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Resilience of coastal communities to climate change in Bangladesh: Research gaps and future directions

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ABSTRACT

The assessment of resilience for people, places, and systems to climate-change hazards is essential for understanding how to reduce disaster risks. Globally, a number of resilience assessment methodologies have been developed and implemented by a variety of entities, including national and local organizations, donor agencies, and academic researchers. In Bangladesh, although a number of resilience studies have been conducted, it has never been determined whether these assessments rightfully addressed conceptual understanding, methodological approaches, and disciplinary underpinnings, and maintained compliance with on-going research communications standards. To unpack this gap, we systematically reviewed 38 articles to characterize how the resilience to climate change, of coastal communities in Bangladesh, is being assessed. To operationalize the study, we have presented a brief overview of the assessment tools and then applied an analytical framework containing six criteria: comprehensiveness of dimensions, scalar relationships, temporal dynamism, addressing uncertainties of climate change by modeling and scenario-making, participatory approaches, and action plans. The overview analysis shows diverse traditions of methodological underpinnings, and reveals authors' often incomplete conceptual understandings of resilience. Results of the review analysis reveal extensive inadequacy regarding multiple dimensionality, scalar and temporal scales, and more importantly, addressing the uncertainty of climate change. In relation to comprehensiveness, current literature has failed to consistently comply with global research communication in regard to the criteria of institutional and infrastructural dimensions. More attention needs to be placed on temporal and scalar dynamics. Most importantly, the uncertainty issue is virtually overlooked in the literature, and iterative processes and the development of alternate states of planning through scenario analysis are also critical, for risk reduction and adaptation to climate-change impacts. Substantial emphasis should be given to include all possible stakeholders in the planning and implementation of any climate-change adaptation or mitigation program.

Contents

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1. Introduction

Resilience assessments (RAs) have emerged as an important way of understanding human responses to disasters, in order to reduce the subsequent negative effects through better preparation, thereby enabling a population to withstand and adapt to a wide range of future disasters, both natural and man-made (Burton, 2014). Development and implementation of resilience assessment tools helps obtain benchmark information on the resilience status of a community, compared to peer communities and best practice standards. Furthermore, these tools can initiate interpersonal communication and afford a platform for acquiring and sharing resilience knowledge among communities (Arbon et al., 2012; Barkham et al., 2014). As awareness has grown about the significance of resilience assessments, scholars from diverse fields—including socio-economists, engineers, geographers, and most recently, urban and regional planners—have joined together to work on these assessments. Consequently, since the first conceptualization of this new approach to hazards management, a consensus has been built among hazards scholars, in understanding how resilience can be measured and operationalized as a preliminary step toward disaster response.

In order to address the existing and awaiting challenges that nations, states, cities, communities, and individuals confronted due to climate change, scientists are increasingly being interested in using the resilience ideas in environmental risk and impact assessment (Summers et al., 2017; Angeler et al., 2018; Kakenmaster, 2018). Over the last four decades, the notion of resilience has become a commonplace as a frontier concept in health, engineering, social, ecological, and spatial sciences (Cutter, 2016). As a result, numerous definitions of resilience has been suggested and argued in each science. For example, in the field of climate change and disaster, resilience is defined as "the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner" (UNISDR, 2009). Similarly, the Intergovernmental Panel on Climate Change (IPCC) defines resilience as "the ability of human communities to anticipate, absorb, accommodate and recover from the effects of disturbances" (IPCC, 2012). To date, however, the integration across the disciplines has lagged, which is noticeable in the case of the community resilience thinking, mainly when a community is considered as an interconnected system (Cutter, 2016).

Resilience assessment studies generally adopt one of five different methods, or some combination of several of these methods, for determining the extent of compliance with resilience criteria. These five methods are: assessment against baseline, assessment against threshold, assessment against principles of good resilience, assessment against peers (benchmarking), and assessment based on recovery speed (Pringle, 2011; Fox-Lent et al., 2015). Based on the overall format of the methods being used in the resilience assessment process, four major approaches can be distinguished: scorecard, index, model, and toolkit, as described by Cutter (2016). For a comprehensive assessment of resilience, a combination of all four formats would actually be most effective (Sharifi, 2016).

With the unprecedented rate of climate change, resilience building has been getting widespread emphasis, including in the fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC, 2014). A consensus has been developed among global research scholars that a robust tool in the process of resilience assessment should cover multiple dimensions of community resilience—environmental, social, economic, infrastructural, and institutional (Cimellaro et al., 2016). Resilience is a multi-scalar phenomenon, and variations at one scale may affect other scales. Hence, it is not realistic to assess resilience without addressing the upper and lower scales in the hierarchy. Moreover, since a community is an open system and built within a hierarchy of spatial scales, its resilience might prejudiced by dynamic interactions between different scales (Frankenberger et al., 2013; Constas et al., 2014; Quinlan et al., 2015; Chelleri et al., 2015).

Addressing temporal changes and uncertainty of climate change by taking into account the past trajectories of climate disaster and anticipating of future changes along with system dynamics are important understanding in resilience assessment (Walker and Salt, 2012). In the literature, emphasis has been given to consider evolutionary strategies (Folke et al., 2010; Collier et al., 2013; Levine, 2014; Watson et al., 2014; Schipper and Langston, 2015) such as an iterative process that involves monitoring performance and updating the baseline conditions and future targets for effectively addressing the uncertainty issues of climate change (Pringle, 2011). Moreover, the development of future scenarios for ensuring better adaptation to more stressful conditions would be an effective strategy in resilience assessment (Frankenberger et al., 2013; McLeod et al., 2015).

Being a normative concept, resilience research should involve participatory approaches to gather knowledge from a diverse range of stakeholder (Sharifi and Yamagata, 2016). Indeed, there has been an increasing global shift in the literature, toward using plural methodologies, i.e., participatory approaches for enhancing community resilience (Norris et al., 2008). Using participatory approaches that involve a wide range of possible stakeholders throughout the assessment process (both development and implementation) improves local understanding of risk and resilience, provides capacity-building benefits, and creates a platform for knowledge and experience sharing (Frankenberger et al., 2013; Pfefferbaum et al., 2014; Tyler et al., 2014). Furthermore, it can be of help in making decisions about trade-offs, and enhancing local ownership and legitimacy, which in turn could better implement the decisions (Gibson, 2006; Pasteur, 2011). Furthermore, the success of any assessment may depend on proper dissemination of its result to

the targeted community of interest. Likewise, potential interventions should be identified and prioritized on the basis of need, and there should be a definite action plan illustrating the road map (Pfefferbaum et al., 2012; Schwind, 2009) to transform a community into one more resilient than ever before.

Bangladesh is becoming one of the most vulnerable countries in the world, facing a wide range of disaster events as a result of global climate change. The coastal region of Bangladesh is the home of about 40 million people where natural resource-based livelihoods such as agriculture are predominant (Lázár et al., 2015). Therefore, the coastal regions of the country are more affected than any other area; these experience various natural and human-made disaster events (sea level rise, cyclones, storm surges, floods, drought, salinity intrusion, river bank erosion, and landslides) (Chowdhury et al., 2012; Lázár et al., 2015; Nasim et al., 2019). In almost every year during the past decades, this region witnessed multiple disaster events that cause enormous loss and damages to human lives, livelihoods, well-being and create uncertainty of food insecurity (BBS, 2016; Lázár et al., 2015; Nasim et al., 2019). Resilience assessment has been carried out in Bangladesh at various scales, by various actors with various goals against various hazards. However, there has been limited interrogation on whether the methodology used in these resilience assessments has evolved along with evolving definitions of resilience. In this study, we begin with a short review of how the concept of resilience has evolved in global research and within Bangladesh. Then, we try to identify the span of methodologies used to assess climate resilience in the coastal regions of Bangladesh. The specific goals of this study were i) to explore the conceptual understanding of resilience in the selected literature, and ii) to discover gaps in current methodologies, in order to maintain compliance with global research communication standards and to address the threats of future climate change.

2. Methodology

2.1. Conceptualization and operationalization of resilience

Resilience is a normative concept as the origin of its application is contested and often argued to be rooted in different disciplines (Sharifi and Yamagata, 2016; Moser, 2008; Bodin and Wiman, 2004). The term resilience has emerged as ancient thinking and initially developed in physics and psychology discipline (Sharifi and Yamagata, 2016; Bodin and Wiman, 2004). It was then introduced in the field of ecology through a series of studies conducted by authors like Holling (1961), Rosenzweig (1971), Moser (2008) and Norris et al. (2008). Over the last four decades, the resilience approach has been used by a myriad of ways in different fields and disciplines adopted for their needs and priorities, leading to multiple definitions of the concepts regardless of its origin. A list of resilience definitions has presented in Table S1 that demonstrates the evolution of the notion and diversity with which the concept has been defined. In the field of psychology, resilience refers to the process, outcome or capacity of individual or community to resist, recover and return to its equilibrium state after being affected by external stressors (Norris et al., 2008; Pfefferbaum et al., 2005).

