ASSESSMENT OF EARLY WARNING SYSTEM FOR FLOODS IN UTTARAKHAND: A Case Study Approach

Master's Thesis

Submitted by:

Abha Nirula

In partial fulfillment for the

Degree of M.Sc. (Economics)

Submitted to:

Department of Policy Studies TERI University

Plot 10, Vasant Kunj Institutional Area

New Delhi 110070

INDIA

May 2017

This study was part of Research Component 3 of the Himalayan Adaptation, Water and Resilience (HI-AWARE) Programme funded by the UK's Department for International Development (DFID) and Canada's International Development Research Centre (IDRC). The study was undertaken at The Energy and Resources Institute (TERI).

DECLARATION

This is to certify that the research that forms the basis of this thesis titled **"Assessment of Early Warning System for Floods in Uttarakhand: A Case Study Approach**" is an original work carried out by me and has not been submitted anywhere else for the award of any degree.

I certify that, to the best of my knowledge, all sources of information and data have been fully acknowledged in the report.

Abha Nirula

M.Sc. Economics

TERI University

Date: 15TH May, 2017

CERTIFICATE

CERTIFICATE

This is to certify that **Abha Nirula** has carried out a Master's Thesis, in partial fulfillment of requirements for the degree of **M.Sc. Economics** on the topic "**Assessment of Early Warning Systems for Floods in Uttarakhand: A Case Study Approach**" during July 2016 to May 2017.

The report embodies the original work of the candidate, to the best of our knowledge.

(Internal Supervisor)

Dr. Nandan Nawn
Associate Professor
Department of Policy Studies
TERI University
New Delhi, India
Date: 15th May, 2017

(External supervisor)

Ms. Suruchi Badhwal
Associate Director
Earth Science and Climate Change Division
The Energy and Resources Institute (TERI)
New Delhi, India
Date: 15th May, 2017

(Head of the Department)

Dr. Shaleen Singhal
Department of Policy Studies
TERI University
Date: 15th May, 2017

ACKNOWLEDGEMENT

First and foremost, I would like to express my heartfelt gratitude to my internal supervisor, Dr. Nandan Nawn who provided his relentless support throughout the course of the thesis and steered me in the right direction. Without his motivation, insightful comments and valuable feedback, this thesis would not have been possible.

I would also like to thank my external supervisor, Ms. Suruchi Badhwal for her patience and guidance during various stages of the work and insights provided before commencement of field visit process.

I express my deepest gratitude to Ms. Sudeshna Maya Sen, Mr. Abhimanue Jalan, Ms. Stella George and Ms. Mrignyani Sehgal for the constant encouragement and support that they have lent from beginning till the very end.

My sincere thanks to the villagers for providing their valuable inputs, time and sharing personal experiences. I would like to extend my gratitude to Ms. Shanti who accompanied to Ginwala and guided me around the village.

Last but not the least, I am grateful for the unconditional support provided by my family during the last few months, bearing with my annoying attitude at times and giving up their leisure time of television watching during the last few days. I am thankful to my brother, Mr. Vaibhav Narula for helping me during the last few hours and proofreading certain sections. Sincere thanks to all the people who have made contribution to this thesis, directly or indirectly.

TABLE OF CONTENTS

ABSTRACT

Extreme events are a result of a confluence between vulnerability and hazard. They pose a risk to human lives, impact they daily functioning and resilience of a society. One of worst disasters plaguing India and especially mountainous regions, such as Uttarakhand are floods which have caused massive economic and social costs in the past. Disaster Risk Management is not a new concept; one of the key components of DRR is a forecast and Early Warning system. While, at an institutional level, there is an established framework of EWS and in the past few years, funding has also been received from multi-lateral funding institutes such as ADB and World Bank. The question remains that is, is a flood warning system effective in eliciting a response from the targeted population or are there any other factors influencing the response curve. We therefore, seek to answer this question through a case study approach using household survey to conduct interviews at three sites- Khadri Khadak Maf, Badal and Ginwala and analyze the response behavior and pattern of the individuals along-with analysis of the communication of the warning to the public in the study areas. The purpose of the study is assess the efficacy, both of the system and community response.

Keywords:

Early Warning System (EWS), flood, preparedness action, response, effectiveness, community

LIST OF ABBREVIATIONS

IMD:	Indian Meteorological Department
CWC:	Central Water Commission
DRR:	Disaster Risk Reduction
DRM:	Disaster Risk Management
EWS:	Early Warning System
UNISDR:	United Nations International Strategy for Disaster Reduction
HI-AWARE:	Himalayan Adaptation, Water and Resilience
DMMC:	Disaster Mitigation and Management Centre
SEOC:	State Emergency Operation Centre
BDO:	Block Development Officer
GAIL:	Gas Authority India Limited

CHAPTER I: INTRODUCTION

1.1 Background

Climate change as defined by the IPCC is the "statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer)". It leads to changes in precipitation, snow cover and cloud cover. These changes especially those relating to extreme climatic events have the ability to alter normal functioning of a community when a confluence between hazardous events and vulnerable social conditions takes place thereby resulting in a disaster.

India is amongst the most disaster prone countries in the world primarily because of its diverse geographical regions and large vulnerable population. In the past few decades, Himalayas have especially observed an increasing number of climate induced disasters such as glacial lake outburst flood, cloudburst led flash floods, droughts and landslides etc. Due to such extreme events, there has been significant loss to lives, property, ecology and massive interruptions in the economy. The Himalayan region is one of the most affected areas due to such extreme climatic conditions because of its fragile ecosystem and massively increasing human settlements alongside its perennial streams. The fifth assessment report published by IPCC also highlights an increasing trend of magnitude of climate-induced hazards.

Amongst various disasters, flood is the most widespread catastrophic event across the world causing economic damage of approx. US$11 million on an annual basis. (IFRC, 2008) Floods are a complex hydro-meteorological phenomenon; it is defined by Indian Meteorological Department (IMD) as "*a great flow of water, especially, a body of water which rises to overflow land usually thus covered*." When seasonal rainfall exceeds its long-period average level by 110 per cent, it is categorized as "excess monsoon" and based on warning levels at respective flood forecasting sites in different states, Central Water Commission (CWC) demarcates flood as per the magnitude, classifying them as low, moderate, high and unprecedented flood. Floods can be of different types- heavy rainfall/riverine floods, flash floods, coastal floods and dam failure floods. While riverine floods are caused by heavy rainfall over a considerable duration (days) in the catchment

leading to increased water levels, flash floods result due to sudden flooding in a small basin in a relatively shorter duration (2-6 hours) but with a high discharge. This categorization is important with respect to this study since in India the focus of meteorological warning is restricted to forecasts of heavy rainfall. Factors that contribute to flood include excessive or heavy rainfall, melting of glaciers, river overflow and ruptured dams. However, the impacts of flood are increasing in size due to increasing human population, large-scale deforestation and activities in the upstream area and the corresponding interaction between upstream and downstream. (IJIRSET, 2014) The nature of flood is similar to what is usually described as 'black swan events' i.e. low-probability, almost negligible predictability and high impact events (Taleb, 2007). Therefore, our objective is to understand whether how that risk is perceived and if the impacts can be reduced through an Early warning system, which is elaborated in the sections below.

1.2 Problem Statement

Uttarakhand has consistently been affected by various disasters as a result of its fragile ecological and geological systems. The state witnessed one of the worst disasters in 2013 when it observed 'heavy' to 'very heavy' rainfall resulting into flash floods and landslides and causing wide spread destruction especially in the districts of Chamoli, Bageshwar, Uttarkashi, Rudraprayag and Pithoragarh. In addition to this, the heavy rainfall combined with glacier melt led to a water rise in the Chorabari Lake and caused the lake's moraine barrier to burst and release the impounding water along with glaciers boulders which severely hit Kedarnath and other towns in the way. The disaster is said to have affected over 900,000 people and have an impact on multiple sectors from agriculture/horticulture, infrastructure, and tourism to environment, thus severely impacting livelihoods and local economies with a total estimated damage of around $1.1 Billion. (GoU, 2013) It caused serious disruption in basic public services such as food, availability of clean drinking water, sanitation, education and women & child care etc.

Given the recent disasters experienced by the state, experts attribute the state's vulnerability to unscientific 'development', changing land-use patterns, increasing forest degradation, poor waste disposal mechanism, rising tourism pressure and unwarranted

change of landscape. (NDIM; Rao et. al, 2014) The situation is worsened since there has been an increasing expenditure on construction of roads and buildings in the state as part of investment in tourist amenities, and that in turn has accentuated the magnitude of the hazards. In the current scenario, the state has become more susceptible to disasters since it has been repeatedly impacted by both geological and hydro-meteorological disasters.

