Resilience Measuring Tools for Risk Assessment & Disaster Preparedness in India: The Current State

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Abstract:

In today's increasingly complex and dynamic environment, the ability to manage environmental risks and seize opportunities for enhanced well-being is paramount for individuals, organizations, and governments. However, translating this concept into practice has proven to be a formidable challenge, primarily due to the absence of robust tools for the comprehensive assessment of resilience and its integration into development initiatives.

This paper presents a systematic approach to systems analysis within the context of resilience guidelines, aiming to empower those responsible for program development to incorporate resilience considerations into their strategies. The objective is to achieve tangible positive outcomes for vulnerable populations and communities in disaster-prone areas.

Drawing insights from an extensive literature review comprising some influential documents, this research underscores the pivotal role of resilience in disaster risk management. The synthesized results offer valuable insights into the current state of affairs. Descriptive statistics are employed to provide a comprehensive overview of the data.

PRISMA Method is used for data gathering and shortlisting. The methodology comprises a series of five modules, guided by a straightforward systemic approach Leveraging the concept of six diverse types of capitals, it offers a concise overview of critical principles and strategy development through a resilience-oriented lens. The accompanying instructions facilitate the practical implementation of this approach, particularly in prototype disaster management scenarios.

Keywords: Capital, Communities, Disaster, Resilience, System Analysis

Introduction

We at present see a lot about diverse risks in developed nations. Many risk assessment / measurement tools are available, showing us how an event (shock) is most likely to occur,

which places are vulnerable toward disasters, and the possibility that pandemics, financial shocks and disasters could spread across various groups and regions (Vogel,2016). We do not know however, currently in what way to address these dangers or in what way to increase the resilience of people, families, communities and nations to the threats they meet. We also do not know which direction should we spend our time, energy, and money to invest at-risk individuals thus they can better survive shocks, or adapt, so they are not as much of vulnerable to shocks.

"In an age characterized by developing frequency and intensity of natural and man-made disasters, measuring resilience has become critical for enhancing organizing and recovery techniques. Several scholars have contributed to the development of resilience measurement tools. Narayan and Cassidy (2001) have proposed a dimensional approach to measuring resilience, while Bihari and Ryan (2012) have explored the influence of social capital on community preparedness for wildfires disaster. Additionally, Cutter, Ash, and Emrich (2014) have discussed the geographies of community disaster resilience. However, the route to understanding and quantifying resilience presents challenges with conflicting viewpoints among scholars and practitioners. While some regard resilience measuring techniques as vital instruments for building stronger communities, others are skeptical, difficult their reliability and usefulness. This disagreement highlights the complexity and multifaceted nature of resilience, calling for a deeper investigation of the usefulness of different measuring methodologies in risk assessment and disaster management. This study article aims to explore this complex terrain, providing insights into the critical function of resilience measuring techniques while acknowledging the various perspectives.

The ability of individual, groups, and entire countries to survive shocks, recover from them, even though productively altering their social and economic systems to manage with continuing trauma, uncertainty, and change (Barrett, 2013). Addressing the underlying grounds of crises while building up a system's abilities and capitals to withstand risks, forces, and shocks is what resilience is all about (Mallick, 2011).

We can prevent crises from destroying or damaging our investments in development by assisting societies to effectively manage risks and shocks (Barrett,2013). States and development workers must collaborate more closely to target vulnerability, since numerous risks (natural disasters, economic shocks, etc.) and stresses (such as urbanization and ageing populations) are multifaceted and interconnected.

The aim of the research is to address the gap by gathering the most essential resilience literature and developing a unified systemic Resilience framework guideline across the disaster management cycle and, hence reduce the impact of disasters.

The objectives of the research are as follows.

1. To identify how reliance can be mobilized and leveraged to develop a systemic guideline, which can be applicable to Indian context.
2. To identify the parameters that influence disaster recovery and develop resilience index suitable for coastal communities in India.

Research Methodology

A suitable research framework is necessary to direct the comprehensive review, offering the chance to investigate the extensive literature on community resilience to disasters. It is based on document survey method. To further making it accurate "Preferred Reporting Items for Systematic Reviews and Meta-Analyses" (PRISMA) is employed for document selection as shown in the Fig. 1. It is a typical tool for examining literature (Moher, 2009). This approach aims in identification, screening & eligibility, and inclusion is the three elements that enable systematic literature detection. In this process, 37 significant articles (as a part of literature data) have been considered for this research. Further considering this particular paper point of view 15 major papers were closely studied. The research papers were selected on basic of their keyword, subjective & citation resemblances. The Result so obtained from the study in the literature, are synthesized to give discrete information about the real time situation.

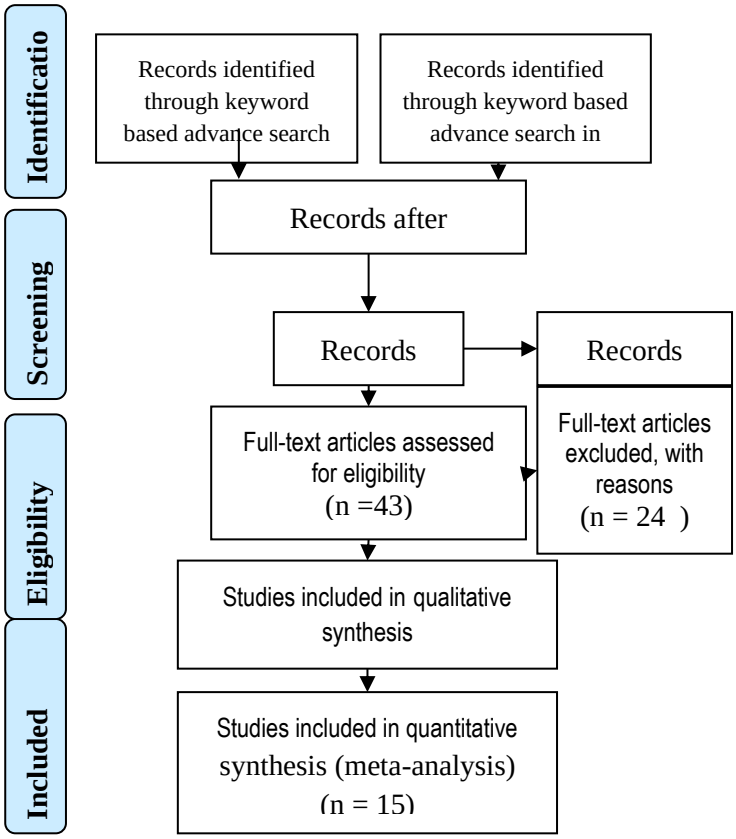

Fig. 1: Stages in PRISMA review as carried out in the study
Source: Moher D, Liberati A, Tetzlaff J, Altman D.G.,2009

Selection of Research Articles

The search for research publications in the Web of Science (WoS) and Scopus databases, which are frequently utilized by researchers utilizing advanced search based on specific keywords to locate the target literature. The search terms "community resilience" and "natural disasters" in the period span 2001 to 2023 was considered.

