Community resilience mechanism in an unexpected extreme weather event: An analysis of the Kerala floods of 2018, India

Joice K. Joseph [a,b,e,*], Dev Anand [b,e], P. Prajeesh [a], Anand Zacharias [a], Anu George Varghese [c], A. P. Pradeepkumar [d,e], K.R. Baiju [b,e]

[a] M S Swaminathan Research Foundation, 686102, Kerala, India
[b] School of Environmental Sciences, Mahatma Gandhi University, 686560, Kerala, India
[c] School of Behavior Sciences, Mahatma Gandhi University, 686560, Kerala, India
[d] Department of Geology, University of Kerala, 695581, Kerala, India
[e] Charitable Society for Humanitarian Assistance and Emergency Response Training (CHAERT), Kerala, India

ARTICLE INFO

ABSTRACT

Community actions have a significant role in disaster response. This study analyses the socio-demographic and satisfaction variables within community resilience in the context of the Kerala floods of 2018 and elucidates its gaps from the perspective of a developing country. The data from the self-administered questionnaire survey among the fishermen who were prominent amongst the first responders during this flood were analyzed using SPSS. Global literature was also reviewed to examine the status of community resilience and its effectiveness in holistic disaster management. This is an issue which has rarely been addressed in past studies from India. The results indicate that the majority of the first responder-fishermen had a primary educational background. They have participated in the rescue mission as groups without much previous experience, but felt high levels of self-satisfaction afterwards. These first responders were well aware of coastal disasters, but had limited exposure to disaster preparedness and mock drills. Although hampered by limited physical and financial resources, they could effectively utilize their social capacities during the disaster. The importance of bottom up approach in disaster management, comprising 'Community-Based Disaster Risk Management' (CBDRM) which can transform vulnerable communities to resilient communities is underlined in this study. The importance of the resilience of the local population, especially the fishermen community in local disaster response is highlighted, and the shortcomings in the current practices are identified. An attempt is also made to recognize and promote further potential through training, awareness and proper early warning.

1. Introduction

1.1. Background and objectives

Attainment of sustainable community resilience towards large scale disasters is now of prime interest in governance [1–4]. But the most vulnerable communities, especially in developing countries, are the unorganized sections of society, such as the fishermen, who do not have sufficient capacities to participate effectively in resilience efforts. Understanding of intrinsic vulnerability awareness and influencing factors of collective efficacy in social resilience are identified as research gaps. Much research on community resilience has focused on interactions of physical, social and economic infrastructures through direct observations, modeling, and social media analysis (Table 1).

Kerala, a southwestern coastal state in India, witnessed its worst ever flood disaster in 2018, which resulted in extensive loss in all spheres of life [27]. One-sixth (5.4 million) of the state's population were badly distressed, 1.4 million were displaced, 433 lives were lost (between 29 May and August 29, 2018), 1,259 out of 1,664 villages affected, and the shutters of 37 out of 41 dams were opened [28]. Kerala is situated between the Arabian Sea to the West and the Western Ghat mountains to the East. It has an average annual precipitation of about 3000 mm, which is controlled by the South-West and North-East monsoons. About 90% of rainfall occurs during the six-month long monsoon period. The high-intensity storms prevailing during the monsoon months result in heavy discharges in all the rivers. Kerala has a total of 44 entirely

Table 1

A chronological review on community resilience.

Authors/Year/Country	Key findings
Rand et al. [5] United States	• Population Resilience Matrix (PRM) is an effective approach for addressing the complex predicament of post- disaster population displacement. • The PRM approach, which is derived from Linkoves [6] resilient matrix approach, is compatible, internationally applicable and addressing physical, social, information, and project management domains of resilience assessment.
Scherzer et al. [7] Norway	• Establishment of baseline to compare and track changes overtime is crucial to strengthen community resilience • Considerable variations in social resilience identified with BRIC tool.
Linkov & Trump [8] United States	• Risk and resilience are two fundamentally different concepts and this distinction is not only a scholarly need, but also a policy necessity. • The scope and applications of resilience can be seen in many fields, ranging from cyber security to architecture and infrastructure development to social cohesion and emergency response.
Goulding et al. [9] Japan	• Local culture and art having a role in social resilience. • socio-cultural dynamics of resilience needs to be understood for Community-based Operational Research (CBOR) intervention
Fox-Lent and Linkov [10] United States	• Resilience is a property of a system, not a property of a component and its focus is on maintaining functionality. • The RM provides a framework to identify and bring together relevant players for structured conversations about performance expectations and responsibilities.
Aldrich and Meyer [11] United States	• Government agencies and NGOs should focus on strengthening social infrastructure at the community level • Currently much research and policy focus on physical infrastructure development.
Fox-Lent et al. [12] United States	• Resilience Matrix (RM) is an effective tool to coastal community resilience. • RM has specific strengths over existing methods and can provides a framework that utilizes stakeholder-informed selection of metrics and critical functions
Hyvarinen and Vos [13] Finland	• Community resilience is often characterized by their geographical location • Community resilience can strengthen by enhancing communication activities in joint preparedness, response, and recovery phases.
Linnell [14] Sweden	• Societal resilience can be observed as a collective effort taken by public, civic and private sectors of the society • The social media, smart phones and other multichannel communication platforms are increasingly utilized for societal crisis management.
Marfai et al. [15] Indonesia	• Community response is crucial in DRR • Training can improve the community response capacity. • First responders are more familiar with local geography
Patterson et al. [16] United States	• Social resilience is always related to theories of "social capital" • Community can became an autonomous actor in DRR
Phaiju et al. [17] Nepal	• Risk knowledge, monitoring, dissemination and response capability are the four critical elements in CBEWS. • CBEWS should have a multi-hazard approach.
Bajek et al. [18] Japan	• Well-trained local communities became autonomous organizations for disaster reduction • Identified the motivations driving Jishubo community members to participate in disaster management activities
Norris et al. [19] United States	• Explored various representative definitions of resilience from global literature • No community is always vulnerable and no community is always resilient

