Climatic Change (2019) 152:291–305
https://doi.org/10.1007/s10584-018-2292-1

Evaluating climate change adaptation through evacuation decisions: a case study of cyclone management in India

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Received: 25 September 2017 / Accepted: 31 August 2018 /Published online: 28 September 2018

Abstract

Adaptations to extreme climatic events like tropical storms are being built into disaster management by empowering vulnerable communities through activities like disaster awareness, trainings on rescue measures, provisions of better infrastructure, and strengthening of societal institutions under the Disaster Risk Reduction and Disaster Risk Management programs. With increasing threats from climate change, it is essential that the effectiveness of such measures is evaluated and limitations are addressed. The State of Odisha in Eastern India had witnessed nearly 10 years of such capacity building for cyclone management when it was hit by the severe cyclone "Phailin" in 2013. The public response to the evacuation order was overwhelming. In some areas, as many as 95% of the residents evacuated, and they were aware of the precautions to be taken before a storm strikes whereas some other areas showed as low as 33% evacuation and least interest in training and capacity building programs and maintenance of critical infrastructure like cyclone shelters. Analyzing evacuation responses with logistic regression, social economic issues like unemployment, prevalence of theft, and no provision for the evacuation of livestock to safety explained the evacuation failure significantly. In the future, such extreme events are predicted to hit coastal areas with more intensity due to climate change, and this necessitates that governments address such socio-economic problems along with cyclone adaptation programs to make disaster management more effective.

This article is part of a Special Issue on "Adapting to Water Impacts of Climate Change" edited by Debra Javeline, Nives Dolšak, and Aseem Prakash.

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s10584-018-2292-1) contains supplementary material, which is available to authorized users.

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1 Introduction

Climate change has necessitated urgent and effective adaptation to climatic disasters that have become intense and are predicted to become more intense in the future (IPCC 2014). In recent years, there has been an exponential increase in human and material loss from disasters (EMDAT 2015) and such losses are argued to be partly from overwhelming disaster intensity and partly from significant economic development in vulnerable areas (Ikefuji and Horii 2012). Increased evidences of more intense tropical cyclone occurrences and the consequent losses are one such example (IPCC 2014; ESCAP and UNISDR 2012). Adapting to this threat has shifted the priority to reducing people's vulnerability and managing the disasters, rather than responding through relief and rehabilitation. Now, hazard assessment, vulnerability analysis, and enhancement of disaster management capacity of society are the components of disaster management framework (Cardona et al. 2012). Natural disaster management capacity is being enhanced by interventions like prior planning, awareness on disasters, capacity building of grass-root institutions, and inclusive approaches through coordination among all related institutions. The threat from climate change warrants that the effectiveness of this disaster management-based adaptation should be evaluated and loose ends tightened. One area of concern is that such activities are undertaken in a similar fashion across all coastal areas with the assumption that all groups will behave similarly during a disaster, though, this may not always be true (Das 2012). The present study delves into this aspect by examining the evacuation behavior of different coastal communities who had received similar disaster-preparedness trainings and shows the heterogeneity in responses of these groups.

The study is based on the Eastern Indian State of Odisha, a poor and disaster-prone state. The combination of poverty and high-impact disasters has overwhelmed the state in many instances (Das 2016; GoO 1999, 2014; Mohapatra et al. 2012). To enhance storm management capacity and reduce vulnerability in cyclone-prone areas, the state undertook many steps like making people aware of the disasters, making them know the dos and do not's, strengthening village-level institutions to provide immediate help and act as the link between government and community, establishing cyclone shelters and equipping those with modern infrastructure (see Sect. 2.2 for details). However, such activities were and are being undertaken similarly across the 480-km coastline of the state that runs along six districts bordering Bay of Bengal. This study explores the impacts of such interventions implemented prior to the severe storm "Phailin," which damaged four of the six coastal districts of the Odisha State in October 2013. Unfortunately, the study neither has a pre-intervention comparable data nor a control area as all affected districts received similar training and capacity building activities from the government. "Whether similar exposure resulted in similar response to evacuation order" and "which factors impacted evacuation behavior" are the queries being examined in the paper with a post intervention survey data. The paper first reviews people's preparedness efforts, their initial response to government warning and evacuation orders, and then conducts statistical analysis to examine the features affecting the evacuation behavior. Evacuation responses are compared across the coastal districts to capture the effect of socio-political heterogeneity. Districts are administrative boundaries; but, for smooth administration, these boundaries are often determined by people's social and cultural practices. Therefore, districts are taken as different socio-political units, and evacuation behavior is compared across the districts.

