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System approach for flood vulnerability and community resilience assessment at the local level – a case study of Sakon Nakhon Province, Thailand

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Abstract

Field-based academic researches play a vital role in the identification of key issues contributing to disaster vulnerability and in uncovering of policy recommendations that will help in reducing vulnerability and improving community resilience. Vulnerability to disasters is embedded in a complex system of societal structures and processes. It is driven by a combination of social, economic, environmental, institutional, and other relevant processes that interact with and influence each other. Thus, assessment of disaster vulnerability requires an approach that captures the dynamics of drivers of disaster vulnerability and accounts for the interactions among them. System approach to disaster vulnerability assessment could be an effective method to understand the drivers of disaster vulnerability and interactions among them. The system approach seeks to look at a problem in its entirety, considering all the facets, all the intertwined parameters to identify the optimum solutions to the problem. Thus, the primary objective of this paper is to review the existing field-based approaches to flood vulnerability assessment aimed at understanding the extent to which system approach has been adopted and identifying gaps in current approaches. Along with a comprehensive review of existing researches on flood vulnerability assessment, this paper will also use learnings from an on-going research project on flood vulnerability assessment using system approach at the local level in Sakon Nakhon Province, Thailand.

Introduction

Disaster undermines societal well-being by causing loss of lives, injuries, damaging social and economic infrastructure, and disrupting livelihoods. Growing exposure of people, property, and infrastructure to the risk of disasters in recent decades has led to the paradigm shift in disaster management from the response-centric approach to the risk-reduction

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approach through international frameworks like Hyogo Framework of Action, Sendai Framework for Disaster Risk Reduction, and Sustainable Development Goals (SDGs).

Vulnerability to disasters is embedded in a complex system of societal structures and processes. Resilience to disasters is driven by a combination of social, economic, environmental, institutional, and other relevant processes that interact with and influence each other (Choudhury & Haqque, 2016). Thus, assessment of disaster resilience requires an approach that captures the dynamics of drivers of disaster vulnerability and accounts for the interactions among them (Choudhury & Haqque, 2016; Mohanty, Hussain, Mishra, Kattel & Pal, 2019). There is a strong connection between disaster resilience, disaster preparedness and risk management. It is imperative to mention that, reduction of the community vulnerability, eventually helps to increase the resilience. Developing community resilience is a multifaceted approach which revolves around various elements of the vulnerability (Cavallo & Ireland, 2014). Disaster preparedness strategies are deployed to mitigate disaster risks and to build community resilience. However, disasters are characterized by interdependent and systemic risks that can trigger cascading effects (Lorenz, Battiston, & Schweitzer, 2009).

A flood resilience is a complex system consisting of multiple processes and is characterized by a significant degree of interdependence between the processes (Bergstrand, Mayer, Brumback, & Zhang, 2015). The present study aims to understand the complex and interconnected issues associated with the community level flood risk management and social resilience in Mueang District using system approach, which views resilience as a system or a cluster of systems. According to United Nations International Strategy for Disaster Reduction (UNISDR, 2017), resilience is the ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management. At present, a system approach, meaning an approach capable of capturing the adaptive complex system of resilience or a system of systems-has yet to materialize (Gall, 2013). For community flood resilience assessment, seven (7) sub-systems of resilience system have been identified; 1. Social, 2. Economic, 3. Physical, 4. Institutional, 5. Human, 6. Natural and 7. Technical Systems. Analysis of resilience sub-systems and impacts of recent flood events is aimed at the identification of key drivers of community resilience sub-systems and the degree of their interdependencies (Pal, Ghosh, & Ghosh, 2017).

Floods are one of the biggest and most severe natural disasters in Thailand (Ananta, Bauer, & Thant, 2013). From 2000 to 2016, out of the total number of natural disasters, the share of flood alone was about 41 percent in Asia. After the devastating floods in 2011, Thailand has increased its focus on both structural and non-structural mitigation and also highlighted preparedness-need, flood forecasting and Early Warning System (EWS) (Marks, 2019). However, loss of lives due to monsoon floods is still a frequent phenomenon in Thailand (Nakasu, 2007). In July 2017, Sakon Nakhon province received 790 mm of rainfall triggered by the tropical storms “Talas” and “Sonca”, leading to the worst floods in the northeastern provinces in two decades. Sakon Nakhon was the worst-hit province, which suffered damages of more than 3 million USD with significant damage to crops, fisheries, business sector, transportation, health sector, water supply, and education sectors (Voeisarnet al., 2017). Eighteen (18) districts of Sakon Nakhon province were inundated, with water levels ranging from 70 to 200 centimeters (Bangkok Post, 2017; The Nation, 2017; Voeisarn et al, 2017).

