Role of coastal ecosystems in enabling resilience of coastal communities post a natural disaster

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Introduction

Building resilience to climate extremes and disasters is a necessary requirement to ensure the success of global efforts to eliminate extreme poverty, the first of the Sustainable Development Goals (SDGs). The east coast of India witnesses frequent cyclonic disturbances, severe fresh water flooding and has some of the most densely populated areas in the country, particularly, in the deltaic plains of the Mahanadi, the Godavari, the Krishna and the Cauvery rivers where more than 400 people live per sq km area. This combination of frequent disasters and high population requires that 'resilience building to disasters' is taken up as an urgent necessity for attaining primary SDGs. Coastal ecosystems (like mangroves and sand dunes) provide various ecosystem services that include protection from storms, as well as livelihood support to coastal communities.

In October 2013, cyclone Phailin, categorized as 5 on the Saffir-Simpson scale, and Extremely Severe on the Indian Meteorological Department scale, made landfall in Golaphur town, on the Odisha coast. It prompted India's largest scale evacuation, and more than 12 million people were affected. In October 2014, another tropical cyclone, Hudhud, classified as Category 4, and Extremely Severe, made landfall near the coastal city of Visakhapatnam, in Andhra Pradesh. The Andhra Pradesh Government estimated damage to be within the vicinity of USD 3.4 billion.

The areas impacted by cyclones Phailin and Hudhud are endowed with natural ecosystems like Casuarina plantations, Palmyra palms, sand dunes, and other green plantation belts including cashew plantations, mixed forests, and coconut grooves. There is limited information on the role that these ecosystems have played in influencing or mitigating the impacts of the cyclones on human habitations, and the role they are now playing in supporting local communities' livelihoods. Some ecosystems may provide better protection from storms and may provide little livelihood support and the reverse may be true for other vegetation types. Casuarina trees have been the prime candidate for shelterbelt plantations along Indian coast and there are concerns that the promotion of such bioshields, which are mostly exotics, as coastal buffers may lead to inappropriate coastal development in some places (Feagin et al. 2010a, 2010b). Recent studies also shown that Casuarina either aggravates damage occurrences or provides little to no protection from disasters, as compared with native vegetation species at different places during the super cyclone of October 1999 in Odisha, India (Das and Sindhu, 2014). Other than mangroves and Casuarina, there is little study on the types of vegetation, especially cashew and palmyra palms which are the dominant species in some of the coastal areas, with regard to the ecosystem services like coastal protection, livelihood support, etc they provide and how they compare with the Casuarina trees. Areas impacted by cyclones Hudhud and Phailin provided a good opportunity to study such services of different types of vegetation and provide recommendations regarding the best coastal buffers to policy and decision makers addressing coastal management.

Importance of coastal buffers

The escalation in the number of natural calamities affecting coastal areas has given rise to numerous discussions on coastal bioshields in recent years (Danielsen et al. 2005; FAO 2007). Several studies have examined the role of coastal vegetation during natural disasters (Iverson and Prasad 2007; Kerr and Baird 2007; Cochard et al. 2008; Feagin 2008; Das and Vincent 2009; Feagin et al. 2009; Choudhart et al., 2009; Koch et al. 2009, Das and Crepin, 2013), but this has been mostly limited to mangroves. Large coastal plantation schemes have been implemented by international organisations such as the Food and Agriculture Organisation (FAO), and the United Nations Development Program (UNDP), particularly on the east coast of India following the 2004 Indian Ocean tsunami (FAO 2007; Mukherjee et al.

2009). Whereas such schemes mostly involve the plantation of Casuarina in non-mangrove habitat coastlines, there is limited research to support Casuarina as the best suitable option for developing coastal shelterbelts, as opposed to native vegetations types.

This study examines the coastal vegetation and other features that helped local coastal communities to better cope with the impacts of cyclones Phailin and Hudhud and thus, contributed to increased community resilience. This project also examined the expectations of local communities in terms of the benefits derived from local vegetation. Such studies are important for policy. With climate change induced disasters and impacts projected to accelerate (IPCC, 2012), the findings from this study can help advice and formulate resilience-building policies for vulnerable coastal regions.

The project addressed the following objectives.

1. To assess the impacts of *Hudhud* on coastal ecosystems and local livelihood in selected coastal villages in Andhra Pradesh
2. To examine the differential impacts of cyclones on vulnerable groups including women, children, and the elderly
3. To develop cyclone impact models to measure the potential impacts of cyclones on selected villages
4. To examine coastal protection services of coastal vegetation in areas affected by cyclones Phailin and Hudhud.
5. To recommend resilience building measures

Implementation of Activities/Methodologies

The study uses a combination of different methods like questionnaire survey, interpretation of GIS and satellite data, simple tabular analysis, econometric models and cyclone impact models to derive the results. Data from both questionnaire survey and secondary sources have been used in the analysis. In Odisha, village level data on house damage due to Phailin was collected from emergency department of Ganjam district and in Andhra Pradesh data was collected through household questionnaire survey. To select the sample villages for questionnaire survey, cyclone affected villages were stratified on the basis dominant occupation of people and then 15 villages were selected randomly. Next 900 households were selected randomly from these villages and surveyed to gather information on cyclone damage and impact on livelihood. Along with secondary data on storm damage, population related village level census data from primary census abstracts, GIS data on village location, coastline, land use and satellite data on forest cover was either collected or purchased for Phailin affected areas of Odisha. After ground truthing, forest cover map was prepared. Information on storms, like landfall point, landfall wind velocity, track of the storm, etc was collected from meteorology department of Government of India. Using GIS and meteorology data, storm impact in terms of potential wind velocity on villages was measured using the tangential wind model (Roy Abraham et al., 1995). Finally all numerical data were used in econometric models like logistic regression, multiple regressions to derive the results on effectiveness of coastal bio-shields to provide coastal protection. Arc View Arc GIS software 9.0 and statistical software STATA were used to generate variables and results.

Hudhud affected areas had sparse vegetation and wherever it existed, it was mixed vegetation type whereas areas affected by Phailin was endowed with different patches of thick vegetation like casuarina, cashew, mixed indigenous forests etc. Thus, primary household survey data from Andhra Pradesh was used to test cyclone impact on livelihood (the first two objectives) and secondary data on house damage from Odisha was used to test coastal protection services of coastal bio-shields (the last two objectives).A summary of activities, as per the project log frame, is provided in Annex 1.

Study Area

The study area consisted of 15 villages from Vishakhpatnam district of Andhra Pradesh and all villages of four coastal blocks, Rangeilunda, Chhatrapur, Ganjam and Khallikot, of Ganjam district in Odisha. This area witnessed the very severe cyclonic storm 'Phailin' in October 2013 and very severe storm 'Hudhud' in October 2014, exactly after one year. Phailin made landfall at a point (19.2N lat and 84.9E long) near Gopalpur town (Rangeilunda block) of Ganjam district in Odisha state and Hudhud made landfall at a point (17.7N lat and 83.3E long) near Vishakhapatnam city of Vishakhapatnam district of Andhra Pradesh state which lies to the south of Odisha. Figure 1 (Annex 3) shows the track of these two cyclones over Bay of Bengal and mainland India as depicted by Indian Meteorological Department and Figure 2 (Annex 3), the approximate proximity of the tracks of these two cyclones. Both were very severe cyclonic storms with landfall wind velocities of 230km/h and 200km/h respectively and both devastated parts of the states of Odisha and Andhra Pradesh and heavily damaged the agricultural kharif crops, October being the harvest period of Karif crops in these states. Figure2 (Annex 3) shows how closely the tracks of these cyclones were located.

Table 1 (Annex 2) shows the details of the villages studied in Andhra Pradesh. All these villages were severely affected by cyclone Hudhud. The result section describes the extent of damage suffered.

Table 2 (Annex 2) and Figure 3 (Annex 3) describe the study area in Odisha. House damage of 288 villages from four coastal blocks of Ganjam district was analysed. All these villages were severely affected during cyclone Phailin and houses were damaged completely or partially depending on the storm impact, the house quality and the type of wind barriers present on the storm path. Secondary data on type of house damage due to Phailin from study area villages of Odisha are used to test the storm protection services of coastal vegetation.

Results

Villages studied in Andhra Pradesh were largely inhabited by impoverished fishermen, fish vendors, salt producers, farmers, and manual labourers. The sample consisted of predominantly illiterate people; Figure 4 (Annex 3) provides an indication of the educational background of the sample. 76 percent were illiterate, only 9 percent had primary or below education and 13 percent attended classes between 6th and 10th standard. All households were of Hindu religion, two percent belonging to general caste, 90 percent backward caste and 8 percent scheduled caste.

Table 3 (Annex 2) shows the socio-economic distribution of sample households. More than 50 percent of these households practiced either fishing or fish vending, 26 percent were manual laborers and 11 percent were engaged in salt production. There were very few farmers in the sample as farming was practiced by few people, may be, due to less availability of land for farming or fishing being an easy occupation due to proximity to coast. Most of these households were very poor. As shown in Figure 5 (Annex3), median annual income of the sample was between INR 50,000 and INR 150,000. More than 66 percent of the households earned this much income in a year, but taken as occupational group, all groups' average annual income was less than INR 100,000 as shown in the 3rd column of Table 3 (Annex 2). Fishermen earned the highest income followed by cultivators, then drivers, and salt producers.

