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Assessment of Existing Flood Preparedness Measures in Flood Vulnerable Communities: A Study in the Deduru Oya Basin in Sri Lanka

WMSB Wanninayake[1*], KWG Rekha Nianthi[2], OG Dayaratne Banda[3]

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Abstract

Flood preparedness measures in the Deduru Oya basin are seemingly not at a satisfactory level to minimize the flood risk in the area. Therefore, a proper study should be done to identify flood preparedness measures and the people's consensus on flood preparedness measures to be implemented in the area. These findings are necessary to establish flood preparedness measures in flood-vulnerable communities. Accordingly, this study aimed to assess the existing flood preparedness measures and to identify the people's consensus on implementing flood preparedness measures in flood-vulnerable communities in the Deduru Oya basin. Flood preparedness measures generally mean the precautionary actions taken in advance to minimize the damages caused by floods. In this context, flood preparedness measures were studied using 16 variables mostly used in the literature and familiar to the locality. The stratified random sampling method was used in the current study to select the

[1] *Department of Environmental Management, Rajarata University of Sri Lanka.* sisirawanninayake@gmail.com
[2] *Department of Geography, University of Peradeniya.*
[3] *Department of Economics and Statistics, University of Peradeniya.*

sample (n = 425). Primary data, which was collected through a questionnaire survey and interviews, was used for the study. Descriptive data analysis and Ordinal Logistic Regression Analysis methods were used as data analysis techniques. The results have shown that only a flood early warning system is operating in the area while all the other flood preparedness measures, i.e., training and awareness programs, village-level disaster management committees and plans, flood hazard maps, land use planning, building codes, flood risk insurances, local emergency fund, mitigation loans, and reconstruction loans are not operating in the area. Further, people's evacuation capacity is satisfactory, while the people's rebuilding capacity, public participation in flood risk management activities, communication and coordination, and the government sector involvement in flood risk management activities are not satisfactory. These results show that the flood preparedness measures in the study area are not satisfactory. Therefore, the government should take necessary actions through the relevant authorities to enhance the flood preparedness measures in the area.

Keywords: Flood preparedness measures, Flood risk, Flood vulnerable communities, People's consensus on flood preparedness, Deduru Oya basin

Introduction

Natural disasters like floods and landslides have become the most frequent disasters in Sri Lanka (UNDRR and ADPC, 2019). The disaster management mechanism in Sri Lanka should be aligned with international initiatives, standards, and agreements (DMC, 2010). Accordingly, modern disaster management tools and methods should be introduced and applied in Sri Lanka. The National Disaster Management Plan (NDMP) of Sri Lanka (DMC, 2014) has stated that the Disaster Management Centre (DMC) will promote Community-Based Disaster Management (CBDRM) in Sri Lanka. Building the resilience of communities is essential to reducing disaster risk (DMC, 2015). Further, the Community Resilience Framework (CRF) has revealed that the activities in community-level disaster risk management, e.g., village-level risk assessments, should be performed with the participation of community members. The community should be aware of all the disaster-related matters in the area, and disaster preparedness in communities should be enhanced to build resilience by reducing vulnerability and developing the capacity of communities. The UNISDR (2009) defines preparedness as the knowledge and capacities developed by governments, other organizations, communities, and individuals by which the people and stakeholders can effectively respond and recover from hazards and related impacts. The author has further mentioned that preparedness should be done following a comprehensive risk analysis: Effective early warning mechanism, contingency planning, building up stocks of equipment and supplies, developing coordination systems, evacuation planning, necessary training, field exercises, etc., are included in preparedness. Recognized institutions must support these preparedness activities through legal and budgetary provisions.

The Sendai Framework for Disaster Risk Reduction 2015-2030 (SFA) has stated that disaster preparedness should be enhanced for effective response and to build back better in the recovery phase (UNISDR, 2015). Accordingly, disaster preparedness policies, plans, programs, establishing people-centered early warning systems, disaster risk, and emergency communication systems, hazard monitoring systems, public awareness programs, land use planning, building standards, recognition of stakeholders, their roles and responsibilities, etc., are essential.

Though the experts have mentioned the importance of preparedness measures and their requirements in Disaster Risk Reduction (DRR), research findings are dearth on the existence and performance of flood preparedness measures in flood-vulnerable communities in Sri Lanka. Accordingly, the JICA (2017) has revealed various gaps in disaster management mechanisms in Sri Lanka, which should be filled. Concerning the research studies on flood risk management in Sri Lanka, several studies have been conducted that have mainly focused on floods in Wet Zone River basins like the *Kelani, Kalu, Niwalla,* and *Gin* (JICA, 2009; Nandala and Ratnayake, 2011; JICA, 2013; JICA, 2017) and some studies have been done in some administrative areas like Municipalities, DSDs etc., (Idris and Dharmasiri, 2015; Dissanayake *et al,* 2018; Weerasinghe *et al,* 2018). However, there is a dearth of research studies on flood risk management in vulnerable communities in dry zone river basins like *Deduru Oya*. Accordingly, this study on flood preparedness measures in vulnerable communities in the Deduru Oya basin has somewhat attempted to fill this gap.