Table 1 (*continued*)

Authors/Year/Country	Key findings
Coles & Buckle [20] Australia	• Resilience can be considered as an abstraction and its strategic value lies in effective interventions and policies. • The affected community requires capacity, skills and knowledge to make its participation meaningful in the recovery process • The less effective traditional command and control model is still practised and the engagement of local people in the recovery process often neglected.
Allen [21] Philippines	• CBDP initiatives having a wider role in developmental planning and debate. • Incomplete CBDP inventeness has several limitations in vulnerability reduction especially in the context of climate change.
Chen et al. [22] Taiwan	• Through Integrated Community-based Disaster Management Programme (ICBDM) the rural villagers in Taiwan have learned to analyze vulnerable conditions and take actions.
Paton and Johnston [23] Australia	• Traditional approaches such as public education and awareness generation are proved ineffective in hazard preparations • Need to develop new hazard resilience models for different communities and for different hazards
Solo et al. [24] Honduras and Nicaragua	• Formation of village Disaster Management committees and village mapping can increase resilience. • Real community participation to risk management is a difficult task and is very energy consuming.
Comfort et al. [25] United States	• Rate of social and environmental change due to natural hazards exceeds the management capacity of existing organizations. • Human vulnerability should be a major concern in the development and evaluation of disaster policies.
Buckland and Rahman [26], Canada	• Communities having higher levels of physical, human and social capital were better prepared and more effective in flood response • Level and pattern of development affects disaster preparedness and response in rural societies.

monsoon-fed rivers which are fast flowing ones, owing to the hilly terrain and the short distance between the mountains and the sea. The state received 2346.6 mm of rainfall, which is 42% above normal, from June 1, 2018 to August 19, 2018 in contrast to an expected 1649.5 mm of rainfall. Between August 1 and 19, 2018 there was a 164% increase in rainfall [29,30]. This lead to the disastrous flooding, which necessitated an immensely large response to mitigate the effects.

Immediate responder is not a term commonly recognized by the emergency management system but is someone who plays a pivotal role in life-saving interventions in disaster response. The first of these immediate responders can be defined as those individuals that through no desire or fault of their own are thrust into disaster response simply by being physically located in the immediate disaster zone and are often not formally trained in disaster management or disaster medicine [31]. The two main objectives of this study are to investigate the level of awareness in intrinsic vulnerability and disaster management among these first responders of the Kerala floods, 2018 and to explore the disaster relief satisfaction of the first responders, who were mostly fishermen, and suggest possible measures to improve community resilience.

1.2. Community resilience and fishermen community response

Community resilience can be referred to as the ability of a community to utilize its available resources in the management of adverse situations and was one of the top priorities of the Sendai Framework for Disaster. This term has gained extensive acceptance in disaster management [32,33]. Former studies clearly described the characteristics of a disaster-resilient community such as integrated emergency communications, up-to-date disaster response plans, periodic mock exercises and a prompt resource inventory [2,3,34–36]; and [37]. The economic and social stress, such as poverty, crime and unemployment will directly
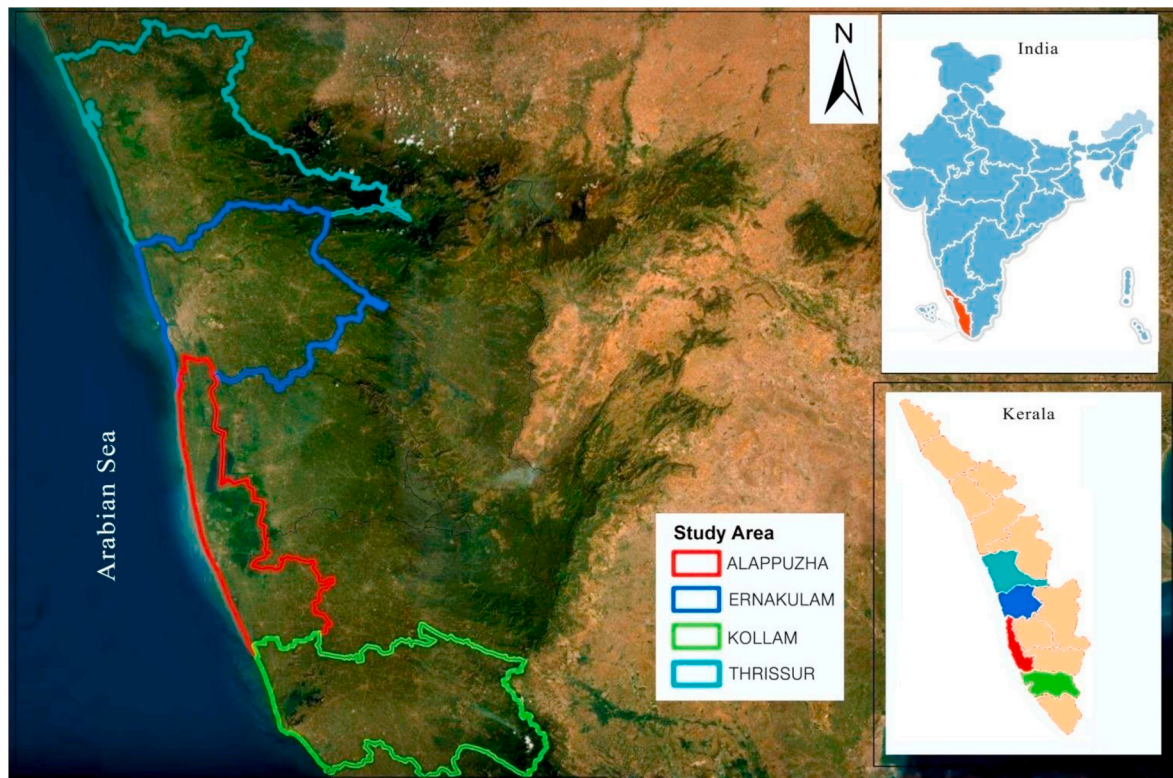
Fig. 1. Location map of the study area, with the worst flooded districts outlined.