1. Losses suffered due to Hudhud

All groups suffered loss during Hudhud, however both farmers and fishermen suffered the highest, the loss being larger than their average annual income (refer to column 4 and 5 in Table 3 (Annex 2)). Salt producers and manual labourers suffered minimum loss indicating that assets based occupations caused more loss and damage (Figure 6, Annex 3). Figure 6

(Annex3) shows the relative loss of occupational groups and clearly farmers and fishermen suffered the highest.

Nearly 37 percent of the households practiced subsidiary occupations, casual labour being the most commonly practiced amongst the sample households. Around 64 percent of households were headed by males and 36 percent headed by females. Comparing the income and loss figures of these households, one finds women headed households to be earning less and to have also suffered less in monetary terms as well (Figure 7, Annex 3). This may indicate women headed households, though comparatively more poor, to be more resilient by not investing in risky assets.

All farmers included in the sample, except two, suffered agricultural loss. This included loss of main crops like rice, vegetables like brinjal, papaya, chillies, onion, drumsticks, and other horticulture crops like coconut, banana, and ground nuts. The main cause was strong wind that either broke or up-rooted the trees and saline inundation. Multiple crop loss and land quality loss due to saline inundation are the reasons for the farming community suffering the maximum during Hudhud.

Nearly 38 percent of households had kuchha or mud structured houses, 33.5 percent pucca or concrete houses and 28.5 percent has semi-pucca houses. 71 percent of the sample households suffered house damage meaning even some concrete house owners had suffered some damage to their houses. Of these 71 percent, house of 48 percent were fully damaged, another 48percent were partially damaged and 4 percent were washed away.

Fishermen suffered both direct and indirect losses. Direct losses included boats, nets, engines and other fishing materials, and loss of fishing days. The indirect losses were the lower catch rates after the cyclone, i.e. drastically reduced sizes and quantities of catch. Table 4 (Annex 2) and Figure 8 (Annex 3) shows the pre and post Hudhud catch per trip of sampled fishermen.

Prior to Hudhud only 13 fishermen used to get 10kg or less of fish per trip whereas following the storm, 141 fishermen reported to have been getting this amount per trip. Fishermen reporting 11 to 15 kg per trip also increased after Hudhud and for higher catch sizes, number of fishermen getting such catch decreased after Hudhud. However, these data and figures related to only inshore fishery, not off shore fishery.

Other than agricultural, house and fishery loss, some 82percent of the households reported to have lost work days because of the cyclone. Work days lost varied from less than 10 days to more than two months. Figure 9 (Annex 3) shows how many people lost how many days of work. Maximum seemed to have lost 21 to 30 days of work in the period immediately after Hudhud. Thus, reported in Table 3 (Annex 2) for different occupation groups include these multiple damage suffered by them.

2. Storm warning and evacuation

Before Hudhud, the Government of Andhra Pradesh issued cyclone warnings and people were advised to shift to cyclone shelters or to other safer places. 68percent of the sampled households evacuated to different places like government storm shelters, schools, neighbours' houses, relatives' houses, temples, *kalyan mandaps* and so on. 32 percent did not evacuate anywhere even though their houses were close to the coast. However, they remained safe as no casualty was reported from these households. Reasons for non-evacuation was reported mostly as owning a pucca/concrete house, though few also mentioned emotional attachment to house, not wanting to leave belongings/assets behind, no place in shelter, not expecting damage as house is far from the shoreline, water surrounded and could not leave house etc. as some of the reasons for not evacuating to anywhere else. Shelter facilities were provided by government both in storm shelters and in schools. Two types of information were collected from people who evacuated to these places in the survey. The first was which media channels they found most useful and convincing and the second, what types of problems they encountered while in shelters. Table 5 (Annex 2) shows media effectiveness. Television and public announcement came out as the most effective media in reaching people and convincing them to evacuate to shelters. Radio and mobile SMS seem to be the least effective ones in convincing people. Similar observation was also found from people who evacuated to shelters during cyclone Phailin in Odisha (Das, 2014).

People faced different types of problems whilst in shelter, like lack of food, sleeping place, toilet facility etc. Table 6 (Annex 3) shows the percentage of evacuees who complained about these problems and the group they belong to. Maximum complains came from elderly, women, children and then girls. Elderly people complained maximum for not getting any place to sleep, while maximum women and girls complained about the lack of proper toilet facilities, and children complained about inadequate food. Minimum number of young boys made any complaints. Whereas 76.4 percent young boys mentioned not facing any problems in the shelter, such percentage was nearly 56 for girls, 50 for children, 27 for elderly people and 24 for women. However, in spite of facing such problems 90.3 percent of the sample, compared to 68 percent who had evacuated during Hudhud, responded that they will evacuate in future if a Hudhud type situation arrives again.

3. Factors affecting resilience to cyclones

Resilience is defined as the ability of an economy or human ecological system to recover from the effects of exogenous shocks such as natural hazards, like floods and cyclones (Briguglio et al, 2008) or more comprehensively as “the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events” (NRC 2012, 1). After a disaster, relief and compensation plays important role in helping people to recover fast. Similarly, many physical features of the area like coastal vegetation, sand dunes etc. also help in building resilience as they absorb some amount of disaster impact that help reduce damage occurrences and thus, contribute in resilience building.

Following Hudhud different types of compensation were provided to people, but not everybody received it. Figure 10 (Annex3) shows the percentage of households receiving those compensations; 7 percent received clothes, 44 percent medicines, and 58 percent utensils. Most of these aids were to provide immediate relief, not for long term help. Though 71 percent of the sampled individuals’ houses were damaged during Hudhud, only 0.6 percent reported to have received house damage assistance when the survey was done, 10 months after the storm hit.

When asked about their expectation from government, maximum wanted government to compensate them monetarily (28 percent) or help rebuilt their houses (36 percent) (Figure 11, Annex 3). Nearly 24percent wanted food support either in terms of food (10percent) or dry ration (14percent). Less than 1 percent wanted shelterbelt plantation.

Figure 12 (Annex 3) shows the recovery period of the respondents. Nearly 86 percent expect to recover within two years but some 5 percent of the households will take 3 to 6 years to recover fully. When coping period was regressed on household characteristics to find out which type of household will recover quickly back to pre-Hudhud situation, except education, no other factor was found to contribute towards resilience building, i.e. helping the households to cope quicker following disasters. High income households were found to take more time to recover which means, education is more important than wealth in making people resilient. Educated people invest their money rationally and suffer less during disaster. Female headed households are found to have quicker coping periods (Figure 13, Annex 3) meaning that they are also more resilient than male headed households. Households were asked to specify, as per their expectation, the best way to manage a cyclone disaster and were given five options to choose from. Figure 14 (Annex 3) shows the percentage of households giving either 1st or 2nd rank to these options. The opinion comes overwhelmingly in favour of Pucca or concrete house followed by constructing cyclone shelter, then early warning, etc.

Raising a mangrove belt was supported by 7percent of respondents as one of the best way to manage storms. Surprisingly, only one household gave opinion in favour of crop insurance cover which shows insurance is not an appealing method to coastal inhabitants, not even to farmers. This finding is important in context of recent announcement by Government of India to provide insurance cover to crop loss due to cyclone under Pradhan Mantri Fasal Bima Jojana.

Next role of vegetation in reducing house damage and providing resilience was accessed with help of Logistic regression. It was accessed at two levels, at level of households taking tree cover surrounding their houses and at level of villages taking patches of coastal vegetation along the coast line.

4. Vegetation in Resilience building to cyclones

Vegetation like mangroves provide buffering services from cyclones, however the role of other vegetation like casuarinas, cashew trees, mixed coastal vegetation etc. is less researched. The role of mixed vegetation is assessed using the household survey data from Andhra Pradesh and Casuarina vs. cashew is tested using house damage data from Odisha

Table 7 (Annex 2) shows the logistic results from household survey data analysis and it proves that the presence of mixed vegetation along coasts, and dense tree cover around the houses reduced the chances of houses being damaged during Hudhud. Here mixed vegetation was compared against open coast and having some vegetation comes out as a resilience building feature. Table 8 (Annex2) shows results of village level house damage data analysis that correspond to cyclone Phailin. It also proves that the vegetation reduced severely and completely damaged houses during Phailin, but this service was provided only by cashew plantation, not casuarina plantation. Thus mixed vegetation and cashew trees are providing protection to houses during storms and helping in resilience of coastal residents.

Recommendations

Based on the above analysis, the following recommendations are made.

- Rich or people with more assets have suffered more during Hudhud which means coastal people should be advised to invest in movable assets like livestock that can be shifted to safer places.
- Provision should be made for keeping fishing boats safe or insurance cover for fishing boats should be thought about. Boat damage seems to be the main reason for fishermen indebtedness after disaster.
- Rather than sending mobile SMS, cyclone warning should be disseminated through TV and public announcement.
- Shelter facilities should be improvised, especially toilet facilities.
- Coastal community is more keen to have safe house, so scope of providing housing insurance with house building assistance should be considered.
- Education and awareness provision should be intensified for coastal people like livelihood opportunities. Earning money is important and keeping it safe is equally important. Education will ensure this.
- Women headed households were found more resilient, so women should be given more active role in village management.

- Coastal vegetation like mixed forest and cashew plantations are found as important resilience building features in both Phailin and Hudhud affected areas. Unfortunately casuarinas monocultures did not show this service. So casuarinas should be mixed with other native, local vegetation in coastal shelterbelt. Cashew plantation should be encouraged.