Floods in the Deduru Oya basin have severely affected vulnerable communities in the areas; as a result, 10,659 people have been affected by the 2010 flood, 78,278 people have been affected by the 2012 flood, 30,568 people by the 2014 flood, and 27,342 people in 2016 flood in 20 Divisional Secretary Divisions (DSD) in the Deduru Oya basin. Further, people have been affected by the 2011, 2015, 2018, and 2019 floods in the Deduru Oya basin (DDMCU, 2020; DMC, 2020a; Divisional Secretariat, 2020a). Considering the number of flood-affected population by DSDs from 2010 to 2019, about 71,664 people have been affected in Chilaw DSD, 50,974 people in Arachchikattuwa DSD, 9,253 people in Bingiriya DSD, and 5,887 people in Pallama DSD. Moreover, the Deduru Oya has been well-known for flash floods for decades (Karunathilaka, 1989; Manchanayake and Madduma Bandara, 1999).

Accordingly, the current research aimed to study the existence of flood preparedness measures and their performance at present in the Deduru Oya basin, as well as the people's willingness to implement flood preparedness measures in the study area. However, the study was limited to assessing the flood preparedness measures (the social aspect of flood management) and did not attempt to study the structural mitigation measures (the engineering aspect of flood management) in the study area. Generally, mitigation focuses on the hazard component, while preparedness focuses on vulnerability and capacity components. Accordingly, the research hypothesis of the current study was that the *"malfunction of flood preparedness measures in the Deduru Oya basin has caused the low capacity of vulnerable people."*

Materials and Methods

The study area was the Deduru Oya basin, located in the western part of Sri Lanka (Figure 01).

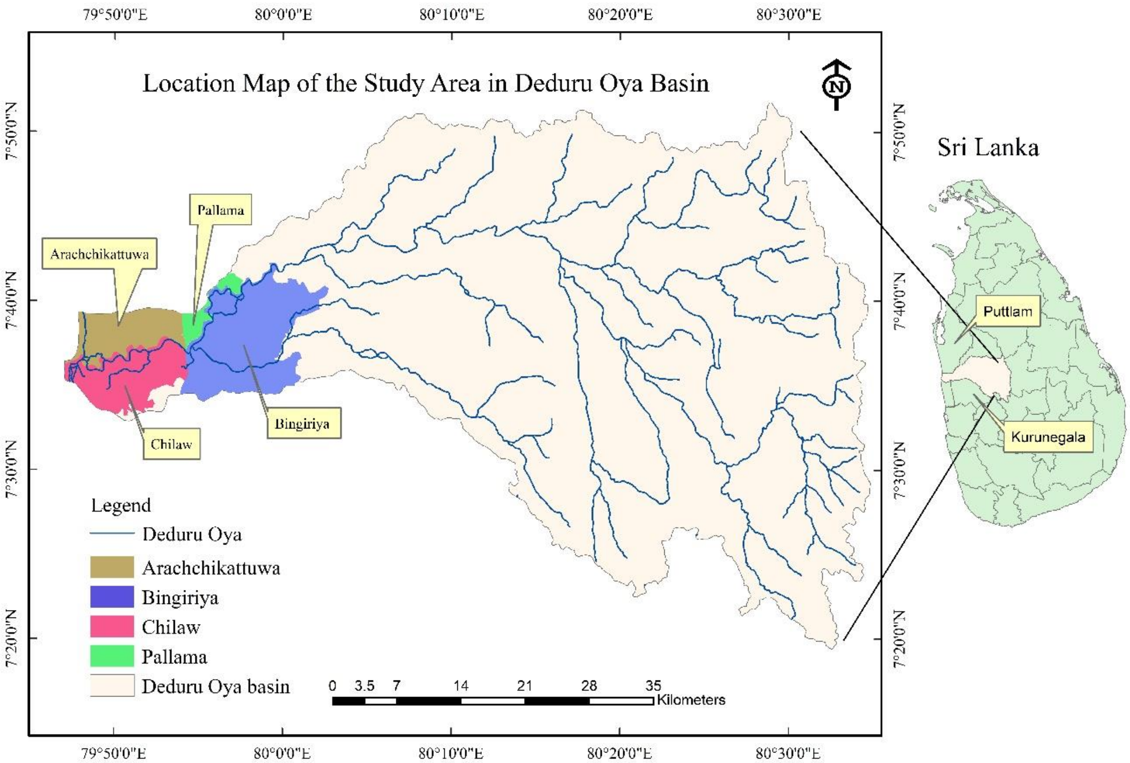

Figure 1 Location map of the study area

Source: Prepared by the researcher based on data from the Survey Department and the Department of Geography, University of Peradeniya, Sri Lanka

The stratified random sampling method was used to select the sample for the study. The four most flood-vulnerable DSDs (04), namely the Chilaw, Arachchikattuwa, Pallama, and Bingiriya, were selected for the study (Figure 1). From these four (04) DSDs, the most flood-vulnerable 15 Grama Niladari Divisions (GND) were selected for the flood preparedness assessment. There were 2830 households (N=2830) in flood inundation areas of selected 15 GNDs, and 425 (15%) households (n=425) out of the total households were selected randomly for primary data collection as the sample. The selected 15 GNDs, were: number 569 A Parappanmulla, 569 B Manuwangama West, 569 C Nariyagama North, 570 Mahawilaththawa, 570 A Wirapandiyana, 579 A

Thimbilla and 579 B Deduruoya GNDs (from Chilaw DSD), 571 Elivitiya, 573 Bangadeniya, 574 Wirakumandaluwa, 574 C Mukkandaluwa, 581 A Dematapitiya (from Arachchikattuwa DSD), 1455 Molaeliya, 1456 Getulawa (from Bingiriya DSD) and 664 Pallama (from Pallama DSD). Chilaw, Arachchikattuwa, and Pallama DSDs are in the Puttlam district, and Bingiriya DSD is in the Kurunegala district.