Literature Review

Thailand has a huge socio-economic gap between the capital Bangkok and rural regions, particularly the northeast. Household assets in Thailand vary widely, and such disparities may have a direct implication on a household’s capacity to cope with and recover from disasters (Siebeneck, Arlikatti & Andrew, 2015). According to the Progress Report on the Implementation of the Hyogo Framework of Action 2009–2011 (CFE-DHMA, 2015), the effectiveness of Thailand’s National Disaster Prevention and Mitigation Committee is hindered by the lack of shared vision between the member organizations and active participation. Government introduced a number of community-based risk management programs; however, a comprehensive monitoring and evaluation system are lacking (Dore & Lebel, 2010). Many scholars (Béné, Godfrey, Newsham & Davies, 2012; Levine, 2014; Mitchell, 2013) have highlighted the at-times uneasy relationship between resilience and vulnerability. Béné Godfrey, Newsham and Davies (2012) and Levine (2014) put forward the critique that a resilience-focused perspective runs the risk of diverting attention away from the most vulnerable or marginalized groups in a community, in favour of a more average community-wide perspective.

According to UNISDR (2017), “Resilience is the ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management”. Systems approach usually refers to a view of resilience as a self-regulating system-or cluster of systems-that are self-correcting through feedback. The system approach seeks to understand how they interact with one another and how they can be brought into the proper relationship for the optimum solution of the problem. A system approach is capable of capturing the adaptive complex system of resilience or a system of systems-has yet to materialize (Gall, 2013). There is a need for a multi-dimensional metric for resilience that captures all relevant dimensions of resilience (Jovanovic, Schmid, Klimek & Choudhary, 2016). As the HFA encourages research on community resilience, systems theory offers a global vision of disasters and their management from the very first steps of preparedness (Cavallo & Ireland, 2014). Resilience is also considered as an emergent property of system components, which being connected through loose relationships, are more autonomous than strongly connected system components (Ramalingam, 2008). Risk networks are subject to causal relationships that are spatial (e.g. environment, other stakeholders, competing systems) and temporal. Systems belonging to the same system of systems can influence each other both in space and time. In standard management, response process to complex problems is to "carve them at the joints" and solve the resulting smaller problems separately. This strategy will not work in complex human-environment systems—actions taken to solve the separate smaller problems will interact to produce outcomes that are both unexpected and unwanted (Newell 2012; Newell & Proust, 2012).

Methodology

Study Area

Sakon Nakhon Province is situated in the north-eastern part of Thailand (Figure 1). Mueang Sakon Nakhon is the capital district (amphoe mueang) of Sakon Nakhon Province. The main natural water resource is Nong Han Lake, the largest natural lake of Northeast Thailand, covering an area of 125.2 km². The main river feeding the lake is the Nam Pung, which originates in the Phu Phan mountains south of the lake. The outflow of the lake is the Nam Kam river, which flows into the Mekong (Mekong, 2010).

Research Design

The present research covered the qualitative and quantitative aspects of vulnerability and resilience context of the targeted community. The research was designed to collect the primary and secondary data through secondary sources and field visit. Secondary data were collected through extensive literature review, and documents from line departments at the provincial level. The target group was selected based on the local level consultation workshops and meetings for focus group interviews, key informant interviews and also to choose experts for AHP analysis. The study uses a system approach that views community flood resilience as a system or a cluster of systems. For community flood resilience, seven (7) components of resilience were identified to reveal the existing vulnerability of the flood resilience components that influence the risk perception of system participants such as government, community, non-government agencies, civil society organizations and private sector (Figure 2). Each of the resilience components is adaptive and self-regulating and can be triggered and driven through interventions from the system participants. A set of questionnaires was employed through the focus group interviews and key informant interviews linked with the indicators of the all seven sub-system of the flood resilience. Analysis of the resilience system components and impacts of the recent flood events in 2017 in Sakon Nakhon were used to identify the key drivers of community resilience components and the degree of their interdependence.

Data Collection

The research undertook a flood vulnerability and resilience assessment of the community in the study area considering seven (7) major components that influence vulnerability and resilience of the community to flood hazards. The primary data collection methods included *field observations* in selected locations in Mueang District of Sakon Nakhon Province to get an overview of existing physical conditions and exposure of the people and assets to flood, followed by the *key-informant interviews* aimed at investigating the perception of professionals and experts from various sectors and community members on flood resilience system of Mueang District, *focus group discussion* involving community members, experts and professionals from the government, the private sector, Civil Society Organizations (CSOs), and community organizations for a deeper understanding of the vulnerabilities of the community to flood and to identify gaps in flood risk reduction interventions and *field observations, key-informant interviews, focus group discussion and stakeholder workshop* on community flood risk management organized at Kasetsart University Chalermphrakiat Sakon Nakhon Province Campus (KU.CSC).

