Macroeconomic Impact of Natural Disasters: Evidence from India

A dissertation submitted to the University of Hyderabad in partial fulfilment of the Requirements for the award of

MASTER OF PHILOSOPHY

IN

ECONOMICS

BY

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NOVEMBER-2016

DECLARATION

I, **Aaqib Ahmad Bhat** hereby declared that the present dissertation entitled ***"Macroeconomic Impact of Natural Disasters: Evidence from India"*** carried out under the supervision of **Dr. Prajna Paramita Mishra,** School of Economics, for the award of Master of Philosophy in economics from the University of Hyderabad, is an original work by me.

The present work is carried out by me during the period of July 2015 up to November 2016 and has not been submitted to any other University or Institute for the award of any degree.

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I declare to the best of my Knowledge that no part of the dissertation was earlier submitted for the award of a research degree to any university or institute.

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ABBREVIATIONS

ADF	Augmented Dickey Fuller test
AIC	Akaike-Information Criterion
AFFP	Percentage of population affected
ARDL	Auto-regressive Distributed Lag model
CRED	Centre for Research and Epidemiology of Disasters
DAMO	Percentage of Damage to annual output
DW	Durbin-Watson Statistic
DI	Disaster Intensity
ECLAC	Economic Commission for Latin America and the Caribbean
ECM	Error Correction Mechanism
EM-DAT	Emergency Database
FDI	Foreign Direct Investment
GCE	Government Consumption Expenditure
GDP	Gross Domestic Product
GDPG	Growth rate of Gross Domestic Product
GPGDP	Growth rate of Per Capita Gross Domestic Product
IMF	International Monetary Fund
INV	Investment to Gross Domestic Product
IFRC	International Federation of the Red Cross and Red Crescent
KILP	Percentage of Population Killed
KPSS	Kwiatkowski-Phillips-Schmidt-Shin Test
NXM	Net Exports to Gross Domestic Product
PGDP	Per Capita Gross Domestic Product
PP	Phillips-Peron test
RBI	Reserve Bank of India
SBC	Schwarz-Bayesian Criterion
UNDRCO	United Nations Disaster Relief Coordinator

USA	United States of America

USD	United States Dollar
WDI	World Development Indicators

ACKNOWLEDGEMENTS

At the outset I would like to thank Almighty Allah for bestowing me with his hidden support and strength that kept me quite consistent and active to put the completion of our research work on time.

Next my deep gratitude goes to my honourable Supervisor Dr. Prajna Paramita Mishra for her guidance, encouragement and co-operation throughout my research work. Her tireless efforts and great enthusiasm for motivating research scholars is remarkable. Her valuable comments and multi-dimensional advice proved quite comprehensive to execute our research work in a better integrated manner.

I am thankful to Prof. B. Kamaiah, Dean School of Economics, and other teaching and non teaching staff for providing constant encouragement to complete this work.

I would also like to thank my Parents, my brother Khursheed Ahmad Bhat and my other siblings and all relatives who are always keen to provide me support for my higher studies. I thank them all for their encouraging behaviour towards my current research work.

I also wish to acknowledge the help provided by Sajad Ahmad Bhat and Javed Ahmad Bhat for their support in my research work. I would also love to thank my seniors namely Tawfeeq Aijaz and Aadil Ahmad who put their valuable services at my disposal throughout the entire work. I would also love to thank my friends Ishfaq Ahmad Khoja, MD Danish and Reffat Mushtaq for their support.

I also want to thank the staff of library at the University of Hyderabad to help me in searching relevant resources for my research work. I also want to thank

everyone who in one way or the other helped me in completion of my research work.

AAQIB AHMAD BHAT

Chapter 1

Introduction

1.1: Introduction

One of the basic concerns of economics over the years has been to address the issues of "development gap" between developed and underdeveloped countries of the world; i.e. why in some countries the standard of living is so high and why in others the people are not even able to satisfy basic necessities of life. From the days of Adam Smith many economists (Ramsey, 1928; Harrod-Domar, 1939; Seers, 1962; Solow, 1956; Swan, 1956; Mydral, 1957; Kuznets, 1973; Romer, 1986; Lucas, 1988; Barro, 1991; Mankiw et al, 1992) have answered this question and thus resulted in emergence of huge amount of literature on growth and development aspects of an economy in particular and economies at general.

In most of the empirical growth analysis, the standard practice has been to address the impact of some key determinants of economic growth. Although various policy measures for combating and reducing the 'developmental gap' were recommended but hitherto instead of various efforts to reduce it, the gap has widened drastically (Dowrick, 1992). The reasons for this widening development gap are many. One of the major reasons is variability to natural disasters among the various countries of the world. In some countries natural disasters may setback the development process initiated and thus it may push them towards the state of being underdeveloped. However, this does not imply that most vulnerable are necessarily least developed.

In developmental theory natural disasters are considered to be exogenous and outside the domain of mainstream economics. However, in some countries the costs of natural disasters are so devastating that they overturn the whole system and go beyond the

capacity of national governments. Reported disaster frequency has doubled every ten years since 1960 with 96 percent of all deaths from natural disasters occurring in the global South (International Federation of the Red Cross and Red Crescent (IFRC/RC), 1999). During the last three and half decades natural disasters have witnessed an increase, especially in developing countries like Central America and Caribbean (Strobe, 2010). In 2011 the earthquake and tsunami that hit Tokyo Japan resulted in $223 billion damage to GDP. Hurricane Katrina of 2005 in USA caused a loss of $219 billion to output and death toll of 1,836 people. The 2004 tsunami in the Indian Ocean killed approximately 250,000 people (Emergency Database (EM-DAT), 2016). Besides these devastating costs, the output impact of natural disaster shock is found to be greater than the terms of trade shock which is considered one of the key determinants of output growth (Raddatz, 2009).

Although over the years preventive and preparedness measures have been taken but till today natural disasters consume a huge chunk of physical and human capital. In 2015, 346 natural disasters were recorded in the EM-DAT database. They claimed 22,773 lives, affected over 98 million people and the economic damage was up to the tone of US$ 66.5 billion (EM-DAT, 2016). In 2015, the largest disaster in terms of economic and human costs was the earth-quake in Nepal which caused 8,831 deaths and over $5 billion losses to GDP.

Most of the literatures on natural disasters have focused on its microeconomic impacts However, in the recent years researchers have started showing their interest in the macroeconomics of disasters. The interest is due to the increase in incidence and intensity of natural disasters around the world, especially in the context of developing countries which are found to bear greater burden of natural disasters. The above figures tell about the devastating impact of natural disasters and a need for high research priority for growth economists to address the impacts of natural disasters. Therefore, while analyzing economic performance of a country besides the standard growth determinants, due consideration should be given to natural disasters.

1.2: Disasters and Types

According to the Centre for Research and Epidemiology of Disasters, "Disaster is a situation or event which overwhelms local capacity, necessitating a request to a national or international level for external assistance; an unforeseen and often sudden event that causes great damage, destruction and human suffering" (Centre for Research on the Epidemiology of Disasters, CRED, 1988). A disaster is an extreme disruption of the functioning of a society that causes widespread human, material, or environmental losses that exceed the ability of the affected society to cope with its own resources (Ministry of home affairs India, 2011). Therefore, disasters concern the interaction of sudden natural hazards with socio- economic systems of a economy.

EM-DAT classifies disasters into two broad categories: natural and technological disasters, with several sub-categories in each category.

Table 1.1: Disaster Sub-Groups, Types and Definitions

Disaster group	Disaster Sub-group	Disaster Type	Definition
Natural	Geo-physical	Earthquake	A hazard caused by movement of massive land areas and displacement of rocks on the earth surface
		Volcanic Activity	Includes eruption of hot lava, gases and ash from the earth's crust.
	Metrological	Extreme Temperature	A hazard caused by short lived micro to meso scale extreme temperature.
		Storm	Winds of unusual force or direction often accompanied by rains, snow, hail, thunder, and lightning or flying sand or dust.
	Hydrological	Floods	A hazard caused by occurrence of high precipitation.
		Landslides	Movement of huge amount of rocks, debris or earth down the slope.
	Climatological	Drought	Caused by low annual precipitation.
		Wildfire	Uncontrolled fire in an area of

			combustible vegetation that occurs in the countryside.
	Biological	Epidemics	Biological hazard are caused by exposure to living organism and their toxic substances e.g. Malaria.
		Insect Infection	
		Animal Accident	
Technological	Industrial accidents		These include chemical spill, collapse, explosion, fire, gas leak, poisoning, radiation etc.
	Transport accident		These include air, road, rail and water accidents.
	Miscellaneous accidents		other collapses, explosions and fires

Source: EM-DAT (2016).

As is mentioned above (Table 1.1), natural disasters can be hydro-meteorological, including floods, waves, storms, droughts, landslides and avalanches; geological including earthquakes, tsunamis and volcanic eruptions; and biological, covering epidemics and insect infestations. Hydro-Meteorological disasters are a result of changes in weather, climate and atmospheric conditions. Floods, storms and landslides are caused by occurrence of higher precipitation and movement of huge amount of freshwater and saltwater, while droughts are due to low precipitation over longer time period. Droughts and floods apparently seem to be opposite disasters but these are intimately connected. Over grazing, deforestation and the resulting erosion can make land more prone to both floods and droughts (Tewari, 1987).

Geological disasters originate under the surface of the earth. They are caused by movement of massive land areas and displacement of rocks on the earth surface. Of all the natural disasters, earthquakes have most devastating nature. However, severity is found to be higher for droughts and its associated famines. Biological disasters includes various diseases which are caused by the exposure of living organisms to various disease-causing insects such as parasites, bacteria etc. The 2nd broad group technological disaster are a result of man-made activities and it includes industrial, transport and miscellaneous (bombing, fire, nuclear explosives etc.) accidents. This study concentrates only on the macroeconomic impacts of natural disasters.

The nature and characteristics of natural disasters vary considerably in terms of their speed of onset, duration, intensity and warning time. Sudden-onset disasters (hurricanes, floods, fires, explosions and earthquakes) primarily damage physical capital, including infrastructure, and may cause destruction to means and stocks of raw materials necessary for the production process. Slow-onset disasters (droughts and some floods) are typically more severe in their impact and may be more destructive in the longer term economic growth as they erode saving rates, investment and domestic demand as well as undermine the productive capacity of the nation. Compound disasters (volcanic activity, complex humanitarian emergencies) have elements of both sudden- and slow-onset disasters where an active period of risk can last for many years with varying intensity, increasing uncertainty and depressing investment, with individual events within this period causing more immediate and focused damage (United Nations Disaster Relief Coordinator, UNDRCO, 1991).

1.3: Impacts of natural disasters

Natural disasters cause destruction to human life, physical capital and environmental resource present in an economy. Among these resources which one gets highest damage depends on which of these are more exposed to natural disasters. Underdeveloped countries are usually found more vulnerable to human and environmental costs of natural disasters. In developed countries the percentage damage to human and environmental capital occurs in smaller proportion than the physical capital. However, due to differences in construction and engineering design, natural disasters of same magnitude may damage physical capital in different amounts. For developed countries, development acts as an insurance against natural disasters (Smith, 1996).

As far as impacts of natural disasters are concerned, ECLAC distinguishes between direct, indirect and macroeconomic damages of natural disasters. Direct damages are the direct effects of natural disasters which happen at the time of occurrence. These include loss to life, infrastructure, residential, output, delays in economic activities, loss to arable land and ecosystem etc. Also expenditure on reconstruction and relief during the time of natural disasters is included in direct impacts. The indirect and macroeconomic impacts occur after some time depends on the magnitude of direct damages and also on the rehabilitation effort. Indirect damages are the disruption caused in the production process.

These include losses in output due to destruction in physical and human capital, delays and temporary span of unemployment. These also include higher prices paid during the time of natural disasters. The secondary or macroeconomic costs of natural disasters comprises the impact of natural disasters on macroeconomic indicators such as economic growth, public debt, fiscal deficits, balance of payments, foreign reserves etc.

Table 1.1: ECLAC methodology for disaster impact appraisal

Direct damages: All damage to fixed assets, capital and inventories of finished and semi-finished goods, raw materials and spare parts that occur simultaneously as a direct consequences of the natural phenomenon causing a disaster. Includes expenditure on relief and emergency response. **Indirect damages and flow losses**: The effect on flows of goods that will not be produced and services that will not be provided after a disaster. Indirect damages may increase operational expenditure following the destruction of physical infrastructure, or inventories. They incur additional costs from the alternative provision of services (additional costs are incurred because of the need to use alternative means of production and/or distribution for the provision of goods and services), losses of income resulting from the non-provision of goods and services, losses of personal income in the case of total or partial loss of the means of production, business or livelihood. **Secondary effects**: The impact on the overall performance of the economy, as measured through the most significant macro-economic variables. Relevant variables may include overall and sectoral gross domestic product, the balance of trade and balance of payments, levels of indebtedness and monetary reserves, the state of public finances and gross capital investment. The effect of a disaster on public finance, such as a decline in tax revenue or an increase in current expenditure can be particularly important. Secondary effects are usually felt during the calendar or fiscal year in which the disaster occurs but may spill over a number of years.

Source: Zapata-Marti (1997)

The duration and geographical area covered by a disaster also play an important factor in determining the consequences of natural disasters. Disasters which are local in nature usually tend to have limited aggregate impacts than those events which occur throughout the whole economy. The impact of natural disaster to a particular economy depends on the degree of diversification of the economy and its macroeconomic performance before the disaster hits (Pelling, 2002). The countries which are mainly dependent on agricultural sector are likely to be severely affected than those which have larger diversification in economic activities. Economic structure present in a country and inter-linkages between different sectors also play an important role in destructive costs of natural disasters. Countries with large informal sectors are likely to suffer greater costs of natural disasters.

1.4: Theoretical Background

Since the evolution of political economy, there has been controversy among the economists regarding the sources of growth and development. As far as growth and development theory is concerned, this controversy has resulted in development of three main traditions namely neo-classical Solow-Swan growth models, AK growth model and Endogenous technical change models. Based on sound arguments and empirical background, all these schools of thought held a different viewpoint regarding exogenous shocks. These theoretical stands in relation to a negative exogenous shock like natural disasters are discussed below.

Neo-classical growth models believe in diminishing returns to capital and as a result on steady state level of per capita equilibrium output. They treat technological progress as exogenous and driving force for long run per capita output growth. They held that deviation from the steady state equilibrium as a result of exogenous changes like natural disasters will enhance output growth (Noy and Nualsri, 2009). Since due to natural disasters more capital than labour is destroyed, so fall in K/L ratio will shift per capita output to a higher level. This process is a result of reconstruction and rehabilitation efforts which lead to more capital accumulation, so output growth will lift until the economy reverts back to the steady state equilibrium level.