A questionnaire survey was administered among the 425 households as the main tool of primary data collection. As the secondary data, information on flood-affected GNDs, flood-affected population, etc., were collected from the Arachchikattuwa, Bingiriya, Chilaw, and Pallama Divisional Secretariats (2020a), Grama Niladaries of the 15 GNDs, District Disaster Management Coordinating Units (DDMCU) of Kurunegala and Puttlam (2020) and the Disaster Information Management System-Sri Lanka (DMC, 2020a). The information on families, persons, and houses of GNDs were collected from Arachchikattuwa, Bingiriya, Chilaw and Pallama Divisional Secretariats (2020b), Grama Niladaries and from the Census Reports of the Department of Census and Statistics (2001 and 2012).

Sixteen (16) variables of flood preparedness were used for the analysis, and from them, 11 variables were used as explanatory variables, and five (5) variables were used as response variables (Table 1). These variables were selected mainly based on the indicators used in the risk assessment model introduced by Bollin *et al.* (2003) and considering several other flood risk assessment methods (Davidson and Shah, 1997; Ferrier and Haque, 2003; Smith, 2004; Nandalal, 2011; Cardona *et al*. 2012; Westen, 2014; Marin-Ferrer *et al*. 2017; Mohammed, 2018; DMC, 2019c).

The explanatory variables were studied under two categories as below;

i. Existence and performance of preparedness measures in the study area.
ii. Agreement/consensus of the people to implement these preparedness measures.

Even though some preparedness measures did not exist in the field, they were tested to identify the people's agreement/consensus on introducing and implementing such new measures.

In the literature, preparedness and non-structural mitigation measures have been considered together at times, while they have been taken separately on some occasions. In the current study, preparedness and non-structural mitigation measures were considered as preparedness measures for easy understanding.

In data analysis, variables were analyzed descriptively initially and then statistically to test the study's hypothesis. The statistical analysis first tested the questionnaire's validity and reliability and the data's normality. Because the data were not normally distributed, Ordinal Logistic Regression Analysis was applied considering the data type. Accordingly, the Model Fitting Test, Goodness of Fit Test, Parameter Estimate Test, and Parallel Line Test were performed. Finally, based on the Test of Parallel Lines, the Chi-Square values were computed for each response variable based on the explanatory variables. Accordingly, the level of preparedness measures in the study area was tested.

Table 1. Variables used for the flood preparedness assessment

Explanatory variables	**Response Variables**
1. Dissemination of flood early warnings (FEW)	Local emergency fund (LEF)
2. Training and awareness programs (T&A)	Mitigation loans (ML)
2. Village-level disaster management committees (VDMC)	Reconstruction loans (RL)
3. Village disaster management plans (VDMP)	People's evacuation capacity (EC)
4. Flood hazard maps (FHM)	People's rebuilding capacity (RC)
5. Land use planning (LUP)	Public participation (PP)
6. Building codes (BC)	Communication and coordination (CC)
7. Flood risk insurance (FI)	Government sector involvement (GSI)

Results and Discussion

Flood early warning (FEW) dissemination has been recognized as an essential tool in flood preparedness. Warnings about impending floods help the public to evacuate to safer places. Therefore, a FEW dissemination system was tested in the study area. About 85% of the respondents mentioned an early flood warning dissemination system in the area, while 15% mentioned no FEW dissemination system. Also, about 52% of the respondents mentioned being satisfied with receiving flood early warnings. Then, the people's consensus on the requirement of performing a FEW system as a preparedness tool was tested, and about 98% of the respondents agreed on implementing a flood early warning system in the area. Accordingly, Table 2 shows the people's consensus on the flood preparedness measures (indicators) in the study area.

About 87% of the respondents mentioned that no training and awareness programs are conducted regularly in the study area, while 96% mentioned that they agree to conduct regular training and awareness programs to help people manage floods. About 100% of the respondents mentioned that village-level disaster management committees are not operating in the area, while 83% said they agree to implement VDMCs. About 99% of the respondents have mentioned that there are no VDMPs prepared in the area, while 93% are interested in implementing VDMPs. About 97% of the respondents mentioned that flood hazard maps have not been developed in the area; however, 86% are interested in flood hazard maps that can be used in flood management. About 90% of the respondents have mentioned that land use plans are not operating in the area, but 80% are interested in LUPs. About 84% of the respondents mentioned that building codes are not operating in the area, but 68% agreed on BCs. About 99% of the respondents mentioned that flood risk insurance schemes are not operating in the area, while 60% mentioned that they agreed on flood risk insurance. However, 31% of the respondents are not interested in flood risk insurance and have mentioned that only the government-led flood insurance scheme can be accepted. About 83% of the respondents mentioned that the local emergency fund is not operating in the area to help the flood victims in flood emergencies. However, 99% of the respondents agreed to operate LEF in the area. About 92% of the respondents have mentioned that the mitigation loan scheme is not operating in the area, and 94% have agreed to operate an ML scheme in the area. In the same way, 94% of the respondents mentioned that no rehabilitation loan scheme is operating in the area, and 99% agreed to implement a rehabilitation loan scheme in the study area.

