Measuring disaster-resilient communities: A case study of coastal communities in Indonesia

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ABSTRACT

Vulnerability reduction and resilience building of communities are central concepts in recent policy debates. Although there are fundamental linkages, and complementarities exist between the two concepts, recent policy and programming has focused more on the latter. It is assumed here that reducing underlying causes of vulnerabilities and their interactions with resilience elements is a prerequisite for obtaining resilience capabilities. An integrated approach, incorporating both the vulnerability and resilience considerations, has been taken while developing an index for measuring disaster-resilient communities. This study outlines a method for measuring community resilience capabilities using process and outcome indicators in 43 coastal communities in Indonesia. An index was developed using ten process and 25 outcome indicators, selected on the basis of the ten steps of the Integrated Community Based Risk Reduction (ICBRR) process, and key characteristics of disaster resilient communities were taken from various literatures. The overall index value of all 43 communities was 63, whereas the process and outcome indicator values were measured as 63 and 61.5 respectively. The core components of this index are process and outcome indicators. The tool has been developed with an assumption that both the process and outcome indicators are equally important in building disaster-resilient communities. The combination of both indicators is an impetus to quality change in the community. Process indicators are important for community understanding, ownership and the sustainability of the programme; whereas outcome indicators are important for the real achievements in terms of community empowerment and capacity development. The process of ICBRR approach varies by country

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and location as per the level of community awareness and organisational strategy. However, core elements such as the formation of community groups, mobilising those groups in risk assessment and planning should be present in all the countries or locations. As this study shows, community resiliency can be measured but any such measurement must be both location- and hazard-specific.

Keywords: community resilience, disaster-resilient community, resilience index, ICBRR model

RESILIENCE AND VULNERABILITY DISCOURSE

Vulnerability reduction, and safety and resilience building of communities are central concepts in recent policy debates.[1–4] Although there are fundamental linkages, and complementarities exist between the two concepts, the focus has been more on the latter in recent policy and programming. The meaning of resilience varies by disciplinary perspective. For most, resilience, with its roots in the Latin word *resilio*, means to adapt and 'bounce back' from a disruptive event.[5] In disaster risk reduction perspective, 'community resilience' is a relative term and refers to an ideal condition of a community in terms of its capacity to anticipate, prepare for, respond to and recover quickly from the impacts of a disaster. The disaster-resilient community is a positive concept, and while complete resiliency is not attainable, every community is striving to achieve it.

Twigg[6] defines a disaster resilient community as a community which has the capacity:

- to absorb stress and destructive forces through resistance or adaptation;
- to manage or maintain certain basic functions and structures during disastrous events; and
- to recover or 'bounce back' with specific behaviour, strategies and measures for risk reduction.

According to Geis,[7] the disaster-resilient community is the safest possible community that we have the knowledge to design and build in a natural hazard context. It seeks to minimise its vulnerability to such hazards by maximising the community capacities through the application of disaster risk reduction (DRR) measures.[8]

Resilience has been used in two ways, one focusing on recovery and return time following a disturbance, the other focusing on how much a system can be disturbed and still persist without changing function. In the last decade, the resilience lens has broadened its application from 'engineering' to 'social-ecological' systems,[9] emphasising three critical features of resilience: persistence, adaptability and transformability.[10] This widening of the concept of resilience has brought within its scope the role of institutions, social capital, leadership, and learning.[11]

Vulnerability is applied as a core concept in disaster risk,[12] in the study of livelihoods and poverty,[13,14] food security[15] and climate change.[16] Gallopin[17] identifies, amid the diverse interpretations of vulnerability, the key concepts of exposure, sensitivity, coping, and adaptive capacity as underpinning many dominant approaches. Downing and Patwardhan[18] indentify the threat, a place or sector, a socio-economic group and the consequences or outcome of vulnerability as the common elements of most approaches to vulnerability.