The engineering, ecological and socio-ecological (adaptive) resilience are the three significant resilience approaches extensively being found in the ongoing scholarships (Sharifi and Yamagata, 2016). The engineering approach of resilience reveals the system's physical resistance against a shock and also, its ability to rapidly return to an equilibrium state whenever it exceeds the threshold level (Norris et al., 2008; Bodin and Wiman, 2004). The ecological approach to resilience admits the uncertainty of climatic shocks. It advocates enhancing the tolerance capacity of the system and prioritizes the needs of a system's flexibility to shift to a new equilibrium state(s) for retaining its pre-disaster functionality even after an extreme shock event (Sharifi and Yamagata, 2016; Holling, 1973). However, the adaptive approach to resilience recognizes systems as the dynamic socio-ecological entity that regularly transforms (Gunderson and Folke, 2005; Adger et al., 2005). Therefore, the system may sometimes fail to return in its equilibrium state and follows vulnerability pathways after exposure to a disruptive event. In contrary, the integrity of the system, its self-organizational capacity, and learning from the past experience are some of the drivers that enhance the system's adaptive capacity and enables not only to bounce back from the shocks but also push forward to a more desired state it was ever before (Sharifi and Yamagata, 2016; Resilience Alliance, 2012; Gunderson and Folke, 2005; Adger et al., 2005). During the past decade, the concept of resilience has got widespread attention in the field of disaster risk management (DRM) as a result of the initiation of "Hyogo framework for action 2005–2015: building resilience of nations and communities to disasters" by United Nations International Strategy for Disaster Reduction (UNISDR, 2007). In the field of DRM, resilience is most commonly expressed as the capacity of a society to 'bounce back,' cope, withstand, resist and recover rapidly from the impacts of hazard events (Ostadtaghizadeh et al., 2015; Turnbull et al., 2013; IPCC, 2012).

RA studies (Table S2) in the coastal region of Bangladesh was started in 2010 with the health sector, and it was then gradually introduced to engineering, ecology, and socio-ecological discipline. For example, agricultural scientists have conducted farming-based resilience assessments in the face of climatic hazards (Rahman, 2012; Kais and Islam, 2017); social scientists have focused on social capital (Islam and Walkerden, 2014; Hassan et al., 2013); scholars with engineering background have focused on infrastructural resilience (Sameen, 2018; Ali et al., 2018; Moles et al., 2014; Mallick, 2013), and some others have focused on policy and institutional resilience (Islam et al., 2017). However, almost one decade of resilience studies revealed that social aspects, i.e., social capital had received more priority by the authors who assessed resilience. However, the higher level of exposure to climate change-induced disasters and comparatively low adaptive capacity by the coastal communities of Bangladesh (Lázár et al., 2015) necessitates a comprehensive assessment of disaster resilience as proposed by IPCC and UNSIDR. Hence, authors take the disaster resilience concept for coastal Bangladesh as "the ability of individuals, households, and communities in a complex socio-ecological system to anticipate, resist, absorb, accommodate, and recover from the effect of climate change (erratic rainfall, inundation, flood, cyclone, drought, erosion etc.) through suitable adaptive and transformative practices without disturbing ecological and environmental systems.

The linkages between disaster resilience and environmental systems (Fig. 1) entail a comprehensive depiction of the extent of hazards, vulnerability, adaptive capacity, and resilience that reflects the exposure of an environmental system to natural hazards (Cutter et al., 2008). The degree of impacts after a hazardous event depends on the existing coping responses of the system, place, or community being exposed. If the exposed system can minimize the sensitivity and absorb the shocks, it can recover to its initial stage very quickly and follow resilience pathways. By contrast, if a system shows higher sensitivity and can't absorb the shocks, then it requires adaptation intervention to recover to its equilibrium stage. However, in some cases, the system never can bounce back to its equilibrium stage, even after interventions are taken, and it follows vulnerability pathways. Hence, it can be generalized that resilient systems or communities are less vulnerable to natural disasters than non-resilient systems. Furthermore, resilience and vulnerability are inversely proportionate, i.e., higher the vulnerability of a system or community, the lower will be the resilience, and vice versa.

2.2. Systematic literature reviews

Systematic Literature Review (SLR) is a rigorous, transparent and replicable form of literature review process (Ford et al., 2011; Delaney et al., 2014) that involves identifying, synthesizing, assessing, and interpreting available evidence (Kitchenham, 2004; Dixon-Woods et al., 2006; Ford and Pearce, 2010; Ford et al., 2011), in order to generate a robust and empirically derived answer to an exhaustive research inquiry (Okoli and

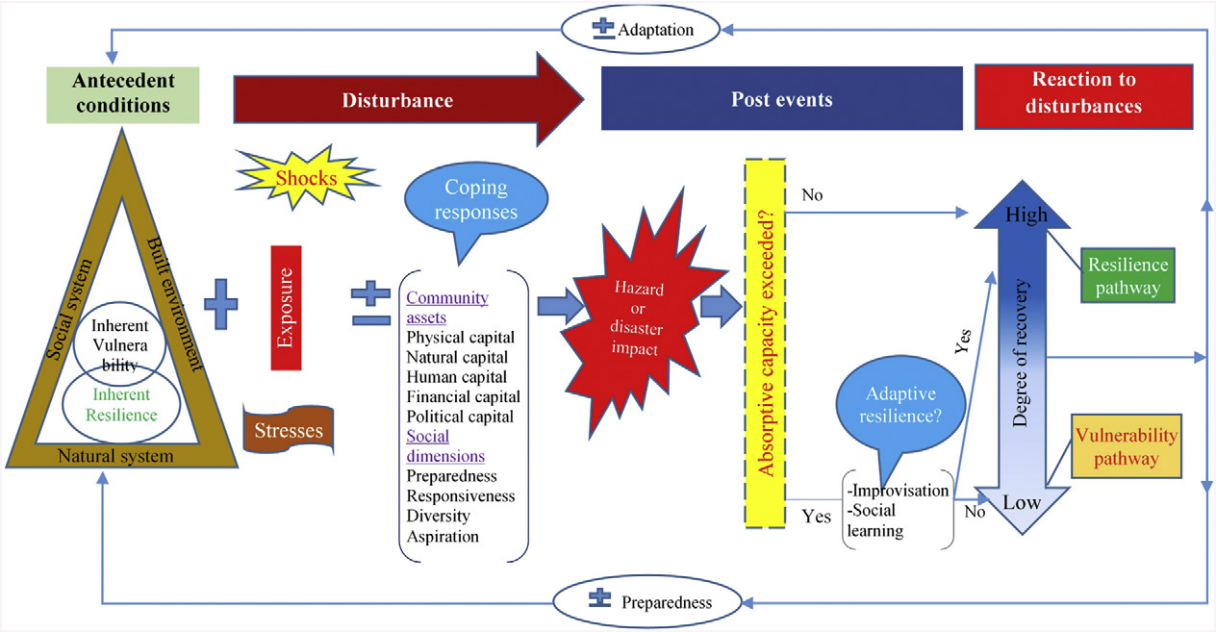

Fig. 1. Schematic diagram of disaster resilience linkages.
(Adapted and modified from Cutter et al., 2008; USAID, 2013 and Frankenberger et al., 2013).

Schabram, 2010). A clearly formulated research question and well-defined inclusion and exclusion criteria in an SLR process can minimize opaqueness and enable replication. Having these strengths, SLR is considered a more robust process than a traditional literature review (Ford et al., 2011). Yet, even though SLR is stronger than a standard literature review, it encounters some practical problems throughout its entire process, especially in the searching, screening, and synthesis stages (Okoli and Schabram, 2010). SLR requires to access in a wide range of databases, peer review journals and institutional reports for inclusive review results. However, access to a wide range of databases and peer review journals may be problematic for non-academic researchers and those from low-income countries. Moreover, access to selected institutions undermines the objectivity of the review process (Mallett et al., 2012). The SLR process adopts inclusion and exclusion criteria for achieving objectivity in screening potential literature which inevitably involves subjectivity especially when more number of researcher engaged in the screening process and their differential interpretation of inclusion and exclusion criteria (Mallett et al., 2012). Synthesis of information from the relevant literature also involves a certain degree of biases because of depending on the authors' self-proclaimed research methods and findings. This limitation could be overcome by involving respective authors in the review process which in reality not feasible for resource constraints (Mallett et al., 2012).

