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STRUCTURAL MODELING AND ANALYSIS OF SOCIAL OBSTACLES IN IMPLEMENTING FLOOD EARLY WARNING SYSTEMS IN PAKISTAN

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Abstract
The study aims to theorize social obstacles in properly implementing flood early warning systems. Overall design of the study comprises of review of relevant literature, primary data collection, structural modeling and analysis of the phenomena. The population under study consists of social and non-social beneficiary groups, and socially and non-social adversely affected groups by floods. The sampling design is purposive sampling (focus group consisting of a panel of experts) and the sample size is twenty-seven experts. The method of modeling is "Interpretive Structural Modelling (ISM)" and the method of analysis is "Cross Impact Matrix Multiplication Applied to Classification (MICMAC)". Results of the ISM model show that social obstacles in implementing an early warning system of floods namely: lack of access to necessities, lack of awareness, lack of comprehension of warnings, lack of coordination, failure to pay to heed the early flood warning system, incomplete warning alerts, emergency plans not implemented, lack of political commitment, un-customized contingency plans, exclusion of social groups, scarce resources, unique and different type of flood, attitude to neglect, misperception of risks and deep cultural connection to ancestral lands occupy Level-I (top of the model). Social obstacle namely: lack of updated information occupies Level-II (middle of the model). Social obstacle namely: inadequate preparedness Level-III (bottom of the model). Whereas, results of scale-centric MICMAC analysis shows that all the factors fall in linkage quadrant and independent, autonomous, and dependent quadrants are empty. It happens in the cases where the system elements are agile, unstable, unsettled, and riddled. It is an original real-time primary data-based study having profound practical implications for stakeholders. It invites attention of the stakeholders to the complex, riddled and unsettled relationships among elements of the phenomenon.
Keywords: *Flood Early Warning Systems, ISM, MICMAC, Pakistan, Social Issues and Social Obstacles*

INTRODUCTION

The phenomenon of flood has a huge impact on social, financial, and socioeconomic aspects of affected nations as a whole that hampers the pace of development (Islam et al., 2024). Five common major effects of floods include threatening lives, inundating properties and businesses, destroying belongings, damaging vital infrastructure, and preventing access to essential public services. Research is rich on the phenomenon of floods, particularly on technical aspects in a wide variety of contexts (Garzon et al., 2023; Cheong et al., 2024). Though the authors are convinced that it is an over researched area but at the same time the contemporary literature leaves certain basic gaps concerning the social dimensions of the issue. Social obstacles to properly implement flood early warning systems particularly in the context of Pakistan is a primary vital issue but rarely studied in recent times. This direly needs to be studied in real-time scenarios in the current era (Grimaldi et al., 2024). Therefore, the research objectives are: i) to ascertain the list of social obstacles that hinder the proper implementation early warning system in Pakistan, ii) to prioritize the issues to be addressed by the policymakers, iii) to make understandable the conundrum relationships among social obstacles to implement early warning system of floods and iv) to classify the social obstacles in easy, understandable and simplifies form. To be more specific research questions are: i) Which are the social obstacles to properly implement flood early warning systems that need high priority?, ii) Which social obstacles are relatively less important?, and iii) What is the contextual relationship among social obstacles? There are plenty of methods to answer these questions. An Array of methodological choices was considered to achieve the objectives of the study. It includes considering Stepwise Weight Assessment Ratio Analysis (SWARA), VIekriterijumsko KOmpromisno Rangiranje (VIKOR), DEcision MAking Trial and Evaluation Laboratory (DEMATEL), Wavelet Analysis (WA), Structural Equation Modelling (SEM), Analytical Hierarchy Process (AHP), Analytical Network Process (ANP), Interpretive Structural Modelling (ISM), Cross Impact Matrix Multiplication Applied to Classification (MICMAC), Data Envelopment Analysis (DEA), Grey Relational Analysis (GRA), Total Interpretive Structural Modelling (TISM), Modified-TISM, Polarized-TISM, Fuzzy-ISM/TISM, Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), Artificial Neural Networks (ANN), Multi-Objective Optimization on the basis of Ratio Analysis (MOORA) as possible choices. It is also considered to use the methods in combination. ISM in combination with MICMAC is found to be the most appropriate because of its simplicity and ease of application & understanding (Sivakumar & Kumar, 2019; Abbass, et al., 2022; Basit, et al., 2021; Fu, et al., 2022; Niazi, et al., 2021; Niazi, et al., 2023; Qazi, et al., 2020; Qazi, et al., 2022; Qazi, et al., 2019; Niazi et al., 2021a; Niazi et al., 2023c). The study, therefore, uses ISM and MICMAC that is useful for simplifying the complex systemic situations (Sushil, 2017; Warfield, 1973; Warfield, 1974; Godet, 1986). The remaining part of the article is arranged as a review of the literature, methodology, modeling/analysis/results/discussion, and conclusion.

LITERATURE REVIEW

A survey of contemporary literature has been conducted by way of exploring the renowned research databases of the world to which the Higher Education Commission of Pakistan has provided official access to Higher Education Institutions (i.e. Wiley Online Library, Taylor & Francis Online, Springer Link, Emerald Insight, Elsevier-ScienceDirect, JStor, etc.) through advanced search tab with appropriate filters. The key words used for the search includes 'flood early warnings', 'social obstacles to implement floods early warning systems', 'early warning systems of floods', 'floods in Pakistan', 'issues of floods early warnings', 'social issues of flood warnings', etc. The search resulted in hundreds of research papers that have been screened on the basis of relevance. Highly relevant research articles have been reported to set out the very outset of the study. We have identified the an array of social obstacles in implementing the flood early warning systems through a review of the literature (Majumdar & Sinha, 2019; Song et al., 2017; Thamsatitdej et al., 2017). This review provides the foundation of knowledge on the topic and prevents objectionable duplication that ultimately leads to a refined process of theory building (Table 1).

