Depreciation of Capital Due to Natural Disaster and Adjusted Net Domestic Product

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Abstract

The conventional measures of national income accounting do not account for the depreciation of physical capital caused by natural disasters. To our knowledge, systematic studies on the economic accounting of loss due to natural disasters in the Indian context, are limited. This paper tries to account for the economic loss due to natural disasters, as the depreciation of capital and provide the adjusted estimate of NDP. We have estimated the Natural Disaster adjusted NDP by deducting the financial losses due to natural disasters from the conventional NDP. Systematic data on economic loss due to natural disasters are limited for all Indian states. Therefore, this paper provides a methodological framework for accounting for the depreciation of the capital due to natural disasters for all Indian states and provides an approximate estimate of adjusted NDP for all Indian states. Due to availability of systematic data on the economic loss due to natural disasters, time series estimates of adjusted NDP are provided for Odisha state which experiences maximum climatic natural disasters. Calculation of adjusted NDP will be very much useful for fiscal transfer from Union to States and other economic policy making.

Keywords: *Adjusted NDP, Natural Disaster, Consumption of Fixed Capital, Depreciation*

1. Introduction

In the last two decades, attempts are being made to compute better metrics to measure the national income that accounts for the environmental resources and costs. The conventional measures of national income accounting do not take into consideration

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the benefits of environmental/natural resources and the cost of their degradations. Therefore, economists have been trying to include the depletion of natural resources as the depreciation of natural capital and measure a modified Net Domestic Product. This adjusted NDP is Gross Domestic Product less the depreciation of physical capital and natural capital. However, this measure also does not account for the depreciation of physical capital caused by natural disasters. Some national and sub-national economies face natural disasters more frequently than others. Capital accumulation through continuous investment and physical capital and human capital are prerequisites for improving the living standard. Therefore, frequent occurrence of natural disasters may deplete the physical capital base (such as public infrastructure, private enterprises etc.) and reduce the fiscal space to invest in human capital (health and education). As a result of this, the capability of individuals and states to improve the living standard may decline or at least not improve. Therefore, NDP calculation should also take into account the depreciation of physical capital caused by natural disasters.

Attempts have been made in other country contexts to measure the full economic cost of disaster (Rasmussen, 2004; Gaddis et al.,2007; Noy 2009; Raddatz, 2009; Shabnam, 2014), and link the effects of disasters on economic growth (Hallegatte and Dumas 2009). Similarly, studies (Raddatz, 2009) have attempted to differentiate the macro economic effects of climatic and other disasters. Other studies have compared the costs of disasters across geographical areas and income levels and to answer structural and policy related aspects of costs due to disasters (Noy, 2008). In Indian context,Das (2012) has attempted to understand the role of natural ecosystems and socio-economic factors in the vulnerability of coastal villages to cyclone and storm surge.

Nevertheless, in Indian context, very few studies have accounted for the depreciation of the physical capital due to natural disasters. In this paper we have computed the Natural Disaster Adjusted NDP by substracting the monetary value of the losses due to natural disasters from the conventional NDP. Data on the full cost of damage and losses due to all types of natural disasters are not available. In this context, we have provided a framework for estimating the Natural Disaster Adjusted NDP and provided estimates for Indian states with the existing data sets. Such estimates will have significant implications for the fiscal transfer to states based on the formula that uses percapita income.

1.1 UN Framework for National Income Accounting

United Nations System of National Accounts (UNSNA, hereafter) provides a systematic and uniform method of calculation of the economic activities which help us in comparing economies throughout the world. GDP has been used as one of the welfare measurements. But how far GDP reflects welfare is a matter of question. What are the components that enter into the measurement of GDP should also be discussed. It has been found that the contributions of environment to the economic growth and human welfare have been ignored in national account system. Environmental costs resulting from human activities and natural disasters have not been accounted for. National Accounts of a country which are measures of economic activities should incorporate the environmental benefits and cost. The System of National Accounts of United Nations prevalent and followed across the economies does not integrate the environmental aspects of an economy. To consider the value of environment and environmental costs in accounting system of the economy, United Nations developed a framework for all countries called Integrated Environmental and Economic Accounting (SEEA) in 1993. The conventional framework for estimation of national accounts may lead to overestimation or underestimation of GDP. In National Account system of India, environmental goods and services like productivity of land, biodiversity are not included. GDP is not adjusted by environmental costs like depletion of natural resources, pollution, deforestation, etc.

