Developing Optimistic Model for Food (Wheat and Rice) Security in India

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Abstract-**In the 21st century; food security being the major concern all over the world, every nation is trying to identify its direct and indirect impact on the economy and social system. India although is a leading producer of food grains in the world, it is also the biggest consumer of it. Today the gap between the demand and availability is large enough so India can afford to export this food grains to other countries too but this trend will not remain for long time since the demand is peaking continuously. Productions of food grains are now touching its peak and according to several studies, it will remain constant or decrease in coming decade, so this may widen deficit between supply and demand. In this paper, effort is made to suggest a model to forecast the crisis of food shortage in future. In this study, several factors have been considered which directly and indirectly influence the demand-supply balance for food availability. Wheat and rice are the food grains selected for this study since are they are most commonly consumed by Indian population. Regression analysis is employed to create the model for predicting the food crisis in near future. Different food crisis situations are discussed in context of Indian agriculture scenario.**

Keywords-food crisis; pre-warning System; regression analysis; forecasting.

I. INTRODUCTION

In last ten years, price of food grains have spiked despite record production of rice and wheat in India, which raises several questions about production of food grains in India. Continuous rising of price from last five years indicate the shortage of stock, although the production of grains has touched its high. Previous data of food production of wheat[1,2] and Rice[3] indicates increment and decrement for subsequent years. Reason behind this is the characteristics of Indian agriculture which is volatile and highly dependent on monsoon. In India maximum amount of wheat is harvested during the month of April-June every year, while harvesting of rice is done throughout the years. For wheat the share of this 3 month production is more than 90% of wheat production throughout the year. June is the beginning month of monsoon raining and storage capacity of India is not too sufficient that whole stock can be stored safely. Approximate 30% of grains are stored in open space from where a large amount (approximately 20-30%) goes waste.For minimizing these food storage losses, several steps have been initiated like public-private partnership, invitation to private player to make storage godowns, but this process is very slow and also not sufficient to cater future needs of India. Food Corporation of India is a central agency for purchasing food grains directly from famers and store into their godowns, besides FCI, state agency or state government and Private parties also purchase the food grains from farmers. India is an agriculture based country where more than 60% population is still dependent of agriculture work. Ten major wheat producing state are Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Rajasthan, Bihar, Gujarat, Maharashtra, Uttarakhand and west Bengal. Even after 60 years of independence, Indian farmers use traditional technique for farming. Reports on agriculture study indicated that annual growth rate in India is now declining continuously and touching 3.5%. Predominant reason of this is high dependency of farming on monsoon.

II. LITERATURE REVIEW

A. Ganesh Kumar et al.[4] discussed the food grains policy of India in current challenging scenario. Several Policies such as monopoly control over international trade, restriction on movement of food-grains, credit facility to FCI, restriction on private storage and restriction on processing have been revived. Several topics related to food security such as providing food security to the Poor, Public Distribution System Versus Other Social Safety Net Program, Rationale for Reforming the Food grain Management Policies, Reform Measures Initiated to Promote Private Participation and Towards an Efficient and Welfare-Improving System of Food grains Management have been deeply described. WANG et al.[5] discussed the food safety and food supply chain management problems The RFID (radio frequency identification technology) is used to track state of development of quality and safety of food. In this study various causes of food safety are discussed and food supply chain management models are used to suggest a new security food supply mechanism.

ZHANG Run-hao et al.[6] discussed the legal system of food safety, political science theory, economics, and management issues. In his study, Food safety and Right of

Food Safety have been reviewed. ZHOU Qiang et al.[7] discussed several problems existing in the field of Chinese food safety such as malfunction and inefficient status of food safety crisis management. Problems for ensuring food safety were identified as overlapping functions, overstaffing, stagnant information changing, inadequate legal protection, poor quality officers, obstructions of restriction in trade association, lacking of food security and social responsibility conscious. The status quo of Chinese food security crisis management was checked and a pre-warning system of public food security crisis model was suggested. The concepts of food consumption warning and its establishment and development, adverse effects of false releasing have been discussed[8]. In this study the defects of food consumption warning system was addressed in which several basic concepts and their different-different condition have been considered along with causes of defects on food safety warning and several advices to improve the current food consumption warning system have been suggested. Chris Hillbruner et al.[9] discussed the failure of early warning system in Somalia to predict the food famine. The plight in Somalia state has been highlighted along with the discussion on the social, political and economic causes which were responsible for the faming.