2 Material and methods

2.1 Evacuation behavior in developing countries

Evacuation behavior of people in developed countries is well studied and findings have been summarized with meta-analysis. However, such studies in developing countries are rather limited, though there are attempts to study this behavior after the Indian Ocean tsunami and typhoon Haiyan (Imamura 2009; Esteban et al. 2015; Lim et al. 2016). Cyclone evacuation is a social process, and people's decision to evacuate depends on how they perceive the risk from the warning message. The characteristics of the warning message—such as content, source, and frequency—have important implications for disaster evacuation (Drabek 2004). When public authorities issue evacuation orders appropriate for the strength of the threat and disseminate these warning messages effectively across multiple audiences, compliance could reach as high as 90% in high and medium-risk areas (Baker 1991). Public response to risk communication was linked to perceived risk (understanding, belief, and personalization), where perceived risk was defined to be a function of the features of warning information received (specificity, consistency, certainty, accuracy, clarity, channel, frequency, source), and personal characteristics of the warning recipient (demographics, knowledge, experience, resources, social network, cognition) (Drabek 1999; Dash and Gladwin 2007). Other possible determinants were described as presence of children in households, prior training or education for coping with crisis, neighbors evacuating, access to transport, economic condition, female head, etc. Recent studies have re-examined the role of these factors in different theoretical framework and have produced synthesis to help develop better evacuation planning. Lindell and Perry (2012) synthesized evacuation responses from three types of perceptions of people—threat perceptions, protective action perceptions, and stakeholder perceptions using a Protective Action Decision Model framework. Environmental cues, social cues, and socially transmitted warnings help people to perceive the environmental threat, alternative protective actions, and relevant stakeholders. These perceptions, combined with situational facilitators and impediments, provide background for a behavioral response in terms of evacuation. In terms of determinants, the statistical meta-analysis shows official warnings, mobile home residence, having residence in risk area, observations of environmental (storm conditions) and social (other people's behaviour) cues, and expectations of severe personal loss to be the consistent and significant ones and demographic factors like home ownership, education, and previous storm experience as the inconsistent ones affecting household evacuation decisions (Huang et al. 2016).

Studies into the role of gender in evacuation efforts have found that women may be more likely than men to evacuate their homes as hurricanes approach (Whitehead et al. 2001; Bateman and Edward 2002), but recent studies find role of female gender to be indirect or mediated (Huang et al. 2012). On evacuation logistics, it is observed that evacuees take multiple cars, rely on personal experience and traffic conditions to choose their evacuation routes, and most likely choose the homes of friends/relatives as their shelter accommodations rather than public shelter due to accommodation quality (Wu et al. 2012; Wu et al., 2013). Pet ownership has been found as an impediment to evacuation and adoption of Pets Evacuation and Transportation Standards (PETS) Act, 2006 in USA after the experience of Hurricane Katrina provides credence to this aspect (Heath et al. 2001; Edmund and Cutter 2008; Hunt et al. 2012).

In developing countries, socio-economic conditions are different and so can be the determinants of evacuation behavior. One important factor causing low evacuation here is identified to be the failure to perceive the potential risk from warning messages by the general public due

to both lack of awareness and knowledge gap between them and the experts (Imamura 2009; Esteban et al. 2015). Unlike in developed countries, majority of the evacuees here travel on foot during evacuation and determinants of such evacuees are described to be departure timing, destination type, age, gender and educational attainment of the household head, presence of small children, presence of health problem, house ownership, number of years living in the residence, vehicle ownership, source of warning, distance to safety, and cost of evacuation (Lim et al. 2016). In Indian context, social fabric is considered a challenge for elicitation of higher compliance, i.e., whether the evacuation decision is made at the household or at the community level and whether the storm warning is targeted accordingly (Sharma et al. 2009). Factors like education, local knowledge, quality of accommodation at shelters, possibility of theft from one's house, and belief in God that "He saves people during crisis," have been identified to influence evacuation behavior in South Asian countries (Sharma et al. 2013; Haque 1995). During Phailin, the evacuation orders elicited high response implying that the awareness and capacity building efforts most likely had an impact. However, the response was not similar across all the severely affected districts and the underlying factors need to be explored. This can help improve the management of climatic hazards in the future.