Given the development path that the country is following, it becomes crucial to focus on disaster risk management to ensure that the development is 'climate-proofed' so that it is sustainable. DRM encompasses a broader framework of management of the risks posed by a disaster both ex ante and ex post thereby including elements of "prevention, mitigation and preparedness" (FAO, 2008) It can be useful framework only when there is an understanding about the contexts in which individuals live, the evolving environment people find themselves in and the effect of that environment on their capability to sustain their lives and livelihood. (USAID, 2011) Government agencies and International organizations have been committed to undertake actions to reduce disaster risks & prepare communities to face the impacts in a strategic manner. The need for such action arises because the severity of the hazard cannot be controlled, but the vulnerabilities and post disaster impacts can be reduced to a certain extent. Since a hazard has the potential to affect stakeholders at all levels and have multi-sectoral impacts, therefore a disaster risk management requires people-centric and multi-sectoral approach. Such actions need to be custom tailored particular to a region and in a local context to effectively implement risk reduction and management measures. A key and the most crucial measure for the same is an early warning system.

As per the Disaster Management Act (2005), Uttarakhand constituted a State Disaster Management Authority (SDMA) for taking responsibility of disaster preparedness in the state which framed its action plan only after the disaster occurred. Disaster Management strategies have also been laid out in State Action Plan for climate change (SAPCC) of Uttarakhand. The GoU has allocated Rs. 3.71 Billion for disaster management in SAPCC. In order to enhance the forecasting system, IMD as a whole is also expanding the observational platforms, weather stations, numerical modeling softwares, computing equipments and communication network in order to upgrade the technology which can

provide more accurate data that can yield greater socio-economic benefits. Such modernization program is definitely the need of the hour, which is also complemented by various other training programmes which the state disaster authorities have taken up in order train staff and personnel. Although the meteorological department disseminates the relevant information regarding weather parameters i.e. rainfall and its characteristics (intensity, frequency and magnitude etc.) to the public, it still needs to be properly understood whether(and how) this information reaches the desired section of population and upon reaching if it results in appropriate course of action with regard to flood preparation. Experience of climate and geography of that area might also be involved in how those people tackle flood related disasters. Therefore, this brings us to the objective of the Study stated in the next section.

1.3 Objective of the study

The aim of the study is to assess the efficacy of the Early warning system vis-a-vis floods in Uttarakhand through a case study approach. In order to address the question, following is the framework that we will follow:

- Understand the different source of information through which a community or households get warned about floods
- Analyze whether the information dissemination as intended by an official warning system resulted into desired action or response and if not, then tracing reasons for the same
- Examine other factors which lead to preparedness measures

In the context of civil protection, this paper tries to provide a multi-dimensional evaluation by undertaking both top-down and bottom-up approach to gauge if an instructed EWS fails and when it does, how other factors determine whether benefits of an EWS will be reaped, and if it differs among different geographical regions. The starting hypothesis is that the communication system is identical for all affected/prone sites.

1.4 Justification of the study

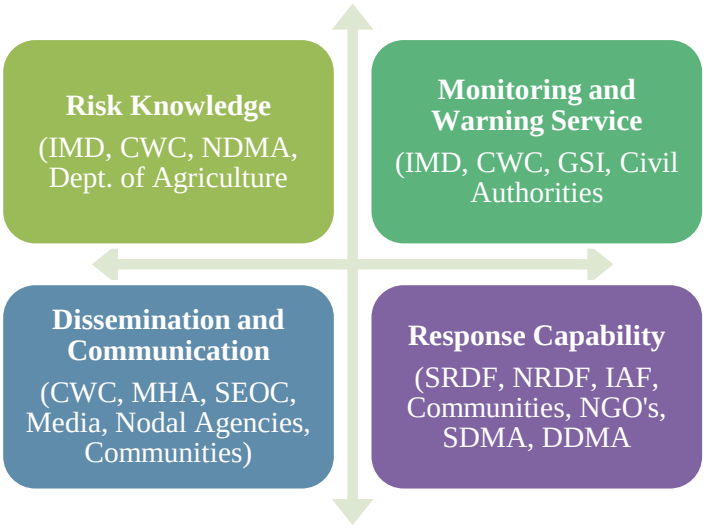
There is sufficient literature to corroborate necessity of a warning system however, an essential warning system doesn't necessarily imply that it is an effective one i.e. produces or triggers desired action. According to Fakruddin (2011), even after a EWS is installed, the system can still falter and fail to reduce vulnerability among the potential beneficiaries if there is lack of understanding among people regarding forecasting and warning messages. The response function or individuals' understanding about risks posed by calamity as well as their ability to respond to an event before or during its occurrence is crucial.

While, it is recognized that "different warning sources elicit different response curves" (Drabek, 2012), in this study we try to speculate whether a single warning source can induce different response curves.

CHAPTER II: LITERATURE REVIEW

2.1 Definition and Components of an Early Warning System

Early warning systems are an integral component of Disaster risk management process and an extension of weather forecast since it aims to provide households and communities with information on relevant variables like rainfall and temperature etc. as well as advisory information so that they can assess the level of risks based on their experience and have the option to undertake informed decisions. According to United Nation International strategy for disaster reduction (UNISDR) the definition of early warning system (EWS) is, "*The set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss*." It is a relatively economical mitigation option, has shorter installation duration and is expected to have least environmental impact as compared to other disaster reduction measures such as dams and sea dykes etc. While in disaster risk reduction framework, EWS is considered to be a non-structural mitigation measures, in the context of climate, it is referred as a planned non-structural adaptation initiative. Before we look at different methodology undertaken for assessment of a warning system, let us first describe its components.



Source- UNISDR

There are essentially, four key elements that define a EWS: risk knowledge, monitoring and warning service, dissemination & communication and lastly response capability. (Downing, 1977; Leon et. al, 2006) Risk knowledge entails systematic collection and analysis of data using various tools such as land-use mapping, hydrological models and climate modeling in order to identify vulnerable areas, nature of hazards and understanding the trend of changes in weather parameters. This first stage is therefore crucial for risk mapping and hazard analysis.

This is followed by monitoring and warning services under which prediction as well as forecasting is made which is backed by sound scientific methodologies which ensures adequate accuracy and provision of sufficient lead time. Hazard parameters are continuously monitored so as to ensure reliability of the system. The relevant agencies have the responsibility to ensure necessary infrastructure and observational network is in place since this forms the core of the EWS.

At dissemination and communication stage, it is the prerogative of the concerned department to ensure warnings reach those at risks in an understandable manner. The dissemination network should be well established and information channel (at national, state and local level) needs to be efficient for the same.

Finally, the response capability component requires that those at risk know how to react which can be achieved to public awareness programmes by trained personnel in order to reinforce the significance of warnings. Furthermore, importance is also place on capability of authorities during post-disaster events to help evacuate people, guide them to safe routes and shelters and conduct mock drills for better preparedness.

In the diagram, we have mentioned concerned authorities in India responsible for undertaking the tasks specified. For the purpose of this study, our focus will primarily be on dissemination & communication and response capability components.

2.2 Evaluation of Early Warning Systems

In order to justify investments in FFEWS and recommend potential improvements in the system, quite a number of studies have used different approaches which vary from

calculation of flood losses to developing performance criterias. (Du Plessis, 2002) Most of such studies are ex post i.e. after the flood incident has occurred. The purpose is to appraise the gaps in information provided by such a system or establish different criterias for its evaluation to gauge potential nodes in the information chain where performance can be improved. Studies have undertaken either qualitative or quantitative approach for the same; however, the work cannot be compared since the function of a EWS is different i.e. while majority of authors focus on forecasting, little emphasis has been laid on the response system. EWS can be evaluated from authenticity, effectiveness and accuracy perspective.

One of the most common approaches is calculation of **flood losses.** Even though risk reduction measures shouldn't entirely by guided by quantitative figures as the information provided by early warning systems is a public good; however it provides an estimate of the effectiveness of the system which is an important information for donors and policymakers. The authors who have used this approach have also at times combined structural and non-structural measures such as sea dykes, embankments and forecast & warning system in order to assess which measure is more economical and effective. One such study is conducted by Mercy Cops (2010) for flood mitigation measures in Nepal. Using a time period of 10 years and discount rate of 12%, the report concluded that for every rupee invested in DRR, a benefit of 3.5 Euros will be reaped. Therefore, the amount of potential damage prevented is treated as the benefit of the warning system or other mitigation measure. Authors such as Pappenberger et. al. (2015), Tiesberg and Weiher (2009) and Wurster and Meissen (2014) have also used the approach for their calculation but only w.r.t. EWS. The costs components in such paper, includes scientific component or technical inputs costs as well as institutional costs required to trained staff and facilitate capacity development at institution level whereas calculation of benefit requires damage-frequency curves. (Haimes et. al, 1996) It is unclear though, if a demarcation is made between costs incurred for forecast and warning for hazards in general and specific hazard such as flood. If it not separated, then costs essentially are overestimated. Another discrepancy exists in these studies is the assumption that the warning will necessarily lead to some sort of preparedness action and in number of instances it fails to take into account all intangible costs and benefits of the warning system.

