & U_s^{1n} \\ & & & & & \\ U_s^{21} & & U_s^{22} & & \cdots & U_s^{2n} \\ \vdots & & \vdots & & \ddots & \vdots \\ U_s^{n1} & & U_s^{n2} & & \cdots & U_s^{nn} \end{bmatrix} \end{array} \begin{array}{l} s_{11} \\ s_{12} \\ \vdots \\ s_{1m_1} \\ s_{21} \\ s_{22} \\ \vdots \\ s_{2m_2} \\ \vdots \\ s_{n1} \\ s_{n2} \\ \vdots \\ s_{nm_n} \end{array} \tag{11}$$

Where $\boldsymbol{U_s^{ij}}$ can be computed from the total relation matrix of barriers and sub-barriers using the following equation:

$$\boldsymbol{U_s^{11}} = \quad (12)$$

$$\begin{bmatrix} t_{s11}^{11}/p_1^{11} & \cdots & t_{s1j}^{11}/p_1^{11} & \cdots & t_{s1m1}^{11}/p_1^{11} \\ \vdots & \cdots & \vdots & \cdots & \vdots \\ t_{si1}^{11}/p_i^{11} & \cdots & t_{sij}^{11}/p_i^{11} & \cdots & t_{sim1}^{11}/p_i^{11} \\ \vdots & \cdots & \vdots & \cdots & \vdots \\ t_{sm_11}^{11}/p_{m1}^{11} & \cdots & t_{sm_1j}^{11}/p_{m1}^{11} & \cdots & t_{sm1m1}^{11}/p_{m1}^{11} \end{bmatrix} = \begin{bmatrix} U_{s11}^{11} & \cdots & U_{s1j}^{11} & \cdots & U_{s1m_1}^{11} \\ \vdots & \cdots & \vdots & \cdots & \vdots \\ U_{si1}^{11} & \cdots & U_{sij}^{11} & \cdots & U_{s1m_1}^{11} \\ \vdots & \cdots & \vdots & \cdots & \vdots \\ U_{sm_11}^{11} & \cdots & U_{sm_1j}^{11} & \cdots & U_{sm_1m_1}^{11} \end{bmatrix}$$

where $p_i^{11}=\sum_{j=1}^{m_1} t_{Sij}^{11}$ (13)

The unweighted supermatrix, Z_S can be computed by transposing the supermatrix $\boldsymbol{U_s}$ by the following equations –

$$\boldsymbol{Z_s} = [\boldsymbol{U}_s]^{\boldsymbol{T}} \quad (14)$$

$$Z_S = \begin{array}{c} \\ B1 \\ \\ \\ \\ B2 \\ \\ \vdots \\ Bn \\ \\ \end{array} \begin{array}{c} \begin{array}{cccccccccccc} B1 & & & & B2 & & & & \cdots & & Bn & \\ s_{11} & s_{12} & \cdots & s_{1m_1} & s_{21} & s_{22} & \cdots & s_{2m_2} & \cdots & s_{n1} & s_{n2} & \cdots & s_{nm_n} \end{array} \\ \begin{bmatrix} Z_S^{11} & & Z_S^{12} & & \cdots & & Z_S^{1n} \\ & & & & & & \\ Z_S^{21} & & Z_S^{22} & & \cdots & & Z_S^{2n} \\ \vdots & & \vdots & & \ddots & & \vdots \\ Z_S^{n1} & & Z_S^{n2} & & \cdots & & Z_S^{nn} \end{bmatrix} \end{array} \quad (15)$$

Step* 7: *Compute weighted super matrix, W can be obtained with the help of the total relation matrix of barriers denoted by $\boldsymbol{T_B}$. The elements of Total relation matrix (t_B^{11}, t_B^{12},…. t_B^{nn}) are

the elements of the $\boldsymbol{T_B}$. R_i denotes the sum of elements of row 'i' of $\boldsymbol{T_B}$. The normalized matrix $\boldsymbol{U_B}$ can be obtained by using equation (17).

