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Integrating System Dynamic Approach to Explore the Dynamic Nexus between Sustainable Development and Rural Vulnerabilities

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Abstract

In the year 1972, the then Indian Prime Minister, Mrs Indira Gandhi, at the United Nation's Conference at Stockholm, concentrated on the theme of "Human Environment" and mentioned that the eradication of poverty was an important element in achieving an environment-focused strategy goal in the entire world. Various concepts, such as interrelatedness, shared planet, global citizenship, and 'spaceship earth' cannot be limited to environmental issues alone. There are strong links between human development and inter-related responsibilities. Indian history has shown large inequalities, leaving almost three-fourths of the world's people living in the under-developed countries and one-fifth of the population living below than the line of poverty. The long-term effects of past industrialization, exploitation, and environmental damage cannot be wished away. It is only right that development in this new century be even more conscious of its long-term impact. The problems are complex and the choices difficult. A common future can only be achieved with a better understanding of our concerns and shared responsibilities. Under the broader context of the outlined discussion, the researcher has applied a system dynamic approach and developed a stock-flow model to represent the various links between existing rural vulnerabilities and sustainable development.

Keywords: System Dynamic, Stock Flow, Social Vulnerabilities, Sustainable Development

Introduction

Introduction to Sustainable Development

The theory of sustainable development, from a global view, looks at the progress, survival, and maintenance of the human community on a regular basis, including exploring improved health and liveliness of the life support system on the earth. This concept can be understood as a system of fundamentally broad changes in our social institution and systems. The concept of sustainable development has been defined differently in various countries and cultures. It can be defined as a combination of social, economic, and environmental objectives of any society that provides substantial opportunities to safeguard the welfare of present and future generations (Remigijus et al., 2011). Further, it can be better explained as various practices that reproduce and preserve natural habitat and resources, innovate and utilize advance technologies, and clean material and indigenous practices to produce environment-friendly livelihoods, jobs, enterprise, and products (Aniruddh Vijay, 2015). The effects of these changes are linked to countering the issues discussed in the new global arena that earth is definite and the life support system on the earth, comprising economic, social, and environmental systems, are interlinked and interdependent. The concept of sustainable development has already been explained from the viewpoint of natural environment-related vulnerabilities, population-related challenges, and fast consumption of natural resources that arise as a result of the destruction of the life support system. From the year 1987 onward, reports published by the world commission on environment and development (the Brundtland Commission), focus on the understanding that the sustainable development concept is concentrated on capacity building, effort to change unsustainable practices, and the requirement for enhancing efficiency in using resources.

It is essential to focus on sustainability, related to activities with a futuristic extension, on a long-term basis; in the present sense, sustainable development is a path, a system

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of humanity to be established in the definite ecosystem. However, sustainable development is not well established. Still, it can be defined as evolution to enhance the human system and natural management through quality knowledge and enhanced understanding. The prime goal of sustainable development is survival of the human race; however, it does not allow unlimited growth due to some restrictions. Generally, sustainable development contains a broader approach than environment protection because it also pre-assumes cultural changes in the long run. Adaptability of culture, people or state is a prerequisite for the same. Other than the ability of adaptation, zeal for sustainability on broader aspects includes innovation related to actions, technology, and ideas. Various vulnerabilities to be encountered by humanity in the 21st century cannot be resolved by indigenous practices.

At the present time, it is widely accepted that sustainable development is a dynamic system depended on three basic pillars — social, economic, and environmental sustainability. These pillars are generally linked dynamically with each other as they are not mutually exclusive. Despite dynamic linkages within these three pillars, there is also a logical hierarchy which is not highlighted generally. There are complex and heterogeneous challenges associated with the goal of sustainable development, as human society and the worldwide natural ecosystem are varied. Associated vulnerabilities are:

- Exploitation of natural limited resources such as oil, minerals, soil, spices, and other non-renewable fuels.
- Unlimited use of renewal sources of energy such as fertility of soil, wildlife, and forests.
- Inequality on socio-economic and political grounds.
- Noise pollution and pollution of water, air, and soil.

The concept of sustainability is very complex, unclear, and difficult to understand in the present scenario.

Introduction to Rural Vulnerabilities

The concept of vulnerability has been described and adopted in various approaches. It is a concept that comprises many types of understandings and descriptions depending on the various fields and/or the approaches of the organizations. In a general sense, vulnerability links the exposition of people, individuals or population groups, to threats, their capacity of reaction, and the consequences in terms of a decline in wellbeing. The level of vulnerability depends, in great part, on the people's capacity to cope with external situations, at times difficult, and also on the social, economic, political, and environmental systems in which they live in.