Inclusion and Exclusion Criteria

This study applied following inclusion and exclusion criteria to select the articles (Table 1).

Table 1: Inclusion and exclusion criteria for the document survey & PRISMA analysis

Inclusion Criteria	**Exclusion Criteria**
Articles about the social aspect of community resilience to natural disasters Published scholarly works between 2001 and 2023 Measurement of resilience Resilience indexes	Articles in which the title, keywords, and abstract did not accurately depict community resilience to natural disasters Human-caused shocks and stresses Articles that are not empirical studies but are theoretical, methodological, or conceptual in nature

Summary of the Documents Studied

The current state of resilience measurement tools

In the context of risk assessment and disaster management, resilience measurement tools are becoming increasingly relevant. As climate change continues to have an impact on communities throughout the world, the need for effective resilience-building methods becomes increasingly pressing (Vogel,2016). Resilience measurement methods offer a systematic way to analyzing resilience levels, identifying gaps, and prioritizing actions to improve resilience (Bihari, 2012). The opinions of researchers on resilience measuring tools for risk assessment and disaster management vary. Some researchers see these tools as a useful way to assess and improve resilience, while others criticize them for oversimplifying complex systems and failing to consider social and cultural factors. The effectiveness of resilience measuring tools also depends on their design, accuracy, and the context in which they are used.

Some common resilience measurement tools

Various tools have been developed to assess and enhance the resilience of infrastructure, systems, and communities in the face of catastrophes and disruptive events. The Disaster Resilient Cities Scorecard (DRSC), designed by the Asian Development Bank (ADB) in 2021, focuses on evaluating how well cities can withstand natural disasters (ADB, 2021). In contrast, the Disaster Resilience Measurement Technique (DRMF), created by the United Nations Office for Disaster Risk Reduction (UNDRR) in 2013, incorporates physical and environmental factors into its assessment of disaster resilience (UNDRR, 2013).

Additionally, the United States Department of Housing and Urban Development (HUD) has instituted the National Disaster Resilience Competition (NDRC). While it offers a framework for evaluating and enhancing communities' resilience to natural disasters, specific authors and publication years related to NDRC's development were not identified in the available sources.

Another tool, the Emergency Preparedness and Response Assessment (EPRA), is attributed to the World Health Organization (WHO). EPRA serves as a metric for evaluating the readiness and capabilities of health systems to respond to crises and disasters. Like NDRC, specific authorship and publication details regarding EPRA's development were not provided in the sources.

These tools collectively offer an organized approach to resilience evaluation and planning, taking into account various physical, social, and economic factors. While there is consensus on the importance of resilience assessment, the sources do not offer explicit agreements or disagreements among authors regarding the effectiveness or limitations of these tools in addressing resilience challenges.

Limitations and scope of a futuristic resilience assessment tool:

Resilience measuring tools may be limited by the data available for analysis, as well as the accuracy and completeness of that data. There is no agreed upon matrix which can be universally adopted and accepted. There is no popular measuring tool for Indian (south Asian context) .These tools have mostly not taken into account the social, regional and cultural aspects of a community, which can play a significant role in resilience. Existing tools often overlook social, regional, and cultural aspects of communities, which can significantly affect resilience (Cutter, 2014). The lack of standardization in these tools makes it challenging to compare findings across studies or communities (Moher, 2009) because there is presently no accepted framework or approach for resilience evaluation. The development of consistent policies or solutions based on resilience assessments may also be difficult as a result. Conducting a resilience assessment may be a time-consuming procedure that calls for a lot of knowledge and money.

Despite these drawbacks, resilience assessment techniques may nevertheless assist direct the development of initiatives to improve resilience and offer insightful information about the strengths and weaknesses of a system or community. A to create a successful tool,

Systems Analysis is an important stage in developing a resilience assessment tool as it can help us to comprehend the complex and interrelated structure of the system under consideration. Resilience evaluation methods are intended to measure a system's ability to endure and recover from shocks and stresses, as well as adapt to changing conditions over time. To do so successfully, it is necessary to have a thorough grasp of the system's many components and how they interact with one another. A systems analysis entails disassembling the system under consideration and analyzing the linkages and feedback loops that exist between them. This can aid in identifying major resilience drivers, as well as possible weaknesses and opportunities for development.

The Need: Why must we conduct a systems analysis of resilience?

Objectives of system analysis of resilience

Systems Analysis of Resilience will be responsible for the following:

- To provide knowledge about environmental risk that people may encounter.
- To broaden awareness about the systemic strategy, necessary for people's general wellbeing.
- To understand the key components of the safety system, their resilience and how risk influences them.
- To set common understanding about authority dynamics, especially how the use or abuse of power impacts the ability of citizens to obtain the resources they need while dealing with shocks.

A consensus can be achieved regarding what must be done to strengthen system resilience and how to include the variables into guidelines, schemes, and development activities at all levels of civilization.

What added value does analysis of resilience systems have in relation to risk management?

- Resilience analysis adds to traditional risk mitigation methods instead of replacing them. It does this:
- Resilience analysis enriches instead of replacing current risk reduction techniques. It does include the following things:
- By bringing together components that increase the interdependence and complexity of various dangers. It addresses, for example, how confrontations enhance people's vulnerability to catastrophe and how disasters might really produce economic shocks.
- Studying how fluctuations in population, environmental degradation, monetary amortization, and climatic changes may influence the type and severity of shocks.
- Making further attempts to improve people's capacity to maintain their well-being despite the hazards they face by making the most of what currently exists rather than focusing on the risks themselves.
- Identifying how power dynamics might aid or hinder resilience. Including both large- and small-scale shocks, as well as recurrent, minor events such as sickness that have a significant influence on one's life.

Who ought to be involved

The conclusions of resilience analysis could be used as input into internal strategy design and multi-agency implementation plans, the latter of which will serve to pinpoint a resilience roadmap for a wide range of actors and stakeholders. Risk experts, subject matter experts, and decision-makers should all be included in both processes. This knowledge is essential for strategic planning and should come from several departments and teams. Members of the following internal groups should be represented on the strategy development team:

- Analysts for the programmed cycle and points of contact
- Development and charity staff who are in charge of planning strategies for each country's situation.
- Contact points for planned implementation and management
- Leads on policy and themes

Diverse Theoretical Perspectives on Community Disaster Resilience

The literature on community disaster resilience based on the fifteen selected documents reveals a diverse variety of theoretical perspectives, with a recent trend of theoretical analysis. Over half of the empirical research studies employ absorptive, adaptive, and transformative capacity as the fundamental theoretical framework, with social capital and other capitals like physical, human etc. also playing a key role. Capital theory (Cuter, 2014), in particular, has gained prominence due to its critical role in fostering community resilience. Perspectives on governance and power, community development, and cultural and institutionalization are all growing. However, it's worth noting that while social capital takes center stage, the importance of other factors such as culture, institutionalism, and social learning, psychology, and health views is somewhat less emphasized. The study focuses on exploring these diverse theoretical views on community resilience to disasters. The analysis, as depicted in Figure 2, underscores the pivotal role played by the concept of capital in comprehending disaster resilience. It underscores the significance of thoroughly studying capital theory before embarking on the design of any parameter matrix for assessing disaster resilience. Capital theory serves as a foundational framework for understanding and measuring the multifaceted aspects of resilience, making it an essential component in the development of effective disaster resilience assessment tools (Russo, 2021).