$$R_i = \sum_{j=1}^{n} t_B^{ij}\,, i = 1,2, \dots \text{n} \tag{16}$$

$$\boldsymbol{U_B} = \begin{bmatrix} t_B^{11}/R_1 & \cdots & t_B^{1j}/R_1 & \cdots & t_B^{1n}/R_1 \\ \vdots & \cdots & \vdots & \cdots & \vdots \\ t_B^{i1}/R_i & \cdots & t_B^{ij}/R_i & \cdots & t_B^{in}/R_i \\ \vdots & \cdots & \vdots & \cdots & \vdots \\ t_B^{n1}/R_n & \cdots & t_B^{nj}/R_n & \cdots & t_B^{nn}/R_n \end{bmatrix} = \begin{bmatrix} u_B^{11} & \cdots & u_B^{1j} & \cdots & u_B^{1n} \\ \vdots & \cdots & \vdots & \cdots & \vdots \\ u_B^{i1} & \cdots & u_B^{ij} & \cdots & u_B^{in} \\ \vdots & \cdots & \vdots & \cdots & \vdots \\ u_B^{n1} & \cdots & u_B^{nj} & \cdots & u_B^{nn} \end{bmatrix} \tag{17}$$

The weight matrix $\boldsymbol{W_B}$ can be computed by transposing matrix $\boldsymbol{U_B}$ according to equation 18.

$$\boldsymbol{W_B} = [\boldsymbol{U_B}]^{\mathrm{T}} = \begin{bmatrix} w_B^{11} & \cdots & w_B^{1j} & \cdots & w_B^{1n} \\ \vdots & \cdots & \vdots & \cdots & \vdots \\ w_B^{i1} & \cdots & w_B^{ij} & \cdots & w_B^{in} \\ \vdots & \cdots & \vdots & \cdots & \vdots \\ w_B^{n1} & \cdots & w_B^{nj} & \cdots & w_B^{nn} \end{bmatrix} \tag{18}$$

After this, the weight matrix for barriers $\boldsymbol{W_B}$ is integrated with the unweighted supermatrix $\boldsymbol{Z_s}$ in order to obtain weighted supermatrix $\boldsymbol{W}$ according to equation 19.

$$W = \begin{array}{c} \\ B1 \\ \\ \\ \\ B2 \\ \\ \\ \vdots \\ Bn \\ \\ \end{array} \begin{array}{c} \begin{array}{cccccccccccc} B1 & & & & B2 & & & \cdots & & Bn & & \end{array} \\ \begin{array}{cccccccccccc} s_{11} & s_{12} & \cdots & s_{1m_1} & s_{21} & s_{22} & \cdots & s_{2m_2} & \cdots & s_{n1} & s_{n2} & \cdots & s_{nm_n} \end{array} \\ \begin{bmatrix} w_B^{11} \times Z_S^{11} & & & w_B^{12} \times Z_S^{12} & & & \cdots & & w_B^{1n} \times Z_S^{1n} \\ & & & & & & & & \\ & & & & & & & & \\ w_B^{21} \times Z_S^{21} & & & w_B^{22} \times Z_S^{22} & & & \cdots & & w_B^{2n} \times Z_S^{2n} \\ \vdots & & & \vdots & & & \ddots & & \vdots \\ w_B^{n1} \times Z_S^{n1} & & & w_B^{n2} \times Z_S^{n2} & & & \cdots & & w_B^{nn} \times Z_S^{nn} \end{bmatrix} \end{array} \tag{19}$$

Step* 8: Obtain steady-state limit supermatrix and generate weight of each sub-barrier:* The limit supermatrix is generated by iteratively multiplying weighted supermatrix, $\boldsymbol{W}$ to itself until the weights in each column of every row converge to the same number. It is documented in the literature that limit supermatrix is obtained by raising power ($2k$+1) to weighted supermatrix, where k is a sufficiently large number (Mikhailov & Singh, 2003). In other words, the weighted supermatrix is being raised power α such that $\lim_{\alpha\to\infty}(W)^{\alpha}$. The local and global weights of each barrier and sub-barrier can be computed using the limit matrix. The global weights of each sub-barrier were obtained by taking the arithmetic mean of elements of each row of limit super-matrix. The local weight of each barrier was procured by adding the global weight of its sub-barriers. The local weight of sub-barriers was obtained through the division of the global weight of sub-barriers by the local weight of their corresponding barriers.

The empirical study for analyzing barriers for the Indian food banks is presented in the next section.

3.3. Results

This section describes the results of analysis of the barriers identified using DEMATEL and the DEMATEL-based ANP method. As mentioned in methodology section, we first obtain an impact relation map using DEMATEL to categorize the barriers into cause and effect. The first step in the DEMATEL process is to get the responses from the experts. Our expert panel consists of a total of 5 ($N = 5$) members, 3 from academia, and two of them were from food banks. An expert gives rating (m_{ij}) on a five-point scale ranging from 0 to 4. Figure 3.2 represents the sample illustration on how to fill matrix for food banks experts.