1.2 Need for Changes in National Account System

The impact of natural disasters has not been included in National Account System of India due to non-availability of complete data. Natural Disasters have bearings on economy. Disasters affect economic system in many ways. They have impacts on production system, consumption pattern, employment, saving, distribution, etc. One of the limitations of conventional GDP measurement is non-inclusion of costs inflicted by natural disasters (NSO, 2013).

Government has to bear huge amount of costs in terms of compensation, rebuilding of damaged infrastructure, etc. Economic damage from natural disasters is enormous. This amount can be used for the increase of welfare of the people if natural disasters are prevented to occur. Natural calamities impose a fiscal burden on the economy. But the accounting system in India completely ignores this huge cost in the process

of calculating Net Domestic Product. The method followed by Central Statistical Organisation, India is as follows:

1.3 Income Accounting in India

1.3.1 The Production Identities

Gross Value Added (GVA) at factor cost= Output – Intermediate consumption

Gross Domestic Product (GDP) at factor cost= Sum of GVA at factor cost

GDP at Market Prices	=	GDP at factor cost
	+	(taxes – subsidies) on production and export/import
	=	final consumption expenditures
	+	Changes in inventories
	+	Gross fixed capital formation
	+	Acquisition less disposals of valuables
	+	Exports of goods and services
	-	Imports of goods and services
	=	Compensation of employees
	+	Operating surplus/ mixed income
		Consumption of fixed capital (CFC)
	+	(taxes – subsidies) on production and export/import

Net Domestic Product at factor cost/ market price = GDP at factor cost/market price – CFC

1.3.2 Saving and Investment Identities

Net Saving + net capital transfers receivable = Gross fixed capital formation – CFC
+ Changes in Inventories
+ Acquisitions less disposals of valuables and Non-produced non-financial assets
+net lending / net borrowing

Net lending (+)/borrowing (-) = net acquisitions of financial assets less net incurrence of financial liabilities

1.3.3 Capital Formation and Consumption of Capital

Gross Capital Formation (GCF) refers to the aggregate of gross additions to fixed assets (fixed capital formation), increase in stocks of inventories or change in stocks (CIS) and valuables. Gross Fixed Capital Formation (GFCF) comprises two main components, (i) construction, and (ii) machinery and equipment. Only new 'Construction' forms part of GFCF from construction. All repairing and maintenance works won't be accounted in GFCF. Natural Calamities such as floods and cyclones cause damages to infrastructure. Public buildings, roads, canals, etc. get destroyed when a severe cyclone or flood or earthquake occurs. Government spends a huge amount of money in repairing those damaged infrastructures resulting in an extra fiscal burden on economy. But this spending does not appear in our national accounts.

Consumption of Fixed Capital is defined as the decline, during the course of the accounting period, in the current value of the stock of fixed assets owned and used by a producer as a result of physical deterioration, normal obsolescence or normal accidental damage. It excludes the value of fixed assets destroyed by acts of war or exceptional events such as major natural disasters which occur very infrequently. But the question arises, what if the natural calamities occur frequently in a country and the costs are enormous. What could be the possible economic implications of the damages of the physical capital on capital stock and income generation? Can we ignore the huge costs borne due to calamities in our national accounts?

We can see in the above method followed by CSO, India only the consumption of fixed capital has been taken into account. Depletion of natural capital is being ignored in the measurement process. Observing this limitation in the methodology, United Nations has developed a new framework named System of Environmental and Economic Accounting which attempts to take environmental costs and benefits into consideration. In this new method, emphasis has been given to depreciation of natural capital.