III. PROPOSED FOOD CRISIS MODEL

In this work, the model proposed by ZHOU Qiang et al.[7] is employed for the context of Indian economy and agriculture. Figure 1 indicates the proposed model for predicting the food crisis problem in advance, plan and co-ordinate accordingly with different administrative agencies to ensure the food safety for every individual.

Fig. 1.Warning system of Food Crisis.

A. *Information Processing Subsystems*

Information processing function of food safety crisis pre-warning system mainly include three aspects -

1. Information collection
2. Information processing
3. Information analysis

The target of pre-warning decision support subsystem of food security crisis is to support decision-makers to decide orderly on semi-structured and unstructured crisis problem by computerized and scientific method on the basis of person's ability of analysis and judgment. Its function is to decide whether to issue an warning of crisis and crisis level based on the results of information processing subsystem and issue instructions to crisis pre-warning subsystem.

1. Information Collection

Collecting information related to food safety crisis is the key of food security crisis pre-warning system. Timely, accurate and adequate information to support pre-warning system of food security crisis is required to develop the correct warning function. In information collection, all the information relevant of food crisis is collected like current status report, records and information. Last 13 years of agricultural data from year 2000 for wheat and rice are collected from different government agencies and government official websites[11,12]. The factors affecting agricultural economy are rain fall, export, import, production, storage capacity, inflation, Government Policy.

2. Information Processing

This step includes the processing the collected information from disorder into order, excluding false and useless information, classify and arrange crisis information. In information processing, only those factors have been selected that directly influence the food safety such as net export, annual production and stock available etc. For quantifying the food availability the difference between total annual distribution by government agencies (such as FCI) and the total consumption is selected as objective function. Factors selected for current study are

- Net Export (deficit between export and import)
- Annual Production
- Stock Available
- Total Distribution
- Total Consumption

In information processing, the processed data is analyzed carefully and forecasted for subsequent period using MS Excel with polynomial curve fitting of order six. Higher order polynomial is selected to take into account the non-uniform variation in the data which was varying sharply at times. The base year for the study is taken as 2000. The figure 2 indicates first thirteen years of actual data followed by the forecasted data for different factors affecting food security for both the food grains rice and wheat.