Example to fill the pair-wise comparison matrix for constructing Direct Relational Matrix

Linkert scare will be used for the pairwise comparison of influence of one barrier with another. One example is done for complete understanding-

0- **No influence**
1- **Very low influence**
2- **Low influence**
3- **High influence**
4- **Very High influence**

Code	Sub-barrier	X	Y	Z
X	Lack of transportation, collection & distribution facilities	0		
Y	Lack of storage		0	3
Z	Dependence on volunteers			0

- **Influence of lack of storage (Y) on Dependence on volunteers is high (3).**
- **Traditionally, influence of barrier X (from row) on barrier X (from column) in the given pairwise matrix is considered as 0. In other words, we can say that influence on barriers on itself is zero i.e., no influence.**

Figure 3.2: Format distributed to experts.

The responses are recorded and the Initial direct influence matrix is obtained by taking their averages as shown in Appendix-A (Table A-1). The normalized matrix is then obtained by considering the normalised weight factor (α) as 0.058 and 0.028 for barriers and sub-barriers, respectively, is also shown in Table A-1 given in Appendix-A. Next, the Total Relation matrix for barriers and sub-barriers is shown in Appendix-A Table A-2 and Table A-3, respectively. The threshold value for barriers and sub-barriers is calculated as 0.817 and 0.199, respectively according to equation 10. With the help of these thresholds and degree of influence and degree of cause ($r_i + c_j, r_i - c_j$) values of barriers and sub-barriers, impact-relation map is plotted as shown in Figure 3.3. For simplicity in visualization arrows are not shown for sub-barriers.