2. Literature on Natural Disaster, Economic Growth and Capital

Macroeconomic consequences of disasters depend upon the economic structure and stage of development. Studies show that developed countries such as the USA suffered less human deaths as compared to the developing countries like India and Bangladesh

even though the former faced more frequent disasters. (Guha-Sapir et al., 2004). The availability of good-quality, trustworthy data is necessary for effective management of natural disaster risk (Benson and Clay, 2004). Hallegatte, Hourcade, and Dumas (2007) find that production losses due to extreme events depend on strong non linearity in the characteristics of the distribution and on the capacity to conduct reconstruction after disaster. Noy (2008) find no correlation between disaster population variables and GDP growth. Rather they find negative relation between property damage and GDP growth. Property cost has short term impact. Human cost impact is long term in nature. Large disasters have more adverse effects. Small economies are more vulnerable because they are less diversified. Hallegatte and Dumas (2009) found that disasters influence short term growth rate and long term production level. They argue that disasters can't influence the long-term growth rate.

Das (2016) argue that disasters can lead to increase in productivity. It is argued that because of the occurrence of calamities old infrastructures are replaced by new ones and related innovations lead to increase in productivity. On the other hand, huge damages due to natural calamities can lead to economic backwardness.

Jonkman, Bockarjova, Kok and Bernardini (2008) estimated the total economic damage to Netherlands due to flooding at 24 billion euro which is 6.5% of GDP of the year 2000. 70% of the total damages were the direct physical damages to residential property. Cuaresma (2009) founda negative long run effect of geological natural disaster risk on secondary school enrolment rates. Raddatz (2009) found that a climatic disaster reduces per capita GDP by 0.6 percent. Geological disasters do not have significant impact on output of the economy. Hallegate and Przyluski (2010) points out that there are large uncertainties on indirect disaster costs because of insufficient data and inadequate methodologies.

Das (2012) appraised the probability of expected human fatality (death risk) due to severe cyclone and storm surge for the villages associated with one of the most cyclones prone districts of India. Shabnam (2014) found that the total number of affected people in floods significantly affects the GDP per capita growth rate whereas the death toll in floods has no substantial effect on annual GDP per capita growth. Floods naturally create havoc in people's livelihoods rather than claiming a high human death toll.

Parida (2019) found that economic development reduces the fatalities and damage due to floods in India. He also observed that along with economic development better

political coordination between the national and sub-national government is essential to mitigate the impact of floods. However, with district-level analysis conducted for Odisha state, Parida et al (2020) found that economic development (proxied by per capita income) is not adequate to minimize fatalities from natural disasters. They also argue that better disaster adaptation measures such as better medical facilities, adequate road infrastructure, higher primary enrolment, village electrification, forest cover, and financial accessibility help in mitigating disaster fatalities to some extent.

Most of the works on natural disasters have dealt with the impacts of disasters on economic growth, human capital, fiscal burden, etc. We did not find any work which deals with the relation between the impacts of natural disasters and national account of the economy. The central question that arises here is, what would be the change in national accounts if economic losses due to natural disasters are incorporated in the measurement of Net Domestic Product (NDP) and Net State Domestic Product (NSDP). In this context our paper attempts to fulfil the following objectives:

3. Objectives

The objectives of our research paper are two fold:

1. To account for the economic loss due to natural disasters for Indian states
2. To provide a framework for estimating Natural Disaster Adjusted Net Domestic Product and compute the same for Indian States.

4. Methodology and Data

The paper provides a conceptual framework for incorporating the depreciation of physical capital due to natural disaster in the Net Domestic Product calculation. Further secondary data have been compiled to assess the economic cost of natural disaster. Data have been collected from several sources namely Central Water Commission, Reports of Finance Commission of India, Reports of Odisha state Disaster Management Authority and Special Relief Commissioner and National Institute of Disaster Management. We have calculated the Disaster Adjusted NDP by subtracting estimated financial loss due to natural disaster from the Net Domestic Product.