2.2 Capacity building in cyclone preparedness in Odisha

The eastern parts of Odisha, especially the north-eastern districts, are highly vulnerable to cyclone and storm surge. Features like proximity to the coast of the Bay of Bengal that is one of the core areas of cyclogenesis, shallow bathymetry, high population density, and the dominance of poverty have been identified as the contributing factors (Das 2012; Sharma and Patwardhan 2008). Odisha experiences the greatest number of cyclones of all the eastern Indian states that border the Bay of Bengal (Das 2011). In October 1999, a category-5 cyclone ravaged 12 of its 30 districts causing nearly 9000 human lives and 500,000 livestock loss. Crops over 1.8 million hectares of land were lost, and the infrastructure loss amounted to US$13.9 billion (GoO 2009). The state took many innovative steps after this cyclone to adapt to such climatic future disasters. It formed specialized disaster management departments like the Orissa[1] State Disaster Management Authority (OSDMA) and the Orissa Disaster Rapid Action Force. The state implemented various disaster management programs and trained volunteers and conducted other capacity-building programs at the grassroots level to help and motivate the coastal population to face such calamities in the future.[2] The state received financial help from the World Bank under the National Cyclone Risk Mitigation Project to construct cyclone shelters. The OSDMA and Red Cross Society (RCS) of India constructed many multipurpose cyclone shelters. Between 2003 and 2009, the Government of India (GOI), the United Nations Development Program (UNDP), and the Odisha government undertook planning, preparedness, and awareness activities through the Disaster Risk Management Project. This program focused on generating awareness and local capacity building, like training village-level volunteers. This was followed by the Disaster Risk Reduction program (2009–2011) which focused on successful preparedness before the strike of a disaster and elicitation of optimal responses during the disasters. Then, the state implemented the GOI-UNDP project on Enhancing Institutional and Community Resilience to Disasters and Climate Change (2013–2017) which aimed at providing technical support to strengthen the capacities

[1] Odisha was formerly known as Orissa.
[2] http://www.osdma.org/menudemo.aspx#, last accessed on 18 March 2018

of government, communities, and institutions to fast-track implementation of the planning frameworks on disaster risk reduction and climate change adaptation.

Such efforts enhanced the cyclone management infrastructure capacity of the state. In 1999, when the above mentioned category-5 cyclone struck, the state had 23 cyclone shelters owned by the RCS of India whereas, now, there are more than 200 shelters (jointly constructed by the RCS and OSDMA), and almost every coastal village has a shelter. There is a Cyclone Shelter Management and Maintenance Committee (CSMMC) in each shelter village to sustainably manage the shelters and to mobilize community members for the annual awareness-generating cyclone drill, help them in preparedness and evacuations after cyclone warning is issued, and manage them in shelters after evacuation. There are other village-level groups, like village task force, village volunteers, and disaster management teams, to help and mobilize villagers and help the CSMMC. These groups have been trained in first aid techniques, safety, and rescue operations. Such activities started in 2003 when the DRM program was implemented and are ongoing in every coastal village. Along with these programs, some of the general community members also receive training for emergencies, and trained members have been equipped with a variety of modern equipments like first aid box, inflatable tower lights, aluminum ladder, power saw, lifebuoy, life jacket, search light, etc. to undertake rescue operations during disasters.[3]

2.2.1 Cyclone Phailin: preparedness, evacuation, and lives saved

After all these activities had been undertaken, Cyclone Phailin made landfall in October, 2013 with winds up to 220 km/h and a maximum storm surge of 2.5 m (IMD 2013). Before the landfall, all cyclone-related institutions were alerted, continuous warnings were issued over various media, and more than 780,000 people were evacuated to safe places (World Bank 2013). This is a tremendous achievement compared to the evacuation of only 44,500 people during the category-5 cyclone of 1999 (RCS 2008) in the state. Phailin made landfall in Ganjam district of the state and caused a minimal death toll of 21 individuals whereas a similar, but low-intensity storm (landfall wind velocity of 180 km/h) that had the same landfall point as Phailin and had battered the same area during 17–18 October 1999, had caused 139 deaths.[4] Again, this is a glaring contrast to the category-5 cyclone that had landfall in Jagatsinghpur district of Odisha and had killed approximately 9000 people. The UNDP (2013) attributed this successful Operation Phailin to the shift in the approach to disaster management in the state.

2.3 Study area and the sample

The entire coastal Odisha has been receiving such disaster management interventions as the entire belt is cyclone-prone, but the evacuation behavior of only four districts, Kendrapada, Jagatsinghpur, Puri, and Ganjam, severely affected by Phailin is studied in this paper (Fig. 1). Whereas Ganjam was the landfall district, Puri was next to Ganjam, and Jagatsinghpur and Kendrapada were next to Puri, with Kendrapada being the farthest from landfall. As all coastal villages had shelter, were receiving similar awareness and cyclone preparedness training, and were evacuated during Plailin, households from two villages of each of these districts are

[3] All details were collected during the many focus group discussions with the CSMMC, and villagers in the study area.

