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Comparative social vulnerability assessment in Purba Medinipur district, West Bengal, India

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Abstract

Social vulnerability assessment is an important element for disaster risk reduction system. Social vulnerability depends on physical, social, economic, environmental factors, etc., which determine the susceptibility of community against the impact of hazards. Over the past two decades, social vulnerability has been measured by using different methodologies. The present work portrays a comparative assessment of social vulnerability methodologies in the Purba Medinipur district located in the eastern part of India. Different standardization techniques of data transformation like, Z score, maximum value, and min-max rescaling have been employed to compare and examine social vulnerability in the study area. The principal aim of this work is to analyse the results between the three methodologies adopted, and identify the vulnerable blocks in the district. The result shows that relationships between three methodologies are moderately strong to very strong and Sutahata block is identified as the most vulnerable block in the Purba Medinipur district.

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1. INTRODUCTION

In 1970´s the concept of social vulnerability within the disaster management context was introduced (Flanagan, 2011). Some populations are prone to suffer more damages and loss from different hazards. Social vulnerability examines social distribution of risk and reasons behind high level of risk associated with some communities to any hazards. It is the adaptation technique between hazard and people. Social vulnerability can be defined as the state of a community before a hazard triggers them. Under the mitigation strategy of adaptation approach, social vulnerability assessment is one of the vital attempts for the building of regional preparedness. Social vulnerability is associated to the level of wellbeing of individuals, communities and society (ISDR, 2004).

Normally two approaches are being used to select and calculate the social vulnerability. First one is deductive approach which is based on theoretical understanding. Second one is inductive (empirical) approach which is based on statistical relationship of a large number of indicators set. Deductive approach is a 'top-down' approach and inductive approach is a 'bottom-up' approach. Cutter *et al.* (2003), Rygel *et al. (2006),* Boruff *et al. (2005)*, Boruff *et al.* (2007), Holand *et al. (2011)*, Chen *et al.* (2013), Mavhura *et al.* (2017), Heß (2017) used inductive approach in their studies. Whereas, Cutter *et al.* (2000), Bernard (2007), Cutter *et al.* (2010), Sajjad *et al.* (2014), de Mello Rezende (2016) chose deductive approach for social vulnerability measurement. Yoon (2012) had compared between deductive approach and inductive approach and developed social vulnerability index for in the Gulf of Mexico and Atlantic coastal areas.

This article is based on the three deductive techniques such as z score transformation, maximum value transformation and min–max rescaling transformation, to measure comparative social vulnerability assessment in 25 blocks of Purba Medinipur district in West Bengal state of India

The assessment of social vulnerability is a key issue of indicator based measurement. Indicators are necessary to determine the social vulnerability. This assessment consists of 12 socio-economic indicators for construction of a social vulnerability index (SVI). Social vulnerability index is a planning tool that helps to identify communities; those may need support in preparation for hazards or recovering after hazards. Comparative analysis is a combination of different methodologies for analyzing data. It involves the analysis and synthesis of the similarities, differences and relationship between several methodologies. It is a new novel approach of vulnerability assessment and it mainly focuses on the relationships between two or more variables. The main objective of this article is to identify the vulnerable blocks in Purba Medinipur district by employing three standardization methods and performing a comparative analysis of the data obtained.

2. SOCIAL VULNERABILITY

Social vulnerability indicates to a population's exposure to potential hazards. Some physical, demographic, social, economic conditions of people expose more or less to a hazard. These factors determine damage, loss and injury of people in any hazard. Social vulnerability is controlled by some indicators. There exist two types of relationship between indicator and social vulnerability. In first one, vulnerability increases with the increasing value of indicator. This is called positive relationship. Another one is negative relationship. Here vulnerability decreases with increasing the value of indicator. Generally higher value of social vulnerability indicates high number of elder population, single living person, child population, female, poverty, unemployment, illiteracy of populations etc. Some of the definitions of social vulnerability are summarized below in Table 1.