5. Framework for Natural Disaster Adjusted NSDP

In conventional method of calculation of National Accounts, the depreciation of physical capital is deducted from GDP to arrive at NDP. But this depreciation of capital does not consider the destruction of physical capital due to natural disasters. Natural disasters like flood, earthquake, cyclone, etc. cause heavy damage to the physical infrastructures of an economy. Industries, school buildings, hospitals, residential houses and other constructions get devastated by natural disasters. Hence, productive capital base of the economy dwindles. Reduction in the capital base of a country or a state reduces the production capability of both state and individual. Reduction in welfare of the people follows. In post-disaster period state has to spend a lot of resources for rebuilding the destroyed or damaged capital base. These expenditures incurred on repairing the damaged and destroyed capital base could have been used to create new physical capital or invested in the formation of human capital or invested in other poverty alleviating schemes. Therefore, the investment for reconstruction is not contributing to the increase in capital base (physical and human capital) of the economy which was there in pre-disaster period. Rather state has to spend a lot of resources forthe maintenance of the capital base existed before occurrence of the disaster. Hence these expenditures should be treated as the depreciation to the existed physical capital rather than entering them in the capital account.

Economists use Domar (1946) equation to forecast the growth rate if the rate of investment is known. The same equation is also used in computing the required investment for achieving a certain level of growth. The equation is written as G = I/k where G refers to growth rate of national output i.e., GDP or at state level Gross State Domestic Product (GSDP); I is level of investment or in case of S=I this is also rate of saving and k is capital output ratio. Therefore, Growth rate of a state depends positively on the rate of productive investment.

When net investment declines, level of national income decreases. Given this relationship between investment and national income, when there is occurrence of natural disaster the real investment which would help in increasing the level of capital stock does not grow resulting in a reduction of national income.

All investments can be classified into two categories: investment for new productive capital I_p and investment for reconstruction I_r.

Total Investment I= I_p + I_r

I_p increases the Gross capital formation of an economy in increasing production and capital in the absence of disasters whereas Investment for reconstruction helps in bringing back the capital to the previous level (Hallegatte and Dumas, 2009).
Usually, the Gross Capital Formation is calculated using the perpetual inventory method given as follows

$$K_{t-1}=K_{t-2}+I_{t-1}$$
$$K_t=K_{(t-1)}+I_t$$
$$K_{t+1}=K_t+I_{t+1}$$
$$K_n=K_{n-1}+I_n$$

If $I= I_p+ I_r$, then capital accumulation in time period n will depend upon only $I_p$not I_r. In this case, a state having higher expenditure on I_r will have lower capital formation and hence lower growth rates.

Effect of destruction of capital or infrastructure due to natural disaster may vary across economies and households. Possibility of the destruction of infrastructure in terms of money value could be high in case of developed countries as compared to underdeveloped ones. Reconstruction cost will also vary accordingly. Recovering capacity of the economies also depends upon the state of the economy. This logic can be applied to household level as well. Economic condition of households determines the amount cost borne and the capacity to bounce back to normal standard of life. Reconstruction investment plays a pivotal role in state economy and household economy at a disaster period.

In this context, we have computed the Adjusted NSDP by deducting the depreciation of the physical capital due to the natural disaster.

6. Analysis

Between 1891 and 2002 a total number of 356 major tropical cyclones have hit the Indian coast (See table 1). Out of these, east coast has faced maximum number of (308) cyclones and west coast only 48 cyclones. In the east coast, maximum number of cyclones have been faced by Odisha, followed by its neighbouring states namely Andhra Pradesh and West Bengal. Table 1 presents the major tropical cyclones in the Indian Coast between 1891 and 2001.

Table 1: Major Tropical Cyclones in the Indian Coast between 1891 and 2002

West Coast		East Coast	
Kerala	3	West Bengal	69
Karnataka	2	Odisha	98
Maharashtra	13	Andhra Pradesh	79
Goa	2	Tamil Nadu	54
Gujarat	28	Puduchery	8
Total	48	Total	308

(Source: NCRMP 2019)

6.1 Cost of Natural Disasters

Natural disasters cause loss of life, loss of individual property such as crop loss, damage of house, assets, livestock, loss of livelihood; damage of public property such as roads, bridges, disruption of power supply and collapse of power supply systems, school and college buildings, fear of outbreak of epidemics and so on. For this reason government needs to prepare for mitigating the disasters through pre disaster evacuation, information and communication for awareness generation; post disaster relief, reconstruction of private and public properties and so on. It is therefore important to calculate the full cost of natural disaster to know the economic implications. The government of India has enlisted the following 12 disasters for estimation of economic loss. Table 2 describes the list of 12 natural disasters for allocating disaster relief funds.

