[Preliminary Draft]

Economic Impact of Floods in Indian States

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Abstract

The present study examines the impact of economic development on flood impacts in terms of human mortalities and economic losses in 19 Indian states from 1980 to 2011. The empirical estimates show that higher economic development causes a decline in flood impact measured in terms of human mortality and economic losses. The study finds that better achievement in Human Development Index (HDI) has significantly minimized flood related mortalities. In addition, the study analyzes the relationship between disaster expenditure and economic loss for all Indian states. The empirical estimates based on IV Tobit model show that disaster expenditure has significantly reduced the size of economic loss due to flood. In this context, the role of politics in the prevention of flood mortalities is also examined. The estimates show that inclusion of state election year and political alignment (measured by the presence of the same political party in government or coalition political party in government both Centre and State) has significantly minimized flood impact in terms of human mortalities in Indian states. In order to obtain robust results, IV Poisson model and IV Tobit model is used to estimate the economic impact of floods in Indian states. Overall, the findings are also consistent with Poisson estimates and Tobit estimates.

Keywords: Economic Development; Flood Fatalities; Political Alignment; IV Poisson model; IV Tobit model; Indian states.

JEL Classification: O1; Q54; P16

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1. Introduction

Natural disasters are a leading cause of human mortality, cause damage to private and public property, deterioration of human health and environmental degradation. Natural disaster impact and disaster intensity are similar across developed and developing countries, but developed countries have better disaster management and advanced disaster warning systems to prevent the post and pre disaster impact compared to developing nations. Evidence shows that USA has faced the highest number of disaster events (506 reported events between 1974-2003) compared to any other country, but less number of people have become victims of these disaster events (4.5 million between1974-2003). On the other hand, developing countries like India and Bangladesh have experienced 303 and 174 numbers of disaster events respectively, but the number of people killed equal to 1832 and 375.1 million respectively between 1974-2003 ((Centre for Research on the Epidemiology of Disasters (CRED, 2004)). Government intervention is necessary to reduce the disaster impact in terms of human mortality and economic losses. Developed nations experienced lower disaster deaths compared to developing nations (Kahn, 2005; Stromberg, 2007; Toya and Skidmore, 2007; Keefer et. al., 2011). Effective and efficient governance partially optimizes the disaster impact, though it cannot completely prevent the impact of a natural disaster. Minimizing disaster impact is one of the key challenges faced by governments across the world. Countries with stronger institution and effective governance have experienced lower disaster deaths and lower economic losses (Anbarci et al., 2005; Kahn, 2005; Escaleras et al., 2007; Stromberg, 2007; Raschky, 2008).

India is one of the ten worst disaster prone countries of the world (Centre for Research on the Epidemiology of Disasters (CRED, 2004)) due to the presence of varying degree of disaster prone areas. The geo-climatic conditions that prevail in different parts of the country have exposed several regions to different natural hazards. Other factors such as global warming, higher population growth, rapid industrialization, urbanization and illegal constructions, deforestation and environmental degradation, equally contribute towards increasing disaster trends in Indian states. In terms of overall Global Climate Risk Index, India has ranked third and ranks first in terms of disaster fatalities and ranks twenty six in terms of disaster losses per unit of GDP in the year 2013 (Global Climate Risk Index, 2015). Every year different states of India experience various forms of natural disasters. The frequent occurrence of various forms of natural disasters directly affects the socio-economic lives of people, private and public infrastructure, and agricultural crops. Disaster damages caused indirectly increase the fiscal pressure of both the central and state governments. India suffered loss of around 2%

of GDP[2] and 12% of the state and central government revenue in all forms of natural disasters during 1996-2000.

Frequent occurrence of flood disaster is one of the common phenomena in India. Different regions face extreme vulnerability due to flood disasters. Various reasons such as heavy rain during monsoon periods, lack of river connectivity, rapid urbanization and illegal construction in urban areas with inadequate drainage and reservoir system are responsible for increasing the risk of exposure to floods in Indian states. In India around 40 million hectares of land is flood prone area[3] out of total 329 million hectares of geographical area. The occurrence of flood disaster events affects both socio-economic lives of people and economic development of the country. The direct impacts of flood disasters are realized through the loss of human lives, damage of public and private property and damage of agriculture crops in different states in India. With respect to the damage caused by floods in India so far on average, 7.2 million hectors of agriculture and non-agriculture land has gotten affected, crop damage Rs 1119 in crores, 1653 human lives were lost, total economic losses including crop damage, house damage and public utilities Rs 3612 crores respectively every year from 1953-2011.

The state wise flood impact in terms of human life lost, economic losses and agricultural crop loss are shown in Appendix-1.The state wise average flood mortality per lakh population is highest in Himachal Pradesh and lowest in Haryana during the periods 1980-2011. Around 11 states in India suffered more than the average figure 0.2 flood mortality per lakh population during these periods (shown in Figure-1). The frequent occurrence of flood not only damage private or public properties, but also damage agricultural crops. Figure-2 shows that average flood damage per unit of Gross State Domestic Product (GSDP) in terms of crop damage, house damage and public utility is highest in Bihar and lowest in Madhya Paradesh. Figure-3 shows that average crop damage per unit of agriculture GSDP is highest in Bihar and lowest in Madhya Pradesh during 1980 to 2011. Around eight states suffered on average 0.011 crop damage per unit of agriculture GSDP during the periods. Crop damage creates indirect effects, such as deterioration of socio-economic condition of people through increasing

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[2] Financing Rapid Onset Natural Disaster Losses in India: A Risk Management Approach, The World Bank, August 2003, Page 8.

[3] In 1980 Rashtriya Barh Ayog (RBA) has estimated state-wise liable to flood affected area “by adding the maxima of flood affected area (1953-78) in any year to the area protected up to 1978 and then deducting portion of the protected area included in the flood affected area due to failure of protection works” . For further details see the “Report of Working Group on Flood Management and Region Specific Issues for XII Plan” , Page No -95, 2011, Planning Commission, Government of India.

poverty and decline in agricultural income. The long term flood management policies are essential to minimize the pre and post flood disaster impact in Indian states.

Why centre state relation is important?

The center state relationship is very important to mitigate the disaster impact and financing the disaster related relief. The financing of disaster relief has been an important aspect of federal fiscal relations. The Central and State Governments play a significant role to minimize the natural disaster impact. Better disaster management and higher economic development are required to minimize the disaster impact. The presence of political lobby between the Centre and State plays an important role for releasing different developmental grants, natural calamity grants and relief and special grant during the disaster. Those grants are more favorable if both center and state have same political party government. In the context of United States (Garrett and Sobel, 2003) have shown that almost half of federal disaster payments are politically motivated. Similarly, Downton and Pielke (2001) have shown that presidential flood declarations are greater in election years where the president is running for a re-election in USA. There is anecdotal evidence of the same in the context of India. For instance, after the Gujarat earthquake in 2001, the Congress party had then claimed that the BJP-led coalition government was discriminating against the Congress state government (January 29, *Tribune News Service, 2001)*. The central government had declared the Gujarat earthquake as a national calamity due to the presence of the same political party in the state and centre. On the other hand, in 1999 when Odisha was hit by a super cyclone, the central government did not declare it as a national calamity due to the presence of the opponent ruling party in Odisha. Similarly, the Bharatiya Janata Party (BJP) demanded the Kosi floods in Bihar to be declared as a national calamity, but center did not agree because National Democratic Alliance led by Janta Dal United government was ruling Bihar and Congress lead United Progress Alliance-1 was ruling at the Center (ANI, 27 August 2008).

Much of the empirical literature has evaluated the economics of natural disaster and its impacts taking into account the cross national comparisons. The objective of the present study is to examine the economic impacts of floods with a political economy dimension in regional difference in 19 Indian states from 1980 to 2011. The present study examined the three main research hypotheses. In the first hypothesis the study examined the higher economic development and state intervention in terms of disaster expenditure can minimize the flood impact in terms of human mortality and flood damage in Indian states. The state with higher per capita income and effective flood management policies in terms of expenditure of flood controls measures and flood warning system to prevent flood disaster impacts. In the second hypothesis the study examined higher rural work force participation rate and better Human Development Index (HDI) can minimize flood mortality in Indian states. The states with higher rural work force participation rate and greater achievement in human development are less likely to suffer flood damages. Finally the study examined the presence of political alignment (measured by the presence of the same political party in government or coalition political party government in both Centre and State) enhanced the efficiency of minimizing the flood impact compared to non alliance political party government due to favorable disaster funding released from central government to the disaster affected states. In addition study examine the occurrence of the state election year can significantly reduce flood mortality. In the state election years, the incumbent state government tries to minimize flood fatalities with the help of different forms of flood disaster funding. If the state government is successful in disaster management activities, it will help the incumbent state government during the election and again occupies the state office for the next five years. In Indian context, no such empirical work has been undertaken to study the economic impact of floods in Indian states. The present study attempts to make a substantive contribution to the empirical disaster literature. The study can also provide policy implications for enhancing the role of states to mitigate disaster impact in Indian states.

The rest of the article is structured as follows. Section 2 presents a detailed literature review of country specific and cross country studies that analyzed the impact of economic development on natural disaster mortalities and disaster losses. Section 3 describes the identification strategies and major data sources. The empirical results are illustrated in section 4. Finally, conclusion and some policy suggestions are discussed in section 5.