Challenges faced and lessons learned

The study faced the only challenge in conducting the household survey, especially in eliciting appropriate response from households. Engagement of more experienced and social science based surveyors should be engaged in future.

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Annex 1. Activity progress as per project log frame

Key Activities per Results	**Achievements and Impacts**
Objective 1. Economic impacts of Cyclone Hudhud on coastal ecosystems and communities assessed	
Activity 1.1. Preparation of questionnaire for assessing the impact of Hudhud in the affected areas	When the project was first conceptualised it was considered that the focus could be maintained on the role of coastal vegetation in protection during a cyclone. However, following the first site visit it was realized that this would not be possible as several of the villages have no vegetation around them. The survey was modified following site visits and discussions, in consultation with SGO, NCB Member MSSRF, and the field partner District Fishermens Youth Welfare Association. In addition to studying the impact of the cyclone on communities and ecosystems, the project will look at implemented and potential adaptation strategies. Most of the vegetation (i.e. palmera, casurina, and coconut trees) along the coastline is planted in areas where there is no inhabitation, on land belonging to the Navy/port authorities and Forest Dep.
Activity 1.2. Field testing and finalising the questionnaire	A pilot survey was conducted in May 2015. Capacity building of the survey team was conducted by NCB partner MSSRF in the second week of June in Visakhapatnam.
Activity 1.3. Field survey for assessing the impact of Hudhud on the coastal community, ecosystem and its services	The surveys began in June, and were completed by September. IEG signed a contract with District Fishermens Youth Welfare Association (approx. INR 3.5 lakhs) to complete the same.
Activity 1.4. Compilation of data and analysis	The compilation and analyses of the data was done by IEG.
Objective 2. Cyclone impact model developed for measuring the potential impact on study villages	
Activity 2.1. Collection of Secondary data on storm damage, meteorological data and GIS data	These data were collected only for Phailin affected areas in Odisha. Data on storm damage: Secondary Data on house damage was available with the State Disaster Management Cell, Ganjam district (not in public domain) and one field assistant was appointed (@Rs2000 per day for 10 days) there to collect this data from primary files for 262 villages of four blocks of Ganjam district. This data is used to test the wind protection services of casuarinas, cashew and mixed vegetation during Phailin. Meteorological Data: Data on both Phailin and Hudhud are available with Meteorological Dep. and was freely accessed from Bhubaneswar Meteorology Office. GIS data: This data was needed for Odisha region to develop the cyclone impact model and to test role of coastal buffers. It was purchased from a private GIS firm in Bhubaneswar, Digital Categraphy and Services (DCS) Limited with Rs.20000/
Activity 2.2. Procuring remote sensing data of the affected area	Remote Sensing data was needed for Phailin affected areas. This data was also provided by Digital Categraphy and Services (DCS) Limited, Bhubaneswar. The firm charged Rs.25000/ to process the remote sensing data, georeference and prepare forest cover and land use map of the area.
Activity 2.3. Generating the variables and developing Hudhud cyclone model	This work is completed by IEG.
Activity 2.4. Validating the	This task is completed by IEG

data and assessing the impact	
Objective 3. Assess the impacts of varying cyclone intensities on coastal livelihoods and communities	
Activity 3.1. Collection of secondary data on Cyclone Phailin	This data was collected freely from Bhubaneswar Meteorology Department
Activity 3.2. Comparative assessment of the impacts of cyclones Hudhud and Phailin	The methodology utilised in this study is similar to that which was implemented by IEG in the study of the impacts of cyclone Phailin in Odisha. To this end, both study results are comparable.
Activity 3.3. Dissemination of the findings through workshops, report, and publications	Yet to be undertaken.

Annex 2: Tables

Table 1: Details of Study area in Andhra Pradesh

Name of the Sample villages	Name of the Gram Panchayats	Name of the block/mandal	Number of Households studied
China mangamaripeta	K. nagarapalem	Bheemunipatnam	61
Chinthapalli	Chinthapalli	Pusapatirega	50
Chokkavanipalem	Chepala uppada	Bheemunipatnam	43
Gollalapalem	Kapuluppada	Bheemunipatnam	90
Jalaripalem	Pudimadaka	Atchuthapuram	44
Konada	Konada	Pusapatirega	46
Kondapalem	Pudimadaka	Pusapatirega	114
Kotturu	Chepalauppada	Bheemunipatnam	53
Moolapalem	Gvmc	Urban	55
Peda mangamaripeta	K. nagarapalem	Bheemunipatnam	54
Pudimadaka	Pudimadaka	Atchuthapuram	142
Pukkallapalem	Chepala uppada	Bheemunipatnam	34
Sivaganesh nagar	Gvmc	Urban 7thward	42
Timmapuram	K. nagarapalem	Bheemunipatnam	36
Uppada	Chepala uppada	Bheemunipatnam	37

Table 2: Details of study area in Odisha

Name of the blocks	Number of villages studied	Number of households present	Total number of households suffering house damage (either full or partial damage)
Chhatrapur	67	25195	15906
Ganjam	76	17419	19908
Khallikote	73	16952	13183
Rangeilunda	72	28559	16611

Table 3: Distribution of households on basis of main occupation

Occupation categories	Percentage of households engaged	Average annual income (Rs.)	Total self reported loss due to Hudhud (Rs.)	Loss as percentage of annual income
Fish vending	12.12	58144	44935	0.77
Fishing	40.38	82155	105136	1.28

Salt	11.12	68450	26697	0.39
Cultivation	3.23	76931	117069	1.52
Driver	1.56	68714	61083	0.89
Labour _manual	26.36	57080	36319	0.64
Labour _mechanical	1.22	47400	26500	0.56
Unemployed (household heads were either house wives or unemployed people)	1.33	59667	57917	0.97
Others	2.67	49783	27045	0.54

Table 4: Pre and post Hudhud inshore fish catch per trip

Catch per Trip (in kg)	Fishermen reporting such catch (total fishermen = 377)	
	After Hudhud	Before Hudhud
<=10 KG	141	13
11KG-15KG	152	130
16KG-20KG	71	112
21KG-25KG	10	81
26KG-30KG	3	21
Above 30 kg	0	20

Table 5: Storm warning and media penetration

Media sources in storm warning dissemination	Percentage who first heard from these source	Percentage who found these sources most convincing
Radio	0.45	0.89
TV	37.83	58.37
Announcement	44.98	37.17
Mobile SMS	3.79	0.11
Neighbors	12.95	3.46

Table 6: Problems faced by different groups of evacuees

Type of difficulty encountered in cyclone shelter	Elderly Percent	Young boys	Women	Girls	Children
Toilet	10.54	9.75	69.94	22.13	9.25
Food/water	22.31	9.98	2.04	1.52	32.69

No place/sleeping problem	35.33	3.85	1.43	1.74	2.15
Medicine	4.96	0	2.54	15.84	0.22
No problem	26.86	76.42	24.04	55.75	50.32

Table 7: Estimated coefficients of Logistic regression (Dependant variable: Probability of a house getting fully damaged during Hudhud)

Name of variables used in estimation	Estimated coefficients	Estimated marginal effects	Name of variables used in estimation	Estimated coefficients	Estimated marginal effects
Coast type (mixed vegetation)	**-3.456*** (0.607)**	**-0.203*** (0.03)**	Kacha house	3.147*** (0.544)	0.467*** (0.083)
Length of open coast	0.002* (0.001)	0 .0002* (0.0001)	Pucca house	-6.811*** (0.146)	-0.628*** (0.022)
Width of open coast	-0.002 (0.002)	-0.0002 (0.0002)	Bheemunipatnam tehsil	-3.886*** (0.693)	-0.332*** (0.065)
Width of mixed vegetation	0.006 (0.004)	0.0006 (0.0005)	Pukkallapalem tehsil	-4.220*** (0969)	-0.201*** (0.035)
Type of tree cover around house (dense)	**-2.004** (0.985)**	**-0.115*** (0.022)**	Pusapatirega tehsil	-4.029*** (0.994)	-0.133*** (0.016)
Distance from sea	-0.001 (0.002)	-.0001 (0.0002)	Urban tehsil	0.390 (0.504)	0.049 (0.069)
Total income	0.000 (0.000)	1.50e-07 (0.000)	Constant	-0.702 (1.419) (1.419)	----
Male headed household	0.769*** (0.290)	0.081*** (0.026)			

Table 8: Estimated OLS coefficients (Dependant variable: Number of houses getting damaged during Phailin)

