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CRITICAL ASSESSMENT OF THE EXISTING DISASTER RESILIENCE FRAMEWORKS AND THEIR APPLICABILITY TO IMPROVE COMMUNITY RESILIENCE

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ABSTRACT

Disasters are inevitable and unique; however, their impact on livelihood can be minimised. Improving disaster resilience is used as one of the key approaches to minimise the impact of disasters. Several disaster resilience models were presented during the last 20 years. However, these disaster resilience models have a vast diversity and research has not been conducted to assess the connectivity of the available models and frameworks. Therefore, this study critically reviews the disaster resilience models and frameworks to identify their positive and negative aspects that support the development of community resilience. The research is following a narrative literature review methodology while using selected journal and conference papers from the last 20 years. The models and frameworks were critically reviewed using the characteristics and availability of different concepts concerning disaster resilience context. the study summarises 10 disaster resilience models and frameworks utilised in different contexts. The outcome illustrates that DROP and Regional Resilience of Process and Outcome frameworks are comprehensive based on the availability of concepts. Moreover, the Regional Resilience of Process and Outcome framework signifies the suitability of the particular framework for disaster resilience based on concepts and characteristics. This study enhances the existing level of knowledge on disaster resilience and its understanding based on diversified discussion.

Keywords: *Community; Disaster; Frameworks; Models; Resilience.*

1. INTRODUCTION

Disasters are complex global issues which are inevitable in the community (Makwana, 2019). Raju et al. (2022) have commented that hazards turn into disasters when society is not equipped to handle the severity of the hazard and is unable to absorb their intensity. In 2021, 367 major disasters occurred affecting 127 countries around the world. According to statistics presented in 2021, floods were indicating the highest frequency

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among other types of disasters. Similarly, its impact in terms of deaths and impact on the population was recorded at 41.87% and 28.03% respectively (United Nations Disaster Risk Reduction [UNDRR], 2022). In 2021, 432 catastrophic events were recorded, which is higher than the average of 357 events that occurred in the last 20 years (Center for Research on Epidemiology of Disasters [CRED], 2022). Kahn (2021) emphasized 2021 was called the era of Anthropocene due to the increased number of disasters.

Disaster resilience is a vital concern in the modern world to minimise the impact of disasters on livelihood (Walker, 2020). In the global context, Takeda, Jones, and Helms (2017) have elaborated on the importance of the community to develop disaster resilience practices. Furthermore, several studies have demonstrated that disaster resilience is an important aspect to uplift the livelihood of the community, irrespective of the different disciplines (Asadzadeh et al., 2017). Moreover, several studies conducted to enhance disaster resilience or recovery with the development of models addressing diversified disciplines (Bruneau et al., 2003; Cutter et al., 2008; Palekiene et al., 2015; Renschler et al., 2010). Tariq et al. (2021) researched community disaster resilience frameworks identifying their characteristics from a stakeholder perspective. However, the available models/ frameworks and previous studies do not provide a common outline for the development of a disaster resilience model. Therefore, this paper aims to critically assess the available disaster resilience frameworks and models and identify their positive and negative aspects that support the development of community resilience.

2. LITERATURE REVIEW

2.1 MODEL OF RESILIENCE

The model of resilience shows the impact of disruptive events and the process of obtaining a new level of functionality. Lester and Smith (2018) presented that resilience taxonomy identifies four principles namely, capacity flexibility, tolerance and cohesion. The presence of extreme events, artificial or natural creates a shock. When the shock exceeds the design capabilities, it creates failure. Figure 1 shows the disaster readiness of the built environment.