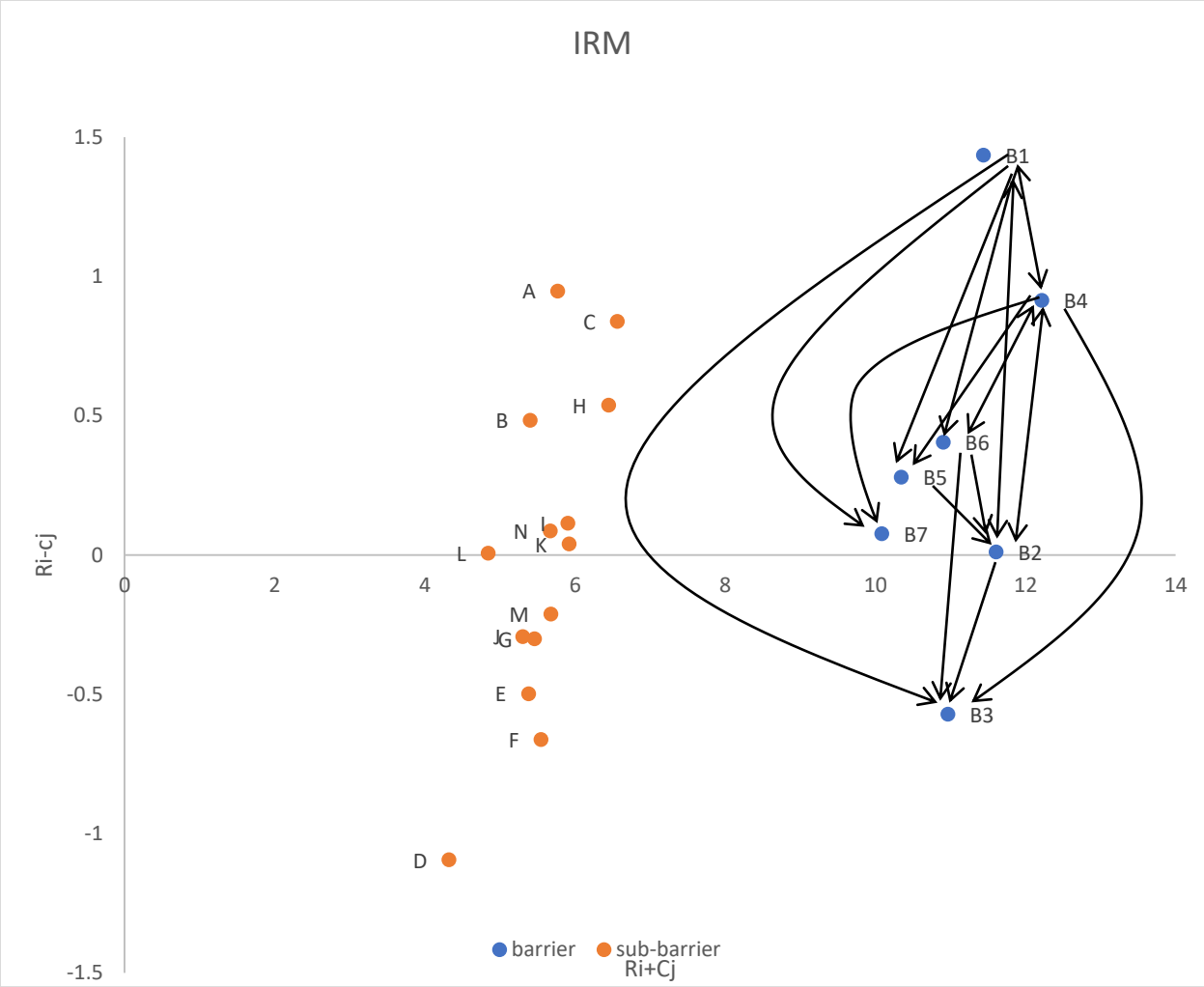

Figure 3.3: Impact Relation Map of barriers and sub-barriers

The values of degree of influence or prominence, degree of cause, local and global weights are tabulated in Table 3.2.

Table 3.2: Prominence, cause-degree, local and global weights and local & global ranks

Barriers/Sub-barriers	Prominence	Cause-degree	Local weights	Local-rank	Global weight	Global Rank
***Policy* (B1)**	**11.440(3)**	**1.436**	**0.137**	***V***		
Low penetration of policies & regulations for donation (A)	5.767	0.948	1	-	0.137	2
***Financial* (B2)**	**11.609(2)**	**0.011**	**0.153**	***I***		

Limited funds /commodities raised from the donation (B)	5.402(2)	0.484	0.462	2	0.070	7
Limited financial support from the government (C)	6.563(1)	0.839	0.537	1	0.082	4
***Infrastructure & HR* (B3)**	**10.965(4)**	**-0.571**	**0.152**	***II***		
Lack of storage (D)	4.320(4)	-1.094	0.231	3	0.035	14
Lack of transportation facilities (E)	5.379(3)	-0.497	0.250	2	0.038	12
Lack of collection and distribution facilities, handling & operations (F)	5.545(1)	-0.661	0.266	1	0.040	10
Lack of manpower (G)	5.457(2)	-0.300	0.250	2	0.038	13
***Planning & Coordination* (B4)**	**12.216(1)**	**0.914**	**0.149**	***III***		
Lack of strategic/tactical level planning & Decision Support System (DSS) (H)	6.448(1)	0.538	0.506	1	0.075	5
Lack of coordination among food banks (I)	5.904(2)	0.114	0.494	2	0.074	6
***Knowledge* (B5)**	**10.344(6)**	**0.280**	**0.132**	***VII***		
Lack of awareness about food bank (J)	5.303	-0.292	1	-	0.132	3
***Uncertainty* (B6)**	**10.902(5)**	**0.405**	**0.138**	***IV***		
Uncertainty in demand (K)	5.918	0.039	1	-	0.138	1
***Characteristics of donated food* (B7)**	**10.086(7)**	**0.076**	**0.136**	***VI***		
Low nutritional value in donated food (L)	4.840(3)	0.006	0.295	3	0.040	11
Perishability and limited shelf life of food items (M)	5.678(1)	-0.212	0.36	1	0.049	8
Uncertainty in supply (N)	5.667(2)	0.087	0.344	2	0.046	9

Prominence analysis of barriers reflects that B4 (planning & coordination) has the highest prominence value (12.216) whereas B7 (Characteristics of donated food) has the lowest value of prominence (10.086). Similarly, analysis of cause-degree for barriers reflects that B1 (Policy barrier) has a maximum value (1.436) and thus acts as a prime dispatcher or most essential cause. Analyzing IRM, we came to know that B1 is connected with all the remaining 6 barriers. Barrier B4 is also connected with all the remaining barriers but it has lower cause-degree value than B1. In other words, we can say that the policy barrier (B1) contributes more than Planning

and coordination barrier (B4) to the system. Similarly, from Table 3.2 it is clear that only B3 (Infrastructure & HR) falls into cause group and acts as a prime receiver or the barrier that affects the system most. IRM depicts that B4 had 4 incoming and 7 outgoing links which means B4 experiences affects from 4 barriers and B4 contributes its effect on all 7 barriers. One can argue that if B4 contributes its effect to a greater number of barriers in comparison to receiving effects from some barriers than B4 should be placed in dispatcher/cause group and that is why DEMATEL stand-alone is not sufficient to model this problem.