[4] Data collected from Emergency Office, Ganjam district, Odisha

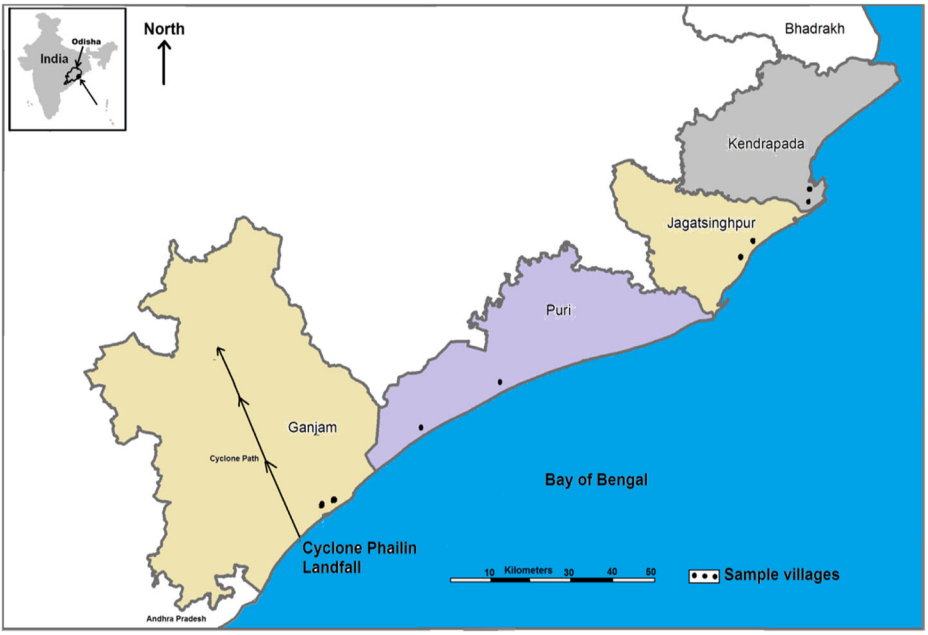

Fig. 1 Study districts (Ganjam, Puri, Jagatsinghpur and Kendrapada) with sample villages and landfall point of cyclone Phailin

selected as sample households to study preparedness and evacuation behavior. A two-stage random sampling procedure is followed to select the households. In stage one, a list of all coastal shelter villages were prepared for each district separately and then two villages were randomly picked up from these lists for each of the four districts. All these villages were located within 1–2 km from the coastline (Fig. 1). The shelters in these villages were similar with respect to structure, facilities, and capacity.[5] All shelters were reported to have 1500 to 2000 people during the storm. It was decided to study 40 households from low socio-economic background in each village so that at least 10% of the evacuees, i.e., 150–200 people, the family size being around 4–5 in coastal Odisha (Census of India 2011), are studied in each village.

The study objective was to analyze the evacuation behavior of people, so the target groups were people who are vulnerable to cyclone and are likely to evacuate. International experience shows households that evacuate to public shelters are usually a small fraction of evacuees, those with lower incomes or are late evacuees (Lindell et al. 2011; Wu et al. 2012, 2013). CSMMC members also reported that the type of households that came to shelters in the study area were mostly the ones having thatched houses, though few having concrete houses with just one or one and half floors in low-lying areas also came. Thus, these areas were purposely oversampled to have a larger proportion of thatched house owners in the sample. Of the 40 households interviewed, 65% or 26 households were thatched house owners (40*0.65 = 26), 25% or 10 households were single-storied concrete house owners, and 10% or 4 households were one and half or two-storied concrete house owners. The concrete houses surveyed were located in comparatively low-lying areas. First, such households were listed in each sample

[5] http://www.osdma.org/multsecretary.aspx?vchglinkid=GL007&vchplinkid=PL040&vchslinkid=SL017, accessed on 18th March 2018

village and were then picked systematically if houses were in rows or were picked randomly from locations if houses were scattered. Thus, the sampling procedure assured that the sample has a diverse set of vulnerability levels and is likely to be representative of coastal population who are likely to evacuate to a public shelter during a storm. The household survey was undertaken in local language through face-to-face interview during April–May 2014, nearly 6 months after the storm. The paper uses descriptive statistics and logistic regression results to test the objectives. All calculations and model estimations are done using statistical STATA software.