Table 1. Definitions of social vulnerability

Working definition(s)	Exemplar reference source
Social vulnerability refers to the exposure of a group or individual to stress as a result of social and environmental changes where stress indicates to unexpected changes and disruption to livelihoods.	Adger, 1999
Social vulnerability is a product of social inequalities. It is defined as a susceptibility of social groups to the impacts of hazards and their resiliency or ability to adequately recover from those.	Cutter et al, 2006
Social vulnerability shows the social construction to prevent a hazard. It is also partially the product of social inequalities.	Veen et al, 2009
The aims of social vulnerability are to identify and understand which groups of people are more sensitive and susceptible to the impacts of natural disasters and why.	Tapsell et al, 2010
The concept of social vulnerability is multidimensional and not directly observable.	Tate, 2012

3. METHODOLOGY

3.1 Study Area

Purba Medinipur district is situated between 21°36′35″N and 22°57′10″N latitudes and 86°33′50″E and 88°12′40″E longitudes. Midnapore district was bifurcated into Paschim Midnapore and Purba Midnapore on 1st January 2002. The location map of Purba Medinipur district is shown in Figure 1. The district has a 65.5 km long coastline along the south and south eastern part. Purba Medinipur district has divided into twenty-five blocks and five municipalities. These municipalities are; Tamluk (Tamluk Block), Panskura (Panskura Block), Haldia (Haldia Block), Egra (Egra-I Block) and Contai (Contai-I Block). The district headquater is Tamluk.

Purba Medinipur district is a part of lower Ganga plain. The slope of this region is from west to east. Haldi, Rasulpur, Keleghai, Kanshabati, Rupnarayan are main rivers of the district. The climate of the district is tropical monsoon type with hot and humid summer and dry winter.

According to 2011 census data (CI, 2011), population of Purba Medinipur district is 5,095,875 and it covers 5.58% of population of West Bengal. The district has a population density of 1081 inhabitants per square km. Purba Medinipur district ranks 8th in terms of population and population density of the state. The northan parts of the district are more densely populated than the other parts of the district. The population growth rate is 15.36%. The sex ratio of Purba Medinipur district is 938 females per 1000 males. Out of the total population 11.6% of population lives in urban area and 88.4% population lives in rural area. Whereas India's urban population is 31.2% (Kumar, 2015).

The literacy rate of Purba Medinipur district is 87.02%. The male literacy rate is 92.32% and female literacy rate is 81.37%. The district has recorded highest literacy rate all over the state. The state literacy rate is 76.26%.

Only 37.49 % of population of the district is workers, whereas 62.51% of population is non-workers. The dependent population ratio is high in the district. Agriculture is the main activity in the Purba Medinipur district. The crops grown in Purba Medinipur district are Paddy, Wheat, Mustard, Jute, Potato, Chillies, Ginger etc. The main crop is Paddy which occupied more than 50% of total production. The coastal blocks are famous for fish cultivation. Many people are engaged with fishing from the sea. Tourism also plays an important role in the economy of the coastal blocks