2. Literature Review

There are a few recent empirical studies that have evaluated the effects of economic development and quality of institution (proxy of democracy, government stability, and quality of public service, income inequality, infrastructure and civil service and lower corruption) on disaster impact in terms of disaster fatalities and disaster damage using cross country panel data. Anbarci et al (2005) has used a theoretical model to show that the earthquake fatalities and per capita income are inversely related and higher income inequality and earthquake fatality rate is positively related. The empirical estimate shows that countries with higher per capita income and lower income equality mitigate the earthquake fatalities. Kahn (2005) has analyzed the impact of level of development, geographical factors and quality of institutions on different type's disaster risk using a new disaster data set for 73 nations from 1980-2002. The study has found that elevation (1000 m above sea level) reduces mortality from windstorms and distance from equator increases the earthquake mortality. The study also found that countries with higher development, lower income inequality and higher democracy experience less natural disaster risk. This study also examined that both richer and poorer countries face the same number of natural events, but richer nations suffer fewer disaster related deaths than poorer nations. Toya and Skidmore (2007) have examined the level of economic development and natural disaster risk in OECD and developing countries using cross country data. The level of development is inversely related to disaster mortality and disaster damage in both OECD and developing countries. The finding of the study shows that the estimate of income coefficient is greater in OECD countries than developing countries, which means OECD countries are better prepared to mitigate disaster risk compared to developing nations. Stromberg (2007) has examined the relation between natural disaster, economic development and humanitarian aid in high income, low income and middle income countries using an ordinary least square (OLS) technique from 1980-2004. The empirical finding of the study are as follows. First, high income countries experience 70 percent lower fatality then low income countries from the same type of disaster in the same year. Secondly, development has reduced the disaster mortality and countries with more effective government (quality of public service, infrastructure and civil service) suffer fewer fatalities, while more democratic countries suffer more. Thirdly, the study examines the impact of news coverage, development and disaster mortality on disaster relief expenditure using both OLS and Instrument Variable (IV) regression technique. This study uses concurrent Olympic game as an instrument for whether or not the disaster was covered in the news. Higher news coverage of disaster gets more international disaster funding. There exists reverse causality between news coverage and disaster funding. The least square estimate shows that, higher disaster mortality and more international news coverage leads to an increased disaster relief. The IV technique (Olympic Games as an instrument for news coverage) shows that there is no causal effect of news coverage and disaster relief. Finally the study examined that, there is a positive relation between common language and donor providing relief and there is a negative relation between geographic distance and donor providing relief. Escaleras (2007) examined the impact of public corruption on major earthquake fatality using crossing countries data from 1995 to 2003. The empirical finding suggests that, country with high corruption in the public sector increase the likelihood of earthquake fatality controlling for other factors such as the country's' level of development, earthquake frequency, earthquake magnitudes and population density. Horwich (2007) critically examines the government response and economic development towards the Kobe earthquake in Japan. The study analyzed that the demand for safety or disaster preparedness, increases with an increase in the level of per capita income. Plumper and Neumayer (2009) have examined famine mortality in developing countries over the period 1972-2000 using Negative binomial estimate. The empirical results show that the famine mortality rate is lower in democracies compared to countries which experience autocracies in their governance. Keefer et. al (2011) investigated the determinants of earthquake mortalities using cross country earthquake data spanning from 19962-2005. The findings of the study suggest that the effect of earthquake propensity varies across countries depending on income and political characteristics. If the earthquake propensity is low, the government lacks incentives to implement an effective earthquake mortality prevention system because of the presence of the high opportunity cost to invest in earthquake preparedness. Thus, based on individual country's reaction to earthquake propensity, mortality is lower in countries where earthquake propensity is higher, and response of the poor countries is lower given the huge opportunity costs

There are a few cross country studies which have examined the nonlinear relationship between economic development and natural disaster in terms of human life losses and disaster damages employing different econometric technique. The study by Raschky (2008) examined the relationship between economic development; the quality of the institution and disaster risk using cross country data set from 1984-2004. The findings of the study showed that there exist a nonlinear relationship between economic development and disaster damage. That means economic development, provides protection against natural disaster, but with a diminishing rate. The empirical findings also show that better institution and higher economic development reduces the disaster mortality and damage. Kellenberg and Mobarak (2008) have analyzed the nonlinear relation between economic development and types of disaster risk using Negative binomial and GLS models covering 133 countries spanning 28 years. This study has found that there is an inverted U-shaped relationship between natural disaster deaths and income. Disaster risk initially increases with an increase in the wealth, but then begins to decline as wealth increases further. The empirical finding shows that, disaster risk increases with an increase in GDP per capita for specific disasters like flood, landslide and wind storm and decrease thereafter. However, the nonlinear relationship does not exist for extreme temperature events and earthquake disasters. Schumacher and Strobl (2011) have examined the relation between wealth and disaster. The simple analytical model shows that countries with lower hazard of disasters are likely to see an initial increase in losses followed by a decrease with increasing economic development. At the same time, countries with higher natural disaster hazard are likely to have a U-shaped relation between wealth and economic losses. The estimate of the Tobit model shows that the coefficient of GDP per capita is positive and statistically significant and its square terms are negative and statistically significant. The results suggest that there exists an inverted U-shaped relation between economic losses from natural disaster and economic development. The study by Ferreira et al (2013) have examined the impact of development and governance on flood fatalities using a new data set of 2171 large floods in 92 countries covering the period 1985 to 2008. The Fixed effect Binomial Model indicates that there exist an inverted U-shaped relation between income and flood fatality. This means that fatality increases at lower levels of income and then it declines at higher income levels. This study also finds the importance of the role of better governance in reducing fatalities during flood events. Neumayer et al (2014) have examined the relation between disaster propensity (from natural disasters like flood, earthquake and cyclone) and disaster damages using a cross country dataset covering the period 1980-2009. The estimate of quantile regression has revealed that the disaster propensity for specific disasters (flood, earthquake and cyclone) and disaster damage are inversely related. The results show that, at the 0.95 quantile of economic damage, a 10% increase in quake propensity lowers expected damage by 2.4%, whereas, the same increase in quake propensity lowers expected damage by only 0.8% at the 0.25 quantile of economic damage.

There are a few empirical studies which have analyzed the relation between political economy of disaster expenditure and disaster impact. The studies by Downton and Pielke (2001) have analyzed the flood-related presidential disaster declarations from 1965 to 1997. The study found that the presidential flood declarations are greater in election years where the president is running for a re-election. Another study by Garrett and Sobel (2003) analyzed the role of presidential and congressional elections on declaring the natural disaster and allocation of the disaster expenditure by the FEMA (Federal Emergency Management Agency) across the United States over the period 1991 to 1999. The results obtained from the Poisson model show that those states that are politically important to the president and have higher representatives on FEMA oversight committees, have higher disaster expenditures. The study by Chang and Berdiev (2015) has examined the impact of natural disaster on the likelihood that a government will be replaced from office using cross country panel data over the period 1975–2010. The estimate of the fixed effect Logit model shows that the number of disasters, occurrence of disaster and damage caused by disaster leads to increasing changes of the incumbent government. The number of deaths related to flood disaster has the largest impact on probability of changing the existing government. Besley and Burgess (2002) argued that political institutions as well as economic development affect government responsiveness (public food distribution and calamity relief expenditure) in the Indian context. This paper has found that calamity relief has been more responsive to needs in states where more people read newspapers.

3. Data Sources and Empirical Methodology

In this section study analyzed data sources and identification strategy. This is the challenging work to matching the state wise flood disaster data with different international disaster data sources to carry out the empirical research. This is the first empirical study using all the flood disaster data to examine the economic impact of flood in case of India. The state wise flood impact data are obtained from the Central Water Commission (CWC), Government of India. This data set provides different flood disaster related information such as crop area affected, total area affected, population affected, number of human lives lost, number of house damage, damage to crops (Rs in crore), value of house damage (Rs in crore), damage to public utilities (Rs in crore) and total damages Rs in Crore. Similarly, the details of flood impact data, such as number of people evacuated, relief distribution, disaster damages and population affected by floods etcetra in few states, namely Odisha and Tamil Nadu are available from United Nations Office for Disaster Risk Reduction (UNISDR; http://www.desinventar.net/DesInventar/results.jsp). However, details of flood disaster data in state of Bihar are obtained Flood Management Information Systems, Government of Bihar. In addition the cross country's flood related data, such as duration of floods, severity of floods and magnitudes, floods damages and flood fatality are available from Dartmouth Flood Observatory (DFO; http://floodobservatory.colorado.edu). The country wise all forms of natural disaster data are collected by the Centre for Research on the Epidemiology of Disasters (CRED), Catholic University of Louvain in Belgium. The EM-DAT database has followed a particular criterion (such as 10 or more people have killed and 100 or more people were affected). The CWC data does not provide important flood related information such as flood magnitude, flood durations and flood severities. Those variables are very crucial for determining the flood disaster impacts. For example, higher flood magnitudes cause an increasing both flood death and flood damages. For empirical analysis, I have matched the state wise CWC data set with DFO data for flood magnitude and flood durations variables. For flood duration variables, I have also matched CWD data set with UNISDR data for two states namely Odisha and Tamil Nadu. In CWC data set some information is missing for example, loss of human life data is reported in case of some states for respective years, but area affected data and total population affected data have not been reported. Thus, I have used DFO and EM-DAT database to fill the missing data.