SLR is increasingly being used in climate-change research, especially in vulnerability and risk analysis. To make sense of resilience research that originates from multiple disciplines—each with its own set of conceptualization and methodological approaches—we chose SLR because it is well suited to help clarify and stabilize different conceptualizations of resilience, and to identify methodological differences that are not otherwise apparent (Delaney et al., 2014). In this study, we had access to a wide range of databases and peer review journals supported by the Chinese Academy of Sciences, China. To overcome the constraints of institutional information collection, the authors communicated with different organizations and ministries of the Bangladesh government and relevant NGOs working in the same discipline. Cross-checking of the screened literature and extracted information was done by multiple authors to attain objectivity in screening the potential studies and data synthesis process. Repetition of the assessment was done wherever any dissimilarity was found.

2.3. Data selection and review process

A systematic literature review was conducted to analyze the current RA studies on climate disasters context. The Preferred Reporting Items for Systematic Review and Meta Analyses (PRISMA) method was used to select RA studies for detailed review as shown in Fig. 2. PRISMA approach consists of four steps such as identification, screening, eligibility, and inclusion (Saja et al., 2019) which has explained below:

Step1- Identification stage: The key search terms, "Resilience" AND "Climate Change" AND "Bangladesh" in title, abstract and keywords were used to identify potential publications on RA. The peer review publications were selected through ISI Web of Science and Google Scholar, whereas the grey literature was selected through the google search engine and direct access to institutional websites. RA studies with no start date and a cut-off publication date of June 2018 initially resulted in 169 publications.

Step 2- Screening stage: In this stage, initially selected publications were screened by removing duplication and narrowing search terms following inclusion and exclusion criteria presented in Table 1. Consequently, 72 relevant publications were selected.

Step 3- Eligibility check: In this step, the selected screened publications were further checked for eligibility to be included in the review analysis following inclusion and exclusion criteria explained in Table 1. Subsequently, 44 publications were found eligible for review analysis.

Step 4- Inclusion: In this step, the eligible publications with full-text accessibility were included for critical review. Finally, 38 full-text literature (Table S2) consisting of peer review article (24), book chapter (2), conference proceedings (4), thesis (5) and working paper (3) were included for data extraction.

2.4. Assessment framework

While several frameworks (Ostadtaghizadeh et al., 2015; Cutter, 2016; Sharifi, 2016; Asadzadeh et al., 2017) are available in the literature for investigating resilience assessment tools, those of Sharifi (2016) and Cutter (2016) have received more attention in the global research community. In this study we followed the frameworks (Fig. 3) of

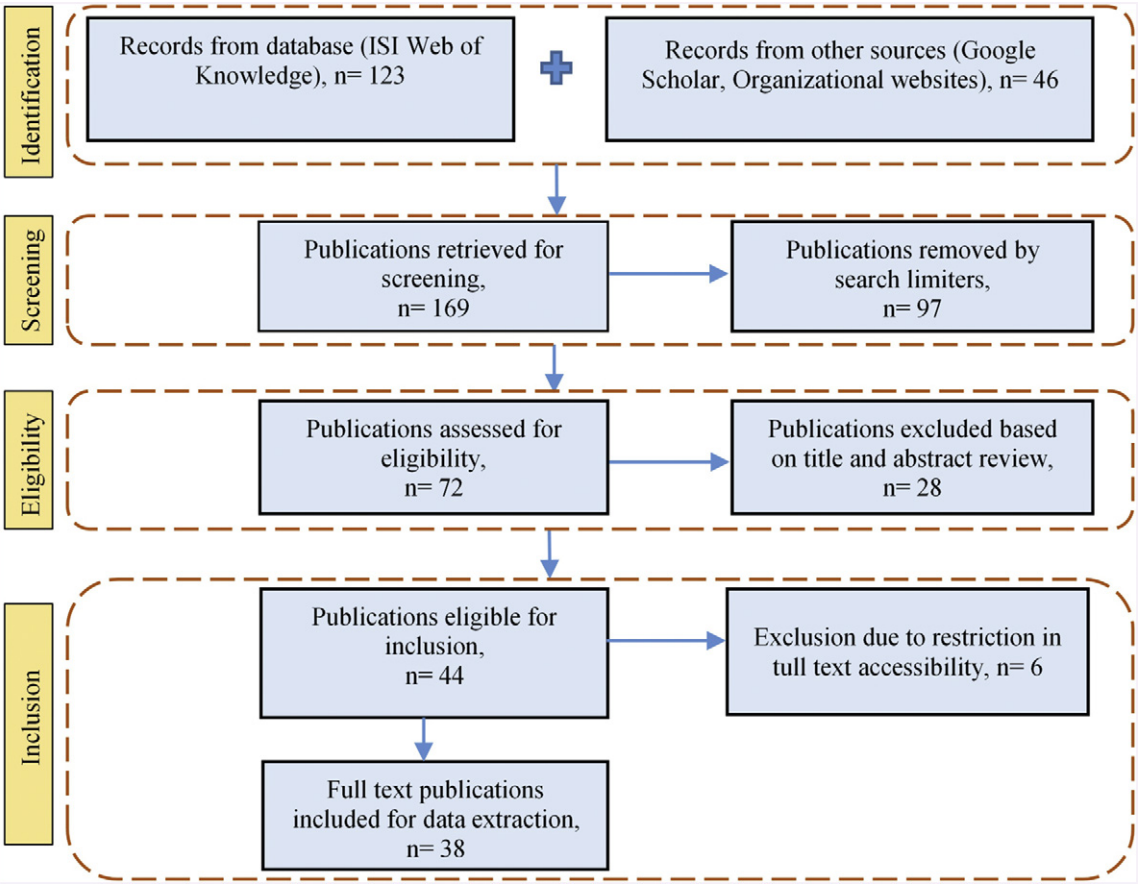

Fig. 2. PRISMA flow diagram for selection of RA studies for review analysis.

Sharifi (2016), who suggests that "a resilience assessment tool should comprehensively address multiple dimensions of community resilience, take into account the connections between different spatial scales, be able to measure changes across temporal scales, develop suitable measures for capturing uncertainties, be developed and implemented in collaboration with stakeholders, and lead to development of action plans for enhancing resilience." To investigate the level of compliance with these typical characteristics, an extensive literature review was conducted to extract important criteria related to community resilience, as was done by Sharifi and Murayama (2015). An initial list of criteria was developed and grouped into five categories, viz., environmental, social, economic, infrastructural, and institutional, as was done by Sharifi (2016). The list was then compared with the criteria used in the selected RA studies, and any inadequacies determined, in the indicators for the dimensions. Then, selected literature were checked, to find out whether they had accounted for interrelationships between upper and lower hierarchies within the community or systems, and whether they considered the continuum of past, current, and future. Both iterative processes and scenario analyses were considered, to ensure that uncertainty issues had been well addressed in the literature. The methodology section of the literature was carefully checked to ensure that the tool had been developed and implemented through participatory approaches like FGD (focus group discussion), KII (Key informant's interview) or other methods. Since formulating policy recommendations has become a common tradition in scientific publishing, the abstract, discussion, policy recommendation, and conclusion sections were carefully checked to ensure that action plans had been incorporated. A detailed data coding plan (Table S3) has been developed and used to extract and input the information in a SPSS database.

Table 1
Inclusion and exclusion criteria for screening and eligibility checking of RA publications in PRISMA method.

Steps of PRISMA	Inclusion	Exclusion
Screening	Literature published in English	Literature published in languages other than English
	Studies conducted in Bangladesh	Studies conducted in other countries
	Studies focused on environmental science, social science, and multidisciplinary sciences	Studies other than focused on environmental science, social science, and multidisciplinary sciences
Eligibility check	Studies conducted at the national, sub-national or local level where entire or a representative part of the coastal region	Studies conducted on other areas except for the coastal region of Bangladesh
	Climate change induced disaster resilience was the primary focus	Focused on other disciplines except for climate change and disasters

3. Results of the review assessment

3.1. Conceptualization of resilience

To explore the breadth of conceptual frameworks used, RAs studies were coded in to six categories such as i) ability to absorb, recover and retain from a disturbance, ii) food security and livelihood, iii) adaptation capacity to hazard, iv) reduction or erosion of vulnerability to climate disaster, v) others or combination of the above, and vi) unclear (Table S3). This categorization was done based on the construct that defines how resilience was defined or explained by the authors. The analysis was conducted because several RA studies didn't explicitly report constructs of resilience. Wherever there was no precise definition or