Table 2. The consensus of the people on flood preparedness measures

	Indicator	Existance and performance			People's agreement to implemet				
		Yes %	No %	Don't know %	S.Agree %	Agree %	Neutral %	Not Agree %	S.Not Agree %
Explanatory Variables	FEW	84.5	15.3		31.1	67.3	1.6		
	T&A	13.4	86.6		8.9	86.8	4	0.2	
	VDMC	0.7	99.3		0.2	82.4	17.2	0.2	
	VDMP		99.3	0.7	0.9	92.5	6.4	0.2	
	FHM		96.9	3.1	0.2	85.5	11.3		
	LUP		90.4	9.65	2.6	77.2	20.2		
	BC		83.8	16.2	0.7	67.3			
	FI		99.5	0.5	0.9	59.3	27.3	10.4	2.1
	LEF		82.6	17.4	2.4	96.5	1.2		
	ML		91.5	8.5	4.2	89.4	6.4		
	RL		94.1	5.9	19.06	80	0.9		
					People's satisfaction				
					S.Satisfied %	Satisfied %	Neutral %	Not Satisfied %	S.Not Satisfied %
Response Variables	EC				0.7	92.2	1.9	2.8	2.4
	RC					3.5	6.4	55.5	34.6
	PP				0.2	6.4	32.7	59.8	0.9
	CC				0.2	9.2	32	57.2	1.4
	GSI					10.1	20.9	51.5	17.4

Considering the response variables, 93% of the respondents have mentioned that they are satisfied with their capacity to evacuate to safer places in flood emergencies. However, the results of other response variables are not satisfying. About 90% of the respondents have mentioned that they are not satisfied with their capacity to rebuild after being impacted by a flood, and about 35% of these respondents have mentioned that they are not satisfied with their capacity to rebuild after a flood. Likewise, 61% of the respondents mentioned that they were not satisfied with public participation in flood risk management activities in the area. About 59% of the respondents have mentioned that they are unsatisfied with the present communication and coordination mechanism for flood risk management activities in the study area. About 69% of the respondents mentioned that they were not satisfied with the involvement of government sector agencies in flood risk management activities in the study area. The people have mentioned that the government sector agencies are not adequately involved in flood DRR activities (Figure 2)

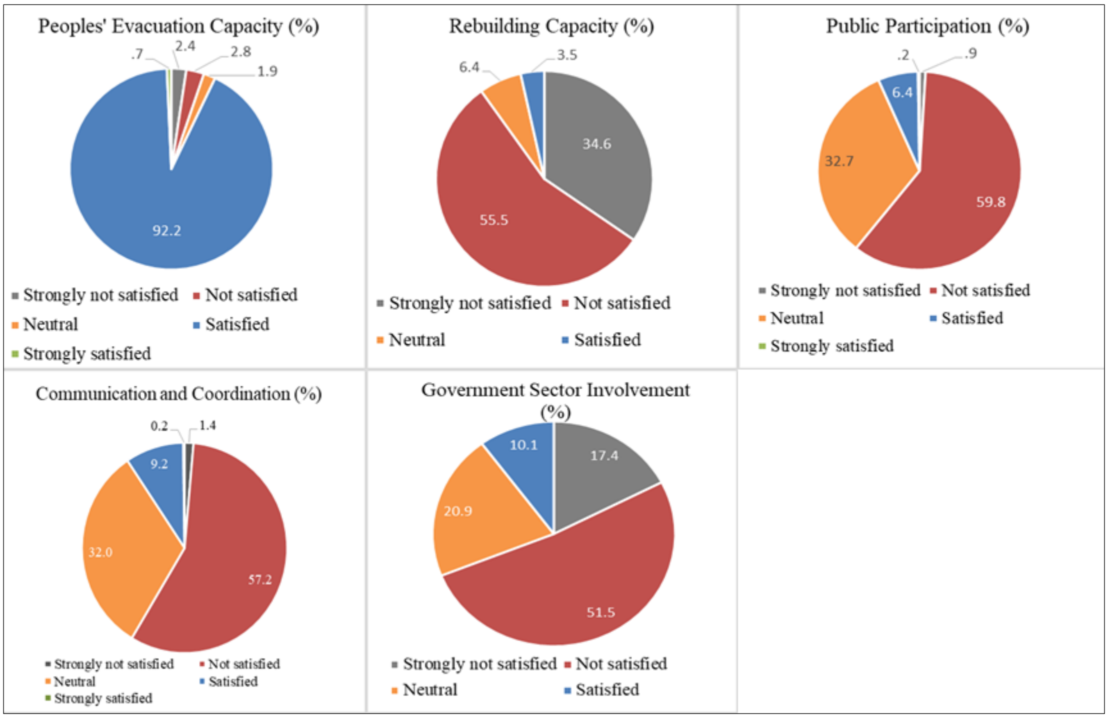

Figure 2. People's satisfaction with response variables

The following results were obtained in the statistical test of preparedness indicators. The validity and reliability of the measurements were tested at the beginning through the Cronbach alpha test. The Cronbach alpha value was 0.681, close to 0.7, confirming that the variables' internal consistency is accepted. In the study, the Kolmogorov-Smirnov and the Shapiro-Wilk tests were performed to check the normality of observations. The significance value of the Shapiro-Wilk test should be greater than 0.05 for the data to be expected. According to the test results, all the values for Kolmogorov-Smirnova and Shapiro-Wilk tests were below 0.05, confirming that the data are not normally distributed. Therefore, Ordinal Logistic Regression Analysis was performed to find the adequacy of flood preparedness measures in the Deduru Oya Basin. Ordinal Logistic Regression can predict an ordinal dependent variable on one or more independent variables. The estimated coefficients reflect how changes in the independent variables affect the dependent variable. The ordinal regression determines which independent variables significantly affect the dependent variable.