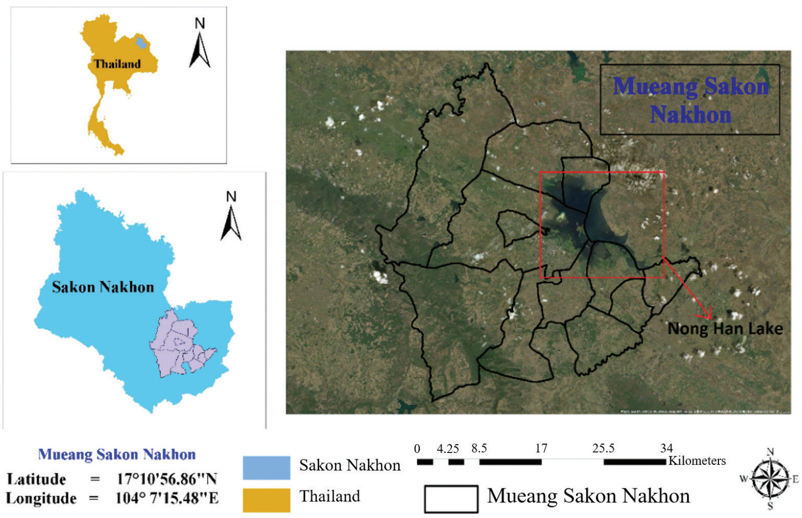

Figure 1 Mueang District, Sakon Nakhon Province, Thailand

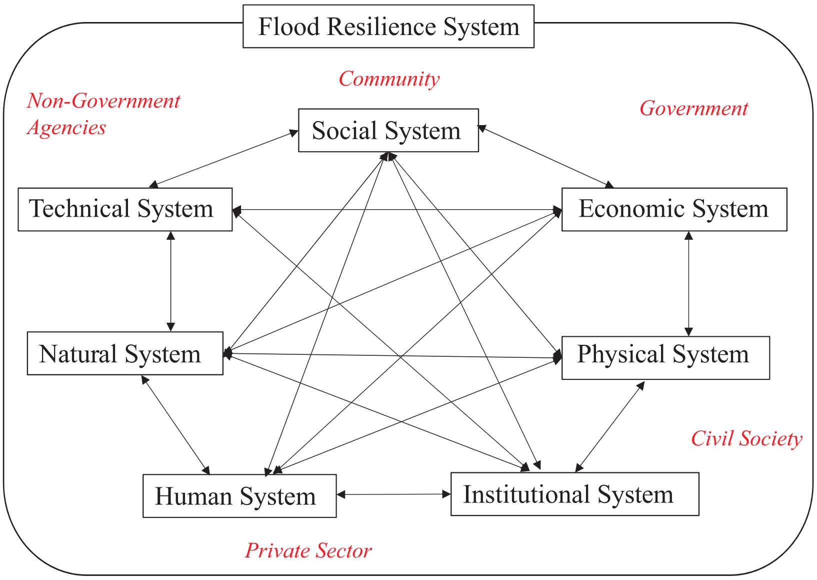

Figure 2 Conceptual Framework-Community Flood Resilience System

Data Analysis Tools

Analytic Hierarchy Process (AHP) tool has been used in this study to decompose a problem into a hierarchy of sub-problems that can more easily be comprehended and subjectively evaluated for flood resilience (Bhushan & Rai, 2004). It allows pairwise comparisons of different aspects of a problem and it relies on the judgments of experts to derive priority scales (Saaty, 2005; Saaty, 2008). Generic AHP process is as follows (Bhushan & Rai, 2004);

Step 1: The hierarchic structure of the community flood resilience system consists of 7 sub-systems (Social, Economic, Physical, Institutional, Human, Natural and Technical) (Figure 3) with multiple variables that influence the respective sub-system (Table 1).

Step 2: Data have been collected from experts in the pairwise comparison of alternatives on a qualitative scale as described in Table 2.

Step 3: The pairwise comparisons of variables and components have been organized in a form of ratio matrix as shown in Figure 4. The variable in the *i*th row is better than variable in the *j*th column if the value of element (i, j) is more than 1; otherwise the criteria in the *j*th column is better than that in the *i*th row.

Step 4: The principal eigenvalue and the corresponding normalized right eigen-vector of the comparison matrix gives the relative importance of the various elements being compared.