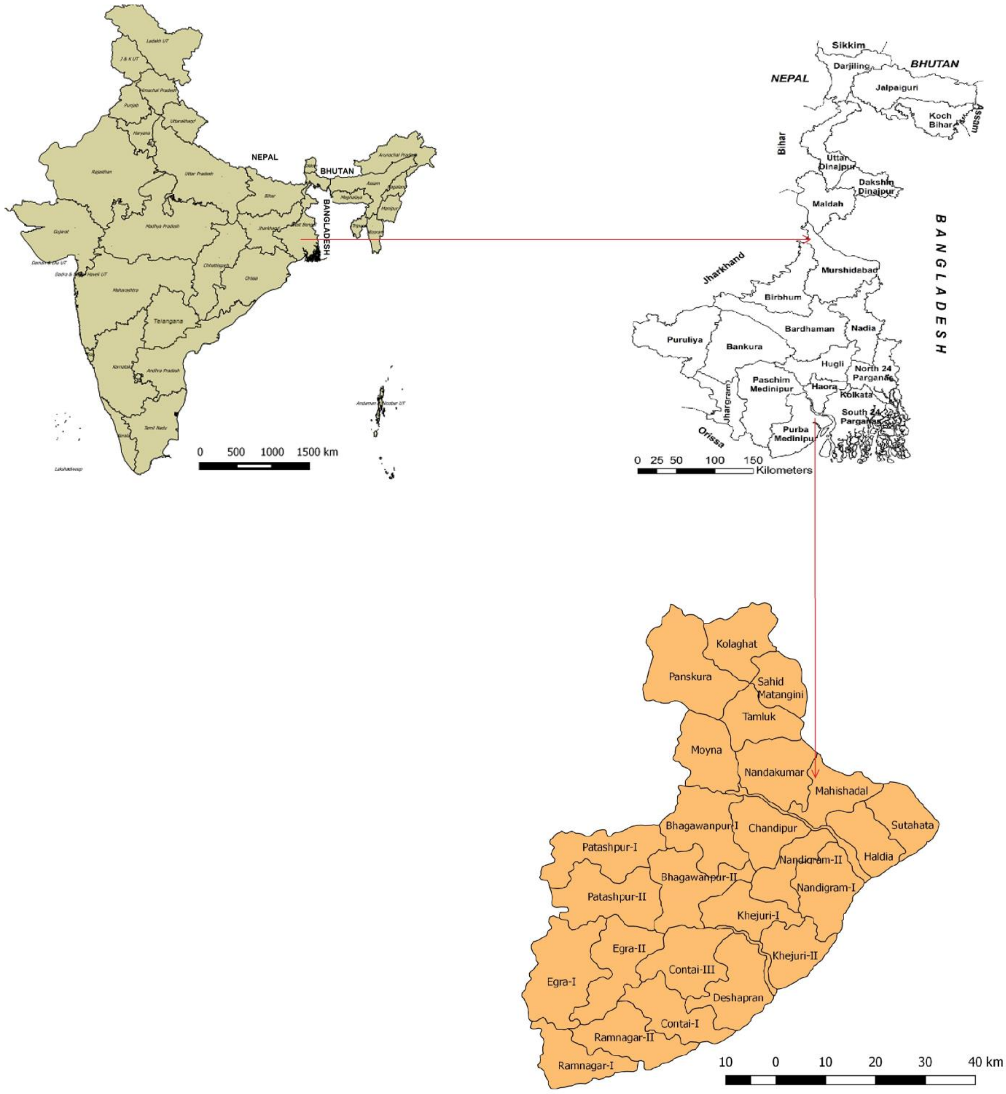

Figure 1. Location Map of Purba Medinipur district

3.2 Data Base

All the data have been collected from census data 2011 (CI, 2011) and district human development report 2011 (DHDR, 2011). The maps were prepared by using ArcGIS.

3.3 Indicator Selection

To determine the methodologies of this work, the main prerequisite was selection of indicators. 12 different indicators have been selected. Table 2 provides classification and the name of the indicators and some basic information about those.

Table 2. Indicators and their description

Sl. no.	Indicators	Name	Description	Relationship with vulnerability	Literature review
1	% of female	PFEP	Women are more	Positive	Müller et

	population		vulnerable than men due to low salary, family responsibilities and emotion.		al, 2011
2	% of child population (0-6 Years)	PCHP	Children are vulnerable due to lack of education, experience and knowledge.	Positive	Girasole et al, 2017
3	% of rural population	PRUP	Rural population is more vulnerable because of lower income and depending on urban for medical treatments.	Positive	Cutter et al, 2003
4	% of minority population	PMIP	Minority people are less educated than other.	Positive	Aksha et al, 2019
5	% of literate population	PLIP	High standard of education present greater chance of employment. Educated people can use the social network comparatively in better way, which is important tool for emergency planning and preparedness.	Negative	Ahmad et al, 2016
6	% of households with no electricity	PHNOEL	Without electricity, it is impossible to access modern communication gadgets like television, mobile, internet. Electricity also helps to make working environment better and increases working hours.	Positive	Mavhura et al, 2017
7	% of households with no sanitation	PHNOSA	Sanitation facility helps to reduce diseases.	Positive	Chen et al, 2013
8	% of households with no car	PHNOCA	Personal vehicles are important in emergency situation.	Positive	Bergstrand et al, 2015
9	% of	PHNOKI	Absence of kitchen in	Positive	Ge et al,

	households with no kitchen		home decrease food safety and increase health risk.		2017
10	% of households with no sewage	PHNOSE	Without sewage people can face unhygienic conditions in surrounding areas. Waste water can contaminate the environment and cause diseases.	Positive	de Mello Rezende, 2016
11	Employment rate	EMR	Employment influences the ability to recover after a disaster.	Negative	Dwyer et al, 2004
12	Infant mortality rate	IMR	High infant mortality rate indicates infants are unsafe from different disease.	Positive	Lee et al, 2014

3.4 Standardization Methods

Three deductive methodologies, which are basically three different mathematical equations, have been adopted to calculate the SVI. It is an additive model measuring the overall vulnerability of a region based on some of selected indicators (Cutter et al, 2003). To calculate SVI, raw data has been standardized by using these methodologies. This approach makes it easier to compare scores as normally the data of variables are found in different scales. The main purpose of standardization is to transfer scores in one scale. Table 3 represents the theory of three standardization methods.