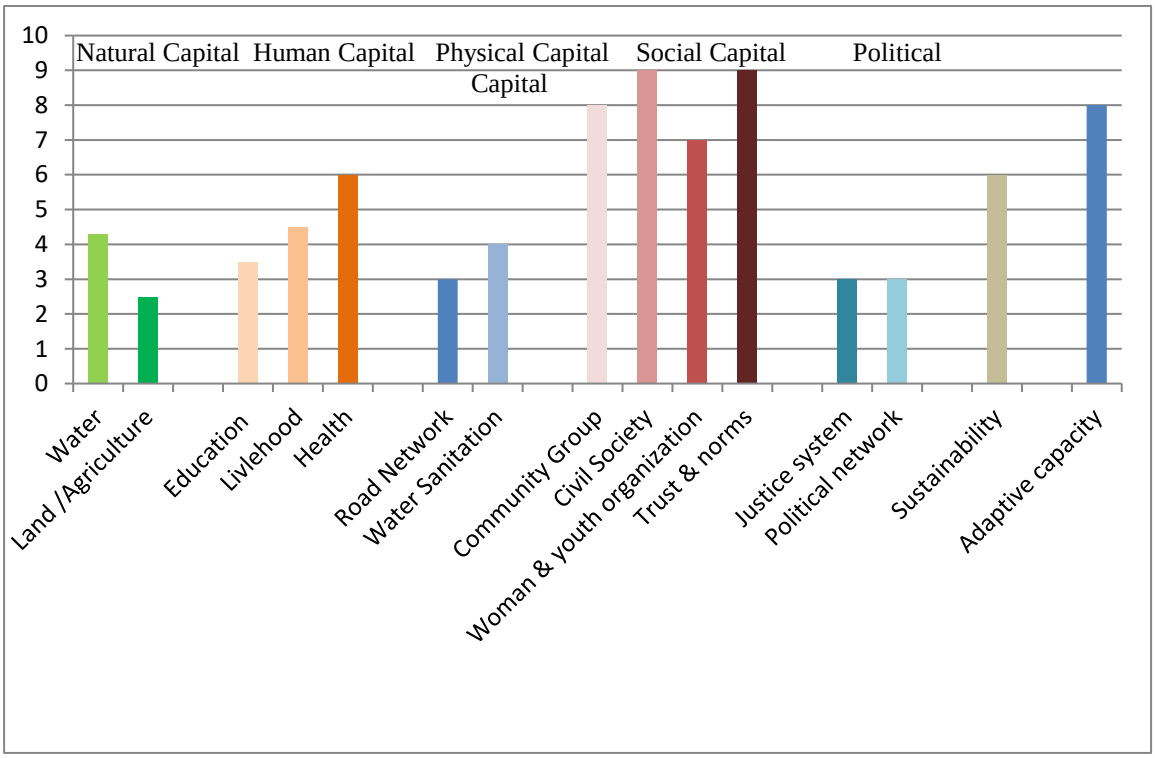

Fig. 2: Diverse Theoretical Perspectives and the Role of Capital Theory in Community Disaster Resilience, based on the document study
Source - Author

Important parameters in resilience assessment design

The capital theory

It is crucial to emphasize that resilience capital theory is an interdisciplinary idea to which many researchers have contributed. These writers and researchers have made major contributions to the area of resilience by emphasizing the significance of different types of capital in improving communities' and systems' ability to endure and recover from disturbances and shocks. Hawkins, 2014 is known for his work on resilience and adaptive cycles, which have contributed to the understanding of natural capital and social capital in resilience theory.

The capital system is significant in resilience measurement tools because it assists in identifying the major resources and assets required for creating and sustaining resilience. Capital may be defined as the pool of resources, assets, and capacities available to a community or system to adapt to and recover from shocks and stresses. KumariA, Frazier (2021), Jeong A Seo. (2013) have explored the concept of social-ecological systems resilience and the importance of social capital and adaptive capacity in building resilience.

Financial, political, natural, human, physical, and social capitals are the six types of properties that add to a thriving community, as outlined by this plan of action (Bene,2013). Depending on the specifics of the circumstance, each of these classes of capital will be made up of a distinct assortment of assets. The following graphic in Fig 3, depicts an illustration of some of the assets that can be used to make up the different forms of capital. The capital system may be used as a resilience measuring tool to determine systems or community's strengths and weaknesses in relation to each category of capital. This can assist to steer the development of resilience-building measures, such as investing in infrastructure, enhancing public health and education, encouraging social cohesion and collaboration, and accumulating financial reserves. Narayan, D., & Cassidy, M. F. (2001,) highlights the significance of capital theory in resilience in post-disaster recovery.

Overall, the capital system is important in resilience measuring tools because it assists in identifying the resources and assets required for building and maintaining resilience, as well as providing a framework for evaluating systems or community's strengths and weaknesses in these areas.

	Financial capital • Property & Land • Economic Migration • Employment • Markets	**Natural capital** • Water • Land/agriculture • Livestock • Oil & natural resources
	Human capital • Education • Health & nutrition • Livelihood skills • Technical skills • Mental health • Creativity • Problem solving skill	**Physical capital** • Road rail& air infrastructure • Water & sanitation infrastructure • Communication & internet • Public service infrastructure