To argue the robustness of such analysis, Smith and Handmer (1986) remarked, "*Improvements in an FFWRS can indeed be economically advantageous, but can also lead to negligible additional consumer satisfaction*". (As cited in Du Plessis, 2012)

As discussed above, the studies attempt to evaluate the effectiveness of a warning system from a damage assessment point of view wherein the analysis is either post an actual flood or through model simulations and using assumption regarding fixed percentage reduction in the 'potential damages' therefore quantifying only direct tangible damages rather than being able to take into account the other indirect tangible and intangible costs. In order to model the actual damages, Molinari and Handmer (2011) used an **event tree approach** which is used to estimate the expected probability of individuals undertaking appropriate action given the receipt and understanding of the warning and thereby calculating reduction in actual damages once effective actions are taken. The advantage of using such an approach is that it integrates the behavior of individuals when and if a flood warning is received and gives a more accurate estimation since actions are considered in a sequence.

Since it is difficult to gauge comprehensive benefit estimates of an Early warning system for flood, a subjective scoring system is also employed in certain studies. This is incorporated under **performance-based approach**. Tiesberg (2009) uses the tool mentioned for different meteorological and geological hazards by scoring them on a scale from 0 to 5 on different criterias such as frequency, severity of the event, predictability and lifesaving potential. For floods, a score of 5 was given for both predictability and frequency since it indicates that it is one of the most frequent hazards amongst other events and given the numeric models, it is a predictable event. According to the experts judgments considered in the study and the geometric average calculated of individual scores, it indicates that effectiveness of having a EWS for flood is ranked 4 i.e. benefits availed from such a system are high. However, such an assessment relies heavily on 'expert' judgment rather than actual potential beneficiaries. To evaluate performance, reliability as a function of lead time is also used as criteria in some studies. In Schroter & Ostrowski (2007), a statistical analysis of observed and predicted precipitation discharged values was undertaken in order to check for accuracy of the system and therefore, its

reliability. Thus, the advantage of this approach is that a specific division of the system can be focused upon for improvements.

In India, performance assessment in terms of accuracy, reliability and coverage is already undertaken by CWC for forecasting sites in different basins and states.

Another approach that can be considered is **evaluation through community satisfaction**. Shrestha (2012) employed the approach to study effectiveness of community-based warning system in Nepal taking into account gendered perspectives of the same. Stakeholder focused interviews, and field based observations, were conducted at sites where a people-centric system is already in place. It was found that a number of lives were saved downstream because of proactive actions by local administration and the communities.

Given the objectives of the study, in this research, we opt for a combination of community satisfaction approach and performance based approach wherein the latter is used for dissemination and communication element while former is employed for ground-truthing purpose. It falls under the framework provided by Krzysztofowicz (1983) in which a **"flood-forecast-response process"** is conceptualized as a system. This system encompasses integration of two components- forecast system that includes flood forecast and dissemination and secondly, the response system which couples decision making and action implementation. Therefore, we apply both top-down and bottom-up approach to achieve the results to our study. However, a limitation of focusing on community satisfaction is that, given the long return period of high-impact floods, the results and analysis are based on mainly 2-3 floods experienced by individuals in a community.

In the section, we will mention the methodology used and study sites chosen in Uttarakhand.

CHAPTER III: METHODOLOGY

In the initial step, three sites were identified across different elevations in the Upper Ganga Basin, one of the study basins of the HI-AWARE project. These were chosen based on criteria of proximity to a river source and prior flooding experience. Following this, household surveys were conducted with a total of 81 respondents using semi-structured interviews in every site which was accompanied by key informant Interviews at local, district and State level and documentation review of the dissemination framework for Uttarakhand.

In the next step, characteristics and dissemination of warning message was analyzed both from sender's and receiver's perspective. As a part of this step, various factors were identified which have an influence on action (or inaction) by vulnerable population to alerts notifications in order to enhance their resilience to floods. This included assessment of respondent's behavior as an individual and as a member of the community. The section below will cover the approach considered for the study and tools employed for the same.

3.1 C**ase Study Approach**

For the purpose of this research, we have employed case study research method. The reason this method has been used is because the impacts of flooding and coverage of an early warning system varies for different geographical regions. Since, it is not feasible to cover all villages in all flood affected districts of Uttarakhand, case study-approach becomes relevant as it helps us study various patterns and inter-linkages between different factors and understand through the 'microscopic nature' of case studies , the efficacy of the warning system and how difference factors can play a role in altering that. "*Qualitative data has the asset of providing in-depth, context- and actor-sensitive, and typically narrative-driven information*." (Matveeva, 2006) One of the main limitations of using this method is the lack of robustness of this method to provide with generalized results. Further, the results of this study cannot be compared with that of similar research in other countries because of variance in socio-economic structure and geographical differences that exists.

3.2 **Tools Used in the Study**

Key Informant Interviews (KIIs)

As put by M.N Marshall (1986), "a key informant is an expert source of information". Key Informant Interviews are one of the most frequently used tools when conducting a research since it provides in-depth information and specific knowledge on a particular issue for a community. The purpose of KIIs is to interview individuals who have better insight and understanding of a community and nature of issues that it faces. It helps to get a larger picture before delving into nuances of the problem and have to the potential to reveal information which may be previously unknown to the researcher. For the purpose of this, an open ended loosely structured interview was conducted with various individuals in order to narrow down the target population, modifying the questionnaire for respondents and to supplement the information obtained from primary survey in terms of consistency.

There are however some limitations to using KIIs as a research tool such as possibility of bias in responses. More often than not, it is a time intensive task especially when a face-to-face is conducted since it is dependent on time and availability of the informant. Furthermore, the findings attained from such interviews are not generalizable since they reflect a particular individual's knowledge and perspective on a topic.

For the purpose of this research, individuals at different hierarchy level of an early warning system were interviewed so as to gauge the information available at each 'node'. Thus, the selection ranged from key personnel involved in Disaster Mitigation and Management at State level, district level and finally the leaders at the village level. A total of 5 informants were interviewed across the verticals whose responses were recorded using audio and were partially transcribed. Informants were selected based on telephone interaction with various individuals who on enquiry of the issue, made recommendation of the relevant personnel.

3.3 **Data Source**

Household surveys have become a key data source to study different social phenomena catering to specific objectives of the researcher. It helps in understanding the characteristics of the population being studies and allows understanding of different social and economic factors which may affect the behavior of the individuals and community present in the setting. It allows the researcher to delve into the nuances at a household level which allows for better analysis of the ongoing phenomena at a macro level. It presents general socio-economic condition of a geographical area and enables researcher to understand diverse perspective on an issue.

3.4 **Data Collection**

The study used census survey method to obtain responses of the population of the three study sites chosen. Sites with different elevation were chosen which were previously affected by flood and while conducting survey it was ensured that individuals were permanent residents of the area.

In view of ethical considerations, respondents were clearly stated the purpose of the interview and their decision to not participate in interviews given their work priorities was respected. Therefore, due to feasibility constraints such as unwillingness of the respondents and unavailability of members, a true census could not be obtained.

3.5 **Study Area**

There are four study basins under the HI-AWARE project: Indus, Upper Ganga, Gandaki and Teesta which were chosen for the project through scoping exercise and expert interviews. In this study, sites chosen were in the Upper Ganga basin. The site map is presented below:

Figure: Study Sites Map

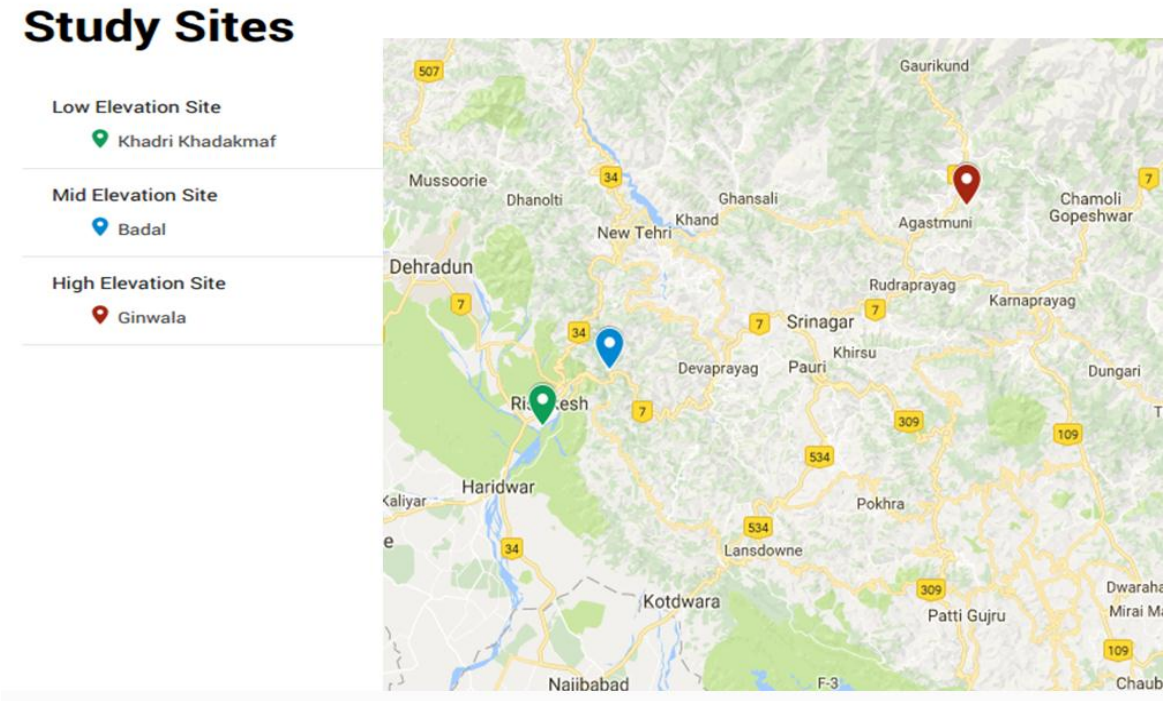


Table: Details of the Study Sites

	Ward	Hamlet	Village
Study Site	**Vishnu Vihar**	**Badal**	**Ginwala**
Tehsil	Rishikesh	Dhoomakot	Ukhimath
District	Dehradun	Tehri Garhwal	Rudraprayag
Main River	Song	Ganges	Mandakini
Elevation	484m	620m	1200 m
Sex Ratio	967	938	1203
Literacy	85.70%	76.63%	85.80%

Source- Census (2011)

As can be observed from the table, all the locations are in different districts of the states with Ginwala having the highest elevation and Khadri Khadak maf, situated at a much lower elevation in a plain region. Details regarding demographic parameters are given in the next section.

3.6 **Description**

3.6.1 **Khadri Khadak maf (Vishnu Vihar)**

Khadri Khadak maf is a census town which by virtue of it being in the proximity of Rishikesh had undergone rapid urbanization in the last decade. The survey was conducted in only one ward of the village, Vishnu Vihar, which was the most affected by floods. There are two prominent social groups in the village, Buksa (Scheduled Tribe) and Garhwali (General) who speak a common language, Garhwali, which is one of the most common regional dialects in Uttarakhand. The village had concrete roads connecting all the houses and had all the major facilities such as school, colleges and bank etc.

The members of the households surveyed work either as daily wage laborers, agricultural labour and/or cultivators. Main crops grown in the area are wheat (in the rabi season) and Paddy (in the Kharif season). The average number of members in the household is 6. The risk perception with regard to floods was of medium magnitude in the village i.e. impacts faced have been in terms of loss of agricultural land, loss to infrastructure facilities such as submergence of Vocational college however no lives have been lost.

3.6.2 **Badal**

Badal is a hamlet under the Gram Panchayat of Bawani village. In contrast to Khadri Khadak maf, there seemed to be an evident diversity among the crops grown which includes kidney beans, wheat, paddy, corn flour and mustard etc. Badal is also close to Rishikesh, and the livelihood of the individuals in the village depends on the rafting business owing to the thriving tourism that Rishikesh is popular for. Therefore most men of the village are either self-employed or daily wage workers. The average family size and language spoken is same as Khadri Khadak maf. Further, in contrast, there is homogeneity in caste of the population as majority of the people are Garhwali with no member of minority group residing there. (Census, 2011)

The flood risk perception is low in Badal since main activity that gets affected is rafting apart from loss to agricultural land and drinking water scarcity in monsoon due to floods. Even for rafting, as per license, the tents are removed during the monsoon season starting mid-june onwards.

3.6.3 **Ginwala**

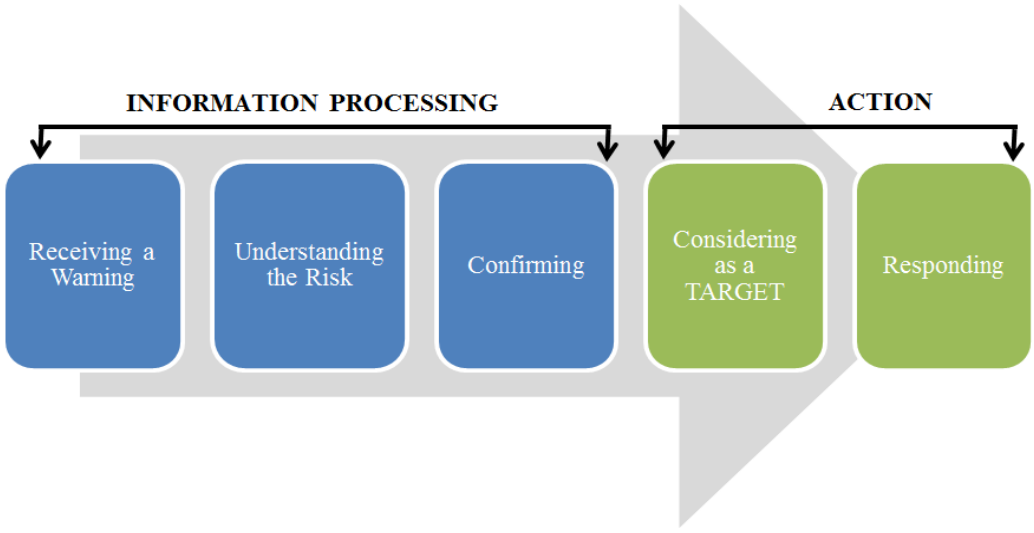
Ginwala has highest elevation amongst the locations selected; a village settled right next to Mandakini River and thus, was the most affected during 2013 disaster. While most women in the village work as agricultural labour in others farmland and cultivators, men are employed either in defense services (particularly Army), self-employed or have other private job (such as driving) apart from being traditionally involved in cultivation.

The main crops grown in Ginwala are Wheat, Paddy, Pulses and mustard. In all the three villages, there exists some form of human-wildlife conflict which was more prominent in Ginwala. The flood risk perception is high in this village which is primarily because of past experiences and number of organizations (Such as Himmothan, GAIL) the village is exposed to who conduct awareness sessions and regular meetings in the village. The village had access to infrastructure such as HelpAge hospital, primary and secondary schools in Agastmuni (a town near Ginwala) and pucca roads connecting the village to other towns.

CHAPTER IV: RESULTS AND DISCUSSION

4.1 The Process of Warning

In this section, firstly we look at the information disseminated to the individuals and then perception of risks among individuals. There is a difference between a warning as defined at the mitigation planning stage and what unfolds at the ground level. The warning system is a social process rather than a single-node event therefore it is important to understand the process once a warning is disseminated.(Mileti, 1995) Secondly, we try to look at the factors which influence warning decision making among individuals and communities i.e. understanding how the preparedness action or the likelihood of people undertaking a protective action in response to notification of a possible flooding event depends not only on the receipt of warning but various other factors.



Source- Drabek (2012)

According to Parker et. al., (2008), *"People rarely respond in a straightforward or mechanical 'stimulus-response' manner. A 'stimulus-actor-response' model is more appropriate in which the actor processes risk communication information. Therefore, the warning may not generate the expected response."*

Warning as a process as presented in the diagram above, can be demarcated into two stages i.e. of information processing and taking preparedness action. The Chain begins when an individual hears or receives the warning which can be of three types- official (through police announcements, warning signage or SMS), unofficial (own observation, through family or community members or via television or radio) and no warning at all. In order to understand what triggers the response, it is important to distinguish the types of warning and analyze how individuals and communities respond to each type. When in official warning, one has to be careful since the warning might be either before the onset of flooding event i.e. one which is forecasted, at the time of the 'event' which is relevant in this case study wherein the event takes place at a higher elevation (Kedarnath) and then simultaneously mid-hill regions are alerted and finally there are also warnings after the onset of flood. (Parker et. al, 2009) As explained before, certain studies falter because of the assumption at first stage itself. If a warning is broadcasted, it doesn't necessarily indicate that the recipients receive it.

In Uttarakhand, early warning system is in its expansion stage. The district offices do have the siren but have a limited range of 2kms, which in itself is a major shortcoming considering the coverage area which should be targeted. Information, however, is broadcasted with the support of various mediums such as television, radio and newspaper etc. With the pace of urbanization and advancements observed in the villages visited, different trends were witnessed with only a handful of individuals still using radio. Even those who had television either didn't use it view weather forecasts or quite a number of individuals despite having TV access lacked the set-up boxes which rendered its functionality futile. Thus, the physical constraints or other factors can cause a gap in receiving the crucial information by the vulnerable population.