Table 1: Summary of Literature

Sr.	Source	Country	Focus	Methodology	Result	Conclusion
1	Muzzamil et al. (2023)	Pakistan	Investigate the causes, effects and potential recommendations to the preparedness of healthcare industries in Pakistan	Thematic research	Healthcare preparedness in Pakistan needs to be active and government must proactively improve the areas especially in shelters and areas where water and sanitation systems have been affected	As a result of flooding, Pakistan continues to be hit stiff by diseases such as dengue fever, watery diarrhea and malaria.
2	Yuan et al. (2023)	Pakistan	Purpose of this study is to examine the main contributors to extreme precipitation in Pakistan in 2022	Moisture tracking model (WAM-2l ayres) and atmospheric circulation analysis.	The results described that an atmospheric blocking over northern Europe enhanced convection in Pakistan in both 2010 and 2022 by way of carrying cold–dry air from the high latitude region and benefiting warm–wet monsoonal air streaming to Pakistan	It is high time to pay attention to the role of subtropical high in the Northern Hemisphere along with the Southern Hemisphere in understanding disastrous extreme precipitation events in Pakistan causing disastrous floods.
3	Shah et al. (2023)	Pakistan	The focus is to reduce the flood risk in Pakistan to minimize the adverse effects of floods on people, infrastructure, and property and to minimize the likelihood of future flood events.	Qualitative content analysis and NVIVO software	The study identified some substantial strategies that relief organizations adopted: managing barriers in communication, administration of educational and information transmission, and managing inter-organizational communications.	The study found strategies being deployed by relief organizations in augmenting disaster risk communication across four sternly affected districts in Khyber Pakhtunkhwa, Pakistan.

4	Ahmed (2018)	Pakistan	Evaluate the effect of the flood on marriages in flooded households as compared to marriages in unaffected households.	Ordinary Least Square estimation method	Findings of the study found that flood decreased marriages, furthermore, the negative impact of the flood on rural marriages is significantly higher and robust.	The decrease in the number of marriages in affected districts appears to be typically associated with economic and financial constraints while the upsurge of marriages in non-flooded areas seemingly happened due to the stable sociological and psychological factors.
5	Cheema et al. (2016)	Pakistan	This study aims to provide a historical analysis of disaster management particularly flood-centric policies and structure in Pakistan between 1947 and 2005	Historic-integrative case study approach	Findings revealed that an effective institutional disaster management structure for reduction or prevention of disaster losses in Pakistan is lacking, particularly at the local level.	Disaster planning and management needs to take corrective measures, particularly at the local level to cater the calamities, particularly flood.
6	Ullah et al. (2018)	Pakistan	To examine the risks associated with climate change vulnerability, flood and in response to deploy adaptation methods	Method for Adaptation	The study found that disastrous floods, storms, severe droughts, extreme temperatures, crop diseases, changes in rainfall patterns, and loss of farmland due to floods are the worst situations negatively affecting agricultural production.	It provides insights into climate-related farmers' risk perceptions including their adaptive responses and vulnerability that constraints their concerns and adaptive capacity hurting agriculture at the farm level.
7	Ali et al. (2020)	Pakistan	Investigate post-disaster activities after the floods and highlight perilous areas obstructing the transition into an effective recovery phase in the Sindh province of Pakistan.	Case study	Results identified the following factors hindering successful transition: local administration, community-level involvement, community capacity, different stakeholders and coordination, disaster governance, information and knowledge management.	Results of the study concluded that long-term recovery is the most unkempt phase of post-disaster recovery.
8	Aijazi (2015)	Pakistan	The proposed model provides guidelines to conceptualize reconstruction and recovery processes to the dismantling of structural disproportions that impede post-disaster recovery.	Case study	The results buttressed that that social relationships have to be restored and transmuted as a result of any disaster recovery intrusion and relationship mapping exercises must be carried out with pretentious communities earlier to the planning recovery interventions.	Taking the case example from post-flood the study suggests that evaluative goals of post-disaster recovery projects ought to be framed in social repair language.
9	Afreen et al. (2022)	Pakistan	The aim is to determine the flood-vulnerable zones in the Panjkora Basin.	Frequency ratio model	Findings confirmed that 43% (nearly half of the area) is located in a very highly vulnerable zone, while only 20% area is categorized as very low vulnerable zone.	The study provides the framework to devise the strategy for proper land use planning to deal with the impacts of flood.
10	Shah et al. (2020)	South East Asian Region particularly Pakistan	To review the literature on flood hazards and risk management in the south Asian region mainly Pakistan.	Real-time secondary data	Findings showed that: major reservoirs of this region are not ready to take the uttermost discharges during the flood seasons, and transmission networks to record the flood-related data need to be strengthened.	Results revealed that countries in this region mainly Pakistan unveil a high level of susceptibility unfortunately because of a lack of resources, namely adaptive as well as coping capacities.
11	Nadeem et al. (2023)	Pakistan	profound psychological and maternal effects of the 2022 floods in Pakistan	Commentary	Flood leads to mental health challenges for women such as panic attacks, lethargy, heightened anxiety, elevated stress levels, antidepressants, irritability sleep disturbances, prescription medications, difficulty concentrating on daily tasks, nightmares, and mood swings.	The study concluded that women and children are often the most susceptible to antagonistic consequences during floods.
12	Amarnat and Rajah (2016)	Pakistan	The objective this study is to devise a methodology that	Time-series imagery-based algorithm	A statistical study is executed to examine false positive and false	A simple threshold method is made to cluster the data to recognize the flood pixels in