Analyzing prominence on the sub-barrier level, one could easily point out that sub-barrier C (limited financial support from the government) of financial/economical barrier attains maximum value of 6.563 having 14 outgoing links and 6 incoming links, followed by H (lack of strategic/tactical level planning and DSS) of planning and coordination barrier followed by sub-barrier K, (uncertainty in supply and demand). Analysis of cause degree on sub-barrier level depicts that sub-barrier D (lack of storage), E (Lack of transportation), F (Lack of collection & distribution facilities, handling & operation), G (lack of manpower), J (lack of awareness about food bank), and M (perishability and limited shelf life of donated food) fall into effect group since values for cause degree $(r_i - c_j)$ came out to be negative for them. Observing the negative values in cause-degree depicts that D (lack of storage) acquires most negative value (-1.094) and thus acts as most prime receiver or net receiver having 0 outgoing link and 7 incoming links/arrow in impact-relation model of sub-barrier plotted in Figure 3.3. F (lack of collection and distribution facilities, handling and operation) with value (-0.661) follow sub-barrier D with 0 out-going arrows and 9 incoming links in IRM plotted in Figure 3.3. Observing the positive values of cause degree $(r_i - c_j)$ for sub-barrier depicts, sub-barrier A(low penetration of policies) of Policy barrier (B1) attains maximum value 0.948 and thus

acts as a prime dispatcher to the system having 12 outgoing links and only two incoming links in impact-relation map of sub-barriers, followed by sub-barrier C (limited support from the government) of financial/economic barrier (B2) having 14 outgoing links and 7 incoming links in impact-relation map of sub-barriers; followed by sub-barrier H (lack of strategic/tactical level planning & DSS). It is worth noting that sub-barriers D, E, F, G of barrier B3 (Infrastructure & HR) are not connected by any of the 4 sub-barriers within the main barrier B3. Therefore, further analysis is needed for sub-barrier prioritization which we have done in the next section by applying ANP on the output of DEMATEL.

DEMATEL technique has underlying inconsistencies and we could not obtain global weights using only DEMATEL. So, to obtain priority weights of barriers and sub-barriers we apply hybridized ANP on the outcomes of DEMATEL. ANP implementation is beneficial for finding out the most critical barrier and sub-barrier of the food banking system. The first step in this process is to obtain the unweighted supermatrix with the help of total relation matrix of barriers and sub-barriers obtained in previous section. To explain the procedure, consider an example. The barrier B7 has 3 sub-barriers (L, M, N) and B2 has 2 sub-barriers (B, C). Then, t_s^{27} represents the sub-matrix corresponding to barrier-pair (2,7) in Total relation matrix of sub-barriers, 's' denotes sub-barrier shown in Appendix – A (Table A-3). The sub-matrix $\boldsymbol{U_s}^{\mathbf{27}}$ is a 2x3 matrix in supermatrix $\mathbf{U_s}$ and is computed as following.

$$t_s^{27} = \begin{matrix} \\ B \\ C \end{matrix} \begin{matrix} \begin{matrix} L & M & N \end{matrix} \\ \begin{bmatrix} 0.190 & 0.220 & 0.205 \\ 0.231 & 0.276 & 0.252 \end{bmatrix} \end{matrix} = \begin{matrix} \\ s_{21} \\ s_{22} \end{matrix} \begin{matrix} \begin{matrix} s_{71} & s_{72} & s_{73} \end{matrix} \\ \begin{bmatrix} 0.190 & 0.220 & 0.205 \\ 0.231 & 0.276 & 0.252 \end{bmatrix} \end{matrix}$$

p_1^{27}=0.190+0.220+0.205= 0.615 and p_2^{27}=0.231+0.276+0.252=0.761

U_{s11}^{27}=0.190/0.615=0.308 and similarly we computed other elements of U_s^{27} as-

$$U_S^{27} = \begin{bmatrix} \frac{0.190}{0.615} & \frac{0.220}{0.615} & \frac{0.205}{0.615} \\ \frac{0.231}{0.761} & \frac{0.276}{0.761} & \frac{0.252}{0.761} \end{bmatrix} = \begin{bmatrix} 0.308 & 0.357 & 0.333 \\ 0.304 & 0.363 & 0.331 \end{bmatrix}$$

Similarly, we computed all the elements of supermatrix $\boldsymbol{Z_s}$. Now, the unweighted supermatrix Z_s for the sub-barriers is shown in Appendix-A (Table A-4). After obtaining unweighted supermatrix we try to find out the weighted super matrix using unweighted supermatrix Z_s obtained in previous step. The normalized matrix $\boldsymbol{U_B}$ and the weight matrix $\boldsymbol{W_B}$ for barriers is shown in Appendix-A (Table A-5). The weighted supermatrix W which is obtained by multiplying the weight factor in W_B to corresponding sub-matrix in Z_s according to equation 19 is shown in Appendix-A (Table A-6).The third step in the process is to find out steady state limit supermatrix, W^{α} which is shown in Table 3.3.