Many attempts have been made to characterise vulnerability in both theory and practice.[19,20] Increasingly, it is seen as a condition encompassing characteristics of exposure, susceptibility, and coping capacity, shaped by dynamic historical processes, differential entitlements, and political, eco-

nomic and power relations rather than as a direct outcome of a perturbation or stress.[21]

Both the resilience and vulnerability approaches are concerned with how a system responds to change. However, each approach considers systems in quite different ways. The resilience community tends to prefer a systematic approach, whereas the climate change adaptation and the vulnerability communities tend to take an actor-orientated approach. The vulnerability research seeks generally to understand the underlying causes of vulnerability, the scale at which it occurs, and the key actors involved, to identify opportunities for risk reduction, coping, and adaptation. The interactions between longer-term and shorter-term changes are missing in this approach however.[22] Likewise, resilience approaches aimed at securing future sustainability cannot be realised without understanding the socio-political processes and environmental linkages that underpin the foundations of vulnerability.[23] In this research, an integrated approach incorporating both the vulnerability and resilience considerations is taken while developing an index for measuring disaster resilient communities.

ELEMENTS OF COMMUNITY RESILIENCE

A resilient community is able to respond to changes or stress in a positive way, and is able to maintain its core functions as a community despite those stresses.[24] Adger[25] and Folke[26] have given recent perspectives:

(1) resilience as stability: buffer capacity;
(2) resilience as recovery: bouncing back;
(3) resilience as transformation: creativity.

Similarly, Fenton *et al.*[27] have summarised vulnerability as:

(1) vulnerability to a hazard;
(2) vulnerability as a 'state';
(3) vulnerabilities as components of a community.

From both explanations, it is seen that vulnerability and resilience are not mutually exclusive, and rather they are part of one system approach. It is assumed here that reducing underlying causes of vulnerabilities, and interactions between underlying causes of vulnerabilities and resilience elements are prerequisites of obtaining a resilient community state. Both the resilience and vulnerabilities are not static. In order to capture the dynamic processes of vulnerability and resilience, a number of indicators from both the process and outcomes of a community-based disaster risk reduction programme were taken. In this paper however, vulnerability is regarded as a subset of a broader concept of social and ecological resilience. In practice, the community that has the following elements can be considered as resilient to future disaster risks:

(1) community-based organisations with trained volunteers;
(2) hazard, vulnerability and capacity assessment done and socialised in the community;
(3) community risk reduction plans formulated and implemented;
(4) involvement of women, children and vulnerable groups in decision-making processes;
(5) integration of community plans into local development planning;
(6) linkage development with local government agencies, private sectors and non-government organisations;
(7) community awareness on key hazards, their vulnerabilities and capacities, and future disaster risk;
(8) diversified local economy;
(9) safe 'critical facilities';

(10) contingency plans;
(11) external support; and
(12) community early warning system linked to government early warning system.

The adoption of capacity-development processes and the outcomes of such interventions were the bases of measuring community resilience. The processes include formation and strengthening of grassroots level organisations, risk assessment, community participation, risk-mitigation activities and monitoring and evaluation capabilities; and the outcomes of such interventions in the five priority areas of the Hyogo Framework for Action[28] are related to risk knowledge, risk governance, preparedness and response, and risk reduction. A community resilience framework should also include the private sector in disaster risk reduction, in the areas of early warning systems, preparedness, and mitigation planning and programming.