With respect to the data on various explanatory variables used in the study, the Gross State Domestic Product (GSDP) and agriculture sector GSDP both current and constant price is available from the Ministry of Statistics and Program Implementation, Government of India. The data on disaster related expenditure, irrigation and flood controls, expenditure on social security and welfare are available from the various volumes of State Finance Reports published by the Reserve Bank of India and Finance Commission Report, Government of India. The state wise total population data, literate population data and adult population data are available for different census years. In India census takes place within ten years. I have used different census rounds such as 1971, 1981, 1981, 1991, 2001 and 2011. The state wise total populations literate population and adult population linearly interpolated for the years when no census was conducted. The state wise drought prone area[4] data are available from the Department of Labour Resources, Ministry of Rural Development, Government of India. The government of India identified 74.6 million hectors as drought prone area in 17 states. The state wise liable to flood prone area were estimated by Rashtriya Barh Ayog (RBA) Planning Commission, Government of India. Rashtriya Barh Ayog estimated that around 40 million hectors land is liable to flood affected area. The rural work force participation data are collected from different rounds of National Sample Survey Office (NSSO) employment and unemployment reports. Usually this survey is conducted at every five year interval. The state wise HDI[5] data used in the study is obtained from Mukherjee et al (2014). The state and national election data are collected from election commission of India. The coalition political different states are taken from E Sridharan, Coalition politics in India. For empirical estimation we have normalized the variables. The details of summary statistics of all variables along with their definition are shown in Table 12 in the Appendix.

The present study analyzed the determinants of flood fatalities and economic losses due to floods using state level panel data in 19 Indian states from 1980-2011. The outcome variables of my study are the number of human life lost, agricultural damage and total damage of both public and private properties

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[4] See Drought Prone Areas Programe, http://www.dolr.nic.in/dpap_annex.htm

[5] For detail estimates of HDI see Mukherjee et al (2014) "Three Decades of Human Development across Indian States: Inclusive Growth or Perpetual Disparity", NIPFP, Working Paper No. 2014-139.

due to flood. The following functions explain the effect of economic development on flood fatalities, total damage and agricultural damage due to floods in Indian states:

$$FF_{it} = \beta_0 + \beta_1 lPCI_{it} + \beta_2 lFM_{it} + \beta_3 PAD_{it} + \beta_4 SED_{it} + \beta_5 Z_{it} + \theta_{r+} \gamma_{t+} \mu_{1it} \quad (1)$$

$$Ln\left(\frac{Total\ Damage}{GSDP}\right)_{it} = \alpha_1 + \alpha_2 lPCI_{it} + \alpha_3 lFM_{it} + \alpha_4 lENC_{it} + \alpha_5 Z_{it} + \theta_r + \gamma_t + \mu_{2it} \quad (2)$$

$$Ln\left(\frac{Crop\ Damage}{Agri\ GSDP}\right)_{it} = \vartheta_1 + \vartheta_2 lPCI_{it} + \vartheta_3 lFM_{it} + \vartheta_4 lENC_{it} + \vartheta_5 Z_{it} + \theta_r + \gamma_t + \mu_{3it} \quad (3)$$

Where FF_{it} is the state wise number of flood fatalities, $lPCI_{it}$ is the natural logarithm of per capita income, lFM_{it} is the natural logarithm of flood magnitude, PAD_{it} is political alignment dummy, SED_{it} is the state election year dummy, $lENC_{it}$ is the natural logarithm of state government expenditure of natural calamities, i indicates 'states' and t stands for 'year', Z_{it} are the control variables, θ_r controls unobserved region effects, $\gamma_{t,}$ indicates year specific effects and μ_{it} is the error term. The study has controlled for unobserved region specific effects instead of unobserved state specific effects because specific natural disaster affects the neighboring states or regions instead of all states in India. There are a couple of empirical studies that have controlled for unobserved time invariant continent effects (Anbarci et al., 2005; Kahn, 2005; Escaleras et al., 2007; Stromberg, 2007). The dependent variable in the equation (1) is flood fatalities, that means number of people died during the flood events in different years in different states. This is a non-negative count variable. The conditional variance of the flood fatality variable exceeds the mean, which means 'flood fatality' variable is over-dispersed. This is shown in Table-12 in Appendix. It clearly shows that flood fatalities have violated the normal distribution assumption in the OLS model. In this case, the Ordinary Least Squares (OLS) estimates produced biased, inefficient and inconsistent results. The study used Fixed Effect Poisson Model as it completely controls for time invariant region effects. First time (Ferreira et al, 2013) used Fixed Effect Poisson Model in cross national flood data set. To obtain robust estimates, the study used unconditional[6] Fixed Effect Negative Binomial to examine the economic impact of flood fatalities. Various cross country empirical studies have also examined the impact of economic development on disaster mortality using unconditional fixed effect negative binomial model controlled time invariant continent effects (Anbarci et al., 2005; Kahn, 2005; Escaleras et al., 2007). The study by Kellenberg and Mobarak (2008) have examined cross country data using fixed effect negative binomial model

[6] Unconditional FE negative binomial model provides consistent parameter estimates only if the number of cross-sectional units is less than about 20 (Hilbe, 2012: 473).

controlling for time invariant country effects. The study satisfies the two assumptions of negative binomial model. First, the dependent variable, number of deaths during the flood events is a count variable and the conditional variance is greater than mean. Secondly, I have controlled time invariant unobserved regions effects. In equations (2) and (3), the study employed fixed effect Tobit estimation to examine the determinants of total economic loses and crop losses due to floods in Indian states. The study uses fixed effect Tobit estimation as the outcome variable in both models consist of a lot of zero observations and lower truncation of the data.

In addition the present study has assumed real Per Capita Income (PCI) as an endogenous variable because there is bidirectional causality between real per capita income and flood impacts. States which have experienced higher severity of floods have suffered a decline in per capita income. On the other hand, higher per capita income helps to reduce flood impacts. To control the problem of endogeneity, I have used state wise '*liable to flood affected area'* or state wise '*drought prone area*' as instruments for real per capita income. Much of cross national empirical literature did not address economic development as an endogenous variable which is mentioned in section 2 in literature review parts. This is the first empirical study in disaster literature addressing economic development (proxied by PCI) as an endogenous variable. To control the problem of endogeneity the study has employed Control Function Approach (CFA) using equation (1) and Instrument Variable Tobit estimate using equation (2) and equation (3). The study has examined the role of state government policies (such as expenditure of natural calamities) to minimize the flood disaster impacts in terms of total economic losses and crop losses using equation (2) and equation (3). Again the study has employed fixed effect Instrument Variable Tobit estimate because expenditure on natural calamity is an endogenous variable. Higher the impact of flood disaster, greater is the expenditure towards the management of flood calamity. There exists a reverse causality between natural calamity expenditure and disaster impact. To correct the problem of endogeneity, the present study uses '*liable to flood affected area*' or '*drought prone area in different states*' as instruments for natural calamity expenditure. The states with more liable to flood affected area or drought prone areas causes higher state government expenditure directed towards minimizing the impact of natural disasters, as well as disaster damages in the Indian states.

4. Empirical Results

4.1 The role of Per capita income, flood magnitude and political alignment in minimizing flood fatalities

The present study has estimated equation (1) using fixed effect Poisson model and estimates are presented in Table-1. In Model-1 the coefficient of per capita income is negative and statistically significant which shows that there is an inverse relationship between real PCI and flood fatalities. Higher PCI has significantly reduced flood mortalities after controlling for flood magnitude and other variables such as population density, population affected by floods, expenditure on irrigation and flood controls and some political factors. In Model-8, the coefficient of PCI is still negative and statistically significant after adding all control variables. However, the magnitude of real per capita income slightly differs from 0.692 to 0.581 throughout the models in Table-1. Hence the estimate is robust throughout the models, even after adding the control variables. This finding is consistent with recent findings by (Ferreira et al, 2013). There are a couple of cross country empirical findings which suggest that economic development is one of the major economic determinants to minimize the natural disaster fatalities (Anbarci *et al.*, 2005; Kahn, 2005; Escaleras *et al.*, 2007; Toya and Skidmore, 2007; Kellenberg and Mobarak, 2008; Raschky, 2008; Keefer *et al.*, 2011). The study by Toya and Skidmore (2007) and Khan (2005) find that developed countries suffer lower disaster death compared to the developing nations. The present study also finds that economic development (proxied by real PCI) is one of the major determinants to minimize flood impacts in terms of flood fatalities in Indian states. The reasons behind this is that, the individual states which have higher PCI are capable to spend more towards flood disaster preparation (disaster safety and securities) to prevent the disaster impacts. The demand for safety or disaster preparedness increases with an increase in the level of per capita income (Horwich, 2007). In other words, state with higher per capita income can invest more for flood precautionary measures in terms of rehabilitation, evacuations, relief distribution and flood disaster warning systems etc to prevent flood disaster impacts. Developed nation invests more towards disaster warning system to prevent hurricane disaster impacts (Sheets & Williams, 2001). Although, flood, disaster impact cannot be prevented completely, but higher economic development and efficient flood disaster policies can partially minimize the flood disaster impacts in Indian states. On one hand, economic development in terms of better flood management, efficient flood control measures, and flood forecasting and warning systems can generate higher adaptive capacity to prevent the flood impacts.

