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Integrating System Dynamics Modeling for Sustainable Rural Development

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Abstract—*In general, sustainable rural development recognized as a function of all those human oriented activities that are using resources in rural regions, concentrating upon increasing socio-economic and environmental development initiatives. Sustainable development which meets the basic present requirements without compromising the ability of future generations to meet their own personal requirements. It also includes investment in general infrastructures and social services along with necessary regulatory, technical and financial tools, all of them contribute to enriching the living standard of the local population whereas Innovation is the successful production, integration and exploitation of novelty in the socio-economic and environmental spheres. At present, rural areas are facing vast challenges which arise specifically from globalization, demographic changes and the migration of educated youth from rural areas and well-trained people. On the other hand, if this human asset can get opportunities of career growth in their local regions then it will definitely contribute towards the socio-economic development of the local region. Policies for rural areas should be aimed to recognise and make use of strengths and opportunities of available local resources. In this study the researcher is intended to identify various challenges and opportunities evolved in context to develop a sustainable rural environment. For this purpose, researcher will conduct an empirical study with the help of a questionnaire and will further extract data onsecondary basis from national and international journals, books, reports,newspapers, magazines, websites etc. For data analysis purpose, researcher is intended to implement analysis techniques like Cronbach alpha, factor analysis, content analysis and system dynamicswhichis a powerful methodology to identify, understand and explain a complex problem by modeling, simulationandexperimenting with the models to design policies for management and change.*

Keywords: *Sustainable, system dynamics, socio-economic, rural, development.*

1. INTRODUCTION TO SUSTAINABLE RURAL DEVELOPMENT

With the passage of time, men has harmed environment for his necessary and unnecessary needs which has resulted in severalnatural calamities for the human beings caused numerous deaths and injuries followed by the tremendous financial losses. Examples of some recent calamities are Jammu and Kashmir flood, Pune landslide due to heavy rainfall and cyclone Hudhud in Orissa and Andhra Pradesh and many more has caused heavy loss of lives. All recent incidences alarming to moves our focus towards environment preservation and creates need of development on sustainable basis because natural environment is fundamental asset for human beings hence it must be preserved and protected. The definition given by Brundtland Commission in 2007 on sustainable development as capacity to build development sustainable—to make sure that it meets requirements of the present without compromising the capacity and ability of future generations to meet their personal needs. Whereas (IFAD, 2007) derives the mean of environment centric sustainability as an "environmentally sustainable system must carry a stable resource base, avoid over-exploitation of renewable resources to preserve biodiversity."

Under the broader context of environment management, Sustainable Rural Development can be referred as various activities that conserve and regenerate the natural resources and habitat, innovate and use clean materials, modern technologies and traditional processes to create environment-friendly products, enterprises, livelihoods and jobs. Poverty mitigation and economic growth can be achieved when natural resources are managed on sustainable basis. Sustainable Rural Development can result in various outcomes for the region or nation which are as follows:

(a) Improved resource conservation

In the Indian context, there are two schemes presently functional: MGNREGS (Mahatma Gandhi National Rural Employment Guarantee Programme) and IWDP (Integrated Watershed Development Programme) focuses on regeneration of natural resources. Enhanced productivity can be achieved by conserving and regenerating land and water resources which leads to increased agricultural outputs and improved livelihood. Such schemes can assist in reduction of soil losses, groundwater recharge and improve biodiversity.

(b) Improved resource efficiency

Such Rural development focused schemes can improve the efficiency and usage of natural resource usage in rural livelihood and essential services. Under the IWDP, a supporting hand to farmer groups can be provided to adopt these methods that improve efficiency of irrigation water

which can be done through appropriate farming techniques, drip and sprinkler irrigation system, adequate crop choices and improved field irrigation practices.

(c) Reduced negative Environmental aspects

Another scheme recently launched by Government of India, Nirmal Bharat Abhiyan, can also greatly help in improvement of local sanitation, hygiene andhealth oflocal residents. (UNDP Report, 2012).

2. NEED OF THE STUDY

Since the objectives of the proposed study requires an understanding and scanning of theSocio-economic and environmental dimensions for identifying vulnerabilities on the basis of stated factors so that researcher can identify and recommend a comprehensive plan for Sustainable Rural Development of backward Mathura Rural Region by involving local residents, regional industries after completion of the study.