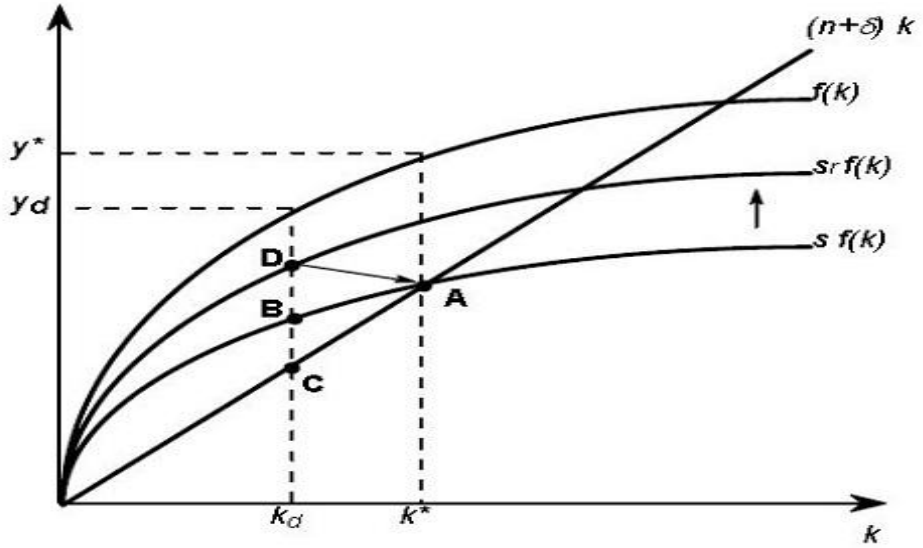

Figure 1.1: Solow Swan growth model and a Disaster

Source: Okuyama (2003)

In figure 1.1 steady state equilibrium output is given at point A where the saving function intersects the exogenously determined growth rate of population. Since natural disasters destroy the physical capital, it is assumed that the effect on population growth is not much. Due to natural disaster output per labour and capital per labour will decrease from $y^*$to $y_n$and k^* to $k_n$respectively. So the initial effect of natural disasters is to deteriorate the growth rate of output and capital stock and in the above figure the economy gets disturbed from the point A to the point D. Any disturbance from the equilibrium point A will result in forces that will move the variables towards the equilibrium level already achieved.

Due to reconstruction and re-habitation programs, more capital accumulation diverts the economy towards the already existing steady state equilibrium level. Besides this during the recovery process saving rate and capital per worker improves, as a result the saving function will shifts above and thus we have a new steady state level of equilibrium at a higher level. This process is a result of investment surge in the aftermath of natural disasters which stimulates output growth to a higher level. The belief that natural disasters can boost economic growth is also shared in Schumpeterian tradition. They held that natural disasters provide a chance to update existing stock of capital and adopt new

technology, leading to improvements in total factor productivity and thus economic growth (Skidmore and Toya, 2002).

AK type growth models held that human capital is an important determinant of output growth and a vital factor that overcomes diminishing returns to capital notion held by neo-classical economists. Besides human capital they advocated the role of economy wide capital in terms of total factor productivity. By incorporating both physical and human capital, AK tradition demonstrated that destruction in stock of physical and human capital due to natural disasters will have no effect on the growth rate of GDP. But it should be noted that the economy that receives destruction to capital stock will lead to a permanent deviation from existing growth path and will never go back to its old growth trajectory (Noy and Nualsri, 2009). Also the magnitude of loss in any particular country will depend on whether the nation is human abundant or capital abundant.

Endogenous growth models suggest technological change as a driving force for achieving higher growth rate of output. In accordance with the AK-models they believe in inherent technological progress and human capital but in addition they consider the impact of knowledge spillovers generated by technical progress and technical adaptation. Endogenous technical change models with increasing returns to production generally predict that destruction to physical or human capital due to natural disasters will lower the long run economic growth and consequently it lead to a permanent deviation from the already existing growth path. The negative long term impact on the economy is as a result of destruction of the capital stock, an increase in the perception of uncertainty, increases in defensive expenditures that draw resources from more productive sectors and an impact on specific industries such as tourism (Noy and Nualsri, 2009).

The aim of this study is to analyse the growth response of natural disasters. Therefore, following exogenous shock like natural disasters I will try to observe which of the theories accords well with the growth experience of a developing country like India.

1.5: Research gap

Natural disasters are not new, they have occurred since the day's human civilisation took birth. However, economic research on natural disasters is still in its infancy stage with

much focus diverted to mitigation and preparedness measures that aim to describe how societies should better prepare themselves against the natural disasters to reduce the devastating impact of natural disasters. Up to now not much attempts have been made to estimate the macroeconomic costs associated with natural disasters. A good estimate of these costs will help the policy makers to execute investment measures on preparedness and mitigation in an efficient way.

Although few papers have tried to examine the macroeconomic consequences of natural disasters, there is no consensus on the economic literature of natural disasters. From the existing literature on macroeconomics of natural disasters two positions can be identified. One position considers natural disasters as barrier for economic development. They held that natural disasters are important from a macroeconomic perspective and it should be taken into account in the economic theory. Most studies on macroeconomics of natural disasters favour this stand (Benson, 1997; Benson, 1998; Mechler, 2003; Rasmussen, 2004; Hochrainer, 2009; Noy, 2009). These authors believe that natural disasters retard economic growth, reduces export growth, worsens public debt, leads to temporary inflation etc.

The second stand (Albala-Bertrand, 1993; Skidmore and Toya, 2002; Jaramillo, 2009; Loazya, 2009; Kim, 2010) believes that natural disasters do not negatively affect GDP growth. They argue that the impact of natural disasters is limited and is not a problem for development. Therefore, they should not be considered from the economic point of view. This stand held that natural disasters can actually boost the output growth by providing a chance to update stock of capital and adopt new technology through reconstruction and rehabilitation.

In this study I have tried to resolve this controversy by examining the growth dynamics of natural disasters in India. The reason behind analysing growth experience of India is due to the greatest exposure and vulnerability of natural disasters to general masses in India. In Indian subcontinent we have widespread poverty, higher income inequality, malnutrition, low medical coverage, weak housing conditions etc., which increases the severity of natural disasters. More ever in case of our country India we do not find any study that has analysed the macroeconomic consequences of natural disasters. Although

many studies (Bagchi, 1955; Chatterjee, 1970; Das, 1975, Banergee, 1988; Gupta, 2003; Gadgil, 2000) have analysed the impact of a single disasters at the regional level but no systematic attempt has been made to examine the impact of all natural disasters at the aggregate national level. Therefore, this study will try to bridge this gap in economic literature of natural disasters.

Apart from all this, most studies (Noy, 2009; Raddatz, 2007; Skidmore and Toya, 2002) have taken natural disasters to be exogenous. However, natural disasters occurrence and their impact depend on the socio-economic conditions present in a country. In a developing country low economic performance at present may lead to occurrence of future disasters. Therefore, natural disasters and its impacts may not be purely exogenous in the highly vulnerable developing economic countries like India. In this study using auto regressive distributed lag (ARDL) an attempt has been made to examine the macroeconomic consequences of natural disasters by considering natural disasters as endogenous.

1.6: Objectives

The main objectives of this study are:

1. To determine the impact of natural disasters on short and long run growth rate of GDP in India.
2. To further check robustness of results by analysing impact of natural disasters on per capita GDP growth in place of GDP growth.

1.7: Data sources

The data on natural disasters and its impacts is taken from the EM-DAT database. EM-DAT is a world wide database and it contains data from 1900 to the present. The EM-DAT database is maintained by Centre for Research on the Epidemiology of Disasters (CRED) at Universite Catholique de Louvain (UCL) in Brussels. The data is compiled from various sources including UN agencies, non-governmental organizations, insurance companies, research institutes and press agencies. The entries in the EM-DAT database are constantly reviewed for redundancy, inconsistencies and incompleteness. EM-DAT reports data on two broad categories of disaster (natural and technological disasters), with

several sub-types in each category. For a disaster to be entered into the EM-DAT database, at least one of the following criteria must be fulfilled:

- 10 or more people reported killed;
- 100 or more people reported affected;
- Declaration of a state of emergency;
- Call for international assistance.

EM-DAT database reports annual data on number of events, killed, total affected and economic damage for all types of disasters. The number of people killed includes "persons confirmed dead and persons missing and presumed dead". As far as total affected is concerned it includes people injured, trauma or an illness, homeless and people those requiring immediate assistance (food, water shelter, sanitation etc.) during the time of emergency. Economic damage includes damage to property, crops and livestock in the year of the event measured in thousand US dollars. The above measures are the direct impacts of natural disasters and on the basis of these measures an assessment is made to estimate secondary cost (economic growth) of natural disasters. In this study focus will be on the macroeconomic implications of natural disasters sub-type only. In EM-DAT database, from 1964 to 2014 data related to 584 natural disasters has been reported for India. Earlier to this time period, no data is available for economic damage. Therefore, this study is restricted to 1964 to 2014.

The impact of a natural disaster on the particular country depends on the magnitude of the natural disaster relative to the size of the economy. Therefore, the disasters measures are standardized here. Here the disaster variable people killed and affected are divided by total population whereas economic damage by the GDP of that particular year to get disasters measures percentage of population killed (KILP), percentage of population affected (AFFP) and percentage of damage to annual output (DAMO).

The statistics on GDP growth rate, gross domestic capital formation, government consumption expenditure and net exports are taken from the World Development Indicators (WDI) at constant 2005 US dollar prices. Although data regarding these variables is also available from RBI Handbook of Statistic, but in order to avoid the

problem of exchange rate conversion (problem of converting economic damage which is in US dollars to Indian rupee), data from WDI is taken.

1.8: Natural disasters in India

Natural disasters are a common occurrence around the world, including India. India one of the developing countries of the world with huge demographic dividend, has been constantly suffering the effects of natural hazards. India, in its history, has come across scores of natural disasters and catastrophes which have taken huge toll of life and property. Quite often India has been among top 10 nations of the world facing largest burden of natural disasters (Kapur, 2005). In 2015, India was at the 3rd position in terms of people killed with 3271 casualties, 2nd in population affected with 10.6 million people affected and it was at the 5th spot in terms of economic damage with 3.3 billion US dollars loss to national wealth (CRED, CRUNCH of EM-DAT, 2016). One interesting fact about the impacts of natural disasters in India is that severity of natural disasters is greatest in terms of destruction to population indicators. This is due to prevalence of mass poverty, inequality, low medical and insurance coverage, weak housing conditions etc. These conditions make the general masses more exposed and vulnerable to natural disasters.

The summary statistics of various natural disasters variables for India during 1964 to 2014 are given (Table 1.3). From the table we can see on average 24 natural disasters hit Indian subcontinent every year which are found to cause 34 thousand casualties every year. Number of people affected is even higher, each year 3 crore people were found to get affected which is about 4 percent of total population.

As far as economic damage is concerned, natural disasters in India every year result in average loss of around $ 164 crore. India has usually remained more prone to natural disasters and its catastrophic destruction is higher than the other countries of the world. The average annual killings in disasters in India was four times more than the average of Asia, eight times more than the world average during the time period1982-2001 (Kapur, 2005).

Table 1.3: Summary Statistics of Disaster Variables

	Events Occurred	Killed Population	Total Affected	Economic Damage
Mean	24.63	33471	39179588	1640934731
Median	25	3333.5	15116646	521767500
Std. Dev.	16.35	207490	70782099	3502239598
Minimum	2	65	25100	400000
Maximum	64	1500560	342029618	23263000000

Source: Authors calculation (2016)

It is evident from above that there is a great amount of variability in associated costs for these three disasters variables. The magnitude impact of population affected is greater in proportion as compared to two direct measures population killed and economic damage. This is in accordance with the earlier facts that destruction of natural disasters is especially in terms human capital in developing countries like India.

Apart from this the standard deviation for these variables is also too high. There have been some years where the death toll was more than one percent and damage as a proportion of GDP was above one percent. Due to greater vulnerability Population affected has been even more devastating, many a times around 10 percent of total population, and in some years it was above 30 percent of total population.

Given these figures, it would to be critical to analyse whether over the year's natural disasters frequently has increased in India and if so then what would be the implications on various macroeconomic indicators? The figure 1.2 shows the incidence of natural disasters in India for the time period 1964 to 2015.

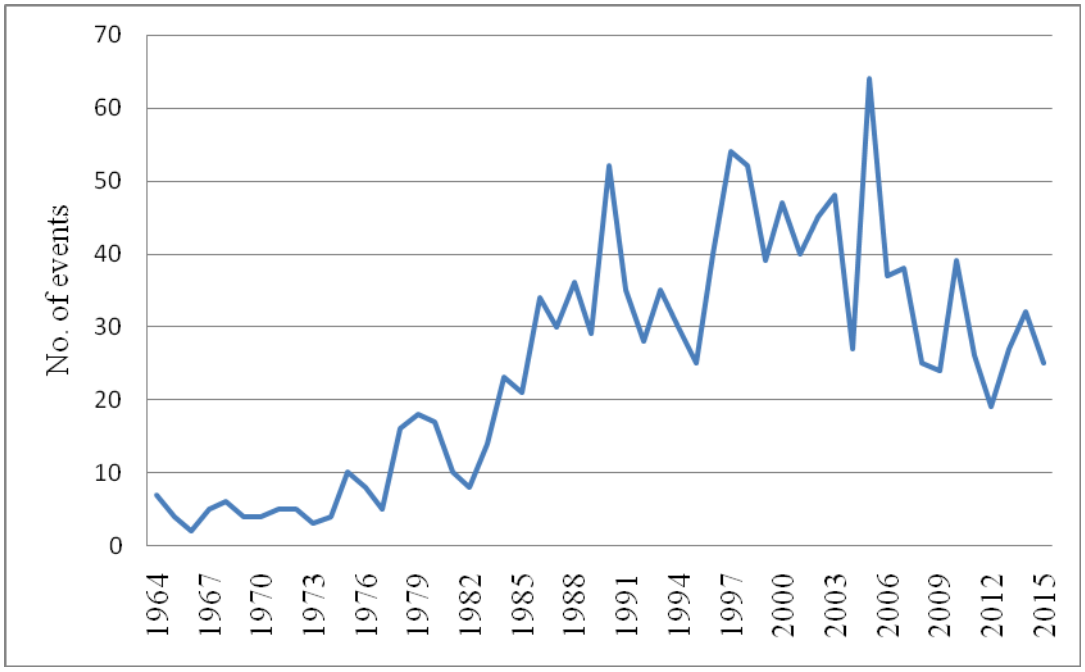

Figure 1.2: Incidence of Natural disasters

Source: Authors calculation (2016)

As is indicated in the figure above, from the last five decades India has been more prone to natural disasters. On average the incidence of natural disasters in India has witnessed threefold increase. Highest incidence of natural disasters was found in 1996-97 and 2005 -06. These periods include disasters like super cyclone in Andra Pradesh and Odisha, widespread flood and tsunamis of 2004. So India besides facing challenges from widespread poverty, higher income and regional inequality, huge educated unemployment, malnutrition etc. has also to face devastating costs of natural disasters which are increasing year after year. Therefore, to assess whether natural disasters have become severe or not, people killed, total affected and economic damage from 1964 to 2015 have been plotted below.