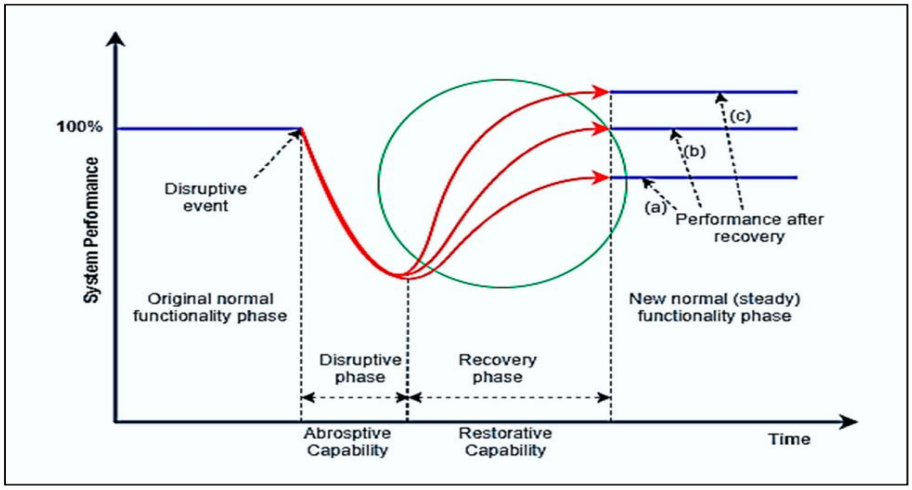

Figure 1: Model of resilience

Source: (Lester & Smith, 2018)

Curve C shows the higher readiness of the community which exhibits exponential recovery while curve A shows the sinusoidal recovery with lower community recovery. Finally, curve B demonstrates the linear recovery with the average level of readiness of the community. Figure 1 shows the model of resilience presenting the four phases of the disaster and the mechanism followed by the community to recover. Nevertheless, the main emphasis has been given to the disruptive and recovery phases, which allows the users of the model to decide the expected resilience at the end of the cycle.

2.2 PANARCHY FRAMEWORK

This framework is a hierarchical structure which connects natural and human systems and involves growth, accumulation, restructuring, and renewal (Cutter, et al., 2008). The particular framework occupies discrete niches in space and time. Moreover, the combination of resilience and sustainability is developed using the adoptive cycles in the use of the human environment mental system. According to Allen et al. (2014), the panarchy framework is used in ecological and social sciences. The panarchy implications are linked with resilience and assess the resilience of complex systems. Accordingly, the panarchy framework allows simplifying complicated systems. From a broader perspective panarchy framework demonstrates the relationship between social and ecological systems with the understanding of enhancing resilience (Brunckhorst, 2002).

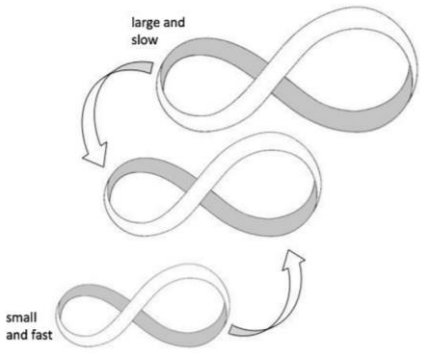

Figure 2: Panarchy consisting of a nested set of adaptive cycles

Source: (Berkes & Ross, 2013)

Figure 2 shows the adaptive cycle with a wider range of systems to accommodate the nested systems. Gunderson and Holling (2002) used the name panarchy concerning the Greek god of nature instead of hierarchy since this Figure 2 is not showing rigid top-down implications.

2.3 DISASTER RESILIENCE OF PLACE MODEL

The DROP model is another reliable technique that supports the development of disaster resilience and comparative assessment along with the support of local and community practices (Béné, 2020; Cutter et al., 2008). Figure 3 demonstrates the DROP model that supports applying resilience for real places based on the applications (Cutter et al., 2008). The DROP model is presenting the relationship between mitigation, preparedness, event, and adaptive resilience. Moreover, the model is consisting of the illustration of the risk formula and the actions that need to be taken when the absorptive capacity of the resilience is exceeded.

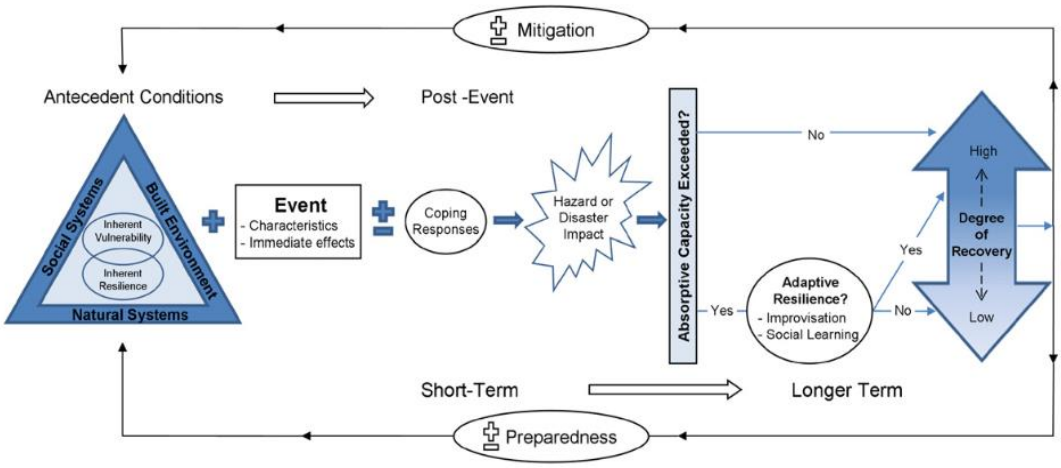

Figure 3: DROP model

Source: (Cutter et al., 2008)

Figure 3 presents the DROP model, which is showing the connectivity of risk and resilience.