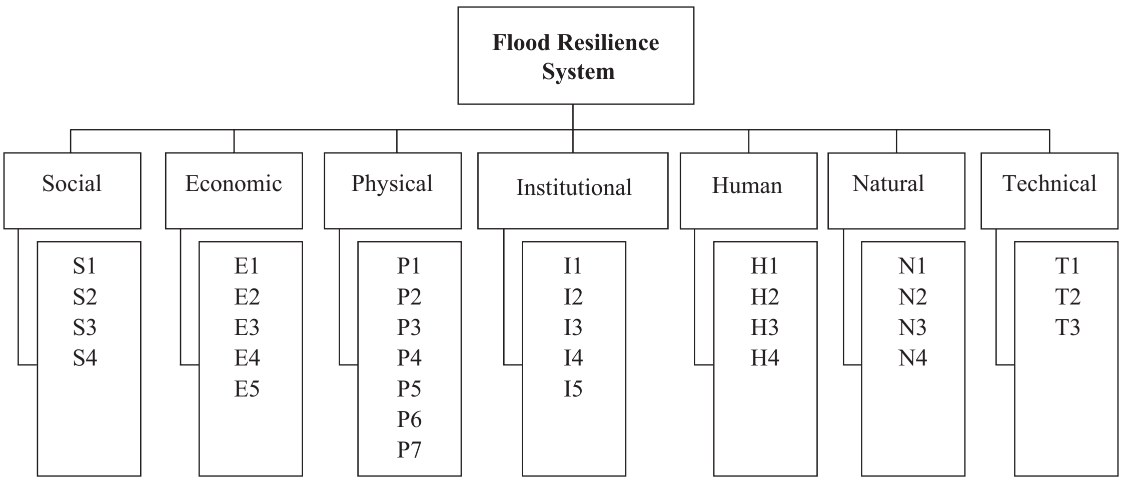

Figure 3 Hierarchic structure of Flood Resilience System

Table 1 Elements/Variables of Flood Resilience System Component

SN	Sub-System	Variable Code	Variable Description
1	Social	S1	Community engagement in Flood Risk Management programs
2		S2	Inclusion of vulnerable groups
3		S3	Community trust towards government agencies
4		S4	Multi-sectoral collaboration for flood risk reduction
5	Economic	E1	Insurance (flood-related)
6		E2	Employment and income stability
7		E3	Diversification of household income source
8		E4	Access to credit, savings and microfinance
9		E5	Social security and safety nets
10	Physical	P1	Structural flood mitigation measures
11		P2	Evacuation Centers
12		P3	Transportation infrastructure
13		P4	Communication infrastructure
14		P5	Access to safe drinking water
15		P6	Medical facilities
16		P7	Facilities for people with disabilities
17	Institutional	I1	DRM institutions setup at local level
18		I2	Adequate Flood Risk Management policies
19		I3	Adequate budget and resources allocated to local government institutions
20		I4	Coordination between Government departments
21		I5	Flood Risk Reduction integrated with development planning
22	Human	H1	Availability of DRR experts and professionals
23		H2	Availability of skilled community members for flood risk reduction
24		H3	Adequate response team
25		H4	Public awareness and knowledge
26	Natural	N1	Protection of natural water bodies
27		N2	Land-use policies and spatial planning
28		N3	Flood-resistant agriculture
29		N4	Natural flood protection measures
30	Technical	T1	Flood forecasting and warning system
31		T2	Proper communication system for flood warning
32		T3	Availability and utilization of flood risk knowledge

Table 2 Pairwise Comparison Scale

Scale	Definition
9	Extremely important
7	Very strongly more important
5	Strongly more important
3	Moderately more important
1	Equally important
8,6,4,2	Intermediate values (compromises between preferences in weights 9,7,5,3,1)

$$a_{ij} = \left\{ \begin{array}{cccc} 1 & a_{ij} & --- & a_{1n} \\ 1/a_{ij} & 1 & --- & a_{2n} \\ - & - & & - \\ - & - & & - \\ - & - & & - \\ 1/a_{1n} & 1/a_{2n} & --- & 1 \end{array} \right\}$$

Figure 4 Ratio/Reciprocal matrix

Step 5: The consistency of the matrix of order n is evaluated. The maximum eigenvalue of the judgment matrix is given by λ_{max}. The Consistency Index (CI) (Equation 1) can be compared with that of a random matrix (RI) to get the Consistency Ratio (CR) (Equation 2). Values of RI of the study conducted by Saaty and Vargas (2006) based on 64,000 sample matrices are shown in Table 3.

Consistency index:

$$CI = \left(\frac{\lambda\ max - n}{n-1} \right) \quad (1)$$

Table 3 Random consistency index

N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

Note: Where N is the size of Ratio / Reciprocal matrix

Consistency ratio:

$$CR = (\frac{CI}{RI}) \quad (2)$$

Step 6: The rating of each component is multiplied by the weights of the sub-components and aggregated to get local ratings. The local ratings are then multiplied by the weights of the components and aggregated to get global ratings.