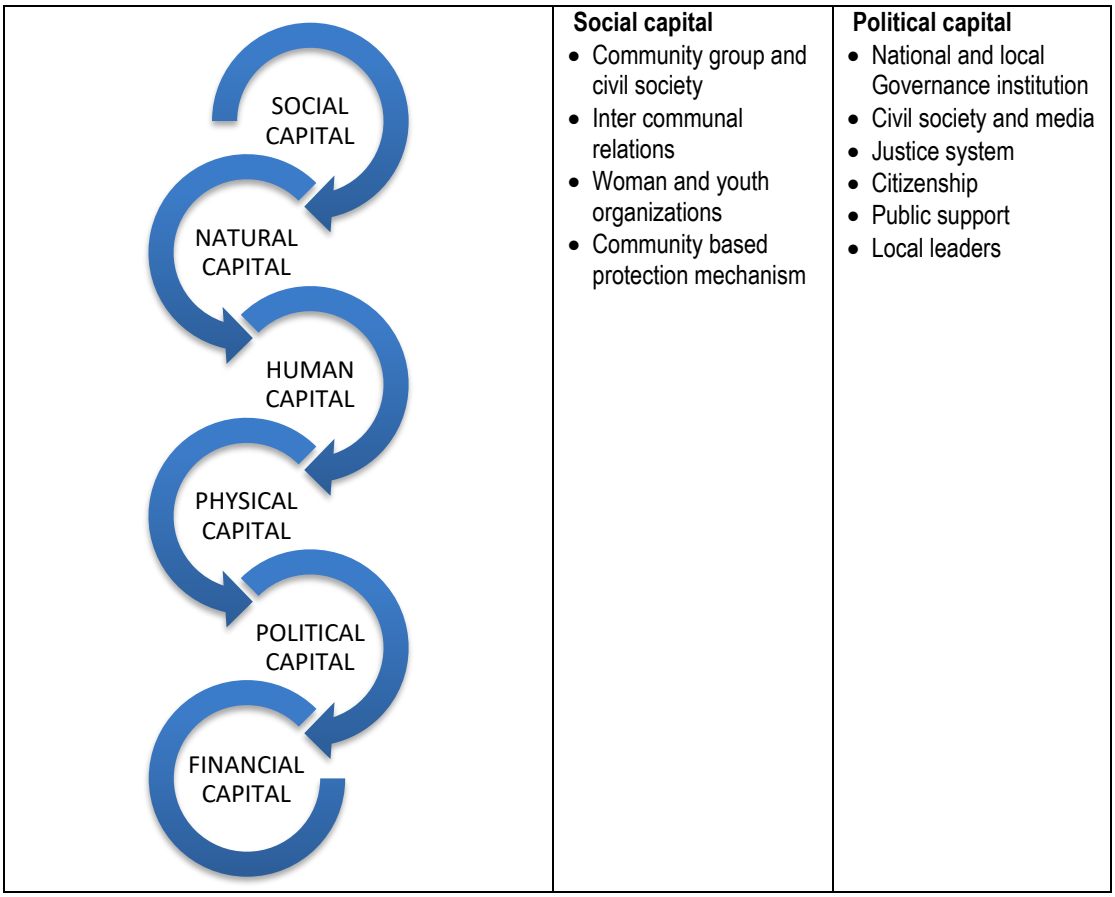

Fig. 3: The six major capital of resilience system
Source - OECD Guidelines for Resilience Systems and Author

Different Capacities for Resilience and its Importance

The capacity of individual, communities, and nations to absorb and recover from different types of shocks while also confidently acclimatizing and adjusting their structures and means for life in the time of continuing stressors, change, and uncertainty is what we mean when we talk about resilience (Mallick, 2011). There are several capacities that are crucial for resilience, and they might vary based on the environment and system under consideration. However, the three capacities that are frequently seen as crucial for resilience are the following. Resilience can be strengthened by supporting these three different types of capacities as shown in Fig 4:

Absorptive capacity: it is a system's capacity which helps foreknow or avoid unfavorable effects utilizing established coping tools in appropriate to maintain and bring back basic structures and functions (Bene,2013). This covers coping tactics engaged when one is shocked. Early storing of requirements, coming home early out of work are a few samples of absorptive ability.

Adaptive capacity: it is the capacity of to alter its behaviors in direction toward reducing probable forthcoming harm and take hold of opportunities so maintain functionality without experiencing substantial changes in job or identity. Diversifying sources of income, including the private sector in the provision of essential services, and developing drought-resistant seed are all examples of adaptive capability.

Transformative capacity: it is the capacity to plan profoundly a system, eliminating need for shock. When the current system becomes unsustainable due to ecological, economic, or societal factors, this may be necessary (Mitchell,2016). The adoption of conflict resolution techniques. Strict policies, planning schemes are a few examples of transformative capacity.

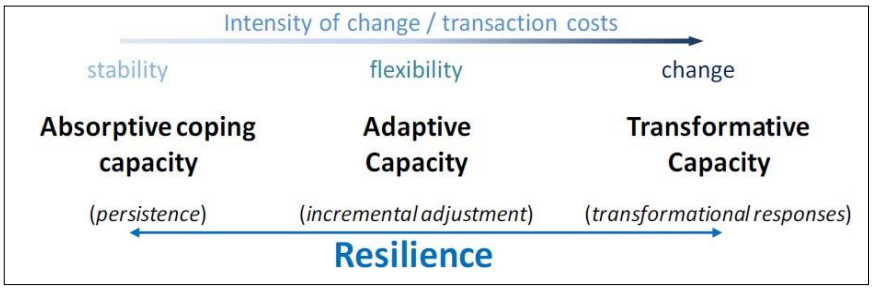

Fig. 4: Absorptive, Adaptive, and Transformational capacities in increasing resilience
Source: Bene, 2013

Each of these three capacities is vital for resilience in distinct ways. Adaptive capacity ensures that a system or society can stay flexible and responsive to changing situations. Absorptive capacity contributes to the capacity of the system or society to recover from stresses and return to normal functioning as rapidly as feasible. Transformative capacity ensures that a system or society can see the need for change and apply new methods and techniques to increase long-term resilience. Overall, the importance of these various resilience capacities highlights the need for a comprehensive approach to resilience-building that takes into account the various challenges and opportunities confronting a system or community, and that leverages the strengths and resources available to promote resilience.

A New Resilience Tool: A five-step Framework

The Resilience system guideline proposed by the author is inspired and referred from Resilience-Increasing Strategies for Coasts (RISC-KIT). The Resilience-Increasing Strategies for Coasts (RISC-KIT) is a research project sponsored by the European Union with the goal of creating tools and strategies for lowering risk and boosting the resilience of coastal regions to natural disasters such storms, floods, and sea level rise. To evaluate and improve the resilience of coastal communities and ecosystems, a 5-Step Resilience Module was created as part of this project.

The drawbacks of the present resilience measuring system and the leads from RICS-KIT has led to creation of a sustainable tool called as RESILIENCE SYSTEM ASSESSMENT TOOL (R-SAT) The R-SAT, 5-Step Resilience Module is a resilience measurement tool developed to test resilience to the effects of climate change and natural disasters limited to a particular type of disaster. The Resilience System Assessment Tool (R-SAT) draws inspiration from the Resilience-Increasing Strategies for Coasts (RISC-KIT), a European Union-sponsored project focused on enhancing coastal resilience (RISC-KIT, 2017). A significant outcome of this project was the creation of a 5-Step Resilience Module, which served as a valuable reference in our research taking reference from a collective endeavor involving contributions from numerous experts and researchers mentioned in the citation.

The guideline, which includes a 5-Step Resilience Module, is designed to complement existing risk management strategies and is intended to be a practical resource for stakeholders involved in resilience-building efforts as shown in Fig-5. The Resilience System Assessment Tool (R-SAT) is introduced to assess resilience in the context of specific disasters, such as climate change-related events or natural disasters. The guideline is structured to provide a systematic approach to resilience analysis and enhancement, benefiting from the knowledge and expertise of the broader research community. It aims to contribute to ongoing efforts to enhance disaster resilience by offering a structured and adaptable framework for analysis and action. The five main steps are as follows Emergencies) Data from the Nairobi study on bonding, bridging, and connecting capital (Gallaher, 2013) can act as a prototype to understand the index but further case studies are required to go in-depth studying all indicative and governing factors for creating a successful index quantification method.