			can be used to identify spatiotemporal changes in the extent of flood inundation.		negative rates using the ALOS sensors as ground truth.	the imagery. Calculations are then made to guesstimate a flood area for each resolution.
13	Hulio et al. (2023)	Pakistan	To identify the factors influencing the decision to select Post-Flood Public Houses (PFPH) in flood-prone zones.	Delta method	Results showed that individuals with higher risk perception are more inclined to pick PFPH, whereas those with stronger place attachment are inclined to choose to rebuild their houses at the same location.	Distance from the village center (how far they would be relocated from their current village) hurt choosing PFPH. Compensation for PFPH has a positive impact on the choice of PFPH.
14	Aqib et al. (2024)	Pakistan	The focus is to estimate the adaptive capacity of farmers of two flood-prone districts of South Punjab, Pakistan	Multi-variate regression and bivariate probit models	Knowledge of the market value of crops and concern for climate change are substantial determinants while farmers with more experience and alternate sources of income are less likely to do so.	Findings highlighted the need for a holistic approach to climate adaptation that ponders complex economic, social, and environmental factors.
15	Lama and Tatu (2022)	Pakistan	Lesson learned from recent floods in Pakistan	Commentary	Pakistan was not prepared at all for calamities like floods even though it had already suffered due to political, economic, and public health crises and preexisting climate change dilemmas.	There is an imperative need to gauge disease scrutiny, restore damaged medical facilities, refill health supplies, and prepare for such calamity with a focus on children, women, and other vulnerable groups.
16	Iqbal and Khan (2016)	Pakistan	To deploy the water sector adaptation strategies	Qualitative research methods-SWOT analysis	Water sector ownership issue, Institutional ambiguity with vague departmental roles, lack of definition of rights and responsibilities at federal and provincial levels institutions are the major weaknesses.	The study highlighted the key shortcomings and challenges towards climate response strategies and actions.
17	Iqbal and Nazir (2023)	Pakistan	To identify key findings regarding flood risk perception	Case study, questionnaires and field survey	Results identified: influence of flood risk awareness/concerns/preparedness on the community's overall perception of flood risks, past experiences of floods significantly shape the perceptions and low risk awareness/preparedness among residents.	The study found inability to recover from frequent flood occurrences, challenges faced by rural communities like crop damage, relocation from dwellings, and loss of income and food shortages.
18	Ashraf et al. (2023)	Pakistan	To ascertain the community perspectives on the socioeconomic impacts of floods	ArcGIS geometry calculation tool	Loss of agricultural land, lack of information resources and displacement of human population, and animal structures were the most conjoint impacts on people.	Results bolstered that attitude, knowledge and practices of communities with first-hand flood experience may improve the flood management
19	Shaikh et al. (2023)	Pakistan	Unprecedented flood causing dengue outbreak	Commentary	Heavy monsoon rain and flood have affected almost 33 million people since June 2022.	Dengue pretenses a unadorned risk to public health globally and to countries particularly Pakistan
20	Mustafa and Wescoat (1997)	Pakistan	To develop the flood hazards policy in River Basin	Thematic research	Nonstructural approaches to flood hazard mitigation have lagged behind engineering approaches	Study sated that the flood damage reduction has received inadequate attention.
21	Akter (2021)	Pakistan	To assess how large-scale environmental tremors amend the gender division of labor in conventional rural societies.	Regression	Findings revealed a significant: increase in women's and men time use as hired labor, decrease in women's time use in care work, and an increase in men's time use in domestic work.	The results disclosed a substantial shift in the gender division of labor for both paid and unpaid work in the flood-affected villages.
22	Karki et al. (2011)	Pakistan	Aim to support water management policies and programs from the design stage to implementation	Thematic research	Findings proposed for the development of a long-term Indus Basin Research Program targeting to form a consolidated, robust, and shared scientific knowledge base.	The study stated that developing water management policies and programs requires knowledge management, multidisciplinary research, and a capacity development process.

23	Shah et al. (2023)	Pakistan	The purpose is to recognize the factors that influence individuals' willingness to abandon during floods and to assess the relationship between them.	Chi-square, correlation, and regression	Results of the study showed that risk perceptions and socio-economic conditions have a direct and indirect effect on evacuation decisions.	Study found that those living in closer to the river inclined to have a lower risk perception and experiencing high levels of fear in regard to floods.
24	Niaz et al. (2023)	Pakistan	To examine the flood scenarios in different seasons.	Resistivity model	Probable flood and dam burst impacts the land cover of 30, 43, 250 m2 and 33, 64, 433 m2 in Patikka and Muzaffarabad areas, respectively.	The flood modeling revealed that aquifer systems mostly lie near the banks of the river and face a grim peril of contamination due to low river flow.
25	Memon et al. (2015)	Pakistan	To check the exactness of MODIS data with respect to LANDSAT in mapping flood events in the country		Results revealed that Normalized Difference Water Index (NDWI), Red and Short Wave Infra-Red (RSWIR), and Green and Short Wave Infra-Red (GSWIR) with kappa coefficient (j) of 46.66%, 70.80% and 60.61% respectively	Study conclude that NDWI and GSWIR have propensities to underestimate and overestimate respectively the inundated area.