COMMUNITY RISK REDUCTION FRAMEWORK: A CASE FROM INDONESIA

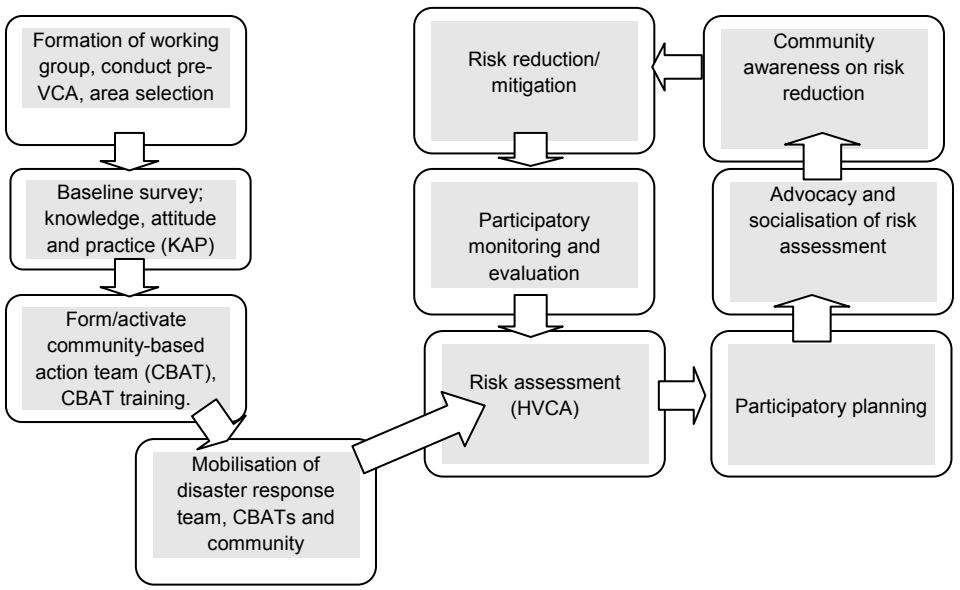
After the devastating tsunami event of 26th December, 2004, a number of community-based approaches were introduced as part of the recovery operations and disaster risk reduction. The Canadian Red Cross (CRC), together with the Indonesian Red Cross Society (PMI) initiated an Integrated Community-Based Risk Reduction (ICBRR — Figure 1) programme in 43 communities of tsunami-affected villages in Aceh and on Nias Islands. The goal of the ICBRR programme was to build disaster-resilient communities in the target villages.

Community-based risk reduction is a process in which at-risk communities actively engage in the assessment and implementation of risk-reduction measures, and monitoring and evaluation of disaster risks in order to reduce their vulnerabilities and enhance their capacities. This means that people are at the heart of decision making. The involvement of the most vulnerable social groups and stakeholders is considered paramount in this process, while the support of the least vulnerable groups is necessary for successful implementation. An ICBRR approach aims to address vulnerability and community risks to reduce disaster impacts by involving other key stakeholders, including the local government agencies, and incorporating all aspects of the disaster management cycle.

A ten-step procedure of ICBRR has been adopted throughout PMI's disaster risk reduction programmes in Indonesia (see Figure 1). The key strengths of the ICBRR process include:[29]

- putting a premium on the organisational capacity of the vulnerable social groups through the formation of community organisations for disaster risk management;
- following a participatory process for risk identification, risk analysis, planning, plan implementation and monitoring and evaluation of activities;
- being highly adaptable and most effective when adapted to match the social, political and cultural environment in specific locations at a specific point in time;
- considering living in communities that are safer from disaster a basic human right;
- being implemented in a gender-sensitive manner;
- recognition of the need for continued innovation: the risk management-related needs of communities may change in different cultural contexts and over time, so new strategies will

Figure 1 ICBRR model



always need to be adopted to meet those needs;
- providing an opportunity to share resources from different stakeholders and complement the limited resources of the government; and
- contributing to empowerment of community members, and being able to engender pride, dignity, self-confidence, a desire to learn more and a willingness to seek improvements in their life.

An integrated approach to reducing disaster risks includes the incorporation of all aspects of the disaster-management cycle, including: response, recovery and prevention; tackling multiple hazards; dealing with multiple stakeholders; and integrating disaster-risk reduction activities into the development plans of a country.

Key accomplishments

The formation and strengthening of community-based action teams (CBATs), as well as conducting risk assessments and implementing risk-reduction plans in all the programme villages were some of the key achievements of the ICBRR programme (Table 1). As the programme is process-oriented and based on capacity-building intervention, the ten-step ICBRR model was institutionalised and CBATs were mobilised for the community disaster-risk assessment, action planning and implementation of micro-level risk-reduction projects.

Risk assessment and risk-reduction plans

Flood, earthquake, epidemics, tsunami and landslides are among the biggest natural hazards in Aceh and Nias. CBAT members mobilised communities to conduct a baseline survey and a hazard, vulnerability and capacity assessment (HVCA) in all the programme villages. Local elected authorities, Red Cross volunteers and community members, along with CBATs, participated in preparing hazard maps and analysing specific disaster risks for their community.