Table 1: Per capita income, flood magnitude and political alignment: FE Poisson Model

Variables	Model-1	Model-2	Model-3	Model-4	Model-5	Model-6	Model-7	Model-8
Ln(PCI)	-0.692***	-0.590**	-0.499**	-0.467**	-0.499***	-0.497***	-0.529***	-0.581***
	(0.239)	(0.232)	(0.205)	(0.193)	(0.187)	(0.182)	(0.169)	(0.192)
Ln(Flood Magnitude)		0.173***	0.089***	0.080***	0.077***	0.076***	0.082***	0.086***
		(0.022)	(0.021)	(0.022)	(0.021)	(0.021)	(0.022)	(0.021)
Ln (Pop Affected / Total Pop)			0.229***	0.138***	0.138***	0.138***	0.149***	0.144***
			(0.031)	(0.021)	(0.022)	(0.022)	(0.023)	(0.023)
Ln(House Damage)				0.103***	0.095***	0.094***	0.090***	0.086***
				(0.033)	(0.031)	(0.031)	(0.030)	(0.029)
Ln(Population Density)					0.357***	0.349***	0.376***	0.036***
					(0.093)	(0.093)	(0.097)	(0.106)
State Election Year Dummy						-0.276**	-0.373***	-0.381***
						(0.113)	(0.143)	(0.142)
Political Alignment Dummy							-0.310**	-0.310**
							(0.144)	(0.150)
Centre State Same Election Year Dummy							-0.012	-0.019
							(0.272)	(0.288)
Literacy Rate							-0.005	-0.003
							(0.004)	(0.004)
Ln (Exp of irrigation & flood control/TE)								-0.008
								(0.120)
Ln (Exp of irrigation & flood control/TE)(-1)								-0.022
								(0.139)
Constant	10.385***	9.566***	9.714***	8.191***	6.812***	7.049***	7.049***	8.502***
	(2.275)	(2.214)	(2.011)	(1.940)	(1.933)	(1.897)	(1.897)	(2.096)
Region FE	Y	Y	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y	Y	Y
Observations	608	608	608	608	608	608	608	589
χ2 (d.f.)	164.89	322.61	621.28	791.31	915.59	937.40	940.19	927.09
	(37)	(38)	(39)	(40)	(41)	(42)	(45)	(46)
Log-likelihood	-41822	-36619	-27664	-25310	-24406	-24114	-23687	-22664
No of States	19	19	19	19	19	19	19	19

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1, Dependent variable is Flood Fatalities.

The coefficient of flood magnitude is positive and significant from Model-2 to Model-8, which shows that flood magnitude has significantly increased flood death toll. This finding is consistent with

(Ferreira et al, 2013). In addition, house damage is positively correlated to flood mortalities which are shown in Model-4 to Model-8. The estimates show that higher flood mortalities occurred due to damage of houses during floods. Strong houses can serve as safety measures to mitigate the direct flood disaster impacts in terms of flood mortalities. The frequent occurrence of flood in different parts of India directly damages the houses. According to the CWC, on an average 1.3 million houses were damaged and average direct losses Rupee 5656.4 million per year from 1950 to 2011. Both state and central government intervention is required to minimize the flood mortalities and provide houses particularly to rural poor. The population affected by flood and flood mortalities are positively correlated, which shows that higher population affected by flood leads to increase flood death. Similarly, population density has significantly increased flood fatalities shown in Model-5 to Model-8. The states with the hightest population density also have higher probability of flood fatalities. In Model-6 to Model-8, some election years have been added. The estimates show that in state election years, flood fatalities is lower compared to non-state election years, because incumbent state government try to minimize the flood fatalities with the help of different flood disaster funding. If the government is successful in disaster management activities, the state incumbent government contests the election in the same year and again occupies the state office for the next five years. In India, when a disaster occurs, all political parties start to play a political game over natural disaster for winning the election battle. The study by Chang and Berdiev (2015) examined that the number of deaths related to flood disaster had the largest impact on the probability of changing the existing government. Similarly Garrett and Sobel (2003) showed that the disaster expenditure by Federal Emergency Management Agency (FEMA) is significantly higher in the election years in USA. The present study finds that the national and state same election year did not significantly affect the flood fatalities because during the national election year the incumbent central government gave equal importance towards all states with regard to the distribution of all central assistance which is shown in Model-7 and Model-8 in Table-1.

Another interesting finding of the study is that the coefficient of political alignment dummy is negative and significant in Model-7 and Model-8. The estimate shows that when centre and state has same political party government or coalition political party government the respective states experienced lower flood fatalities compared to non-alliance political party government or different political party government in both state and centre. The same political party ingovernment or coalition political party government had enhanced the efficiency in terms of administrative issues of minimizing the flood fatalities in various states of India. The reason behind this is that the central government had released favorable disaster funding to the respective states which had the same political party or coalition political government in the states. Another reason is that opposition political party lobby more disaster grant for respective disaster affected states. Those political lobby shows that the opposition political party is more concerned about the natural disaster impact than ruling parties. There are a few evidences shown in section 1 in introduction part. In the context of United States, Garrett and Sobel (2003) have shown that almost half of federal disaster payments are politically motivated. In the context of India, the central government had been discriminating against those states which are governed by different or non-coalition political parties. There are evidences which show that the central government is often reluctant to declare a specific natural disaster as a national disaster due to non-alliance political party government in different states in India. However, during the disaster the opposition political parties show more concern about the natural disaster than the ruling party government in order to attract public opinion in their favors during the election or popular support from potential voters during the election. As a result, a political blame game gets started over disaster. When the ruling party is in power, the opposition blames them over disaster and if the opposition political party comes in power, the previous ruling party starts to blame them over disaster. This is the tradition of political parties in India doing political business over disaster. Similarly expenditure of irrigation and flood control and literacy are not significantly minimizing the flood disaster death.

For robust results, I have estimated equation (1) using unconditional fixed effect negative binomial model. The estimates represented in Table 2. The coefficient of PCI is negative and significant in Table-2 after adding the all control variables. Overall, our estimates are robust throughout the models, which are consistent with our earlier findings (Table-1, Poisson regression estimates). Flood magnitude is positively and significantly associated with flood fatalities, while house damage and population affected by flood are positively correlated with flood fatalities. The estimated coefficient of the state election year is negative and statistically significant in Model-6 & Model-7. Again the coefficient of political alignment dummy is negative and significant in Model-6 and Model-7 in Table-2. Again, this finding is consistent with our earlier findings in Table-1. The estimated coefficient of density of population is not significant, but it is significant in the Poisson estimate shown in Table-1. In addition same election years of both centre and state have not significantly affected the flood fatalities in both models in Table-1 and Table-2. Again estimate of literacy rate and expenditure of irrigation and flood control have not significantly mitigate the flood disaster impacts in terms of flood deaths in both Models, which is shown in Table-1 and Table-2.

Table 2: Per capita income, flood magnitude and political alignment: FE NB Model

Variables	Model-1	Model-2	Model-3	Model-4	Model-5	Model-6	Model-7
Ln(PCI)	-0.689***	-0.542***	-0.611***	-0.694***	-0.710***	-0.753***	-0.889***
	(0.185)	(0.189)	(0.181)	(0.165)	(0.167)	(0.163)	(0.174)
Ln(Flood Magnitude)		0.208***	0.129***	0.141***	0.142***	0.141***	0.144***
		(0.020)	(0.020)	(0.020)	(0.020)	(0.019)	(0.019)
Ln (Pop Affected / Total Pop)			0.237***	0.137***	0.136***	0.138***	0.136***
			(0.018)	(0.019)	(0.019)	(0.019)	(0.019)
Ln(House Damage)				0.105***	0.103***	0.102***	0.101***
				(0.011)	(0.011)	(0.011)	(0.011)
Ln(Population Density)					0.086	0.096	0.110
					(0.080)	(0.079)	(0.081)
State Election Year Dummy					-0.130	-0.309**	-0.326**
					(0.114)	(0.148)	(0.146)
Political Alignment Dummy						-0.283**	-0.292**
						(0.132)	(0.133)
Centre State Same Election Year Dummy						0.295	0.391
						(0.267)	(0.283)
Literacy Rate							-0.005
							(0.005)
Ln (Exp of irrigation & flood control/TE)							0.107
							(0.174)
Ln (Exp of irrigation & flood control/TE)(-1)							-0.239
							(0.177)
Constant	10.051***	8.808***	10.467***	9.922***	9.755***	10.087***	12.942***
	(1.839)	(1.869)	(1.785)	(1.653)	(1.680)	(1.636)	(1.910)
Region FE	Y	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y	Y
Observations	608	608	608	608	608	608	589
$\chi2$ (d.f.)	254.52	385.59	611.26	804.33	828.08	844.50	831.61
	(37)	(38)	(39)	(40)	(42)	(44)	(46)
Log-likelihood	-3131	-3092	-3016	-2969	-2968	-2965	-2875
No of States	19	19	19	19	19	19	19

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1, Dependent variable is Flood Fatalities.