Table 2: List of Disasters recognized by National Disaster Response Force

Sl. No.	List of Disasters
1	Flood
2	Drought
3	Fire
4	Hailstorn
5	Cyclone
6	Earthquake
7	Tsunami

8	Landslide
9	Avalanche
10	Cloud Burst
11	Pest Attack
12	Cold Wave/Frost

Systematic data are not available in public domain for researchers to carryout in-depth analysis on the full cost of natural disaster. Informations are available for specific disasters and for a few states only. Very recently some data have been generated by the Forecast Monitoring Directorate, Central Water Commission, Government of India (2018) on the economic damage caused by the floods in all states of India. Table 3 presents the total cost of floods in India from 1953 to 2016.

Table 3: Statement Showing Damage Due to Floods / Heavy Rains During 1953 to 2016, All India

			Damage to Crops		Damage to Houses					
Year	Area affected in Million Hectares	Population affected in Million	Area affected in Million Hectares	Value in Rs. Crore	Nos	Value in Crores	Cattle Lost in Nos	Human Loss in Numbers	Damage to Public Utilities in Rs. Crore	Total Damages, Crops, houses and Public Utilities in Rs. Crores
1	2	3	4	5	6	7	8	9	10	11
1953	2.29	24.28	0.93	42.08	264924	7.42	47034	37	2.9	52.4
1954	7.49	12.92	2.61	40.52	199984	6.561	22552	279	10.15	57.231
1955	9.44	25.27	5.31	77.8	1666789	20.945	72010	865	3.98	102.725
1956	9.24	14.57	1.11	44.44	725776	8.047	16108	462	1.14	53.627
1957	4.86	6.76	0.45	14.12	318149	4.979	7433	352	4.27	23.369
1958	6.26	10.98	1.4	38.28	382251	3.896	18439	389	1.79	43.966
1959	5.77	14.52	1.54	56.76	648821	9.418	72691	619	20.02	86.198
1960	7.53	8.35	2.27	42.55	609884	14.309	13908	510	6.31	63.169
1961	6.56	9.26	1.97	24.04	533465	0.889	15916	1374	6.44	31.369
1962	6.12	15.46	3.39	83.18	513785	10.655	37633	348	1.05	94.885
1963	3.49	10.93	2.05	30.17	420554	3.701	4572	432	2.74	36.611
1964	4.9	13.78	2.49	56.87	255558	4.588	4956	690	5.149	66.607
1965	1.46	3.61	0.27	5.87	112957	0.195	7286	79	1.07	7.135
1966	4.74	14.4	2.16	80.15	217269	2.544	9071	180	5.736	88.43
1967	7.12	20.46	3.27	133.31	567995	14.264	5827	355	7.857	155.431
1968	7.15	21.17	2.62	144.61	682704	41.112	130305	3497	25.373	211.095
1969	6.2	33.22	2.91	281.9	1268660	54.423	270328	1408	68.112	404.435
1970	8.46	31.83	4.91	162.78	1434030	48.606	19198	1076	76.441	287.827
1971	13.25	59.74	6.24	423.13	2428031	80.241	12866	994	129.113	632.484