3. REVIEW

From the system point of view, the consistent or sustainable system has components as productivity,resilience, vulnerability and adaptability (Rusko and Prochazkova, 2011)while achieving sustained prosperity for all will require development pathways that respect ecological boundaries and restore health of ecosystem while optimizing the contribution of the environment to economic progress (TigheGeoghegan, 2015) and in order to preserve the natural world, socio-economic and environmental factors must be considered and harmonized (Dr. Andy Johnston, 2007). Jennifer A. Elliott, 2006 has outlined the challenges in building sustainability where he has highlighted poverty as a major barrier in sustainable development due to its complex linkages with environment, the people's numberbelow the poverty line remains high and it is the groups of poor people who suffers the consequences of environmental degradation at a higher level and acutely reason being such groups of people have been barred from accessing the general opportunities for development and an acceptable life quality, it is very much important to know where these peopleresides, the hurdles they are experiencing and capacities they bring towards changing these development processes. (Winkler et al, 2011) has suggested that there should be equitable access to the sustainable development policies, technological and financial transfers so that people within poverty line can also avail the benefits of such opportunities. Ravi Chopra and UNDP Associates, (2012) states that green rural development can stimulate rural economies, create jobs and helps in maintaining critical ecosystem services and strengthen climate resilience of the poor. This report summarizes the insights and potential of six major rural development schemes for delivering environmental benefits. It also highlights the green results of six schemes initiated by the government and also suggests some scheme-wise recommendations to the Ministry of Rural Development.ShahidSadruddinNanavati, (2004) highlights the model of rural development by "Village Adoption Scheme" to energize rural economy in India. GaoVikasSangathitPrayatna (GVSP), A NGO of Mumbai, has revealed 6 backward villages in the state ofMaharashtra sent the most migrants into cities. GVSP planned a project in identified region considering legal, social, traditional, cultural, economic and political layers and enable the region to build upon them to create new methodology of operation. In span of 5 years ending in 2002, they have initiated 3 secondary schools, 4 new fully equipped clinics, new city buses with the coordination of Royal and Lions clubs and some funding bodies of districts which has raised the standard of living and provided basic facilities to the villagers which caused lesser migration of people from villages to cities. After 6.5 years, GVSP handed over the title of the house, temple and the leased land in the central village to the village council is just like advising body to the village council and now acts as advising body to the village council when they ask for it.

4. RESEARCH METHODS

Research method is a procedure to findstep by step solution of the research problems. It is a science of studying how research is done on scientific basis. A research view point refers to amixed set of research principles and general procedure related guidelines. Researcher is intended to collect data on primary basis with the help of questionnaire and on secondary basis from national and international journals, magazines, periodicals, reports, newspapers, websites, blogs and other online resources.

For empirical analysis, proposed research tools are cronback alpha, factor analysis, Correlation, Regression and System dynamics modeling.

4.1 Objectives of the Study

Under the broader context of proposed study, researcher is intended to conduct research focused on following dimensions:

1. To map social, Economic and Environmental Vulnerabilities of backward areas and villages of Mathura Region.
2. To analyze the various dimensions of Sustainable Rural Development of the Mathura Region.

4.2 Geographical Area Coverage

Mathura has an ancient history. According to Hindu mythology, Mathura is birthplace of Lord Krishna therefore it is a prime destination for pilgrimage in India.Mathura District has 734 inhabited villages; all villages are further divided into 89 rural panchayats which is further divided into 10 Blocks named Baldeo, Chaumuha, Chhata, Farah, Goverdhan, Mat, Mathura, Nandgaon, Nauhjhil and Raya. Though the district has been covered by roadway an railway but its rural component still remain underdeveloped from social and

economical dimension while 70% of total population of Mathura region still resides in the rural areas. Researcher has collected primary data through questionnaire from the five villages of five different blocks of Mathura Rural Region as Baldeo Block- Mahavan village, Goverdhan Block- Datiya village, Mat Block- Sikandarpur, Mathura Block- Satoha village, Raya Block – Gosna village are identified to collect the data.

4.3 Sampling Techniques

To select the backward blocks and their villages, researcher has applied cluster technique while to select the respondents, researcher has applied convenience technique.

4.4 Sample Size

Researcher has calculated the sample size of 97 respondents to be collected from one village each from five different blocks of Mathura Rural Region with the help of cochran'sformula where the confidence level is 95%.