Once the information is received, different people understand it differently i.e. it is possible that each individual attaches unique risk probability to the event in terms of the magnitude and depth that might be faced. Following this, individuals try to authenticate and confirm the warning within the households and the community. After the warning is confirmed, individuals make a value judgment even within a village wherein quite a number may think that the warning doesn't apply to them. It is often at this stage that

people absorb the information and risk knowledge once it is shared among the community members. Community participation plays a pertinent role in this case which we will discuss in the next section. Furthermore, even after confirmation, certain households may not consider themselves as a target. As observed in Ginwala, one of the study sites, given the distance from the main river, some individuals assumed their shops or agricultural fields would not be affected. Therefore, it becomes crucial to personalize the context of warnings so as to avoid "it can't happen to me syndrome." (Rossi et. al, 1994) In a study by Weinstein and Klein (1995) the authors show how "optimistic biases" which are not random but systematic biases lead people to make unreliable and inaccurate assessment as they underestimate the probability of adverse impact given their situation.

Once people undergo the 'process', it is then that they get to the 'final stage' which is where they choose to undertake an appropriate action to the risk facing them. However, even after considering them a target, the response varies among individuals and households, which again depend on different factors which we shall discuss. Response may vary from moving to a higher location, preparing an emergency bag, discussing within community about possible plan of action or people may decide not to act at all.

In the next section we delineate the characteristics of flood warning, in order to gauge whether individuals are provided sufficient information, before we delve into socio-economic factors which trigger differential response action.

4.2 Top-Down Approach

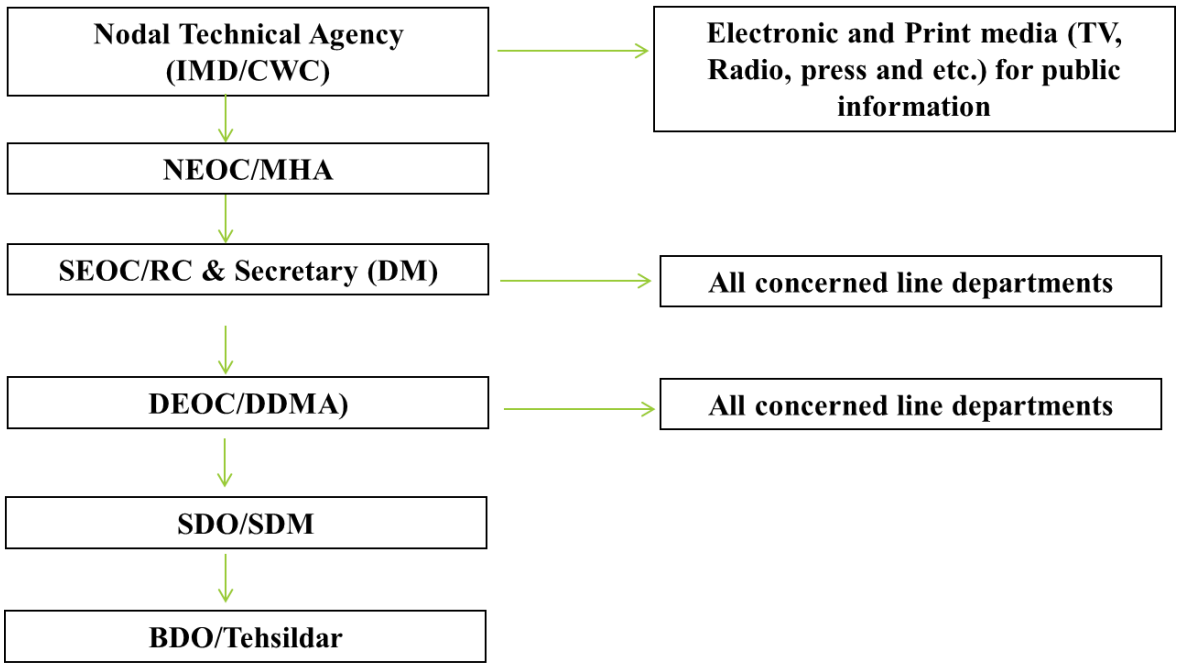
For the purpose of analyzing content of the warning messages, a documentation review was done. Information on warning dissemination during the year 2015-16 was collected from Disaster Mitigation and Management Centre, Dehradun.

As explained in the literature review, there are four components to an Early warning system. Looking at how the information reaches the consumer, means focusing on dissemination and communication pathway as established by the relevant institutional authority. To evaluate the efficacy, it is crucial to review what information is gathered from the official/formal source of warning, what the perceived accuracy of the same is and whether the information provided is sufficient.

When rainfall is expected to cross the threshold of around 70mm on any day, heavy rainfall warning is issued to all the district officials along with various other agencies such as Irrigation department, public service and railway officials etc. so that there is readiness for disaster management. (CWC, 2012)

Following diagram shows the dissemination channel as established in the disaster management framework for India.

Figure: Dissemination Pathway

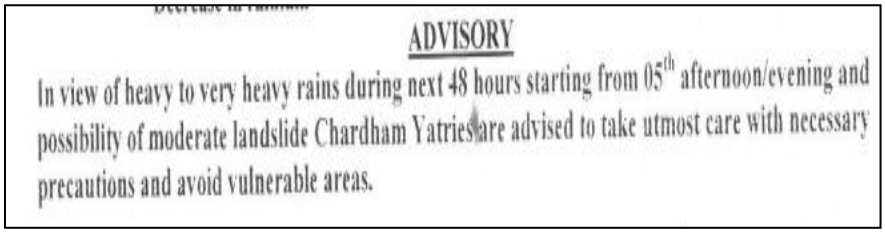


Source- CWC (2014)

There are three main information categories when IMD releases a weather forecast along-with a warning which includes warning type, outlook for next 48 hours and advisory. There are four warning type- Green (no warning), Yellow (Be aware), Orange (Be prepared) and Red (most vigil). On review of different weather forecasts released for different warning types, following observations were made-

Advisory: Distinct levels of warning signify different magnitude of rainfall in any geographical region which can differ from village to village. In the IMD forecast and warning, the advisory specifies that char dham yatris should take necessary precaution and

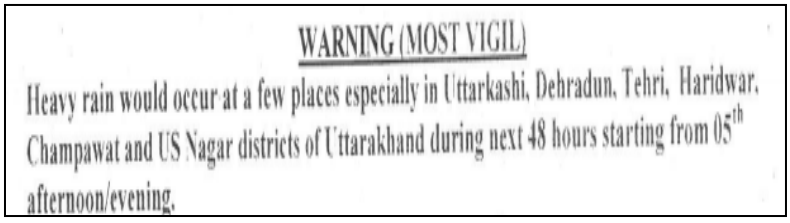
avoid vulnerable areas. While the website contains the necessary dos and don'ts, the document does not explicitly elaborate on the precautionary measures that should be taken or the vulnerable areas which should be avoided.



ADVISORY

In view of heavy to very heavy rains during next 48 hours starting from 05th afternoon/evening and possibility of moderate landslide Chardham Yatries are advised to take utmost care with necessary precautions and avoid vulnerable areas.

Affected Areas: The forecast is released at a district level rather than a village level. The problem in this case arises because even if it does rain in some of the areas mentioned among the vulnerable areas specified; the population residing in areas where it didn't rain but received the same information, may consider it to be a case of 'false warning' even when it might not entirely be so.



WARNING (MOST VIGIL)

Heavy rain would occur at a few places especially in Uttarkashi, Dehradun, Tehri, Haridwar, Champawat and US Nagar districts of Uttarakhand during next 48 hours starting from 05th afternoon/evening.

Furthermore, from discussion with Key personnel at Rudraprayag District Office, it was conveyed that when rainfall levels cross a threshold where likelihood of flood increases, even then the warning is still released as 'heavy rainfall' warning and not for 'flood' per se. A rationale that was given for the same was to not induce extraneous panic among people and keep the message content simple. Thus, there is a cost associated with 'false' warnings which the agencies try to avoid that have both positive & negative implications.

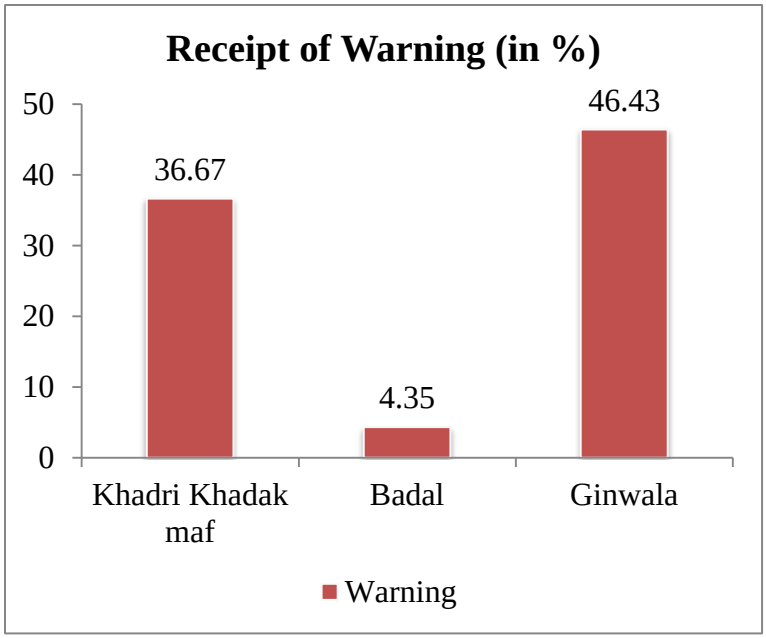
In addition, from another interview conducted with Executive Director of DMMC, it was learnt that IMD along with other organizations is part of an Inter-Agency Group (IAG) wherein from time-to-time weather and disaster related information is circulated. However, there exists very few NGO's in that network. Given the level of trust such social enterprises hold in any community and the pivotal role they can potentially play in disseminating timely information, there should be synchronized working between

government and NGO's which can complement the existing structure at local level already in place.