	Severely damaged houses	Completely damaged houses	Washed away houses	Partially damaged houses	Total number of houses damaged
Adults in a village	0.04*** (4.39)	0.05*** (4.06)	0.01** 2.19)	0.25*** (6.42)	0.31*** (7.49)
Share of sc and st	3.62 (0.49)	1.88 (0.22)	-1.74 (0.88)	13.79 (0.60)	4.11 (0.14)
Share of literates	-32.67 (1.17)	-45.79 (1.43)	-13.1*(1.86)	-24.04 (0.37)	-69.74 (0.91)
Share of farmers	114.89* (1.93)	122.43* (1.90)	7.54 (0.77)	-33.38 (0.43)	118.84 (1.05)
Share of other workers	84.56 (1.48)	115.44 (1.44)	30.88 (1.25)	-35.76 (0.29)	65.36 (0.69)
Share of workers in household industries	-64.53 (0.72)	-64.65 (0.65)	-0.12 (0.01)	485.52 (1.37)	339.05 (1.03)
Share of marginal workers	8.64 (0.33)	14.92 (0.44)	6.28 (0.69)	-53.06 (0.91)	-65.86 (1.22)
Wind velocity at the village	0.15 (0.58)	0.16 (0.58)	0.01 (0.36)	0.91+ (1.44)	0.84 (1.02)
Distance from coast	-0.11 (0.15)	-0.50 (0.59)	0.39**(2.29)	2.09 (0.91)	2.81 (0.97)
Width of casuarina	12.66 + (1.59)	14.99 (1.42)	2.33 (0.78)	44.61* (1.71)	61.33** (2.23)
Width of mixed plantation	-3.25 (0.40)	-5.51 (0.57)	-2.26 (1.14)	9.94 (0.46)	11.48 (0.39)
Width of cashew forest	**-13.59 ** (2.03)**	**-14.85* (1.85)**	**-1.26 (0.76)**	**-12.29 (0.48)**	**-26.56 (0.82)**
Width of other plantation	13.51 (1.35)	12.62 (1.10)	-0.89 (0.36)	27.67 (0.58)	47.71 (0.80)
Ganjam block dummy	3.13 (0.23)	4.34 (0.28)	1.21 (0.42)	143.06***(3.2)	143.09*** (2.81)
Khallikote block dummy	-11.36 (0.53)	-9.70 (0.40)	1.67 (0.38)	43.17 (0.62)	23.92 (0.28)
Rangeilunda block dummy	-51.27*** (4.38)	-57.07 *** (4.31)	-5.80** (2.71)	-26.93 (0.59)	-80.97 (1.43)
Constant	-13.07 (0.28)	-8.92 (0.16)	4.15 (0.40)	-213.65(1.59)	-173.03 (1.07)
Number of observations	288	288	288	288	288
F value (F(16,70)	3.61 (p=0.00)	3.78 (p=0.00)	1.83(p=0.00	8.18 (p=0.00)	9.16 (p=0.00)
R squared	0.33	0.32	0.23	0.59	0.62
Root MSE	40.36	48.18	11.22	121.05	143.66

Annex 3

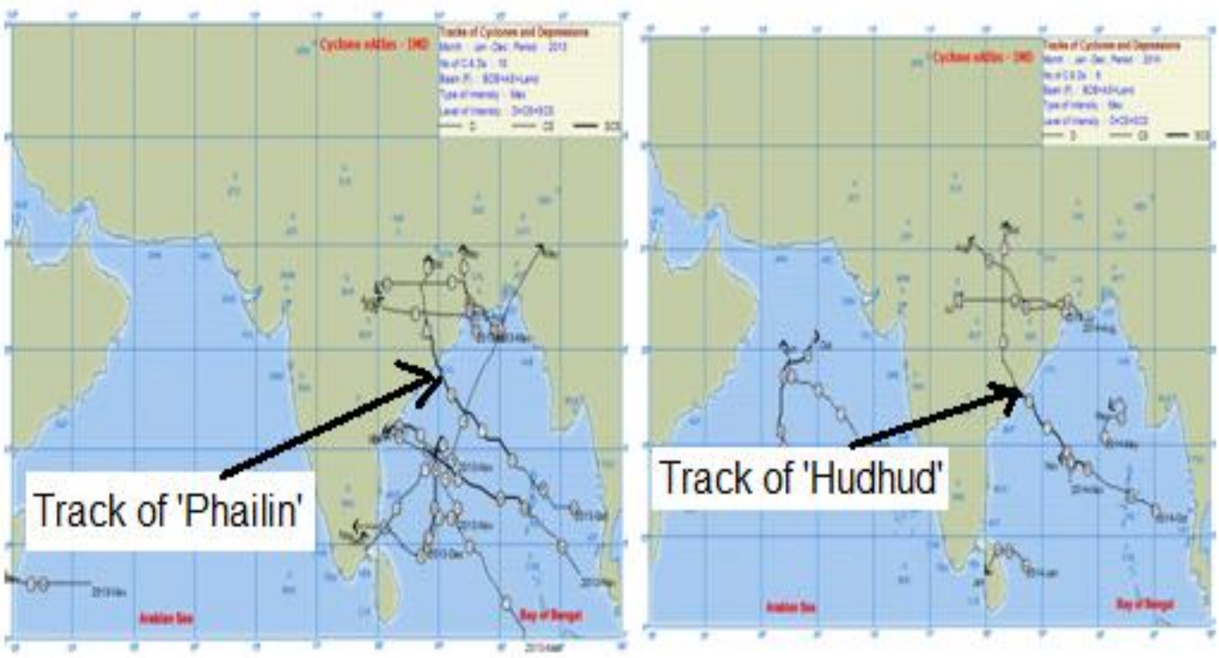

Figure 1: Track of the storms Phailin and Hudhud (Source: Indian Meteorological Department, Government of India)

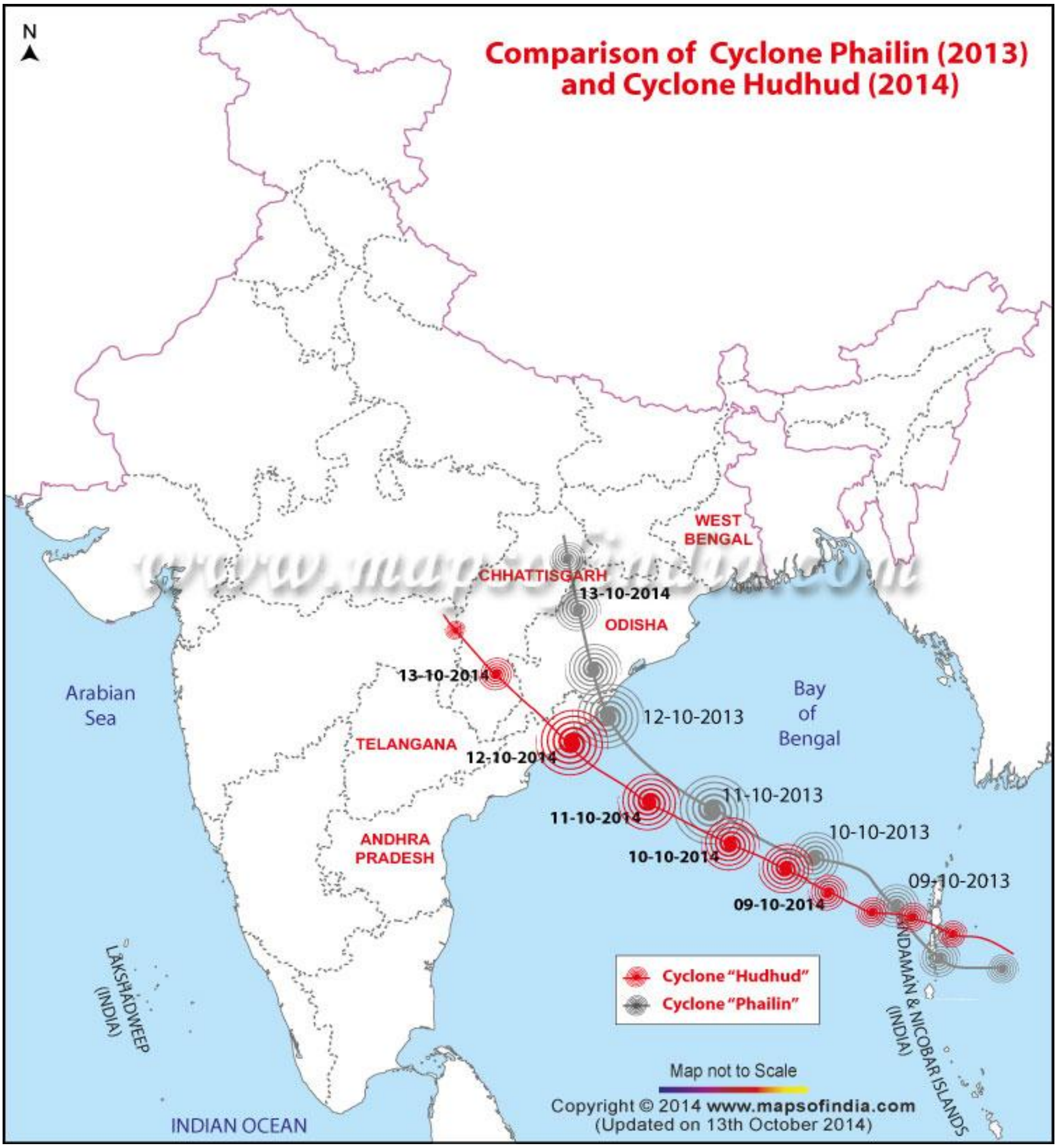

Figure 2: Comparison of approximate tracks of Phailin and Hudhud (Source: Maps of India)