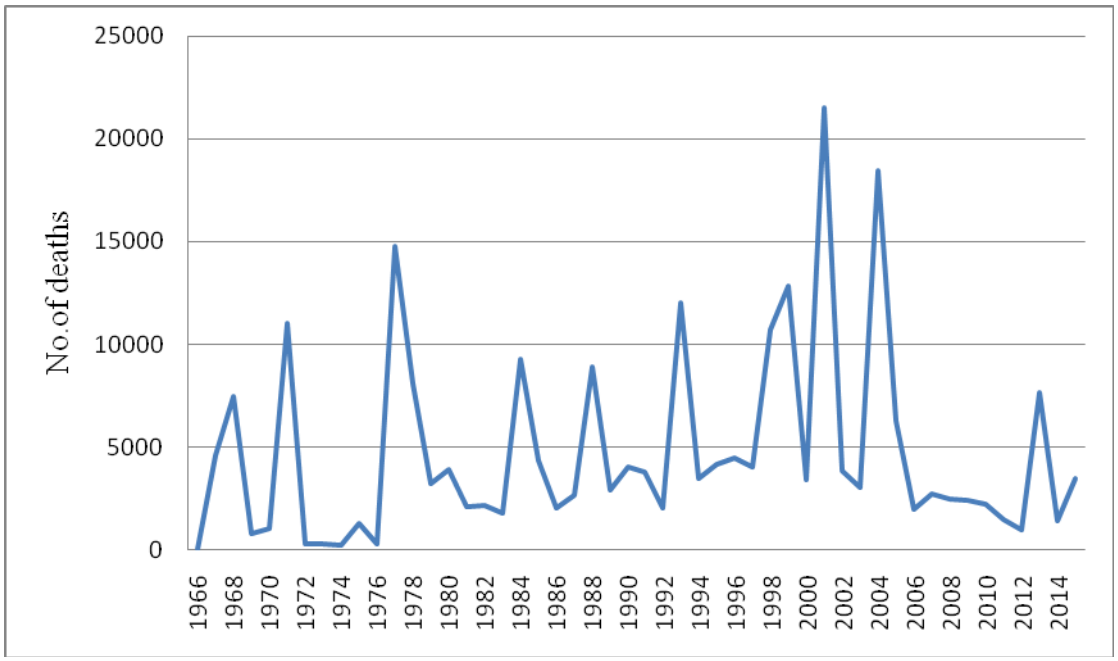

Figure 1.3: People killed due to natural disasters

Source: Authors calculation (2016)

As can be seen from the figure 1.3, from 1966 to 2004-05 on average there has been an increase in death totals that resulted from natural disaster. After this time period there has been a little dip in deaths from natural disasters and then again it increased in 2012 to 2014. On the whole a huge chunk of population in India is found to be consumed by natural disasters and its magnitude is increasing year after year. There have been some years where the death toll was more than one percent of the total population. These includes severe droughts in 1971 which occurred in large part of the country, 1977 cyclone in Andhra Pradesh, 1993 Latur earthquake of Maharashtra, 1999 super cyclone in Odisha, 2001 devastating earthquakes in Gujarat and lastly widespread flood of 2004 that hit the eastern coast.

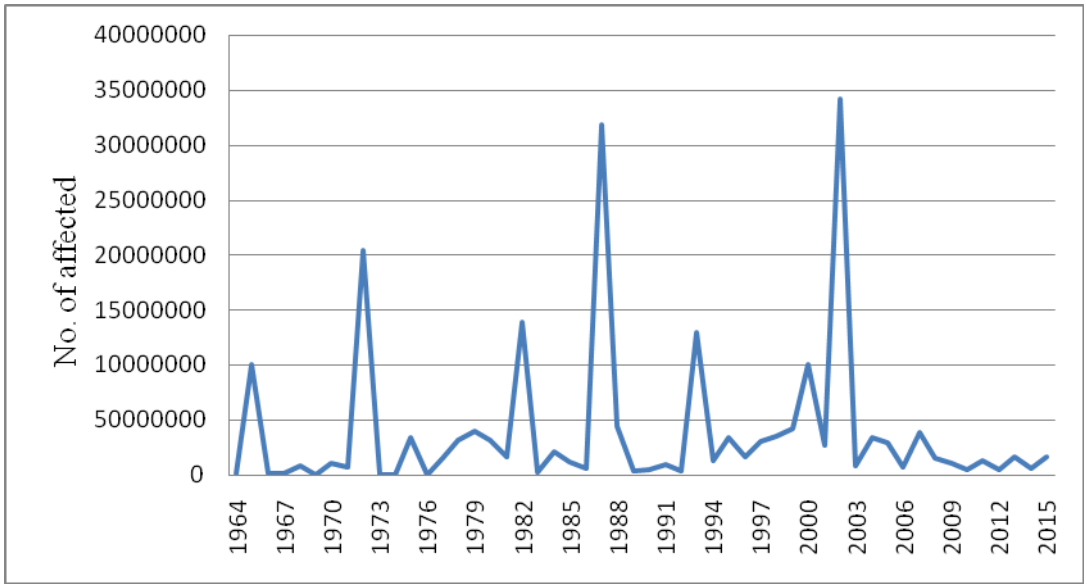

Figure 1.3: People affected by natural disasters

Source: Authors Calculation (2016)

Due to greater Vulnerability, population affected has been even more acute to natural disasters in India (Figure 1.4). From the above figure it can be inferred that on average the number of people affected has been constant, only slight reduction were observed after 2004. This clearly reveals that the mitigation and preparedness measures taken by the Government of India has not been on the line. Many times number of people affected has been more than one crore which is around 10 percent of total population, sometimes even 30 percent of the population was found to get affected. These include droughts of 1965 and 1972 which prevailed over large parts of the country, 1977 flood that swept West Bengal; again droughts occurred in 1987 in 15 states, 1993 earthquake in Maharashtra and 2004 tsunami that hit eastern cost of India. These costs are intolerable for any economy and particularly for a developing country like India whose main source of economic growth is its high demographic dividend.

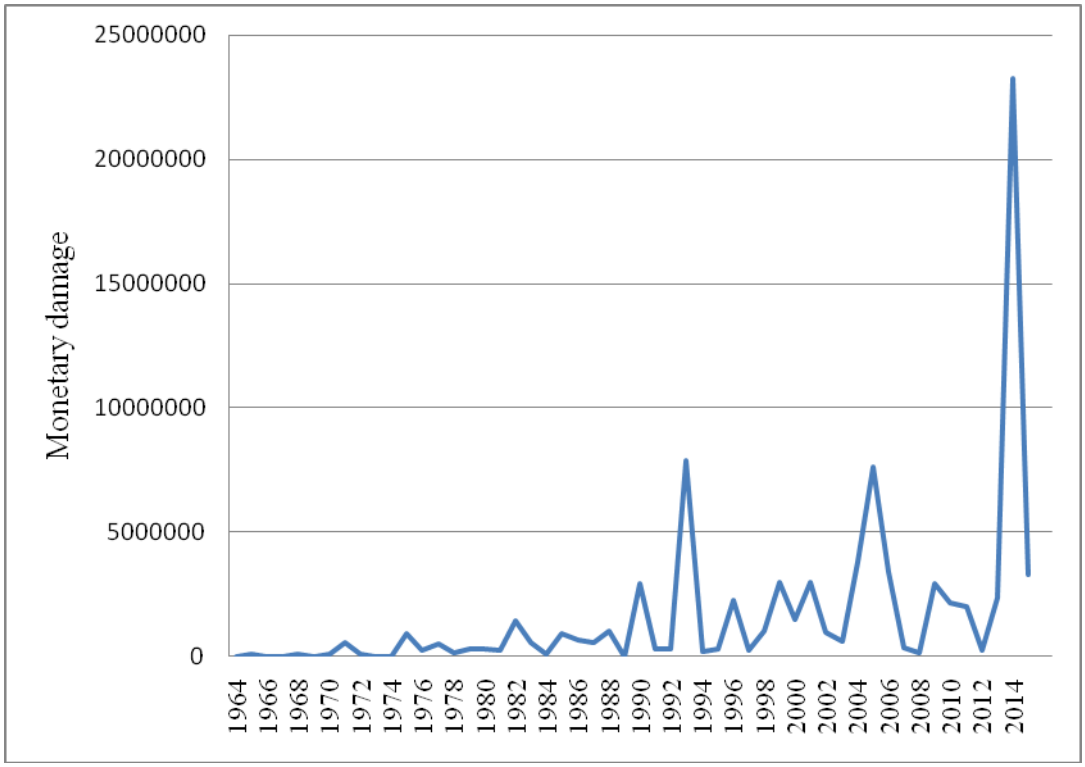

Figure 1.4: Economic damage (000) due to natural disasters

Source: Authors calculation (2016)

As far as economic damage is concerned in spite of engineering and technological improvements its value has been continuously increasing, especially in the recent time period (Figure 1.5). Percentage of economic damage to GDP many a times remained around or above one percent. Economic damage has been greatest in 1993 when earthquake hit latur region in Maharashtra, 2001 earthquake in Gujarat, 2004 tsunami of south eastern part of India and repeated and relentless flooding in Northeast India in 2013. This economic cost is only the cost which is observed in the year of the event, if indirect and macroeconomic cost i.e. impact observed in the aftermath of disaster are also taken into account then it would be a big amount of GDP of India.

India being a subtropical nation has been facing various types of natural disasters every year. Since India is a country of contrast in terms of physical relief, climate, soil, economic condition etc. The type of natural disasters in a particular area to its physiographic and socio-economic conditions can be correlated. Floods are the most common natural disasters in India. Most of the parts of India are flood prone especially

areas like Bihar, West Bengal, Assam, Uttar Pradesh, and Arunachal Pradesh and also in parts of Punjab. Other parts like Rajasthan, Madhya Pradesh, Andhra Pradesh, Chhattisgarh, western parts of Punjab and Haryana and some parts of Gujarat are more prone to severe droughts. Cold waves which rise during winter are mainly found in Jammu and Kashmir and Himachal Pradesh and also in some parts of northern India. Heat waves are found during summers in northern belt and in parts of central India. Tropical cyclones are particularly common in the northern reaches of the Indian Ocean and around the Bay of Bengal. Each year, an average of eight storms with sustained wind speeds greater than 63 kilometres per hour (39 mph) develop in coastal areas of our country. Landslides and Avalanches are mainly observed in lower Himalayas and Deccan plateau. Tsunamis that occur mainly as a result of earthquakes are observed in Indian Ocean and Arabian Sea. Apart from these many parts of our country are economically backward where huge chunk of population live in slums, they are more exposed to epidemics and insect infections.

The percentage number of events occurred, people killed, people affected and economic damage for various types of natural disasters occurring in India from 1964 to right now have been calculated below (figure 1.6).

In the figure below we can see that over the years India has been more prone to climatic disasters like floods, storms, extreme temperature, landslides etc. Climatic disasters were mainly found to cause greater percentage of economic damage and also a sizable portion of people affected. However, these are not among the prominent disasters which cause highest percentage of deaths. People killed in India were mainly associated with droughts and epidemics. These two calamities have although not been common in India occurring only 2 and 5 percentage times but they have claimed huge percentage of fatalities sharing 49 and 47 percent respectively.

The main reason for this is that they directly affect general masses. Other types of climatic disasters mainly cause damage to property. Droughts are found to be more severe causing the highest percentage of fatalities (49 percent) and population affected (52 percent). Earthquakes, landslides and extreme temperature even though occurred good in number but their impact on population and national income has been meagre. Among these only earthquakes are found to cause 6 percent damage to property. Economic damage is mainly associated with earthquakes and floods with 67 percent

caused by floods alone. In our country about 20 percent of the geographical area is drought prone which on average affect 12 percent of the total population. This is the type of natural disaster which has tremendous devastating character.