2.4 Results

First behavior and responses across districts are compared through tabular representation of summary statistics of the survey data, and then logistic regressions have been estimated to analyze and find out the features that significantly affected the evacuation behavior during Phailin.

2.4.1 Sample features

The sample consisted of 320 households who mostly belonged to either backward castes or Scheduled Castes and Scheduled Tribes. Of these, 204 had evacuated to shelters. Electonic Supplementary Material (ESM) Table S1(ESM 2) shows the district-level socio-economic distribution of the sample households and sheds light on the caste system in India. There were two observations regarding the socio-economic features: (i) the household heads in Jagatsinghpur district were more literate and (ii) those in Ganjam were the richest. Most household heads were educated until 10th standard (primary) and the modal annual income was in between INR50,000 to INR300,000. In all districts, farming, fishing, or wage labor were the dominant primary occupations of the sample household heads. Only Jagatsinghpur and Kendrapada had some unemployed household heads having no primary occupation. With the exception of Ganjam, some household heads in other districts were seen to engage in subsidiary occupation. Asset ownership of people, especially assets like cycle and scooter that make one mobile and assets like radio, TV, and mobile phones that provide information, are important in making disaster management successful. The most commonly owned asset, owned by 60–90% of the sample households in all four districts, was mobile phone, followed by cycle and then TV. In contrast, assets like scooter or radio were found to be quite uncommon among the respondents, radio being the least owned asset. Most households owned more than one asset. Households in all these districts suffered house damage as seen from the last rows of the table which confirm the cyclone impact being severe across the study area. Broadly, the sample households from these four districts seem to have similar features.

2.4.2 Participation in storm preparedness and awareness activities

Next, sample household participation in storm awareness and disaster resilience capacity building activities in villages and their storm preparedness and response to warning and evacuation is compared. Table S2 in ESM 2 shows more than 80% (except Jagatsinghpur district) of sample households to have been aware of storm preparedness activities in their villages, but the positive response rates are much lower to questions like whether you or your family members participated and whether you have learnt something from such activities.

Between 65 and 84% of household heads reported that no other member of their families, especially women, participated in these programs though women have been specifically encouraged by the government to participate. Various reasons were given for the low participation rate of both household head and their family members like "no time," "away from village on that day," "not interested," "no financial incentive by government to participate," "not informed in time," "nobody invited me," "women feel insecure," etc. (Das 2014). Only 20% in Jagatsinghpur and 33% in Ganjam reported to have learnt something, though the response rates were higher (55%) in Kendrapada and Puri districts. Most households responded to have learnt the technique of rescuing people and carrying the elderly, women, and disabled to shelter. Both on awareness and learning, households in Jagatsinghpur district seem to be less enthusiastic towards disaster preparedness as evident from the low response rates compared to the people of other districts.

2.4.3 Cyclone warning and evacuation to shelters

The storm warning was widely broadcasted 1 week before (intensively 2–3 days before) the storm hit and all sample households reported to have received it. Around 88% reported that they fully understood the warning message, and 90% replied that they heard it from television. Television was ranked as the most convincing media, which has some commonality with behavior in developed countries (Lindell et al. 2017). Surprisingly, not a single household replied to have read or believed the warning message that came as mobile SMS, though mobiles were owned by most of the households (Table S1). One may assume that very high mobile ownership will result in making mobile SMS an effective communicating media, but these are seen to be least effective in reaching or convincing people during Phailin (Das 2014). People's evacuation behavior was assessed by asking two questions: (i) whether they thought of evacuating to a shelter after they heard of storm warning and (ii) whether they actually evacuated to shelter or not. The purpose of such assessment was to understand whether coastal households are transforming their thoughts to actions and whether the government had to apply coercion and force to make people evacuate in spite of so much of training and preparedness. Table S3 in ESM 2 shows the type of action people considered taking after they heard the storm warning and evacuation orders and Table S4 in ESM 2 shows the actual evacuation statistics.

Table S3 shows that the percentage of respondents who considered evacuating to the shelter after hearing the Phailin warning was dissimilar across districts. Such households were much higher in Puri (94%) and Ganjam (80%), but lower in Kendrapada (55%) and much lower in Jagatsinghpur (33.8%). Surprisingly, 17.5% from Kendrapada and 35% from Jagatsinghpur replied that they had thought of not evacuating, 10% were undecided, and another 16–17% in these districts thought of waiting and watching others before taking any action. The thought of people in the other two districts was highly in compliance with government advice to shift to shelter. From these responses, it can be concluded that coastal communities do not think similarly, at least residents of the Jagatsinghpur district seem to be much less compliant compared to other adjoining districts, even though the villages studied in this district were devastated during the previous category-5 super cyclone in 1999.