Table 3. Three standardization methodologies

Methodology	Theory		Significance	Literature review
	Positive relationship	Negative relationship		
Z score transformation	$x = (q - \mu) / \sigma$ Final value adds with total value.	$x = (q - \mu) / \sigma$ *Final* value deducted from total value.	*q*= Actual value μ= Mean σ= Standard deviation	Zhang et al, 2013 Evans et al, 2014
Maximum value transformation	$x = \frac{x_i}{max}$	$x = 1 - \frac{x_i}{max}$	*max*= Maximum value x_i= Actual value	Wu et al, 2002 Koks et al, 2015
Min-max rescaling transformation	$x = \frac{x_i - min}{max - min}$	$x = \frac{max - x}{max - min}$	*max*= Maximum value *min*= Minimum	Tali et al, 2016 Kablan et al,

			value x_i= Actual value	2017

Final value was calculated by averaging of all indicators for each methodology for each block.

4. RESULT AND DISCUSSION

4.1 Vulnerable Zone Construction

Blockwise social vulnerability value of Purba Medinipur district by different methodologies are shown in Table 4 to 6. Higher value indicates higher level of vulnerability.

Table 4. Result of z score transformation standardization method

Block name	Indicators name												Average
	PFEP	PCHP	PRUP	PMIP	PLIP	PHNOEL	PHNOSA	PHNOCA	PHNOKI	PHNOSE	EMR	IMR	
Tamluk	0.36	0.08	-1.18	-0.69	0.31	-0.61	1.60	-0.05	-1.17	0.04	0.62	-0.70	-0.27
Sahid Matangini	-0.79	-0.77	0.09	-1.02	-0.08	1.83	1.54	-1.28	-0.86	-1.38	-0.24	0.29	-0.17
Panskura-I	0.76	-0.14	-0.53	-0.24	-1.62	1.83	1.81	0.22	-0.22	0.41	2.14	-0.94	0.20
Kolaghat	-0.83	-1.06	-0.56	-0.72	-1.09	0.17	1.29	0.50	-0.03	-1.79	0.08	-0.39	-0.20
Moyna	-1.63	0.01	0.40	0.91	-0.40	-1.00	1.27	1.25	1.09	0.93	0.32	0.15	0.29
Nandakumar	-0.13	0.36	0.59	-0.16	-0.78	0.22	1.09	-0.35	-0.06	0.95	0.68	0.82	0.29
Chandipur	-0.22	0.81	0.19	-0.58	0.33	0.06	-0.31	0.70	-0.69	0.87	-0.37	-0.93	-0.01
Mahishadal	-0.03	-0.29	0.38	-0.47	-0.46	0.78	-0.78	-0.95	-1.17	-0.77	-0.44	-0.13	-0.21
Nandigram-I	0.65	2.60	0.41	0.26	-1.11	1.44	0.00	0.57	-0.24	-0.39	-1.73	-1.36	0.57
Nandigram-II	0.69	0.78	0.31	-0.30	0.99	-1.39	-0.99	0.70	-1.96	-0.48	-0.76	-0.36	-0.27
Sutahata	1.01	0.83	0.32	1.44	-0.85	1.61	1.50	-2.13	-0.47	-0.69	-1.55	1.48	0.61
Haldia	-1.64	0.23	-3.85	-0.06	0.27	-0.72	0.28	-1.18	-1.78	1.92	-1.54	3.07	-0.20
Potashpur-I	-0.32	-0.91	0.35	-0.14	-0.56	-0.72	-0.96	1.47	1.35	1.54	1.59	0.97	0.13
Potashpur-II	-0.09	0.03	0.59	-0.32	-0.32	-1.28	-0.92	0.92	1.28	-0.10	0.28	1.43	0.13
Bhagawanpur-I	-0.66	0.87	0.26	-0.16	0.48	-0.83	-0.05	1.05	0.34	1.48	0.33	-1.21	0.02
Egra-I	0.01	-0.48	-0.42	-0.48	-1.80	0.00	-0.11	-1.35	1.65	-1.29	-1.10	0.43	0.07
Egra-II	-0.84	-0.91	0.59	0.45	-0.33	-0.78	-0.98	0.92	1.28	0.30	0.42	-0.53	-0.05
Khejuri-I	0.26	0.40	0.59	-0.26	0.86	-0.17	-1.19	-0.73	-0.21	-0.94	0.18	-0.83	-0.34
Khejuri-II	1.73	2.21	0.59	4.11	-0.88	-1.00	-0.28	-1.40	0.66	0.60	-0.93	0.01	0.75
Bhagawanpur-II	0.08	-0.61	0.59	0.17	1.89	0.44	-0.83	0.65	0.43	-0.64	-0.29	-0.58	-0.16
Ramnagar-I	2.44	-0.70	0.38	-0.24	0.34	0.33	-0.16	-0.53	-0.99	-0.15	1.58	-0.81	-0.20
Ramnagar-II	0.26	-1.57	0.59	-0.19	1.10	0.33	-0.48	0.25	-0.02	0.55	0.08	-0.50	-0.16
Contai-I	-2.11	-1.38	-1.72	-0.43	1.82	1.72	-0.92	0.35	0.12	-1.51	-0.75	0.25	-0.56
Deshapran	0.06	-0.19	0.39	-0.61	0.58	-0.89	-0.28	-0.90	1.34	-0.11	0.13	0.53	-0.11
Contai-III	0.56	-0.34	0.59	-0.27	1.35	-0.78	-1.11	1.05	0.33	0.65	1.29	-0.15	-0.17