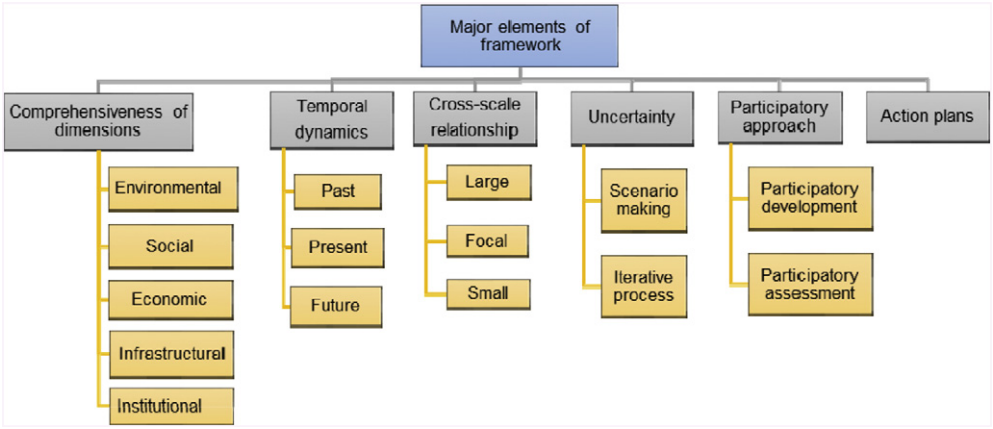

Fig. 3. Elements of evaluation framework.
(Adopted from Sharifi, 2016).

conceptualization of resilience, this was coded as 'unclear or not explicit' which in itself is a significant finding. Such RAs may not help in replicating research because it is quite impossible to conclude the validity or utility of literature that had shallow reporting (Delaney et al., 2014). Although resilience has been defined in diverse ways by scholars from a wide range of disciplines, IPCC's (2012) definition is being widely accepted in the global community. Yet of the RAs, only a single study (Akter and Mallick, 2013) used the IPCC's latest definition of resilience, however, some studies used an earlier definition from IPCC's fourth assessment report (IPCC, 2007). One possible reason behind the lower number of studies being focused on the latest IPCC definition might be the distinctive lag time between conceptual developments and publication in peer-reviewed literature. In almost 45% of the articles (Fig. 4), resilience is not clearly defined, which is a matter of concern: how could assessments be possible without a clear definition of what resilience is? In 26% of the studies, resilience was conceptualized as the ability to absorb, recover from, and retain stability after a disturbance, mainly those disturbances caused by natural disasters and climatic stresses, whereas 13% of the studies focused on adaptation capacity. Similarly, resilience as 'reduction of vulnerability' was reported in 8% of the studies. On the other hand, resilience as 'food security and livelihood improvement' was reported in only 5% of the articles. One possible reason for these inconsistencies might be that we explicitly looked for resilience studies, not poverty- or development-related research.

3.2. Methods and approaches used in the selected RA studies

In addition to the selected six criteria in assessment framework, a general investigation has been done to see the type of risk/hazard/disaster/addressed, methods and tools being used in RAs to reveal the assessment strategy, overall format, and style of presentation of findings (Tables 2 & S4). Whether or not we focus on resilience to climate change, the question of how we characterize the specific shocks and

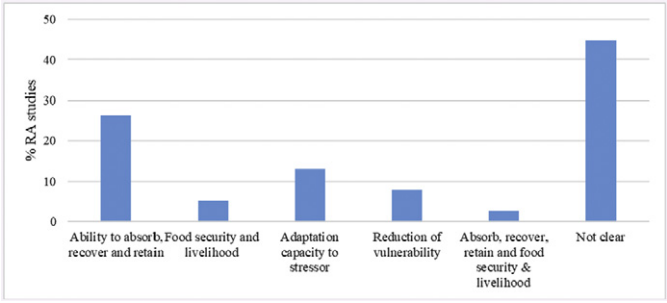

Fig. 4. Conceptualization of resilience in different traditions.

stresses that could threaten the community population at multiple spatial or temporal scales across systems is an important issue to be considered. Of the RAs, more than 90% of the studies focused on climatic shocks and stresses, and of these, 76.3% focused on cyclones, whereas 26.3, 23.7, and 21.1% of the studies focused on salinity, storm surges, and floods, respectively (Table 2 and Fig. S1). The predominance of studies focused on cyclones might be because the coastal area of Bangladesh is a hotspot of cyclone activity, where each year one or more cyclonic events have occurred, causing enormous loss and damage to the targeted community.

The household was the most commonly used unit for assessing resilience in the selected studies (Table 2 and Fig. S2). Very few studies were conducted at the community, state or city level, showing that the geographic dynamics of resilience were undermined in the previous studies. However, being an intermediate unit of assessment, district- or city-level resilience assessments could reflect dynamics at both wider and smaller scales (O'Brien et al., 2004). The reason behind the limited number of resilience studies at the district or city level might be limited access to the required data. In the context of Bangladesh, before 2011 or even early 2012, the availability of biophysical and socio-economic data at the community level was practically nil, or at least not satisfactory.

As can be seen from Table 2 and Fig. S3, assessments against baseline conditions, assessments against principles of good resilience, and benchmarking were the most common methods adopted by the selected RA studies. As shown in Table 2, the selected RAs relied on both secondary and primary data collections to conduct resilience assessments. Secondary data has been collected from different sources like census data, historical records, and statistics provided by national/local departments and non-profit organizations. On the other hand, household surveys, FGDs and key informant's interviews were the most frequently used techniques of primary data collection.

Both qualitative and quantitative methods were adopted by a majority of the selected RA studies (Table 2), where quantitative methods used numerical data and qualitative methods included accounts of local peoples' perception and experts' opinions. Qualitative methods are important where there is limited data, whereas quantitative methods can better address the concerns of subjectivity (Sharifi, 2016). Since resilience is a value-laden concept and influenced by perceptions, preferences and attitudes within the community, qualitative assessment is needed for better understanding of the needs, vulnerabilities, coping capacities, and opinions of local people, to ensure better resilience capacity (Jones and Tanner, 2015; Olazabal and Pascual, 2016).

As shown in Table 2 and Fig. S4, among the RA studies, scorecards (63.2%) were found most frequently, followed by toolkit (15.8%), index (13.2%) and model (7.9%) methods.

Results (Table 4 and Fig. S5) show that selected resilience assessment studies followed distinct styles to present their results. Illustration

Table 2
Basic characteristics of the selected RA studies and methodologies followed.

Sample literature[a]	Year of publication	Risk/disturbance/hazards	Scale of measurement	Format of assessment methods	Data source	Ql/Qn	Measurement against				
							Baseline	Threshold	Principles of good resilience	Benchmark	Recovery speed
1	2010	Health	Household	Scorecard	Both	Both	×	×	√	√	×
2	2012	Multiple	Household	Scorecard	Both	Both	√	×	√	√	×
3	2012	Multiple	Community	Scorecard	Primary	Qn	√	×	√	×	×
4	2012	Multiple	Household	Toolkit	Both	Both	√	√	×	√	×
5	2013	Cyclone	Household	Model	Primary	Qn	√	√	×	√	×
6	2013	Multiple	Community	Scorecard	Primary	Both	×	√	√	√	×
7	2013	Cyclone	Household	Scorecard	Both	Both	×	×	×	√	×
8	2013	Cyclone	Household	Scorecard	Primary	Both	√	×	×	√	×
9	2013	Multiple	Household	Toolkit	Primary	Both	√	×	×	×	×
10	2014	Cyclone	Household	Scorecard	Primary	Both	×	×	√	×	√
11	2014	Multiple	Household	Scorecard	Primary	Both	√	×	×	√	×
12	2014	Multiple	Region	Toolkit	Primary	Both	√	√	√	√	√
13	2014	Poverty	Household	Scorecard	Both	Both	×	×	√	×	×
14	2015	Cyclone	Household	Toolkit	Primary	Both	×	√	×	√	×
15	2015	Cyclone	Household	Scorecard	Primary	Both	×	×	×	×	√
16	2015	Multiple	Household	Model	Primary	Qn	√	×	×	√	×
17	2015	Multiple	Household	Index	Primary	Qn	×	×	×	√	×
18	2015	Multiple	Household	Index	Both	Both	√	×	×	√	×
19	2016	Multiple	Household	Scorecard	Primary	Both	×	×	√	√	×
20	2016	Cyclone	Community	Scorecard	Primary	Both	√	√	√	×	×
21	2016	Health	Household	Scorecard	Primary	Both	√	×	×	√	×
22	2017	Multiple	Household	Scorecard	Both	Both	×	×	√	√	×
23	2017	Multiple	Community	Scorecard	Both	Both	×	×	√	×	×
24	2017	Cyclone	Household	Scorecard	Primary	Both	×	×	√	×	×
25	2017	Flood	District	Model	Primary	Qn	√	√	√	×	×
26	2017	Cyclone	Household	Index	Both	Both	×	×	×	√	×
27	2017	Cyclone	Household	Index	Primary	Both	√	×	×	×	×
28	2017	Salinity	Household	Scorecard	Both	Both	√	×	×	√	×
29	2018	Cyclone	Community	Index	Both	Both	√	×	×	√	×
30	2018	Cyclone	Household	Scorecard	Both	Ql	×	×	√	×	×
31	2018	Cyclone	City	Toolkit	Both	Both	√	√	×	×	×
32	2018	Multiple	Household	Toolkit	Both	Both	√	×	×	√	×
33	2018	Cyclone	Community	Scorecard	Both	Both	×	×	×	√	×
34	2018	Multiple	Household	Scorecard	Primary	Ql	×	×	√	×	×
35	2018	Multiple	Household	Scorecard	Primary	Both	×	×	√	×	×
36	2018	Water	Household	Scorecard	Both	Both	√	√	√	√	×
37	2018	Multiple	Household	Scorecard	Primary	Both	×	×	√	×	×
38	2018	Multiple	Household	Scorecard	Primary	Ql	√	×	×	√	×