2.4 CONCEPTUAL MODEL OF RECOVERY

Miles and Chang (2006) developed the comprehensive Conceptual Model of Recovery is developing the relationship between households, neighbours, businesses, and infrastructure systems. The particular model is focused on the investigation of community recovery and operational levels including household income, businesses, building construction and building retrofit.

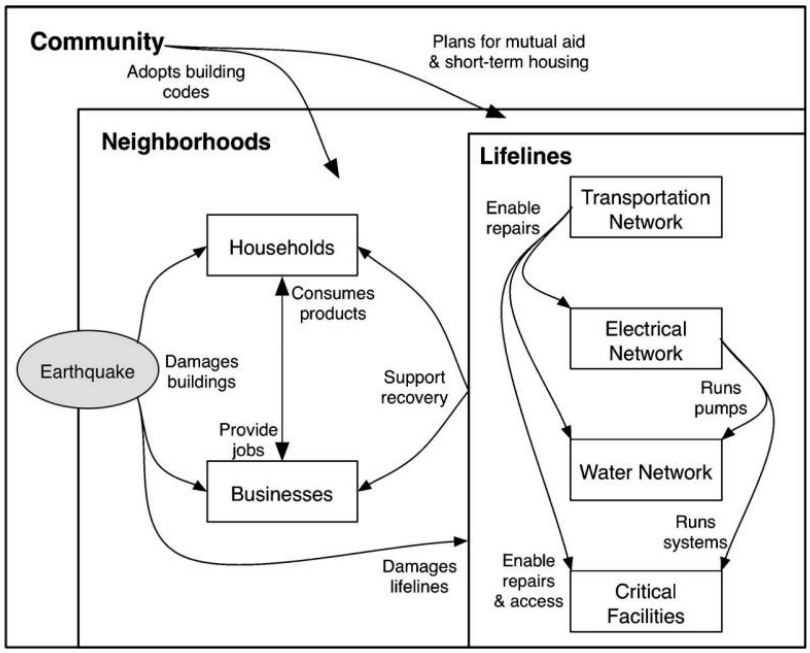

Figure 4: Conceptual Model of Recovery

Source: (Miles & Chang, 2006)

2.5 GENERAL FRAMEWORK

The General Framework was introduced by Bruneau et al. (2003) to quantify seismic hazard identifying the resilience of the community based on 'reduced failure probabilities' reduced consequences from failures' and 'reduced time to recovery'. Bruneau et al. (2003) further elaborated that the framework applies to individual systems and a combination of systems. Figure 5 demonstrates the applicability of different systems for the resilient community system. Accordingly, the framework shows the feedforward and feedback loops. Furthermore, it is demonstrated as an open loop and closed loop system. Since the General Framework has been defined for the seismic retrofit it shows the specification for the earthquakes. Figure 5 is showing that the General Framework systems diagram is consisting of 3 layers. The bottom layer is illustrating the situation where it has no intervention for the existing systems. The middle layer is showing the first level of actions and decisions taken based on simple triggers. The top level of the diagrams demonstrates the multi-attribute information which is gathered and used for decision-making. The decision system is consisting of advanced technical-organisational-socioeconomic information.