The reported research studies well cover the technical aspects of the floods but hardly address any social aspect. Particularly, there are less studies found on implementation of early flood warning systems in Pakistan. The authors could not find any study that accounts for the social obstacles in implementing the flood early warning system in Pakistan. A list of social obstacles in implementation flood early warning system is prepared from broad scanty literature in national and international contexts. The extracted social obstacles to implementing an early flood warning system are presented to the panel of experts for approval vote to include them in the study in the context of Pakistan. Therefore, the study is built on only after mentioned seventeen social obstacles that attained approval vote of majority of the experts i.e. lack of access to necessities (1), lack of awareness (2), lack of comprehension of warnings (3), lack of coordination (4), failure to pay heed early to flood warning system (5), incomplete warning alerts (6), emergency plans not implemented (7), inadequate preparedness (8), lack of political commitment (9), un-customized contingency plans (10), exclusion of social groups (11), scarce resources (12), unique and different type of flood (13), lack of updated information (14), attitude to neglect (15), misperception of risks (16) and deep cultural connection to ancestral lands (17).

METHODOLOGY

The study follows the qualitative paradigm of research and Interpretivism as a research philosophy. The research approach is inductive by design. The overall design of the study is envisaged to review the contemporary literature, data collection by field survey, structural modeling, and analysis (Qazi et al., 2020a; Basit, Qazi, & Niazi, 2020). Population under study consists of social and non-social beneficiary and adversely affected groups by the floods. That includes national governments (i.e. policy makers, planners, project executors, plethora of departments and ministries like: irrigation, planning and development, housing and town planning, environmental protection agencies, revenue authorities, forest and wildlife, water and power development authorities, canals, rivers and lakes management departments etc.), regulators, local government, industry representatives, landowners, farmers (who lose their crops), general public (including households, local communities, village community workers, local labor, disabled people, minorities, senior citizens and women), scientific community and others contributors to system, institutions engaged in disaster management, international donor agencies, academia, politicians & political parties, flood-prone communities, NGOs, volunteers, regional institutions, media, suppliers of goods & material, civil organizations, private institutions and other affected, interested or other vulnerable groups. The sampling design consists of a focus group that best represents the population under study. A panel of experts has been constituted from the population under study according to the predetermined criteria given below in the section titled as *Panel of Experts (*Shaukat et al., 2023; Qazi et al., 2023; Qazi et al., 2023a; Qazi et al., 2023; Niazi et al., 2020a). The sample size is twenty-seven experts. Interpretive Structural Modeling is used as a technique for structural modeling (Abbass et al., 2022a; Niazi, Qazi, & Sandhu, 2019; Basit et al., 2019; Arshad & Mukhtar, 2019; Audi & Al Masri, 2024), whereas, Cross Impact Matrix Multiplication Applied to Classification is used for structural analysis (Rashid et al., 2021; Niazi et al., 2020; Niazi, Qazi, & Basit, 2019b).

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Panel of Experts

The panel of experts is necessary where there is either no data available or the data is not reliable. Since, there is no data as such available on the phenomenon, and it is intended to elicit the same from the minds of the people therefore, a panel of experts is constituted. There are two types of panels i.e. heterogeneous panel and homogenous panel (Qazi et al., 2021a; Qazi, Niazi, & Basit, 2021). The size of both panels also varies according to the nature of studies. Keeping in view the nature of current study, a heterogeneous panel of twenty-seven experts is constituted from within the stakeholders (Shaukat et al., 2021; Qazi et al., 2021; Niazi et al., 2023b; Niazi et al., 2019. In order to recruit the expert on a panel, a set of criteria has been developed. The criteria consist of: i) the expert on panel must be a university a graduate, ii) the expert must have at least 10 years of working experience, iii) the expert must have some research acumen, iv) willing to participate in the research study, v) ideally should be from within directly affected groups, and vi) should have a reasonable level of general awareness about the floods and the early warning systems of floods (Dwivedi et al., 2017; Majumdar & Sinha, 2019; Niazi, Qazi, & Basit, 2019a; Basit et al., 2023). On the basis of this criteria, the panel comprises the area experts, representatives from relevant industries, academia, researchers, flood fighting bodies, policymakers/government representatives, and representatives of the public at large from flood affected areas. The data has been elicited from the experts using VAXO based classical type of $n(n-1)/2$ matrix instrument of measurement (Tariq et al., 2023; Niazi et al., 2020b; Farid et al., 2023). The data are collected in the office (field) setting of experts (Niazi, Qazi, & Basit, 2019; Basit, Qazi, & Khan, 2021). The background of the study is first briefed to them and 'face to face one on one method' of completing the questionnaire is used to be in exact. Field survey (data collection) is administered by the authors themselves in the experts' office setting. The data collected from the field is aggregated using some functions of MS Excel. The method of aggregation used is a mode (i.e. majority rule: minority gives way to majority).

MODELLING, ANALYSIS, RESULTS AND DISCUSSION

Modelling

Modelling applied to the data set follows classical stepwise procedure of ISM devised by Warfield, 1973 enumerated by Attri et al., 2013 and Thakkar et al., 2008 and used by Niazi et al., 2019a, Niazi, Qazi, & Basit, 2021, Basit, Qazi, & Niazi, 2020a. As a first step, a Structural Self-Interaction Matrix-SSIM (Table-2) is prepared by aggregating the opinion of experts using rule 'minority gives way to majority'.

Table 2: Structural Self Interaction Matrix

Code	Social Obstacles	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	Lack of access to necessities		O	X	V	O	A	A	A	O	O	X	O	X	V	A	O	O
2	Lack of awareness			A	V	A	A	V	V	X	A	O	X	A	V	V	X	O
3	Lack of comprehension of warnings				X	A	A	V	V	V	X	O	V	O	V	V	X	O
4	Lack of coordination					A	O	V	A	V	O	V	X	V	V	O	V	A
5	Failed to heed early flood warning system						V	V	A	A	X	V	X	V	A	A	X	V
6	Incomplete warning alerts							V	A	V	V	O	X	X	X	X	V	X
7	Emergency plans not implemented								V	V	V	O	V	A	V	V	X	X
8	Inadequate preparedness									V	X	V	V	V	V	A	V	V
9	Lack of political commitment										A	A	V	O	O	A	A	O
10	Un-customized contingency plans											V	V	X	V	X	X	V
11	Exclusion of social groups												O	O	O	X	A	V
12	Scarce resources													O	A	O	A	O
13	Unique and different type of flood														A	X	A	O
14	Lack of updated information															A	X	O
15	Attitude to neglect																X	X
16	Misperception of risks																	O
17	Deep cultural connection to ancestral lands																	

Converted the SSIM Table 2 into initial reachability matrix (Table 3) by applying the classical rules used in ISM procedures (Attri et al., 2013; Thakkar et al., 2008).