affect the communities' disaster preparedness and resilience [38]. Disaster management organizations must identify and improve critical societal segments in community resilience for an effective response towards various hazards and to build a resilient social capital [39–41]. Despite the limited physical and economic resources available to local communities, they nevertheless possess unlimited social capacities that can be useful for coping with catastrophic events [24,42].

The concerns such as linkage between stakeholders at community, district, state, and national level Disaster Risk Management (DRM) authorities, inadequate community-based early warning systems, improper resource inventories, absence of training and mock drills were reported in the 2018 Kerala flood relief activities. A detailed review of notable global literature in the community resilience mechanism towards Disaster Risk Reduction (DRR) was conducted (Table .1) with the goal of exploring the relevant factors, which could lead to enhanced resilience in the Indian context.

Collective actions emerged spontaneously in the flood-affected locations particularly amongst the coastal communities to survive and cope with this disaster. Though Kerala have had its share of disasters in the form of stampedes at religious congregations [43–45] the state had never witnessed such a large scale disaster and subsequent rescue operation and the official emergency departments faced crucial challenges in undertaking timely action. The Government of Kerala with the support from National Disaster Response Force, Army, Navy and Air Force worked tirelessly to provide rescue and relief support to the affected population. The community's apt response overcame the widespread notion of passive victim hood at the time of disasters, and such resilience has been noted in communities with strong social capital and community cohesiveness, like for example in the Philippines [46]. Neglecting their safety, their families or any monetary gains from the government, the fishermen joined the rescue mission and rescued more than 65,000 marooned people from some of the worst flooded districts. The floods were of such a large dimension that skilled canoe and boat navigators and divers, in very large numbers, capable of sailing in turbulent waters, were required. Here the fishermen and their expertise at

seafaring in all weather conditions fit the bill perfectly. Government mechanisms were grossly inadequate, and hampered by the unavailability of large number of sturdy canoes and boats, as well as manpower skilled in sailing and diving. Due to the incessant rains, proper early warning information did not reach the local communities in time and consequently, people could respond only after their immediate surroundings started flooding [47]. Interestingly the poor and marginalized fishermen community pooled money from their own pockets to hire trucks that would transport their boats to flood-hit areas [48]. And they reached out to the worst-affected areas far away from their native places with their mechanized boats and fuel, in trucks, with day and night operations [49]. The small but sturdy twin-engine fishermen boats which are mainly made up of wood or fiber could navigate through flooded narrow lanes with strong undercurrent of water [50].

2. Materials and methods

The present study was exploratory and primarily based on a questionnaire survey conducted on convenience sampling of coastal population who has directly participated in the Kerala flood relief operations in 2018. The questionnaire was prepared in the native language of the

Table 2
Basic respondent demographics.

Education	Frequency	Percentage	Marital Status		
Primary	220	52.6	Single	258	61.4
Primary Graduate	161	38.5	Married	160	38.6
Post Graduate	37	8.9			
Profession			**Gender**		
Fishing	244	58.4			
Business	89	21.3	Male	414	99
Service	72	17.2	Female	4	1
Farmer	13	3.11			
Domicile			**Income (Rs)**		
Rural	391	93.5	>10000	355	85.3
Urban	27	6.5	<10000	63	14.7

Table 3
Response to 2018 Kerala flood rescue operations.

Individual/Group relief operation	Frequency	Percentage	Injuries during rescue mission		
As Group	412	98.6	No	392	93.8
AsIndividual	6	1.4	Yes	26	6.2
Previous experience in flood rescue activities			**Level of confidence after the rescue mission**		
No	269	64.4	High	357	85.6
Yes	149	35.6	Low	61	14.6
Proper flood early warning			**Self satisfaction after rescue participation**		
Not received	385	92.1	Yes	396	94.7
Received	33	7.9	No	22	5.3
Motive behind the rescue activity			**Governmental financial support after the rescue mission**		
Humanity	414	99	No	373	89.2
Adventure	4	1	Yes	45	10.7

Table 4
Response to general DRR questions.