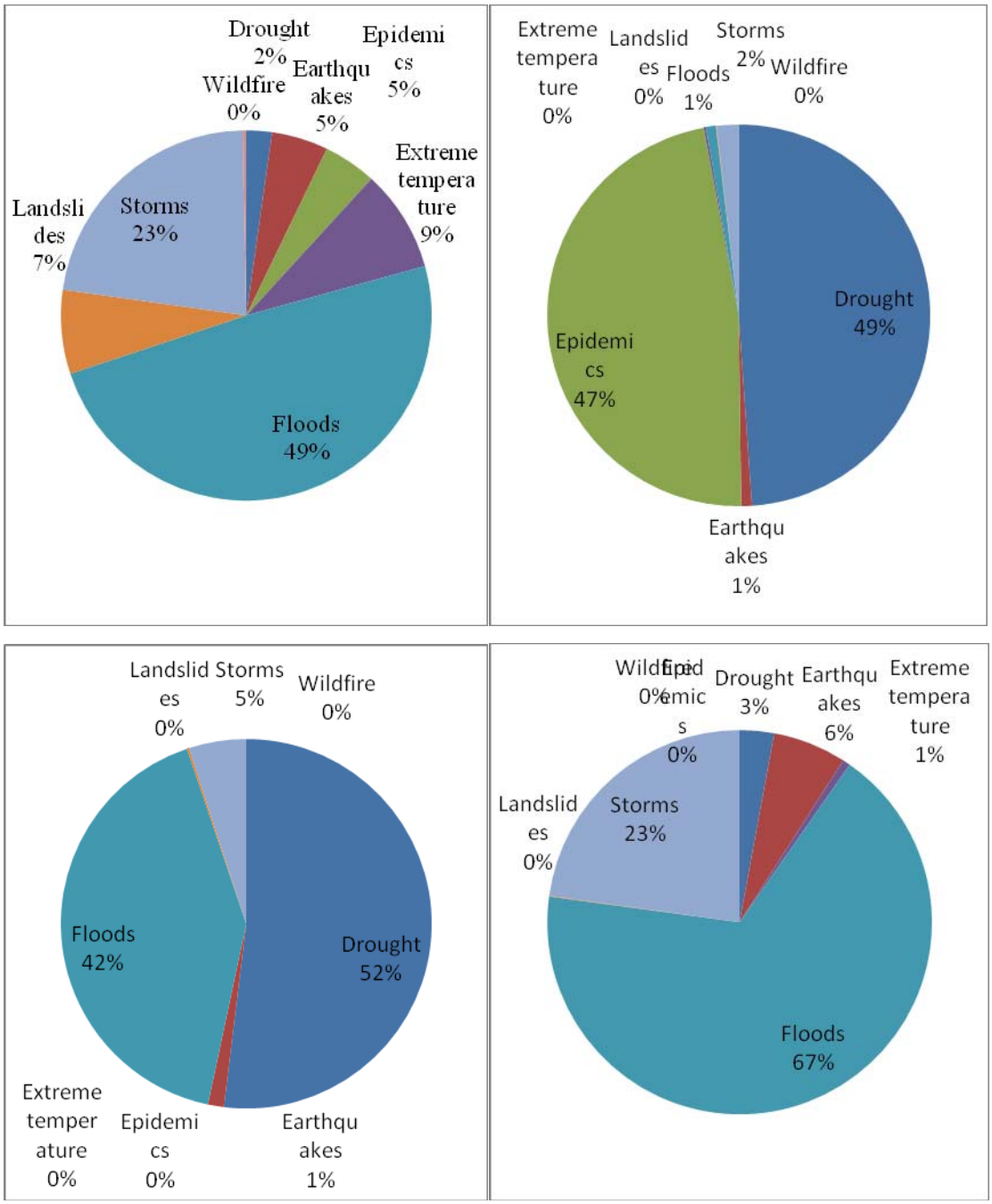

Figure 1.5: Proportion of Events Occurred, People Killed, People Affected and Economic Damage among different Disasters

Source: Authors calculation (2016)

One interesting point to note is fatalities and population affected in India are mainly associated with droughts, earthquakes and tsunamis. Therefore, it is important to analyse the macroeconomic implication of natural disasters.

1.9: Chapter outline

The present chapter is an introduction to this work. Chapter Two begins with the macroeconomic literature on natural disasters. It comprises of three sub-sections. The first part reviews the studies related to the short run growth effects of natural disasters. The second one discusses studies on long run growth response of natural disasters. Both these sections are further divided into two sub-sections, one related to studies which held belief in adverse negative impacts and another with studies relating to positive or insignificant impact of natural disasters. The third part discusses studies which examine the impact of natural disasters on other macroeconomic indicators. Other socio political aspects of natural disasters are also reviewed in this section.

Chapter Three presents the methodology and result analysis part of the study. This section is divided into two sub-sections, one discussing the key growth variables and construction part of auto-regressive distributed lag model (ARDL) and the advantage of using ARDL model in the studies of macroeconomics of natural disasters. The Second sub-section reports the empirical results of the ARDL model. It comprises of four sub-sections. In the first part co-integration among the various variables is tested by using ARDL Bounds test. This section also includes estimates of various diagnostic tests. Second part of this section is related to long run estimates of ARDL model. The third part is related to short run estimates by using Error Correction Mechanism versions of ARDL model and the final part of this section checks robustness of results by using per capita GDP as the dependent variables in place of GDP growth rate. Finally chapter four concludes this study.

Chapter 2

Macroeconomic Impacts of Disaster: A Review

2.1: Introduction

Economic research on natural disasters is only in its initial stage with most of the studies focusing on mitigation and preparedness measures. Main focus over the years has been to describe the ways and means through which societies should better prepare themselves against natural disasters so as to reduce severity of these disasters. A good estimate on these catastrophic costs will help policy makers to devise mitigation and preparedness measures in an appropriate manner.

Although few studies have tried to analyse the macroeconomic impacts of natural disasters; there is no consensus on the economic literature on natural disaster. From the existing literature on macroeconomics of natural disasters two positions can be identified:

(a) The First stand considers natural disasters a setback to development process initiated. Several studies (Benson, 1997a,b; Benson and Clay, 2004; Mechler, 2003; Hochrainer, 2009; Noy, 2009; Raddatz, 2009; Strobl, 2010; Formby, 2013) held that damage of natural disasters is important from the macroeconomic perspective and therefore should be taken into account in the economic theory. According to this stand natural disasters retard economic growth, reduces export growth, sharpen indebtedness and public debt, leads to temporary inflation. The body of research subscribing this view generally finds negative significant macroeconomic consequences associated with natural disasters especially in disaster prone developing countries which face highest burden of natural disasters.

(b) The second stand held that the impact of natural disasters is limited (Albala-Bertrand, 1993; Skidmore and Toya, 2002;Jaramillo, 2009; Loazya, 2012; Kim, 2010). This stand does not find any adverse impact of natural disasters on output growth. Therefore, natural disasters are not a problem for economic development and should not be considered in the economic theory. They held natural disasters can actually boost the economic growth of a country by providing a chance to

update stock of capital and adopt new technology which will improve total factor productivity and therefore growth rate of GDP.

In economics we generally distinguish between the short run and the long run[1]. Therefore, in the following subsections the macroeconomic literature on natural disaster is discussed both in the short run and long run. The final subsection reviews some literature on other socio-economic effects of natural disasters.

2.2: Short run growth effects

2.2.1: Negative short run growth effects

Most of the studies on macroeconomics of natural disaster find that natural disasters lead to short-term negative impact on economic growth (Benson, 1997a,b; Rasmussen, 2004;Noy, 2009; Hochrainer, 2009; Raddatz, 2009; Formby, 2013;Sedeghi et.al, 2009;Strobl, 2010;Cavallo et. al, 2013). They consider natural disaster a barrier for development in disasters prone countries of the world.

Benson (1997a, 1997b) analysed the economic impact of natural disasters in Fiji and Vietnam. According to him natural disasters have a substantial negative impact on annual GDP growth in Fiji. The negative growth impact was also present in agricultural and manufacturing sectors. According to the study over the years there has been an increase in vulnerability to natural disasters in Fiji economy and particularly in the agricultural sector.

Benson (1997b) study in Vietnam shows that the country has been experiencing devastating flood every year due to environmental degradation and global warming. These natural disasters have a significant impact on the development forgone, widening regional and income equalities and in strengthening poverty. Vietnam being an agrarian economy, the adverse costs of natural disasters in Vietnam are more pronounced than other economies.

[1]Usually up to three years it is short run and anything beyond five years is typically considered as the long run.

Using a cross sectional analysis, Rasmussen (2004) examined the incidence of natural disasters among 150 advanced, developing and Eastern Caribbean Currency Union (ECCU) countries of the world. The study found that developing countries suffer greater costs (in terms of people affected and economic damage) of natural disasters while small Island states which are located in disaster prone areas face greater frequency to natural disasters. The author held that although Small Island economies have highest frequency of natural disasters but they are not highest vulnerable ones due to relatively higher levels of income and resilient measures, which lessen the costs of natural disasters in these economies. The results indicated that there is a negative relationship between GDP and number of people affected by natural disasters while economic damage was not found to affect GDP significantly. In general the author found that the disaster measure number of events standardised by population was found to have more significant coefficient than the disaster measure number of events normalised by land area. Based on 12 large natural disasters in ECCU, the study found that GDP growth deteriorated by 2.2 percentage points.

Noy (2009a) analysed the short run macroeconomic response of natural disasters for several developed and developing countries during the time period 1970 to 2003. In order to examine the potential costs of natural disasters in different countries, the author standardised the disaster measure population killed and affected by population while economic damage by current years GDP. Further these disasters magnitude measures were adjusted according for the onset month in which disasters occur. Based on panel data the study revealed that natural disasters have an adverse impact on the GDP in terms of the disaster measure property damage. On the other hand when relying on population indicators (killed and affected), no statistical significance on GDP has been found, although during past 20 years number of people affected and killed has increased. In order to overcome exogeneity problem, the author assumed that disaster damage is predetermined and exogenous i,e there is no causality from GDP growth variable to future disasters.

Besides this by using Hausman Taylor (1981) random effect algorithm, the authors made a close attempt to study determinants of macroeconomic output shocks which revealed several interesting facts. The study found that countries with higher literacy rate, better

institutions, higher per capita incomes, larger governments (measured in government consumption as a percent of GDP), higher economic diversification , higher degree of openness to trade seem to be better withstand against initial disaster shock and prevent its effects from spilling deeper into the macro economy. Moreover the study held that financial conditions, more foreign reserves and higher domestic credit appear to be significantly important in order to mitigate the adverse impact of natural disasters. Further in accordance with Rasmussen (2004), the author found that the developing countries bear much larger burden to macroeconomic indicators following a disaster of same relative magnitude than do developed countries. Macroeconomic impact were even larger found for small island economy, thus the study held that development acts as an insurance against natural disasters for developed countries.

In another study Noy (2009b) employed Blundell-Bond System GMM procedure to examine the impact of natural disasters on annual GDP and annual growth rate GDP in Vietnam. In this study he focused only on production dynamics of natural disasters, even though there are other macroeconomic costs of natural disasters such as fiscal, trade, inflation, debt costs etc. The results indicated that disaster damage in terms of people killed and people affected seem to lower annual GDP whereas economic damage (in terms of capital lost) was found to boost the growth rate of GDP in the short run. Negative impact of natural disasters was found short lived as it affects annual GDP significantly rather than GDP growth. Also a regional analysis show that most of the regions with higher frequencies of disaster do not enjoy higher output growth than the regions with lowest frequency.

Hochrainer (2009) analysed the determinants of the economic impacts by taking disaster impacts as a function of hazard, exposure of assets and physical vulnerability. The author employed autoregressive integrated moving average (ARIMA) model to extrapolate pre disaster trends of GDP to construct counterfactual observations (GDP without a shock) and then compared it with observed GDP. The results revealed that natural disasters lead to significant negative effects on GDP, although the negative effects may be small, but it can become more pronounced depending on direct damage in terms of loss of capital stock. On the whole the study found direct damage of natural disaster seems to be more critical. Therefore, evidence of ‘GDP gap’ between the counterfactual and observed GDP

has been confirmed. Further the study revealed that remittances, inflows and aid are found to lessen the adverse macroeconomic consequences of natural disasters.

Raddatz (2009) analysed the output costs of natural disasters by fallowing panel vector auto-regression (VAR) model. According to the study output impact of natural disasters shocks is greater than the terms of trade shocks[2]. However, natural disasters still are outside the domain of economic theory. The study revealed that climatic disasters have a moderate negative impact on real per capita GDP and about 0.6 percent of the real per capita output is reduced by the climatic disasters. Besides this the study found that among climatic disasters only droughts have severe macroeconomic consequences while other type of climatic disasters do not have a significant negative effect on output growth. More ever the study found that Geological disasters are insignificant determinant of output growth.

In accordance with other studies the study revealed that the output costs of natural disaster are greater in low income countries. However, low income countries in this study were found to respond more strongly in the aftermath of natural disasters. In middle and high income countries, natural disasters of any kind were not found to have significant impact on economic growth. Also small states were not found to get significantly more affected than the large big economies. Apart from this the study revealed that international aid flows does not play a big role in reducing the macro economic consequences of natural disasters. Also no evidence of any relationship between level of indebtedness and severity of any types of natural disasters has been found in this study.

Sedeghi et.al. (2009) examined the short term and long term consequences of property damages caused by natural disaster on Iran's GDP. By using auto-regression distributed lag model (ARDL), the study revealed that natural disasters have an adverse impact on the short run economic growth. The study also found disasters damages variable has negative effect on non-oil GDP, thus indicating natural disasters initially slows down GDP growth, later on it may increase due to renovation and reconstruction activities taken in the aftermath of natural disasters.

[2]Terms of trade shocks are considered as important source of fluctuations in growth rate of GDP in the mainstream economics.

Formby et al. (2013) in order to analyse the macroeconomic aftermath of natural disasters followed panel VARX methodology for 87 countries in 48 years (1960-2007). The study especially focused on the mean annual response of GDP growth, both aggregated and disaggregated into agricultural and non-agricultural components to four types of natural disasters: drought, floods, earthquakes and storms. Apart from this the study also analysed the impact of development by examining the effects of natural disasters in both developing and advanced economies to moderate and severe disasters.

The study found that different types of disasters have different output consequences in different dimensions of the economy. The study revealed that drought has a negative impact on economic growth. Statistically Stronger and immediate impact of drought was found in agricultural sector. In non-agricultural sector droughts were also found to contribute negatively to the growth but here the impact comes after some delay. The study held that the effect of droughts for both agricultural and non-agricultural sectors was negative in developing countries, but in advanced economies the negative effects of droughts was found only in agricultural sector.

The study also found that impact of flood was positive both in agricultural and non-agricultural sector but larger benefits of floods were found in agricultural sector due to improvements in land productivity. The study held same results for developing countries but in rich countries only agricultural sector was found to boost after floods. The study found Earthquake and storms are negatively related with economic growth but statistical significance in both cases was weaker than droughts. Only in developing economies earthquakes effect agricultural growth negatively. As far as non-agricultural sector is concerned, earthquakes were found to effect its growth strongly. The effect of storms was found to be meager in the advanced economies. Moreover the study held that only moderate disasters can have a positive impact; severe disasters never contribute to economic growth positively.

Cavallo et al. (2010) summarized the literature on macroeconomics impacts of natural disasters. The author held that although large disasters are rare, but the direct cost of observed catastrophes is still huge, with developing countries bearing the largest burden. The author revealed that as far as short run impact on GDP is concerned, most of the

studies empirically found negative impact with only a few exceptions. The author held that among the three broad types of natural disasters, hydro-metrological events have the greatest bearing on people. Moreover based on various empirical studies, the author argued that severity of natural disasters among different country is not purely exogenous; it also depends on the prevailing economic, social and political conditions of the affected country.

Strobl (2010) examined the effects of hurricane strikes in Central America and Caribbean (CAC) region on annual growth from 1950 to 2008. In place of monetary loss, Strobe (year) in his study took wind speed as a measure of hurricane destruction in this geographical zone. The study found that damages due to hurricane wind have a negative impact on economic growth and it has reduced GDP growth by 0.8 percentage points. However, it should be noted that the negative impact was found true only for the year in which disaster occur; no significant long term affect has been found. Also the study revealed that hurricane wind affected different regions differently as hurricane wind has been mostly local in nature.

2.2.2: Positive or limited short run growth effects

There are only few studies (Albala-Bertrand, 1993; Jaramillo, 2009; Loazya, 2009; Cunado and Ferreira, 2014) in favour of positive impact of natural disasters in short run. These studies do not find significant retarding impact of natural disasters on the growth rate of GDP.