The Model Fitting Information (Table 3) provides the -2 log-likelihood for the intercept-only and final models. Looking at the effects of each explanatory variable in the model, it needs to determine whether the model improves the ability to predict the outcome. The Model Fitting Information table provides the -2 log-likelihood (-2LL) values for the baseline and the final model, and the SPSS executes a Chi-square to test the difference between the -2LL for the two models. As per the model fitting information, the Chi-Square statistics for the final model of Evacuation Capacity was 7.713, which is significant at 2 degrees of freedom, where the p-value 0.021 indicates the probability of obtaining a Chi-Square value of 7.713. Suppose there is no effect from independent variables. Since this is less than the critical value of 0.05, it can be concluded that the model's regression coefficient is not equal to zero, which tells that the model gives a much better prediction based on the marginal probabilities for the outcome categories. The Chi-Square statistics for the final model of Rebuilding Capacity was 5.379 with a p-value of 0.048. The Chi-Square statistics for the final model of Government Involvement was 12.735 with a p-value of 0.002. The Chi-Square statistics for the final model of Public Participation was 5.802 with a p-value of 0.042.

In the same way, The Chi-Square statistics for the final model of Communication and Coordination was 5.32, which is significant at 2 degrees of freedom. The p-value is 0.047, indicating the probability of obtaining a Chi-Square of 5.320 if there is no effect from the independent variables. Since this is less than the significance value of 0.05, it can be concluded that the model's regression coefficients are not equal to zero. It tells that the model gives a much better prediction based on the marginal probabilities for the outcome categories.

As per the significance values for the dependent variables of the table (p-value <0.05), the null hypothesis (*H_0: The proper functioning of flood preparedness measures in the Deduru Oya basin has caused the capacity of vulnerable people)* can be rejected, confirming that the malfunction of flood preparedness measures in the Deduru Oya basin has caused the low capacity of vulnerable people.

Table 3. Model fitting information

Response variable	**Model**	**-2 Log-Likelihood**	**Chi-Square**	**df**	**Sig.**
Evacuation Capacity	Intercept Only	140.623			
	Final	132.91	7.713	2	0.021
Rebuilding Capacity	Intercept Only	181.819			
	Final	176.44	5.379	2	0.048
Government Involvement	Intercept Only	210.473			
	Final	197.738	12.735	2	0.002
Public Participation	Intercept Only	171.219			
	Final	165.417	5.802	2	0.042
Communication and Coordination	Intercept Only	177.316			
	Final	171.996	5.320	2	0.047

Link function: Logit.

Goodness-of-Fit (Table 4) contains the Deviance (and Pearson) chi-square statistic for the model. These statistics test whether the observed data are consistent with the fitted model. The null hypothesis is that the 'model fit is good.' The Deviance Chi-Square statistic for Evacuation Capacity, 89.348, is insignificant (p-value 0.92). Since the p-value is more significant than 0.05, there is no evidence to reject the null hypothesis. Therefore, it can be concluded that the model fit is good. Also, the Deviance Chi-Square statistics for Rebuilding Capacity, Government Involvement, Public Participation, and Communication and Coordination are insignificant (Table 4). Since the p-value > 0.05, there is no evidence to reject the null hypothesis, which states that the model fit is good.

Table 4. Goodness of fit

Response variable	Test	Chi-Square	df	Sig.
Evacuation Capacity	Pearson	204.351	110	0.623
	Deviance	89.348	110	0.926
Rebuilding Capacity	Pearson	85.218	82	0.382
	Deviance	85.816	82	0.365
Government Involvement	Pearson	85.607	82	0.371
	Deviance	86.052	82	0.358
Public Participation	Pearson	344.282	110	0
	Deviance	75.062	110	0.996
Communication and Coordination	Pearson	82.435	110	0.977
	Deviance	66.102	110	1

Link function: Logit.

The Parameter Estimates in Table 5 denote the response variables in the ordered logistic regression. The threshold estimate provides cut-off values for response variables in each category in the parameter estimate values. At this point, the last category of the response variable has been used as the reference level. Estimates represent the ordered log-odds (logit) regression coefficients. The standard interpretation of the ordered logit coefficient is that a one-unit increase in the explanatory variable will change the response variable by its respective regression coefficient in the ordered log-odds scale. In contrast, the other model variables remain unchanged. The Parameter Estimates of each response variable are mentioned in Table 5.