Are natural hazards becoming more common?	Frequency	Percentage	Familiarity in community based EWS		
Yes	410	98.1	Yes	69	16.5
No	6	1.4	No	349	83.5
Don't know	2	.47			
Types of natural disasters threatening your community			**Familiarity in village disaster management plans**		
Tsunami	180	43.06	Yes	129	30.8
Flood	120	28.7	No	289	29.1
Seasurge	64	15.3			
Cyclone	31	7.4			
Earthquake	23	5.5			
Have any household level disaster Preparedness?			**Familiarity with local Flood Evacuation Routes**		
Yes	90	21.5	Yes	250	70.8
No	309	73.9	No	168	28.7
Don't know	19	4.5			
Experience in disaster volunteerism			**Participation in mock drills**		
Yes	365	87.1	Yes	65	15.6
No	53	12.7	No	353	84.4
Familiarity in first aid and basic life support			**Knowledge of Swimming**		
Yes	38	9.10	Yes	365	87.3
No	380	91.10	No	53	12.7

state – Malayalam – and self-administered by the researchers in approximately 40 days. The worst affected coastal regions from four districts of Kerala, namely Thrissur, Ernakulum, Alappuzha and Kollam were selected as the sampling area of the study (Fig. 1). The respondents were directly approached by the research team for rapport building and survey. Since the total number of persons involved in rescue activities was not clear, the sampling frame in the present study was considered infinite. The number of respondents was 418 which was much above the minimum sampling size of 384 which would be considered representative of the first responders in the study area [51].

The questionnaire was pre-tested; and was roughly divided in to three main sections. Each part dealt with questions/aspects which are significant in assessing the community resilience in the context of the Kerala flood of 2018. Part A included questions regarding flood relief operations such as motive behind the rescue activity, level of confidence and self-satisfaction after the mission, early warnings, injuries to the first responders and governmental financial support. Part B included questions on public awareness such as recurrence of natural hazards, types of natural hazards, familiarity to community-based early warning systems, village disaster management plans, household level disaster preparedness, mock drill participation and first aid/basic life support

requirements. Part C consisted of attributes to assess the satisfaction level of the first responders regarding the flood relief operations. The satisfaction parameters assessed included availability of facilities such as telecommunication, transportation, water, food, relief camps, the involvement of social media, police/military, fishermen community, various government line departments, religious groups and nongovernmental organizations. A five-point Likert scale (adopted from Ref. [45,52]) was used to rate the attributes ranging from high satisfaction to high dissatisfaction.

The collected data were analyzed using Microsoft Excel and Statistical Package for Social Science (SPSS) software. Percentage and Discriminant analysis were used to examine the demographic profile of the respondents. Mean Score analysis was used to describe the frequency (number of times each attribute occurs) and percentage (frequency observation) of various aspects in the questionnaire. Factor Analysis was used to separate the satisfaction parameters into consequential groupings. Reliability of scale was checked using Cronbach's Alpha and Kaiser–Meyer–Olkin (KMO) for sampling adequacy. After Principal Component Analysis with Varimax Rotation, the parameters were arranged into three factor groupings. Factor analysis is a technique that reduces a large number of variables into fewer numbers of factors by

putting them into a common score. The Principal Component Analysis is the most common method of factor analysis, which extracts the maximum variance and puts them into the first factor, followed step-by-step up to the last factor [53]. Also literature survey was carried out using various academic search engines with key words such as Community Resilience and Community-Based Disaster Risk Management.

3. Results

The number of respondents in the present work was 418 (450 questionnaires were distributed with a response rate of 92.8%). The basic socio-demographic profile of the respondents is listed in Table 2. It clearly indicates that the majority of participants were rural (93.5%) male (99%) fishermen (58%), with a primary educational background (52.6%).

3.1. 2018 Kerala floods rescue operations

This section of questionnaire dealt with the aspects of rescue mission conducted by the respondents. A majority of the respondents (98.6%) participated in the flood rescue operations as groups rather than in individual capacity, which is understandable, given the circumstances (Table 3). Kerala had never faced an extreme event of large magnitude, so the previous experience in participating in relief activities was limited to only 35% of the respondents. Humaneness was the prime motivating factor for the vast majority of respondents (99%) in rescue activities and they have felt high levels of self-satisfaction (94.7%) after the mission. Also their level of confidence has increased significantly (85.6%) though a few were physically injured (6.2%) during the operations.

3.2. General awareness of the respondents in DRR

The recurring nature of natural hazards in their locality was familiar to a vast majority of the respondents (98%) and they were well aware about the typology of common coastal disasters too. But 73.9% of this coastal community was found lacking in awareness of household disaster preparedness and 91% of them lacked first aid training. Also they were not familiar with Village Disaster Management Plans (69.1%) and mock drills (84.4%). The community had some knowledge about the local geography; hence they were familiar with flood evacuation routes (70.8%). The detailed frequency percentage distribution of this section is given in Table 4.

3.3. Respondent satisfaction towards various flood relief components

Factor Analysis has brought out the first responders' satisfaction level towards various elements related to flood relief activities. Before applying the Factor Analysis, KMO and Bartlett's Test of Sphericity for determining sample adequacy (Table 5) was done. In the present study, the KMO value was 0.811 and hence the sample was adequate and highly significant for further analysis. Principal Component Analysis with Varimax Rotation was adopted to reduce 14 attributes to a few correlated dimensions. Items having cumulative extraction values below 0.4 were avoided in the Factor Analysis.

As a result of the Factor Analysis, the tested attributes were reduced to 13 and these were arranged into three factor sections (Table 6). The first factor (Factor I) included four valid attributes, with 19.31%

Table 5
Result of KMO and Bartlett's test of sphericity.

KMO and Bartlett's test	
Kaiser-Mayer-Olkin Measure of Sampling Adequacy	.811
Aprprox.Chi-Square	3589.260
Df	91
Sig.	0.000

Table 6
Results of factor analysis.