The study employed Control Function Approach (CFA) to examine the impact PCI on flood fatalities using equation (1). This model is used for two reasons, first, outcome variable (flood mortalities) is non-negative count variable. Secondly PCI is continuous endogenous variable. This is the first empirical study that has used CFA in disaster data in the context of India.. The state with higher PCI leads to minimize the flood death and higher flood death cause a lower PCI. To control the endogeneity, I have used state wise 'liable to flood prone area' and state wise 'drought prone area' as an instrument for PCI. State with higher liable to flood prone area and drought prone area suffered lower PCI. The validity of instrument is shown in Table-11 in Appendix. Model-1 to Model-8 the coefficients of liable to flood affected area and drought prone area is negative and significant.

This shows that lower PCI due to higher liable to flood affected area and more drought prone area in the states. The significant of ρ in Table-11 shows that PCI is endogenous variable. The estimate of CFA is representing in Table-3. The coefficient of PCI is still negative and significant throughout the models and magnitudes of coefficient is four times greater than the previous estimates which is shown in both Table-1 and Table-2.

Table 3: Per capita Income and Political Alignment: IV Poisson Model (CF Approach)

Variables	Model-1	Model-2	Model-3	Model-4	Model-5	Model-6	Model-7	Model-8
Ln(PCI)	-2.846*** (0.394)	-2.887*** (0.426)	-2.769*** (0.425)	-3.050*** (0.402)	-2.430*** (0.374)	-2.402*** (0.374)	-2.418*** (0.371)	-2.728*** (0.386)
Ln (Area Affected lh)		0.175*** (0.017)	0.080*** (0.016)	0.048*** (0.016)	0.028* (0.016)	0.030** (0.016)	0.031** (0.016)	0.050** (0.016)
Ln(House Damage)			0.135*** (0.013)	0.102*** (0.013)	0.098*** (0.013)	0.098*** (0.012)	0.096*** (0.012)	0.093*** (0.012)
Ln(Population affected/Total pop)				0.157*** (0.022)	0.131*** (0.021)	0.127*** (0.021)	0.132*** (0.021)	0.122*** (0.022)
Ln (Flood Durations)					0.120*** (0.017)	0.124*** (0.017)	0.124*** (0.017)	0.117*** (0.018)
Ln(Social security Exp/Total Exp)					-0.092 (0.087)	-0.098 (0.085)	-0.102 (0.088)	-0.189* (0.112)
Ln(Social security Exp/Total Exp)(-1)					-0.078 (0.096)	-0.075 (0.094)	-0.070 (0.097)	0.006 (0.109)
State Election Year Dummy						-0.244* (0.131)	-0.322** (0.138)	-0.325** (0.141)
Political Alignment Dummy							-0.309** (0.142)	-0.269* (0.147)
Literacy Rate							0.007 (0.005)	0.001 (0.005)
Ln (Exp of irrigation & flood control/TE)								0.039 (0.219)
Ln (Exp of irrigation & flood								-0.429** (0.218)

control/TE)(-1)								
Constant	30.708***	31.571***	29.173***	32.763***	29.807***	29.542***	29.860***	31.266***
	(3.859)	(4.141)	(4.130)	(3.910)	(4.161)	(4.163)	(4.132)	(4.073)
Region FE	Y	Y	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y	Y	Y
Observations	608	608	608	608	589	589	589	589
No of States	19	19	19	19	19	19	19	19

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Dependent variable is Flood Fatalities. **Instrument:** State wise Liable to flood prone area and Drought prone area as an instrument for Ln (Per Capita Income).

In additions the coefficients of house damage and population affected by flood is positive and significant while coefficients of state election year and political alignment is negative and significant respectively. Which is consistent with earlier findings and estimates are shown in Table-1 and Table-2. In this model study used area affected by flood and flood durations instead of flood magnitude. In Table-3 the coefficient of area affected by flood and flood durations is positively correlated with flood fatalities, this implies that higher flood death caused by higher area affected by flood and longer flood durations of floods respectively. The one year lag coefficient of irrigation and flood controls has negatively correlated in flood fatalities in Model-8. The estimate shows that expenditure of irrigation and flood control has significantly mitigating the flood death in Indian states. Similarly expenditure on social security's has negatively correlated with flood mortalities. This shows that higher government expenditures in different social activities cause a decline the flood death in Indian states. Social security's is one of short term insurance to minimize the flood disaster impacts.

The study also examined the relationship between Human Development Index (HDI), rural Workforce Participation Rate (WPR) and flood fatalities using equation (1). For robust result, the study used state wise HDI instead of real PCI because HDI is one of the better economic indicators measure to show the overall socioeconomic performance of the Indian states. The state with higher achievement in HDI represents better socioeconomic conditions for people compared to the states with low levels of HDI. The state wise HDI includes three major components such as PCI, state wise education attainments and health attainments respectively. The estimated results are shown in Table-4. The estimated coefficient of HDI is negative and statistically significant in Poisson estimation model after controlling for the population affected by floods and literacy rate. This shows that states with higher levels of HDI have experienced lower flood fatalities.

Table 4: HDI, Rural WPR and Flood Fatalities

	FE Poisson Model			FE NB Model		
Variables	Model-1	Model-2	Model-3	Model-1	Model-2	Model-3
HDI Index	-2.184***	-1.670**	-1.193**	-1.255*	-0.436	-1.990***
	(0.797)	(0.788)	(0.620)	(0.653)	(0.719)	(0.709)
RWPR	-0.007***	-0.006***	-0.003**	-0.003	-0.004	-0.003
	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)
Ln (Flood Magnitude)		0.165***	0.076		0.237***	0.122*
		(0.047)	(0.048)		(0.065)	(0.062)
Ln (Population			0.287***			0.271***
affected/Total pop)			(0.053)			(0.037)
Literacy Rate			-0.006			-0.001
			(0.013)			(0.010)
Constant	7.688***	7.241***	8.218***	8.218***	5.467***	8.067***
	(1.171)	(1.113)	(1.481)	(1.481)	(1.389)	(1.547)
Region FE	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
Observations	133	133	133	133	133	133
$\chi2$ (d.f.)	49.64	190.03	477.92	75.55	97.27	163.23
	(13)	(14)	(16)	(13)	(14)	(16)
Log-likelihood	-8652	-8023	-5151	-682	-676	-655
No of States	19	19	19	19	19	19

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1, Dependent variable is Flood Fatalities.

In Model-3 the coefficient of HDI is still negative and significant after adding all control variables in Poisson model. The results indicate that the states with higher rank in terms of per capita income, better education attainment and better medical facilities have experienced fewer fatalities during the floods. The state capable to handle disaster impacts efficiently due to higher per capita income, better education attainment and availability better medical faculties respectively. The coefficient of rural workforce participation rate is negative and significant in all models in Poisson model in Table-4. The estimates show that there exists an inverse relationship between rural work force participation rate and flood fatalities, the state with higher the rate of rural work force participation experienced lower flood fatalities. The rural work force participation is one type of insurance to prevent flood disaster impacts in rural areas. It serves as a better social security instrument for rural household as it generates higher ability of the household to spend towards disaster preparedness such as construction of strong house. The frequency of flood affects the rural population, compared to the urban areas. In rural area around 58 per cent of households depend on agriculture sector (National Sample Survey, 2012-13). Frequency of flood in rural areas directly affects the agricultural crop and agricultural wage as well as workforce participation rate. Lower agricultural incomes reduce the level of social security arrangements among the rural household in India. Similarly, more population affected by flood leads to increasing the flood fatalities.

For robust results, the study has employed fixed effect NB estimates to examine the impact of HDI and rural WPR on flood fatalities. The estimated results are shown in Table-4. The study finds that HDI has significantly reduced the number of flood deaths in Model-1 in Negative Binomial model after controlling flood magnitude, literacy rate and population affected by floods. The HDI coefficient is negative and significant in Model-3 in Negative Binomial estimate after adding all control variables. This finding is also consistent with Poisson model estimates shown in Table-4.The coefficient of rural WPR is not significant in Negative Binomial model shown in Table-4. Again, flood magnitude and population affected have significantly increased the flood fatalities in Indian states.

4.2 Impact of Economic Development, Flood magnitude on Flood Damages in Indian States.

In this section, the study employed fixed-effect Tobit model to examine the impact of economic development proxy of real PCI on total economic loss due to flood using equation (2). The estimate of Tobit model is presented in Table-5. In Model-1, the coefficient of PCI is negative and statistically significant at 1 percent level, which shows that higher PCI causes decline economic losses after controlling other factors. The coefficient of PCI is still negative and statistically significant in Model-4 after adding different control variables. The magnitude of coefficient of PCI varies from 0.97 to 0.60. The estimate is robust throughout the estimated models. This result is consistent with (Neumayer et al., 2014). There are other studies (Toya and Skidmore, 2007; Raschky, 2008; Schumacher and Strobl, 2011), which suggest that economic development is one of the major determinants to mitigate disaster impacts in terms disaster losses.