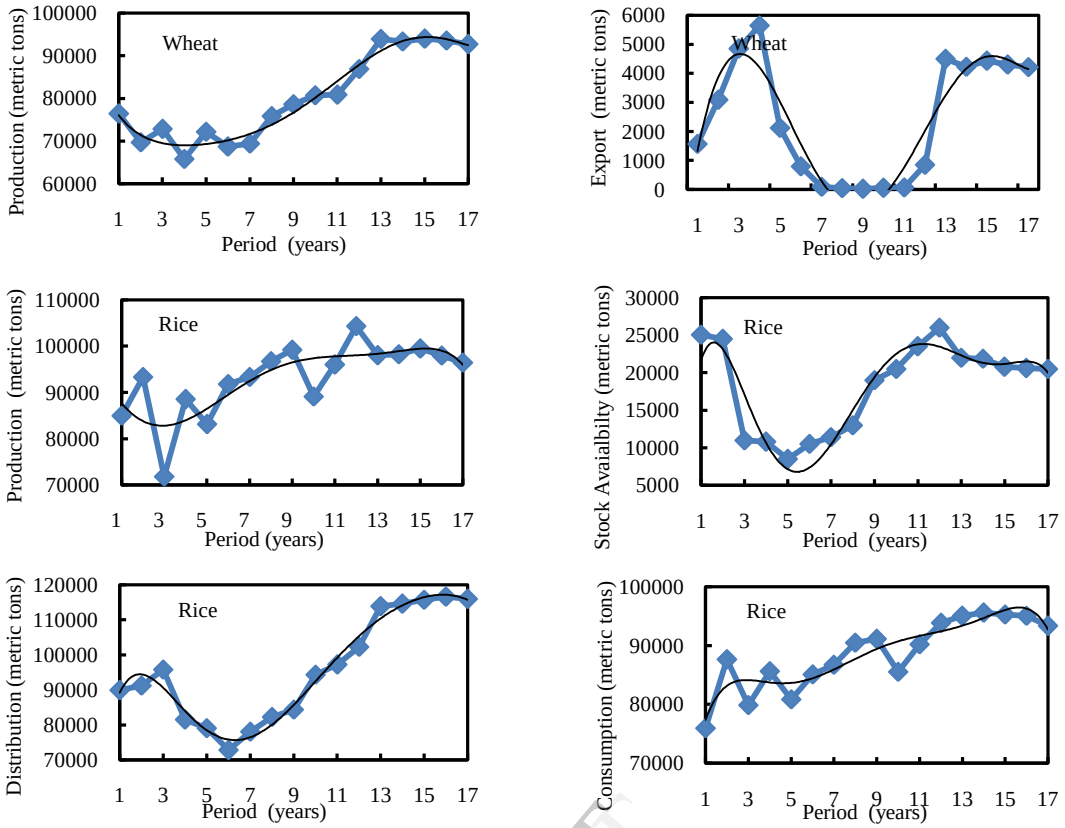


Fig.2. Data for factors affecting food safety for both the food grains.

3. Information Analysis

The data derived from information collection and information processing, is used in information analysis. Non-linear regression analysis is used to create mathematical model for predicting the deficit between the total supply and total demand of the food grains. The deficit between total annual supply and annual consumption expressed in terms of three parameters such as net export (x_1), production (x_2) and stock available (x_3) is mathematically given as equation 1.

$$\Phi = \alpha_0 + \alpha_1 x_1 + \alpha_2 x_2 + \alpha_3 x_3 + \alpha_4 x_1^2 + \alpha_5 x_2^2 + \alpha_6 x_3^2 + \alpha_7 x_1 x_2 + \alpha_8 x_1 x_3 + \alpha_9 x_2 x_3 \quad (1)$$

Actual data for thirteen years are selected starting from 2000 up to 2012 for the regression analysis which is done using MS Excel. Regression model consists of linear terms, square terms along with their interaction. The regression coefficients based data from 2000 to 2013 are determined as follows using equation 2 and 3. The matrix used for the regression model for wheat is given in table 1.

$$\{\Phi\}_{(13*1)} = [X]_{(13*10)} \{\alpha\}_{(10*1)} \quad (2)$$

$$\{\alpha\} = [X^T * X]^{-1} [X^T] \{\Phi\} \quad (3)$$

The regression coefficients (Table 2) are used to calculate the simulated values of the objective function and the results are compared with the actual values. Table 3 indicates small error between these values indicating the correctness of the model which will be further used to predict the food crisis in future.

TABLE I. MATRIX USED FOR THE REGRESSION ANALYSIS FOR WHEAT

x_1	x_2	x_3	x_1^2	x_2^2	x_3^2	$x_1 x_2$	$x_1 x_3$	$x_2 x_3$	Φ
1128	76369	21500	1272384	5832224161	462250000	86144232	24252000	1641933500	23069
3055	69680	23000	9333025	4855302400	529000000	212872400	70265000	1602640000	26087
4816	72770	15700	23193856	5295472900	246490000	350460320	75611200	1142489000	20550
5642	65760	6900	31832164	4324377600	47610000	371017920	38929800	453744000	12550
2112	72150	4100	4460544	5205622500	16810000	152380800	8659200	295815000	6220
760	68640	2000	577600	4711449600	4000000	52166400	1520000	137280000	2801
-6627	69350	4500	43917129	480942250	20250000	-459582450	-29821500	312075000	4594

				0					
-1913	75810	5800	3659569	5747156100	33640000	-145024530	-11095400	439698000	5849
16	78570	13430	256	6173244900	180364900	1257120	214880	1055195100	13453
-160	80680	16120	25600	6509262400	259854400	-12908800	-2579200	1300561600	16177
-200	80800	15360	40000	6528640000	235929600	-16160000	-3072000	1241088000	15432
825	86870	19950	680625	7546396900	398002500	71667750	16458750	1733056500	20849
4500	93900	22450	20250000	8817210000	504002500	422550000	101025000	2108055000	29310

(all indicated figures are in metric tons)

TABLE II. REGRESSION COEFFICIENTS FOR WHEAT

Coefficients	Values
α_0	-11267.737
α_1	-0.388
α_2	0.147
α_3	1.370
α_4	0.0001
α_5	4.09e-7
α_6	1.149e-5
α_7	1.518e-5
α_8	-6.769e-6
α_9	-9.291e-6