Field Survey Results

The indicators and variables used to define the demographic, physical, social and economic situation of the respondents were mentioned and an explanation given below. All of the selected households were from Sakon Nakhon province of Thailand. Thus, they were similar in social and cultural traditions. Out of 365 interviewed respondents, 67 percent were female and 33 percent were males. Gender roles at times define how male and female would react and cope with floods. In this research, respondents were categorized into three age groups; children (less than 18 years old), adults (19 to 59 years) and elderly (more than 60 years old). The majority of the responses received were from adult group (67.1%), whereas 31.5 percent were from elderly group and only 1.4 percent were children group. The study shows that there is a constant relationship between respondents' age category and respondent sex. Extreme ends of age such as very young age and old age show higher vulnerability due to dependence on others for help and support. The study had a diversity of occupations that were categorized into ten major types, as shown in table and graph, to understand the occupational status of the community under study. The data revealed that agriculture is the most engaged occupation of the study area. Type of occupation helps to determine the level of vulnerability of people engaged in a particular job. For example, a person dependent on agriculture might suffer a loss of income due to flooding of agricultural land, but a person engaged in service will suffer no such loss. Thus, occupation and income of the household play a very significant role in determining the level of vulnerability of a respondent (Table 4). Overall, the majority of respondents, 58%, were farmers having agriculture occupation, followed by business (13%), household work (9%), wage labor (8%), service (6%). 3 percent of the respondents were students, whereas less than 1 percent were in social work and foreign employment, and less than 1 percent were unemployed.

In this study, the educational categories were made based on Thailand's education system. Respondents were sorted into classes like illiterate, primary, secondary, diploma/certificate, bachelor, masters, doctoral, vocational and others. In this study, the educational level showed 63 percent of the respondents attended primary education, 23 percent secondary, 7 percent had bachelor degree, 4 percent diploma course and 1 percent had vocational course. Less than 1 percent were illiterate, had masters or doctoral degree (Table 5).

Monthly income is primarily based on education, livelihood sources, etc., and varies considerably from household to household, therefore, the monthly income is divided into classes to comprehend easily. The households with lower incomes were at greater risk than higher income. On the whole, around 70 percent of the total respondents earned a monthly income of less than 10,000 baht. About 26 percent of the respondents had an income between 10,000 to 20,000 baht. Income refers to the total income of the household for a month (Figure 5).

Degree of Impact

The study also tried to find out the impact of the Sakon Nakhon flood 2017. The impact was measured in different aspects like education, health (physical and psychosocial), basic necessities (food, water, clothes, etc.), source of income and household assets. The data were collected through household survey using a Likert scale (i.e., very high, high, moderate, low and no impact). The quartile method was applied to assess the Household (HH) level impact from the flood on different aspects. Out of the total, 2 percent HH was very highly impacted, 19 percent was highly impacted, 41 percent was moderately impacted, and 37 percent HH had low impact of the flood (Table 6).

Table 4 Occupation of Respondents

Occupation	Frequency	%
Agriculture	212	58.1
Household work	33	9
Social work	2	0.5
Services	23	6.3
Wage Labor	29	7.9
Business	49	13.4
Student	12	3.3
Foreign Employment	1	0.3
Unemployed	3	0.8
Total	364	99.7
Missing	1	0.3

Table 5 The educational qualifications of the respondents

Education	Frequency	%
Illiterate	1	0.3
Primary	230	63
Secondary	84	23
Diploma/Certificate	15	4.1
Bachelor	26	7.1
Master	1	0.3
Doctoral	1	0.3
Vocational	4	1.1
Others	3	0.8
Total	365	100

Table 6 Degree of Impact of Flood

Classes		F	%	Descriptive Statistics
Low	Q1 (0.20–0.40)	136	37	Min = 0.20
Moderate	Q2 (0.40–0.60)	149	41	Max = 1.00
High	Q3 (0.60–0.80)	71	19	Mean = 0.4882
Very High	Q4 (0.80–1.00)	9	2	*SD* = 0.162
Total		365	100	Range = 0.80