$V: i \rightarrow j$	$A: i \leftarrow j$	$X: i \leftrightarrow j$	$O: i \not\leftrightarrow j$
1	0	1	0

Every 0 (i.e. no relation) in initial matrix is checked for any possible transitive relationship and replaced every

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0 with 1* if there is any transitive relation found. In this way a new reachability matrix namely transitive reachability matrix (Table-4) is prepared.

Table 3: Initial Reachability Matrix

Code	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	1	0	1	1	0	0	0	0	0	0	1	0	1	1	0	0	0
2	0	1	0	1	0	0	1	1	1	0	0	1	0	1	1	1	0
3	1	1	1	1	0	0	1	1	1	1	0	1	0	1	1	1	0
4	0	0	1	1	0	0	1	0	1	0	1	1	1	1	0	1	0
5	1	1	1	1	1	1	1	0	0	1	1	1	1	0	0	1	1
6	1	1	1	0	0	1	1	0	1	1	0	1	1	1	1	1	1
7	1	0	0	0	0	0	1	1	1	1	0	1	0	1	1	1	1
8	1	0	0	1	1	1	0	1	1	1	1	1	1	1	0	1	1
9	0	1	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0
10	0	1	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1
11	1	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	1
12	0	1	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0
13	1	1	0	0	0	1	1	0	0	1	0	0	1	0	1	0	0
14	0	0	0	0	1	1	0	0	0	0	0	1	1	1	0	1	0
15	1	0	0	0	1	1	0	1	1	1	1	0	1	1	1	1	1
16	0	1	1	0	1	0	1	0	1	1	1	1	1	1	1	1	0
17	0	0	0	1	0	1	1	0	0	0	0	0	0	0	1	0	1

Table 4: Transitive Reachability Matrix

Code	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Driving
1	1	1*	1	1	1*	1*	1*	1*	1*	1*	1	1*	1	1	1*	1*	1*	17
2	1*	1	1*	1	1*	1*	1	1	1	1*	1*	1	1*	1	1	1	1*	17
3	1	1	1	1	1*	1*	1	1	1	1	1*	1	1*	1	1	1	1*	17
4	1*	1*	1	1	1*	1*	1	1*	1	1*	1	1	1	1	1*	1	1*	17
5	1	1	1	1	1	1	1	1*	1*	1	1	1	1	1*	1*	1	1	17
6	1	1	1	1*	1*	1	1	1*	1	1	1*	1	1	1	1	1	1	17
7	1	1*	1*	1*	1*	1*	1	1	1	1	1*	1	1*	1	1	1	1	17
8	1	1*	1*	1	1	1	1*	1	1	1	1	1	1	1	1*	1	1	17
9	1*	1	1*	1*	1	1*	1*	1*	1	1*	1*	1	1*	1*	1*	1*	1*	17
10	1*	1	1	1*	1	1*	1*	1	1	1	1	1	1	1	1	1	1	17
11	1	1*	1*	1*	1*	1*	1*	1*	1	1*	1	1*	1*	1*	1	1*	1	17
12	1*	1	1*	1	1	1	1*	1*	1*	1*	1*	1	1*	1*	1*	1*	1*	17
13	1	1	1*	1*	1*	1	1	1*	1*	1	1*	1*	1	1*	1	1*	1*	17
14	1*	1*	1*	1*	1	1	1*	0	1*	1*	1*	1	1	1	1*	1	1*	16
15	1	1*	1*	1*	1	1	1*	1	1	1	1	1*	1	1	1	1	1	17
16	1*	1	1	1*	1	1*	1	1*	1	1	1	1	1	1	1	1	1*	17
17	1*	1*	1*	1	1*	1	1	1*	1*	1*	1*	1*	1*	1*	1	1*	1	17
Dependency	17	17	17	17	17	17	17	16	17	17	17	17	17	17	17	17	17	

Using the elementary concepts of set theory the transitive reachability matrix is partitioned into sub-matrices through three iterations Table 5-7.

As a result of stepwise procedure of ISM process, the iterations indicated the ISM model that was captured on diagonals of conical matrix and the same was converted into the diagraph. From the diagraph, a detailed ISM Model is extracted as shown in Figure-1. The conical matrix and diagraph is omitted from reporting for the sake of brevity.

It can be observed from Figure 1 that social obstacles to implements early warning system of floods coded as (1), (2), (3), (4), (5), (6), (7), (9), (10), (11), (12), (13), (15), (16) and (17) fall at *Level-I*. Social obstacle coded as (14) fall at *Level-II*. Social obstacle coded as (8) falls at *Level-III*.

MICMAC Analysis

Matriced' Impacts Croise's Multiplication Appliquée a UN Classement (Godet, 1986) is popularly known as 'MICMAC analysis' or 'driving-dependence power analysis' or 'Cross Impact Matrix Multiplication Applied to Classification' in the literature. It is a technique of structural analysis of the phenomenon. There are two approaches for MICMAC analysis (i.e. data-centric approach and scale-centric approach). The study follows scale-centric approach, therefore, the classical procedure of classification of elements of the system is applied. As a result, diagram represented as Figure-2 is prepared.