5. FINDINGS AND ANALYSIS OF MATHURA RURAL REGION

5.1 Findings

Researcher has collected data from 97 respondents from all the five blocks based upon the self-structured questionnaire covering the questions related to the Social, economic and environmental vulnerabilities, socio-economic and environment vulnerabilities related solutions, relevance of traditional knowledge for sustainable rural development and dimensions of green rural development. Where researcher found the responses as stated:

i) Social Vulnerabilities

With reference to social vulnerabilities existed in the Mathura Rural Region, respondents has marked lack of non-farm employment opportunities as number one because majority of local residents dependent upon agriculture for their livelihood and to join the non-farm employment opportunities, while absence of agricultural research universities and institutions marked second vulnerable condition in the region and lack of well- equipped hospitals marked as third.

ii) Economic Vulnerabilities

Respondents have marked most prone vulnerabilities to the non-coverage of crop insurance due to the unawareness of the same while less numbers of water resources for the irrigation purpose is second most prone vulnerabilities and less agricultural support from the government is marked as third.

iii) Environmental-Vulnerabilities

Respondents accepts that excessive usage of chemicals has caused the soil and water related pollution in the region and decreasing level of ground water is a serious problem for the region while they also accepts that one of the major reason for increase in these environmental related vulnerabilities is not using the renewal sources of energy.

iv) Solutions to the Social Vulnerabilities

Respondents have agreed upon that small farmers requires special attention and incentive given by the government so that they can efficiently produce the crops while the second major solution suggested is establishment of well equipped hospitals in the local region so that they can avail good treatment locally and respondents also needs that non-farm agricultural opportunities should be available in the region itself.

v) Solutions to the Economic vulnerabilities

First solution which is marked most important is crop insurance policy should be formed by the government so that farmers can get financial assistance during natural calamities, while another important solution is the availability of subsidies to the farmers directly without any intermediary body and majority of the respondents also believes that insurance of local residents and his family is very essential.

vi) Solutions to the Environmental Vulnerabilities

"Special aids should be given to farmers in case, lack of rain" marked as the most important solutions to the environmental vulnerabilities while second most important solution referred by the respondents is farmers need special packages in case of natural disasters such as droughts, flood etc and rural development should be balanced with environment management.

5.2 Analysis

5.2.1 Factor Analysis

Researcher has conducted factor analysis for the focused outcomes. This technique is used to select small set of data from a large set of data. Under the broader context of this study, researcher has used eigen value as 0.4 and selected 9 variables out of 11 as analysed below with the help of SPSS:

Total Variance Explained

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.332	30.293	30.293	1.621	14.735	14.735
2	1.339	12.175	42.468	1.345	12.224	26.958
3	1.155	10.502	52.969	1.120	10.184	37.142
4	1.082	9.836	62.806	1.085	9.862	47.005
5	.884	8.036	70.842	1.075	9.773	56.777
6	.816	7.416	78.257	1.045	9.502	66.279
7	.707	6.430	84.687	1.038	9.435	75.714
8	.571	5.189	89.876	1.016	9.233	84.947

9	.471	4.285	94.162	1.014	9.215	94.162
10	.382	3.474	97.635			
11	.260	2.365	100.00			
Extraction Method: Principal Component Analysis.						

5.2.2 Reliability Analysis

Researcher has calculated Cronbach's alpha score to test the reliability of the questionnaire, where the outcome through SPSS is stated below:

Reliability Statistics	
Cronbach's Alpha	**N of Items**
.684	6

As per the derived result, cronbach's alpha score for the social, economic and environmental vulnerabilities and solutions to the social, economic and environmental vulnerabilities is 0.684 which means that internal consistency is acceptable.

5.2.3 Existing Vulnerability Mapping

Researcher has explained top three vulnerabilities existing in the Mathura rural region and needs to mitigate for sustainable rural development plan as stated below:

5.2.3.1 Social Vulnerabilities

i)Most prone vulnerability with the weighted average of **4.92** is 'Non-farm employment opportunities are not available for local residents' due to which educated people are bound to move to the urban areas of Mathura or to the other cities. Agriculture is the main source of livelihood in the Rural region and as per the local residents it is an immense requirement of establishing non-farm employment opportunities in the rural region.

ii) 'Agricultural research University and institutions are not available in the region', this vulnerability is on the second rank with weighted average of **4.90**. As agriculture is the main source of livelihood in rural region hence there is a need of establishing Agricultural institutions and Universities who can do research in this field and can provide training on new scientific techniques of Agriculture so that farmers can increase their productivity.

iii)'Well equipped hospitals are not in adequate numbers', this vulnerability is on third rank with weighted average of **4.82** as in the whole Mathura region there is only one district hospital in Mathura city while there is a population more than twenty lacks in the whole region which creates a huge imbalance in health services to the Rural residents. Poor people do not have financial capacity to get the treatment into the private hospitals due to the high charges. Therefore there is need of establishing more government hospitals for the welfare of rural local residents so that they can get affordable treatment for their family members.