Table 5: Economic Development, Flood magnitude and Flood Damages: FE Tobit Model

Variables	Model-1	Model-2	Model-3	Model-4
Ln (PCI)	-0.979***	-0.822**	-0.713***	-0.604**
	(0.359)	(0.334)	(0.272)	(0.286)
Ln(Flood Magnitude)		0.276***	0.079**	0.073*
		(0.038)	(0.036)	(0.038)
Ln(Population affected/Total pop)			0.542***	0.448***
			(0.037)	(0.042)
Ln(House Damage)				0.095***
				(0.027)
Literacy Rate				0.001

				(0.007)
Ln (Exp of irrigation & flood control/TE)				0.314
				(0.282)
Ln (Exp of irrigation & flood control/TE)(-1)				-0.124
				(0.276)
Constant	2.885	1.613	3.664	1.540
	(3.491)	(3.260)	(2.675)	(3.091)
Region FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Observations	608	608	608	589
Left Cens.	314	314	314	306
Pseudo R2	0.054	0.080	0.237	0.246
Log-likelihood	-856	-832	-690	-658
No of States	19	19	19	19

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1, Dependent variable is Log of (Total Damage/ GSDP+0.01).

The coefficient of flood magnitude is positive and statistically significant in all models. The estimation results show that there is a positive relationship between flood magnitude and flood damage. The higher flood magnitude associated with more economic losses due to flood. Similarly the total population affected and house damage is also positive and statistically significant in Model-4. The results indicate that higher economic losses due to large number of people are affected and more houses were affected by floods. In Model-4, expenditure of irrigation and flood control and literacy rate is not significantly reduced the economic losses.

Next, I have tried to examine the impact of economic development proxy of PCI on economic loss due to flood using Fixed Effect IV Tobit model. The real PCI is an endogenous variable, to control endogeneity; I have used state wise *liable to flood affected area* and *drought prone area* as instruments for real PCI. Larger the size of liable to flood affected area and drought prone area, lower will be the state gross domestic products. This leads to lower the per capita income levels of the states. The estimates of fixed effect IV Tobit models are presented in Table-6. The coefficient of real PCI is negative and statistically significant in Model-1 in Table-6 after controlling other variables. In Model-4 magnitude of coefficient of real PCI greatly reduced after adding the control variables. The estimates show that there is an inverse relationship between PCI and flood damage. Again the flood magnitude and population affected by flood is positive correlated with flood damages. This shows that higher magnitude of flood causes huge flood damage in terms of total economic loss in Indian states. This finding is consistent with our earlier findings (FE Tobit model in Table-5).

Table 6: Economic Development, Flood magnitude and Flood Damages: IV Tobit Model

Variables	Model-1	Model-2	Model-3	Model-4
Ln (PCI)	-4.317***	-2.915**	-3.026***	-2.937***
	(1.268)	(1.183)	(0.943)	(1.100)
Ln(Flood Magnitude)		0.503***	0.108*	0.111*
		(0.073)	(0.065)	(0.066)
Ln(Population affected/Total pop)			0.978***	0.973***
			(0.058)	(0.060)
Ln (Exp of irrigation & flood control/TE)				-0.062
				(0.573)
Ln (Exp of irrigation & flood control/TE)(-1)				0.062
				(0.566)
Literacy Rate				0.044
				(0.013)
Constant	32.654***	19.543*	26.467**	27.339**
	(12.188)	(11.386)	(9.077)	(11.109)
Region FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Observations	608	608	608	589
Left Cens.	130	130	130	128
Wald test of exogeneity (chi2(1)) (P-value)	9.17	3.99	9.10	7.98
	(0.002)	(0.045)	(0.002)	(0.004)
Log-likelihood	-1508	-1487	-1341	-1276
No of States	19	19	19	19

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1, Dependent variable is Log of (Total Damage/ GSDP+0.01), **Instrument:** *Liable to flood prone area* and *Drought prone area* as an instrument for Ln (Per Capita Income). The significant of Wald test of exogeneity test shows that real PCI is endogenous variable.

4.2.1 Role of the government to mitigate economic losses due to flood

In this section the study examines the relationship between government intervention in terms of expenditure on natural calamity and economic losses due to floods in Indian states using equation (3). The study applied FE IV Tobit model to examine the causal impact of expenditure on natural calamity and economic losses due to floods. The expenditure on natural calamity is an endogenous variable. Higher flood intensity causes higher state spending towards mitigating flood impact in terms of flood damages. Again higher state expenditure to words helps to reduce flood impacts to a larger extent. I have used state wise '*liable to flood affected area'* as an instrument for expenditure on natural calamity. If the particular state has larger flood prone area, the state government is likely to be more active in terms of minimizing the flood impact through disaster funding. The estimates of FE IV Tobit model are presented in Table-7. Another interesting finding of the study is that the coefficient of expenditure of natural calamity is negative and significant in Model-1 in Table-7 after controlling total population affected by flood, flood durations and house damage by floods. Overall the estimates are consistent because the coefficient of expenditure on natural calamity is significant in the Model-4 after adding all the control variables. The estimate results show that expenditure on natural calamity reduces the impact of flood damage in Indian states. The reason behind this is that the state government plays a significant role to mitigate the flood impact with the help of different disaster funding. The expenditure on natural calamity is one of the key instruments of the state government to mitigate disaster damage. The state governments partially minimize flood impacts through different long term government's policies such as river reforms and river connectivity and flood warning and flood forecasting systems and construction of dams and reservoir etc. Therefore an efficient flood management policy is essential to mitigate flood impacts.

Table 7: Expenditure of natural calamity and Flood Damages: IV Tobit Model

Variables	Model-1	Model-2	Model-3	Model-4
Ln (Exp of Natural Calamity/ TE)	-1.595** (0.769)	-1.909** (0.935)	-2.585** (1.244)	-1.645* (0.868)
Ln(Area affected lh)	0.246*** (0.051)	0.221** (0.050)	0.167*** (0.056)	0.074 (0.049)
Ln(Flood Durations)		0.151** (0.061)	0.165** (0.073)	0.103* (0.053)
Ln(House damage)			0.142*** (0.053)	0.019 (0.053)
Ln(Population affected/Total pop)				0.312*** (0.072)
Literacy Rate				-0.015 (0.011)
Constant	-11.531*** (3.461)	-12.524*** (4.083)	-16.654*** (5.625)	-9.717*** (3.676)
Region FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Observations	608	608	608	606
Left Cens.	526	526	526	526

Wald test of exogeneity (chi2(1)) (P-value)	8.62 (0.003)	7.41 (0.006)	6.65 (0.009)	6.13 (0.013)
Log-likelihood	-1027	-1020	-1010	-991
No of States	19	19	19	19

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1, Dependent variable is Log of (Total Damage/ GSDP+0.01).), **Instrument:** State wise *liable to flood prone area* is an instrument for Ln (Expenditure of Natural Calamity/Total Exp). The significant of Wald test of exogeneity test shows that real PCI is endogenous variable.

4.3 Impact of Economic Development, Flood magnitude on crop damage

In this section the study has examined the impact of economic development on crop damages in Indian states using equation (3). The study has estimated Fixed-effect Tobit model to examine the causal impact because the dependent variable consists of zero observations. The estimated results are shown in Table-8. The empirical results show that there exists an inverse relationship between real PCI and crop damage. The coefficient of Per Capita Income (PCI) is negative and significant, which means higher real PCI results in reducing crop damages after controlling flood magnitude, populations affected, literacy rate and expenditure of irrigation and flood controls. In Model-4 the coefficient of Per Capita Income (PCI) still negative and significant after adding all control variables. The estimates are robust throughout the models. Overall, higher level of economic development reduces the extent of crop damage in all models shown in Table-4. I find that the coefficient of flood magnitude is positive and significant in Model-2, which means that there exist a positive relationship between flood magnitude and crop damages in Indian states. The population affected by flood has a positive and significant effect on crop damage in Model-3 and Model-4, while expenditure of irrigation and flood controls is not significantly reduce crop damage.

Table 8 :Economic Developments, Flood Magnitude and Crop Damage: FE Tobit Model

Variables	Model-1	Model-2	Model-3	Model-4
Ln (PCI)	-0.743* (0.396)	-0.631* (0.381)	-0.583** (0.276)	-0.596* (0.306)
Ln (Flood Magnitude)		0.255*** (0.044)	-0.010 (0.036)	-0.007 (0.037)
Ln(Population affected/Total pop)			0.761*** (0.065)	0.764*** (0.067)
Ln (Exp of Irrigation Flood control/TE)				0.088 (0.287)
Ln (Exp of Irrigation Flood				-0.198 (0.287)

control/TE)(-1)				
Literacy Rate				-0.009
				(0.008)
Constant	0.852	-0.056	3.472	3.269
	(3.833)	(3.687)	(2.749)	(3.223)
Region Dummy	Y	Y	Y	Y
Time Dummy	Y	Y	Y	Y
Observations	608	608	608	589
Left Cens.	390	390	390	381
Pseudo R2	0.068	0.085	0.321	0.318
Log-likelihood	-686	-674	-500	-482
No of States	19	19	19	19

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1, Dependent variable is a Ln of (Agriculture Crop Damage/ Agriculture GSDP+0.01).