Variables	Factor loadings	Percentage variance
Factor sector – I		
Telecommunication	0.62	19.31
Transportation	0.84	
Water and food	0.80	
Social media	0.87	
Factor sector – II		
Police/military	0.88	69.18
Fishermen community	0.90	
Revenue department	0.58	
Health department	0.68	
Panchayat department	0.70	
Religious groups	0.78	
NGOs	0.57	
Factor sector – III		
Participation of youth	0.85	11.51
Relief camp availability	0.83	

variance. Social media received the highest factor loading (0.87) followed by Transportation (0.84) and Water and Food (0.62). Factor II with seven valid attributes has explained 69.18% of variance. Fishermen community was found to have maximum factor loading (0.90) followed by Police and Military (0.88), Religious groups (0.78), Panchayat department (0.70), Health department (0.684), Revenue department (0.58) and Non-Governmental Organizations (0.57). The factor III has a percentage variance of 11.51. Participation of youth (0.857) and Relief camp availability (0.83) were the valid attributes in this section.

4. Discussion

The present study examined the Kerala floods, 2018 as a case study to explore community resilience mechanism in a severe disaster. The survey demographics point out that the majority of the respondents participated in rescue activities as groups (98.6%) and had previous experience in disaster relief (64.4%). Studies by Chen et al. [22] and Cutter et al. [41] have also reported similar facts of united emergency response by experienced residents in vulnerable regions. Team work plays a key role during emergencies, whether they work for prevention, response or in eliminating the consequences of hazards [54,55]. It is evident that the remarkable accomplishment in rescue operations was actually a result of such joint operations and rapid voluntary assistance that was provided by experienced local community. Also 78.80% of the respondents were well aware of the topography of the regions, both its advantages and disadvantages and this might have aided the rescue operations. Increased self-satisfaction and confidence level are other significant observations from the study. The community/interpersonal resilience and the belief in their own capabilities are positively correlated with confidence and satisfaction [56–58]. As pointed out by Alexander [59]; this kind of increase in self-satisfaction and public confidence will definitely foster DRR activities.

Public awareness about natural hazards and their management is one of the key components for improved emergency actions [60,61]. People must be made aware of natural hazards that they are likely to face. A portion of the present survey questionnaire was dedicated to the general awareness of the respondents towards various aspects of their local vulnerability (Table 3). The results indicate that the coastal community in the state was familiar with the nature and typology of common coastal hazards. Nevertheless they have had no exposure to a well-structured CBDRM framework, which includes village DM plans, house hold DM preparedness and mock drills.

The three factor sectors derived in the study are the critical attributes of effective CBDRM activities in the study area. Fishermen community, Police/Military forces and the Social Media were the segments having high factor loadings. The Government Departments (other than Defense)

Table 7
Identified issues in community resilience and suggestions.

Sl. No.	Issues in community Resilience	Suggestions
1	Absence of community-based early warning systems (CBEWS)	Develop appropriate CBEWS and ensure its timely dissemination [78].
2	Inadequate alliance between the community and government authorities	Administrative authorities need a paradigm shift from the traditional passive response to a progressive community-based approach [64].
3	Inadequate awareness on local resources for crisis management	Detailed village resource maps and inventories are in place and their regular updation is necessary [65,66].
4	Less access to risk communication	Ensure access to cell phone, internet, radio, wireless, HAM and print media along coastal belt for effective crisis communication [67,68] and [79].
5	Insufficient response capacity among potential community services	Ensure per capita number of police, fire force, medical staff, shelters and volunteers [69].
6	Lacking household disaster Preparedness	Policies that address household level approach in DRR like the CARE model has to be brought in Ref. [70].
7	Inadequate exposure to mock drills and first aid	Emergency departments need ensure adequate mock drills and first aid training to the community as per standard guidelines [71,72].

and Non-Government Organizations have received least factor loadings in immediate flood rescue activities. These must be the areas of urgent concerns because the involvement of Government and NGO sectors in the grass root level DRR process is equally important in community resilience [62,63]. Table 7 presents the key issues identified from this multidimensional study of community resilience mechanism and its possible recovery actions.

5. Key limitations to consider

The present study was based on the sociopolitical context of a niche state in a developing country like India and its design, application and wider generalization may have some practical difficulties. The effects of strong sub-nationalism in a highly politicized geographic region like Kerala, as defined by Singh [73]; on Disaster Resilience would be a very new area of research to address, and the possible returns of government investment in the social, educational and health sectors could be increased, thereby enhancing the involvement of the community in disaster management.

6. Conclusion

This analysis of the Kerala floods of 2018 has revealed that community resilience plays a crucial role in coping with and recovering from natural hazards. Our findings have elucidated the issues of the current stage of community involvement in DRR in the Indian context. A comprehensive and integrative approach is essential to set a new model in disaster relief operations. The socially developed nature of resilience can challenge the importance of physical and economic resources and current institution development policies in disaster management. The use of social capacities which are easily available can be activated anytime, freely and abundantly and is crucial for better community resilience in the state. It is concluded that there is a necessity of policy integration, by incorporating the community to reduce socio-economic impacts and vulnerabilities of floods and other natural hazards in the state.

Declaration of competing interest

The authors declare that there is no conflict of interest on the research article entitled- Community resilience mechanism in an

unexpected extreme weather event an analysis of the Kerala floods of 2018, India.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijdrr.2020.101741.