As per Table S4, 95% of the sampled households in Puri and 74% in Ganjam evacuated to shelter, but such households were only 54% in Kendrapada and 33% in Jagatsinghpur resulting in an 64% average evacuation rate. Though both Jagatsinghpur and Kendrapada were far from landfall, Kendrapada was much further compared to Jagatsinghpur and still had a much higher

evacuation rate. The evacuation rates closely match the percentage of households who considered evacuation after hearing the warning. With both Puri and Ganjam being close to landfall, evacuation was high and many people had to take shelter in schools and colleges as storm shelters were full. Thus, average travel distance was high, though distance traveled to reach storm shelter was low. In Jagatsinghpur and Kendrapada, evacuation was low; therefore, everyone could stay inside the village storm shelter and average distance traveled is lowered. Around 50% of evacuees in both Ganjam and Puri reported to have been persuaded and convinced by village task force committees to evacuate to shelters, which shows the active role played by these groups. On the other hand, only 8% in Jagatsinghpur and 21% in Kendrapada reported to have been convinced by village committees, which means either village committees did not play any active role here or households did not pay attention to what village committee volunteers said. Evacuees from all districts reported to have faced problems during their shelter stay, the percentages of complainers being 54 in Ganjam, 59 in Puri, 65 in Jagastsinghpur, and 47 in Kendrapada. There were many common problems, like shortage of space (33), shortage of food (16), water (13), no proper toilet facilities (09), no cooked food (5), electricity problem (3), rain water seeping inside (3),[6] etc. Lastly, when asked whether they would evacuate to shelter if such a storm strikes their area in the future, the response was encouraging. It was higher than the evacuation rate for most districts meaning some people who did not evacuate to shelter or evacuated elsewhere would likely evacuate to shelter in the future along with the ones who did during Phailin. Whereas almost the same number would evacuate to shelter in Puri district (94%) in future, such response was 81.25% in Ganjam and 68.75% in Kendrapada, but only 38.75% in Jagatsinghpur.

Thus, households of Jagatsinghpur district look to be most non-compliant to evacuation orders. Of all the households studied in the four districts, households of Jagatsinghpur were the poorest and most vulnerable being in low-lying areas and had experienced 5–6-m high storm surge during the 1999 super cyclone, which others did not face as reported by households. They experienced more intensive disaster awareness and evacuation training being the landfall district of super cyclone but still seem to be the most non-compliant group. They were more formally educated than others, as is evident from Table S1, and this raises the question whether literate people are non-compliant to evacuation or if there are other reasons than disaster awareness, shelter availability, persuasion by government, storm warning etc. that influence evacuation behavior of people. These questions are examined statistically by estimating a logistic model using the data on household features from the survey.

2.4.4 Logistic results

The logistic model took into account the variables that can possibly affect individual household's behavior towards evacuation order, keeping literature from both developed and developing countries and the study area features in mind. However, only those variables are included in the analysis for which information could be extracted during the questionnaire survey. The correlation matrix of variables is shown Table S5 in ESM 1. With the exception of low- and medium-income variables, other variables have much lower correlation, though significant. The dependant variable Y equals 1 for households who evacuated to public shelters (either storm shelter or school college buildings), so the estimated coefficients show the

[6] The numbers in parenthesis are percentage of households who replied to have faced these problems.

variable's effect on probability of evacuation. Table 1 reports the marginal effects of variables, i.e., change in predicted probability due to unit change in the explanatory variables when other variables are held constant. These are measured with STATA software and are calculated at mean values of other variables.