Table 9 :Economic Developments, Flood Magnitude and Crop Damage: IV Tobit Model

Variables	Model-1	Model-2	Model-3	Model-4
Ln (PCI)	-1.619**	-1.609**	-2.105***	-2.291***
	(0.764)	(0.732)	(0.614)	(0.802)
Ln (Flood Magnitude)		0.144***	0.010	0.017
		(0.038)	(0.032)	(0.032)
Ln(Population affected/Total pop)			0.547***	0.533***
			(0.087)	(0.083)
Ln (Exp of Irrigation & Flood control/TE)				0.113
				(0.275)
Ln (Exp of Irrigation & Flood control/TE)(-1)				-0.510**
				(0.255)
Literacy Rate				0.001
				(0.009)
Constant	10.550	10.562	17.990***	19.993**
	(7.378)	(7.059)	(5.903)	(7.967)
Region Dummy	Y	Y	Y	Y
Time Dummy	Y	Y	Y	Y
Observations	608	608	608	589
Left Cens.	505	505	505	491
Wald test of exogeneity (chi2(1))	2.60	3.03	7.85	5.71
(P-value)	(0.106)	(0.081)	(0.005)	(0.016)
Log-likelihood	-342	-674	-233	-195
No of States	19	19	19	19

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1, Dependent variable is a Ln of (Agriculture Crop Damage/ Agriculture GSDP+0.01). **Instrument:** State wise *drought prone area* is an instrument for Ln (PCI). The significant of Wald test of exogeneity test shows that real PCI is endogenous variable.

Apart from the above analysis, the study has also examined the impact of economic development on crop damage using FE IV Tobit model. The study employed FE IV Tobit model because Per Capita

Income (PCI) is an endogenous variable. This is already explained in details in section-4. Frequency of floods and higher magnitude of flood affects not only human lives but also causes destruction of agricultural crops. Agriculture output is one of the major contributes to words the total value of output or gross state domestic products. The lower agricultural output leads to a fall in gross state domestic products, drives down the per capita income of the states. So there exist causal relationship between flood impact in terms of crop damage and PCI. To control the endogeneity I have used *drought prone area* as an instrument for per capita income. The state with higher drought prone area adversely affected by agriculture outputs, which leads to less contribute to state GSDP. The FE IV Tobit model estimates are presented in Table-10.The coefficient of per capita income is negative in all models in Table-10. The estimate model is consistent with the earlier FE Tobit model in Table-9.

4.3.1 Impact of expenditure of natural calamity on crop damages

In this section I have examined the impact of expenditure on natural calamity on crop damages using Fixed-effect IV Tobit Model. The government expenditure on natural calamity is an endogenous variable. Higher crop damage caused due to floods results in larger government spending on natural calamity heads. There exists a reverse causality between crop damage and government spending on natural calamity. To control the endogeneity problem, the study has used state wise *liable to flood affected area* as instruments for the government spending on natural calamity. Table-10 represents the estimates of the IV Tobit model.

Table 10: Expenditure of natural calamity and Crop Damages: IV Tobit Model

Variables	Model-1	Model-2	Model-3	Model-4
Ln (Exp of Natural Calamity/ TE)	-1.637** (0.658)	-1.017** (0.908)	-1.993* (1.154)	-1.551* (0.867)
Ln(Crop Area affected lh)	0.530*** (0.060)	0.529*** (0.061)	0.531*** (0.065)	0.241*** (0.057)
Ln(Flood Durations)		0.086 (0.070)	0.083 (0.082)	-0.028 (0.063)
Literacy Rate			0.018 (0.012)	-0.010 (0.010)
Ln(Population affected/Total pop)				0.720*** (0.088)
Constant	-12.269*** (2.960)	-13.695*** (3.913)	-14.348*** (4.929)	-8.652** (3.569)
Region FE	Y	Y	Y	Y

Year FE	Y	Y	Y	Y
Observations	608	608	608	606
Left Cens.	390	390	390	390
Wald test of exogeneity (chi2(1)) (P-value)	9.20 (0.002)	7.17 (0.007)	4.39 (0.036)	3.76 (0.052)
Log-likelihood	-1370	-1364	-1362	-1271
No of States	19	19	19	19

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1, Dependent variable is Ln (Agriculture Crop Damage/ Agriculture GSDP+0.01). **Instrument:** State wise *liable to flood prone area* is an instrument for Ln (Expenditure of Natural Calamity/Total Exp).

In Model-1 to Model-4, the coefficient of expenditure on natural calamity is negative and significant, which shows that expenditure on natural disaster has significantly reduced crop damages. The reason behind this could be that the government tries to minimize crop damage through different disaster funding. Generally, after the disaster occurrence, the government announces loan waiver and release the crop damage compensation for the affected farmers. Similarly population affected and has significantly increased the extent of crop damage the result is shown in Model-4. Higher crop area affected by flood adversely affected the crop damage which is shown in Model-4.

Section 5: Conclusion and policy implications

The cross country empirical studies have suggested that higher economic development and democratic institution and lower public sector corruption can cause a decline in the natural disaster impact. There is no such literature available in the Indian context. The present study has examined the relationship between socio-economic development and flood impact in case of Indian states. The study empirically shows that higher economic development (proxied by real per capita income) can significantly reduce human mortality and economic losses due to flood disaster. Apart from economic development, the study confirms that higher flood magnitude, duration of flood and areas affected by flood have significantly increased the flood mortalities and flood damages. Government activities such as expenditure on natural calamity can minimize the flood impact in terms of crop damage and total flood damages. The empirical study also finds that during the state election year the flood impact in terms of flood mortalities is lower compared to a non election year. Political alignment (presence of same political party government in both centre and state) can significantly minimize the disaster impact due to favorable disaster funding.

The empirical results suggest that both central and state governments should take long term actions to mitigate the flood impacts in terms of flood mortalities and economic losses including agriculture crop losses. The government can make an effort of creating non-structural measures such as pre flood warning system, flood forecasting, effective flood managements in terms of evacuation and rehabilitation and relief distributions etc to partially mitigate the flood impacts. Again, both state government and central government can emphasize on structural measures such as construction of river embankments, maintenance of dams and reservoirs, river reforms and river connectivity to channelize food water from one river to the other in order to minimize the flood impacts. Apart from the above measures, strong institutional coordination is also required to prevent the flood impacts. Other measures such as Government spending on flood control and irrigation, provision of houses for rural poor and creating community awareness programme about flooding can also considerably reduce the flood impacts.

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Appendix:

Table 11: First stage regression result

Variables	Model-1	Model-2	Model-3	Model-4	Model-5	Model-6	Model-7	Model-8
Ln (State wise drought prone area)	-0.039*** (0.002)	-0.039*** (0.001)	-0.040*** (0.001)	-0.040*** (0.001)	-0.043*** (0.001)	-0.045*** (0.001)	-0.043*** (0.001)	-0.042*** (0.002)
Ln (State wise liable to flood affected area)	-0.073*** (0.006)	-0.074*** (0.005)	-0.078*** (0.005)	-0.079*** (0.005)	-0.086*** (0.005)	-0.086*** (0.006)	-0.085*** (0.006)	-0.080*** (0.006)
Control Variables		Y	Y	Y	Y	Y	Y	Y
Region FE	Y	Y	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y	Y	Y
Observations	608	608	608	608	589	589	589	589
No of States	19	19	19	19	19	19	19	19
ρ	2.921*** (0.454)	2.931*** (0.456)	2.505*** (0.450)	3.024*** (0.424)	2.257*** (0.414)	2.235*** (0.414)	2.209*** (0.415)	2.528*** (0.442)

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1, Dependent variable is Ln (PCI).