1972	4.1	26.69	2.45	98.56	897301	12.46	58231	544	47.174	158.194
1973	11.79	64.08	3.73	428.03	869797	52.482	261016	1349	88.489	569.001
1974	6.7	29.45	3.33	411.64	746709	72.434	16846	387	84.942	569.016
1975	6.17	31.36	3.85	271.49	803705	34.097	17345	686	166.05	471.637
1976	11.91	50.46	6.04	595.03	1745501	92.16	80062	1373	201.495	888.685
1977	11.46	49.43	6.84	720.61	1661625	152.29	556326	11316	328.948	1201.848
1978	17.5	70.45	9.96	911.09	3507542	167.574	239174	3396	376.1	1454.764
1979	3.99	19.52	2.17	169.97	1328712	210.606	618248	3637	233.627	614.203
1980	11.46	54.12	5.55	366.37	2533142	170.851	59173	1913	303.283	840.504
1981	6.12	32.49	3.27	524.56	912557	159.63	82248	1376	512.314	1196.504
1982	8.87	56.01	5	589.4	2397365	383.869	246750	1573	671.607	1644.876
1983	9.02	61.03	3.29	1285.85	2393722	332.327	153095	2378	873.429	2491.606
1984	10.71	54.55	5.19	906.09	1763603	181.308	141314	1661	818.164	1905.562
1985	8.38	59.59	4.65	1425.37	2449878	583.855	43008	1804	2050.043	4059.268
1986	8.81	55.5	4.58	1231.58	2049277	534.41	60450	1200	1982.535	3748.525
1987	8.89	48.34	4.94	1154.64	2919380	464.49	128638	1835	950.59	2569.72
1988	16.29	59.55	10.15	2510.9	2276533	741.6	150996	4252	1377.8	4630.3
1989	8.06	34.15	3.01	956.74	782340	149.82	75176	1718	1298.77	2405.33
1990	9.303	40.259	3.179	695.61	1019930	213.733	134154	1855	455.266	1708.92
1991	6.357	33.889	2.698	579.015	1134410	180.421	41090	1187	728.893	1488.329
1992	2.645	19.256	1.748	1027.578	687489	306.284	78669	1533	2010.67	3344.532
1993	11.439	30.409	3.206	1308.627	1926049	528.324	211193	2864	1445.534	3282.485
1994	4.805	27.548	3.963	888.622	914664	165.206	52315	2078	740.762	1794.59
1995	5.245	35.932	3.245	1714.787	2001898	1307.894	62438	1814	679.627	3702.308
1996	8.049	44.729	3.827	1124.491	726799	176.589	73208	1803	861.393	3005.743
1997	4.569	29.663	2.258	692.743	505128	152.504	27754	1402	1985.934	2831.181
1998	10.845	47.435	7.495	2594.167	1932874	1108.783	107098	2889	5157.771	8860.721
1999	7.765	27.993	1.753	1850.873	1613260	1299.057	91289	745	462.83	3612.76
2000	5.382	45.013	3.58	4246.622	2628855	680.943	123252	2606	3936.979	8864.544
2001	6.175	26.463	3.964	688.481	716187	816.474	32704	1444	5604.461	7109.416
2002	7.09	26.323	2.194	913.092	762492	599.368	21533	1001	1062.083	2574.543
2003	6.12	43.201	4.268	7307.23	775379	756.481	15161	2166	3262.154	11325.87
2004	5.314	43.725	2.888	778.694	1664388	879.601	134106	1813	1656.09	3314.385
2005	12.562	22.925	12.299	2370.923	715749	380.531	119674	1455	4688.219	7439.672
2006	1.096	25.224	1.822	2850.668	1497428	3636.848	266945	1431	13303.93	19790.92
2007	7.145	41.402	8.795	3121.532	3280233	2113.108	89337	3389	8049.037	13283.68
2008	3.427	29.91	3.186	3401.563	1566809	1141.891	101780	2876	5046.481	9589.935
2009	3.844	29.537	3.592	4232.609	1235628	10809.8	63383	1513	17509.35	32551.76
2010	2.624	18.297	4.994	5887.38	293830	875.952	39706	1582	12757.25	19520.59
2011	1.895	15.973	2.718	1393.847	1152518	410.475	35982	1761	6053.57	7857.892
2012	2.141	14.689	1.95	1534.108	174526	240.572	31558	933	9169.968	10944.65
2013	7.546	25.927	7.484	6378.078	699525	2032.83	163958	2180	38937.84	47348.75
2014	12.775	26.505	8.007	7255.151	311325	581.978	60196	1968	7710.948	15548.08
2015	4.478	33.203	3.374	17043.95	3959191	8046.969	45597	1420	32200.18	57291.1
2016	7.065	26.555	6.658	4052.723	278240	114.676	22367	1420	1507.926	5675.325
TOTAL	460.26	2040.266	251.047	102273.6	79465079	44390.34	6022676	105472	199730.2	347581.2
AVG	7.192	31.879	3.923	1598.026	1241642	693.599	94104	1648	3120.784	5430.956
MAX	17.5	70.45	12.299	17043.95	3959191	10809.8	618248	11316	38937.84	57291.1
(YEAR)	1978	1978	2005	2015	2015	2009	1979	1977	2013	2015