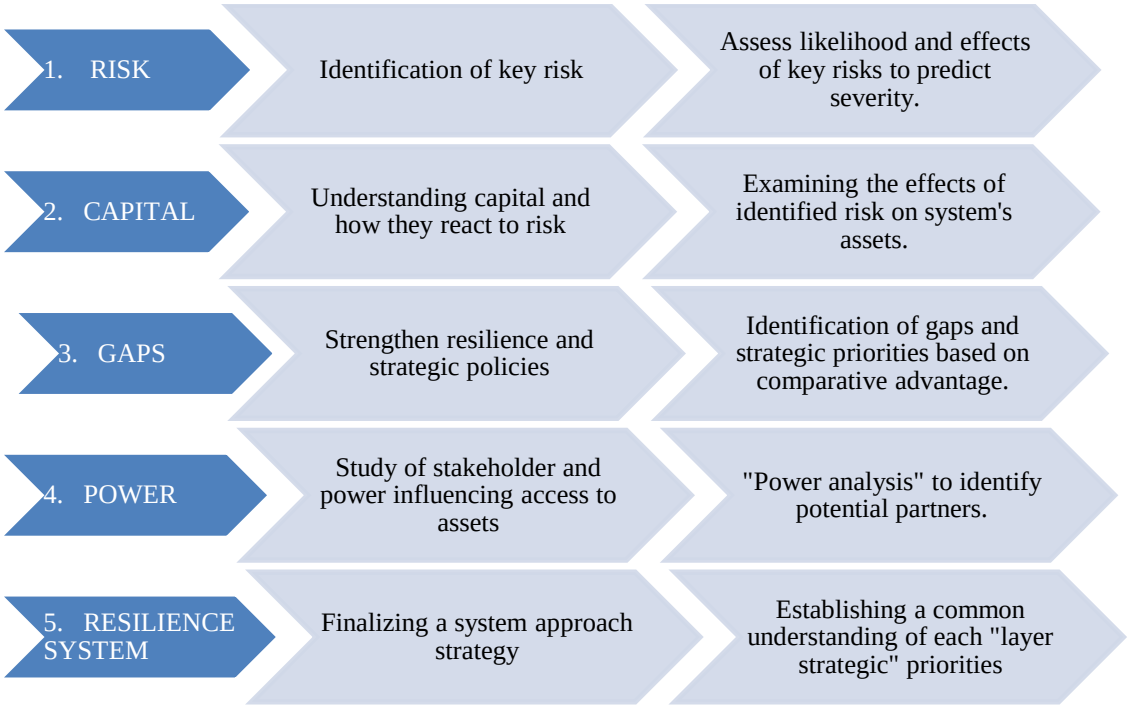

Fig. 5: Components of the 5-Step Resilience Module
This graphic visually depict the key components and steps within the 5-Step Resilience Module of R-SAT, providing a clear overview of the framework.
Source: Author

The five-step module system approach to create a resilience tool

- Module 1/step 1: Identifying key risks
- Module 1/step 2: Assessing likelihood and effects of the risks - the team should identify the key risks and assess their likelihood based on the prior analysis's five-step modular resilience system approach.
- Module 1/step 3: Evaluating the total seriousness of various threats - The likelihood that a risk may materialize is multiplied by the risk's overall consequence on system to predict its severity.
- Module 2/step 1: Recognizing the system's essential elements
  This step's goal is to identify the critical system elements that the resilience systems guidelines will be focusing on. Use of sustainable approach, examines the structure in face of effects on various forms of "capital".
- Module 2/step 2: examining the effects of identified risk on system's assets
  The group here decides how each risk identified in Module 1 will affect each system component listed in Module 2's initial step.
- Module 2/optional step 3: Planning capital asset resilience to display trends across time
- Module 3/step 1: Examining current initiatives
  The analysis has thus far been on establishing a shared knowledge of the risks that have been identified, the assets present in the community or system, and how these assets respond to the threats. The next lesson begins to discuss ways to increase resilience or how to address the relative strength or weakness of these assets.
- Module 3/step 2: Gap identification
  The team should start by finding current programming to either further improve an asset or fill in a deficit to acquire a better knowledge of potential gaps. That is already displaying resilience, or addressing an asset's weakness, where it has been demonstrated to respond badly to risk.

- Module 3/step 3: The determination of priorities based according to comparative advantage
  The strategy team's final step in this portion of the study entails identifying holes that their own organization may fill as well as pertinent elements of their ongoing strategy and programming.
- Module 4: Conducting a "power analysis" to determine who has access to what
  Module four's purpose is to assist the strategy team in developing a shared understanding of which stakeholders are important in the system and may support to strengthen assets in the face of some threats. This is a phase for the strategy team to be specific since it will help them identify possible partners to carry out the selected and authorized plan.
  The strategy team should create a list of every player who can have an influence on the system, taking into account participants at all system tiers. Although not compulsory, stakeholders, government, public, the commercial sector, civil society, international organizations, and unofficial players should all be considered.
- Module 5/step 1: establishing a common appreciative of each layer strategic priorities
  Module five builds on analysis from previous module in order to develop a shared knowledge of how the strategic priorities can be incorporated into a systems approach that reinforces means at different layers the system. The subsequent stage assists the team in comprehending how the priorities can be used to increase system's capabilities for transformation.
- Module 5/step 2: Mapping resilience's absorbing, adapting, and transformative powers.
  Similar to step 1, the analyst can finish the next step using the strategy team's prior work. Similar to the phase before, this section of the analysis aids in creating a shared understanding among participants and the strategies focus on enhancing absorptive, adaptive, or transformative skills.

How the resilience measuring tool created with system analysis

In comparison to existing resilience assessment tools, the R-SAT, 5 Step Resilience Module focuses on both physical and social components of resilience. It also provides a formal framework for assessing and planning resilience, allowing for a more complete and integrated approach to resilience development. Furthermore, the tool involves stakeholder and community involvement, which can lead to more successful and long-term resilience solutions. Unlike other tools which focus on handling various disasters but this tool will focus on single type of disaster like coastal disaster. This tool helps to establish common systemic understanding for cyclone disaster in all the coastal areas of India. Thus, this tool will be disaster & geography specific. Though the model may be applicable to various places, it is crucial to keep in mind that there might still be adjustments and unique factors that need to be taken into account for each region separately. The qualities of these states might vary depending on things like geography, climatic patterns, socioeconomic conditions, and cultural aspects. As a result, it would be wise to carry out a careful evaluation and adaption of the model to fit the particular circumstances and needs of each distinct coastal location. For making the resilience tool (R-SAT) universally accepted in other coastal states, the universal principles should be taken into considerations. Some of the Universal Principles and Factors for Disaster Resilience in Coastal Areas include Community Engagement, Adaptive Capacity, Infrastructure Quality, Access to Resources etc. By incorporating universal principles into the resilience model's design, a universal framework can be created that can be applied to various coastal regions, including Gujarat, Maharashtra, Goa, and others. Therefore, the tools can have minor tailored adaptations for specific regions. The most important aspect of the tool is involving local communities and stakeholders in the application of the resilience model. Local knowledge and insights are invaluable for tailoring the model to regional needs.