The scale centric MICMAC analysis (Figure 2) shows that all the factors fall in linkage quadrant and independent, autonomous and dependent quadrants are empty. It happens in the cases where the system elements are agile, unstable, unsettled and riddle (Kim et al., 2023).

Table 5: Partitioning Iteration-I

Code	Reachability Sets	Antecedent Sets	Intersection Sets	Level
1	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	I
2	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	I
3	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	I
4	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	I
5	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	I
6	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	I
7	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	I
8	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,15,16,17	
9	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	I
10	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	I
11	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	I
12	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	I
13	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	I
14	1,2,3,4,5,6,7,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,9,10,11,12,13,14,15,16,17	
15	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	I
16	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	I
17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	I

Table 6: Partitioning Iteration-II

Code	Reachability Sets	Antecedent Sets	Intersection Sets	Level
8	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,15,17	1,2,3,4,5,6,7,8,9,10,11,12,13,15,17	
14	1,2,3,4,5,6,7,9,10,11,12,13,14,15,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,17	II

Table 7: Partitioning Iteration-III

Code	Reachability Sets	Antecedent Sets	Intersection Sets	Level
8	1,2,3,4,5,6,7,8,9,10,11,12,13,15,16,17	1,2,3,4,5,6,7,8,9,10,11,12,13,15,17	1,2,3,4,5,6,7,8,9,10,11,12,13,15,17	III

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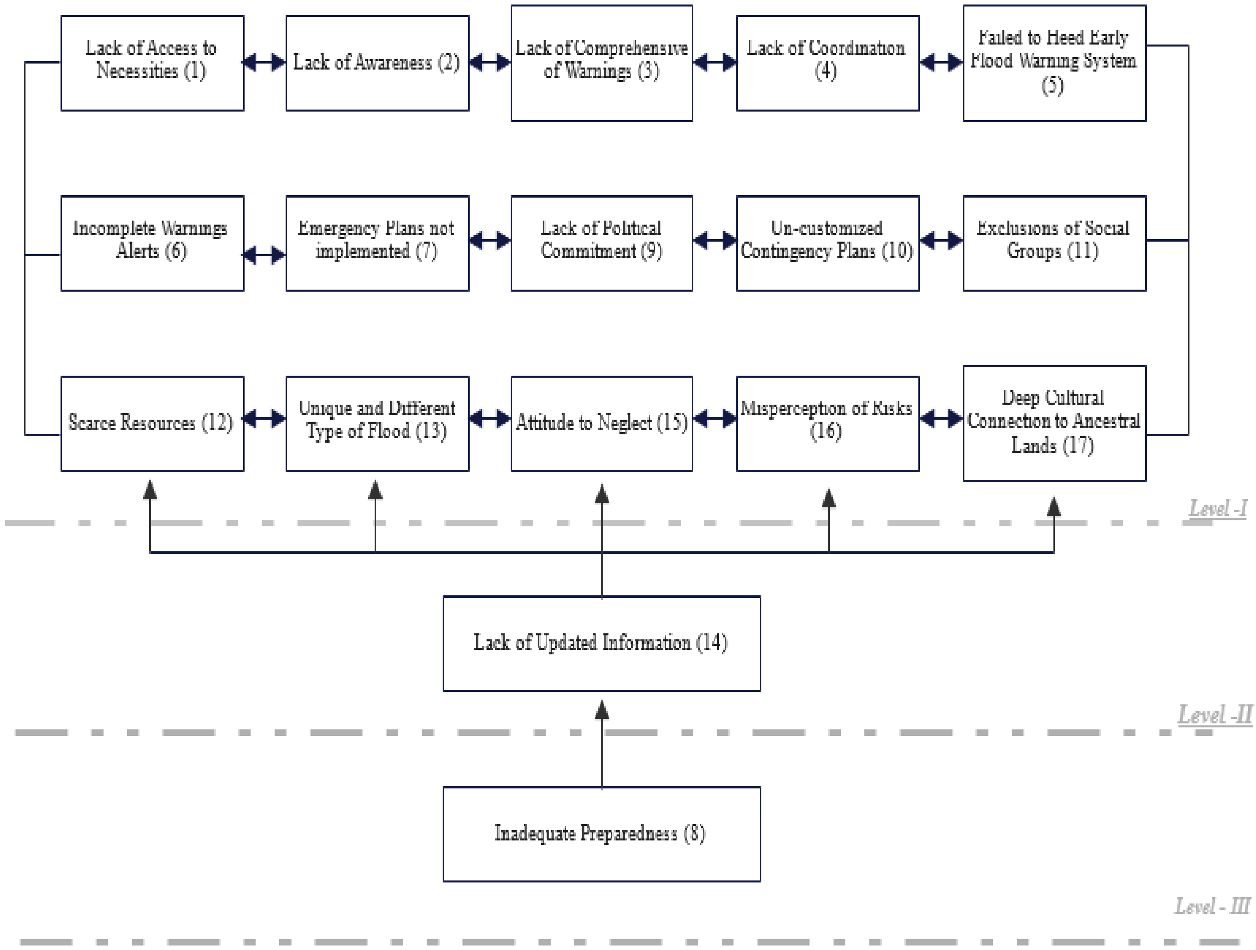