Table 3.3: The limit supermatrix, W^{α} for sub-barriers

Sub-barriers code	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**
A	0.137													
B	0.070													
C	0.082													
D	0.035													
E	0.038													
F	0.040													
G	0.038													
H	0.075													
I	0.074													

J	0.132
K	0.138
L	0.040
M	0.049
N	0.046

Using the weights from Table 3.3, we can compute local and global weights of barriers and sub-barriers are shown in Table 3.2. Analyzing the local weights of barriers, we could observe that B2(Financial/economical barrier) with value 0.153 scores maximum and hence is the most critical barrier to be taken care of by decision-makers. The order of priorities of barriers according to their local weights are B2(Financial/economical barrier)>B3(Infrastructure and HR)>B4(Planning and Coordination)>B6(Uncertainty in supply)>B1(Policy barrier)>B7(Characteristics of donated food)>B5(Knowledge barrier). Similarly, analysis of the local weight of sub-barrier B2(Financial/economical barrier) suggests that sub-barrier C (limited financial support from the government) with value 0.537 is followed by sub-barrier B (limited funds/commodities raised from donations) with value 0.462.

3.4. Discussion

In this section, the barriers and sub-barriers that fall under cause-and-effect categories and the most important barriers found out by DEMATEL and DEMATEL-based ANP are discussed. Then, a critical discussion on the interrelationship and possible causes of the important barriers is presented.

Analysing the cause degree in Table 3.2, the barriers and sub-barriers entries having positive values fall under the cause category, and those having negative values fall under the effect

category. The causal relationship of policy and coordination barrier in our model corroborated the works (Irani et al., 2018; Luthra et al., 2019). Luthra et al. (2019) found out that lack of regulatory framework is the most consequential challenge in re-distributed manufacturing problem context in emerging countries. However, their findings for the financial barrier as 'effect' vary from our result.

The least essential barrier according to the local weight of barriers came out to be a knowledge barrier (B5) with value 0.132. It is worth noting that consistent results are obtained in the ranking of the prominence of sub-barriers and ranking of the local weight of sub-barriers. The ranking of barriers and sub-barriers according to prominence was shown in Table 3.2 under the prominence column within parenthesis. Although the ranking of the prominence of barriers varies merely and is not fully consistent with the ranking of the local weight of barriers. Analysing, global weights of sub-barrier, the exact one child sub-barrier scores more than multi-child sub-barriers is observed. Moreover, it also depicts that lack of awareness about food banks (J) is globally important above all sub-barriers. Analysing the local weights of barriers, one could observe that the most essential barrier is financial/economic barriers and is critical for the growth and adoption of food banks in India. Several authors pointed out it as a significant challenge in the extant literature (Hecht & Neff, 2019; V. Tarasuk & Eakin, 2005). Amongst the top 5 barriers according to their respective local weights, only one falls in the cause group. The results of DEMATEL analysis yields that sub-barrier low penetration of policies(A), limited funds/commodities raised from the donation (B), limited financial support from the government (C), lack of strategic/tactical level planning, and DSS (H), lack of coordination among food banks (I), Uncertainty in demand (K), the low nutritional value in donated food (L) and Uncertainty in supply (N) fell into 'cause' group and remaining sub-

barriers were fell into ‘effect’ group. Analysing the IRM shown in Figure 3.3 and reachability matrix **K** of sub-barriers in DEMATEL analysis it came to an inconsistent result that B3 (Infrastructure and HR) which is the only entity in the effect group has no underlying relation in its sub-barriers D, E, F, G whereas

DEMATEL-based ANP analysis yields ranking of local weights of these sub-barriers consistent with the ranking of prominence values**.** Overall, the only barrier B3 (Infrastructure and HR) among 7 main barriers falls into the ‘effect’ cluster that has a net receiving effect from all the remaining main barriers that fall into the category of ‘cause’ group. Furthermore, these remaining barriers have a net dispatch effect on the overall system of the food bank. The result can also be explored as the remaining barriers B1(Policy), B2(Financial aid), B4(Planning and coordination), B5 (knowledge), B6(uncertainty) and B7(Characteristics of donated food) have a causal relationship to the barrier B3 and the effect of all these causes is visible on barrier B3 (Infrastructure and HR).