Discussion and the Analysis

The analysis must be converted into agency-specific forms, index formats, and tool-specific indication formats after completing the five modules. Drawing from the final tables, which are described in Module 5, makes this simple to accomplish. To focus the links and dependences between organization's efforts to build resilience at various layers of the society or system, it may be worthwhile for the strategy team to come to consensus on, if the analysis will be followed by a multi-stakeholder study. Hence with systemic approach a resilience tool kit can be created one best option can be to prepare a DISASTER RESILIENT MEASUREMENT TOOL with disaster-resilient indices comprising INDEX PARAMETERS of capital theory as discussed above. Capital theory can be best opted as capitals are a convenient way to measure the qualitative and quantitative nature of disaster resilience. However, other theories can also be tested to see the feasibility. The guideline so prepared can be used to provide a general framework for resilience based on different factors like social capital. They can be referred to and implemented during a disaster outbreak for smooth disaster management.

Disaster Resilient Measurement Tool

Coming to measuring the resilience, an index to calculate is require to study the context and apply to similar contexts. A tentative abstract index chart can be created. The framework can comprise the head Capital theory like social capital ,human capital ,political capital ,financial capital ,physical capital ,natural capital followed with the indicators and sub 0indicators ,derived from the study. Further to make the model measurable, a quantitative quotient can be added to it.

One of the most accepted and convenient models in measuring resilience can be a parameter model guide where each indicator can be grouped and graded out of a number. This study constructs its five indices by acquiring several variables that describe different aspects of the concept, scaling them from 0 to 5, where 0 indicates weakest social capital or vulnerability and 5 indicates strongest, and combining these each into an index. This study mirrors (Bihari, 2012; Ryan, 2012) approach for its social capital indices and (Cutter, 2014) approach for its social vulnerability index. (Solomon, 2023)

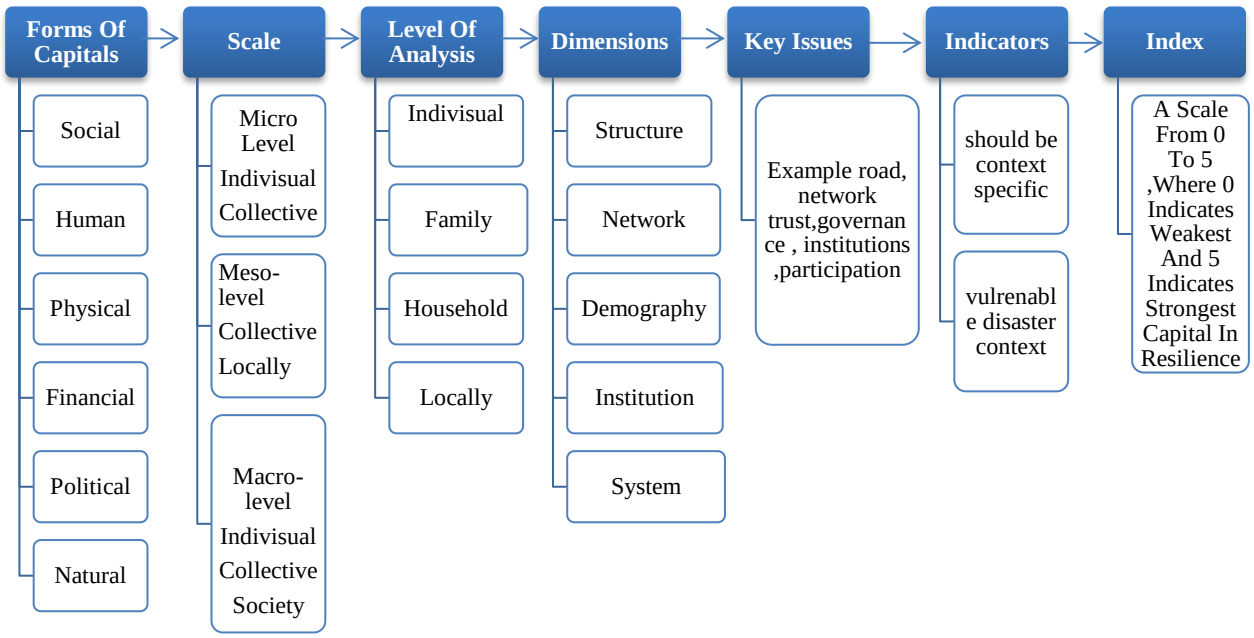

Fig. 6: Proposed Disaster Resilient Measurement Tool–Resilience System Assessment Tool (R-SAT)
Source: Author

Each capital has to be studied in detail to understand its indicator and concept goal. One such capital is studied in detail to further simplify the model. Out of all capitals social capital forms as the simplest as well as very initial capital adaptation during any disaster. Therefore, social capital in detail is studied to derive a demo model of disaster resilience.

The social capital indicator model demonstrates the multilevel and multidimensional conceptualization of the nature of social capital. According to (Grootaert,2002) social capital goes from cognitive to structural, and from micro to macro, while reflecting multiple aspects as claimed by (Narayan, 2001). It also extends from the individual to the collective to the social level, illustrating the concept's multilayered structure (Woolcock, 2021) Such an approach will help in understanding how bonds, bridges, and linkages are utilized for improved availability and versatility to address vulnerabilities in a particular setting.

Early findings indicate that, when suitably tailored to context, quantitative indicators can give insights into components of the framework. The indicators of IDSUE (Indicator Development for Surveillance of Urban