Figure 1: ISM Model

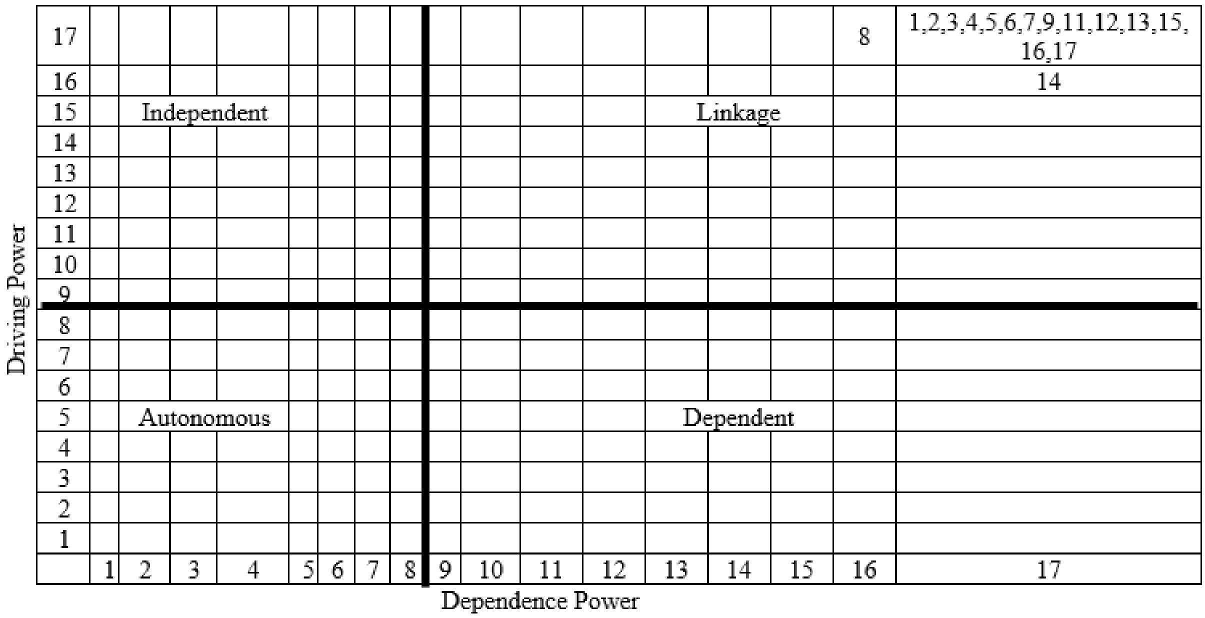

Figure 2: Scale Centric MICMAC Analysis

RESULTS

It is appropriate to recall that: aim of the study is to theorize social obstacles in properly implementing flood early warning systems in Pakistan, and overall design of the study comprises of review of relevant literature, primary data collection and then structural modelling and analysis of the phenomena, before, embarking on to results. The literature discourse comprising of articles, research reports, statistical bulletins, year books, official documents and authoritative websites resulted in formulating a list of total seventeen social obstacles in implementing flood early warning system i.e. lack of access to necessities (1), lack of awareness (2), lack of comprehension of warnings (3), lack of coordination (4), failed to heed early flood warning system (5), incomplete warning alerts (6), emergency plans not implemented (7), inadequate preparedness (8), lack of political commitment (9), un-customized contingency plans (10), exclusion of social groups (11), scarce resources (12), unique and different type of flood (13), lack of updated information (14), attitude to neglect (15), misperception of risks (16), and deep cultural connection to ancestral lands (17). Results of ISM model show that social obstacles in implementing early warning system of flood namely: lack of access to necessities (1), lack of awareness (2), lack of comprehension of warnings (3), lack of coordination (4), failed to heed early flood warning system (5), incomplete warning alerts (6), emergency plans not implemented (7), lack of political commitment (9), un-customized contingency plans (10), exclusion of social groups (11), scarce resources (12), unique and different type of flood (13), attitude to neglect (15), misperception of risks (16) and deep cultural connection to ancestral lands (17) occupy *Level-I*. Social obstacle namely: lack of updated information (14) occupy *Level-II*. Social obstacle namely: inadequate preparedness (8) *Level-III*. The scale centric MICMAC analysis (Figure 2) shows that all the factors fall in linkage quadrant and independent, autonomous and dependent quadrants are empty. Hence, the system elements are agile, unstable, unsettled, riddle, conundrum, and challenging (Kim et al., 2023). The abridged representation of results of literature discourse, ISM Modelling and MICMAC Analysis is presented as Table-8.
From the abridged results, it can be inferred that "inadequate preparedness" for facing the floods is the key obstacle in implementing the early warning system.

DISCUSSION

It can be learnt from Table 1 that previous studies conducted in context of floods in Pakistan are narrow by scope i.e. focusing on adaptive capacity of farmers in flood prone districts (Aqib et al., 2024); preparedness of healthcare industries during flood (Muzzamil et al., 2023); flood risk preparation (Iqbal & Nazir, 2023); post-disaster recovery of floods (Aijazi, 2015). Whereas, the current study indicated far more deep insights into the phenomenon by not only identifying nearly all major factors but also ranking and categorizing them and determining their intensity and developing linkages as well. The study has contributed a list of social obstacles in implementing flood early warning system in Pakistan, ISM model, MICMAC diagram, and a set of inter social-obstacle relationships, framework for future research, and policy guidelines towards the contemporary body of knowledge, and a lot of useful information for the stakeholders.