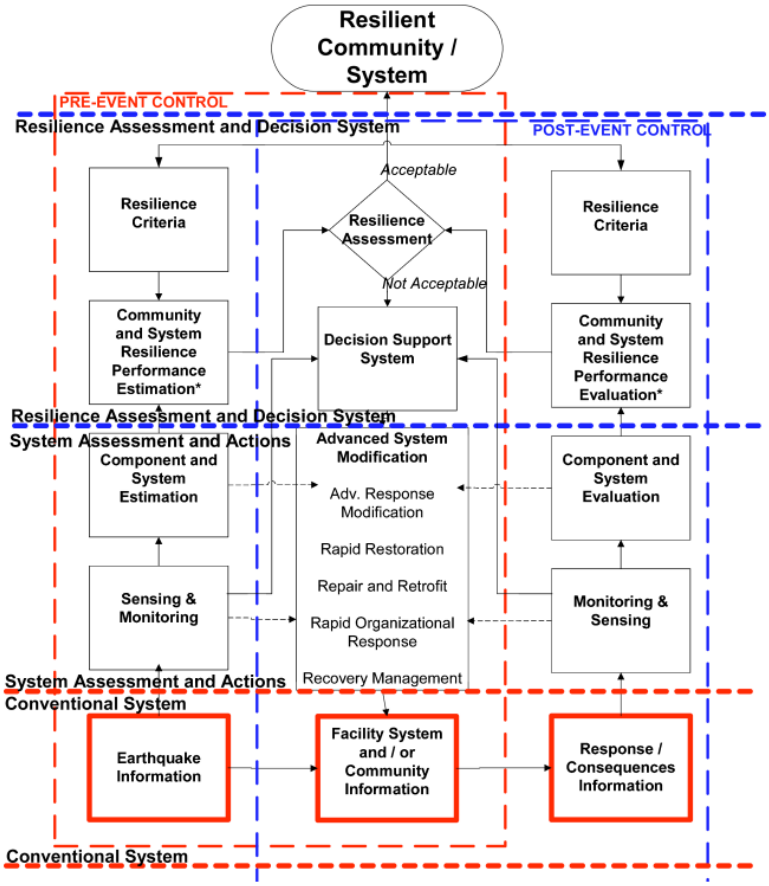

Figure 5: General framework systems diagram

Source: (Bruneau et al., 2003)

2.6 PEOPLES RESILIENCE FRAMEWORK

Renschler et al. (2010) introduced a resilience framework consisting of seven dimensions to assess community resilience namely, population and demographics, environment or

ecosystem, organized governmental services, physical infrastructure, lifestyle and community competence, economic development, and social-cultural capital, which was highlighted as PEOPLES Resilience Framework.

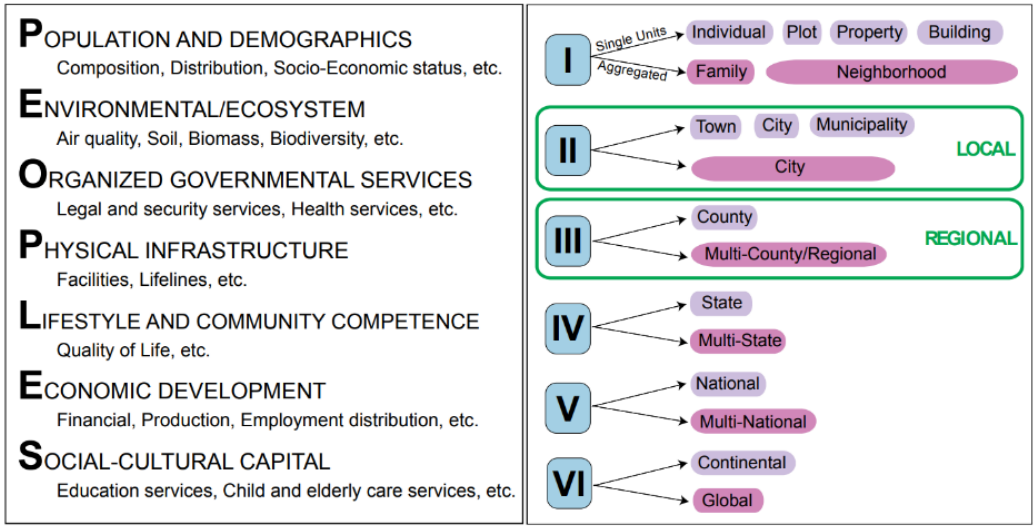

Figure 6: Association of the geographic scales among the PEOPLES Resilience Framework

Source: (Renschler et al., 2010)

2.7 THE REGIONAL RESILIENCE PROCESS AND OUTCOME FRAMEWORK

The Regional Resilience Process and Outcome Framework explained by (Palekiene et al., 2015) is evaluating the resilience notion based on the different regional development contexts and regional resilience capacity-building factors.