[a] See detailed sample literature list with title and author (s) in supplementary information (Table S2). Ql = Qualitative, Qn = Quantitative.

techniques have been addressed well in most of the studies, but comparatively fewer studies have addressed strengths and weaknesses. However, much less attention has been paid to addressing ongoing communications and changing patterns of the resilience status over different time horizons.

3.3. Evaluation against the framework

3.3.1. Comprehensiveness of the resilience criteria

Incorporating multiple dimensions and aspects in a unifying framework has been emphasized in earlier investigations of the resilience assessment process. Hence, following a thorough review process, criteria used in the selected resilience studies were identified and grouped into five common dimensions: environmental, social, economic, built environment and infrastructure, and institutional, as has been done by other scholars (Alshehri et al., 2014; Cutter, 2016; Sharifi, 2016).

Information presented in Table 3 and Fig. 5 shows that a majority of the resilience assessment studies were broad and incorporated multiple dimensions, but that only a few of them covered all five dimensions. A considerable number of studies relied on a single dimension of resilience—a major drawback of the assessments. On average, the social dimension got maximum attention, followed by economic, infrastructural, institutional, and environmental dimensions. However, it is evident that the environmental dimension has received much less attention in the current resilience studies (Fig. 6), despite its significant role in building resilience. Earlier evidence has indicated that efficient management of natural resources, protection of ecosystems, and availability of natural assets can enhance shock absorption capacity and ensure quick recovery from losses (Cutter et al., 2008; Hughes et al., 2013; Burton, 2014). Hence, the minimal inclusion of environmental dimensions in the resilience assessment studies—especially in a country like Bangladesh, which is recognized as among the countries most vulnerable to experiencing negative consequences of natural hazards—can significantly undermine the resilience of the coastal people. Further, the impressive achievement in reducing disaster risks by holistic efforts from government organizations, NGOs, other multilateral supporting agencies, has not been properly reflected in the selected resilience assessment studies.

In order to see the level of compliance with the globally used resilience dimensions, the findings of this study on resilience criteria were compared with the findings of Sharifi (2016), which included 36 community resilience assessment tools developed and implemented globally. The spider diagram (Fig. 6) shows that a similar level of attention has been given between resilience studies of Bangladesh (BD) and those of the rest of the world (global) in terms of economic, infrastructural, and environmental dimensions, but wide variations were evident in institutional and social dimensions. Of the RA studies in the coastal region of Bangladesh, institutional criteria got comparatively less attention than globally conducted assessment processes that argued that despite many NGOs, donor agencies, and multilateral organizations being involved in coastal rehabilitation and livelihood projects, their role was not properly investigated. However, integrating multiple agents and

Table 3
Persistently used criteria in the selected RA studies.

Dimension	Sub-dimension	Most frequently used criteria
Environmental	Natural assets (environment and resources)	Ecosystem monitoring and protection, access and availability of natural resources, biodiversity conservation, natural resource management, mangrove restoration and management
Social	Social structure	Population, land and home ownership, education, age, gender
	Community bonds, social support, and social institutions	Connectedness, empowerment, social safety net mechanisms, organizational participation, bonding and bridging networks
	Safety and wellbeing	Health care, access to physicians
	Equity and diversity	Access to basic needs, infrastructure and services, services for disabled persons
	Local culture & traditions	Past experience with disaster recovery, learning from the past, cultural and historical preservation, indigenous knowledge and traditions
Economic	Structure	Income, occupation, employment opportunity
	Security and stability	Savings, insurance, access to community resources
	Dynamism	Diverse livelihood opportunity, income sources in critical periods
Built environment and infrastructure	Robustness and redundancy of critical infrastructure	Housing structure; redundancy, robustness and fortification of critical infrastructure, vital assets and ecosystems; location of critical infrastructure; shelter and relief facilities and services
	Infrastructure efficiency	Regular monitoring, maintenance, and upgrade of critical infrastructure; retrofit, renewal, and refurbishment of the built environment; promotion of efficient infrastructure
	Transportation infrastructure	Road networks; capacity, safety, reliability, connectivity, and efficiency of transportation
	ICT infrastructure	Early warning; weather forecasting; access to information sources
	Land use and urban design	Accessibility of basic needs and services over time (food, water, shelter, energy, health)
Institutional	Leadership and participation	Leadership development; transparency, accountability and corruption in the service sectors; multi-stakeholder planning and decision making
	Management of resources	Efficient management of resources (funds, staff), population with emergency response and recovery skills (first aid)
	Contingency, emergency, and recovery planning	Early warning, evacuation plan, and access to evacuation information; relief
	Collaboration	Cross-sector collaboration and partnership among organizations
	Research & Development	Innovation and technology update
	Education and training	Educational program for awareness, training for skill development; and preparedness

forces can better influence any efforts toward boosting community resilience (Sharifi, 2016).

3.3.2. Cross-scale relationships

Resilience is a multi-scalar concept, and changes at one scale may affect the other scales. Hence, it is unrealistic to assess resilience of a community in isolation from the upper and lower scales in the hierarchy. Each community is an open system, nested within a hierarchy of spatial scales, and its resilience is influenced by dynamic relationships and dependencies that may exist between different scales (Frankenberger et al., 2013; Constas et al., 2014; Chelleri et al., 2015; Quinlan et al., 2015). As shown in Table 4 and Fig. S5, the notion of cross-scalar relationships and panarchy of scales was mostly overlooked in the selected studies; only eight studies considered dynamic hierarchical systems of scale. However, emphasis should have been given to understanding how resilience intervention affects or is affected by actions, processes, dynamics and interventions compared to other scales of measurement (Alliance, 2007; Davis et al., 2013; Frankenberger et al., 2013).

The landscape focus of most of the RA studies (57.9%) spanned rural areas; 34.2% of the articles spanned multiple landscapes, and only 7.9% of the studies spanned urban landscapes (Fig. S6). In the context of Bangladesh, it is perceived that rural peoples are more disadvantaged, as they live on the periphery and are more exposed to natural hazards and more vulnerable than any other group—perceptions that have led researchers from diverse disciplines to conduct their studies in rural areas. Moreover, evidence has shown that multilateral agencies and NGOs are more focused on rural areas (SDC, 2009; Practical Action, 2009; GIZ, 2014). However, none of the studies focused on peri-urban areas, possibly because the term peri-urban is difficult to conceptualize, especially from the perspective of Bangladesh. Among the 38 resilience assessment studies examined, a majority were spread across exposed coastal regions (Fig. 7), with the highest number in the southwestern region. The interior coastal region and the central region had the lowest representations. That most of the RAs were conducted in the exposed coastal regions, with significantly fewer in interior regions, indicates a skewed focus on areas that are vulnerable to multiple hazards (cyclones, SLR, salinity intrusions).

3.3.3. Temporal dynamism

The significance of a temporal continuum in resilience assessment is well recognized (Norris et al., 2008), and usually every stage of resilience measurement should intractably link to what precedes and what succeeds it (Sharifi, 2016). Yet our findings revealed that only 8% of the studies took all phases of the temporal continuum into consideration, although 42% accounted for past and present conditions (Table 4, Fig. S7). The majority (47%) of the studies focused on only the present conditions, and usually overlooked the evolutionary and emergent nature of resilience; hence their output simply reflects 'a snapshot in time' view of resilience (Schipper and Langston, 2015). And almost no studies accounted for the present and future portions of the continuum; only Ahmed et al. (2016) included this perspective.