References

[1] K.J. Tierney, From the margins to the mainstream? Disaster research at the crossroads, Annu. Rev. Sociol. 33 (2007) 503–525.
[2] C.E. Colten, R.W. Kates, S.B. Laska, Three years after Katrina–Lessons for community resilience, Environment 50 (2008) 36–47.
[3] C.E. Colten, R.W. Kates, S.B. Laska, Community Resilience: Lessons from New Orleans and Hurricane Katrina, Community & Regional Resilience Institute, Oak Ridge, TN, 2008. Available at, www.rwkates.org/pdfs/a2008.03.pdf. (Accessed 23 July 2019).
[4] S. Magsino, Applications of Social Network Analysis for Building Community Disaster Resilience: Workshop Summary, The National Academies Press, Washington, DC, 2009.
[5] K. Rand, M. Kurth, C. Fleming, I. Linkov, A resilience matrix approach for measuring and mitigating disaster-induced population displacement, Int. J. Disaster Risk Reduction 42 (2020) 101310.
[6] I. Linkov, D.A. Eisenberg, M.E. Bates, D. Chang, M. Convertino, J.H. Allen, T. P. Seager, Measurable resilience for actionable policy, Environ. Sci. Technol. 47 (18) (2013) 10108–10110, https://doi.org/10.1021/es403443n.
[7] S. Scherzer, P. Lujala, K.J. Rod, A community resilience index for Norway: an adaptation of the Baseline Resilience Indicators for Communities (BRIC), Int. J. Disaster Risk Reduction 36 (2019), https://doi.org/10.1016/j.ijdrr.2019.101107.
[8] I. Linkov, B.D. Trump, The Science and Practice of Resilience, Springer, Amsterdam, 2019, https://doi.org/10.1007/978-3-030-04565-4.
[9] C. Goulding, M. Kelemen, T. Kiyomiya, Community based response to the Japanese tsunami: a bottom-up approach, Eur. J. Oper. Res. 268 (3) (2018) 887–903.
[10] C. Fox-Lent, I. Linkov, Resilience matrix for comprehensive urban resilience planning, in: Y. Yamagata, A. Sharifi (Eds.), Resilience-Oriented Urban Planning, Lecture Notes in Energy 65, Springer, 2018, pp. 29–47, https://doi.org/10.1007/978-3-319-75798-8_2.
[11] D.P. Aldrich, M.A. Meyer, Social capital and community resilience, Behavioral Scientist 59 (2) (2015) 254–269.
[12] C. Fox-Lent, M.E. Bates, I. Linkov, A matrix approach to community resilience assessment: an illustrative case at Rockaway Peninsula, Environ. Syst. Decis. 35 (2) (2015) 209–218, https://doi.org/10.1007/s10669-015-9555-4.
[13] J. Hyvarinen, M. Vos, Developing a conceptual framework for investigating communication supporting community resilience, Societies 5 (3) (2015) 583–597.
[14] M. Linnell, Citizen response in crisis: individual and collective efforts to enhance community resilience, Hum. Technol. 10 (2) (2014) 68–94.
[15] M.A. Marfai, A.B. Sekaranom, P. Ward, Community responses and adaptation strategies toward flood hazard in Jakarta, Indonesia, Nat. Hazards 75 (2) (2014) 1127–1144.
[16] O. Patterson, F. Weil, K. Patel, The role of community in disaster response: conceptual models, Popul. Res. Pol. Rev. 29 (2) (2010) 127–141.
[17] A. Phaiju, D. Bej, S. Pokharel, U. Dons, Establishing Community Based Early Warning System-Practitioner's Handbook, Mercy Corps and Practical Action, 2010.
[18] R. Bajek, Y. Matsuda, N. Okada, Japan's Jishu-bosai-soshiki community activities: analysis of its role in participatory community disaster risk management, Nat. Hazards 44 (2008) 281–292.
[19] F.H. Norris, S.P. Stevens, B. Pfefferbaum, K.F. Wyche, R.L. Pfefferbaum, Community resilience as a metaphor, theory, set of capacities, and strategy for disaster readiness, Am. J. Community Psychol. 41 (2008) 127–150.
[20] E. Coles, P. Buckle, Developing community resilience as a foundation for effective disaster recovery, Aust. J. Emerg. Manag. 19 (2004) 6–15.
[21] K.M. Allen, Community-based disaster preparedness and climate adaptation: local capacity-building in the Philippines, Disasters 30 (1) (2006) 81–101.
[22] L.C. Chen, Y.C. Liu, K.C. Chan, Integrated community-based disaster management program in Taiwan: a case study of Shang-An Village, Nat. Hazards 37 (1–2) (2006) 209–223.
[23] D. Paton, D. Johnston, Disasters and communities: vulnerability, resilience and preparedness, Disaster Prev. Manag. 10 (4) (2001) 270–277.
[24] T.M. Solo, M. Godinot, O. Velasco, Community participation in disaster management: reflections on recent experiences in Honduras and Nicaragua, in: S. Rawlings, et al. (Eds.), Thinking Out Loud IV: Innovative Case Studies on Participatory Instruments, The World Bank, Washington D.C, 2003, pp. 19–26.
[25] L. Comfort, B. Wisner, S. Cutter, R. Pulwarty, K. Hewitt, A. Oliver-Smith, J. Wiener, M. Fordham, W. Peacock, F. Krimgold, Reframing disaster policy: the global

evolution of vulnerable communities, Global Environ. Change B Environ. Hazards 1 (1) (1999) 39–44, https://doi.org/10.3763/ehaz.1999.0105.

[26] J. Buckland, M. Rahman, Community-based disaster management during the 1997 red river flood in Canada, Disasters 23 (2) (1999) 174–191.

[27] C.L. Vishnu, K.S. Sajinkumar, T. Oommen, R.A. Coffman, K.P. Thrivikramji, V. R. Rani, S. Keerthy, Satellite-based assessment of the August 2018 flood in parts of Kerala, India, Geomatics, Nat. Hazards Risk 10 (1) (2019) 758–767.