In his seminal monograph, Albala-Bertrand (1993) sets out a framework to analyse the economic and social consequences of 28 large natural disasters in 26 developing countries during the time period 1960 to 1979. He held that the economic and social costs of natural disasters are often exaggerated. Based on various surveys, the author found that natural disasters hardly have any adverse effect on GDP growth, even in some cases the growth rate of GDP was found to improve. So he argued that natural disasters are not necessarily a ‘problem for development’ but a ‘problem of development’. According to the author the impact of natural disasters depend on the socio-economic scenario present in an economy. The author held that except widespread droughts, significant macroeconomic consequences are unlikely to be observed as most of the natural disasters

are local in nature. Therefore, they do not exhibit sound macroeconomic implications for the whole economy.

Using panel data for 113 countries from 1960 to 1998, Jaramillo (2009) analysed the short run effects of different disaster measures such as disaster frequency, damage as a proportion of GDP, killed and affected as a proportion of population. The study revealed that the direction and magnitude of effects of natural disasters depend on the type and intensity of a particular disaster. The study found that in the case of countries with predominance of climatic disasters, people killed had a significant positive affect on GDP growth. The study held that this may be due to investment surge or exceptional spending by government in these countries. Countries which are more prone to geological disasters, disaster damage measure was found to have a significant positive impact due to technological adoption.

The study revealed that for low incidence group countries, natural disasters measure in terms of damage and frequency seems to boost the GDP growth through reconstruction and technological adoption. For medium incidence group, cumulative affected and cumulative killed measures of disasters are found to be significant determinant of GDP growth. People affected was found to contribute positively due to government expenditure on disaster preparedness and human capital while people killed measure had a negative impact on output growth. Only for severe disasters, disasters measure damage and frequency were found to have negative short run impact on economic growth. However, for affected and killed measure of disasters, no significant impact of natural disasters on economic growth has been in this study.

Using panel vector autoregressive models (VAR), Cunado and Ferreira (2014) examined the output growth dynamics of agricultural and non-agricultural sectors to major flood events, using the flood specific database for 135 countries between the time periods 1985 to 2008. Since disaster magnitude and frequency also depend on the socioeconomic factors in particular on output growth by affecting the provision of public goods relating to flood management, so the flood variable in their study has been taken as endogenous variable. The author revealed that floods tend to have positive impact on output growth and it remains peak up to four to five years after the disaster. The effect on agricultural

growth was also found to be positive due to effect of floods on land fertility and productivity. As far as non-agricultural sector is concerned, the study revealed that non-agricultural sector also witnessed higher growth after the event but the improvement in growth was smaller as compared to agricultural sector. According to the study the magnitude of floods is slightly greater in developing countries than in developed countries. The author held that the increase in agricultural output was larger and more persistent in developing economies than in developed economies. The positive effect of floods on non-agricultural growth was found to be significant only in developing economies because of relatively larger importance of agricultural growth that spills over to manufacturing and services sector in developing economies. However, the results were only true for moderate floods.

In order to reconcile the above stands of macroeconomics of natural disasters in short run, Loazya (2012) followed the generalized methods of moments (GMM) to analyse the impact of natural disasters for 94 developing and developed countries, over the time period 1961- 2005. The author found that small natural disasters have a positive effects (due to reconstruction and rehabilitation) while large natural disasters always have severe negative effects. Further disaggregating the disaster into types and GDP in terms of economic activities, the study revealed that different disasters affect economic sectors differently.

Droughts and earthquakes were found to affect GDP growth negatively where as floods and storms had negative impact. However, only floods were found to be statistically significant. In contrast to insignificant effect of natural disasters on aggregate output growth, the author found that in agricultural sectors; floods, droughts and storms were found to exhibit statistically significant impact on agricultural growth. Floods were found to stimulate agricultural growth while storms and droughts retard agricultural growth. In the industrial sector, none of the type of natural disasters had a statistically significant affect. As far as service sector is concerned, the study found that only floods showed a positive significant impact on service sector growth.

Apart from this to observe the severity of natural disasters, the study further segregated the impact of different types of natural disasters among developing and developed

economies. In developing countries the study revealed that the natural disasters do not affect the overall GDP growth significantly, while in agricultural sector floods and droughts were found to have significant but opposite effect. Also the study revealed that the effect in the industrial sector in developing countries was analogous to their agricultural sector, floods leading to higher growth while droughts affecting industrial growth negatively.

Earthquakes and storms surprisingly were found to affect industrial growth positively; the author held it may be due to decline in K/L ratio (which improves productivity and growth) as a result of these disasters. Lastly for service sector the study held that in developing economies only floods were found to improve service sector growth and that may be due to inter-sectoral linkages between agricultural, industrial and services sectors. However, the author did not found any evidence of significant impact of natural disasters in developed countries. So on the whole the study revealed that degree of vulnerability to natural disasters was found higher in developing countries than in developed economies. Also the study revealed that the positive impact of any type of natural disasters was found only with moderate disasters, severe disasters do not stimulate output growth.

From the above literature we can see that in the short run negative impact of natural disasters on economic growth seem to dominate. To analyse whether the impact of natural disasters is permanent or not; we need to identify the channels through which natural disasters retard GDP growth. Unfortunately in the above studies no such analysis has been done. Therefore, to observe whether the impact of natural disasters is permanent or temporary the long run literature on macroeconomics of natural disasters has been discussed.

2.3: Long run growth effects

2.3.1: Negative long run growth effects

Noy and Nualsri (2007) analysed the growth dynamics of exogenous shocks like natural disasters in 98 developing OECD and non-OECD countries. The author held that since the inception of political economy, growth theories like Solow- Swan theory, A-K models and endogenous technical change dominated the theoretical and empirical research on

economic growth. The authors tried to analyse which of growth theories is in accordance with the growth response of natural disasters in developing countries. The author used two measures of exogenous shocks human capital (loss of life) and physical capital shocks (economic damage) over several 5 year intervals from 1975 to 1999. The study found that physical capital shock is positively related with output growth but statistically insignificant; however at the same time a negative shock to human capital is found to lower output growth permanently. The study found the same long runnegative impact of natural disasters in non- OECD countries. However, for OECD countries, no statistically significant impact on life and property following natural disasters has been observed which might be due to higher per capita income in these countries. So the study revealed that the neo-classical growth theories do not fit the empirical growth experience of developing countries facing natural disasters. Endogenous technological change growth model which held belief in negative long term impact of natural disasters seems to be more in compatible with the results of the study.

By using Auto-Regressive Distributed Lag (ARDL) model, Sedeghi et al. (2009) in his study on Iran found that natural disasters retard both short run and long run growth rate of GDP, however severity of damage is found to be highest in short run. Also the author found that there exists long run equilibrium relationship between GDP and explanatory variables disasters damage and gross investment. More ever the results of error correction mechanism (ECM) of the study showed low value with a negative sign (-0.685), indicating slow speed of adjustment from the long run equilibrium, only 17% of the disequilibria corrected each year after the natural disasters.

To analyse the long run growth dynamics of natural disasters, Cavallo et al.(2010) constructed counterfactual GDP using a 'synthetic' control group of countries unaffected by disasters and then compared these counterfactual observations with actual observation for 202 countries during the period 1968-2008. The study found large natural disasters on average have a negative impact on GDP growth in long run. The study found even after 10 years after the disaster, the extent of loss is up to the tone of 10 percent of GDP per capita. However, for middle and smaller events, the study does not found any evidence of significant impact on GDP growth either in short or in the long run.

Jaramillo (2009) by using structural model tried to examine whether the impact of natural disasters is permanent or transitory but long lived. In accordance with the earlier studies he found that negative significant impact of natural disasters is true for severe large disasters only. For most of the countries the author revealed that the impact of natural disasters was short lived except in few economies which have a history of devastating natural disasters, in these countries negative effect were found to be truly permanent.

2.3.2: Positive or insignificant long run growth effects

Skidmore et al. (2002) following a semi-logarithmic regression function examined the long run relationship between disaster frequency, investment decisions, total factor productivity and output growth during 1960 to 1990. The study revealed that natural disasters normalised by land area has a positive and statistically significant impact on the growth rate of GDP and about 9 percent of the variation in per capita GDP is explained by natural disasters. Further climatic disaster variable was found to be positively related with the economic growth while geological disaster seems to retard output growth. One standard deviation increase in climatic disasters was found to result in 22.4 percent increase in annual growth rate of GDP.

The empirical results of the study suggest that adoption of new Technologies (total factor productivity) and increase in human capital investment provoked by climatic disasters are the primary route through which natural disasters improve economic growth (creative destruction hypothesis). As far as negative relationship between geological disasters and economic growth is concerned, the author held that it may be due to physical capital destruction or as a result of loss of life (human capital destruction) spurred by geological disasters. In order to avoid any kind of spurious correlation, the study included several dummy variables which are vital to output growth; however the statistical significance of the disaster coefficients hardly changed.

By using endogenous growth models, Cuaresma et al. (2008) criticallyanalysed the creative destructive hypothesis notion held by Skidmore and Toya (2002). The study examined whether technological up gradation as a result of natural disasters gives

developing countries a chance to replace obsolete technology as a result enhance the total factor productivity and output growth. To analysethis, the author estimated the relationship between the knowledge spillovers due to imports of foreign technology and catastrophic events. In his study the author used R&D stock (technological content of average imports) as a proxy for knowledge spillovers between developing and from G-5 industrialised countries. Cross sectional panel data analysis for 49 developing countries showed that disaggregating disasters into climatic and geological disasters hadimpact on GDP growth similar to that of Skidmore and Toya (2002) finding, but their implication on technological transfers was altogether different.

After controlling for important determinants of trade, the study did not found any evidence for positive association between R&D content of imports and frequency of natural disasters, thus the author held that the creative destruction process as a result of natural disasters did not seem true by empirical verification. Moreover the study also analysed the impact of overall level of development on technological adaptation, the study revealed that only those countries which have higher levels of GDP per capita benefit from the technological up gradation after a natural calamity.

Kim (2010) extended the work done by Skidmore and Toya (2002) to analyse the relationship between growth and disaster frequency during the recent period (1990 to 2004). Using semi logarithmic regression, the author revealed that there is positive and statistically significant relationship between growth rate and no. of disasters normalised by the land area. However the results were not as significant as that in 1960 to 1990 time period in Skidmore and Toya (2002) study.

Cavallo et al. (2010) summarized the literature on macroeconomics impacts of natural disasters. The author revealed that in long term economic effects of natural disasters were inconclusive making it hard to draw any firm conclusion. The author argued that insurance and capital markets, good building practices and other preliminary investment measures can play a prominent role in mitigating the costs of natural disasters. Based on various empirical studies, the author argued that severity of natural disasters among different country is not purely exogenous; it also depends on the prevailing economic, social and political conditions of the affected country.

As compared to short run, the economic literature on long term growth effects of natural disasters is scare and seems to be inconclusive. This may be due to limited data availability on impacts of natural disasters. Only damage at the time of natural disaster is recorded. However, no attempt is made by the national and international agencies to collect information on future macroeconomic repercussions of natural disasters. Also it may due to difficulty in constructing counterfactual observation (what would have been the growth rate of GDP in the absence of natural disasters) and then comparing these with the actual growth rate of GDP.

2.4: Effects on other macroeconomic indicators

Besides economic growth, natural disasters do influence other macroeconomic indicators of the economy such as fiscal deficit, public debt, trade deficit, international aid etc. Below we have examined the impact on these indicators thoroughly;

2.4.1: Fiscal deficit and Public debt effects

In order to avoid the recurring consequences of natural disasters, governments are supposed to incur expenditure on relief and reconstruction measures. However, these expenditures withdraw resources from other developmental expenditures and may put the government under serious financial constraint. Due to limited financial capacity many developing countries may resort to borrowing from domestic and international sources to complement the reconstruction process initiated in the aftermath of natural disasters. Most of the studies on macroeconomics of natural disasters (Benson, 1997; Pelling, 2002; Rasmussen, 2004; Narayan et. al, 2007; Acevedo, 2014; Lugay et. al, 2014) find that natural disasters deteriorate financial conditions of the government. Benson (1997) found disasters in Fiji are so serious that they erode the budgetary position of the government. Many times natural disasters in Fiji where so devastating that they were outside the control of Fiji government.

Pelling et al. (2002) held that policy makers face problems while allocating funds for disaster investment due to budget constraint and uncertainty about occurrence of natural disaster. Therefore, the author believed in creating a disaster fund or flexible adjustment by selling government bonds and securities for natural catastrophes.

Mechler (2003) examined the macroeconomic implications of natural disasters on GDP growth, balance of payments, and public debt and on indebtedness in developing economies. In this study he takes the case of Honduras, Hurricane Mitch in October 1998 and El Salvador, Earthquakes in 2001. The author argued that due to Hurricane widespread floods were observed, the Honduras economy experienced depression. The study observed that Honduras financial dependence on market borrowing from domestic and foreign markets increased after the Hurricane Mitch of 1998, as it is an underdeveloped economy with limited ability to finance loses through its own tax revenue, domestic saving and credit. Same situations have been found in El Salvador where the public debt and debt servicing payments got worsened. The results indicated that it would be inadvisable to borrow on market terms, so external help in terms of foreign aid is most relevant in order to reduce the severity of natural disasters in these developing economies.

Rasmussen (2004) held that natural disasters in small Island economies are found to have enormous impact on output growth, including large effects on fiscal balance. Based on 12 large natural disasters in ECCU, the author found that public debt to GDP ratio worsened by 6.5 percent cumulative points over three years.

Using computable general equilibrium model, Narayan and Prasad (2007) analysed the long term economy wide impacts of 2000 coup on Fiji's economy. Based on 35 domestic industries, 34 commodities and 2 occupational types; the study found that coup 2000 has an adverse impact on GDP. GDP declined by 8.2 percent which resulted in declining government revenue by 4.8 percentage points while government expenditure increased substantially, thus worsening the overall debt situation.

Acevedo (2014) analysed the impact of two types of natural disasters (floods and storms) on public debt to GDP ratio in Caribbean economies. The author in this study considered the effect of both severe and moderate disasters. The author found floods increase public debt while storms do not. However, in a subsample of countries, (in some ECCU countries) results indicated that storms do significantly increase public debt both in the short and long run. Lugay et.al (2014) using panel data examined whether natural disasters lead to accumulation of public debt in six EUUC countries. The study found

natural disasters have a significant impact on the growth of debt to GDP ratio in EUUC countries. The results indicated that natural disasters which retard GDP by 2 percentage or more points cause 6.7 percentage increases in the debt to GDP ratio.