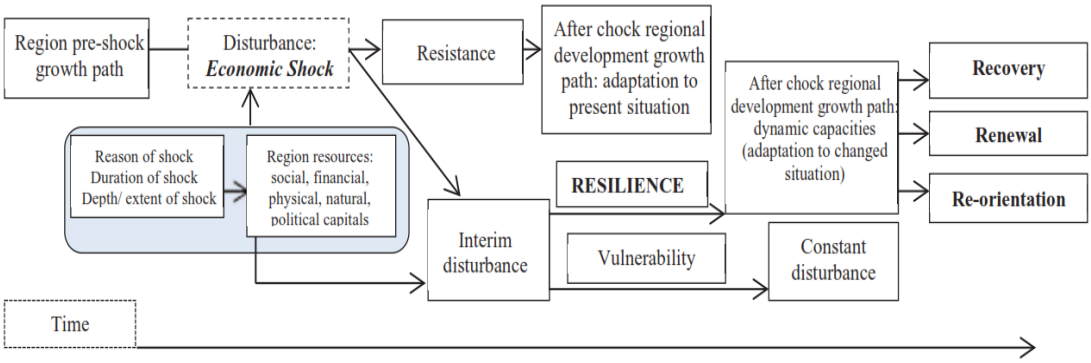

Figure 7: Regional resilience process and outcome framework

Source: (Palekiene et al., 2015)

Resilience is having different perspectives. Tierney and Bruneau (2007) developed resilience as an outcome. Another review has illustrated resilience as a process. However, Cutter et al. (2008) represented resilience as a combination of process and outcome. Similarly, regional resilience is addressed as a combination of process and outcome (Palekiene et al., 2015). This framework shows the significance of the interim disturbances on resilience and the four types of economic resilience's response to shock. Furthermore, the amount of time taken for the resilience and economic declines in the region is demonstrated with the particular model.

2.8 FLOODING DISASTER RESILIENCE INFORMATION FRAMEWORK

Then, Kumar et al. (2019) introduced Flooding Disaster Resilience Information Framework, which collects data from flooding situations and provides a personalised response to the human actuators. The model ensures the minimisation of injuries and infrastructural damage with early warning and a personalised response process.

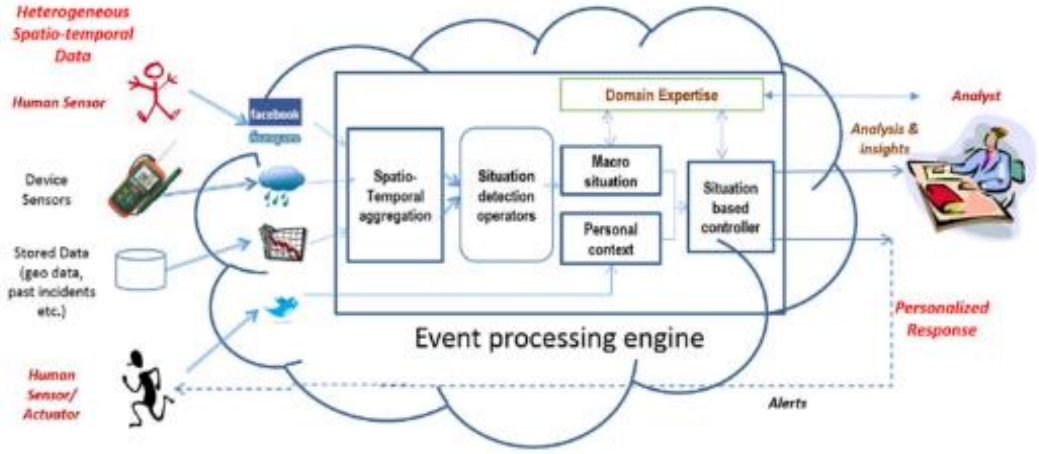

Figure 8: Flooding Resilience Information Framework

Source: (Kumar et al., 2019)

The framework is consisting of the inputs generated via human sensors, stored data and an actuator. Then the output is generated via a human actuator. However, the working condition for the particular model is consisting of several challenges such as data uncertainty, modelling with domain experts, and collaboration of data into a physical prediction model. Despite the challenges the Flooding Disaster Resilience Information Framework has been validated for Hurricane Irma that occurred in the United States of America (USA).

2.9 HOSPITAL DISASTER RESILIENCE MODEL

Fallah-Aliabadi et al. (2020) developed the Hospital Disaster Resilience (HDR) model showing the method of engaging with hazards occurring in hospitals. Hence, it indicates that resilience and disaster concepts are not limited to a particular discipline.