The major community vulnerabilities

Table 1: Key performance indicators and achievements

Number	*Indicators*	*Planned (Number)*	*Achieved (%)*
1	Community-Based Action Teams (CBATs) are able to recruit, train, support and motivate community volunteers for DRR and work together to do so	43	100
2	CBATs trained as Red Cross volunteers	860	100
3	Training courses organised for CBATs	43	100
4	Persons in the community (both villages and schools) with knowledge of hazards, vulnerability and risk	6,000	87
5	Hazard, vulnerability and capacity assessment (HVCA) completed in participatory process including representatives of all vulnerable groups	43	100
6	CBAT members, including vulnerable groups and women, involved in the plan-formulation process	1,060	100
7	Villages submitted proposals for the community risk-reduction plan implementation	43	100
8	Programme support villages linked with PMI Early Warning System (EWS)	43	100
9	Number of PMI staff, volunteers and potential facilitators received training	432	100
10	EWS focal points at CBATs appointed and trained	43	100
11	Implementation of risk reduction plans by CBATs	43	95

were identified as: lack of trained volunteers on disaster response and risk assessment; few appropriate community organisations to deal with disaster and vulnerability issues, lack of proper drainage systems, no stock of disaster-preparedness kits including kitchen sets, and no diverse livelihood options.

As flooding was the most important and most frequently recurring hazard, a majority of the risk mitigation activities were reduction of flood impacts. Construction of drainage, tree planting along the river and coastal areas, constructing escape routes, providing disaster-response kits including kitchen sets, and evacuation centres and community-awareness training were among the needs identified by the communities.

Sectoral integration

ICBRR was the one of four CRC-supported programmes in the communities where CRC built houses. Other sectoral programmes included livelihoods, environmental health, and shelter. The key intersectoral activities for overall risk mitigation in the communities were: development of the baseline survey questionnaire; implementation of public health activities, such as sanitation, health education and solid waste management; support for the relocation of the internally displaced people (IDPs); and livelihood activities including construction of escape routes, provision of transitional shelter, arrangement of disaster preparedness kits and staff training.

Involvement of local government

Local government, including *Pak Camat* (sub-district head) and *Pak Gechik* (village head), were involved from the beginning of programme implementation. Basic orientation on the programme was provided to all the village heads and housing committee coordinators, along with representatives of the key line agencies. Village heads were present and gave guidance

Table 2: Outcome indicators

Priority areas as per Hyogo Framework for Action (HFA)	*Key outcome indicators*
Risk governance (1)	1. A community organisation 2. Access or influence of vulnerable groups to policy making and programming 3. Linkage with the local government agencies, private sectors and other NGOs/stakeholders 4. Ownership of risk community reduction plans by local government planning 5. Capacity of CBATs and CDMCs in disaster response and risk mitigation 6. Popular participation (linkage with PMI, private sector, NGOs, civil society and other agencies.
Risk assessment (5)	1. Conduct of baseline survey, risk assessment (HVCA), establishment of disaster database. 2. Knowledge of risk and risk-reduction system among CBATs, community and local governments 3. Level of participation of vulnerable groups in the risk assessment
Knowledge and education (2)	1. Trained volunteers and community members 2. Awareness-raising materials and activities 3. Formulation of standard operating procedure (SOP) for early warning system and emergency communications 4. DRR activities in schools 5. Documentation of traditional, existing DRR practices and early warning systems in the community
Risk management and vulnerability reduction (4)	1. A DRR and disaster-preparedness plan 2. Implementation of RR plans 3. Monitoring and evaluation system in place 4. Quality of houses, physical location 5. Diversified local economy (livelihoods) 6. Environment and natural resources management 7. Social protection (health, livelihoods etc) provisions
Disaster preparedness and response (3)	1. An effective community early warning system 2. Contingency plans 3. Volunteerism/participation 4. PMI (SATGANA) and CBAT capacity

Note: The figures in parentheses indicate the weight of that particular area among five priority areas of HFA

during the formation of Community Disaster Management Committee (CDMC) and CBATs in all the villages. No intervention was made into the agenda and procedure however. The HVCA results and risk-reduction plans were shared among with the district level stakeholders.