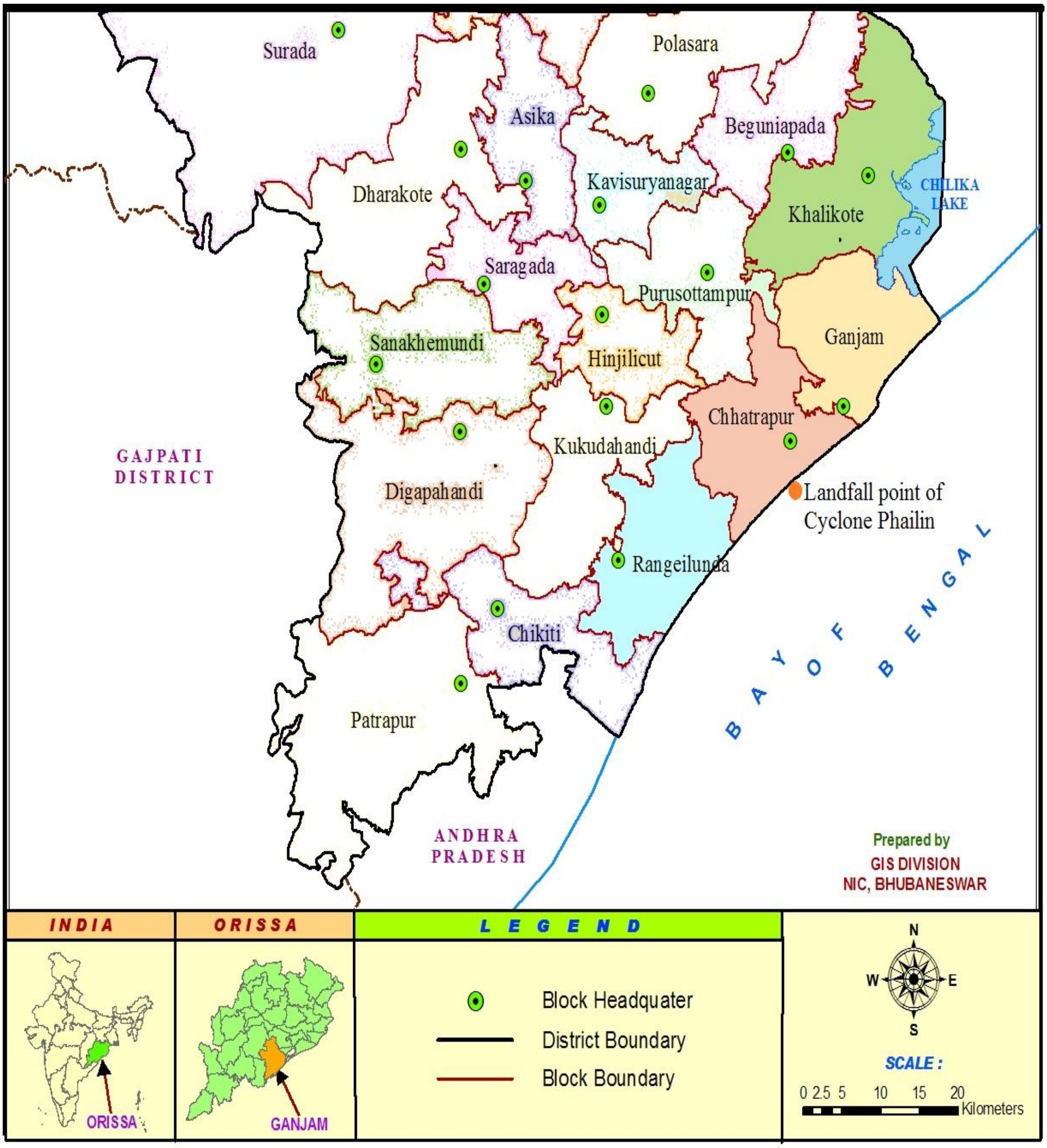

Figure 3: Location of blocks used as study area in Ganjam district of Odisha

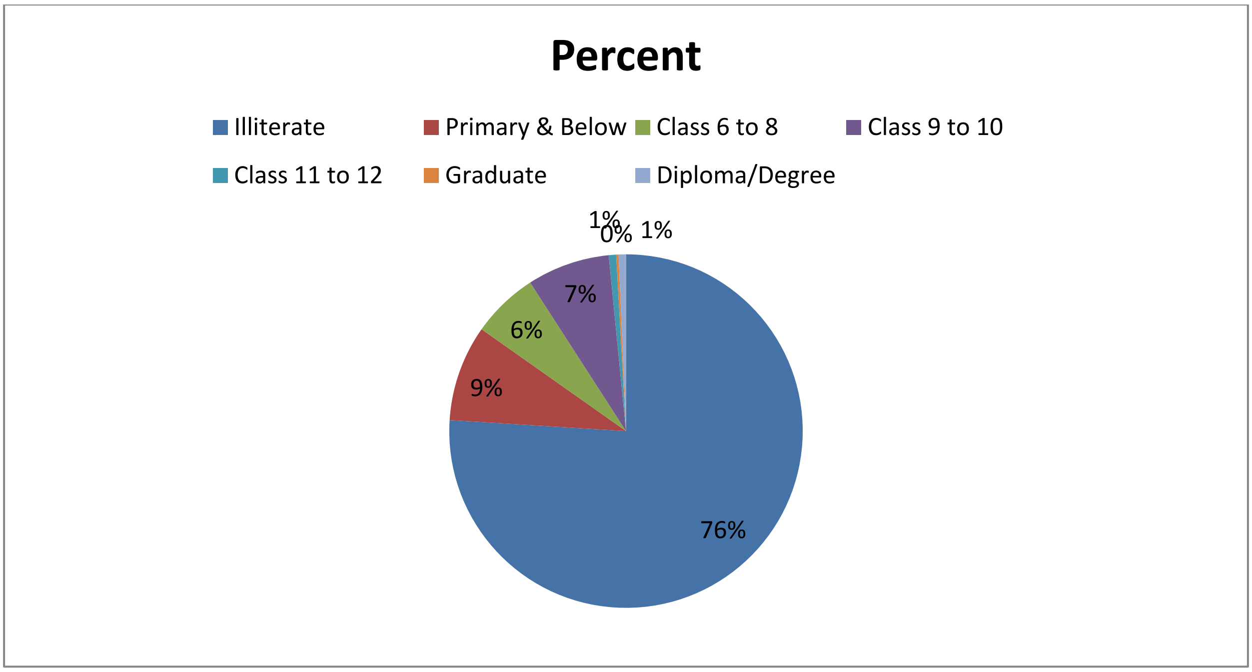

Figure 4: Educational Qualification of sample households

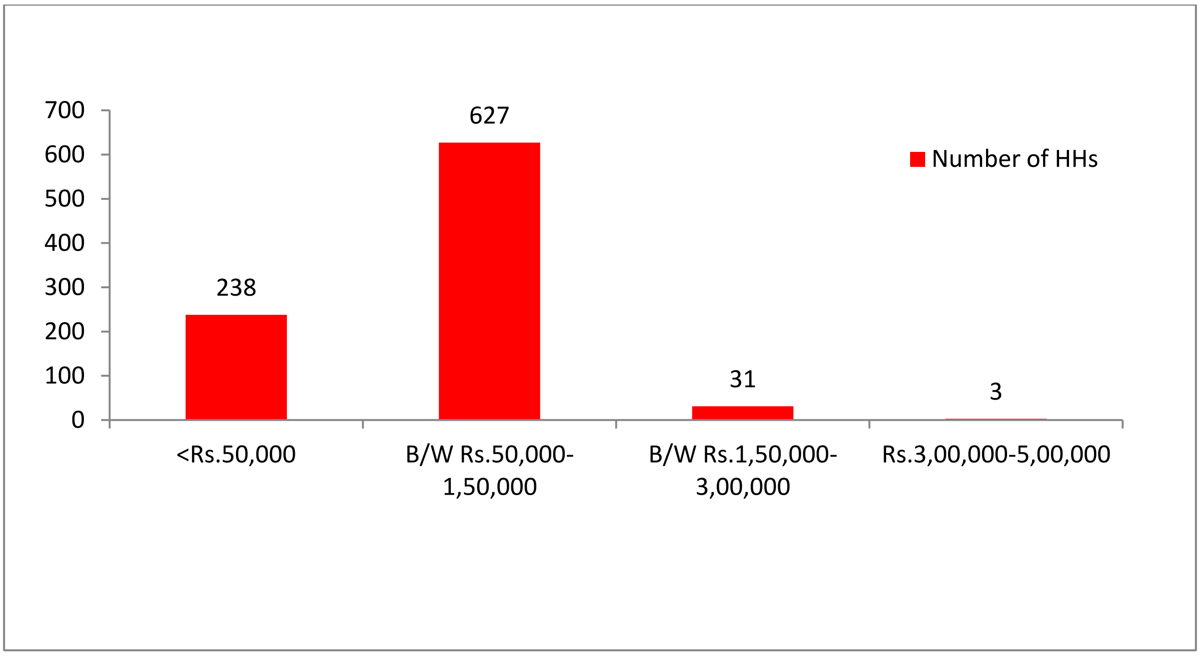

Figure 5: Income distribution of sample households.