The review of resilience and its subsequent implications are vital to demonstrate the theory of complexity (Turner & Baker, 2019). Arias-Pineda and Ramirez-Martinez (2019) elaborated that the theory of complexity is applied to manage complex organizations to establish preliminary warning systems and obtain lessons from previous incidents. Hence, disaster resilience and related frameworks are demonstrating the application and suitability of disaster resilience concepts in different disciplines to minimise the impact of disasters.

2.10 THE DISASTER RESILIENCE INTEGRATED FRAMEWORK FOR TRANSFORMATION

The Disaster Resilience Integrated Framework for Transformation (DRIFT) conceptualises and operationalises the relationship between resilience and capacity (Manyena et al., 2019). Figure 9 shows the key features of the DRIFT model with a

critical review. The model is connected with risk drivers while understanding the capacities of the system to absorb disasters. This model presents the bounce forward terminology in addition to bounce back. It highlights improved disaster resilience. Furthermore, according to Figure 9, disasters and disaster resilience are interrelated with prevention, anticipation, absorption, adaption, and transformation. The DRIFT model is focusing creating a resilience index of countries based on hazard, vulnerability, and resilient capacities. Furthermore, the application of the DRIFT model is diversified in temporal, spatial, and institutional scales (Manyena et al., 2019).

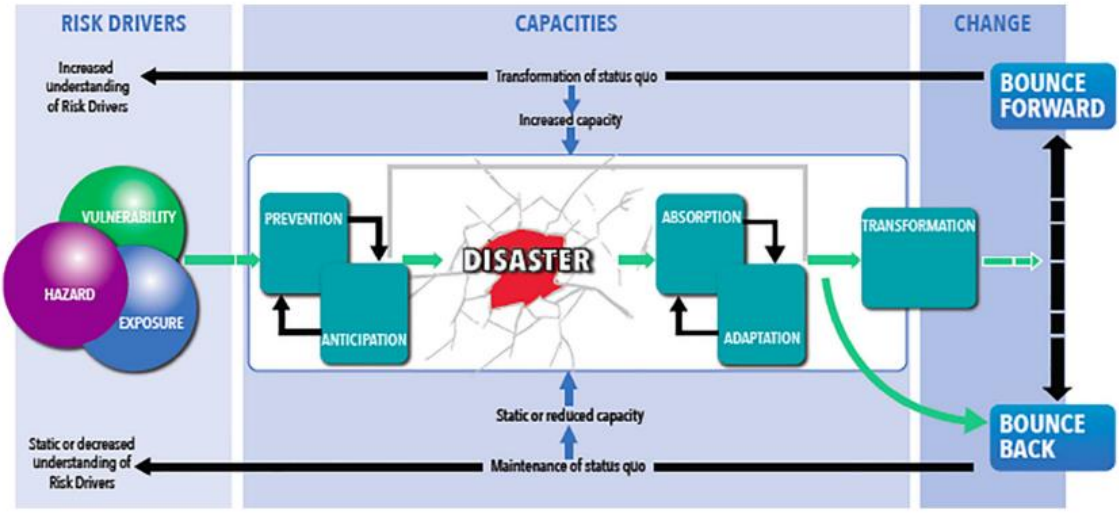

Figure 9: DRIFT model

Source: (Manyena et al., 2019)

3. METHODOLOGY

The research has been conducted using narrative literature review using, journal articles and conference papers. The selection of the articles is expanded to the last 20 years and connects the old and new knowledge for the identification of the strong existing model or framework related to disaster resilience. Clarke and Oxman (2000) confirmed narrative literature review articles are publications that describe and discuss the state of the science of a specific topic or theme from a theoretical and contextual point of view. These types of review articles do not list the types of databases and methodological approaches used to conduct the review nor the evaluation criteria for inclusion of retrieved articles during databases search. The narrative review consists of a critical analysis of the literature published in books and electronic or paper-based journal articles (Khan et al., 2000).

4. FINDINGS AND DISCUSSION

Some researchers also criticized resilience for promoting conservatism and the status quo, which contrasts with the point of view that adaptation is a fundamental characteristic of resilience (Bankoff, 2019). The most common misinterpretation of resilience is gaining the previous level of resilience. Resilience is the ability to adapt and change, to reorganize, while coping with disturbance. A resilient system responds to a disturbance by changing the relative amounts of its various parts and how they interact, thereby changing the way it functions (Walker, 2020). Resilience is having different overviews

and based on these varieties; resilience is utilized in organizations (Somers, 2009), networks, and communities. Another review has maintained that resilience is applied to crisis management at organizational, inter-organizational, and local community levels (Normandin & Therrien, 2016).