The number of significant predictors is much less compared to the number of variables having significant correlation with the dependant variable as per the correlation matrix (Table S5). The results on districts confirm that compared to Ganjam, there was no significant difference in evacuation from Puri, but the evacuation was significantly less in Kendrapada and much less in Jagatsinghpur. The other significant findings are compared to educated people, illiterate people evacuated more and so did cycle owners, households having low or medium income, having experience of the previous storm, the October 1999 super cyclone. On

Table 1 Factors affecting evacuation to public shelter during cyclone Phailin in Odisha

Dependent variable = whether evacuated to a shelter (yes = 1, no = 0)	
Name of the independent variable	Marginal effect after logit (Standard error in parenthesis)
Puri district dummy	0.148 (0.147)
Jagatsinghpur district dummy	− 0.805*** (0.074)
Kendrapada district dummy	− 0.663*** (0.119)
Female headed households	0.218 (0.152)
Age of the household head	0.002 (0.005)
HH_head_Illiterate	0.231** (0.105)
HH-head_Primary educated	− 0.009 (0.115)
HH_head_Unemployed	− 0.494*** (0.156)
HH_head_Wage laborers	− 0.054 (0.121)
HH_head_Farmers	− 0.006 (0.127)
HH_head_Fishermen	0.076 (0.139)
Cycle owners	0.255** (0.110)
Scooter owners	− 0.042 (0.121)
Number of cyclone awareness programs attended	0.005 (0.005)
Other backward castes	− 0.273** (0.110)
Scheduled castes and scheduled tribes	0.035 (0.146)
House type—RCC (cemented floor with concrete walls and concrete roof)	− 0.354*** (0.123)
House type—Asbestos (cemented brick walls and floor with asbestos sheet covered roof)	0.051 (0.136)
Age of house	− 0.001 (0.002)
Low income (annual income less than INR50000 (US$830[a])	0.491*** (0.143)
Medium income (annual income in between INR50000 and INR100000	0.532*** (0.177)
Previous storm experience	0.511*** (0.085)
Fear of theft in absence	− 0.419*** (0.145)
Have dependants at home	0.021 (0.159)
Scared to leave livestock behind	− 0.493*** (0.170)
God will save me even if I do not evacuate	− 0.199 (0.229)
Number of Observations = 320	
Wald Chi2 (26) = 134.28, Prob > Chi^2 = 0.00	
Log pseudo likelihood = − 81.7038, McFadden's pseudo R^2 = 0.61	

***indicate levels of significance to be 1%; **indicate levels of significance to be 5%

[a] The exchange rate used is US$1 = INR61 as prevalent in year 2013

the other hand, features that reduced evacuation include unemployment, having concrete houses (RCC houses), fear of theft, and fear of leaving livestock behind. Compared to general caste people, other backward castes evacuated less.

The Logistic model was re-estimated after interacting all the significant variables with the district dummies to see if the responses varied across the districts and results are in Table S6 in ESM 2. Many of the interaction terms either dropped (predicted failure or success completely) or were omitted due to collinearity. Problem of theft as a reason of non-evacuation was reported mostly from Jagatsinghpur and Kendrapada, but it predicted failure (non-evacuation) completely in case of Jagatsinghpur (Table S6) and was insignificant for Kendrapada. Similar results were found for livestock holding. There were unemployed household heads in Jagatsinghpur and Kendrapada, but the interaction was significant only for Jagatsinghpur.

3 Discussions

Previous studies on evacuation show features like vehicle ownership, low income, and bad house (mobile homes) as some of the globally recognized factors that increase evacuation to shelters (Huang et al. 2016; Wu et al. 2013) and the present analysis confirms some of these findings, though, the context is very different. Among the sample households, vehicle ownership is mainly bicycle ownership whereas it is automobile ownership in case of developed countries. In study area, only 2% of evacuees went to storm shelters using government vehicles and the rest went on foot as shelters are located close to their villages; the average shelter distance being around 400 m (Table S4). Population density in coastal Odisha varies between 500 to700 people per sq. km and thus, almost every village has a cyclone shelter. People walked to these shelters with their movable assets on bicycles, as most of them were poor with little to carry. In developed countries evacuation distances are longer and automobiles are needed for transportation. On house quality and evacuation, people owning thatched or low-quality non-concrete houses evacuated whereas RCC (reinforced concrete construction) house owners did not. RCC houses have concrete walls, floors, and roofs and thus, safe during a cyclone if located at an elevated area and have strong foundation to resist scour, and people having such houses seemed to have remained safe inside as no mortality was reported from sample villages. Literature cites people with mobile homes to evacuate more in developed countries (Huang et al. 2016) fearing personal loss due to weak structure of these houses. Thatched house and asbestos house owners in Odisha could be having similar perceived threats or expected personal loss (Lindell and Perry 2012) due to very weak structure of such houses. Informal education like traditional indigenous knowledge have been argued to increase compliance to government order to evacuate (Sharma et al. 2013), and this was most likely the reason for high evacuation of formally illiterate people. The other reason could be that such people are poor and have their peer network in the neighborhood and all evacuated to government shelters together. The other noticeable feature increasing evacuation significantly is "previous storm experience," though meta analysis has shown it to have a consistently insignificant effect (Huang et al. 2016). The present result may be due to the fact that the previous storm was an unusually high-impact super cyclone and had caused colossal loss of lives and properties, especially in Jagatsinghpur and Kendrapada districts. Features like "faith in God" seemed to have played an insignificant role in evacuation decisions during Plailin, even though the coefficient bears a negative sign.