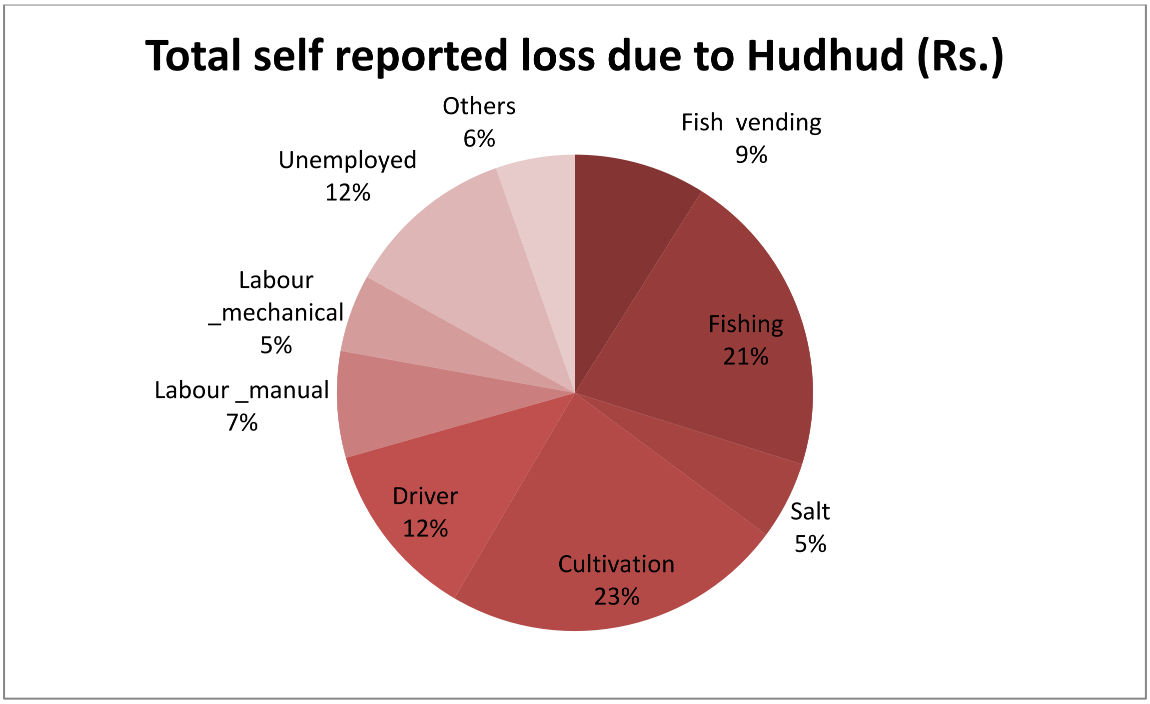

Figure 6: Self reported loss suffered by occupational groups during Hudhud

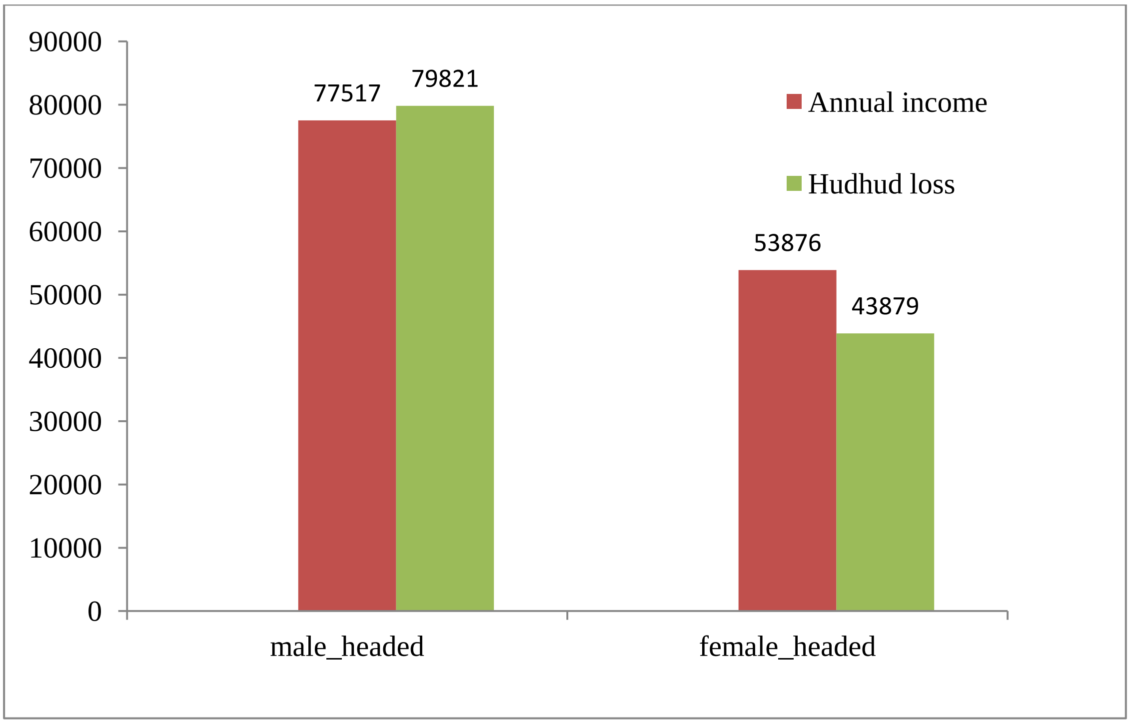

Figure 7: Annual income and loss suffered during Hudhud by male and female headed households