Table 5. Parameter estimates

Response variable			Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Evacuation Capacity	Threshold	[Evacuation Capacity = 1]	-1.538	5.1	0.091	1	0.763	-11.534	8.458
		[Evacuation Capacity = 2]	-0.708	5.095	0.019	1	0.889	-10.695	9.279
		[Evacuation Capacity = 3]	-0.372	5.095	0.005	1	0.942	-10.358	9.613
		[Evacuation Capacity = 4]	7.346	5.151	2.034	1	0.154	-2.75	17.442
	Location	Available or Not	-7.663	3.578	4.586	1	0.032	-14.676	-0.65
		Agreement	2.235	1.084	4.254	1	0.039	0.111	4.359
Rebuilding Capacity	Threshold	[Rebuilding Capacity = 1]	4.148	2.882	2.072	1	0.15	-1.5	9.796
		[Rebuilding Capacity = 2]	7.025	2.897	5.879	1	0.015	1.346	12.703
		[Rebuilding Capacity = 3]	8.125	2.906	7.819	1	0.005	2.43	13.82
	Location	Available or Not	-0.84	2.095	0.161	1	0.689	-4.947	3.267
		Agreement	1.402	0.614	5.22	1	0.022	0.199	2.605
Government Involvement	Threshold	[Government Involvement = 1]	-10.494	2.814	13.911	1	0	-16.009	-4.98
		[Government Involvement = 2]	-8.085	2.792	8.388	1	0.004	-13.557	-2.614
		[Government Involvement = 3]	-6.68	2.787	5.747	1	0.017	-12.142	-1.219
	Location	Available or Not	-0.856	2.022	0.179	1	0.672	-4.819	3.108
		Agreement	2.087	0.593	12.395	1	0	3.249	0.925
Public Participation	Threshold	[Public Participation = 1]	-9.995	3.029	10.89	1	0.001	-15.931	-4.059
		[Public Participation = 2]	-4.882	2.972	2.699	1	0.1	-10.706	0.942
		[Public Participation = 3]	-2.654	2.969	0.799	1	0.371	-8.472	3.165
		[Public Participation = 4]	0.748	3.126	0.057	1	0.811	-5.378	6.874
	Location	Available or Not	-0.615	2.162	0.081	1	0.776	-4.853	3.622
		Agreement	1.224	0.625	3.84	1	0.049	2.449	0
Communication and Coordination	Threshold	[Communication and Coordination = 1]	-7.61	2.94	6.701	1	0.01	-13.372	-1.848
		[Communication and Coordination = 2]	-3.011	2.903	1.076	1	0.3	-8.7	2.678
		[Communication and Coordination = 3]	-1.089	2.901	0.141	1	0.707	-6.776	4.597
		[Communication and Coordination = 4]	2.698	3.064	0.775	1	0.379	-3.307	8.702
	Location	Available or Not	-1.203	2.123	0.321	1	0.571	-5.363	2.957
		Agreement	0.598	0.611	0.955	1	0.328	0.196	0.901

Link function: Logit.

Evacuation Capacity

Regarding the Evacuation Capacity, the threshold estimate for Strongly not Satisfied for evacuation capacity [1] was -1.538, which is the cut-off value between Strongly not Satisfied and Satisfied, evacuation capacity [2] was -0.708, which is the cut-off value between not Satisfied and Neutral, evacuation capacity [3] was -0.372 which is the cut-off value between Neutral and Satisfied. In contrast, evacuation capacity [4] was 7.346, the cut-off value between Satisfied and Strongly Satisfied. Those are the values of the response variable when all predictor variables are evaluated at zero.

Under the parameter estimates, the location includes explanatory variables. The availability or non-availability of flood preparedness measures in the study area and the people's agreement on the available or proposed flood preparedness measures have been considered explanatory variables. Availability or not availability is the ordered log-odds estimate for a one-unit increase in the availability of flood preparedness measures on the expected evacuation capacity level, while the other variables remain the same in the regression model. In another way, it needs to move the availability to not availability; ordered log-odds of being in a higher evacuation capacity satisfaction category would decrease by 7.66, while the other variables remain the same. If the agreement needs to be increased from a lower level to a higher, ordered log-odds of being in a higher evacuation capacity satisfaction category would increase by 2.23 while the other variables in the model are held constant.

According to the significance values of the parameter estimates test, it can be concluded that the Wald test statistic for the predictor, availability or not availability, is 4.58 with an associated p-value of 0.032. If the alpha level is set to 0.05, the null hypothesis will be rejected and concluded as the regression coefficient for availability or not availability is statistically different from zero in estimating evacuation capacity in the model. In the same way, the Wald test statistic for the predictor agreement is 4.25 with a p-value of 0.039, where the alpha level is set to 0.05, the null hypothesis can be rejected, and it can be concluded as the regression coefficient for agreement is statistically different from zero in estimating evacuation capacity.

Rebuilding Capacity

In Rebuilding Capacity, the threshold estimate for Strongly not Satisfied for rebuilding capacity [1] was 4.14, which is the cut-off value between Strongly not Satisfied and Satisfied, rebuilding capacity [2] was 7.02, which is the cut-off value between not Satisfied and Neutral and rebuilding capacity [3] was 8.12 which is the cut-off value between Neutral and Satisfied. Those are the values of the response variable when all predictor variables are evaluated at zero.

As mentioned above, the same explanatory variables (Availability or not availability of flood preparedness measures and agreement on the available or proposed flood preparedness measure) were considered for this response variable. Availability or not availability is the ordered log-odds estimate for one unit increase in the availability or not availability in flood preparedness measures on the expected rebuilding capacity level. At the same time, the other variables remain the same in the regression model. In another way, it needs to move the availability to not availability; ordered log-odds of being in a higher rebuilding capacity satisfaction category would decrease by 0.840 while the other variables remain the same. If the agreement needs to be increased from a lower level to a higher, ordered log-odds of being in a higher rebuilding capacity satisfaction category would increase by 1.40 while the other variables in the model are held constant.