Coming to features that promoted non-evacuation, being unemployed comes out as a surprising factor. People who were primarily unemployed would be poor and non-evacuation could be a risky decision. People having irregular jobs take risks like guarding other's properties during disasters with the hope of earning some extra money and such people have been found to have died more during the previous super cyclone in 1999 (Das 2012). Probably, unemployed people did something similar during Phailin and did not evacuate to shelters. As per Table S6, this was the case only in Jagatsinghpur district.

Families having livestock did not evacuate as there were no facilities for livestock at the shelters. The reason could be fear of livestock death or chances of being stolen if left behind. Pet ownership has been identified as one of the risk factors for evacuation failure (Hunt et al. 2012; Edmonds and Cutter 2008; Heath et al. 2001). Though livestock are not pets, emotional bonding with livestock in developing countries can be similar to bonding with pets in developed countries. Fear of theft of household assets also came out as a significant variable limiting evacuation, though international experience on effects of expected looting is mixed (Huang et al. 2016). In 1999, there were many newspaper reports of looting during the category-5 cyclone in Odisha (Das 2011) which support such fears, whereas fears of looting had been largely exaggerated during Hurricane Ike in Texas, USA (Siebeneck et al. 2013). Both fear of theft and livestock holding explained non-evacuation completely in Jagatsinghpur (Table S6).

Social factors work as modifiers of evacuation behavior (RicchettiMasterson and Horney 2013) and lack of trust and faith in one's community is found to be a strong deterrent of evacuation in the present case, especially in Jagatsinghpur district. Only in this district, fear of theft and having livestock predicted non-evacuation completely and being unemployed explained it significantly (Table S6). These indicate social stress with lack of trust, social bonding, and social cohesion and even trading of life for some monetary gain. Such social fabric could have been the reason for differential responses to evacuation order during Phailin. There are evidences of different emotional reactions and risk perceptions from people having similar socio-economic background and similar exposure to hazards (Lindell et al. 2015) and the differences in evacuation response from Jagatsinghpur and other districts, especially Kendrapada are such examples. As the survey was conducted just after 6 months of the disaster, it is expected that replies regarding preparedness, help received, evacuation, and shelter experiences are accurate because of near past experiences. Thus, beyond raising awareness and strengthening local institutions, behavioral and social factors need to be taken into account to extract optimal evacuation compliance from people.

4 Conclusion and policy implications

Based on evidence from cyclone Phailin, the disaster management approaches and policies adopted by the Government of Odisha, with help from the Government of India, World Bank, and the UNDP, seem to have been successful in reducing the region's vulnerability to tropical storms. The state conducted many institutional capacity-building programs because of which compliance with evacuation orders was high. However, compliance varied across coastal districts, although the capacity building programs were the same across all districts. Cooperation was the highest in Puri, followed by Ganjam, less in Kendrapada, but quite poor in Jagatsinghpur. Kendrapada is similar to Jagatsinghpur socio-economically and also have similar hazards history but showed a much higher rate of evacuation. This is in spite of the fact that Kendrapada was less affected than Jagatsinghpur during Phailin as it was further away

from the cyclone landfall. Unemployment, feat of theft, and having livestock explained low evacuation in Jagatsinghpur. These findings on social behaviors and responses call for a differential disaster management strategy taking behavioral and social traits of the area into account, rather than a generic one, to mobilize civil society in different areas.

In some districts, evacuation was very high and one of the reasons could be the repeated training and mock evacuation drills being carried out in those areas. Though, such trainings and drills seemed to be effective in sensitizing some people and making them realize the threat to their lives, there are others who are yet to realize it. Probably, they require a differential training inclusive of behavioral and social traits to be sensitized. Simultaneously, other social issues like theft, employment options, and arrangements for evacuation of livestock also need to be addressed to manage storms better.

Acknowledgments This study was undertaken under the Government Of India-United Nations Development Programme project "Enhancing Institutional and Community Resilience to Disaster and Climate Change" and financial help from the Government of Odisha is sincerely acknowledged. Sincere thanks go to all three anonymous reviewers for their excellent suggestions and to Tejal Johri for efficient research assistance.

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