3.3.4. Uncertainties

Setting long-term goals for resilience becomes a very challenging task, due to uncertainties in climate models, which are constantly shifting their adaptation thresholds. To address this problem, an evolutionary process is required to predict climate scenarios, keeping in mind that resilience is an emergent feature of multifaceted adaptive socio-ecological systems (Folke et al., 2010; Collier et al., 2013; Watson et al., 2014; Schipper and Langston, 2015; Levine, 2014). The compliance of addressing uncertainty in the selected resilience studies was evaluated by the presence or absence of an iterative approach and scenario development. Uncertainty in the decision-making process can be minimized through a continuous and iterative process (Sharifi, 2016) whereas future challenges can be addressed through planning severity scenarios (UNISDR, 2014). Moreover, scenario making, along with perfect elaboration of alternate states, can enhance the performance of the communities in the event of disaster and enable them to understand their strengths and weaknesses (Monaghan et al., 2014). Findings revealed that almost 90% of the RA studies paid attention to conducting assessments at regular intervals (Table 4 and Fig. S8). They did this

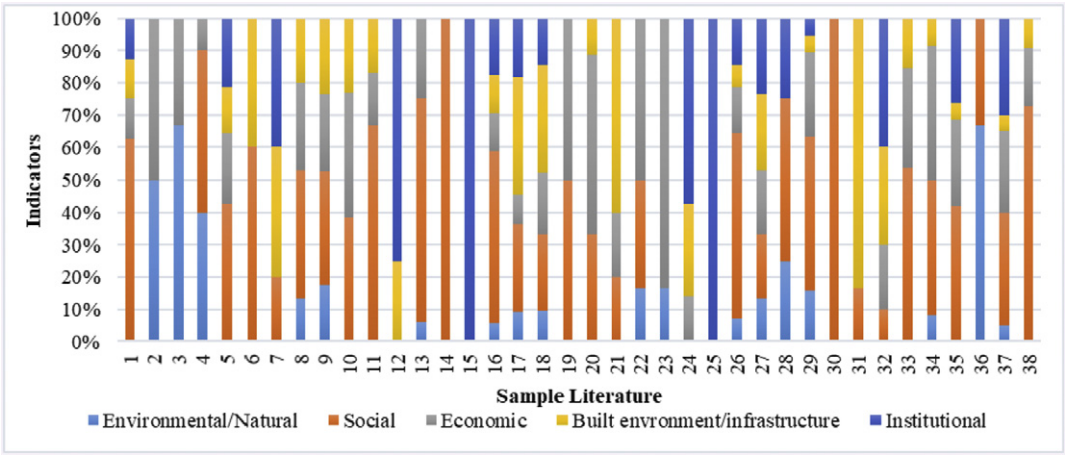

Fig. 5. Percentage distribution of the frequency of criteria following different dimensions.

through measures such as regular monitoring and continuous update of baselines and threshold values (Sharifuzzaman et al., 2018; Islam and Walkerden, 2014; Ayeb-Karlsson et al., 2016; Islam and Walkerden, 2015; Ray-Bennett et al., 2016). Of the RA studies, only one paid attention to scenario making and modeling alternate states to determine how the BCR (benefit cost ratio) of V2R (vulnerability to resilience) programs can shift when critical thresholds are crossed (Ahmed et al., 2016).

3.3.5. Participatory approaches

The adoption of participatory approaches in the development and implementation of resilience assessment is important to emphasize because of its multiple benefits. As shown in Table 4 and Fig. S9, only about 8% of the selected resilience studies followed participatory methods in the development of assessment tools, whereas 55% of the studies followed different participatory methods to ensure multiple stakeholder participation in the assessment process. However, emphasis should have been given for adopting participatory approaches in all stages of measurement, from the development of tools to using the tools, identifying priorities, and also developing action plans based on the assessment results (Sharifi, 2016). Participatory approaches like focus group discussion (FGD) was more frequently used in the selected resilience studies. However, few studies adopted multiple participatory approaches like FGD, social mapping, resource mapping, Venn diagrams, institutional relations through mapping, or climate hazards mapping, in their assessment process (Akter, 2015). Local peoples' experience and know-how has sometimes been incorporated, though, through the active participation of community people in developing resilient housing and critical infrastructure (Ali et al., 2018; Sameen, 2018; Mallick, 2013; Moles et al., 2014).

3.3.6. Action plan

One of the most important purposes of resilience assessment is to enable communities to identify gaps and to prioritize concerns, also in order to ascertain leverage points for intervention and remedial action (Sharifi, 2016). Findings revealed that in about 87% of the resilience studies attention was paid to developing action plans for enhancing resilience (Table 4 and Fig. S10). Although policy formulation in scientific articles is common, in this research a number of the RA studies explicitly stated that their findings were intended to enhance the effectiveness of resilience-building capacity and adaptation planning (e.g. Sameen, 2018; Akter and Mallick, 2013; Islam and Walkerden, 2015; Hassan et al., 2013; Rahman, 2012; Yu et al., 2017; Ahsan and Takeuchi, 2015). Al-Maruf (2017) adopted the technique of identifying the influencing factors of community resilience and suggested including them as a basis for an action plan. On the other hand, limitations in the local governments' and NGOs' services were identified, and specific strategies were suggested to overcome these constraints (Islam et al., 2017; Islam and Walkerden, 2015). Furthermore, local peoples' experiences and lessons were considered (Ali et al., 2018; Sameen, 2018; Mallick, 2013; Moles et al., 2014) in developing adaptive housing and

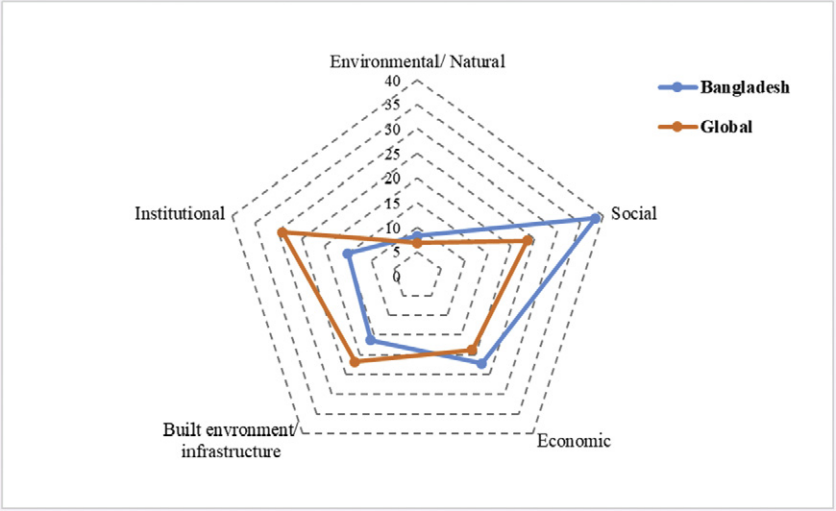

Fig. 6. Comparison of average frequency of five major dimensions between Bangladesh and the rest of the world (global). Global data were collected from Sharifi (2016) who has investigated 36 community resilience assessment tools developed and implemented worldwide.

Table 4
Extent of compliance with criteria outlined in the framework for analysis.