Lastly, at a local level, police authorities announce precautionary measures for people at the river banks to evacuate the area during heavy monsoon season. Even during a possible flood-like scenario, a similar alert is given i.e. there is no differentiation between a 'precautionary notice' during pre-flooding and 'alert message' before/at the time of flood onset. This may hinder the perception of the local population. Thus, there are a few areas of improvement which should be incorporated for information released by relevant authorities.

Given, the characteristics of warning, let us now analyze the coverage of warnings in our three sites as presented.

Graph 1: Percentage of Individuals who received a warning

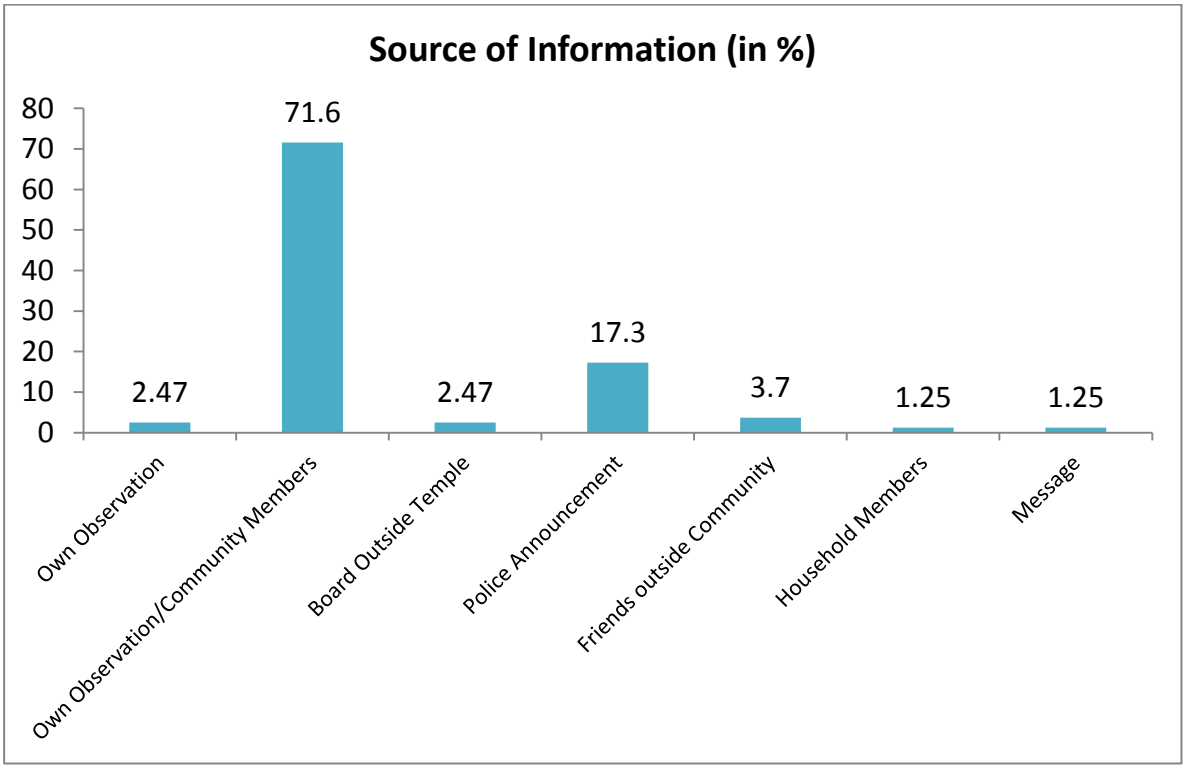


The above graph represents the percentage of individuals who received a warning either through official or unofficial source. As can be seen, it is highest for village Ginwala which was exposed to highest risk because of the elevation and lowest for Badal, where people perceived risk to be low and faced least impacts as compared to other locations. In all three locations, 26 out of 81 individuals i.e. one third of the surveyed population

responded that they received some sort of a warning. Only 16 out of the 26 responses were for instructed warnings and this was mainly the case in Ginwala. In Khadri Khadak maf, police announcements were made but post the initiation of field inundation.

The classification of warning type is presented in the graph below. Here, we have categorized for all individuals of who received the information and not just warning i.e. even those who didn't get a 'warning' before the onset of the disaster, did get information after the event did strike.

Graph 2: Source of Information of flooding



As shown, most of the individuals became aware of flooding through a mix of their own observation and details provided community members during the event either by constant monitoring of the river level or through strong flood stench that enveloped the area. Repetition of similar information by multiple individuals acts as a confirmation that the threat is credible. This credibility increases the 'cost of inaction' perception amongst households and triggers least a discussion chain which entails 'how to go, what to do, where to go' kind of questions. Only around 17 per cent of village members first got

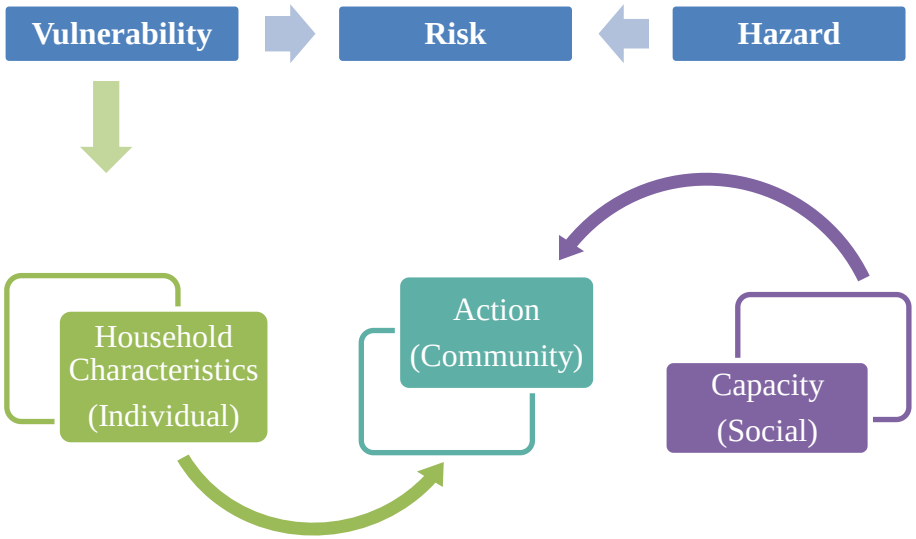
notified by police announcements. The other source such as ‘friends’ outside community signify wherein individuals actively sought information from relatives or friends uphill to gauge the risk level or they were notified from acquaintances in Police who suggested them to take appropriate measures. An interesting finding is that, even though there was strong information sharing among all the communities; it was not ‘shared’ until the threat seemed plausible.

It is evident that instructed mode of communication does not seem to be effective in being the first mode of information channel and having consistent coverage in an area.

4.3 Bottom-Up Approach

Human response to risks can be explained by ‘Protection Motivation Theory’ which was introduced by Rogers (1983) according to whom individuals intention to engage in protectionist measure are influenced by four crucial perceptions that includes severity or magnitude of the risk, individual’s vulnerability, self-efficacy of undertaking risk reduction behavior and response efficiency of the same. It also conjectures that rather than actual, it is the perceived benefits and costs of undertaking protective steps than can affect the decision. Before looking at the factors, it is important to understand their importance in a general hazard and vulnerability.

Figure: Relation between Socio-economics Factors and Community Capability



Actions at a community level are determined by household characteristics at an individual level such as age, gender and education level etc. and capacity related factors at a social level like village infrastructure, social capital etc. This gives a broad framework of detailed description which is given below. As individuals, the capacity to take effective actions is limited whereas, a community, which is the multitude of individuals having close bonds is essentially like an autonomous body which its own set of new capabilities, resources and interests. (Patterson et. al, 2010)

4.5 Timeline Analysis: How Early Is Early?

Before proceeding to the analysis of warning received by the community and their response to the same. It is crucial to understand the context in which people perceived the meaning of early. The IMD forecasts provide a lead time of 5-days whereas there is hardly any difference between early warning or mere warning to individuals, in the sense that, often a warning is not given because of forecasts but at the onset of a flood, therefore at times, it can preceede or immediately follow after the actual event. It is primarily because of this reason, that respondents were asked the lead time that they would require to ensure their safety.