According to the significance values of the parameter estimates test, it can be concluded that the Wald test statistic for the predictor availability or not availability is 0.16 with an associated p-value of 0.68. Suppose the alpha level is set to 0.05. In that case, there is not enough evidence to reject the null hypothesis, and it can be concluded that the regression coefficient for availability or not availability is statistically not different from zero in estimating rebuilding capacity in the model. In the same way, the Wald test statistic for the predictor agreement is 5.22 with an associated p-value of 0.022. If the alpha level is set to 0.05, the null hypothesis can be rejected, and it can be concluded that the regression coefficient for agreement is statistically different from zero in estimating rebuilding capacity in the model.

Involvement of Government Agencies

Considering the Involvement of Government Agencies, the threshold estimate for Strongly not Satisfied for Government Involvement [1] was -10.49, which is the cut-off value between Strongly not Satisfied and Satisfied, Government Involvement [2] was -8.08, which is the cut-off value between not Satisfied and Neutral and Government Involvement [3] was -6.68 which is the cut-off value between Neutral and Satisfied. Those are the values of the response variable when all predictor variables are evaluated at zero.

As mentioned above, the same explanatory variables (Availability or not availability of flood preparedness measures and agreement on the available or proposed flood preparedness measure) were considered for this response variable. Availability or not availability is the ordered log-odds estimate for one unit increase in the availability of flood preparedness measures on the expected government involvement level. At the same time, the other variables remain the same in the regression model. In another way, it needs to move the availability to not availability. Ordered log odds of being in a higher Government Involvement category would decrease by 0.856 while the other variables remain the same. If the agreement needs to be increased from a lower level to a higher, ordered log odds of being in a higher Government Involvement category would increase by 2.087 while the other variables in the model are held constant.

According to the significance values of the parameter estimates test, it can be concluded that the Wald test statistic for the predictor availability or not availability is 0.179 with an associated p-value of 0.672. Suppose the alpha level is set to 0.05. In that case, there is not enough evidence to reject the null hypothesis, and it can be concluded that the regression coefficient for availability or not availability is statistically not different from zero in estimating Government Involvement in the model. In the same way, the Wald test statistic for the predictor agreement is 12.395 with a p-value of 0.00. If the alpha level is set to 0.05, the null hypothesis can be rejected, and it can be concluded that the regression coefficient for agreement is statistically different from zero in estimating Government Involvement in the model.

Public Participation

In Public Participation, the threshold estimates for Strongly not Satisfied for Public Participation [1] was -9.99 which is the cut-off value between Strongly not Satisfied and Satisfied, Public Participation [2] was -4.88 which is the cut-off value between not Satisfied and Neutral, Public Participation [3] was -2.65 which is the cut-off value between Neutral and Satisfied and Public Participation [4] was 0.74 which is the cut-off value between Satisfied and Strongly Satisfied. Those are the values of the response variable when all predictor variables are evaluated at zero.

As mentioned above, the same explanatory variables (Availability or not availability of flood preparedness measures and agreement on the available or proposed flood preparedness measure) were considered for this response variable. Availability or not availability is the ordered log-odds estimate for one unit increase in the availability or not availability in flood preparedness measures on the expected Public Participation level. At the same time, the other variables remain the same in the regression model. In another way, it needs to move the availability to not availability, ordered log-odds of being in a higher Public Participation satisfaction category would decrease by 0.615 while the other variables remain the same. If the agreement needs to be increased from a lower level to a higher, ordered log-odds of being in a higher Public Participation satisfaction category would increase by 1.22 while the other variables in the model are held constant.

According to the significance values of the parameter estimates test, it can be concluded that the Wald test statistic for the predictor availability or not availability is 0.081 with an associated p-value of 0.776. Suppose the alpha level is set to 0.05, in that case, there is not enough evidence to reject the null hypothesis and conclude that the regression coefficient for availability or not availability is statistically not different from zero in estimating Public Participation in the model. In the same way, the Wald test statistic for the predictor agreement is 3.84 with a p-value of 0.049. If the alpha level is set to 0.05, the null hypothesis can be rejected, and it can be concluded that the regression coefficient for agreement is statistically different from zero in estimating Public Participation in the model.

Communication and Coordination

Considering Communication and Coordination, the threshold estimates for Strongly not Satisfied for communication and coordination [1] was -7.61, which is the cut-off value between Strongly not Satisfied and Satisfied, communication and coordination [2] was -3.011, which is the cut-off value between not Satisfied and Neutral, communication and coordination [3] was -1.089 which is the cut-off value between Neutral and Satisfied and communication and coordination [4] was 2.69 which is the cut-off value between Satisfied and Strongly Satisfied. Those are the values of the response variable when all predictor variables are evaluated at zero.

As mentioned above, the same explanatory variables (Availability or not availability of flood preparedness measures and agreement on the available or proposed flood preparedness measure) were considered for this response variable. Availability or not availability is the ordered log-odds estimate for one unit increase in the availability or not availability in flood preparedness measures on the expected communication and coordination level. At the same time, the other variables remain the same in the regression model. In another way, it needs to move the availability to not availability, ordered log-odds of being in a higher communication and coordination satisfaction category would decrease by 1.203 while the other variables remain the same. If the agreement needs to be increased from a lower level to a higher, ordered log-odds of being in a higher Communication and Coordination satisfaction category would increase by 0.598 while the other variables in the model are constant.