The three important barriers found in our study are (B2) financial/economic barrier, (B3) Infrastructure & HR barrier, and (B4) Planning and Coordination. The result of DEMATEL-based ANP states that the most critical barrier for the adoption and growth of food banks in India is (B2) financial/economic barrier with the value of local weight as 0.153. It is clear that the limited availability of funds hampers every aspect of the functioning of food banks and poses a threat to their sustenance. Digging deeper, its sub-barrier (C) limited financial support from the government is having more importance than the other sub-barrier. To summarize, the government intervention/financial support to the food banks would help in alleviating the most important barrier to the growth and sustenance of the food banks in India.

It is also interesting to see the influence of the policy barrier on the other barriers. Though it has attained the fifth priority according to local ranking, it is at the second position in the global ranking. Similar to the financial barrier, the policy also strongly affects the functioning of the food banks. As an example, the interviews with the executives from the Indian food banks revealed the fact that several food banks in India have a policy not to accept monetary donations with a notion to avoid legal complexities. Such food banks are compelled to rely solely on volunteering. With no clarity in the norms or regulations for disposing of the leftover food, the restaurants, retail outlets, supermarkets would not be motivated to donate the food. Further, the policy of fixing responsibility of the organization/individual donating and distributing the food to hold responsible in case of any untowardly incident is discouraging the food recovery and re-distribution and poses a threat to the very existence of the food banks. This scenario has strongly advocated the need for a strict regulatory framework for the food banks in India to stop dumping edible foods by supermarkets, to frame a model that promotes food donation practice, eradicate the bottlenecks and legal complexities in the donation process, and adequate funds sanctioning from the government for charitable organizations to support their logistics. As a silver lining, the Food regulator of India, Food Safety and Standards Authority of India (FSSAI) had made "Food Safety and Standards (Recovery and Distribution of Surplus Foods) Regulations" in 2019 to promote the donation of food in India. This regulation was formed to protect the organizations and individuals for their allegiance in the donation. The policy states the responsibilities of food business operators/surplus food donation organizations, norms for not wasting leftover foods, formulation of the central body, and its functioning to guide the unstructured network of the food bank. Nevertheless, it needs significant time to decipher the proposed framework into the practice of food banks and the

resulting acceleration in their growth. This type of policy framework has been adopted /implemented by several countries to promote donation to food banks on large scale (Busetti, 2019; Fleischer, 2009).

The barrier that attained the second-most priority was the Infrastructural and human resources barrier which fell into the effect group in our DEMATEL analysis as shown in IRM in Figure 3.3. Unavailability of storage capacity limits the extent and possible reach of the food banks as well as the type of food items they can distribute. Gharehyakheh and Sadeghiamirshahidi (2018) pointed out that food bank managers perform their daily operations under limited resources. For example, refrigerated storage may extend the shelf life of the food items and provide a cushion in terms of its distribution. It is observed that most of the Indian food banks are working at the front end and have very limited or no storage space. As a result, they have to synchronize the food collection with food distribution in a very restricted time window. A similar challenge is the availability of limited vehicles for the transportation of food. To the best of our knowledge, no food bank in India possesses a refrigerated vehicle for the distribution of surplus food. The limited availability of other resources such as utensils and packaging material which is required to carry out the safe and hygienic collection, handling, and distribution of the food also becomes a bottleneck in the operations of food banks. It has rather scored more weight than the other three sub-barriers in the category of infrastructural barriers. It suggests that the resources involved during the process of collection and distribution drive, handling, and operation are more essential. It simply means that the cause barrier group should be looked upon for reducing the effect of infrastructural & HR barrier. Intuitively, the most possible cause for the infrastructural and human resources barrier can be traced to the limited availability of funds. Facchini et al. (2018) mentioned that government policies could

revitalize food banks and uplift donations with incentives. However, the results showed that planning and coordination have the highest prominence value ($r_i + c_j$=12.216) while the financial/economic barrier scores the second position in the cause group with prominence value $r_i + c_j$=11.609. This indicates that the financial barrier is undoubtedly contributing towards the infrastructure and HR barrier. However, the prime position of planning and coordination urges the effective utilization of available resources in the Indian food banks. Planning of the food bank functions includes activities such as forecasting of the donation, route planning for pickup and delivery of donated food, planning of human resources, and record keeping. The interviews with the Indian food bank officials reveal the fact that food banks in India rarely follows a scientific modelling/problem-solving approach or a decision support system for these functions. Most of the activities are planned based on previous experience or carried out with the ad-hoc planning as per the availability and convenience of volunteers.