Village	Required Lead Time
Khadri Khadak Maf	1-2 Hours
Ginwala	1-2 Hours
Badal	2-3 Hours

In Badal, minimum time required for safety was higher since the amount taken to pack all the tents in an emergency situation was stated to be at-least 2 hours.

4.6 Factors Influencing Preparedness Action

Age

In different geographical areas, researchers have previously studied differential vulnerability impact of floods on certain categories of age group that either falls below the age group of 15 or above the age of 65 comprising of senior citizens. (Tapsell et al., 2002;

Dao & Peduzzi, 2003 and Lee et. al. 2005) Despite having relatively more experience and knowledge in respect to flood, people aged 65 and above are disproportionately affected by disasters in general since the age restricts their ability respond effectively and affects their mobility, thus, increasing the vulnerability. Furthermore, the assistance required post a disaster is greater for individuals falling in older age group. (VCOSS, 2014) In contrast, the vulnerability of children arises in the context of difficulty a household faces for undertaking preventive measures to protect their children.

In this case study, it was observed that in areas where alert message through police announcement was broadcasted, some people aged 65 and above either didn't hear the warning or didn't seek out to confirm additional information because of inability of process the information. Respondents even shared knowledge of an incident of psychological impact experienced by an 83 year old widow post the 2013 flood. According to Rufat et. al (2015) old age vulnerability can be reduced by anticipatory behavior by 'experts' who by virtue of their experience sense weather changes earlier than other members of the community. However, no individual with the described characteristic was identified in any of the village. As can be seen in the table, the distribution of vulnerable population is highest in Khadri Khadak maf.

Table: Age Distribitution of Vulnerable Population in Study Areas

Age Category	**Khadri Khadak maf**	**Badal**	**Ginwala**
% of children (≤ 0-14 Years)	39	33	21
% of Senior members (> 65 Years	11.9	12.38	22.31

Network

Studies in the past hypothesize and find evidence that social networks do serve to integrate dynamic responses present in a system and thus help build some form of

resilience. (Carpenter et. al, 2012) Furthermore, the social bonds tend to enhance during disasters. (Drabek and Key, 1983)

Majority of the households have been residing in their respective areas since their childhood which is more than 50 years. This indicates a strong sense of social network. The concept of social capital then becomes relevant in the context of disaster risk management. As defined by OECD, social capital is "networks together with shared norms, values and understanding that facilitate co-operation within or among groups." During the occurrence of a disaster, potential benefit can arise out of social capital in the form of support, mutual aid and potential for collective action. Given this context, we look at how such network facilitate in responding to flood in different sites selected.

Table: Level of Community Participation in the Study Areas

Village	Type of Participation	Explanation	Response Type	Response
Khadri Khadak Maf	Information (Least)	Merely sharing what is Observed	Voluntary	Constant monitoring of river level and keeping community members informed
Badal	Activity Specific Task	Members acting together when required	Instructed	Removal of Camps, Gathering together
Ginwala	Consultation	Offering some options in case of worst case scenario	Voluntary	Consultation among community members and preparation of emergency bags

The above table is based on community participation framework by Bina Agarwal (2001)

Previous Experience

An individual's response to a warning is also dependent on whether people have prior flood experience and whether the experience is recent or distant and the magnitude of the

event. (Parker et. al., 2009) Even though majority of the respondents had experienced inundation in their area and agricultural fields, very few had personally had been affected by flooding at their house or had damage caused to their personal property prior to the 2013 floods. As per literature, past experience should be positively related with preparedness action since individuals are aware of the possible impacts and consequences.

However, during the field visit, one of the respondents aged above 50 residing in a pucca house in Ginwala mentioned that:

"*The return period of the flood is generally 50-100 years. We have experienced few floods in the past, but none like the one which occurred in 2013. We have lost most of our agricultural land post the 2013 flood. A flood of that magnitude would probably occur once we have died. Even if it does hit, there is hardly anything left for us to lose now*."

The above statement signifies that for certain individuals especially who are aged and have limited resources; there is very little incentive for them to undertake any response measure since value attached to life is less. In addition, according to Reynaud et. al (2013), when individuals have prior experience, they re-calculate their risk perception that is, post an experience of high-magnitude flood, individuals also tend to undervalue events of a lesser magnitude. Another perspective regarding the same is that, individuals who may have been affected psychologically in the past during disaster may experience more anxiety when a similar disaster strikes again. (Hussain et. al, 2011)

Investment in Housing

As per a 52-year old respondent from Badal Village, who resides in a pucca house with 9 other members describes:

'*Construction of a room here in Badal costed us Rs. 2-3 lacs, a brick costs Rs. 3 in Rishikesh but it increases to Rs. 10 due to transportation costs and slight uphill trek that is involved. We have invested a lot in our houses, even if disaster strikes, if we would want to die in our own home.*'

It is often presumed that to enhance disaster resilience people invest in housing especially pucca houses which is constructed from bricks and cements etc. While that may be true, in

the surveyed villages, the reason for 'inaction' in a few cases prevalent in Badal and Ginwala, individuals don't seek to respond actively because they assume their houses to be disaster resilient rather because of the investments incurred and a sense of possession, it inhibits them from undertaking proactive measures. "A household may perceive the risk of evacuation, in terms of losing control of its assets and resources, as more devastating than the risk of hazard." (Zschau, 2013)

Capability Building

In order to assist communities and households to intiate self-action during floods, another important factor is the presence of an external agency or organisation which can provide with training to individuals through knowledge sharing on prevalent risks, possible precautionary measures and actions to be taken during the occurrence of a disaster. A capability building initiative improves preparation for hazards as it aims to maximise readiness to respond to flood warnings, even if issued at a short notice. (Yeo, 2000)

The effect of community education on household preparedness was evident in one of the sites, Ginwala. In Ginwala village, regular monthly/fortnightly meetings are conducted by trained personnel from GAIL who provide advice related to all disaster events. People were enquired whether they attended the meetings or were members of the organisation. Further, if they were members, individuals were asked if they found the preparedness advise useful. Those who attended the meetings regularly responded positivity and informed that they indeed found the sessions informative. As advised, a few of them have even started keeping an emergency bag prepared, which carries essential documents, torch and few piece of clothing so that even if they are warned at a short notice, they would relatively be better equipped than other members psychologically and physically. Thus, capacity building through an external organisation helps in transition from flood awareness to preparedness.

Existence of Social Leaders

Apart from formal leaders, there also exists certain informal leaders within a community who play an important role during extreme events. In Vishnu Vihar ward of Khadri Khadak maf, there exists a few informal leaders who are either members of local council,

long-term resident of the village or a social activist. During an emergency situation, community members rely on these social leaders for confirmation of information and initiate action within village since usually evacuation of a village isn't an individuals response but depends on whether the all households are vacating the village or not.

CHAPTER V: CONCLUSION

Firstly, while investment in a Flood forecasting warning system may be required, it doesn't necessarily mean that the coverage of such a process will be consistent across areas and will provide information to the targeted population uniformly. Response curve of individuals is dependent on warning characteristics. Therefore, it is required that alert issued for different magnitude for flood and different areas be customized. In our case, the coverage of instructed alerts was less than 50 per cent in all areas, which means the top-down is ineffective in reaching to the affected people. There should be efforts to take into account community response behavior into the institutional framework in order to improve the performance of the EWS.

At the ground level, there are many factors which trigger or influence Individual's action making decision which include age, gender, investment in housing, and Past experience. Community also plays a crucial role in shaping an individuals role through social network, community participation, existence of social leaders and capability building programmes. Public awareness programmes along-with trust-building through external organization can strengthen the EWS which should be incorporated well within the institutional structure. There are other factors as well such as gender and educational status which also affect the vulnerability and response curve of the particpants. However, EWS performance with respect to gender requires a more detailed study because of the complexity and nuances involved. A more in-depth analysis is also possible with a focus on compensation and insurance.

REFERENCES

Agarwal, B. (2001). Participatory exclusions, community forestry, and gender: An analysis for South Asia and a conceptual framework. *World development*, *29*(10), 1623-1648.

Carpenter, S. R., Arrow, K. J., Barrett, S., Biggs, R., Brock, W. A., Crépin, A. S., & Li, C. Z. (2012). General resilience to cope with extreme events. Sustainability, 4(12), 3248-3259.

de León, J. C. V., Bogardi, J., Dannenmann, S., & Basher, R. (2006). Early warning systems in the context of disaster risk management. Entwicklung and Ländlicher Raum, 2, 23-25.

Downing, T. E. (1977). Warning for flash floods in Boulder, Colorado (No. 31). Institute of Behavioral Science, University of Colorado.