5.2.3.2 Economic Vulnerabilities

i)'Lack of rain affects the productivity badly', this economical vulnerability ranked one with the weighted average of **5.00** which means all the respondents were strongly agree with this statement. As Mathura rural region has Agriculture as the main business for their residents, Lack of rain creates so many vulnerabilities to the farmer as they have to manage jet pump to explore the ground water or to take water from the canal which means they have to invest more money in farming.

ii) 'Water resources are not enough for irrigation', this vulnerability ranked second with the weighted average of **4.78** as Indian farmers are totally dependent on rain for the irrigation purpose due to the unavailability of other resources of water like tube wells, ponds, wells etc.

iii) 'Agricultural support is not satisfactory from government', this vulnerability lies at third rank with the weighted average of **4.66**. Government has already launched so many schemes for empowering the farmers of the country but the real benefit is very far from them due to which farmers are totally dependent on their own traditional knowledge for the agriculture due to which productivity is less.

5.2.3.3 Environmental Vulnerabilities

i) 'Chemicals are polluting soil and water resources', with the weighted average of **4.96**, this vulnerability ranked one as per the survey. According to the respondents, Chemicals are in use more than the requirement to get the higher production which causes degrading and polluting soil and water resources and it results in loss to the farmers in long run in terms of lesser production due to polluted soil and water.

ii) 'Decreasing level of ground water is a serious problem', this vulnerability also ranked as one with the same weighted average of **4.96**. According to the respondents farmers have two major sources of irrigation where one is rain water and second one is ground water because other sources of water are either not available or are very few. Therefore, when there is lack of rain then farmers have to be dependent upon ground water which is resulting decreasing level and with the passage of time ground water usage have become expensive due to its decreased level.

iii) 'Renewal sources of energy are not in use', this vulnerability ranked second by the local residents of rural region with the weighted average of **4.90**. As per the respondents, there are not even single renewal sources of energy in use in the rural region.

5.2.4 Proposed solutions to the existing vulnerabilities:

5.2.4.1 Proposed solutions to the social vulnerabilities:

i)'Small farmers requires special attention and incentives by Government', this solutions to the social vulnerability ranked one with the weighted average of 4.95 because there is no attention and incentives are given by government to the growth of small farmers. Although there are several schemes

launched by the government but there real benefit is still far from the small farmers. If government will focus on the growth of small farmers then they can givehigher productivity by implementing new scientific techniques for the agriculture.

ii) With the weighted average of 4.92, 'Special hospitals should be opened in rural areas to control serious diseases', this solution ranked second because health is the prime concern for each and every individual and if better treatment facilities are not available then there is chance of increased mortality due the unavailability of health care services. If special hospitals will be established then local rural residents can get the treatment in their own block without any delay.

iii)'Adequate opportunities for the employment should be available' this solution to the social vulnerability ranked third with weighted average of 4.90. As of now there are only farm related employment opportunities are available while for educated people there are very few opportunities for the employment. Hence there is requirement to establish some institutions which can provide jobs to the educated people in the blocks.

5.2.4.2 Proposed solutions to the economic vulnerabilities:

i)'Insurance of crops is also needed', with the weighted average of 5.00 this solution to the Economical vulnerabilities ranked one. As per the respondents, every year farmers have to suffer loss in agriculture due to lack of rain or drought or sometimes due to flood and there is no financial assistance available from government side. Therefore there is a need of crop insurance so that farmers can get the sum assured when natural calamities arise.

ii) 'Subsides provided for farmers are necessary', with the weighted average of 4.96 this solution to the Economical vulnerability ranked two. Although there are various schemes through which pesticides and seeds can be provided to the farmers on subsidized rate but the real benefit is still far from the small farmers due to the corruption.

iii)'Insurance of farmer and his family is necessary', this solution to the Economical vulnerability ranked three with the weighted average of 4.92. As per the respondents if the in case earning member of family dies then the survival of his family becomes critical due to the absence of any financial assistance hence there is a need of Insurance to the farmer and to his family so that financial support can be available when needed.