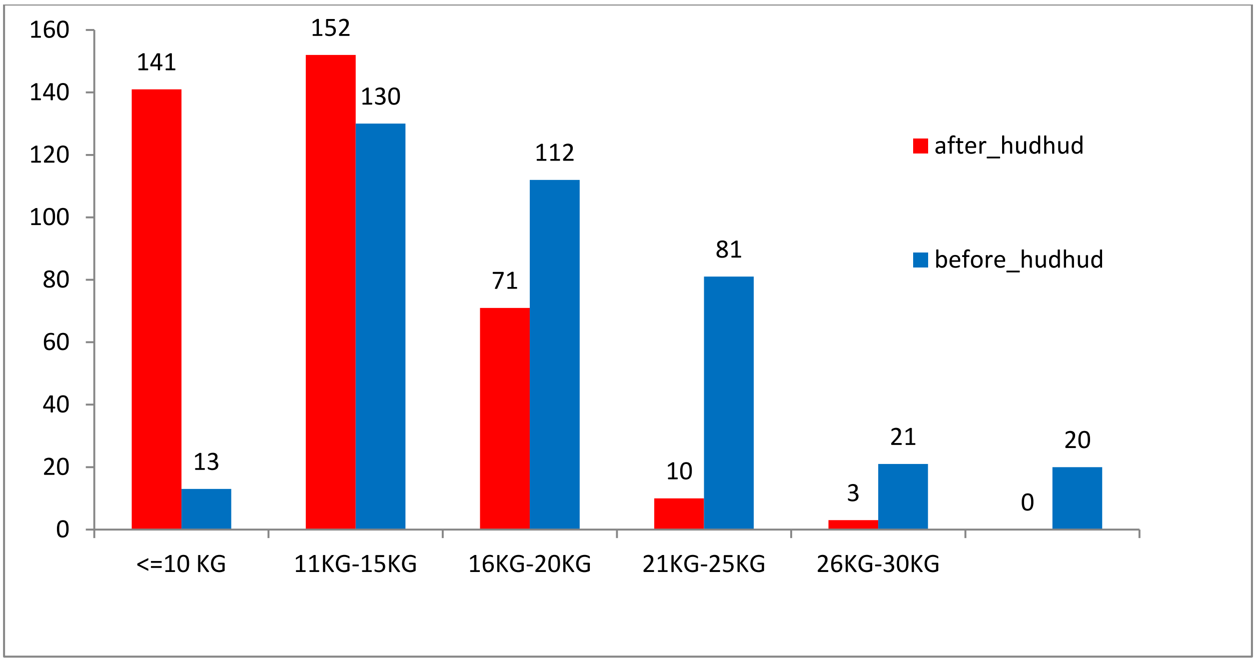

Figure 8: Pre and post Hudhud fish catch per trip

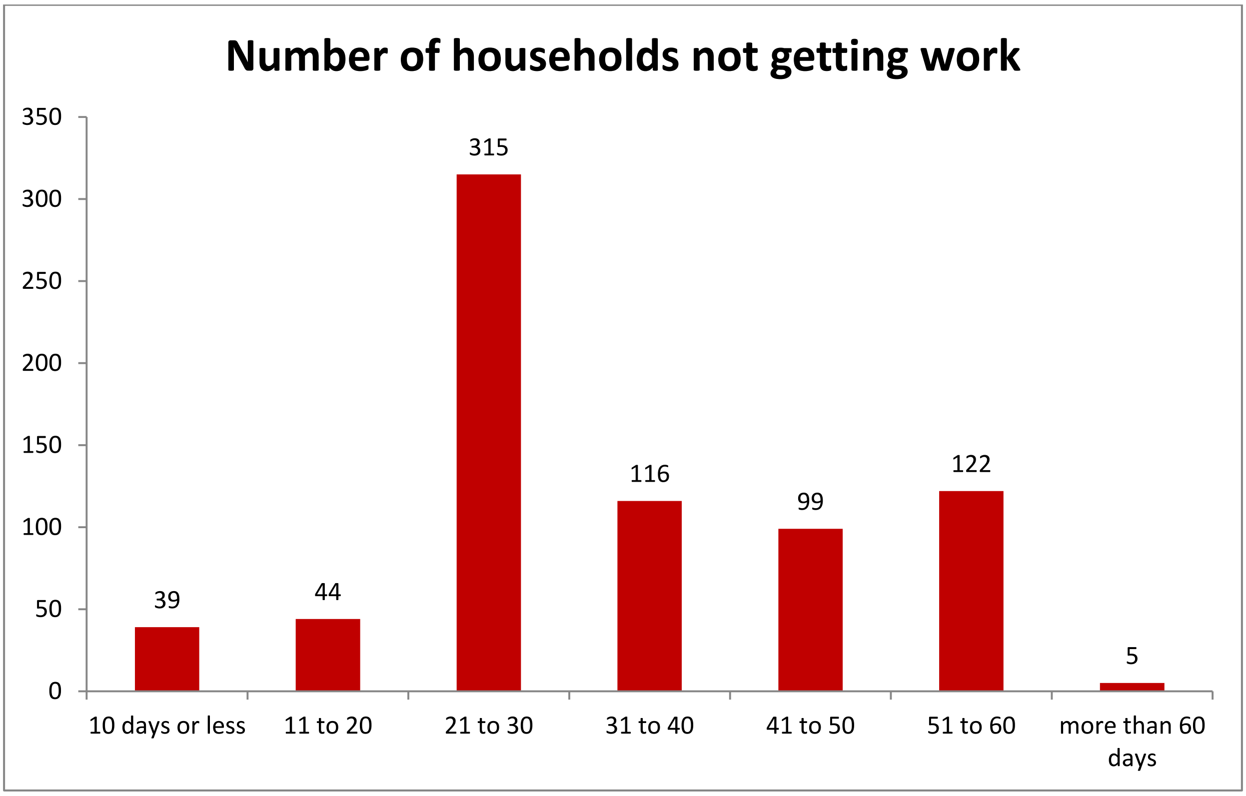

Figure 9: Work days lost immediately after Hudhud

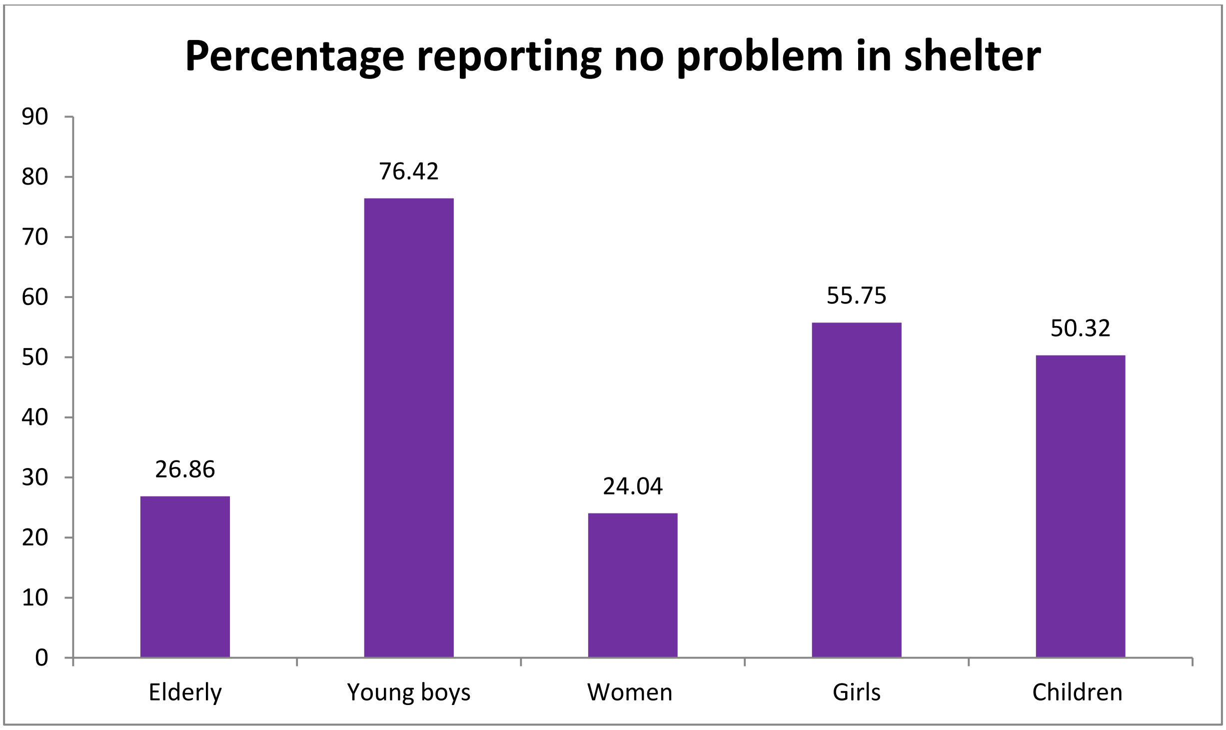

Figure 9: Respondents who did not face problems in Shelter

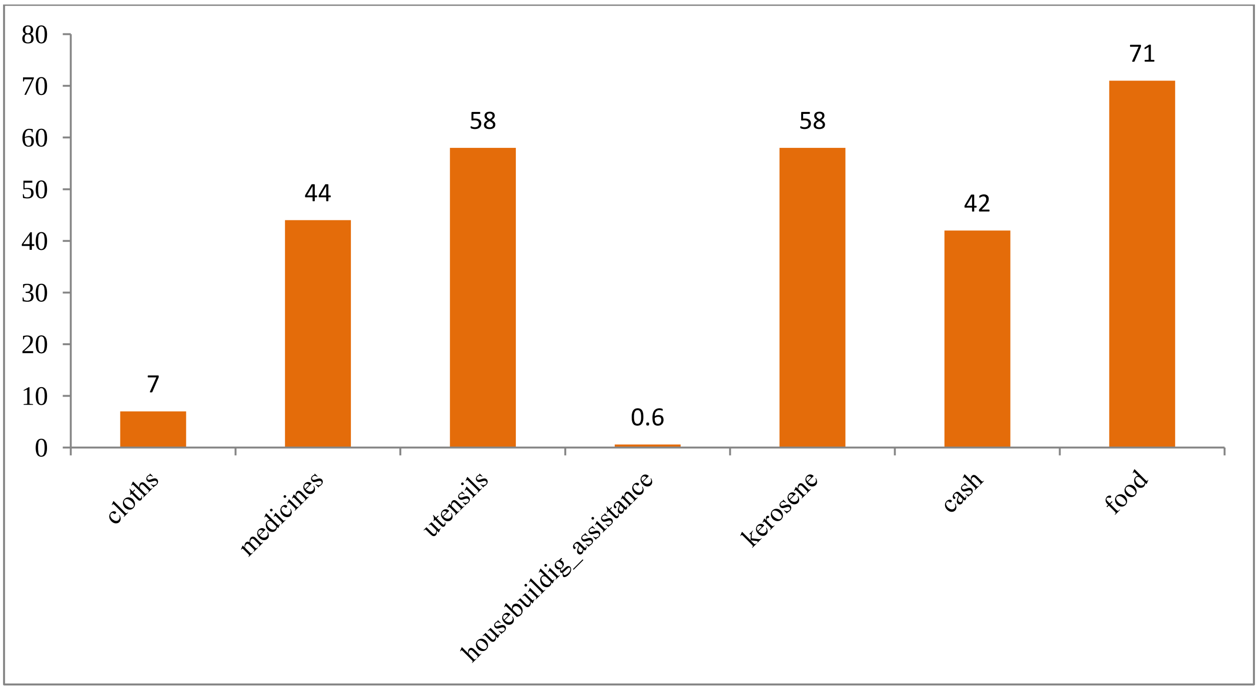

Figure 10: Percentage (%) of sample households receiving assistance