According to World Bank, 2015, Poverty Reduction and Equity, Measuring Vulnerability, "Vulnerability is defined as the probability or risk today of being in poverty or to fall into deeper poverty in the future. It is a key dimension of welfare since risk of large changes in income may constrain households to lower investments in productive assets – when households need to hold some reserves in liquid assets – and in human capital".

As per UNEP, 2003, Assessing Human Vulnerability to Environmental Change, "Vulnerability is the manifestation of social, economic and political structures, and environmental setting. Vulnerability can be seen as made up of two elements: exposure to hazard and coping capability. People having more capability to cope with extreme events are naturally also less vulnerable to risk".

Understanding the concept of vulnerability requires one to distinguish between external and internal factors. When defining strategies to build resilience, taking these factors into account is of utmost importance.

- External elements are those beyond the control of people; they can be part of the "drivers of vulnerability" (failures in services and policies, unfair norms, and so on), or they can be part of the "drivers of resilience" (for instance, well-adapted policies or tools, solid governance mechanisms, among others), and can provide adequate responses to address vulnerability.
- Internal elements mainly refer to people's resilience, which is comprised of both ex-ante (preparedness, sharing mechanisms, information, social networks, and so on) and ex-post coping strategies. Key elements in this matter are: the stress or shock to which a system is exposed; the economic, physical, environmental, and social resources available, and their distribution; the formal or informal; local, national or even global institutions that play a role in their management and distribution of those resources.

Introduction to System Dynamics

System dynamics is a powerful methodology to explore, identify, understand, and discuss a complex problem (Sterman, 2001). A problem always becomes complex when there is human intervention. The reason for this is the difference in nature, attitude, personality, religion, culture, perception, and other behavioral aspects. In this present study, the researcher has applied system dynamics modeling to develop a replica for showing the dynamic nexus between sustainable development and rural vulnerabilities. Sterman's (2000) definition of System Dynamics is: "System dynamics is a method to enhance learning in complex systems. Just as an airline uses flight simulators to help pilots learn, system dynamics is, partly, a method for developing management flight simulators, often computer simulation models, to help us learn about the dynamic complexity, understand the sources of policy resistance, and design more effective policies." In this research paper, the researcher has applied this tool to develop a replica to highlight the dynamic linkages between sustainable development and rural vulnerabilities.

Literature Review

A rich number of literatures are available related to the implementation of the theory of socio-economic vulnerabilities to the risks associated with the environment. Fundamentally, vulnerability can be viewed as the output of an integrated blend of social, economic, environmental, cultural, and institutional structures and processes linked to health and poverty-related risks, which means it is not a concept related to challenges associated only with the environment.

An exhaustive discussion and review related to the present theory-based and applied studies on vulnerabilities conducted by Few in the year 2003 is provided. Various definitions of the concept of vulnerability concentrates on risks and probability of risk on the one hand, while and the mechanism of adaptation on the other hand (Pelling, 1999). Apart from the probability of risk, adaptive capacity is witnessed as the prime construct of the vulnerability concept (IPPC, 2001; Adger, 2000). Various primary survey-based researches concentrate more on the differences in the occurrence of both natural hazards and the capacity of people to deal with such hazards (Few, 2003). Inclusion of different socio-economic, environmental, institutional, technological, and cultural adaptive systems was explored by Cardona (2001).

Another speciality of the concept of vulnerability is the scale or level of analysis, with the help of various existing tools and techniques. Changes in socio-economic vulnerability toward environment-related risks can be further discussed at an individual level or at a community level. In other researches, some of the national constructs are well arranged and utilized (Vincent, 2004). Adger (1999) argues that individual vulnerability is determined by other factors than collective (community) vulnerability, but uses similar indicators for both levels of analysis (for example, income either measured at the individual household level or at the level of a region or country).

As highlighted by Kidd (1992), the phenomenon of sustainability is not recent; there is a long history behind it, which has evolved over a period of time. Importantly, this evolution has been affected by different "intellectual and political streams of thought that have molded concepts of sustainability" (Kidd, 1992). In the current section, the researcher will rely on the related existing literature, which has highlighted the concept of sustainability as per the different streams of thoughts. The literature review of such studies allows the identification of three main discourses that have shaped and characterized the evolving debate on sustainability. The researcher has labeled these terms as 'environmental', 'social', and 'business' discourses.