[28] UNDP (United Nations Development Programme), Post-disaster needs assessment: Kerala, India, 22-07-2009, https://www.undp.org/content/undp/en/home /librarypage/crisis-prevention-and-recovery/post- disaster-needs-assessment—ke rala.html, 2018.

[29] IMD (Indian Meteorological Department), Customized rainfall information system (CRIS), Available at, hydro.imd.gov, 2018. (Accessed 22 July 2019).

[30] CWC (Central Water Commission), Study report on Kerala floods, August 2018 available at, https://reliefweb.int/sites/reliefweb.int/files/resources/Rev-0.pdf, 2018. (Accessed 22 July 2018).

[31] C. Harris, K. Carthy, E.L. Liu, K. Klein, R. Swienton, P. Prins, T. Waltz, Expanding understanding of response roles: an examination of immediate and first responders in the United States, Int. J. Environ. Res. Publ. Health 15 (2018) 534, https://doi. org/10.3390/ijerph15030534.

[32] UNISDR (United Nations International Strategy for Disaster Reduction), The Sendai Framework for Disaster Risk Reduction 2015-2030, United Nations Office for Disaster Risk Reduction, 2015.

[33] S.B. Manyena, The concept of resilience revisited, Disasters 30 (2006) 433–450.

[34] W.N. Adger, Social and ecological resilience: are they related? Prog. Hum. Geogr. 24 (2000) 347–364.

[35] E. Buikstra, H. Ross, C.A. King, P.G. Baker, D. Hegney, K. Mclachlan, C. Rogers-Clark, The components of resilience–perceptions of an Australian rural community, J. Community Psychol. 38 (2010) 975–991.

[36] N. Agrawal, Natural disasters and risk management in Canada - an introduction, in: Advances in Natural and Technological Hazards Research, Springer, 2018, https:// doi.org/10.1007/978-94-024-1283-3.

[37] R.K. Waghwala, P.G. Agnihotri, Flood risk assessment and resilience strategies for flood risk management: a case study of Surat City, Int. J. Disaster Risk Reduction 40 (2019) 101155, https://doi.org/10.1016/j.ijdrr.2019.101155.

[38] NRC (National Research Council), Building Community Disaster Resilience through Private-Public Collaboration, The National Academies Press, Washington, DC, 2011, https://doi.org/10.17226/13028.

[39] D.P. Aldrich, Building Resilience: Social Capital in Post-Disaster Recovery, University of Chicago Press, Chicago, 2012.

[40] A. Chandra, J. Acosta, S. Stern, L. Uscher-Pines, M.V. Williams, D. Yeung, J. Garnett, L.S. Meredith, Building Community Resilience to Disasters: A Way Forward to Enhance National Health Security, RAND Corporation, Santa Monica, Calif, 2010. TR-915-DHHS.

[41] S.L. Cutter, L. Barnes, M. Berry, C. Burton, E. Evans, E. Tate, J. Webb, A place-based model for understanding community resilience to natural disasters, Global Environ. Change 18 (4) (2008) 598–606.

[42] D. Silva, A. Kawasaki, Socioeconomic vulnerability to disaster risk: a case study of flood and drought impact in a rural Sri Lankan community in, Ecol. Econ. 152 (2018) 131–140.

[43] F.T. Illiyas, S.K. Mani, A.P. Pradeepkumar, K. Mohan, Human stampedes during religious festivals: a comparative review of mass gathering emergencies in India, Int. J. Disaster Risk Reduction 5 (2013) 10–18.

[44] J.K. Joseph, N. Babu, K. Akhildev, A.P. Pradeepkumar, Identification of potential health risks in mass gatherings: a study from Sabarimala pilgrimage, Kerala, India, Int. J. Disaster Risk Reduction 17 (2016) 95–99.

[45] J.K. Joseph, K.G. Ambady, K. Akhildev, E.B. Hsu, A.P. Pradeepkumar, Pilgrim satisfaction in a mass religious gathering: study from Sabarimala destination, Kerala state of India, J. Relig. Health (2019) https://doi.org/10.1007/s10943-019-00814-w.

[46] J. Field, What is appropriate and relevant assistance after a disaster? Accounting for culture(s) in the response to Typhoon Haiyan/Yolanda, Int. J. Disaster Risk Reduction 22 (2017) 335–344.

[47] A. Anamika, The role of technology in responding to disasters: insights from the great deluge in Kerala, Curr. Sci. 116 (6) (2019) 913–918.

[48] The Hindustan Times, Sons of the sea: Kerala's fishermen are the unsung heroes of relief work during the floods, available at, https://www.hindustantimes.com/india -news/sons-of-the-sea-kerala-s-fishermen-are-the-unsung-heroes-of-relief-wor k-during-the-floods/story-WVD860u37XusZ5WTENqLiO.html, 2018. (Accessed 22 July 2019).

[49] The Indian express, Why flood-battered Kerala is hailing its fishermen as superheroes, available at, https://indianexpress.com/article/in dia/kerala-floods-fishermen-relief-rescue- operation-5317511/, 2018. (Accessed 22 July 2019).

[50] Times of India, Kerala floods: fishermen set a new model in rescue mission, available at, https://timesofindia.indiatimes.com/city/thiruvananthapuram/ker ala-floods-fishermen-set-a-new-model-in-rescue-mission/articleshow/65434376. cms, 2018. (Accessed 23 July 2019).

[51] W.G. Cochran, Sampling Techniques, third ed., John Wiley & Sons, New York, 1977.

[52] L. Oviedo, S. de Courcier, M. Farias, Rise of pilgrims on the Camino to Santiago: sign of change or religious revival? Rev. Relig. Res. 56 (3) (2014) 433–442, https://doi.org/10.1007/s13644-013-0131-4.