The implementation of resilience in the global context has been able to reduce the impact of disasters over time from a financial perspective and impact lives. Wildavsky (1988) explained that the development of resilience is demonstrating the ability to address risk and prevention in particular situations. Therefore, resilience is identified as the method of implementing stability in any situation (bounce back, persistence, same relationships) and the level of adaptability (learning, absorbing change). According to Olsson et al. (2015), resilience has been divided into five perspectives in social science namely, ecological approach (Holling, 1973) organization and management sciences (Wildavsky, 1988), safety sciences (Bergström, 2019), crisis management and sociology of disasters and the study of socio-technical systems (Emery, 2016). The concept of community resilience is consisting of planning for, resisting, absorbing, and rapidly recovering from disruptive events (Koliou et al., 2020). Hence, community resilience comprises factors related to emergency response, preparedness and security, mitigation, risk communication, and recovery of communities from physical, economic and social disruptions. Table 1 is connecting the characteristics of different models/ frameworks with the light of community resilience.

The discussion on the identified models and frameworks demonstrates the similarities and contracting points. Table 1 summarises the critical aspects of the disaster resilience models and frameworks. Accordingly, it identifies the suitability and the application of different characteristics of the aforementioned models. The application of different characteristics was identified through the comparative evaluation of the models and frameworks.

Table 1: Discussion on the disaster resilience models/ frameworks

Application of Different Characteristics	**Model/ Framework**									
	[1]	**[2]**	**[3]**	**[4]**	**[5]**	**[6]**	**[7]**	**[8]**	**[9]**	**[10]**
Pre-disaster events	✓			✓		✓	✓	✓	✓	✓
Post-disaster events	✓		✓	✓	✓	✓	✓	✓	✓	
Presence of hazard	✓		✓				✓	✓	✓	✓
Presence of disaster	✓		✓				✓	✓	✓	✓
Presence of resilience	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Presence of the time factor	✓	✓	✓				✓	✓		
Presence of community				✓	✓			✓	✓	✓
Presence of risk			✓				✓	✓	✓	
Use of technology				✓	✓	✓		✓		
Use of human resources			✓	✓				✓		
Theoretical perspective	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Practical perspective			✓	✓	✓		✓	✓		

[1] Model of Resilience **[2]** Panarchy Framework **[3]** DROP **[4]** General Framework **[5]** Conceptual Model of Recovery **[6]** PEOPLES Resilience Framework **[7]** The Regional Resilience Process and Outcome **[8]** Flooding Disaster Resilience Information Framework **[9]** DRIFT **[10]** HDR

According to the findings of Table 1, resilience is a common factor, which was presented in all the disaster resilience models/ frameworks. Additionally, all the models and

frameworks were developed from a theoretical perspective and only DROP, General Framework, Conceptual Model of Recovery, the Regional Resilience Process and Outcome and Flooding Disaster Resilience Information Framework have presented the practical perspective of the models. Furthermore, except Panarchy Framework and HDR, all the other models and frameworks are elaborating on the post-disaster events.

Additionally, Panarchy Framework, DROP, and PEOPLES Resilience Framework are not discussed in the pre-disaster events. According to the discussion, Panarchy Framework has been highlighted as the theoretical model which is only consisting of resilience and time factor. Hence, further evaluation is required on the particular framework when assessing the suitability of the Panarchy Framework as a disaster resilience framework. Time is another unique factor which is only present in the Model of Resilience, Panarchy Framework, DROP, The Regional Resilience Process and Outcome, and Flooding Disaster Resilience Information Framework. The concept of community is only addressed in the General Framework, Conceptual Model of Recovery, DRIFT, HDR, and Flooding Disaster Resilience Information Framework.

Table 2 critically discusses the unique characteristics of the different disaster resilience models. Accordingly, except for the Model of Resilience, PEOPLES Resilience Framework, and The Regional Resilience Process and Outcome all the other models are illustrating the circular information flow for disaster resilience. Conceptual Model of Resilience, Flooding Disaster Resilience, and Hospital Disaster Resilience have been developed for specific disasters. Meanwhile, all the other models have the potential to apply to any type of disaster.