Table 5. Result of maximum value transformation standardization method

Block name	Indicators name												Average
	PFEP	PCHP	PRUP	PMIP	PLIP	PHNOEL	PHNOSA	PHNOCA	PHNOKI	PHNOSE	EMR	IMR	
Tamluk	0.99	0.86	0.73	0.16	0.04	0.25	0.94	0.99	0.53	0.96	0.11	0.22	0.56
Sahid Matangini	0.98	0.81	0.92	0.10	0.04	1.00	0.92	0.99	0.58	0.92	0.17	0.42	0.66
Panskura-I	0.99	0.85	0.83	0.24	0.08	1.00	1.00	0.99	0.69	0.97	0.00	0.17	0.65
Kolaghat	0.98	0.79	0.83	0.15	0.07	0.49	0.85	1.00	0.72	0.91	0.15	0.28	0.60
Moyna	0.98	0.85	0.97	0.44	0.05	0.14	0.85	1.00	0.91	0.98	0.13	0.39	0.64
Nandakumar	0.99	0.87	1.00	0.25	0.06	0.51	0.80	0.99	0.72	0.98	0.10	0.53	0.65
Chandipur	0.99	0.90	0.94	0.18	0.03	0.46	0.40	1.00	0.61	0.98	0.18	0.17	0.57
Mahishadal	0.99	0.84	0.97	0.20	0.05	0.68	0.27	0.99	0.53	0.94	0.18	0.34	0.58
Nandigram-I	0.99	1.00	0.97	0.32	0.07	0.88	0.49	1.00	0.69	0.95	0.27	0.08	0.64
Nandigram-II	0.99	0.90	0.96	0.23	0.02	0.02	0.21	1.00	0.40	0.94	0.21	0.29	0.51
Sutahata	0.99	0.90	0.96	0.53	0.06	0.93	0.91	0.99	0.65	0.94	0.26	0.67	0.73
Haldia	0.98	0.87	0.33	0.27	0.04	0.22	0.57	0.99	0.43	1.00	0.26	1.00	0.58
Potashpur-I	0.99	0.80	0.96	0.26	0.05	0.22	0.21	1.00	0.95	0.99	0.04	0.56	0.59
Potashpur-II	0.99	0.86	1.00	0.22	0.05	0.05	0.23	1.00	0.94	0.95	0.13	0.66	0.59
Bhagawanpur-I	0.98	0.90	0.95	0.25	0.03	0.19	0.47	1.00	0.78	0.99	0.13	0.11	0.57
Egra-I	0.99	0.83	0.85	0.20	0.08	0.44	0.46	0.99	1.00	0.93	0.23	0.45	0.62
Egra-II	0.98	0.80	1.00	0.36	0.05	0.20	0.21	1.00	0.94	0.96	0.12	0.25	0.57
Khejuri-I	0.99	0.88	1.00	0.23	0.02	0.39	0.15	0.99	0.69	0.93	0.14	0.19	0.55
Khejuri-II	1.00	0.98	1.00	1.00	0.06	0.14	0.41	0.99	0.84	0.97	0.22	0.37	0.66
Bhagawanpur-II	0.99	0.82	1.00	0.31	0.00	0.58	0.25	1.00	0.80	0.94	0.17	0.24	0.59
Ramnagar-I	1.00	0.81	0.97	0.24	0.03	0.54	0.44	0.99	0.56	0.95	0.04	0.19	0.56
Ramnagar-II	0.99	0.77	1.00	0.25	0.02	0.54	0.35	1.00	0.72	0.97	0.15	0.26	0.58
Contai-I	0.98	0.78	0.65	0.20	0.00	0.97	0.23	1.00	0.75	0.92	0.21	0.41	0.59
Deshapran	0.99	0.84	0.97	0.17	0.03	0.17	0.41	0.99	0.95	0.95	0.14	0.47	0.59
Contai-III	0.99	0.83	1.00	0.23	0.01	0.20	0.17	1.00	0.78	0.97	0.06	0.33	0.55