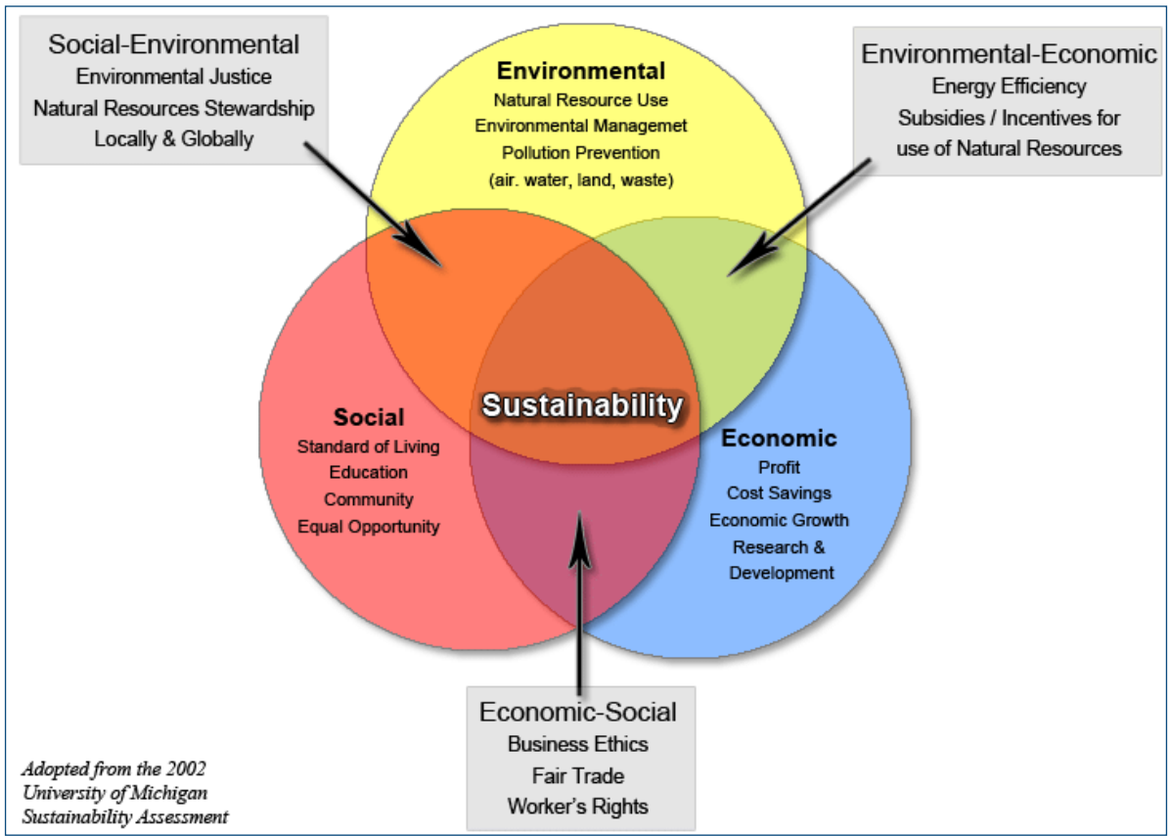
Under the broader context of this study, the researcher has outlined the following objectives to be discussed further in this paper:

- To study the constituents of sustainable development and rural vulnerabilities.
- To explore the dynamic nexus between sustainable development and rural vulnerabilities with the help of system dynamics modeling.

Constituents of Sustainable Development

At present, it is very common to hear about the concept of sustainability discussed by many experts. This term can be further explained as "meeting the needs of the present generation without compromising the ability of future generations to meet their own needs". In our world, sustainability can be defined based on three important

areas related to it. There are three interlinked dimensions related to sustainability that explain the significant linkages among socio-economic and environmental dimensions. These dimensions are a linked group of concepts and in integrated form, they establish a strong background out of which crucial actions and related decisions can be applied. Illustrations related to such types of decisions could comprise planning of land usage, management of surface water, construction of buildings and their designs, and even law-making. When the concepts compiled in three dimensions of sustainability are implemented in situations of the present world, it becomes a win-win approach, which means having a protected environment, preserved natural resources, strong economy, and providing quality life for people.