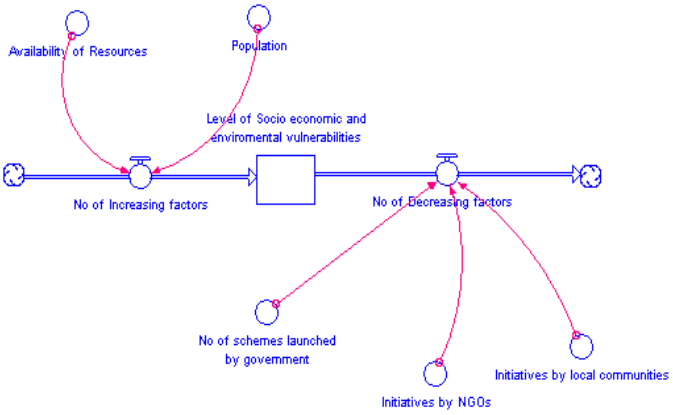
5.2.4.3 Proposed solutions to the environmental vulnerabilities

i) 'Special aids given to farmers in case of lack of rain' with the weighted average of 4.96 this solution to the Environmental vulnerability ranked one among all the solutions because due to changing environment, lack of rain creates water scarcity for the farmers which creates many difficulties for the farmers in production of crops. Hence some special aids should be provided to the farmers when there is existence of such situation.

ii) 'Farmers needed special packages in case of natural disasters such as Droughts, Floods etc.' this solution to the vulnerability ranked two with the weighted average of 4.94 because due to the changing environment sometimes there are situation of droughts in whole the region while sometimes excessive rain creates the situation of flood. In all the cases farmers are not able to do farming which creates financial difficulty to them hence there should be some special packages from the government side so that they can sustain in such situations.

iii) 'Rural development should be balanced with environmental management' with the weighted average of 4.94, this solution to the Environmental vulnerability ranked two along with the above one. As per the local residents if any development plan is to be implemented by the government to the Mathura Rural Region then it should not be at the cost of degrading the environment. Policy maker should consider that rural development should be balanced with environment management so that there should not be any loss to agriculture as it is the main source of livelihood for local residents.

Dynamic view of Linkages between Socio-economic and Environmental Vulnerabilities:



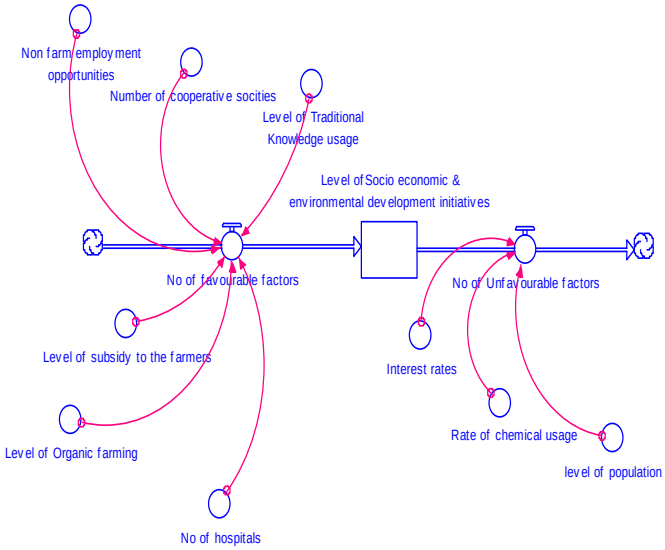
As per the above shown stock flow diagram, it is clearly visible that here stock variable is level of socio-economic and environmental vulnerabilities, inflow variable is number of favourable factors and outflow variable is number of unfavourable factors. It means that number of favourable factors increases the level of these vulnerabilities while on other side, number of unfavourable factors decreases the level of socio-economic and environmental vulnerabilities.

Further favourable factors comprising the population level in the selected region, if population is high then it will lead to more consumption of the available resources and more consumption leads to greater demand of the resources which indicates towards increasing in the price which can cause vulnerabilities to the poor people of that region. Therefore these two factors: availability of resources and population

level decides the level of socio-economic and environmental vulnerabilities.

Dynamic view of Linkages between Solutions to the Socio-economic and Environmental Vulnerabilities:

Below highlighted figure indicates those factors which can positively contribute to the socio-economic and environmental development initiatives and also those factors which can negatively contribute to these development initiatives. In this stock flow diagram Stock variable is level of socio-economic and environmental development initiatives, Inflow variable is number of favourable factors and outflow variable is number of unfavourable factors.



6. CONCLUSION

This study identifies that there are existence of Socio-economic and Environmental vulnerabilities in the Rural Region of Mathura, which are responsible for the backwardness of this region. These identified vulnerabilities are resulting into lower agricultural production, degradation in soil and water quality, unavailability of drinking water, absence of quality education, lack of non-farm employment opportunities, non-availability of good quality seeds, fertilizers and pesticides, lack of health care related services etc. These vulnerabilities can be reduced effectivelywith the successful implementation of already running Government programme such as MGNREGS, NRLM, IAY, NBA, IWDP etc because these programmes consists the solutions to the above stated vulnerabilities. Further the assistance from non-government organizations (NGOs), corporate groups and local communities can be taken into consideration for achieving the Sustainable Rural Development.

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