[53] F.B. Bryant, P.R. Yarnold, Principal components analysis and exploratory and confirmatory factor analysis, in: L.G. Grimm, P.R. Yarnold (Eds.), Reading and Understanding Multivariate Analysis, American Psychological Association, Washington, DC, 1995.

[54] K. Bergstrand, B. Mayer, B. Brumback, Y. Zhang, Assessing the relationship between social vulnerability and community resilience to hazards, Soc. Indicat. Res. 122 (2) (2015) 391–409, https://doi.org/10.1007/s11205-014-0698-3.

[55] M. Koliou, J.W. van de Lindt, T.P. McAllister, B.R. Ellingwood, M. Dillard, H. Cutler, State of the research in community resilience: progress and challenges, Sustainable and Resilient Infrastructure (2018), https://doi.org/10.1080/ 23789689.2017.1418547.

[56] K.G. Tidball, M.E. Krasny, E. Svendsen, L. Campbell, K. Helphand, Stewardship, learning, and memory in disaster resilience, Environ. Educ. Res. 16 (2010) 591–609.

[57] G.A. Bonanno, C.R. Brewin, K. Kaniasty, A.M.L. Greca, Weighing the costs of disaster consequences, risks, and resilience in individuals, families, and communities, Psychol. Sci. Publ. Interest 11 (2010) 1–49.

[58] S.L. Cutter, C.G. Burton, C.T. Emrich, Disaster resilience indicators for benchmarking baseline conditions, J. Homel. Secur. Emerg. Manag. 7 (1) (2010).

[59] D. Alexander, Principles of Emergency Planning and Management. Oxford, Oxford University Press, 2002.

[60] M. Teo, A. Goonetilleke, A. Ziyath, An integrated framework for assessing community resilience in disaster management, in: P. Barnes, A. Goonetilleke (Eds.), Proceedings of the 9th Annual International Conference of the International Institute for Infrastructure Renewal and Reconstruction, Queensland University of Technology, Australia, 2013, pp. 309–314.

[61] S.S. Patel, M.B. Rogers, R. Amlôt, G.J. Rubin, What do we mean by 'Community Resilience'? A systematic literature review of how it is defined in the literature, PLoS Curr. Disasters (2017), https://doi.org/10.1371/c.

[62] W.N. Adger, K. Brown, D.R. Nelson, F. Berkes, H. Eakin, C. Folke, K. Galvin, L. Gunderson, M. Goulden, K. O'Brien, J. Ruitenbeek, E.L. Tompkins, Resilience implications of policy responses to climate change, Wiley Interdisciplinary Reviews: Climate Change 2 (5) (2011) 757–766.

[63] J. Cinner, M.M.P.B. Fuentes, H. Randriamahazo, Exploring social resilience in Madagascar's marine protected areas, Ecol. Soc. 14 (1) (2009) 41.

[64] S. Nuanchan, Flood risk management in Thailand: shifting from a passive to a progressive paradigm, Int. J. Disaster Risk Reduction 25 (2017) 92–100.

[65] N.A. Marshall, D.M. Fenton, P.A. Marshall, S.G. Sutton, How resource dependency can influence social resilience within a primary resource industry, Rural Sociol. 72 (3) (2007) 359–390.

[66] N.A. Marshall, P.A. Marshall, A. Abdulla, Using social resilience and resource dependency to increase the effectiveness of marine conservation initiatives in Salum, Egypt, Environmental Planning and Management 52 (7) (2009) 901–918.

[67] J. Handmer, Are flood warnings futile? Risk communication in emergencies, Australas. J. Disaster Trauma Stud. 2 (2000), 2000–2.

[68] L.K. Comfort, T.W. Haase, Communication, coherence, and collective action: the impact of Hurricane Katrina on communications infrastructure, Publ. Works Manag. Pol. 10 (4) (2006) 328–343.

[69] D. Etkin, Disaster Theory an Interdisciplinary Approach to Concepts and Causes, Elsevier, 2016, ISBN 978-0-12-800227-8.

[70] CARE (Cooperative for Assistance and Relief Everywhere, Household Livelihood Security Assessments: A Toolkit for Practitioners, Prepared by TANGO International Inc., Tucson, Arizona for CARE USA, 2002. Available at, http://www. proventionconsortium.org/themes/default/pdfs/CRA/HLSA2002_meth.pdf. (Accessed 7 August 2019).

[71] NDMA (National Disaster Management Authority), Standard operating procedure for conduct of mock exercises/table top exercises in various states and union territories, available at, https://ndma.gov.in/images/policyplan/SOP- for MockExercises.pdf, 2014. (Accessed 7 August 2019).

[72] IFRC(International Federation of Red Cross and Red Crescent Societies), Training for response, Available at, https://www.ifrc.org/en/what-we-do/disaster-manage ment/preparing-for-disaster-prepardness-tools/training-for-response, 2015. (Accessed 7 August 2019).

[73] P. Singh, Subnationalism and social development: a comparative analysis of Indian states, World Polit. 67 (3) (2015) 506–562, https://doi.org/10.1017/ S0043887115000131.

[78] Lenton T.M., Early warning of climate tipping points Nat. Clim. Change, 1 pp. 201-209. Nat. Clim. Change 209 (2011) 201.

[79] Reed, et al., Who's In and Why? a typology of stakeholder analysis methods for natural resource management. Journal of environmental management 90 (2009) 1933–1949, https://doi.org/10.1016/j.jenvman.2009.01.001.