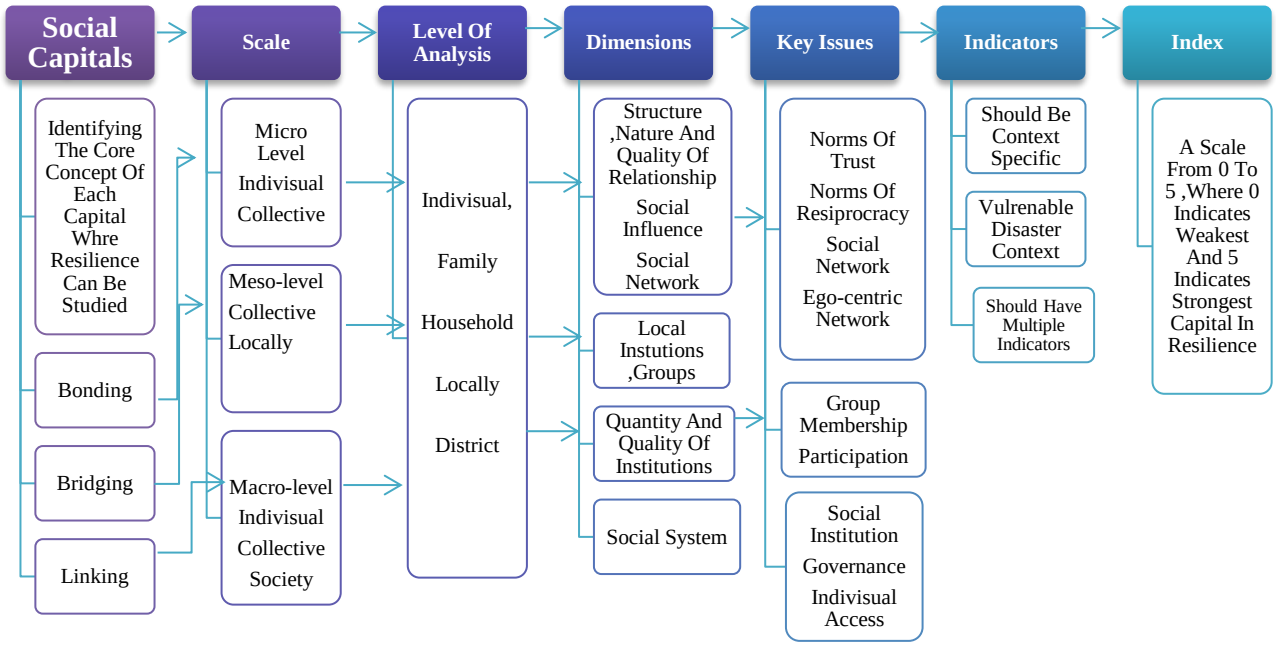

Fig. 7: R-SAT: A Semi-Quantitative Framework for Measuring and Disaster Resilience based on social capital index
Source: Author

Research Findings

In this research, several common resilience measurement tools have been discussed, (Prashar 2012) developed the Climate Disaster Resilience Index (CDRI), while UNDP introduced the Community Based Resilience Analysis (CoBRA) toolkit (UNDP, 2012). Other tools including the Disaster Resilient Cities Scorecard, the Disaster Resilience Measurement technique (DRMF), the National Disaster Resilience Competition (NDRC), and the Emergency Preparedness and Response Assessment (EPRA). These tools are designed to assess and improve the resilience of infrastructure, systems, and communities to various disasters and disruptive events, taking into account physical, environmental, and social factors.

However, it's important to note some limitations and the need for a more context-specific and comprehensive resilience assessment tool. These existing tools often lack consideration for social, regional, and cultural aspects of a community, which can significantly impact resilience. Moreover, the lack of standardization makes it challenging to compare findings across studies or communities. Despite these limitations, resilience assessment

techniques can still provide valuable insights into a system or community's strengths and weaknesses.

The research proposes the development of a new tool called the Resilience System Assessment Tool (R-SAT), which takes a systems analysis approach, to resilience assessment. This tool aims to address the limitations of existing tools by focusing on both physical and social components of resilience. It also emphasizes stakeholder and community involvement for more effective and long-term resilience solutions. Additionally, the research discusses the importance of different capacities for resilience, including absorptive, adaptive, and transformative capacities. These capacities are crucial for building and maintaining resilience in the face of various shocks and stresses.

Conclusions

Understanding the concept of resilience is essential for appreciating the significance for social interaction of the effective localization of response in fragile environments (UNICEF). Yet, it is necessary to comprehend what defines such traits and how they can be measured based on context-specific like geography, disaster type etc. indications. This paper tried to develop the concept, resulting in a multilevel and multidimensional framework that should be tailored to susceptible circumstances during disaster management.

Ultimately, this research underscores the need for a comprehensive and context-specific resilience assessment tool for effective disaster management. Such a tool should consider various factors, including social, human, political, financial, physical, and natural capital. It should also incorporate a quantitative index to measure resilience, tailored to the specific vulnerabilities of an area.

In summary, this paper contributes to the understanding of resilience measurement tools and advocates for a systems-based approach to assess and enhance resilience in the context of disasters and disruptive events. It emphasizes the importance of a holistic and adaptable framework for building resilient communities and enhancing disaster preparedness and response.

An assessment model so designed for an area can be followed in similar areas. Therefore, a strong guideline needs to prepare and implemented as an integral part of the disaster master plan.

Appendix. List of selected articles (n = 15)

sl.no.	Year of Publication	References of the selected articles	Dimension that is selected. Framework /toolkit/ theory
1	2001	Narayan, D., & Cassidy, M. F.	Social Capital theory
2	2012	Bihari, M., & Ryan, R.	Social Capital theory & community resilience
3	2014	Cutter, S. L., Ash, K. D., &Emrich, C. T.	Disaster resilience theory
4	2012	Prashar	Climate Disaster Resilience Index (CDRI)
5	2012	UNDP	Community Based Resilience Analysis (CoBRA) - toolkit
6	2017	Norris	Community Resilience Index (CRI2) - index
7	2021	Russo, B., & Martínez-Gomariz, E.	Community Resilience Index (CRI) - index
8		Arbon	Community Disaster Resilience Scorecard and Toolkit (CDRST)-toolkit
9	2022	Jin, H. R., Kim, D. W., & Beak, J. M.	Scorecard and Toolkit
10	2022	Saja, A. A., Teo, M., Goonetilleke, A., & Ziyath, A. M.	Scorecard and Toolkit

11	2009	Creswell, J.W.,	Resilience theory
12	2010	Cutter, S.L., Burton, C.G., Emrich, C.T.,.	Social, economic, institutional, infrastructure, environmental, community capital/ resources
13	2021	Kumari, A., & Frazier, T. G.	Evaluating capital Theory
14	2007	Murphy, B. L.	Resilience Theory
15	2017	Villagra, P., & Quintana, C.	Community Resilience theory

References

Arbon, P., Steenkamp, M., Cornell, V., Cusack, L. & Gebbie, K. M. (2016) Measuring disaster resilience in communities and households. International Journal of Disaster Resilience in the Built Environment; Emerald Publishing Limited. https://doi.org/10.1108/ijdrbe-03-2015-0008

Barrett, C. B., Upton, J., Tennant, E. & Florella, K. (2021) A Comparative Assessment of Resilience Measurement Approaches. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.3992734

Béné, C. (2013) Towards a Quantifiable Measure of Resilience. IDS Working Papers, 2013 (434), 1–27. https://doi.org/10.1111/j.2040-0209.2013.00434.x

Bihari, M. & Ryan, R. (2012). Influence of social capital on community preparedness for wildfires. Landscape and Urban Planning, 106(3), 253–261. https://doi.org/10.1016/j.landurbplan.2012.03.011

Cutter, S. L., Ash, K. D. & Emrich, C. T. (2014) The geographies of community disaster resilience. Global Environmental Change, 29, 65–77. https://doi.org/10.1016/j.gloenvcha.2014.08.005

Cutter, S. L., Burton, C. G. & Emrich, C. T. (2010) Disaster Resilience Indicators for Benchmarking Baseline Conditions. Journal of Homeland Security and Emergency Management, 7(1). https://doi.org/10.2202/1547-7355.1732

Gallaher, C. M., Kerr, J. M., Njenga, M., Karanja, N. K. & WinklerPrins, A. M. G. A. (2013) Urban agriculture, social capital, and food security in the Kibera slums of Nairobi, Kenya. Agriculture and Human Values, 30(3), 389–404. https://doi.org/10.1007/s10460-013-9425-y

Gallaher, C. M., Kerr, J. M., Njenga, M., Karanja, N. K. & WinklerPrins, A. M. G. A. (2013) Urban agriculture, social capital, and food security in the Kibera slums of Nairobi, Kenya. Agriculture and Human Values, 30(3), 389–404. https://doi.org/10.1007/s10460-013-9425-y

Grootaert, C. (2002) Social Capital, Household Welfare and Poverty in Burkina Faso. Journal of African Economics, 11(1), 4–38. https://doi.org/10.1093/jae/11.1.4

Hawkins, R. L., & Maurer, K. (2011). Unravelling Social Capital: Disentangling a Concept for Social Work. British Journal of Social Work, 42(2), 353–370. https://doi.org/10.1093/bjsw/bcr056

https://www.un.org/en/development/desa/policy/untaskteam_undf/thinkpieces/3_disaster_risk_resilience.pdf. (n.d.).