Social Sustainable Development

Social sustainable development is totally dependent on the theory that a project or decision results in the upliftment of society or a particular rural region. On general grounds, it can be said that upcoming generations will have equal rights on all resources, such as is enjoyed by the current generation today. This theory can also cover many types of things such as environment-related laws, human rights security, environmental laws, and active involvement of public and their participation. If proper focus cannot be given to the social aspects of a project, action or decision, it can result in the steady destruction of one dimension related to sustainable development. Social sustainable development goals can be achieved if the impact of existing social vulnerabilities such as health issues, unawareness, lack of education, and poverty can be reduced further with the help of decisions made by policymakers.

Economic Sustainable Development

Similar to social sustainable development, economic sustainable development involves the creation of economic values from whatever projects or decisions are taken. Economic sustainable development means that with proper consideration to the other dimensions of sustainable development such as socio-economic dimension, these decisions or projects will emphasize their focus on the

environmental dimension of sustainable development. In a majority of cases, decisions and projects are formed with the intention of gaining long-term advantages instead of short-term advantages. If in such decisions only the economic dimension or social dimension is in focus, then fundamentally, such decisions may not result in a clear picture of true sustainable development.

For a majority of people associated with the world of business, their main focus for sustainable development is associated with only one aspect, which is economic sustainable development, because it results in higher profit. On a large scale, either locally or globally, such narrow-minded viewpoints result in dissatisfactory outputs for businesses. Although, on the other hand, if good business and management practices are clubbed with the environmental and social dimensions of sustainable development, it can result in positive results for humanity.

Some good ideas can result in the establishment of economic sustainable development. It can be well articulated with the help of an example: if the Government of India plans to promote the concept of 'smart growth' through proper, sensible land usage, related planning and subsidies or tax reliefs, sustainable development may be achieved. Effective financial assistance for educational institutions, educational programs, technological usage, universities, and research and development is an essential part of economic sustainable development.

Environmental Sustainable Development

True environmental sustainability includes biodiversity, population growth, and total functionality during an extended time period. In an ideal condition, decision-making should result in positive growth in the country. Unwanted and unexpected interruptions to the environment should be avoided up to the extent possible. If there is any kind of interruption, it should be cautiously and sincerely reduced by taking the maximum effort. Whenever decisions are taken, at least one part of that decision should be environment-oriented and should result in a positive impact on the environment, so that the decisions can be focused on bringing vital changes to ecological growth.

Constituents of Rural Vulnerabilities

Accompanying conceptual development, with specific reference to rural vulnerabilities, there has been an increase in the interest shown in assessing the level of rural vulnerabilities in developing countries (for example, Kochar, 1999; Dercon & Krishnan, 2000; Chaudhuri, Jalan & Suryahadi, 2002; McCulloch & Calandrino, 2003; Ligon & Schechter, 2003; Gaiha & Imai, 2009; Jha, Dang & Tashrifov, 2010; & Kurosaki, 2010). Vulnerability is always risk-specific, and the concept of forward-looking discusses future output, whereas rural vulnerability explains the current or past status. Therefore, poverty and vulnerability are close but distinct concepts. One definition of ex-ante vulnerability is 'Vulnerability as Expected Poverty' (VEP – e.g. Chaudhuri, Jalan & Suryahadi, 2002; Pritchett, Suryahadi & Sumarto, 2000). In this research paper, the researcher has identified three types of vulnerabilities — socio-economic and environmental vulnerabilities — which are discussed further.

Social Vulnerability

The theory of social vulnerability has been explored and further defined in a number of ways. Neumayer and Plumper (2007); Zahran et al. (2008), ethnicity and racism (Fothergill, 2004), and assessment of economic positions such as poverty and income (Fothergill & Peek, 2004). Technically, it can be argued that many individuals or social groups are vulnerable on social grounds when they encounter stress. They are more likely to adjust the level of stress. "The level of influence and the way that stress manifests itself on individuals or groups is often determined by different characteristics of the individual or group under stress. Cutter et al. (2003) take note of an emerging consensus within the social sciences community about some of the major influences or characteristics of social vulnerability. These include:

- Lack of access to resources (including information, knowledge, and technology).
- Limited access to political power and representation.
- Social capital, including social networks, and connections.

- Beliefs and customs.
- Building stock and age.
- Frail and physically limited individuals.
- Type and density of infrastructure and lifelines".