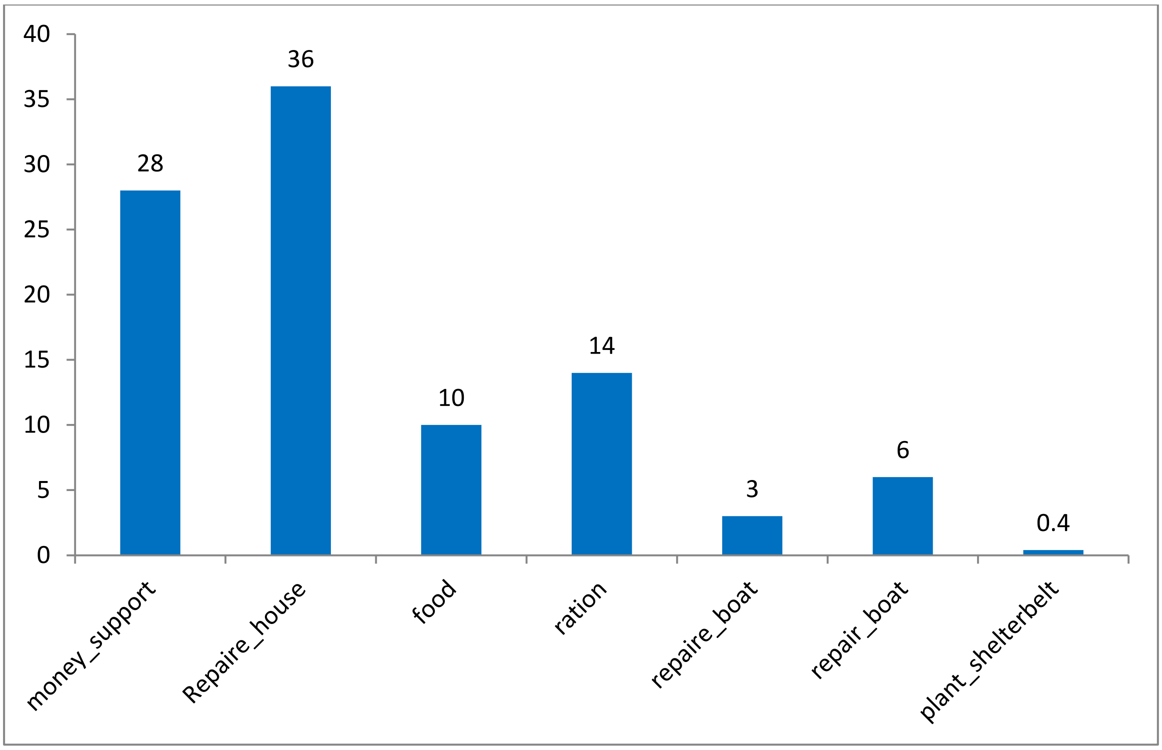

Figure 11: Percentage of households having different expectation from government

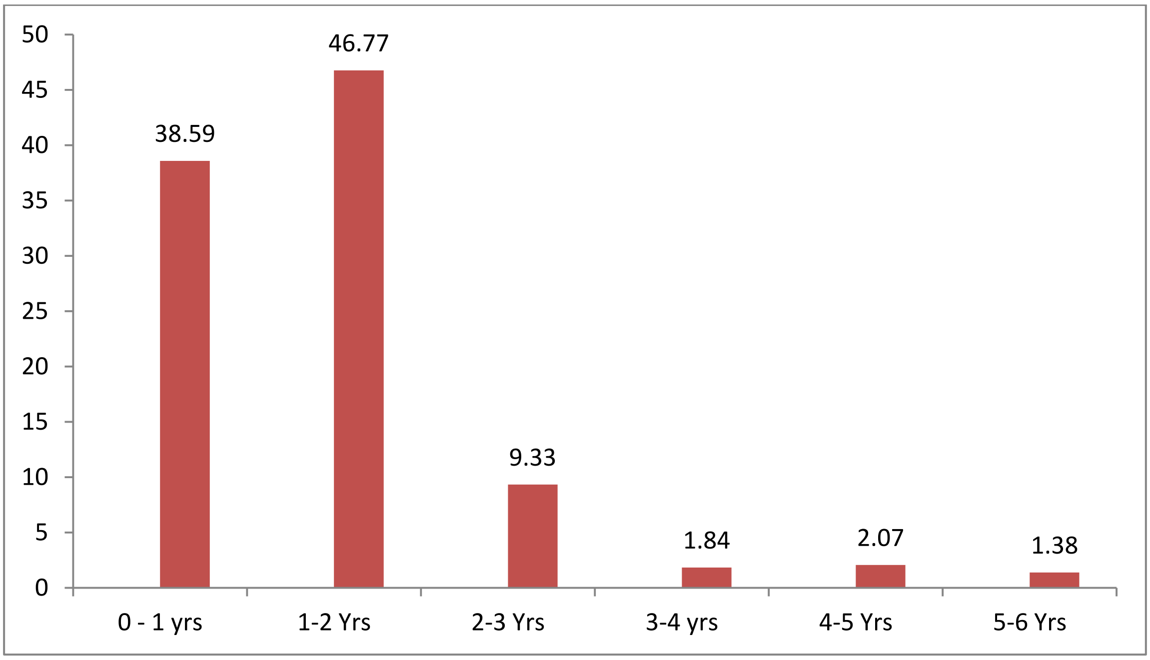

Figure 12: Time required recovering completely from Hudhud effect

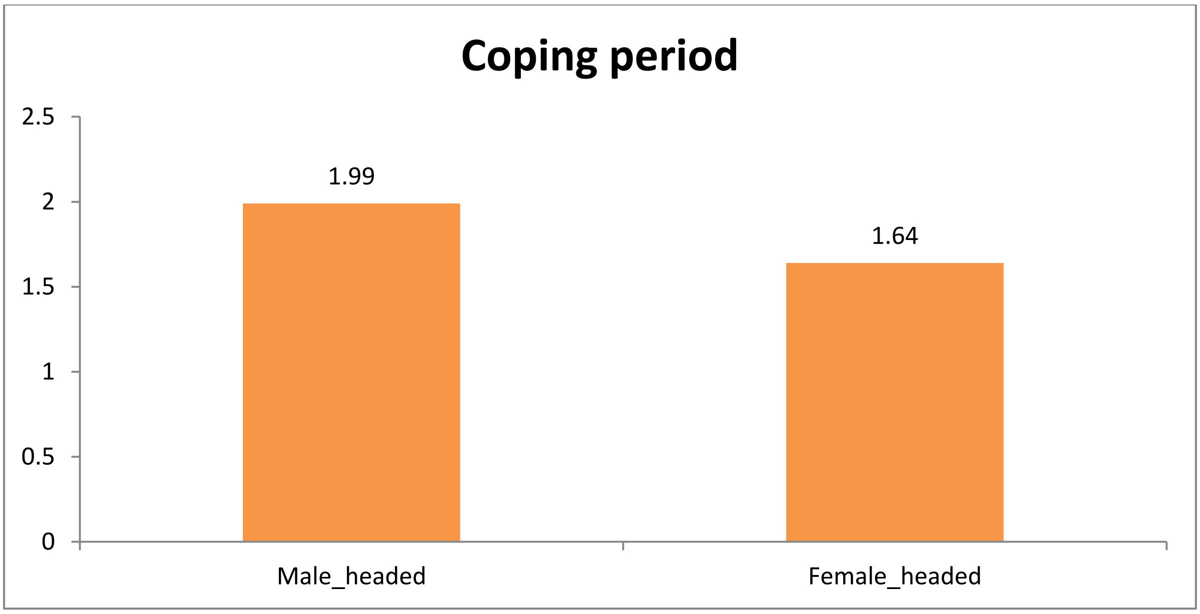

Figure 13: Time needed to recover the loss of Hudhud

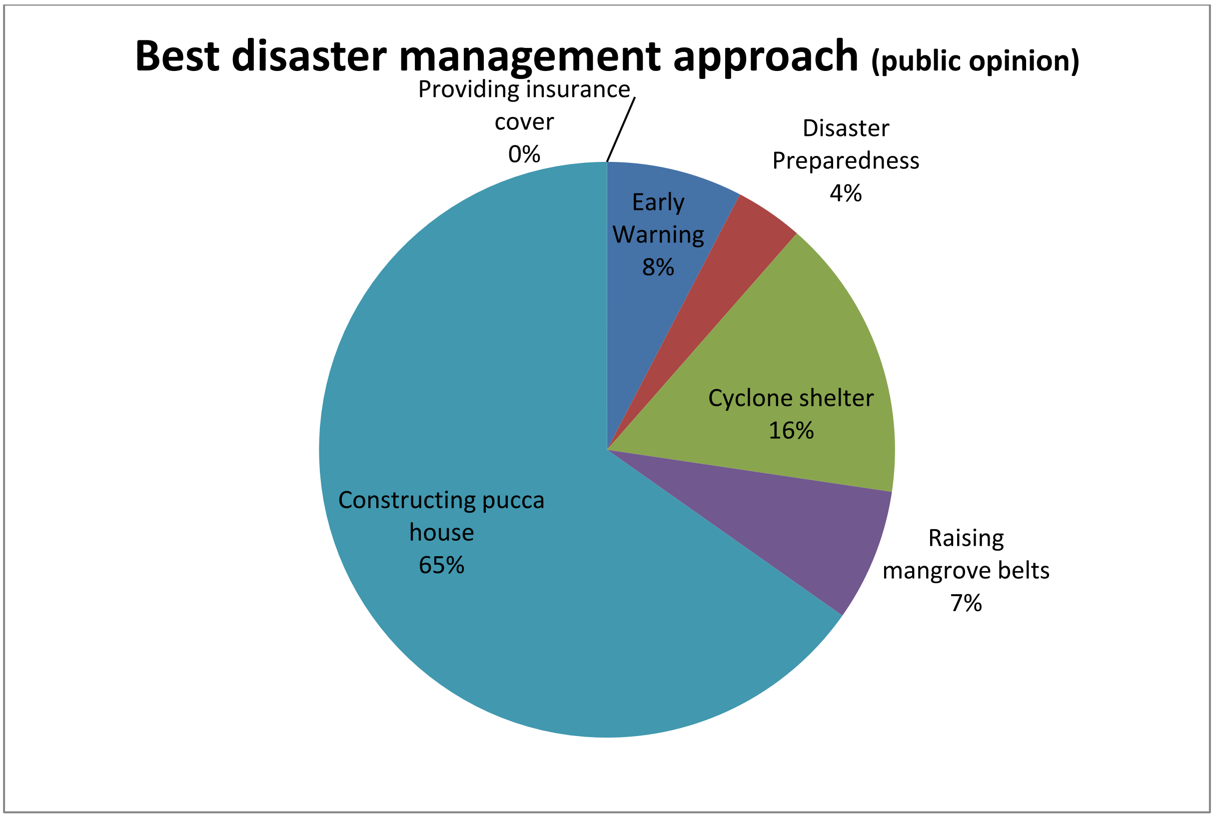

Figure 14: Public opinion on best method to manage storms