TABLE III. COMPARISON BETWEEN ACTUAL AND SIMULATED VALUES OF OBJECTIVE FUNCTION FOR WHEAT

Year	Actual Deficit (metric tons)	Simulated Deficit (metric tons)	Error (%)
2000	23069	22733.16	1.46
2001	26087	26217.278	-0.50
2002	20550	20655.398	-0.51
2003	12550	12396.436	1.22
2004	6220	6452.247	-3.73
2005	2801	2838.049	-1.32
2006	4594	4684.550	-1.97
2007	5849	5500.125	5.96
2008	13453	13527.964	-0.56
2009	16177	16171.227	0.04
2010	15432	15404.051	0.18
2011	20849	21164.882	-1.52
2012	29310	29195.632	0.39

TABLE IV. MATRIX USED FOR THE REGRESSION ANALYSIS FOR RICE

x_1	x_2	x_3	x_1^2	x_2^2	x_3^2	$x_1 x_2$	$x_1 x_3$	$x_2 x_3$	Φ
1685	84980	25051	2839225	7221600400	627552601	143191300	42210935	2128833980	26736
6300	93340	24480	39690000	8712355600	599270400	588042000	154224000	2284963200	30782
5440	71840	11000	29593600	5160985600	121000000	390809600	59840000	790240000	16440
3100	88530	10800	9610000	7837560900	116640000	274443000	33480000	956124000	13900
4569	83130	8500	20875761	6910596900	72250000	379820970	38836500	706605000	13069
4688	91790	10520	21977344	8425404100	110670400	430311520	49317760	965630800	15210
5740	93350	11430	32947600	8714222500	130644900	535829000	65608200	1066990500	17170
4654	96690	13000	21659716	9348956100	169000000	449995260	60502000	1256970000	17654
2090	99180	19000	4368100	9836672400	361000000	207286200	39710000	1884420000	21090
2082	89090	20500	4334724	7937028100	420250000	185485380	42681000	1826345000	22582
2774	95980	23500	7695076	9212160400	552250000	266248520	65189000	2255530000	26274
8000	104320	26000	64000000	10882662400	676000000	834560000	208000000	2712320000	34000
7000	98000	22000	49000000	9604000000	484000000	686000000	154000000	2156000000	29000

(all indicated figures are in metric tons)

TABLE V. REGRESSION COEFFICIENTS FOR RICE

Coefficients	Values
α0	-34.655
α1	1.004
α2	0.0005
α3	1.0006
α4	8.232E-09
α5	-5.923E-11
α6	2.092E-08
α7	-4.934E-08
α8	5.188E-08
α9	-1.617E-08

TABLE VI. COMPARISON BETWEEN ACTUAL AND SIMULATED VALUES OF OBJECTIVE FUNCTION FOR RICE

Year	Actual Deficit (metric tons)	Simulated Deficit (metric tons)	Error (%)
2000	26736	26847.19	-0.42
2001	30782	30890.42	-0.35
2002	16440	16488.54	-0.30
2003	13900	13948.18	-0.35
2004	13069	13106.84	-0.29
2005	15210	15255.14	-0.30
2006	17170	17220.84	-0.30
2007	17654	17711.85	-0.33
2008	21090	21174.19	-0.40
2009	22582	22672.33	-0.40
2010	26274	26378.18	-0.40
2011	34000	34115.01	-0.34
2012	29000	29097.70	-0.34

Similar procedure is followed for rice and the data used is shown in table 4.The regression coefficients and error between the actual and simulated values are indicated in table 5 and 6 respectively. Small error between these values indicates the correctness of the model which will be further used to predict the food crisis in near future.

B. Crisis Decision Making Support System

Crisis decision making support system consist of two subsystems which are information data base and processing knowledge.

1. Information Database

In this the information related to food security is stored in very specific manner such that it can be accessible very easily. The kinds of information are stored are following:

- Government Policy: Government declaration about food policy, several government schemes such as Public Distribution System, Food Security bill, foreign direct investment. etc.
- Location and state wise rainfall data and prediction of rainfall from Indian Metrological Department.
- Last year's production and current year's production and their pattern of production.
- Storage capacity of different-different agencies like Food Corporation of India, State Procurement agencies, Private Players or Open market Buyers.
- Economic and Social condition of Exporting and Importing nations, and their relations with other countries.
- Total storage capacity of food grains and future requirement of storage and transportation facility.