Involvement of women and the elderly

More than 43 per cent of those in the training and 48 per cent in the CBATs are women. As CBAT members are to be mobilised in times of disaster for response activities, most of the CBAT members are young and energetic. CDMC members on the other hand, are elderly and experienced people who can guide the youth and provide supervisory and advisory roles in the community. In partnership with HelpAge International, a manual was prepared for integrating the needs and concerns of the elderly into the community risk-reduction planning, and was used in vulnerability and capacity assessment, and programme planning.

Outcome indicators

Altogether 25 outcome indicators under five priority areas of the Hyogo Framework for Action were selected to measure the outcome of the disaster-risk reduction interventions. It was assumed that both the process and outcome indicators constituted the elements of the resilient communities (see Table 2).

COMMUNITY RESILIENCE INDEX: A MEASURE OF RESILIENCE

A conceptual framework was developed to measure the disaster-resilient communities using process and outcome indicators. For the assessment of process indicators, the ten steps of the ICBRR were weighted 'W' ($i = 1$ to 10) based on their importance in the overall risk reduction. For the value of each step a rank 'R' ($j = 0$ to 5) was assigned to each, based on its status of achievement.

$$\text{Process score (PS)} = \sum_{i=1,j=0}^{i=10,j=5} \mathrm{P}(\mathbf{W}i^{*}\mathbf{R}j) \quad \text{(i)}$$

The values and weights were given by the author based on their relative importance and his experience while designing and implementing the programme. The weight and scores for the values were verified and adjusted in consultation with the community members. The five point scores given for value are expected to minimise the personal error of the evaluators.

Weight (rank) was given to the process indicators as per their importance in the overall disaster-risk reduction; whereas their corresponding values were given based on the completion of the task, quality in terms of participation of stakeholders, clarity of the process to the stakeholders, and the level of outputs. Similarly, outcome indicators were identified based on the programme proposals and United Nations International Strategy for Disaster Reduction (UNISDR). The five priority areas of the Hyogo Framework for Action[30] provided the basis of choosing the outcome indicators. The priority areas are:

(1) governance;
(2) risk assessment;
(3) knowledge and education;
(4) risk management and vulnerability reduction;
(5) disaster preparedness and response.

For the calculation of the outcome index, ranking and values were given in a similar way to that of process indicators. The measurement of community resiliency was done using the following index:

For the calculation of the outcome index, ranking and values were given in a similar way to that of process indicators.

$$\text{Outcome score (OS)} = \sum_{i=1,j=0}^{i=25,j=5} \mathrm{O}(\mathbf{W}i^{*}\mathbf{R}j) \quad \text{(ii)}$$

Hence, overall resilience score can be calculated by summing up both the process and outcome scores:

$$\text{Resilience score (RS)} = (\mathrm{PS} + \mathrm{OS})/2 \quad \text{(iii)}$$

The measurement of community resiliency was done using the following index see equation (iv) below:

Where, OS = Overall score expressed in percentage

$$\text{Resilience index (RI)} = [\sum_{i=1,i=0}^{i=10,j=5} \mathbf{P}(\mathbf{W}i^{*}\mathbf{R}j) + \sum_{i=1,i=0}^{i=25,j=5} \mathbf{O}(\mathbf{W}i^{*}\mathbf{R}j)]/2 \quad \text{(iv)}$$

P = process indicators ranging from 1 to 10
O = Outcome indicators ranging from 1 to 25
W*i* = Weight of process and outcome indicators *i*
R*j* = Rank or value of process and outcome indicators *j*

Altogether, ten process and 25 outcome indicators were identified in order to measure the level of community resilience. The overall index value of all 43 communities was 63, whereas the process and outcome indicator values were 63 and 61.5 respectively.