3.5. Conclusion

Food banks are doing a recognizable job world-wide. There have been studies documented in the extant literature on food banks. Food banks have been studied for forecasting supply donation, solving the problem of uncertainty associated with supply donation, for its connection with food insecurity, psychological thinking of food bank users in several parts of the world. This study is novel in terms of identifying barriers to food banks. The identified barriers effect this humanitarian supply chain and the results mentioned in the discussion round can be used by food bank managers and its stakeholders, government, district, and state-level bureaucracy and monitoring body to reduce the effect of barriers of the system. Infrastructural

and HR-related barriers came into effect group which consists of lack of storage, lack of transportation, lack of collection and distribution facilities and lack of manpower as its sub-barrier. The effect of these sub-barriers can be diminished out by constructing strategic network design or by scheduling vehicles such that minimum cost is incurred and the maximum distance/demand is covered. Understanding the relative importance of barriers is useful in overcoming them and working out policies for boosting their developments. We highlight a few suggestions for an actionable plan for fostering growth and ensuring the sustenance of food banks in India.

- Formation of a nodal agency such as Indian Food Sharing Alliance (IFSA) that can bring all the food banks and non-government organizations working for ensuring food security through surplus food recovery/collecting donations and distributing food to the needy. The IFSA has already been formed and completed the required policy guidelines. There is a strong need for this platform to foster to bridge the gap between government, food banks, corporates, and food industries and beneficiaries. Moreover, to decline the liabilities of donor and to delineate the concept of food bank, policy makers and practitioners can contemplate a law akin to the "Good Samaritan Act" implemented by USA to decrease food wastage and increase its recovery and re-distribution (Lipinski et al., 2013). Similarly, France had passed law to decline food wastage and proscribe supermarkets and retailers from destroying unsold food and compelling them to donate it (Chrisafis, 2016; Vlaholias et al., 2015). Our study indicated a strong need of such policies in India also.
- Institutionalization of food banks is an essential step and need of the hour in India. There are food banks in India that are already supporting the government's initiatives

such as the Mid-day meal scheme in the schools. The food banks can work in synergy with the existing Public Distribution System (PDS) and the food banks can complement the very purpose of the PDS. In the light of excess procurement of the food grains for PDS, the excess quantity can be channelized through food banks to reach the needy. Food banks operating in UK has been fully institutionalized.

- The infrastructure development of food banks has been a key challenge. The most important aspects are the storage warehouses, cold storages, and collection and distribution capacity. These aspects are directly related to the financial aspects. There is a need for government intervention and promoting the corporates/industry partners to facilitate the food banks with the required capacity.
- Instead of operations in silos, coordination among the food banks should be encouraged. This will allow sharing of the capacities that will generate a synergy to work towards a common goal. This leads to achieve the efficient and effective operations of the food bank. A few examples of such synergies are Feeding America in USA, Trussel trust in UK, FBAO (*Fondazione Banco Alimentare Onlus)* in Italy, and Food Banks Canada.
- There is a strong need for an effective decision support system for collection, storage, network design, forecasting of supply and demand and effective distribution of food. This calls for the use of an integrated approach using mathematical modeling, simulation and support systems.
- Knowledge - In addition to it, print media has also played a significant role for publicizing and the food banking movement in UK. Furthermore, events such as

National Collection Day (*Colletta Alimentare*) in Italy helped in imparting awareness among donors, volunteers and beneficiaries about food banks.

Apart from the hunger-relief operations, food banks can also be used for the collection and redistribution of other essential items for the needy. This could be an excellent addition to humanitarian logistics operations. The recent crisis due to the COVID-19 pandemic has demonstrated such capabilities of food banks and NGOs as facilitators for humanitarian operations.

In spite of the contributions made, there are certain limitations of the present study. Food banks are recent phenomenon in India and thus getting reliable data and information on Indian food banks is a tedious task and worked as a limitation of this study. As a consequence of this, the barriers identified are largely dependent on the inputs received from the food bank executives through qualitative interviews. Also, inputs from only bare minimum number of experts are obtained who actually contributed in the weighing process of DEMATEL method. Similar type of studies can be conducted in the context of other developing and developed countries in future. Further, the limitations of unidimensional scale and biased experts view can be resolved by extending the study by incorporating fuzzy logic with hybrid MCDM models.