2. *Processing Knowledge*

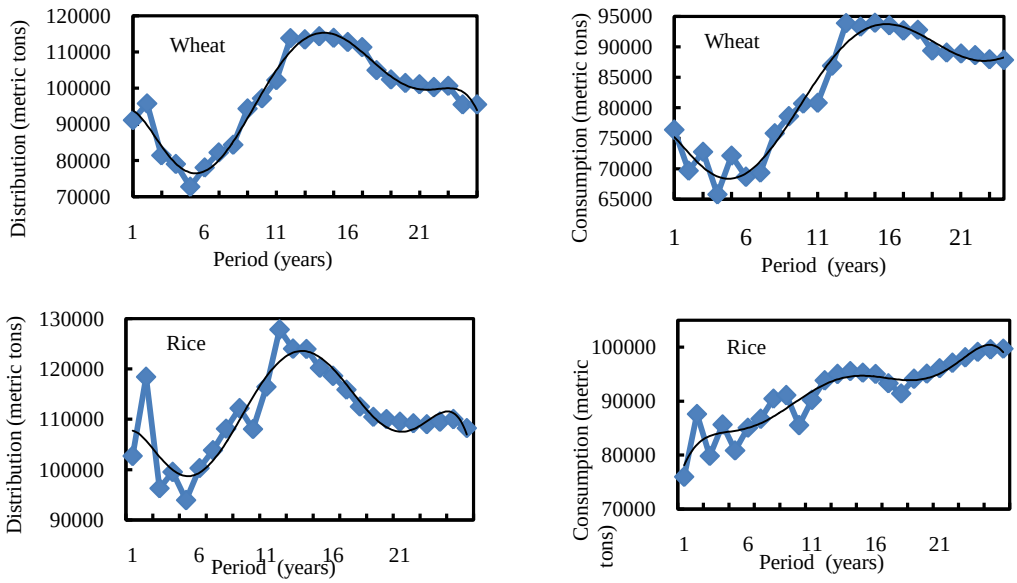
In Processing Knowledge, all the relevant information which has been come out from Information Database is processed and stored.

C. Information on the Early Warning System

Information on the early warning system is the final and last subset of the basic model. It gives the initial indication towards the food crisis in future.

1. Scoping Food Safety Early Crisis Warning

In scoping food safety early crisis warning subsystem on the basis of deficit between future Rice Total Distribution and Total Domestic Consumption, possibility to identify the food crisis warning is explored. Different probabilistic and mathematical approaches can be used to predict such a crisis in 10-15 years in future. In this work the regressive models developed for both wheat and rice is used to identify such a crisis in future. The data available for different factors which may be responsible for food crisis is used to forecast the situation in future. For this study forecasting of food grain distribution and consumption is done up to 2025 indicated in figure 3.



Fig,.3. Forecasted distribution and consumption for rice and wheat.

2. Determine The Early Warning Of Crisis

Determining the crisis only based on forecasting of total distribution and total consumption is not adequate because several factors also play crucial role on deciding food crisis problem. There are several factors like economy, foreign trade, government policy etc. Hence for identifying the method of early warning crisis several factors have been considered and several assumptions have been assumed-

- Population at the end of 2025 would be 1.4 billions.
- No climatic or natural/unnatural events will occur which cause sharp decrement in production of crops.
- Export of grains will not face drastic increment or decrement.
- Consumption of Rice and Wheat are inter-related.
- There will not be consecutive 3 years rain drought situation [23].

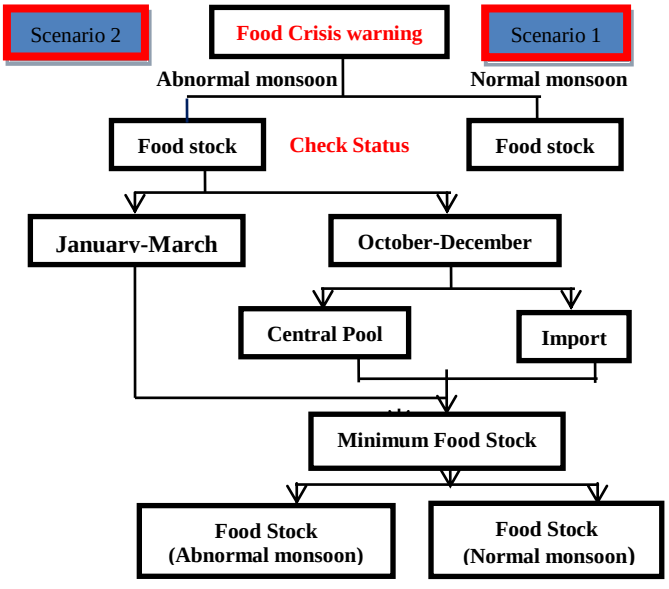


Fig. 4.Food Crisis Warning System.