2.4.2: International trade and foreign aid effects

Besides the impact on GDP growth and public finances, natural disasters are found to sharpen trade deficit and lowers the international financial assets held by an economy. Exports get reduced due to natural disasters as a result decline in production, damage to physical capital and infrastructure etc. On the other side imports increase due to more demand for food and capital goods during reconstruction and rehabilitation process. Therefore, on the whole current account deficit are found to sharpen (Albala- Bertrand, 1993; Mechler, 2003; Rasmussen, 2004, Gassebner et. al, 2006, Da Silva et. al, 2012). Foreign aid and remittance are the measures which lower the severity of natural disasters especially in underdeveloped countries which have low fiscal capabilities. Most of the studies on natural disasters held that remittances, inflows and aid lessen the negative macroeconomic consequences of natural disasters (Benson, 1997a,b; Pelling, 2002; Mechler, 2003; Rasmussen, 2004; Hochrainer, 2009 etc).

Albala-Bertrand (1993) in his monograph found that natural disasters have no impact on inflation and public deficit, however capital formation and capital inflows increased and trade deficit was found to sharpen. The study held that international organisations, national and local governments, household and individual actions can help in mitigating the negative costs of natural disasters. He also argued that the level of development and underlying socioeconomic structure prevailing in the developing countries also determine the implications of natural disasters.

Benson (1997) held that funds released for mitigating floods has put Vietnam government under serious financial constraint. Therefore, external assistance in terms of aid is important in order to reduce severity of natural disasters in Vietnam.

Mechler (2003) takes the case of Honduras, Hurricane Mitch in October 1998 and El Salvador, Earthquakes in 2001 to examine the impact of natural disasters on balance of payments and indebtedness in developing economies. The author argued that due to

Hurricane widespread floods were observed, the Honduras economy experienced depression and as a result GDP and income were reduced, exports showed a steep decline but the decrease in imports was not much. The study observed that Honduras financial dependence on market borrowing from foreign markets increased after the Hurricane Mitch of 1998.Based on 12 large natural disasters in ECCU countries, Rasmussen(2004) found that GDP growth deteriorated by 2.2 percentage points, current account deficit increased to 10.8 percent of GDP over three years. Thus natural disasters in small Island economies were found to have enormous impact on output growth, including large effects on external balance.

By following gravity model for 170 countries during the period 1962-2004, Gassebner et al. (2006) found that disasters reduce trade in both exporting and importing countries. Most importantly, the author revealed that governance is a key factor determining the magnitude of trade effects of natural disasters. In a less democratic and small country, natural disasters are found to cause more loss to international trade.

Da Silva et. al (2012) analysed the impact of natural disasters on developing countries trade flows by using gravity model,. The results indicated that exports are negatively affected in small developing countries. On average 22 percent of exports are reduced and these negative effects were found to last for about 3 years. However, for larger developing countries, natural disasters do not significantly affect the exports. The exception to above arguments in favour of foreign aid and increase in trade deficit is the study by Raddatz (2009). He found that international aid flows does not play a big role in reducing the macro economic consequences of natural disasters. Moreover the author found no evidence of relationship between the level of indebtedness and severity of any types of natural disasters.

2.4.3: Other aspects of natural disasters

Besides macroeconomic impacts there are some studies which examined other aspects of natural disasters. These include studies like Pelling et al.(2002) who highlights the importance of natural disasters in economic theory, Okuyama(2003) study on modelling and theoretical framework of natural disasters, Cohen et al.(2008) work on political

economy aspects of natural disasters and more importantly 'the impact of economic development on natural disaster occurrence' by Mercer et al. (2015).

2.4.3.1: Theoretical framework and natural disasters

Pelling et al. (2002) held that over the year's frequency of natural disaster has increased and they have become more severe. He believed that due to natural disasters, development process has not been smooth and continuous in order. Until now exogenous shocks like natural disaster have held a relatively marginal place in development theory and actual planning practices. Since disasters lead to disturbance of whole economic system, the author held that its impact depend on the disaster magnitude relative to the size and structure present in an economy.

According to the author economies with higher economic diversification are found to be more resilient than those who mainly depend on agriculture. The study revealed that natural disasters are not a 'problem for development' and it is not obligatory that most vulnerable are least underdeveloped. Apart from this the author found effectiveness of disaster aid is hampered due to delays in releasing funds and soft loans which worse national debt. Also it has been observed that FDI which is more suitable than soft loans has not been available to least developed countries and also it has not been put in productive sectors. Moreover the author held that private sector especially insurance companies can play a prominent role in disaster mitigation practices and thus in reducing vulnerability. Increasing public awareness of hazards, risks and mitigation strategies is also seen as a key to address this problem. Information scarcity is a big hurdle for calculating the actual costs of natural disaster. National governments often manipulate damage of natural disasters. Therefore, to develop a universally holistic methodology has been the main aim in his study.

Okuyama (2003) held that in recent times most of the research on natural disasters focused on modelling and estimating the spatial economic impacts of natural disasters. Little has been done to rebuild the economic theory behind natural disasters. The author argued that a sound empirical estimate of natural disasters is possible only if a good theoretical analysis is available. The study reviewed and updated Dacy and Kunreuther (1969) to empirical findings from recent studies. In order to improve decision making for

emergency responses at immediate short term, the author believed that uncertainty and risks elements need to incorporated, because the decision making by the economic agents will be quite different than in the pre disaster content. The study also highlights the need to incorporate natural disaster shocks in the domain of main economic theory, so that a sustained development and growth process is guaranteed. Moreover disasters are not frequent, and damages vary from disaster to disaster and country to country. Theoretical analysis of the disaster impacts will also provide new insights and directions to conduct future disaster related research.

2.4.3.2: Effect of development on natural disasters impacts

Mercer et al. (2013) in their study replicated the work done by Toya and Skidmore (2007) about the effect of level of development in mitigating the impacts of natural disasters. To checks the robustness of the results, the authors updated the original data to new time periods. The author found that the results of the study were akin to Toya's and Skidmore (2007) main conclusion that the level of income is significantly related to mitigation of adverse effects of natural disasters. However, in addition to that the author argued other variables of development such as higher educational attainment, greater openness, strong financial markets and smaller governments are also important in reducing the fatalities and economic damage of natural disasters. Apart from using the updated data, the author held that all coefficients retained their signs as that of Toya and Skidmore study, however the coefficient of income become small and statistically insignificant both for the all countries sample and the developing countries subsample.

The study also found that the coefficient of size of government increased and become statistically significant for all countries and even larger increase and highly significant coefficient for developing countries. The results of the interval regression (used to remove truncation bias and skewness) of the study showed that none of the variables of economic development was found to be statistically significant in mitigation of impact of natural disasters. Thus the author revealed that time and country fixed effects actually increase the estimate of income and make them statistically significant. The study argued the sole exception to above analyse being economic damage variable which was found to have negative relationship with income and most of the time damage variables were found to be significant and larger than in the Toya and Skidmore findings. Thus the study

revealed that level of development to be insignificant determinant in mitigating costs of natural disaster with sole exception that the advanced economies face lower economic costs of natural disasters.

2.4.3.3: Political aspects of natural disasters

Cohen et al. (2008) argued that natural disasters occur in a political space. He held that Governments use disasters as a political tool and favour spending in regions that are politically aligned to that particular government. By using political economy model of disaster prevention and taking support from case studies and preliminary empirics, the study found that in a given area political motives and policy interventions determine the severity of natural disasters. Since disasters are uncertain, the Governments were found to be more willing to spend on relief than on prevention and investment measures before the disaster shock.

Those Governments who focus on preventive measure were found to face less severe natural disasters. Also it was found that international relief aid increases severity of disasters and create moral hazard problem as it rewards the bad behaviour of poorly run economies, thus increases the chances that they will underinvestment in disaster prevention measures. Like all transfers it was found that disaster relief was distorted by self-interested political leader and was used to gain government income. The pattern of onset and reconstruction process with special reference to political economic aspects has also been analysed. According to Albala-Bertrand (1993) the costs of natural disasters are exaggerated in order to gain more revenue.

2.5: Conclusion

From the above review it can be concluded by saying that in the short run natural disasters are mainly of destructive nature as a result negative retarding impact on economic growth seem to dominate. However, to observe whether the impact of natural disasters is permanent or not; there is no unanimity among the various scholars on economics of natural disasters. As compared to short run, the economic literature on long term growth effects of natural disasters is scare and seems to be inconclusive. As far as the impact on government expenditure, public debt, fiscal deficit, trade balance and international position is concerned, most of studies found natural disasters increase

government expenditure as a result deteriorate public debt and financial conditions of the country. Natural disasters seem to worsen international trade positions of the country and measures such as remittances, inflows and aid lessen the negative macroeconomic consequences of natural disasters.

Besides macroeconomic performance, vulnerability, socio-economic development, political considerations etc. also govern the implications of natural disasters. Therefore, while analysing the costs associated with natural disasters to ensure accuracy and accountability, many studies advocated the use of a holistic methodology which incorporates the effect of all aspects of natural disasters.

Chapter 3

Methodology and Estimation

3.1: Introduction

In order to develop the idea regarding the inter-relationship between natural disasters and economic growth, first of all it will be useful to discuss the key determinants of economic growth and how natural disasters play a role. Economics is a behavioural science which is influenced by so many factors determinants; so do macroeconomic indicators. Economic performance as measured by annual GDP growth is influenced by many factors like capital formation, human capital, trade, macroeconomic stability, good governance, social and environmental factors. In most of the empirical analysis, the standard practice has been to address the impact of some key determinants on economic growth. These include investment, education, health, government expenditure, exports, imports, foreign direct investment (FDI), foreign reserves etc. In addition to this set of variables, other variables do influence GDP growth rate of any economy. This study has tried to examine the effects of natural disasters on annual GDP growth.

Natural disasters are usually considered to be exogenous and outside the domain of mainstream economics. However, sometimes the costs associated with natural disasters are so high that it overthrows the whole economic setup of a country. The shocks due to natural disaster have important quantitative effects; sometimes their magnitude impact is greater than the terms of trade shock which are considered to be vital in the mainstream economics (Raddatz; 2007). As far as India is concerned, as already noted some natural disasters have been too devastating that they deteriorated more than one percentage of total annual output. Besides this at certain times it was found to affect around 38 percent of the total population. Therefore, to analyse the economic performance of any economy, it becomes obligatory to take natural disasters along with other key determinants of output growth.

In this study in addition to natural disaster variable, other variables like the impact of investment, government consumption expenditure and net exports are taken as

explanatory variables. Although education, health, FDI and reserves are also important but due to missing data these variables could not be taken into account in this study.

As far as the impact of these explanatory variables on economic growth is concerned, gross domestic capital formation as measured by investment to GDP leads to additions in the stock of capital. Its impact on GDP growth is expected to be positive. Trade leads to economies of scale through specialisation; it increases competitiveness, and allows underdeveloped countries to adopt foreign technology. Similar to investment, the effect of trade balance is expected to improve economic growth. The impact of government expenditure on GDP depends on which component dominates the overall composition of government expenditure. As far as impact of natural disasters is concerned, there seem to be little harmony among the various scholars but on the whole negative impact seems to dominate.

3.2: Methodology

In order to analyse the macroeconomic implications of natural disasters in India during the time period 1964 to 2014, an autoregressive distributed lag model (ARDL) model of co-integration analysis has been used. In most of the studies related to natural disaster (Noy; 2009, Raddatz; 2009, Skidmore and Toya; 2002 etc), damage variable is taken to be exogenous. However occurrence and severity of natural disasters in a particular country depend on the economic conditions present in a country. Low economic growth in an underdeveloped country may infuse additional costs for a disaster of relatively same magnitude than in a developed country enjoying higher growth. Therefore, destruction associated with natural disasters can also be a result of past low economic performance of an economy. Therefore, direction of causation may also run from annual GDP growth to future disaster.

The main advantage of using ARDL is that it overcomes the issue of taking natural disasters and its impacts as exogenous. In addition to that ARDL testing procedure is possible even when the explanatory variables are endogenous (Alam and Quazi; 2003). Unlike most co-integration models, ARDL bounds test can be applied to series which are combination of both stationary I(0) and non stationary I(1) as is in the present case some

variables are integrated of order zero and some integrated of one[3]. Apart from this in ARDL bounds test we have unrestricted model of Error Correction Mechanism (ECM), in which various explanatory variables are not required to have same lag length. In ARDL no restriction is imposed on the lags length of various endogenous variables, thus losing no long run information.

In this analysis the ARDL model is used for exploring the short run and long run growth dynamics of natural disasters. The general form of the ARDL model is:

$$Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \ldots + \alpha_p Y_{t-p} + \beta_0 X_t + \beta_1 X_{t-1} + \ldots + \beta_p X_{t-p} + \gamma_0 Z_t + \gamma_1 Z_{t-1} + \cdots + \gamma_p Z_{t-p} + \epsilon_t \quad \ldots\ldots\ldots\ldots\ldots \quad (I)$$

Where Y_t is the annual output growth (in constant US$ 2005 prices), Y_{t-1} and Y_{t-p} are lagged values of dependent variable annual GDP growth, X_t denotes the set of natural disasters measure Killed, Total Affected and Total Economic Damage, the symbol Z_t is a vector of other determinants which are key to economic growth such as ratio of investment to annual Gross Domestic Product (INV), ratio of government consumption expenditure to Gross Domestic Product (GCE) and share of net exports to Gross Domestic Product as measured by net exports (NXM). Here population affected and killed are in population indicators while all other variables are in monetary terms. Therefore, in order to club them in a single regression equation all variables are expressed in percentage terms. The residual term $\epsilon_{i,t}$ in the above regression function is assumed to be white noise.

As already mentioned we have three measures of natural disasters namely People Killed (KILP), Total Affected (AFFP) and Economic Damage (DAMO). On the basis of destruction to population indicators due to natural disasters, many studies have created a new variable disaster intensity (DI) (Fomby; 2013, International Monetary Fund (IMF); 2003, and Becker and Mauro; 2006), measuring the magnitude of the event relative to the

[3] Stationary series is one whose statistical properties such as mean, variance, autocorrelation are time invariant i,e they remain constant over different time periods. In case of non-stationary series, these statistical properties do change, thus making it hard to predict about future behaviour of the economic variables.

size of the economy i,e sum of the number of casualties and 30 percent of the total number of people affected divided by the total population such as:

$$DI = \frac{(Killed + (.3)TotalAffected)}{TotalPopulation}$$

In accordance with these studies, similar disaster intensity measure has been used. Finally we have two measures of natural disasters DI and DAMO, in order to analyse which among the two measures is a significant determinant of annual output growth rate in India. Least square estimation method has been used for preliminary analysis results (Table 3.1). Here in addition to these measures of natural disasters, lagged value GDP growth rate is taken along with these two explanatory variables in order to capture the effect of all other important omitted variables.