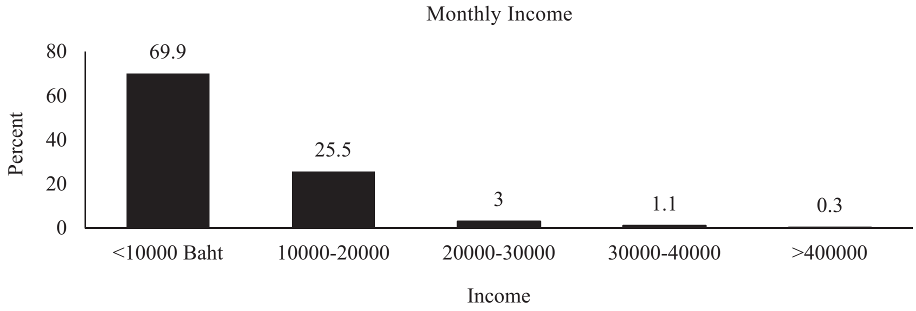

Figure 5 Monthly Income of Respondents

As majority of the respondents' occupation was agriculture (58%), the result of HH Survey revealed that the source of income from agriculture activities like crop cultivation (0.56), aquaculture (0.18), and animal husbandry (0.24) were affected by the flood but impact was not severe. The majority of respondents (53%) reported as low impacted and 40 percent HH were moderately impacted. Only 8 percent of respondents reported as highly impacted (Figure 6).

This study also examined the community perception for various agencies' activeness (government, army, community organizations, volunteers, NGOs, INGOs, and private sector), on flood risk interventions before and after the flood. The results showed that the government agency played the most active role in flood risk intervention with the value 0.78 before flood, whereas volunteer played the most active role after the flood with the WAI value of 0.77. The role of community organization was also significant along with the government agencies in pre and post flood interventions respectively (Figure 7A and 7B). The interesting aspect of the results is the NGO and INGO were the least active in both stages (before and after) of intervention. In totality, the perception of households was clearly seen in that 93 percent of HH expressed the moderate level of activeness of agencies before flood, whereas the same number of households (93%) reported low activeness of agencies after a flood situation. This means that the households were not satisfied with the agencies that work on flood risk interventions, either before or after flooding.

Analysing Community Flood Resilience System

The study recognizes community flood resilience as a complex system consisting of 7 components or sub-systems- Social, Economic, Physical, Institutional, Human, Technical and Natural. Due to the differential importance, AHP tool was used to derive the relative priorities of the community flood resilience components and sub-components. The study uses responses from 12 experts to rank the flood resilience system components and sub-components referring to the numerical scale. Prior to conducting the key-informant interview for priority ranking, a Focus Group Discussion was conducted for familiarization. The pairwise comparison matrix has acceptable consistency, i.e. Consistency Ration (CR) < 0.10. Local and Global weights for each sub-component of the flood resilience components were calculated independent of the weights in the other component categories. Thus, the sum of the local weights within each sub-component is 1. The global weight for each sub-component is calculated by multiplying the local weight of the sub-component by the local weight of the corresponding main component.

Relative Priorities of Community Flood Resilience Components

The experts from various stakeholder groups identified social component as the most important component of the community flood resilience system with an importance factor