This tool can be used to measure community resilience as an outcome of a community-based DRR intervention. It can be used for baseline survey, progress monitoring of the Community Based Disaster Risk Reduction (CBDRR) programme, and benchmarking for programme evaluation. The core components of this tool are process and outcome standards. The tool has been developed with an assumption that both the process and outcome standards are equally important in building disaster-resilient communities. The combination of both standards is an impetus to the quality change in the community. Process indicators are important for community understanding, ownership and the sustainability of the programme; whereas outcome indicators are important for the real achievements in terms of community empowerment and capacity building.

SOME EXAMPLES

Although the community resilience index could not be tested in the large-scale disasters such as the Indian Ocean tsunami of December 2004, some examples of increased community resilience could be observed however. The effective functioning of institutional mechanisms and emergency communication systems at the community level are some of the initial indications.

CBAT members are considered PMI volunteers at community level. They are the trained cadres at community level and are first respondents along with community members in times of disaster events. During the flooding of January 2008 in Aceh Besar, CBAT members were the first to inform PMI chapter and branches. CBAT members informed branch staff at around 10 pm about the increasing flood level, and PMI Aceh chapter and Aceh Besar branch could immediately mobilise volunteers and staff to assess the situation and provide necessary support to the vulnerable people.

PMI's early warning system has been effective in communicating in the event of disasters. During the flooding of December 2007/January 2008 in six districts of Aceh province, PMI radio systems were the only means of communication for government, as well as aid agencies and humanitarian organisations. Telecommunications and road access were disrupted, and even helicopters could not land in the flood-affected areas. PMI Aceh chapter received messages from radio systems from the PMI branches and mobilised volunteers and aid agencies to provide relief support. Similarly, during the earthquake in mid-2008 on Simulue Island, the PMI radio system was the only means of communication for PMI and government agencies. PMI Aceh chapter provided information to the provincial government in order to provide support to those in need.

Formulation of community risk-reduction plans based on the participatory disaster-risk assessment by the community members, coordination with local government and non-government agencies, mobilisation of vulnerable community members in the implementation of those

plans and operation of community-based early warning are clear indications of increased community resilience in the study area.

THE WAY FORWARD

The concept of a disaster-resilient community can best be described by the processes the community follows, and the outcomes it achieves. The process of the CBDRR approach varies by country and location according to the level of community awareness and organisational strategy, and can therefore be modified accordingly. However, core elements such as the formation of community groups, mobilising those groups in risk assessment and community risk-reduction planning should be present in all the countries or locations. As this study shows, community resiliency can be measured; however, any such measurement must be both location- and hazard-specific. CBATs are increasingly becoming the backbone of the PMI system at community level. Institutionalising CBATs could be the next step in making communities more resilient to future disaster risk.

REFERENCES

(1) Millennium Ecosystem Assessment (MA) (2005) 'Ecosystems and human well-being: synthesis', Island Press, Washington DC.

(2) International Federation of Red Cross and Red Crescent Societies (IFRC) (1996) 'Vulnerability and capacity assessment toolbox', IFRC, Geneva.

(3) Janssen, M. A. (2007) 'Synthesis: an update on the scholarly networks on resilience, vulnerability, and adaptation within the human dimensions of global environmental change', *Ecology and Society,* Vol. 12, No. 2, Art. 9, pp. 1–9, available at: http:www.ecologyandsociety.org/col12/iss2/art9/ (accessed 31st July, 2011).

(4) Miller, F., Osbahr, H., Boyd, E., Thomalla, F., Bharwani, S., Ziervogel, G.' Walker, B., Birkmann, J., Van der Leeuw, S., Rockstrom, J., Hinkel, J., Downing, T., Folke, C. and Nelson, D. (2010) 'Resilience and Vulnerability: Complementary or Conflicting Concepts?' *Ecology and Society*, Vol. 15., No. 3, pp. 1–25.

(5) Klein, R. J. T., Nicholls, R. J., and Thomalla, F. (2003) 'Resilience to natural hazards: How useful is this concept?' *Global Environmental Change, Part B: Environmental Hazards*, Vol 51, Nos. 1 and 2, pp. 35–45; S. Manyena, (2006) 'The Concept of Resilience Revisited', Disasters, Vol. 30, No. 4 pp. 434–450.