According to the significance values of the parameter estimates test, it can be concluded that the Wald test statistic for the predictor availability or not availability is 0.321 with an associated p-value of 0.571. Suppose the alpha level is set to 0.05, in that case, there is not enough evidence to reject the null hypothesis and conclude that the regression coefficient for availability or not availability is statistically not different from zero in estimating communication and coordination in the model. In the same way, the Wald test statistic for the predictor agreement is 0.955 with a p-value of 0.328. If the alpha level is set to 0.05, there is insufficient evidence to reject the null hypothesis and conclude that the regression coefficient for agreement is statistically different from zero in estimating communication and coordination in the model.

The test of parallel lines explains the assumptions of proportional odds. As mentioned in Table 6, the Chi-Square value for Evacuation Capacity is 3.74; the associated p-value is 0.71, which is greater than 0.05. Therefore, the null hypothesis cannot be rejected. Accordingly, it can be concluded that the assumptions hold. In the same way, the Chi-Square value for Rebuilding Capacity is 12.45, where the associated p-value is 0.054, which is greater than 0.05. Therefore, the null hypothesis cannot be rejected. Therefore, it can be concluded that the assumptions hold. The Chi-Square value for Government Involvement is 2.536; the associated p-value is 0.63, which is greater than 0.05. So, the null hypothesis cannot be rejected, and it can conclude that the assumptions hold. The Chi-Square value for Public Participation is 14.70; the associated p-value is 0.053, which is greater than 0.05. Therefore, the null hypothesis cannot be rejected, and it can conclude that the assumptions hold. The Chi-Square value for Communication and Coordination is 2.663, and the associated p-value is 0.85, more significant than 0.05. Therefore, the null hypothesis cannot be rejected. Accordingly, it can be concluded that the assumptions hold.

Table 6. Test of parallel lines

Response variable	Model	-2 Log-Likelihood	Chi-Square	df	Sig.
Evacuation Capacity	Null Hypothesis	132.91			
	General	129.166	3.744	6	0.711
Rebuilding Capacity	Null Hypothesis	176.44			
	General	163.985	12.455	4	0.054
Government Involvement	Null Hypothesis	197.738			
	General	195.202	2.536	4	0.638
Public Participation	Null Hypothesis	165.417			

	General	150.711[a]	14.706[b]	6	0.053
Communication and Coordination	Null Hypothesis	166.59			
	General	163.927	2.663	6	0.85

The null hypothesis mentions that the location parameters (slope coefficients) are the same across response categories.

a. Link function: Logit.

Conclusion and Recommendations

In this study, the researcher intended to assess the flood preparedness measures in the study area. Sixteen variables were used for the study, and because the estimates were on an ordinal scale, the Logistic Regression Analysis method was used as the statistical data analysis tool. Based on the results, the following facts can be summarized.

Despite some shortcomings, the area has a mechanism to disseminate flood early warnings to the last mile. However, most people are satisfied with the prevailing flood early warning mechanism. The people have a good understanding of using a FEW systems. Therefore, the people agree to function as a FEW mechanisms. Further, the stakeholders stated that the existing FEW systems should be further developed to disseminate messages to every household promptly.

Training and awareness programs are being conducted to enhance people's knowledge of flood risk and flood risk management at a marginal level. As the stakeholders stated, limited fund allocation by the authorities for T&A programs has caused this lack. Nevertheless, no NGOs operating in the study area can fund T&A programs. However, the community has reached a consensus on the requirements of the T&A programs, and the local-level stakeholders have confirmed the requirements for proper T&A programs for both the community and stakeholders.

In the same way, village-level disaster management committees are not correctly operating in the study area, and village-level disaster management plans and flood hazard maps have also not been prepared in almost all the GNDs. This indicates a wide gap in the flood management mechanism in the local context. The community and the stakeholders have even proposed some alternatives to activate the VDMCs in the area. However, the community has not rejected these preparedness measures, and they have agreed to operate these methods in the area for the benefit of the people. However, the divisional level disaster management committee is operating, and the divisional level disaster preparedness plan has also been prepared, though there are several issues. The stakeholders have mentioned the need for these flood preparedness measures at the local level.

Although land-use planning and building codes are more critical in flood risk management, they are not operating in the area. Most of the lands in the inundation area have been encroached and used for house constructions, crop cultivations, etc., and these houses and cultivations are vulnerable to floods. Stakeholders have urged the requirement of these measures, and the people are also interested in implementing land-use planning and building codes to mitigate flood risk in the area.

Flood risk insurance, local emergency funds, mitigation loans, and reconstruction loans are not operating in the area, though these methods have been identified as market-based instruments for flood risk reduction. However, the people and the local stakeholders are interested in implementing these risk reduction measures to reduce the flood risk.

All the indicators mentioned above (11 variables) were considered explanatory variables in the analysis. In contrast, people's evacuation capacity, rebuilding capacity, public participation in disaster management activities, communication and coordination system in the area, and the government sector involvement in flood risk management activities (5 variables) were considered response variables. From the response variables, only the people's evacuation capacity was at a satisfactory level, while others were not at a satisfactory level. The functionality of flood preparedness measures in the study area was tested using ordinary logistic regression analysis. As per the analysis, there is enough evidence to reject the null hypothesis, confirming the research hypothesis that the malfunction of flood preparedness measures in the Deduru Oya basin has caused vulnerable people to have a low capacity level.

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