(Cutter et al., 2003, p. 245 & Wisner et al., 2003)

Economic Vulnerability

In rural India, despite lots of initiatives taken by the Government of India, corporate sectors, and residents, the rate of development in the region is very low in comparison to the other developed countries. Poor infrastructure in rural areas is one of the major vulnerabilities due to which lots of schemes initiated by the government are not able to reach the residents of rural areas easily. The huge population is another major vulnerability which results in slower rate of development in the rural regions. It is clear that resources of production are rare while population is vast. Therefore, proper utilization of resources in a manner that benefits everyone becomes a challenge. "The impact of excessive growth in population has the potential to be great for economic development; after all, the more people you have, the more work is done, and the more work is done, the more value (or, in other words, money) is created. So, surely this can be nothing but good. There is a reason that farmers often have a lot of kids – more kids means more workers."

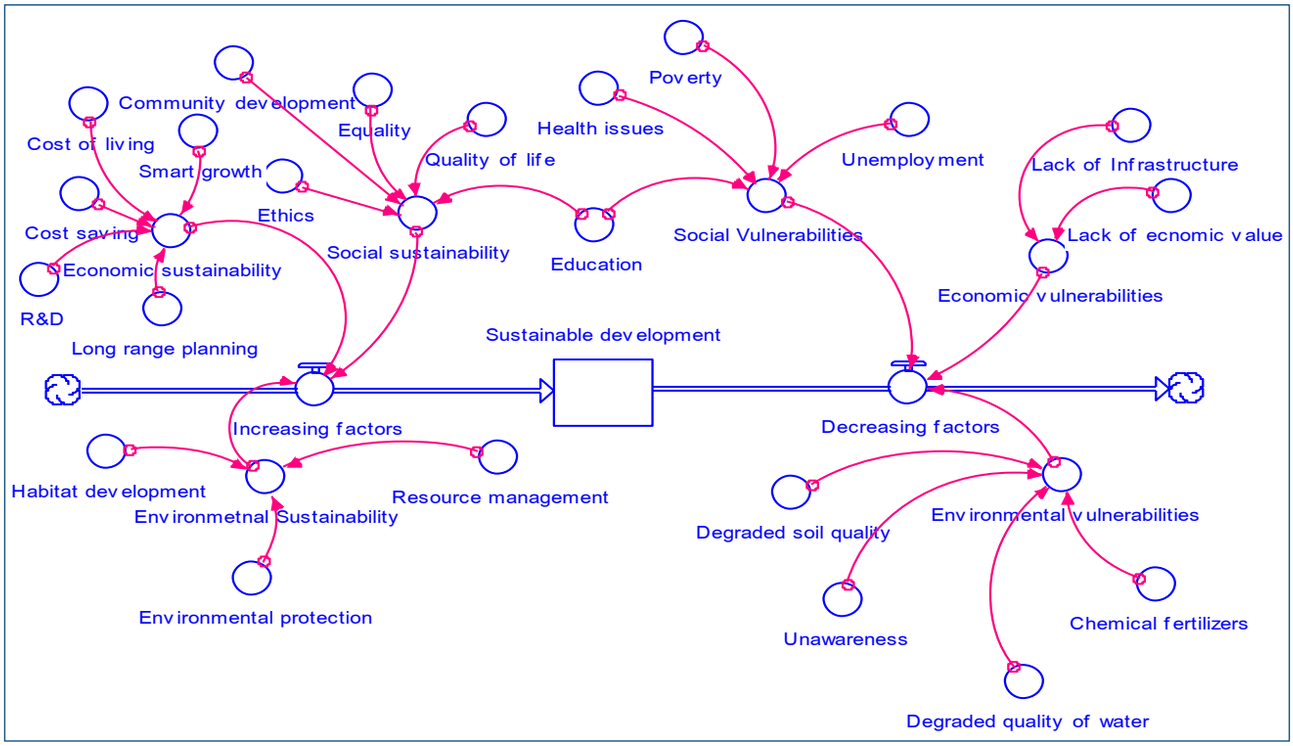
But, unfortunately, it is not that simple. Perhaps, in a country with excess resources and money – a rich country – more people is a good thing. But that is not always the case in countries with scarcity of resources. Scarcity of resources and a large population places pressure on the existing resources. More people means more mouths to feed, more health care and education services to provide, and so forth. So, population can be a mixed bag.