Sample literature	Presentation of results				Time horizon			Hierarchy			Alternate state	Iterative process	Participatory development	Participatory assessment	Action plan
	On-going communication	Strength/weaknesses	Changes over time	Illustration techniques	Past	Present	Future	Large	Focal	Small					
1	√	√	×	×	×	√	×	√	√	√	×	×	×	√	√
2	√	×	×	√	√	√	×	√	√	√	×	×	×	√	√
3	×	√	×	×	√	√	×	×	√	×	×	×	×	×	√
4	×	×	√	√	√	√	×	×	√	√	×	×	×	×	×
5	√	√	×	√	√	√	×	×	√	√	×	×	×	×	√
6	×	√	×	√	×	√	×	×	√		×	×	√	√	√
7	×	√	√	√	×	√	×	×	√	√	×	×	×	×	√
8	×	√	√	√	√	√	×	×	√	√	×	×	×	×	√
9	√	×	×	√	√	√	×	×	√	√	×	×	×	×	√
10	√	√	×	√	×	√	×	×	√	×	×	×	×	√	√
11	×	√	×	√	√	√	×	×	√	×	×	×	×	×	×
12	×	×	×	√	√	√	√	×	√	√	×	×	√	√	√
13	×	×	×	×	×	√	×	×	√	×	×	×	×	√	√
14	×	×	×	×	×	√	×	√	√	√	×	×	×	√	√
15	√	√	×	√	×	√	×	×	√	√	×	×	×	×	√
16	√	√	√	√	√	√	×	√	√	√	×	×	×	×	√
17	×	×	×	√	×	√	×	√	√	×	×	×	×	×	√
18	√	√	√	√	×	√	×	×	√	√	×	×	×	√	√
19	√	√	×	×	×	√	×	√	√	√	×	×	×	√	√
20	√	√	√	√	√	√	√	×	√	√	√	×	×	√	√
21	√	√	×	√	×	√	×	√	√	√	×	×	×	×	√
22	×	×	×	√	×	√	×	×	√	√	×	×	×	√	×
23	√	√	×	×	√	√	×	×	√	×	×	×	×	×	×
24	√	√	×	√	×	√	×	×	√	×	×	×	×	√	√
25	√	√	×	√	√	√	√	×	√	×	√	√	×	×	√
26	√	√	×	√	×	√	×	√	√	√	×	×	×	√	√
27	×	×	×	√	×	√	×	×	√	×	×	×	×	√	√
28	√	√	√	√	√	√	×	√	√	√	×	×	×	√	√
29	√	√	×	√	√	√	×	×	√	√	×	×	×	√	√
30	×	×	×	√	×	√	×	√	√	×	×	×	√	√	√
31	×	×	×	×	√	√	×	×	√	×	×	×	×	×	×
32	×	√	×	×	×	√	×	×	√	√	×	×	×	×	√
33	√	√	√	√	×	√	×	×	√	√	×	×	×	√	√
34	×	√	×	√	×	√	×	×	√	×	×	×	×	√	√
35	×	√	×	√	×	√	×	×	√	×	×	×	×	√	√
36	√	×	×	√	×	√	×	×	√	×	×	×	×	×	√
37	×	×	×	√	×	√	×	×	√	×	×	×	×	√	√
38	√	√	√	√	√	√	×	×	√	×	×	×	×	×	×

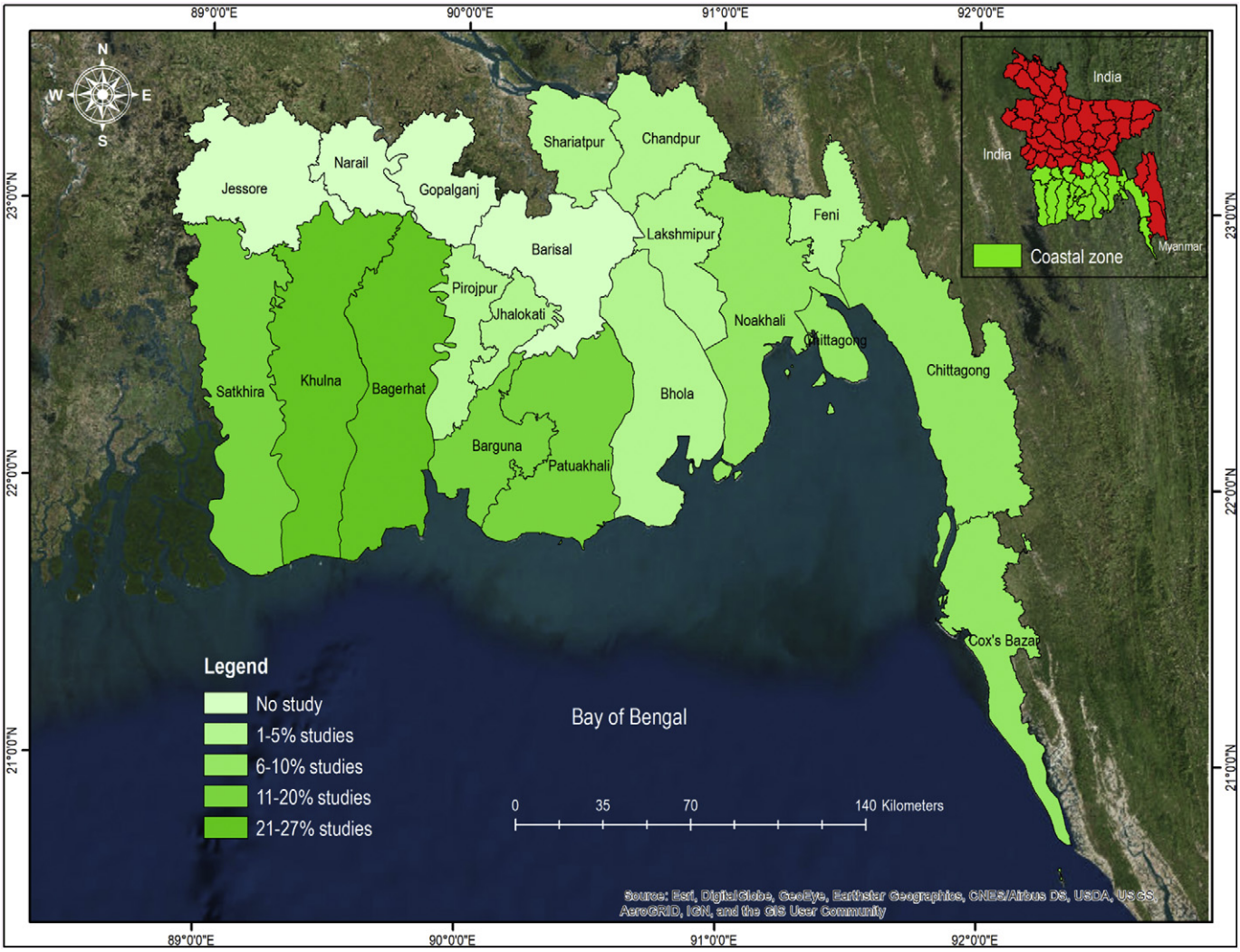

Fig. 7. Distribution of RA studies across the coastal districts of Bangladesh.

critical infrastructures that can be included in the action plan for strengthening the resilience capacity of coastal communities.

3.4. Implications of assessment tools on findings and research gaps

Through qualitative investigation of the findings, discussion, and conclusion sections, efforts were made to examine whether the resilience assessment exercise expected to further the conceptual understanding of resilience, the methodological features of assessing resilience, policy formulation, or practice. After carefully analyzing all the articles, we arrived at several categories of resilience assessment studies. First, a considerable number of RA studies focused on identifying the drivers of resilience (e.g. Rahman and Li, 2018; Islam et al., 2017; Ahsan and Takeuchi, 2015). Some studies contributed to further methodological development for assessing resilience. For example, Ayeb-Karlsson et al. (2016) developed a resilience building approach called "People Centered Approach" whereas Mallick (2013) used a 'Participatory Planning Approach' for increasing the capacity of community for building resilient houses. Studies using models, such as Yu et al. (2017), successfully incorporated institutions and collective actions with a socio-hydrological model for flood resilience assessment. Furthermore, some of the RA studies focused on categorizing who is more resilient by comparing different social structures: e.g., gendered resilience, by Sameen (2018), and caste-driven resilience, by Ali et al. (2018). Other studies focused on specific places, community groups, or ecological systems, like Kais and Islam (2017), who conducted a study on a fisheries community. Finally, some RA studies discussed the implications of their findings on further resilience conceptualization, and used other framings to understand resilience. For example, everyday health security practices as disaster resilience, an approach taken by Ray-Bennett et al. (2016) and, Matin and Taylor (2015), integrated socio-ecological and behavioral theories to address community resilience.

Efforts have also been made to identify the gaps in current resilience research in Bangladesh. First, environmental and institutional dimensions of resilience assessment received less attention than other dimensions, in the selected RA studies. In this connection, global research communication incorporated criteria like erosion protection, protection of wetlands and watersheds, availability and access to natural resources, reduction of pollution, quality of resources and resource recycling (Sharifi, 2016) which has not yet reflected in the current literature. Besides, information on the policies, plans, projects, and programs of multilateral governmental bodies, along with those of NGOs, donor agencies, and multi-national companies, should be incorporated, to strengthen the institutional dimension. Secondly, most of the RA studies measured resilience at one specific time after a disaster event, with no attention to temporal resilience or past trajectories of change. Thirdly, most of the RAs were conducted at the household scale, and seldom was emphasis given toward any higher-order scale. Moreover, multi-scalar assessments of resilience were not well emphasized in any of

the current RA studies. Furthermore, a considerable number of RA studies did not involve participation of all categories of stakeholders in the development and assessment process. Finally, uncertainty issues of resilience assessment were totally overlooked in the selected RA studies.

4. Discussion

With advancing global climate change, the increasing needs for resilience assessment tools has resulted in widespread popularity for these assessments, by the global research community, over the past few decades, and a growing number of tools have been developed and implemented worldwide. Further, there is a growing recognition of the need for content analysis of resilience assessment tools, in order to improve resilience capacity. But no such content analysis study has yet been carried out, on the resilience assessment studies being conducted in the coastal regions of Bangladesh. In response to this need, 38 selected RA studies were critically examined in this evaluation. This review highlights the importance of conceptual understanding of resilience by the authors, addressing of multiple dimensions of resilience, taking account of cross-scale relationships, capturing temporal dynamism, addressing uncertainties, employing participatory approaches and developing action plans. This paper affords the first comprehensive review of RA tools for the coastal regions of Bangladesh, having examined the conceptual and methodological extensiveness of these studies.