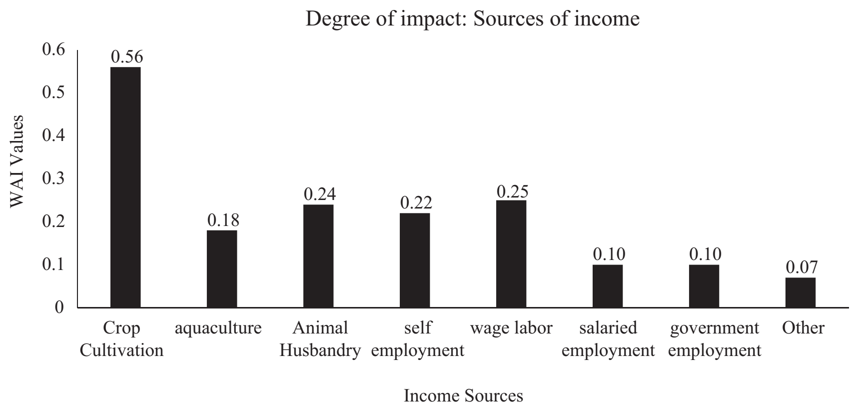

Figure 6 Degree of Impact of source of income

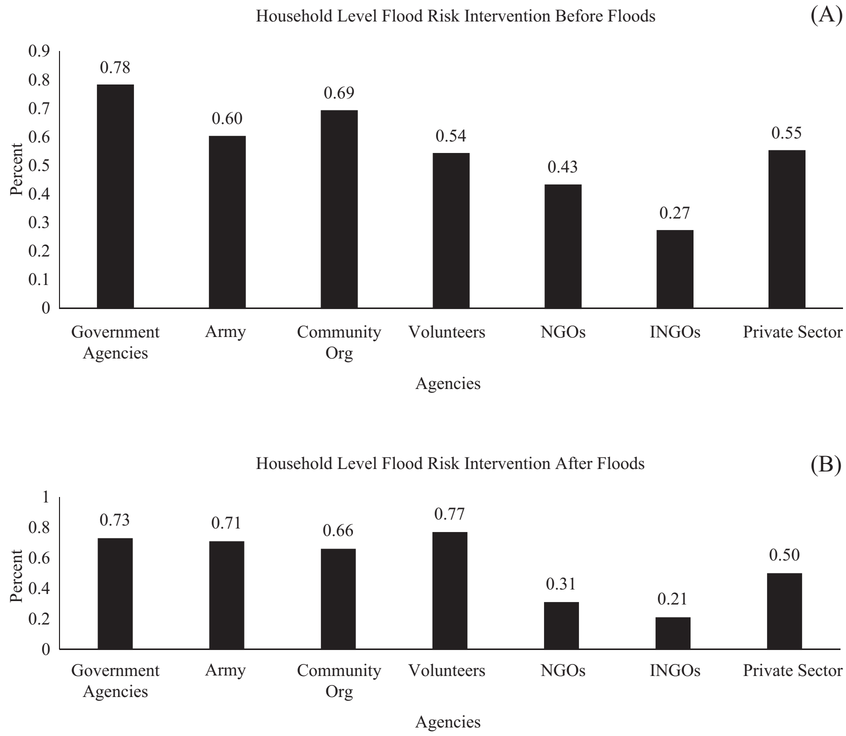

Figure 7 Effectiveness of agencies on flood risk intervention before (A) and after flood (B)

of 25.49 percent, which signifies the ability of the community including the vulnerable groups to initiate and sustain actions for flood resilience. Social component consists of societal system such as inclusion, trust, and networks which influence collective action. Social dimension aids the links to exchange ideas and access to the resources among stakeholders (Zurich Insurance Group, 2014). According to (Bergstrand, Mayer, Brumback & Zhang, 2015) social system plays a prominent role in human vulnerability to hazards, and understanding social vulnerability is an essential step toward helping communities to acquire the resources and strategies needed to minimize losses from disasters. Surprisingly, the experts ranked the natural component (16.57%) before the economic and physical components (Figure 8). The expert perception could be influenced by the topography and geographical characteristics including the presence of Nong Han lake and multiple tributaries flowing towards the lake and only one river for the discharge of water from the lake. The local stakeholders or experts in the context of the study seemed to understand the importance of conserving and managing natural resources in order to enhance flood resilience. The institutional component consists of formal setups such as governance system and functions as well as guiding policies and frameworks (Pal, Ghosh & Ghosh, 2018). Interestingly, institutional factor was ranked among the least important components, at 6^{th} position among the seven (7) components. Global weight reflects the relative weightage between the primary flood resilience components (i.e., seven components), whereas local weight defines the weightage of various indicators or elements for each of the components. Global and local weightage were normalised for the uniformity and analysis.

Community Resilience and Social System Component

The social component was ranked as the most important component of the community flood resilience system. Within the social component, 'community engagement in flood risk management' was rated as the most important sub-component, with a local importance factor of 42.24 percent (Figure 9) and a global importance factor of 10.77 percent as shown in Table 7. The priority ranking of the sub-components of the social component shows that the experts seemed to give the highest importance to the participatory method of disaster risk management. Participation of the community in all phases of disaster risk management including risk assessment, mitigation planning, capacity building, participation in implementation and development of a system for monitoring empowers the community and ensures their stake (Pandey & Okazaki, 2005). The participatory approach provides community members with more access and control over resources and opportunities to undertake actions for their resilience, which is required for the continuity of the disaster risk management efforts. Focus group discussions suggested that higher importance should be given to the community engagement with different groups despite their vulnerability level to generate more effective disaster resilience actions. The key concern expressed by the stakeholders was the type of vulnerability depended on community or group characteristics and physical settings requiring vulnerability type specific planning and mitigation actions.

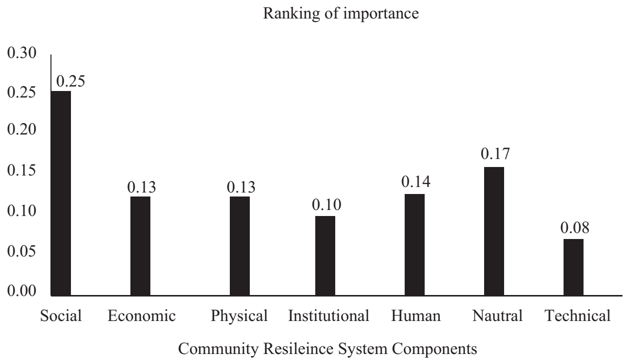

Figure 8 AHP Weights of Community Flood resilience Components

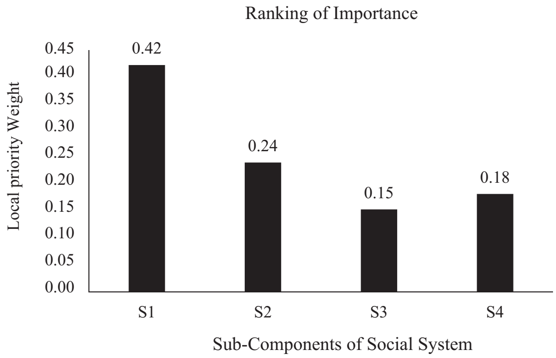

Figure 9 AHP Weights of Sub-Components of Social System

Table 7 Priority Weights of Community Flood Resilience Components and Sub-components