Table 8: Abridged Results of Literature, MICMAC and ISM

Results of literature Review		Results of MICMAC Analysis				Results of ISM	Comment
Code	Determinants	Driving	Dependence	Effectiveness	Cluster	Level	
1	Lack of access to necessities	17	17	0	Linkage	*I*	
2	Lack of awareness	17	17	0	Linkage	*I*	
3	Lack of comprehension of warnings	17	17	0	Linkage	*I*	
4	Lack of coordination	17	17	0	Linkage	*I*	
5	Failed to heed early flood warning system	17	17	0	Linkage	*I*	
6	Incomplete warning alerts	17	17	0	Linkage	*I*	
7	Emergency plans not implemented	17	17	0	Linkage	*I*	
8	Inadequate preparedness	17	16	1	Linkage	*III*	*Key Factor*
9	Lack of political commitment	17	17	0	Linkage	*I*	
10	Un-customized contingency plans	17	17	0	Linkage	*I*	
11	Exclusion of social groups	17	17	0	Linkage	*I*	
12	Scarce resources	17	17	0	Linkage	*I*	
13	Unique and different type of flood	17	17	0	Linkage	*I*	
14	Lack of updated information	16	17	-1	Linkage	*II*	
15	Attitude to neglect	17	17	0	Linkage	*I*	
16	Misperception of risks	17	17	0	Linkage	*I*	
17	Deep cultural connection to ancestral lands	17	17	0	Linkage	*I*	

Findings of the study are helpful for: i) politicians & political parties, ii) flood-prone communities, iii) NGOs, iv) institutions engaged in disaster management, v) volunteers, vi) regional institutions, vii) civil organizations and viii) private institutions for understanding issues on ground. The study has also profound practical implications for: i) suppliers of goods & material, ii) industry representatives, iii) landowners, iv) general public (including households, local communities, village community workers, local labor, disabled people, minorities, senior citizens and women) and v) other affected, interested or vulnerable groups, to be insightful of the situations, preventive and careful. The study has also thoughtful theoretical and practical implications for academia because it provides understanding for developing research framework for further research avenues. It is also insightful for scientific community and others contributors to system as it builds deeper understanding for offering some solutions to address existing problem of floods. It is discerning for international donor agencies for understanding issues on ground to help the affectees. It also gives awareness lead to farmers (who have lost their crops) by way of understanding to be preventive, careful, cooperative and be prepared to take even advantage by exploring the positive side of the floods (i.e. like reinstatement of land fertility etc.). It is helpful to media for comprehending the issues of implementation of flood early warning systems in Pakistan and highlighting the same. The findings are also equally valuable for: i) national governments (i.e. policy makers, planners, project executors, plethora of departments and ministries ii) regulators and iii) local government and other employees in form of generating a caution that they should be careful because the system elements are agile, unstable, unsettled, riddle, conundrum, entangled and challenging. Therefore they should adjust/readjust, formulate and implementing polices with caution. The study also have some limitations like more databases and research documents could be securitized to extend the list of factors. Other research methodologies and statistical techniques like SEM (co-variance based or PLS based) that will enhance utility of the model can be utilized. The same design of the study could be replicated in different contexts, countries and/or sectors. Future researches could be conducted by taking inputs from other stakeholders.

CONCLUSION

Floods are high impact natural phenomenon that have both positive and negative effects on lives, properties, businesses, livestock, crops, natural resources, infrastructure, wildlife, forests, and so on. Hardly any community, group or thing is left that is not affected by floods. Therefore, it has got high degree of importance in research agenda. Issue understudy 'social obstacles in properly implementation of flood early warning system in Pakistan' is, therefore, considered as something very important to be researched that currently is highly under researched flood-related area of study. The study employed qualitative design to address the issue. Overall design consists of literature review, data collection, and analysis i.e. using literature discourse for extracting a list of social obstacles, ISM for modeling and MICMAC for analysis. Literature review show that there are total seventeen major obstacles (lack of access to necessities (1), lack of awareness (2), lack of comprehension of warnings (3), lack of coordination (4), failed to heed early flood warning system (5), incomplete warning alerts (6), emergency plans not implemented (7), inadequate preparedness (8), lack of political commitment (9), un-customized contingency plans (10), exclusion of social groups (11), scarce resources (12), unique and different type of flood (13), lack of updated information (14), attitude to neglect (15), misperception of risks (16) and deep cultural connection to ancestral lands (17)). Results of ISM modeling (Figure 1) show that social obstacles in implementing early warning system of flood codes as (1), (2), (3), (4), (5), (6), (7), (9), (10), (11), (12), (13), (15), (16) and (17) fall at *Level-I* indicating that they have mild effect and attract relatively less attention of policy makers. Social obstacle coded as (14) fall at *Level-II* indicating that it has moderate sever effects and accordingly gain precedence over obstacles occupying top level. Social obstacle coded as (8) 'inadequate preparedness' fall at *Level-III* indicating that it is the key independent obstacle that needs immediate attention of policy makers. That factor, in fact, leads to others and controlling this will be helpful to circumvent other obstacles. The scale centric MICMAC analysis (Figure 2) shows that all the factors fall in linkage quadrant and independent, autonomous and dependent quadrants are empty. It depicts that the system elements are agile, unstable, unsettled and riddle. However all obstacles included in study are relevant as there is no autonomous factor. All the factors have potential to be independent and/or dependent as shown in linkage. It is an original valuable study because it is based on real time experimental first hand data collected by the authors that have hands on job of data collection for decades. The methodology used is simple, unique and clearly understandable by wide range of stakeholders. Its results are also logically appealing and realistic, corresponding to ground realities. This study enriches the understanding of national/local governments, regulators, industry representatives, farmers, general public, scientific community, disaster management institutions, international donor agencies, academia, politicians & political parties, flood-prone communities, NGOs, volunteers, regional institutions, media, suppliers of goods & material, civil organizations, private institutions and other affected, interested or vulnerable groups by way of deeper insights into the conundrum issue of flood early warning systems. The lesson learnt is that the system elements are agile, unstable, unsettled, riddle, conundrum, and challenging, therefore, the stakeholders are cautioned that beware of actions taken on these factor will affect others and in turn will affect themselves too. To handle this issue at national policy level needs extra ordinary care.

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