Environmental Vulnerability

"Disasters are not random and do not occur by accident. They are the convergence of hazards and vulnerable conditions. Disasters result in worsening the social, economic, and environmental vulnerabilities. Such events pose serious challenges to development, as they erode hard-earned gains in terms of political, social, and educational progress, as well as infrastructure and technological development." The Millennium Declaration recognizes the risk to development stemming from disasters and calls on the global community to "intensify our collective efforts to reduce the number and effects of natural hazards and man-made disasters" (UNGAR, 2000). "Several studies have recently highlighted the fact that investments in development are in jeopardy unless precautionary action is taken toward reducing disaster risk (DFID, 2005). Yet few development organizations adopt a precautionary approach in the design and management of projects, and fewer still recognize the role of environmental management in reducing disaster risk. Environmental degradation, settlement patterns, livelihood choices, and behavior can all contribute to disaster risk, which in turn adversely affects human development and contributes to further environmental degradation. The poorest are the most vulnerable to disasters because they are often pushed to settle on the most marginal lands and have least access to prevention, preparedness, and early warning. In addition, the poorest are the least resilient in recovering from disasters because they lack support networks, insurance and alternative livelihood options."

Dynamic Linkages between Rural Vulnerabilities and Sustainable Development

Dynamic linkages, especially when a problem is complex in nature, can easily be identified, understood, and discussed with the help of system dynamics modeling technique. With the help of this technique, researchers can develop a replica for different situations. In this present study, the researcher has developed a model which comprises tools to enhance the level of sustainable development in rural regions. This model comprises two types of variables, stock and flow variables. The level of stock variable increases by inflow variables and it decreases by outflow variables. In this model, the stock variable is sustainable development, whereas the inflow variable is the increasing factors, which includes social, economic, and environmental sustainability.



Social sustainability comprises various components such as quality of life, equality, community development, education, and ethics. Quality of life is very crucial with reference to Indian rural regions. The reason for this is the higher cost of quality life due to increased cost for the same. If proper focus can be given to promote gender equality, then women can also significantly contribute to the growth of the country. As of today, contributions made by women are physical in their house but do not contain any monetary value. Therefore, their physical contribution cannot be transformed to be a part of the gross domestic product of the country. There are various communities residing in a particular rural area which are divided based on caste, such as general caste, other backward classes, scheduled castes, scheduled tribes, and minority communities. Other than the general communities, the rest of the communities are underdeveloped. Hence, there is a need to provide more opportunities of development to these communities so that they can also actively participate in the achievement of the goal of sustainable development. The concept of smart growth in rural areas refers to growth with the implementation of advanced technology in sectors such as agriculture. If scientific methods along with upgraded advanced technology can be implemented, then it will lead to an increase in the level of sustainable development in rural regions by way of proper focus on ecological development and enhanced productivity from the agricultural farm lands. Ethics also plays a vital role in the achievement of the goal of sustainable development. In the absence of ethics, effective implementation of various policies launched by the government cannot produce the desired outcomes. Therefore, ethical training to the local residents and other stakeholders is essential to reach the goal of sustainability.

Economic sustainability consists of various factors such as cost of living, cost of saving, research and development, and long-range planning. These factors are positively linked to sustainable development. The third determinant of increasing factors is environmental sustainability, which comprises development of the local habitat and its preservation, resource management, and protection of the environment. These goals can only be achieved if socio-economic and environmental vulnerabilities can be controled.

In addition, this model also consists of outflow variables, which are known as decreasing factors. In this specific model, there are three factors which lead to a decrease in the level of sustainable development. Social vulnerabilities consists of various social problems such as the problem of poverty, unawareness related to health related issues, lack of education, and high unemployment rate especially in the rural regions. The second variable

is economic vulnerabilities, which consists of the lack of infrastructure, which includes educational, medical, industrial, agricultural, and institutional infrastructure. The third variable is environmental vulnerabilities, which comprises the erosion of soil quality, unawareness about present changes in the world, degraded quality of water, and overuse of chemical fertilizers in agricultural production, which causes a negative effect on the natural environment. Therefore, there is a need to emphasize on both increasing and decreasing factors so that sustainable development can easily be achieved.

Conclusion

At present, rural regions of India are not growing at the same rate as the urban regions. There are various reasons for this. The main reason is the increasing impact of vulnerabilities prevalent in rural India. Social, economic, and environmental vulnerabilities have a major impact. Therefore, there is a need to emphasize more on socio-economic and environmental sustainability methods, and sincere efforts have to be made to reduce the impact of social, economic, and environmental vulnerabilities.

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