Table 3.1: Least Square Estimation: Dependent Variable (GDPG)

Variable	Coefficient		t-Statistic
C	5.247	(0.919)	5.705
DI	-0.427**	(0.166)	-2.576
DAMO	1075.43	(979.81)	1.098
GDPG(-1)	0.059	(0.130)	0.668

** indicates significant at 5%level of significance, Std. Error are given in parentheses.

Source: Authors calculation (2016)

The above results point to two broad conclusions. First, percentage damage to output (DAMO) has little or no statistical significance with output growth (GDPG). Second evidence of significant negative relationship between output growth (OUTG) and disasters damage in terms of population affected and killed (DI). Therefore, natural disasters damage measure DI is significantly related with the growth rate of GDP. In rest of this study DI has been used as a measure of both intensity and severity of natural disasters. Besides this output damage measure (DAMO) has missing data problem and also its value is often overestimated in order to gain more international support. Therefore, taking population damage indicator DI as a measure of severity of natural disasters seems to be closely related with the vulnerability of natural disasters in India.

By using DI measure of natural disasters in place of X_t, incorporating other key determinants of economic growth for Z_t and expressing in summation terms, equation (*I*) can be alternatively written as:

$$Y_{t,t} = \varphi_t + \sum_{j=1}^{p} \alpha_t Y_{t-j} + \sum_{j=0}^{p} \beta_t D_{t-j} + \sum_{j=0}^{p} \gamma_t INV_{t-j} + \sum_{j=0}^{p} \theta_t GCE_{t-j} + \sum_{j=0}^{p} \delta_t NXM_{t-j} + \epsilon_{t,t} \quad \ldots\ldots\ldots\ldots\ldots \quad (II)$$

Just like in the first equation $Y_{t,t}$ and Y_{t-j}, denotes annual output growth and its lagged values, INV, GCE and NXM refers to investment by output, government consumption expenditure by annual output and trade balance by annual output respectively; whereas D_t represents disaster intensity measures as defined above. Since we know most of the economic variables respond after some lag, so '*p*' in the above function is number of lags determined by Akaike Information Criterion (AIC) and Schwarz-Bayesian Criterion (SBC). Optimal lag is selected where the value of AIC, and SBC is least. Usually when the sample size is less than 100 as is in the present case, Schwarz- Bayesian Criterion (SBC) is used to select optimal lag length and to conserve degrees of freedom.

In order to estimate the long and short run growth coefficients, first of all existence of co-integration analysis among the various variables is determined by using the ARDL Bound test based on F-statistic. In testing the existence of long term equilibrium relationship, error correction versions of the above ARDL model is represented by:

$$\Delta Y_{t,t} = \varphi_{t1} + \sum_{j=1}^{p} \alpha_{t1} \Delta Y_{t-j} + \sum_{j=0}^{p} \beta_{t1} \Delta D_{t-j} + \sum_{j=0}^{p} \gamma_{t1} \Delta INV_{t-j} + \sum_{j=0}^{p} \theta_{t1} \Delta GCE_{t-j} + \sum_{j=0}^{p} \delta_{t1} \Delta NXM_{t-j} + \alpha_{t1} Y_{t-1} + \beta_{t1} D_{t-1} + \gamma_{t1} INV_{t-1} + \theta_{t1} GCE_{t-1} + \delta_{t1} NXM_{t-1} + \epsilon_{t,t} \quad \ldots\ldots\ldots\ldots \quad (III)$$

In the above equation all the variables are in change (Δ) form which is the representation of taking error correction process on the earlier equation. In addition to this, here we have other parameters like α_{t1}, β_{t1}, γ_{t1}, θ_{t1}, δ_{t1}, these are long term multipliers of annual output growth.

The Null Hypothesis H_0 set in ARDL Bounds test is that the variables are not co-integrated:

$$H_0 = \alpha_{i1} = \beta_{i1} = \gamma_{i1} = \theta_{i1} = \delta_{i1} = 0$$

Against Alternative Hypothesis H_1:

$$H_1 \neq \alpha_{i1} \neq \beta_{i1} \neq \gamma_{i1} \neq \theta_{i1} \neq \delta_{i1} \neq 0$$

The null hypothesis tested in the ARDL bounds test does not fallow any standard asymptotic distribution. Appropriate critical values for different number of explanatory variables are given in Pesaran et al. (2001), where one set of critical values assume all variables are I (1), other assume all variables are I (0). These two sets of critical values provide us a band for stationary and non stationary variables. If the value of F-statistic is above than the upper bound I (1), then we reject the null hypothesis of no co- integration. If the value of F-statistic lies within the two critical limits then the results are inconclusive and we cannot rely on the ARDL bounds test for testing the co-integration and therefore in exploring the short run and long run growth coefficients.

Before exploring the short run and long run growth estimates, it is necessary to go for diagnostic and stability checking. This include testing whether the model is free from the problems of serial correlation, hetroscedasticity, function form misspecifications, dynamic stability etc.

Once long term equilibrium relationship is confirmed, the long term growth coefficients of $Y_{i,t}$ can be estimated by:

$$Y_{i,t} = \varphi_{i2} + \sum_{j=1}^{p} \alpha_{i2} Y_{t-j} + \sum_{j=0}^{p} \beta_{i2} D_{t-j} + \sum_{j=0}^{p} \gamma_{i2} INV_{t-j} + \sum_{j=0}^{p} \theta_{i2} GCE_{t-j} + \sum_{j=0}^{p} \delta_{i2} NXM_{t-j} + \epsilon_{i,t} \quad \ldots\ldots\ldots\ldots\ldots\ldots (IV)$$

Finally, short term coefficients in the ARDL test are estimated by Error correction mechanism (ECM) associated with the long term coefficients. The specified equation of ECM is:

$$\Delta Y_{i,t} - \varphi_{i3} + \sum_{j=1}^{p} \alpha_{i3} \Delta Y_{t-j} + \sum_{j=0}^{p} \beta_{i3} \Delta D_{t-j} + \sum_{j=0}^{p} \gamma_{i3} \Delta INV_{t-j} + \sum_{j=0}^{p} \theta_{i3} \Delta GCE_{t-j} + \sum_{j=0}^{p} \delta_{i3} \Delta NXM_{t-j} + \mu_i ECT(-1) + \epsilon_{i,t} \quad \ldots\ldots\ldots\ldots \quad (V)$$

Where α_{i3}, β_{i3}, γ_{i3}, θ_{i3}, δ_{i3} are the short run growth coefficients and μ_i is the coefficient of error correction term which shows the speed of adjustment towards the long run equilibrium. The sign of the Error Correction Coefficient should be negative and significant in order to validate the conclusion of long term equilibrium relationship.

3.3: Results and Analysis

First of all to avoid the problem of spurious regression it is necessary to conduct the unit root tests[4]. In the table 3.2 below, Augmented Dickey Fuller test has been employed to check the unit roots of the various variables in question.

Table 3.2: Unit root test of various explanatory variables

	Augmented Dickey Fuller Test statistic	
Variables	Level	First difference
GDPG	-6.357	.....
DI	-8.002	.....
INV	-1.071	-8.611
GCE	-1.976	-5.652
NXM	-2.03	-6.557
Mckinnon critical value at the level 5%: -2.931		

Source: Authors calculation (2016)

As can be seen from the above table, GDPG and DI variables are integrated of order zero I(0) while INV, GCE, and NXM are integrated of order one I(1). Therefore we have a combination of both stationary and non-stationary variable. To explore the short run and

[4] Spurious regressions include a situation when the economic variables are not causally related to each other (relationship between shoe size and intelligence) but due to some unknown factors we infer that the variables are correlated. In time series analysis these include when the variables in question are non-stationary i,e they have a unit root. Tests used to check the presence of unit root are known are unit root tests such as Augmented Dickey Fuller test, Phillips Peron test, KPSS test etc.

long run growth coefficients, it is necessary to follow ARDL method of co-integration analysis.

3.3.1: Co-integration and Diagnostic analysis

Before estimating short run and long term growth coefficients, we have first followed the standard process of analysing co-integration analysis among the various variables. By doing so we will get some idea about the trend of annual GDP growth and annual damage associated with the natural disasters. This is examined in ARDL Bounds test below (Table 3.3). It can be seen that the value of F-statistic (4.653) is greater than upper bound (3.49) at 5 percent level of significance, so we reject the null hypothesis of no long run relationship and conclude that the variables have long term equilibrium relationship. Thus there is an indication that annual GDP growth rates share the same trend as explanatory variable disaster intensity (DI) damage variable.

Table 3.3: ARDL Bounds Test

Dep. Variable	Optimal Lag	F-statistic	Outcome
GDPG(GDPG, DI, INV, GCE, NXM)	4,0,0,0,0	F(4,47)= 4.653**	Co-integration
F-statistic AIC	SBC	R-square	DW statistic
8.857***4.95	5.30	0 .6509	2.254

, * indicate significant at 5 and 1% level respectively, for k=4, by pearson et. al (2001) lower bounds I(0)= 2.56 and upper bounds I(1) = 3.49 at 5%level of significance

Source: Authors calculation (2016)

The above table also reports estimate of F-statistic which shows overall significance of the regression coefficients. The value of f-statistic is found to be significant at 1 percent level of significance. The value of R-square which measures goodness of fit is high and equal to 0.6509. The value of AIC and SBC at the optimal lag are found to be 4.95 and 5.30 respectively. On the basis of SBC criterion, maximum lag is found to be 4 for dependent variable and 1 for all other variables. The value of Durbin Watson statistic is equal to 2.254 which is in inconclusive range of DW limits. Therefore, no conclusion about the problem of autocorrelation can be drawn.

Various diagnostic tests (like Breusch-Godfrey, Breusch-Pagan-Godfrey and Ramsey's RASET tests) have been estimated to check the accuracy of the model (Table 3.4). Stability of the regression model has also been checked by the CUSUM test.

Table 3.4: Results of diagnostic test for GDPG

Problem	Test- statistic	F value (prob.)
Serial correlation	Breusch-Godfrey Test	1.374 (0.249)
Hetroscedasticity	Breusch-Pagan-Godfrey Test	0.637 (0.742)
Functional Form	Ramsey RESET Test	0.118 (0.733)

p-values are given in parentheses

Source: Authors calculation (2016)

F-Statistic in case of BG and BPG tests is statistically insignificant (Table 3.4). This is an indication that the model is free from the problems of Serial Correlation and Hetroscedasticity. The results of the Ramsey RESET test reveal that the functional form we adopted here is correctly specified. In all the three cases, F-statistic is not significant even at 10% level of significance.

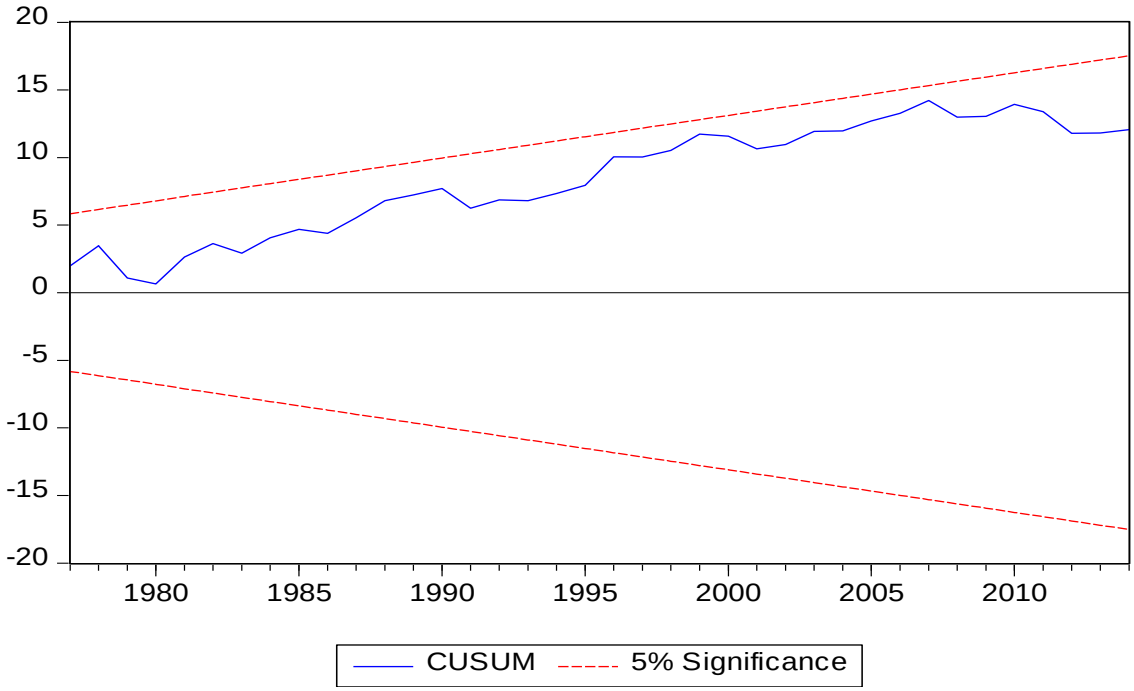

Figure 3.1: CUSUM Stability test

Source: Authors calculation (2016)

The diagram of the CUSUM test lies within the upper and lower bounds at 5 percent level of significance revealing that the regression model we are fallowing is dynamically stable (Figure 3.1). Thus the regression model adopted here is stable and free from the problems of serial correlation, hetroscedasticity and functional miss-specification. Now we conclude that the estimates of the model will be quite reliable and thus better future projections can be made.

3.2.2: Long Run estimates

As highlighted above in the long run output growth and natural disasters damage have co-movement, so it would be quite interesting to examine the impact of natural disasters on long run output growth. The long run growth coefficients of the various explanatory variables have been estimated in table 3.5. In accordance with the economic theory, the impact of gross domestic capital formation (INV) was found to accelerate long term output growth and significant at 1 percent level of significance. Contrary to the general perception, the coefficient of government consumption expenditure although insignificant was found to improve long term GDP growth. This is possibly due to prevalence of strong aggregate consumption demand effect present in India. As far as net trade balance(X-M) is concerned, it showed a positive but insignificant impact on long term growth. This may be partly due to huge accumulated import debt or as a result of India being a primary exporting country with income elastically of exports less than one (Secular deterioration Hypothesis).