4.1. Conceptualization of resilience

The findings demonstrate that in the coastal region of Bangladesh, resilience is conceptualized in multiple ways where a number of RAs constructed in the field of food security, poverty reduction and livelihoods, as their core theoretical lineages. We strongly argue that accepted conceptualizations of resilience are predisposed to certain methodological approaches, an assumption that has implications for identifying who is resilient and how they become resilient. However, surprisingly, the majority of the selected studies failed to include any definition of resilience, in their assessment process. Such vagueness in the field of resilience assessment could hinder the effectiveness of resource allocation and the efficiency of mitigation and adaption practices at the local level—a neglect that can reduce the resilience capacity of the communities (Berke and Godschalk, 2009; Frazier et al., 2013).

4.2. Addressing resilience to what?

Although resilience assessment has been conducted against many different hazards, cyclones are the entity that has received the most emphasis. However, resilience against one type of hazard does not guarantee resilience against other types of hazards (Frankenberger et al., 2013), especially for the coastal region of Bangladesh which are highly exposed to different types of climate disasters and environmental problems such sea level rise, salinity intrusion, flood, erosion and arsenic contamination. Therefore, communities should have plans for responding to multiple types of hazards. Further research should be conducted, using a unified framework, to see whether there are any trade-offs among multiple hazard types. Moreover, more attention should be given to selecting specific indicators, instead of an overly generalized approach that might fail to reflect any hazard-specific issues (Sharifi, 2016).

4.3. Addressing comprehensive dimensions in RAs

In terms of dimensionality of the resilience criteria, the selected RA studies were most inclined to address social capital i.e. society and wellbeing, in measuring resilience capacity. Environmental and institutional dimensions also need to be addressed, however, and more attention should be focused on these criteria. Hence, erosion protection, protection of wetlands and watersheds, availability and access to natural resources, reduction of pollution, quality of resources and resource recycling are some of the environmental criteria currently being recognized in the global scholarships to reflect environmental dimensions of resilience. Moreover, information on the policies, plans, projects, and programs of multilateral governmental bodies, along with those of NGOs, donor agencies, and multi-national companies, should be incorporated, to strengthen the institutional dimension.

4.4. Scalar issues: spatiality and temporality in RAs

An important finding of the study is that RAs in the coastal parts of Bangladesh have failed to conclusively reveal the dynamic nature of resilience by focusing on the interface of forces act over various geographic and temporal scales. In most of the RAs, resilience was assessed as a snapshot, thus rendering an inherently dynamic concept static. Such a static view of resilience tends to ignore the highly dynamic nature of the system in which people are situated. In a country like Bangladesh, where government service terms (usually five years) have a strong influence on planning and resource allocation, there are direct repercussions on peoples' coping and adaptation behaviors. Moreover, rapid urbanization is on the verge of dissolving traditional rural-urban binaries, thereby changing the very context within which current RAs are conducted.

The failure of RAs to address and assess resilience as something changing over time is a major limitation of the RAs that have been conducted in the coastal areas of Bangladesh, because comparing baseline conditions with those recorded before a disruptive event provides information on the context in which past intervention measures have been effective in absorbing the shocks, as well as on the extent of recovery following the event. Furthermore, changing climatic conditions make it difficult to create resilience communities by referring only to past and existing conditions; it is also necessary to understand system dynamics and develop strategies for anticipating future changes (Walker and Salt, 2012).

4.5. Addressing uncertainty of climate change in RAs

Whenever thinking about any climate model or framework, the first and foremost question comes forward in a discussion is how uncertainty issues being considered. In this connection, the climate researchers suggested adopting an iterative process through the assessing of alternative states and extreme scenario analysis for addressing future uncertainty in resilience research. However, selected RA literature have failed in effectively applying these strategies to address the uncertainty issue. In particular, there has been negligible assimilation of scenario making in the RAs process. Hence, a meaningful strategy for enhancing adaptive capacity and improving RAs would be to adopt an iterative assessment and recognize that communities need to be adequately aware and flexible to accommodate the impacts of different severe future scenarios (Sharifi and Yamagata, 2016).

4.6. Employing participatory approaches in RAs

Participation of all possible stakeholders needs to be emphasized by global research scholars, in order to enhance community resilience capacity (Norris et al., 2008). A participatory approach, which is open and engages a wide range of stakeholders in the decision-making process, can provide multiple benefits (Sharifi, 2016). Moreover, if participatory approaches can be effectively used in the development and implementation process, it will improve local peoples' understanding of risk and resilience, provide capacity building aids, and afford a platform for sharing knowledge and experiences (Frankenberger et al., 2013; Pfefferbaum et al., 2014; Tyler et al., 2014). Pfefferbaum et al. (2011) suggested bottom-up approaches, where assessment surveys should be conducted before and after an intervention, to determine the impact points. A similar approach was conducted by Ahmed et al.

(2016) to gather information on non-monetary benefits from project interventions using the FGD method. Cutter (2016) claims that a bottom-up approach is better for reflecting community needs and priorities, whereas the top-down method is suitable for standardizing and making comparisons across different scales, due to its data variability and contextual differences. Hence the decision to select appropriate methods largely depends on the purpose of the assessment, and no doubt, in some cases, a combination of both methods can be recommended. Realizing the needs of an iterative process and the limitations of dependence on bottom-up strategies for community inputs, a substantial amount of time and resources is required to reach a consensus on the best method for any particular study (USIOTWSP, 2007; Tyler et al., 2014; Sharifi, 2016). It has also been suggested (Glandon, 2015) that long-term project initiatives and sufficient resource allocation by the investors and funding agencies can ensure more participation of multiple stakeholders.

5. Conclusion

Resilience assessment studies in Bangladesh have been inadequate in number, considering the challenges of coping with the threats of global climate change in this small, deltaic and highly populous country. Furthermore, the authors' incomplete conceptual understanding of resilience is a matter of great concern, casting doubt upon the usefulness of their conclusions for improving resilience-building capacity. Hence, developing countries like Bangladesh need to conduct more resilience studies, keeping pace with the developed economies. Although the majority of the RA studies have been broad in scope and have addressed multiple dimensions, they have failed to incorporate adequate criteria for complying with global trends, especially in regard to the infrastructural and institutional dimensions. Like the ongoing research trend, resilience assessment in Bangladesh has also failed to incorporate an adequate number of criteria to reflect the environmental dimension. Further attention is therefore required, to ensure optimal integration of criteria under these three dimensions. Current RA studies have also failed to adequately reflect the dynamic nature of resilience by addressing the interaction of forces operating over various geographic and temporal scales. Hence, developing methodologies to address dynamic conditions through modeling and projection is another area requiring further work. Furthermore, uncertainty issues of resilience assessment have been totally overlooked in the selected RA studies which indicate the necessity of further studies based on a projection of climate change hazards by modeling and scenario analysis to address the future climate change. To this end, assessment should be conducted through an iterative process, and should acknowledge that communities need to be flexible enough to accommodate the impacts of different types of severe scenarios. Long-term project initiatives and sufficient resource allocation by the government, along with other investors and funding agencies, can ensure more participation of multiple stakeholders and minimize data limitations.

Besides the criticism of being resource intensiveness, a flexible and coding iterative analytical template that we used in SLR may seem to be an area of further drawback. However, the scanning and filtering strategy we used, following PRISMA, facilitated the work and reduced the time invested. Further, searching for literature using search engines (e.g., Google Scholar) potentially directed us toward peer-reviewed articles. Hence we supplemented the search upon consultation with experts, and looked at organizational websites of donors and NGOs, to identify resilience-related project reports. Finally, we used specific search terms that may have excluded some disciplines or resilience assessments. Addressing these limitations, we conclude that the SLR in this study provides a clear understanding about the strengths and weaknesses of current RA studies in Bangladesh, which can be useful to the policy makers and scientists working in the resilience assessment discipline.

Declaration of competing interest

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

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Authors contribution

The authors Shenghui Cui and Muhammad Ziaul Hoque had the original idea for this review study. Muhammad Ziaul Hoque had reviewed and written draft manuscript. The authors Xu Lilai, Imranul Islam, Ghaffar Ali, and Jianxiong Tang had reviewed the draft report very minutely and provided extensive effort in revising and finalizing the manuscript. All authors have read and approved the final paper.

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