Flood Resilience Components	Global/ Local Weight	Rank		Elements of Flood Resilience Components	Local Weight	Global Weight	Local Rank
Social	0.2549	1	S1	Community engagement in Flood Risk Management	0.4224	0.1077	1
			S2	Inclusion of vulnerable groups	0.2411	0.0615	2
			S3	Community trust towards government agencies	0.1539	0.0392	4
			S4	Multi-sectoral collaboration for flood risk reduction	0.1827	0.0466	3
				SUM	1	0.2549	
Economic	0.1280	5	E1	Insurance (flood-related)	0.3312	0.0424	1
			E2	Employment and income stability	0.2373	0.0304	2
			E3	Diversification of household income source	0.1758	0.0225	3
			E4	Access to credit, savings and microfinance	0.1103	0.0141	5
			E5	Social security and safety nets	0.1454	0.0186	4
				SUM	1	0.1280	
Physical	0.1347	4	P1	Structural flood mitigation measures	0.2584	0.0348	1
			P2	Evacuation Centers	0.1830	0.0247	3
			P3	Transportation infrastructure	0.1871	0.0252	2
			P4	Communication infrastructure	0.1070	0.0144	4
			P5	Access to safe drinking water	0.1030	0.0139	5
			P6	Medical facilities	0.0885	0.0119	6
			P7	Facilities for people with disabilities	0.0730	0.0098	7
				SUM	1	0.1347	
Institutional	0.0989	6	I1	DRM institutions setup at local level	0.2796	0.0277	1
			I2	Adequate Flood Risk Management policies	0.1728	0.0171	3
			I3	Adequate budget and resources allocated to local government institutions	0.2383	0.0236	2
			I4	Coordination between Government departments	0.1499	0.0148	5
			I5	Flood Risk Reduction integrated with development planning	0.1594	0.0158	4
				SUM	1	0.0989	
Human	0.1363	3	H1	Availability of DRR experts and professionals	0.4178	0.0569	1
			H2	Availability of skilled community members for flood risk reduction	0.2314	0.0315	4
			H3	Adequate response team	0.1760	0.0240	2
			H4	Public awareness and knowledge	0.1749	0.0238	3
				SUM	1	0.1363	
Natural	0.1657	2	N1	Protection of natural water bodies	0.3686	0.0611	1
			N2	Land-use policies and spatial planning	0.3175	0.0526	2
			N3	Flood-resistant agriculture	0.1327	0.0220	4
			N4	Natural flood protection measures	0.1812	0.0300	3
				SUM	1	0.1657	
Technical	0.0815	7	T1	Flood forecasting and warning system	0.4144	0.0338	1
			T2	Proper communication system for flood warning	0.3191	0.0260	2
			T3	Availability and utilization of flood risk knowledge	0.2665	0.0217	3
				SUM	1	0.0815	

Conclusion

Flood vulnerability is dynamic and varies across temporal and spatial scales (Forino, 2015). Individuals and communities are differentially vulnerable based on inequalities expressed through levels of wealth and education, disability, health, gender, age, class, and other social and cultural characteristics (IPCC 2012). Disaster resilience is a broad and multi-dimensional entity with a shared responsibility of all sectors of society. Community engagement and multi-sectoral collaboration have been identified by this study as the core aspects of disaster risk reduction and management efforts in achieving disaster resilience. Achieving disaster resilience requires sustained behavioral change across the community. The process of building resilience needs to be a networked process incorporating community assets rather than solely identified risks. The participation of relevant stakeholders in flood defense decision-making can support resolving conflicting interests and assist in identifying the optimal solution. Capacitating community members with knowledge, skills, and awareness regarding disaster risk reduction and management enhances safety culture allowing the community to effectively prepare for the risks they face. Developing an effective early warning system and proper information dissemination and communication planning can significantly reduce the impact of a flood by providing people with timely information to protect their lives and property. Natural flood protection measures are more sustainable than structural measures as they are environment-friendly, commonly accepted and are more flexible than the structural measures. In communities where people's livelihood is closely intertwined with nature, it is important to initiate ecosystem-based approaches to managing floods. Participatory planning for water and natural resource management can support enhance adaptation to natural disasters that reduces the social and economic impacts of natural disasters.

Conflict of Interest

There is no conflict of interest.

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