Figure 1: Average flood mortalities per lakh population during 1980-2011

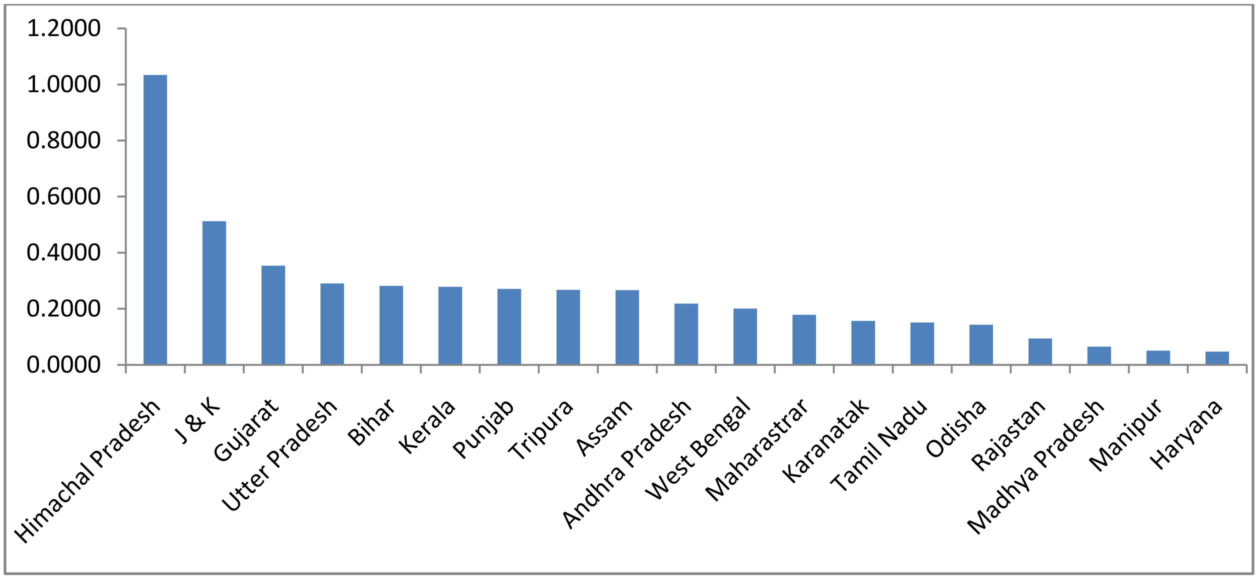

Figure 2: Average total damage due to flood per unit of GSDP during 1980-2011

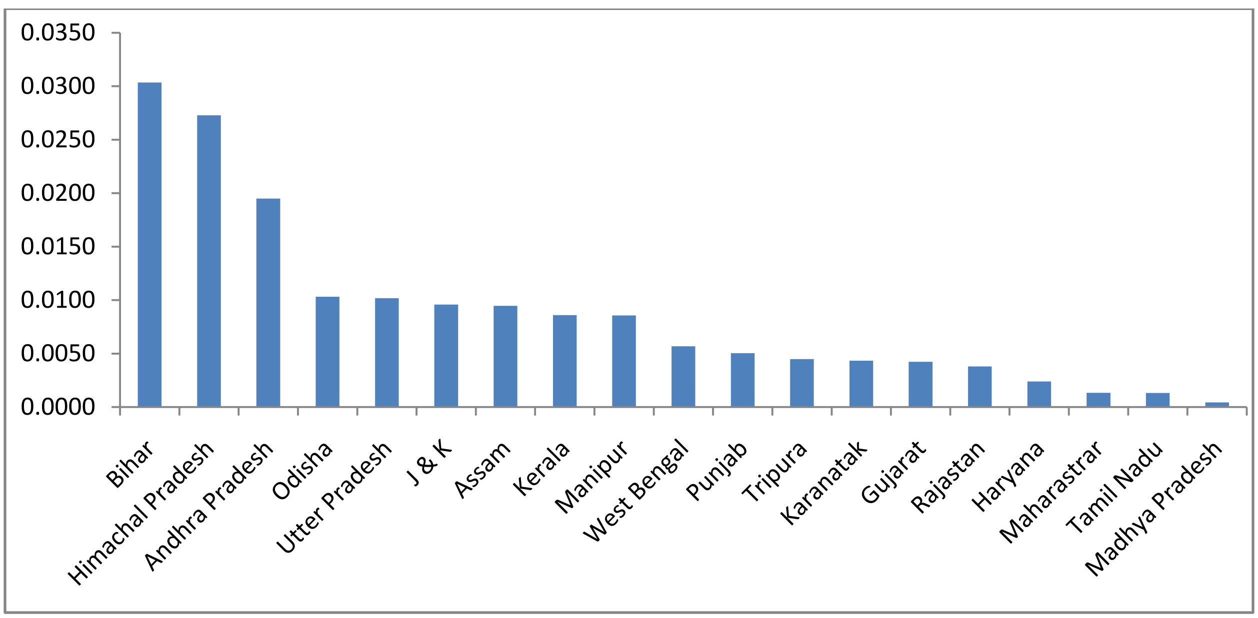

Figure 3: Average crop damage due to flood per unit of agriculture GSDP during 1980-2011

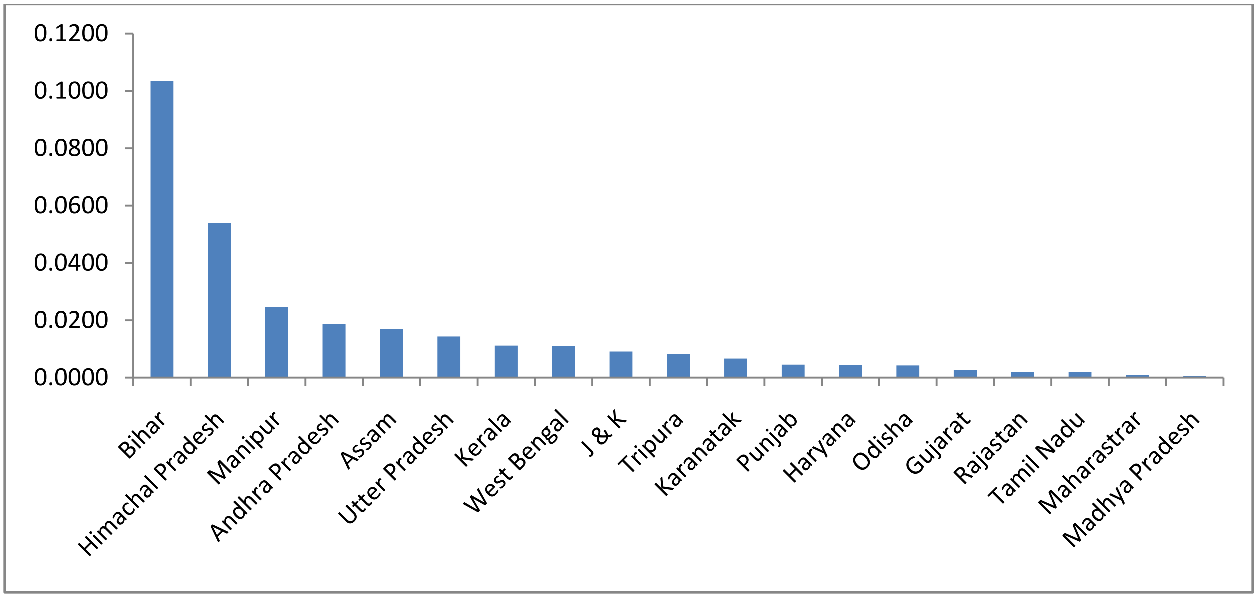

Table 12: Summary Statistics and definition of Variables

Variables	Definition of Variables	Obs	Mean	Std. Dev	Min	Max
Flood fatalities	State wise number of people died during floods events	608	99.55	182.91	0.00	1399.00
Ln (Total Damage/GSDP)	[State wise flood damage included crop losses, house damage and public utility losses Rs in Crore/GSDP at current price) +0.01]	608	-9.38	5.94	-23.19	-0.37
Ln (SDP Damage/Agriculture GD)	[State wise crop losses Rs in Crore/Agriculture GSDP at current price) +0.01]	608	-10.34	6.38	-21.14	1.04
Ln (PCI)	Real Gross State Domestic Product (GSDP)/ State wise population	608	9.85	0.54	8.41	11.15
Ln (Liable to flood affected area in lakh hectors)	Rashtriya Barh Ayog (RBA) has estimated state-wise liable to flood affected area “by adding the maxima of flood affected area (1953-78) in any year to the area protected up to 1978 and then deducting portion of the protected area included in the flood affected area due to failure of protection works”	608	2.02	1.57	-1.61	4.30

Ln (Drought prone area in lakh hectors)	State wise drought prone area in lakh hectors	608	-0.55	5.96	-9.21	5.27
Ln (Flood magnitude)	(Area affected by flood in sq km × Severity × Duration in Days)	608	2.03	2.98	0	8.28
Ln (Flood duration)	[(End days - beginning days + 1)+0.01]	608	-0.78	3.49	-4.61	5.08
Ln (Total area affected)	State wise total area affected by flood including crop area in lakh hectors+0.0001	608	-1.83	4.58	-9.21	4.60
Ln (Crop area affected)	State wise crop affected area by flood in lakh hectors+0.0001	608	-2.88	4.52	-9.21	4.59
Ln (Population affected by flood/Total Pop)	(State wise population affected by flood + 0.01)/ State wise total population	608	-5.67	3.41	-12.19	-0.52
Ln (House damage)	State wise number of house damage by floods + 0.01	608	6.95	6.00	-4.61	20.11
Ln (Population density)	State wise total population / State wise area in square K.M	608	5.61	0.80	3.27	7.01
Literacy rate	Ratio of state wise literate population over state wise adult population	608	55.13	11.95	22.70	94.00
Ln (Exp of irrigation & flood control)	Expenditure of irrigation and flood controls by state government / Total expenditure of the state government.	608	-3.41	0.97	-6.11	-1.78
Ln (Exp of irrigation & flood control) (-1)	One year lag expenditure of irrigation and flood controls by state government / Total expenditure of the state government.	589	-3.37	0.96	-6.11	-1.78
Ln (Exp of natural calamity/Total Exp)	Revenue expenditure of natural calamities by state government / Total expenditure of the state government.	608	-5.32	1.19	-10.95	-1.94
Ln(Social security Exp/Total Exp)	Expenditure on social security and welfare by state government / Total expenditure of the state government.	608	-4.40	0.84	-10.79	-2.06
Ln(Social security Exp)(-1)	One year lag expenditure on social security and welfare by state government / Total expenditure of the state government.	589	-4.39	0.84	-10.79	-2.06
State Election Year Dummy	State election held in different years in different states is equal to 1, otherwise zero.	608	0.22	0.41	0.00	1.00
Political Alignment Dummy	Centre and state has same political party or coalition political party governments in particular years and particulate states are equal to 1, otherwise zero.	608	0.29	0.46	0.00	1.00

Centre State Same Election Year Dummy	National election and state election held in same year is equal to 1, otherwise zero.	608	0.08	0.26	0.00	1.00
HDI Index	State wise Human Development Index. It combines three important components such as per capita consumption expenditure, composite index of educational attainment and health attainment.	133	0.36	0.21	0.02	1.00
RWPR	Rural Work Force Participation Rate per 1000 population = State wise number of rural persons employed per thousand rural persons.	133	438.94	75.79	275.00	622.00