(6) Twigg, J. (2007) 'Characteristics of a Disaster-resilient Community: A Guidance Note' for the DFID Disaster Risk Reduction Interagency Coordination Group, London.

(7) Geis, D. E. (2000) 'By Design: the Disaster Resistant and Quality-of-Life Community', *Natural Hazards Review,* Vol. 1, No. 3, pp. 151–160.

(8) Twigg, ref. 6 above.

(9) Berkes, F., and Folke, C. (1998) 'Linking social and ecological systems: Management practices and social mechanisms for building resilience', Cambridge University Press, Cambridge.

(10) Folke, C. (2006) 'Resilience: The emergence of a perspective for social-ecological systems analyses', *Global Environmental Change*, Vol. 16, No. 3, pp. 253–267.

(11) Miller *et al.* ref. 4 above.

(12) Burton, I., Kates, R. W. and White, G. F. (1978) 'The Environment as Hazard', Oxford University Press, Oxford.

(13) Chambers, R. (1989) 'Editorial introduction: vulnerability, coping and policy', *Institute of Development Studies Bulletin*, Vol. 20, No. 2, pp. 1–7.

(14) Chambers, R., and Conway, G. R. (1992) 'Sustainable rural livelihoods: practical concepts for the 21st century', IDS Discussion Paper 296, Institute of Development Studies, University of Sussex, Brighton.

(15) Sen, A. (1981) 'Poverty and famines: An essay on entitlement and deprivation', Oxford University Press, Oxford.
(16) Klein, R. J. T. and Nicholas, R. J. (1999) 'Assessment of coastal vulnerability to climate change', *Ambio*, Vol. 28, No. 2, pp. 182–187.
(17) Gallopin, G. C. (2006) 'Linkages between vulnerability, resilience and adaptive capacity', *Global Environmental Change*, Vol. 16, No. 3, pp. 293–303.
(18) Downing, T. and Patwardhan, A. (2002) 'Vulnerability assessment for climate adaptation', Adaptation Planning Framework technical paper, Oxford.
(19) Birkmann, J. (2006) 'Measuring vulnerability to natural hazards — towards disaster resilient societies', UNU-Press, Tokyo.
(20) Ionescu, C., Klein, R. J. T., Hinkel, J., Kumar, K. S. and Klein, R. (2009) 'Towards a formal framework of vulnerability to climate change', *Environmental Modeling and Assessment*, Vol. 14, No. 1, pp. 1–16.
(21) Blaikie, P., Cannon, T., Davis, I., and Wisner, B. (1994) 'At risk: Natural hazards, people's vulnerability and disasters', Routledge, London.
(22) Miller *et al*. ref. 4 above.
(23) *Ibid*.
(24) Maguire, B. and Cartwright, S. (2008) 'Assessing a community's capacity to manage change: A resilience approach to social assessment', Australian Government, Canberra.
(25) Adger, N. W. (2000) 'Social and ecological resilience: Are they related?' *Progress in Human Geography*, Vol. 24, No. 3, pp. 347–364.
(26) Folke, ref. 10 above.
(27) Fenton, M., Kelly, G., Vella, K. and Reid, P. (2004) 'Climate change and the Great Barrier Reef: Industries and communities' in: Johnson, J. E. and Marshall, P. A. (eds.) 'Climate Change and the Great Barrier Reef: A Vulnerability Assessment', Great Barrier Reef Marine Park Authority and the Australian Greenhouse Office, Department of the Environment and Water Resources, Townsville, Australia, pp. 15–50.
(28) UN ISDR (2005) 'Hyogo Framework for Action: Building the Resilience of Nations and Communities to Disasters', United Nations, Geneva.
(29) Kafle, S. K. (2005) 'Community Based Disaster Risk Reduction Framework for Southeast Asia', World Youth Foundation, Melaka, available at: http://www.wyf.org.my/2005/Shesh%2520Kanta%2520Kafle%2520.doc. pp. 1–14 (accessed 5th August, 2011).
(30) UN ISDR, ref.28 above.