Table 6. Result of min-max transformation standardization method

Block name	Indicators name												Average
	PFEP	PCHP	PRUP	PMIP	PLIP	PHNOEL	PHNOSA	PHNOCA	PHNOKI	PHNOSE	EMR	IMR	
Tamluk	0.55	0.40	0.60	0.07	0.43	0.24	0.93	0.58	0.22	0.49	0.39	0.15	0.42
Sahid Matangini	0.29	0.19	0.89	0.00	0.53	1.00	0.91	0.24	0.31	0.11	0.61	0.37	0.45
Panskura-I	0.63	0.34	0.75	0.15	0.95	1.00	1.00	0.65	0.48	0.59	0.00	0.09	0.55
Kolaghat	0.28	0.12	0.74	0.06	0.81	0.48	0.82	0.73	0.54	0.00	0.53	0.22	0.44
Moyna	0.11	0.38	0.96	0.38	0.62	0.12	0.82	0.94	0.85	0.73	0.47	0.34	0.56
Nandakumar	0.44	0.46	1.00	0.17	0.72	0.50	0.76	0.49	0.53	0.74	0.38	0.49	0.56
Chandipur	0.42	0.57	0.91	0.09	0.42	0.45	0.29	0.78	0.35	0.72	0.65	0.10	0.48
Mahishadal	0.46	0.31	0.95	0.11	0.64	0.67	0.14	0.33	0.22	0.28	0.67	0.28	0.42
Nandigram-I	0.61	1.00	0.96	0.25	0.81	0.88	0.40	0.75	0.48	0.38	1.00	0.00	0.63
Nandigram-II	0.62	0.56	0.94	0.14	0.24	0.00	0.07	0.78	0.00	0.35	0.75	0.22	0.39
Sutahata	0.69	0.58	0.94	0.48	0.74	0.93	0.90	0.00	0.41	0.30	0.95	0.64	0.63
Haldia	0.11	0.43	0.00	0.19	0.44	0.21	0.49	0.26	0.05	1.00	0.95	1.00	0.43

Potashpur-I	0.40	0.16	0.95	0.17	0.66	0.21	0.07	1.00	0.92	0.90	0.14	0.52	0.51
Potashpur-II	0.45	0.38	1.00	0.14	0.60	0.03	0.09	0.85	0.90	0.46	0.48	0.63	0.50
Bhagawanpur-I	0.32	0.59	0.93	0.17	0.38	0.17	0.38	0.88	0.64	0.88	0.47	0.03	0.49
Egra-I	0.47	0.26	0.77	0.11	1.00	0.43	0.36	0.22	1.00	0.13	0.84	0.40	0.50
Egra-II	0.28	0.16	1.00	0.29	0.60	0.19	0.07	0.85	0.90	0.56	0.45	0.19	0.46
Khejuri-I	0.52	0.47	1.00	0.15	0.28	0.38	0.00	0.39	0.49	0.23	0.51	0.12	0.38
Khejuri-II	0.85	0.91	1.00	1.00	0.75	0.12	0.30	0.20	0.73	0.64	0.79	0.31	0.63
Bhagawanpur-II	0.48	0.23	1.00	0.23	0.00	0.57	0.12	0.77	0.66	0.31	0.63	0.18	0.43
Ramnagar-I	1.00	0.21	0.95	0.15	0.42	0.53	0.34	0.44	0.27	0.44	0.14	0.12	0.42
Ramnagar-II	0.52	0.00	1.00	0.16	0.21	0.53	0.24	0.66	0.54	0.63	0.53	0.19	0.44
Contai-I	0.00	0.05	0.48	0.12	0.02	0.97	0.09	0.69	0.58	0.08	0.75	0.36	0.35
Deshapran	0.48	0.33	0.95	0.08	0.35	0.16	0.30	0.34	0.91	0.45	0.52	0.43	0.44
Contai-III	0.59	0.30	1.00	0.15	0.15	0.19	0.03	0.88	0.64	0.66	0.22	0.27	0.42

To understand the degree of social vulnerability, all the 25 blocks have been categorized in five different vulnerable zones. The results of the analysis show that most socio-economically vulnerable blocks are located in the eastern part of the Purba Medinipur district. Except Sutahata block, all the blocks (Tamluk, Haldia, Contai-I and Egra-I) having municipalities within, and so are positioned in comparatively least vulnerable region. The municipalities are composed of urban population and they are facilitated with more and better possibilities than rural regions.