Hence, the Model of Resilience, General Framework, Conceptual Model of Recovery, Flooding Disaster Resilience Information Framework, The Regional Resilience Process and Outcome, DRIFT, and PEOPLES Resilience Framework are identified as the applicable disaster resilience models and frameworks for community resilience.

Table 2: Application of Models and Frameworks

Model/ Framework	Year	Unique Characteristics	Applicable Situations
Model of Resilience	2018	Level of resilience among the community during the pre-disaster and post-disaster event The impact of time on the disaster event and the relationship between time and the disruptive phase Relationship of the recovery phase Performance of the system/ community	Any disaster events
Panarchy Framework	2002	Behaviours of the Social and ecological systems Nested relationship of the resilience system Impact of the lower level on community resilience (organisational level) Impact of change on the higher level of the system (national and global aspects) Presents socio-ecological resilience and circular flow of the system	Focused on socio-ecological system
DROP	2008	Discusses the existing resilience and vulnerability in social, built, and natural systems including recovery Hazard or disaster occurs with the combination of vulnerability, resilience, event and coping responses Presents the concept of adaptive resilience The feedback mechanism is demonstrated with mitigation and preparedness concepts Illustrates the impact of time short and long categories Related to the pre and post-event the disasters and circular flow of information	Not specified to specific disaster type
General Framework	2003	Discusses the pre and post-event control for the resilient system Demonstrates 3 different systems under the resilient community system (resilience assessment and decision system, system assessment and actions, conventional system) Use of technology for sensing and monitoring Resilience criteria introduced Resilience and performance evaluation and estimation processes discussed Advanced system motivation demonstrates the combination of response, restoration, repair, retrofit, and recovery.	Applied for earthquakes Has the potential to apply to other disasters
Conceptual Model of Recovery	2006	Disaster information, community information systems and response information systems are used as the bottom level Information flow and interconnectivity presented The project consists of 3 boundaries as community, neighbourhood and lifelines Community boundary focused on building development Neighbourhood boundary discusses the impact on households and businesses only Lifeline boundaries are demonstrating the factors affecting the livelihood of the people (transportation, electrical network, water network, critical facilities)	Defined for earthquakes

PEOPLES Resilience Framework	2010	Lifeline boundaries are supporting the neighbourhood development Interconnected circular approach Discusses the community resilience Focusing the national perspective with large-scale resilience Connected with the geographical aspects/ locations using GIS Diversified in local, regional, global, continental, organisational, family and national	All types of disasters
The Regional Resilience Process and Outcome	2015	Pre-disaster event is presented Availability of resources discusses The disturbance occurred with the economic shock Resilience is presented in 4 categories (resistance, recovery, renewal, re-orientation) Constant disturbances affect the system to become resilient Post-disaster event is presented	For any type of disaster
Flooding Disaster Resilience Information Framework	2019	Following the linear approach Presents the impact of time Feeding data to the system using human sensors, devise sensors, past data from databases, and actuator Use the event processing engine consisting of situation decision operators, macro situations, personal context, and situation-based controller Use the knowledge of expertise Human analyser used for the process Personalised response system Circular information system	Flooding disasters only
DRIFT	2019	Demonstrates 3 steps (risk drivers, capacities/ Change) The basics for the disaster are hazard, vulnerability, and exposure Prevention and anticipation are 2 aspects that decide the occurrence of disasters Absorption and adaptation are key aspects of the transformation Resilience is presented with 2 levels (bounce forward and bounce back) Increased capacity and reduced capacity have 2 different impacts on disasters Circular information system	Not specified applicable for any disaster
HDR	2020	Method of engaging with disasters at hospitals Connected with the theory of complexity Supports the installation of a preliminary warning system	Hospital-related disasters only

5. CONCLUSIONS AND RECOMMENDATIONS

In conclusion, all the disaster resilience models and frameworks discuss the different aspects of disaster resilience. Accordingly, critical discussion on the applicable concepts of the frameworks and models shows that DROP and The Regional Resilience Process and Outcome models are more comprehensive. Furthermore, the combination of characteristics of the models and frameworks signifies that the Regional Resilience Process and Outcome is the ideal disaster resilience framework for improving community resilience in a disaster resilience context. The study concludes that the presence of hazard, disaster, time factor, community, and risk improve community resilience. Additionally, the use of human resources and technologies supports community resilience. Hence, the development of a common model/ framework for the improvement of community resilience needs to combine the aforementioned factors. Application of all these factors in a single model helps to implement a platform for improved community resilience.

6. ACKNOWLEDGMENT

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