Table 3.5: ARDL Model; Dependent variable: GDPG

Long Run Coefficients			
Variable	Coefficient		t-Statistic
DI	-0.117*	(0.064)	-1.825
INV	0.222***	(0.045)	4.873
GCE	0.236	(0.182)	1.300
NXMO	0.154	(0.167)	0.924
C	-2.183	(-1.675)	-1.303

*, **, *** indicates significant at 10, 5, 1% level respectively, Std. Error are given in

parentheses

Source: Authors calculation (2016)

Now coming to the explanatory variables of interest, natural disasters as measured by DI was found to retard economic growth in the long run significantly at 10 percent level of significance. The results revealed that 1 percent increase in DI will reduce long run growth rate of GDP by 0.11 percentage points. The humanitarian loses as measured by disasters intensity (DI) are mainly associated with droughts, cyclones and tsunamis in India. The negative impact on the long run growth can be readily explained as India has been more prone to Droughts and associated famines than any other country of the world (Tewari, 1987). Droughts have greater coverage while cyclones and tsunamis have most devastating feature and they overturn the whole economic setup present in a country. As compared to other disasters, droughts are more destructive in their impact, they erode long term saving, investment and undermine productivity capacity of an economy (United Nations Disaster Relief Coordinator (UNDRCO), 1991).

Besides this India has greater vulnerability to natural disasters in terms of widespread poverty, higher income and regional inequality, weak housing conditions, low medical coverage, less insurance cover etc present in India. These are the factors which increase the severity of natural disasters in any particular country. Also due to weak institutional setup, natural disasters some times were so devastating that they affected more than 10 percentage of population. Therefore, given these factors natural disasters are bound to retard the growth rate of annual GDP. Since human capital is important input in the output, the negative impacts of natural disasters also highlights the importance of demographic dividend in growth accounting in India. Thus India besides facing challenges from persistent poverty, unemployment, inequality, malnutrition etc, has to face severe adverse cost of natural disasters whose magnitude is increasing year after year. Thus the study reveals natural disasters damage in India is so severe that even in the long run the negative significant impact of natural disasters prevails.

3.2.3: Short Run estimates

The short run growth coefficients in the ARDL model have been estimated through error correction mechanism (Table 3.6).

Table 3.6: ARDL Model (4, 0, 0, 0, 0, 0); Dependent Variable: GDPG

Short Run Coefficients based on Error Correction Mechanism			
Variables	Coefficients		t-Statistic
d(GDPG(-1))	-0.442	(0.289)	-1.534
d(GDPG(-2))	-0.269	(0.258)	-1.041
d(GDPG(-3))	-0.121	(0.195	-0.622
d(GDPG(-4))	-0.278**	(0.134)	-2.07
d(DI)	-0.254*	(0.123)	-2.062
d(INV)	0.463*	(0.276)	1.678
d(GCE)	-0.163	(1.037)	-0.157
d(NXMO)	0.559	(0.613)	0.912
ECT(-1)	-0.549*	(0.462)	-1.601
C	-0.008*	(0.46)	-0.019

*, **, *** indicate significant at 10, 5, 1% level respectively, Std. Error are given in parentheses

Source: Authors calculation (2016)

As far as growth coefficients in the short run are concerned, except coefficient of government consumption expenditure all the explanatory variables retained the same sign as that of their long term counterparts. The results found that the coefficient of output growth with lag 1, 2, 3 and 4 indicate inverse relationship between with that annual GDP growth rate; indicating that poor economies like India with low initial output growth tends to grow faster. This fact is very well documented in the 'convergence hypothesis' advocated by neoclassical economists. Similar to long run analysis, investment was found to have positive significant relationship on growth rate of GDP. The coefficient of government consumption expenditure was found to reduce short run output growth. The effect is well in line with the economic doctrine because in India government consumption expenditure is mainly diverted to paying interest payment and defence expenditure which are unproductive, as a result antagonistic with the growth rate of GDP. As far as net trade balance (X-M) is concerned, in accordance with the long run analysis its impact was found to improve output growth but it is statistically insignificant.

As far as natural disaster coefficient is concerned it was found to retard GDP growth significantly at 1 percent level of significance. One important point to note is that its adverse impact was found to be more serious in the short run than the long run; one percentage change in DI was found to deteriorate annual GDP growth by 0.25 percentage points. These figures show the degree of severity of natural disasters in India. As pointed earlier the negative impact is due to devastating impact of droughts and tsunamis which mainly lead to huge human capital destruction. Greater vulnerability associated with the natural disasters in India than in any other country might be another reason that increases the severity of natural disasters in India. Thus from the above analysis, evidence of adverse short term impact of natural disasters on the economic growth has been found and also it devastating nature was found to be such that its impact does not fades away in the following few years of natural disasters.

In the above table, also coefficient of ECM has been estimated. It is found to be negative and significant, thus supporting and validating the earlier result of long term equilibrium relationship among the various variables analysed in the study. According to the ECM coefficient, the speed of adjustment towards long run equilibrium was found to be 54 percent.

3.2.4: Robustness

Table 2: ARDL Model (4, 0, 0, 0, 0, 0,); Dependent Variable: PGDPG

Short Run Coefficients Based on Error Correction Model Dependent variable: PGDPG			
Variables	Coefficients		t-Statistic
d(PGDPG(-1))	-0.436	(0.289)	-1.510
d(PGDPG(-2))	-0.262	(0.258)	-1.017
d(PGDPG(-3))	-0.119	(0.195)	-0.608
d(PGDPG(-4))	-0.277**	(0.134)	-2.062
d(DI)	-0.250**	(0.121)	-2.065
d(INV)	0.455*	(0.271)	1.679
d(GCE)	-0.175	(1.019)	-0.172
d(NXM)	0.556	(0.602)	0.923
ECT(-1)	-0.544*	(0.337)	-1.612

C	0.034	(0.455)	0.074

*, **, *** indicates significant at 10, 5, 1% level respectively, Std. Error given in parentheses

Source: Authors Calculation (2016)

Table 3.8: ARDL Model; Dependent Variable: PGDPG

Long Run Coefficients

Variable	Coefficients	t-Statistic
DI	-0.126* (0.072)	-1.748
INV	0.273*** (0.051)	5.330
GCE	0.186 (0.204)	0.916
NXMO	0.196 (0.188)	1.049
C	-4.85** (1.874)	-2.5488

*, **, *** indicates significant at 10, 5, 1% level respectively, Std. Error given in parentheses

Source: Authors calculation (2016)

In order to check robustness of results, next per capita GDP growth in place of annual GDP growth has been taken as the dependent variable (Table 3.7 and 3.8).

The above report the impact of natural disasters on short and long run per capita GDP growth respectively. The results with per capita GDP as dependent variable hardly modified earlier conclusions, thus indicating that the impact of natural disasters on per capita GDP growth is negative and statistically significant both in short run and long run. In the short one percentage increase in DI was found to retard economic growth by 0.25 percentage points while in the long run half percentage disturbance impact of the short run percentage impact on GDP growth prevails. In accordance with the earlier results, similar analysis has also been found for other growth determinants.

3.4: Conclusion

Thus from the above analysis we can conclude that in India catastrophic costs are so devastating that it does not only shrinks output growth but also per capita growth of aggregate income both in the short run and long run. The devastating costs of natural disasters are due to greater vulnerability (in terms of widespread poverty, high inequality,

weak housing conditions, low medical coverage etc) and also as a result of India being more prone to droughts and tsunamis. From the above analysis there is a clear indication that not much effort has been made by the government of India to repeal the immediate and future costs of natural disasters. Also preventive and mitigation measures taken by the government of India against natural disasters has not been up to the mark. Apart from this, India has higher frequency and also bears both short and long run growth consequences of natural disasters. Therefore, an attempt should be made to include natural disasters in long term economic planning.

Chapter IV

Summary and Conclusion

4.1: Introduction and Background

Economic performance in a country as measured by GDP is influenced by a set of factors. In most of the studies on economic growth, the standard practice is to examine the impact of some key determinants such as investment, education, health, government expenditure, exports, imports, foreign direct investment (FDI), foreign reserves etc. Although this process has many advantages but still the issue of development gap between developed and underdeveloped remains a great concern. Over the years many questions have raised on the adequacy and accuracy of the standard models used in growth accounting. Therefore, in this study besides the standard determinants, natural disasters have also been taken among the pool of explanatory variables. The reason for including natural disasters among the set of explanatory variables is due to increase in intensity and occurrence around the world especially in developed countries like India.

Natural disasters which concern the interaction of sudden natural events with the socio-economic setup of the country cause destruction and suffering to human, physical and environmental capital of any economy. Natural disasters are a common occurrence around the world including India. India in its history has come across scores of catastrophic events which have taken huge toll of life and property. India besides facing challenges from poverty, inequality, unemployment, malnutrition etc. has been constantly facing devastating costs of natural disasters. Quite often India has been among top 10 countries of the world facing highest burden of natural disasters. Due to greater vulnerability (in terms of widespread poverty, higher inequality, less medical coverage, unemployment, malnutrition etc), natural disasters in India are found to be more severe than other countries.

From last five decades, there has been a threefold increase in incidence of natural disasters in India. These constantly increasing natural disasters in India are found to cause a huge toll of deaths; many times it remained well above 1 percent of the total population.

Due to greater vulnerability in India, the percentage of population affected is even more acute to natural disasters. In several years total population affected was more than 10 percent of total population of India. Economic damage due to natural disasters has shown a drastic increase particularly in the recent time period. Due to higher exposure and vulnerability to general masses, the destruction of natural disasters in India is found to be greatest in terms of population indicators (population killed and affected).

In order to design the preparedness and preventive measures against natural disasters, most of the literature on natural disasters has focused only on the assessment of direct costs of natural disasters. Up to now little attempts have been made to analyse the impact of natural disasters on macroeconomic indicators. Moreover the meager literature that is available on the macroeconomics of natural disasters has shown little consensus. Some authors held that natural disasters have adverse impact on macroeconomic indicators while others believe that the impact is limited and even natural disasters can boost the economy during the reconstruction and rehabilitation process. Moreover the prior research has shown that short run negative impact of natural disasters seems to dominate where as the empirical estimates regarding growth response of natural disasters in the long Run seem to be inconclusive. Therefore in this study an attempt has been made to reconcile this controversy on the one hand and also analysis of dichotomy of results between the short and long growth dynamics of natural disasters will be made.

In most of the studies on macroeconomics of natural disasters, disaster damage is taken to be exogenous. However besides disaster magnitude, severity of damage also depends on the prevailing socio-economic conditions in an economy. For a disaster of relatively same magnitude, low economic performance may also infuse additional costs of natural disasters. The exogeneity issue of natural disasters becomes more critical for a developing country like India which faces greater vulnerability to natural disasters. So destruction as a result of natural disasters is not purely exogenous, causation may also run from low economic growth to future disaster damage.

To analyse the decimate role played by natural disasters in the economic performance of India, data regarding natural disasters is taken from EM-DAT during the time period 1964 to 2014. The database reports data on the initial damages (events occurred, people

killed, affected and total economic damage) of natural disasters and on the basis of these initial costs, an attempt has been made to analyse the secondary macroeconomic costs associated with natural disasters. Data on natural disasters is available regarding destruction to population indicator and to property damage. However, India being a underdeveloped country with greatest damage to population indicators and also due to missing data on economic damage, the study makes use of population indicators as a measure of magnitude and severity of natural disasters.

In this study by using Auto Regressive Distributed Lag (ARDL) model, an attempt has been made to explore short run and long run growth dynamics of natural disasters by taking disaster damage as endogenous variable. The presence of both stationary and non stationary variables also made it necessary to follow the ARDL model of co-integration analysis.

4.2: Main Findings

In this study besides key growth determinants, effort has been made to analyse the impact of natural disasters on short and long run growth dynamics. The results regarding most of the economic variables were found to be in line with economic theory. Investment and trade balance was found to improve economic growth. However, only investment was found to be statistically significant both in short and long run. The effect of government consumption expenditure on the output growth seems to be negatively dominated.

The natural disasters economic growth empirics was found to be negatively related in India. The impact of natural disasters was found to be long lived retarding both short and long run growth rate of GDP. In the short run, one unit increase in disaster intensity were found to retard 0.25 percent of the GDP growth while in long run its catastrophic cost was found to be equal to 0.11 percent of the GDP growth. Such a devastating negative impact on growth rate of GDP is due to greater human capital destruction associated with droughts and tsunamis in India. Among various natural disasters, droughts in India are found to be more severe causing the highest percentage of fatalities (49 percent) and population affected (52 percent). Droughts erode long term saving, investment and undermine productivity capacity in India. In our country about 20 percent of the

geographical area is drought prone which on average affect 12 percent of the total population. Also most parts of southern India are prone to tremendous tsunamis which have been continuously occurring in these areas. Moreover greater vulnerability associated with natural disasters also readily explains the adverse impact of natural disasters in India.

Further to check robustness of results, per capita GDP growth in place GDP growth was taken as the dependent variable. The results were similar to the earlier counterparts, thus confirming that natural disasters reduce both GDP growth and per capita GDP growth in India. Also the impact of natural disasters was not found to fade away in the fallowing years of natural disasters. Evidence of negative impact on both short run and long run per capita GDP has been confirmed.

From this study on growth dynamics of natural disasters in India, the results seems to be in accordance with the endogenous technical change models which predict that destruction to physical or human capital due to natural disasters will lower the long run economic growth and consequently a permanent deviation from existing growth trajectory.

4.3: Implications and Scope for Future Research

The study makes a clear indication that not much effort has been made by the government of India to repeal the immediate and future costs of natural disasters. The preventive and mitigation measures taken by the government of India against natural disasters has not been up to the mark. The magnitude of deaths, total affected, total economic damage is huge which is unacceptable for a growing economy like India.

Since India is constantly facing natural disasters and also its costs are so devastating, therefore efforts should be made to consider natural disasters in long term economic planning. Apart from this in our country main source of growth and development is demographic dividend. Therefore, steps should be taken to reduce vulnerability and exposure of general masses to natural disasters in India.

4.5: Limitations of the study

Analyses from the EMDAT database can provide us good insights about the severity of natural disasters, but well developed national disaster database are required to a great extent. Also micro level studies and surveys both at regional and national level are required for effective policy analysis.

The present study only analyses the impact of natural disasters on economic growth. Besides economic growth, implications on other macroeconomic indicators such as public debt, fiscal deficit, trade balance, inflation and many more are also of great importance. It was not possible to analyse the impact on other macroeconomic indicators for paucity of time. However, to design and adopt policies against the implications of natural disasters, it is required that all catastrophic costs should be taken care of. Therefore, efforts should be made to follow a holistic approach which will analyse the impact of natural disasters on all macroeconomic indicators.

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