Result shows five different levels of vulnerability among twenty-five blocks of Purba Medinipur district (Fig. 2). Sutahata block is very high vulnerable because of high rate of rural population, less employment rate, poor sanitary and electricity problems. By using z score transformation and min–max rescaling transformation very high vulnerability have also been found in Nandigram-I and Khejuri-III blocks. The main causes of vulnerability in Nandigram-I and Khejuri-III are similar to Sutahata block. On the other side, high employment rate, less child and female population, better sanitation and sewage make Contai-I block very low vulnerable. According to maximum value transformation theory, very low vulnerable block is Nandigram-II. Although this block has high female, child and rural population, but high literacy and employment rates and low infant mortality rate make Nandigram-II very low vulnerable.

Table 7 shows the vulnerability zonation of blocks in Purba Medinipur district after employing three different methodologies separately. Out of the 25 blocks, 12 blocks are categorized with same vulnerable zone irrespective to the methodologies adopted. This also signifies a strong relationship between the three different methodologies.

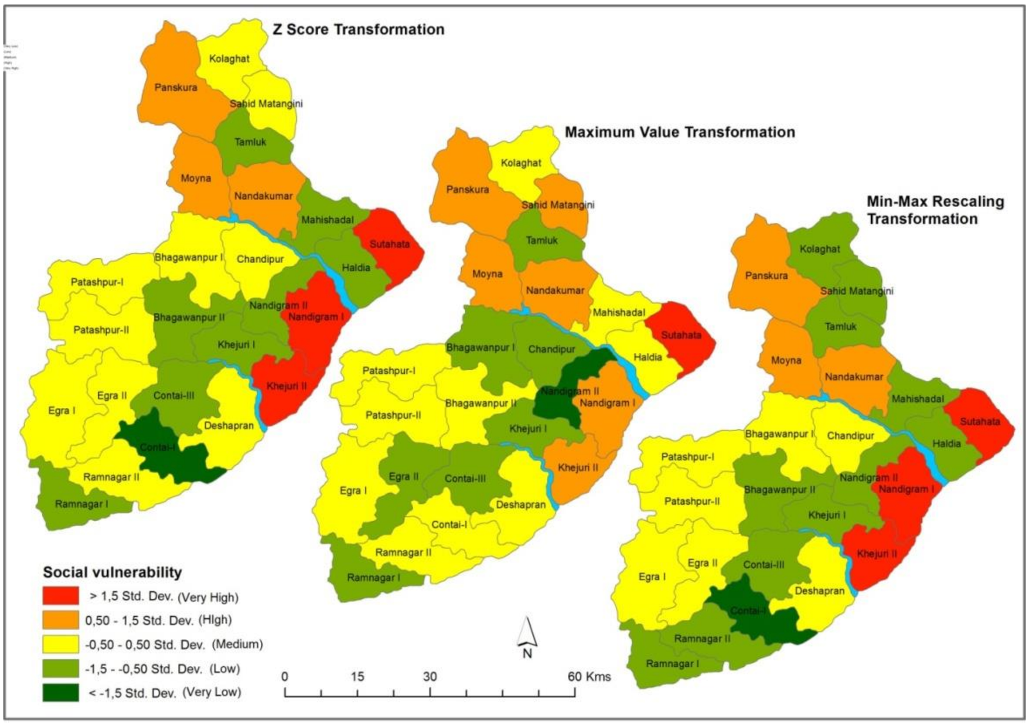

Figure 2. Social vulnerability map of Purba Medinipur district based on three different methodologies