Islam, M. R. (2023) Disaster, Displacement and Resilient Livelihoods. Emerald Group Publishing.

Jeong A Seo. (2013) The Effects of Family Social Capital and Community Social Capital on Youth's School Adaptation. Korean Journal of Social Welfare Studies, 44(1), 135–164. https://doi.org/10.16999/kasws.2013.44.1.135

Jin, H. R., Kim, D. W. & Beak, J. M. (2022) Analysis of Disaster Characteristics and Measurement of Disaster Resilience in Korea. Crisis and Emergency Management: Theory and Praxis, 12(7), 21–30. https://doi.org/10.14251/jscm.2022.7.21

Kim, H. & Marcouiller, D. W. (2015) Natural Disaster Response, Community Resilience, and Economic Capacity: A Case Study of Coastal Florida. Society & Natural Resources, 29(8), 981–997. https://doi.org/10.1080/08941920.2015.1080336

Kumari, A. & Frazier, T. G. (2021) Evaluating social capital in emergency and disaster management and hazards plans. Natural Hazards, 109(1), 949–973. https://doi.org/10.1007/s11069-021-04863-x

Mallick, B., Rahaman, K. R. & Vogt, J. (2011) Coastal livelihood and physical infrastructure in Bangladesh after cyclone Aila. Mitigation and Adaptation Strategies for Global Change, 16(6), 629–648. https://doi.org/10.1007/s11027-011-9285-y

Mallick, B., Rahaman, K. R. & Vogt, J. (2011) Coastal livelihood and physical infrastructure in Bangladesh after cyclone Aila. Mitigation and Adaptation Strategies for Global Change, 16(6), 629–648. https://doi.org/10.1007/s11027-011-9285-y

McCrea, R., Walton, A. & Leonard, R. (2014) A Conceptual Framework for investigating community well-being and resilience. Rural Society, 5250–5268. https://doi.org/10.5172/rsj.2014.5250

Moher, D. (2009) Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. Annals of Internal Medicine, 151(4), 264. https://doi.org/10.7326/0003-4819-151-4-200908180-00135

Murphy, B. L. (2007) Locating social capital in resilient community-level emergency management. Natural Hazards, 41(2), 297–315. https://doi.org/10.1007/s11069-006-9037-6

Narayan, D. & Cassidy, M. F. (2001) A Dimensional Approach to Measuring Social Capital: Development and Validation of a Social Capital Inventory. Current Sociology, 49(2), 59–102. https://doi.org/10.1177/0011392101049002006

Norris, F. H., Stevens, S. P., Pfefferbaum, B., Wyche, K. F. & Pfefferbaum, R. L. (2007) Community Resilience as a Metaphor, Theory, Set of Capacities, and Strategy for Disaster Readiness. American Journal of Community Psychology, 41(1–2), 127–150. https://doi.org/10.1007/s10464-007-9156-6

Ostadtaghizadeh, A., Ardalan, A., Paton, D., Jabbari, H. & Khankeh, H. R. (2015) Community Disaster Resilience: A Systematic Review on Assessment Models and Tools. PLoS Currents. https://doi.org/10.1371/currents.dis.f224ef8efbdfcf1d508dd0de4d8210ed

Prashar, S., Shaw, R. & Takeuchi, Y. (2012) Community action planning in East Delhi: a participatory approach to build urban disaster resilience. Mitigation and Adaptation Strategies for Global Change, 18(4), 429–448. https://doi.org/10.1007/s11027-012-9368-4

Prashar, S., Shaw, R. & Takeuchi, Y. (2012) Assessing the resilience of Delhi to climate-related disasters: a comprehensive approach. Natural Hazards, 64(2), 1609–1624. https://doi.org/10.1007/s11069-012-0320-4

Russo, B. & Martínez-Gomariz, E. (2021) Integrated Assessment of Climate Change Impacts and Urban Resilience. MDPI.

Saja, A. A., Teo, M., Goonetilleke, A. & Ziyath, A. M. (2021) Assessing social resilience in disaster management. International Journal of Disaster Risk Reduction, 52, 101957. https://doi.org/10.1016/j.ijdrr.2020.101957

Smith, J. W., Anderson, D. H. & Moore, R. L. (2012) Social Capital, Place Meanings, and Perceived Resilience to Climate Change*. Rural Sociology, 77(3), 380–407. https://doi.org/10.1111/j.1549-0831.2012.00082.x

Soleimani, A., Fahim Nia, F., Naghshineh, N. & Soleimani Nejad, A. (2021) Providing a framework for the reuse of research data based on the development dynamic framework of United Nations Development Program (UNDP). Library Hi Tech, 41(2), 642–665. https://doi.org/10.1108/lht-01-2021-0007

Solomon, P. (2023) Can cooperatives be a tool for poverty reduction? Social capital perspectives of fisher's cooperatives in India. Marine Policy, 147, 105373. https://doi.org/10.1016/j.marpol.2022.105373

Talley, A. E., Gilbert, P. A., Mitchell, J., Goldbach, J., Marshall, B. D. L. & Kaysen, D. (2016) Addressing gaps on risk and resilience factors for alcohol use outcomes in sexual and gender minority populations. Drug and Alcohol Review, 35(4), 484–493. https://doi.org/10.1111/dar.12387

Twycross, A. (2004) Research design: qualitative, quantitative and mixed methods approaches & Research design: qualitative, quantitative and mixed methods & approaches, Creswell John W Sage 320 £29 0761924426 0761924426. Nurse Researcher, 12(1), 82–83. https://doi.org/10.7748/nr.12.1.82.s2

UNICEF on disaster management. (n.d.). Https://Www.Unicef.Org/India/What-We-Do/Disaster-Risk-Reduction#:~:Text=UNICEF's%20risk%20reduction%20strategies%20focus, Supply%20chain%20management%20for%20relief.

Villagra, P. & Quintana, C. (2017) Disaster Governance for Community Resilience in Coastal Towns : Chilean Case Studies. International Journal of Environmental Research and Public Health, 14(9), 1063. https://doi.org/10.3390/ijerph14091063

Vogel, G. (2016) Don't blame sports for Zika's spread. Science. https://doi.org/10.1126/science.aaf9828

Woolcock, M. (2021) The social life of academic articles: some reflections on the making and impact of "Social capital and economic development." Theory and Society, 50(3), 381–392. https://doi.org/10.1007/s11186-021-09431-7