Based on the above assumptions, for normal and abnormal monsoon in 2024 the possibility of food crisis is identified and strategies are suggested to tackle the food crisis (Figure 4).

Harvesting of wheat is done mainly during April-June and production of wheat is not enough to meet the demand. Rice harvesting is done throughout the year and its production is more than current requirement so there will be more chance of food crisis due to wheat in year 2025. For wheat two scenarios are discussed based on the rain conditions in previous years in detail as follows.

Scenario 1: Year 2025.
Rain fall – Normal,
Wheat Total Distribution: 95516.5625 MT
Wheat Total Consumption: 87399.6875 MT
Rice Total distributions: 108281.4375 MT
Rice Total Consumption: 99699.2580 MT
If there will be normal rain fall then production of wheat and Rice will be satisfactory and there will not any food crisis on this year.
Scenario 2: Year 2025
Rain fall – Abnormal,
Wheat Total Distribution: 95516.5625MT
Wheat Total Consumption: 87399.7MT
Forecasted production of wheat: 92343.4875MT,
If 30% rainfall deficit occurs, then
Forecasted production of Wheat: 64640.44125MT
Wheat Total Distribution of 2024: 90717.5296MT
Wheat Total Consumption of 2024: 90470.9696MT

The share of wheat production will be almost 95% of total distribution of wheat in year 2025, so 30% deficit will impact supply very badly but share of rice production will be 85% of total distribution of Rice and 30% rain deficit would decrease production from 91954.6875MT to 64368.2812 so total distribution would be 80694.2815MT which will be 19000MT less from total requirement.

After 30% production deficit of wheat, forecasted total wheat distribution would be 67813.4712 MT and

forecasted total consumption would be 87399.6875MT so there would be 19586.22MT deficit. Since there will be less amount of rainfall in previous year (2024), so consecutive 2nd year of rain fall deficit will impact the net storage of food grains, if in the year of 2025 shortage of food grains rises then a condition will be checked to address it

In which duration of month, shortage of food grains occurs. There are 2 durations in which shortage can occur: Duration 1: January-March, Duration 2: October-December

Duration 1st's Condition [January-March]

Since harvesting of wheat is done in the duration of April –June so shortage of wheat will be remains for only duration of January-march periods.

Since year 2024, the difference between total distribution and total consumption of wheat was very less. So Government of India may use following tool:

- Increase inflation or decrease supply from month of July 2025, so that wheat will be available coming few months.
- Use buffer stock in the duration of January-March so that inflation or price hike may be retarded
- Wheat may be imported
- Rice can be used as supplement of wheat.

Duration 2nd's Condition [October-December]

If the shortage of wheat would be happened in the duration of October-December so condition will become critical because Food Corporation have to release their buffer stock and reserve stock too. Generally Food Corporation of India release 66 % of their stock throughout the year and out of remaining 20% is buffer stock and 14 % is reserve stock is kept for emergency conditions.

Since shortage has been happened duration of October-December and new stock arrival is 6 months far away so there will be food crisis situation because

- Normal stock of FCI will be ended because of last year rain drought situation
- Not only wheat production will have been fallen down but also Rice production will be less
- Export of food grains will also affect the food crisis situation.

In 2025, almost all countries will be suffering from food crisis problem so Import of food grain in large quantity will not be possible

IV. CONCLUSION

Today inflation of food-grains is very high though higher production which nor raises alarm about the availability of food grains and its related governing policy. There is an urgent need to address the factors which negatively impact the food crisis problem especially proper storage of food grains. Today Food Corporation of India has total of 34 million tonnes of storage capacity of which 4 million tonnes is under open-space storage [24]. Every year approximate 15-20 percent of food-grains goes into wastage due to negligence of authorities.

The project was initiated with the intention of developing a model to deal with crisis scenario for Food Security. Several factors, case studies, research papers and reports have been studied and on this basis a basic model is developed. Information collection, Forecasting, Regression Analysis and making a model are the main steps of this project. Food Crisis problem has been identified and a condition based analysis is performed to check how conditions impacts the storage. With gradually advancing of social change and transformation, different levels of crisis have taken place in almost all areas of life. In these different types of crisis events, the frequency and negative impact of food safety is on the forefront and it brought us irreparable damage to health or even loss of life. Under the background of advocating people-oriented and harmonious society in our country, the urgency and importance to establish and improve the food security crisis management mechanism is self-evident.

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