Table 7. Location of blocks in different vulnerable zone

Sl. no.	Block name	Methodologies		
		Z score transformation	Maximum value transformation	Min–max rescaling transformation
1	Tamluk	Low	Low	Low
2	Sahid Matangini	Low	High	Medium
3	Panskura	High	High	High
4	Kolaghat	Low	Medium	Medium
5	Moyna	High	High	High
6	Nandakumar	High	High	High
7	Chandipur	Medium	Low	Medium
8	Mahishadal	Low	Medium	Low
9	Nandigram-I	Very high	High	Very high
10	Nandigram-II	Low	Very low	Low
11	Sutahata	Very high	Very high	Very high
12	Haldia	Low	Medium	Low
13	Patashpur-I	Medium	Medium	Medium
14	Patashpur-II	Medium	Medium	Medium
15	Bhagwanpur-I	Medium	Low	Medium
16	Egra-I	Medium	Medium	Medium
17	Egra-II	Medium	Low	Medium
18	Khejuri-I	Low	Low	Low
19	Khejuri-II	Very high	High	Very high
20	Bhagwanpur-II	Low	Medium	Low
21	Ramnagar-I	Low	Low	Low

22	Ramnagar-II	Low	Medium	Medium
23	Contai-I	Very Low	Medium	Very low
24	Deshapran	Medium	Medium	Medium
25	Contai-III	Low	Low	Low

4.2 Relationship Measurement

It is very essential to find correlation between three different methodologies employed in this work. Pearson's correlation coefficient has been adopted to find the correlation. It is a statistical measure of the strength and direction (negative or positive) of a relationship between two data.

Result obtained from the correlation (Table 8) shows both positive and negative relationship between different indicators. It is also important thing that no relationships are strongly correlated with each other. Value of 0 between minority population and households with no sanitation indicates that there is no linear relationship between the two indicators.

Table 8. Pearson's correlation coefficient between different indicators

	PFEP	PCHP	PRUP	PMIP	PLIP	PHNOEL	PHNOSA	PHNOCA	PHNOKI	PHNOSE	EMR	IMR
PFEP	1											
PCHP	0.36	1										
PRUP	0.47	0.13	1									
PMIP	0.34	0.53	0.19	1								
PLIP	-0.15	-0.29	-0.04	-0.23	1							
PHNOEL	0.02	-0.11	-0.09	-0.16	-0.16	1						
PHNOSA	-0.04	0.08	-0.24	0.00	-0.51	0.38	1					
PHNOCA	-0.28	-0.17	0.21	-0.24	0.26	-0.33	-0.30	1				
PHNOKI	-0.15	-0.17	0.39	0.20	-0.21	-0.26	-0.22	0.27	1			
PHNOSE	-0.04	0.22	-0.10	0.23	0.01	-0.48	-0.03	0.31	0.06	1		
EMR	0.17	-0.43	0.27	-0.27	0.03	-0.14	0.06	0.45	0.21	0.29	1	
IMR	-0.32	-0.11	-0.48	0.09	-0.12	-0.16	0.08	-0.37	0.03	0.21	-0.28	1

The correlation coefficient between z score and min–max rescaling transformation is 0.99 (Table 9). This value shows positively ´´very strong´´ (Chan, 2003) relationship between z score and min–max rescaling transformation. The correction value between z score and maximum value transformation is 0.74, whereas the same between maximum value transformation and min–max rescaling transformation is 0.79. The values of 0.74 and 0.79 signify the relationships are positive and ´´moderately strong´´ (Chan, 2003). Such a ´´very strong´´ and ´´moderately strong´´ positive relationships provide an important implication that there lies no significant differences between three standardization methods employed.

Table 9. Pearson's correlation coefficient between three methodologies

	Z score transformation	Maximum value transformation	Min–max rescaling transformation

Z score transformation	1		
Maximum value transformation	0.74	1	
Min–max rescaling transformation	0.99	0.79	1

5. CONCLUSION

This study contributes to vulnerability analysis by presenting social vulnerability index using three different methodologies. Outcomes of three different methodologies have no significant differences. Selection of vulnerable zone using Z score transformation and Min–max rescaling transformation standardization method are similar for 22 blocks. In a social vulnerability zonation map, selection of methodologies depends on decision of the investigator. Since relationships are moderately strong to strong between the three methods employed in this study, any method can be chosen for social vulnerability assessment.

This block level analysis will potentially help to develop a monitoring and evaluation framework for local level adaptation projects. This analysis will also assist for preparedness of natural hazards and thereafter to reduce the impacts of future natural disaster events. Better socio-economic conditions mainly; electricity, sanitation, sewage facility and employment opportunity can improve the resistance power of high vulnerable blocks and then can improve social vulnerability index of Purba Medinipur district. Lack of data at block level for some of the indicators is one limitation of this study and a potential for future scope of work.

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