Drabek, T. E. (2012). Human system responses to disaster: An inventory of sociological findings. Springer Science & Business Media.

Drabek, T. E. (2012). Human system responses to disaster: An inventory of sociological findings. Springer Science & Business Media.

Drabek, T. E., & Key, W. H. (1984). Conquering disaster: Family recovery and long-term consequences. Irvington Publishers.

Du Plessis, L. A. (2002). A review of effective flood forecasting, warning and response system for application in South Africa. Water Sa, 28(2), 129-138.

Haimes, Y. Y., Li, D., Tulsiani, V., Lambert, J. H., & Krzysztofowicz, R. (1996). Risk-Based Evaluation of Flood Warning and Preparedness Systems. Volume 1-Overview (No. IWR-96-R-25). Army Engineer Inst For Water Resources Fort Belvoir Va.

IPCC, 2014: Annex II: Glossary [Mach, K.J., S. Planton and C. von Stechow (eds.)]. In: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change

Krzysztofowicz, R., & Davis, D. R. (1983). Category-unit loss functions for flood forecast-response system evaluation. *Water resources research*, *19*(6), 1476-1480.

Marshall, M. N. (1996). The key informant technique. Family practice, 13(1), 92-97.

Matveeva, A. (2006). Early warning and early response: Conceptual and empirical dilemmas. European Centre for Conflict Prevention/International Secretariat of the Global Partnership for the Prevention of Armed Conflict.

Mileti, D. S. (1995, November). Factors related to flood warning response. In US-Italy Research Workshop on the Hydrometeorology, Impacts, and Management of Extreme Floods (pp. 1-17).

Molinari, D., Molini, S., & Ballio, F. (2012). Flood Early Warning Systems PERFORMANCE: an approach at the warning chain perspective. WIT.

Pappenberger, F., Cloke, H. L., Parker, D. J., Wetterhall, F., Richardson, D. S., & Thielen, J. (2015). The monetary benefit of early flood warnings in Europe. Environmental Science & Policy, 51, 278-291.

Parker, D. J. (2000). Floods (Vol. 1). Taylor & Francis.

Parker, D. J., Priest, S. J., & Tapsell, S. M. (2009). Understanding and enhancing the public's behavioural response to flood warning information. Meteorological applications, 16(1), 103-114.

Patterson, O., Weil, F., & Patel, K. (2010). The role of community in disaster response: conceptual models. Population Research and Policy Review, 29(2), 127-141.

Rao, K. H. V., Rao, V. V., Dadhwal, V. K., & Diwakar, P. G. (2014). Kedarnath flash floods: a hydrological and hydraulic simulation study. Curr Sci, 106(4), 598-603.

Rogers, D., & Tsirkunov, V. (2011). Costs and benefits of early warning systems. Global assessment report on disaster risk reduction. ISDR and World Bank.

Sättele, M., Bründl, M., & Straub, D. (2016). Quantifying the effectiveness of early warning systems for natural hazards. Natural Hazards and Earth System Sciences, 16(1), 149-166.

Smith, D. I., & Handmer, J. W. (1986). Flood warning in Australia. Centre for Resource and Environmental Studies, Canberra.

Taleb, N. N. (2007). The black swan: The impact of the highly improbable (Vol. 2). Random house.

Teisberg, T. J., & Weiher, R. F. (2009). Background paper on the benefits and costs of early warning systems for major natural hazards. World Bank, Washington, DC.

Weinstein, N. D., & Klein, W. M. (1996). Unrealistic optimism: Present and future. Journal of Social and Clinical Psychology, 15(1), 1-8.

Yeo, S. W. (2000). Ba community flood preparedness project: Final report. South Pacific Applied Geoscience Commission.

Zschau, J., & Küppers, A. N. (Eds.). (2013). Early warning systems for natural disaster reduction. Springer Science & Business Media.

ANNEXURE I: QUESTIONNAIRE

I) INDIVIDUAL INFORMATION

Name: _____

Village: _____ **Taluka** : _____ **District :** _____

Sex: Male ( )/ Female ( )

Age or range:

_____

Mobile Number (If applicable):

_____

Years of Education:

_____

a) Unable to read and write
b) Can read printed Material (English/Hindi/Vernacular language)
c) Can write-Hard copy
d) Can read and understand SMS
e) Can write sms
f) Other

_____

Religion: Hindu ( ) / Muslim ( ) / Christian ( )/ Buddhist ( )/ Sikh ( )/ Other ( ) _____

Traditional Occupation of the Family:

_____

Marital Status: Married ( ) / Unmarried ( ) / Divorced ( ) / Widow ( )

Total number of household members (including the respondent):

_____

Male: _____ **Female:** _____ **Children**: _____ **Adults above @55 years**_____

Total Number of Earning Members staying in the household :

_____

Occupation of adult household members:

Own Farm labour ( ) / other's farm labour ( ) Non-Farm labour ( )/ Other( )

_____

(Monthly Income or range**) Expenditure on regular things and assets over the last year + savings or debt**

_____

How long has you household been living here?

_____

Type of Housing: Kachcha( ) / Pucca( ) / Semi-Pucca ( )

_____

When was it built?_____

Type of Ownership: Owned/Rented/Other Building/Structure_____

Land Ownership (area): _____

Area of Agricultural Land (If occupation is own farm labour) _____

Crops Grown _____

Average Yield: Kharif Season_____ Rabi Season_____

Number of Rooms in the House: 1 ( ) / 2( ) / 3 ( ) / 4( ) / 5( ) / more ( )

Important items in the house: Lamps / Radio / TV / Cooking Gas / Cooker/ / Livestock (bullock and other animals) / Sewing Machine / Bicycle / Two wheeler bike / Four Wheeler/ Other

_____

Access to banks/Institutional Credit_____

II. Knowledge and perception about flood hazard

1. **Have you ever experienced flooding in your area?** Yes ( )/ No ( )

2. **When was the last time your area was flooded? (Tick only one)**
   a) Never
   b) In the last year
   c) In the last 2-3years
   d) In the last 5 years
   e) Don't know/Can't Recall

3. **If yes, what was the magnitude of the effect in terms of life and assets?**
   a) Very High
   b) High
   c) Low
   d) Very low

4. **Do you believe it is necessary to make preparations for possible future floods?**
   a) Yes
   b) Not sure

c) No
d) If "No", why not? _____

5. **Do you expect flood(s) in coming years?**
   a) Yes
   b) No
   c) Not sure

III. Information related to flood protection and flood warnings.

1. **In case of heavy to very rainfall, do you receive a 'warning' message/ have received before?**
   a) Yes
   b) No
   c) Don't Remember

2. **If yes, from which source? From whom? How frequent?**
   a) Media (TV/radio/Newspaper)
   b) Indigenous Knowledge (informal Warning)
   c) Government Formal Warning (Siren/ police announcements)
   d) Personal Observation (Noticed Unusual changes in wind direction and cloud conditions)
   e) Other
      _____

3. **Do you think your neighbors also receive the warning?**
   a) Yes
   b) No
   c) Not sure

4. **Do you trust the warning received? (Have there been incidence(s) of false warnings? Are you aware of false warning or experienced yourself in the past?)**

   _____

5. **What is your perceived accuracy of the warning?**

   1=100% 2=75% 3=50% 4=25% 5=0

6. **What information do you gather from the source?**

   1=Timing 2=Intensity 3=Duration 4=How to Respond

   _____

7. **How do you perceive the seriousness of the floods upon receipt of the information?**

   1=Not serious 2=Potentially Serious 3=Serious 4=Very Serious

8. **What was the lead time between the receipt of warning and occurrence of the 'event'?**
   a) Less than two hours

b) Two to four hours
c) More than Four Hours
d) Knew a day or two in advance

9. Do you receive any advice for flood response Activity?

a) Yes
b) No

10. Do you think these warning are useful for your household and/or the community?

a) Yes
b) No
c) Don't Know

11. Did you share the information received by you with other members in the community/neighbors?

a) Yes
b) No

12. What actions do you take/have taken in response to the early warning information?

a) Move to safer Locations/Higher Ground
b) Discuss and Validate information from the community
c) Discuss Things within Household
d) Wait for External Assistance
e) Do Nothing
f) Don't Know
g) Moving possessions/livestock, protecting assets
h) Other _____

13. Who decides to take these actions? Is it an individual or group decision i.e. who takes the risk?

_____

14. Please indicate in what situation your household/ individual reacts to the early warning?

a) When someone dies in the community
b) When people observe some damage in property
c) When hazard arrives in the area
d) In case of panic situation only/officials put enforcement
e) When the information is widely spread in community
f) Whenever early warning is heard
g) Other_____

15. Is there any community based organization for flood prevention and mitigation?

a) Yes
b) No
c) Have no idea

ANNEXURE II

Field Visits

Discussion in Ginwala

Camps in Badal

Primary School in Khadri Khadak Maf