(Source: Flood Forecast Monitoring Directorate, Central Water Commission, Government of India (2018) State Wise Flood Damage Statistics)

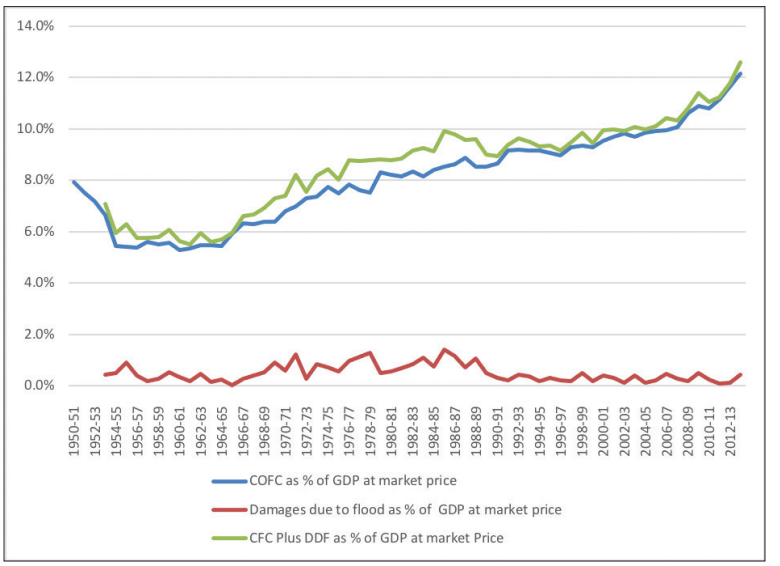

Figure 1: Consumption of Fixed Capital and Damage Due to Floods as Percentage of GDP at Market Price from 1950-51 to 2013-14

Figure 1 presents the Consumption of Fixed Capital (CFC) as percentage of GDP and aggregate economic loss due to floods in India. The objective behind plotting this figure is to see the trends of both indicators. For this purpose, we have used the CFC and GDP at market price in 2004-05 constant prices. The economic losses due to floods are given in constant prices. We used the GDP deflator to bring it to 2004-05 constant prices and then calculated the economic losses due to floods as a percentage of GDP. Between 1950-51 and 2012-13, the rate of CFC as a percentage of GDP varied between eight percent to a little above 12 per cent. The economic loss due to floods as a per cent of GDP varied from 0.4% to 1.4% during 1953-2013. If we consider all the economic loss due to floods as depreciation of capital, the total consumption of capital for the country would increase by 0.4% to 1.4%. We have shown this in figure 1.

Table 4 presents the state wise per capita average annual loss due to floods and heavy rains. We do not find any consistent trend in this table, except, that smaller states have recorded maximum per capita loss due to floods and heavy rainfalls. However, the loss due to floods and rains do not capture all losses due to many other natural disasters such as cyclones, earthquakes, landslides etc. It should be noted that weather related

natural calamities such as cyclones and floods cause maximum damage compared to other disasters. Our objective is to assess the full economic cost of all disasters. But due to lack of systematic data in public domain we are not able to do so rather we rely upon indirect data sources to provide an indicative measurement.

Table 4: State Wise Average of Per Capita Annual Loss due to Floods/Heavy Rains

States	1997-98 to 2001-02	2002-03 to 2006-07	2007-08 to 2011-12	2012-13 to 2016-17
Andaman and Nicobar Islands	0.0	0.0	0.0	2.3
Andhra Pradesh	161.8	736.4	1243.2	193.6
Arunachal Pradesh	17.4	12744.7	5832.4	7937.7
Assam	71.4	86.8	4.7	203.2
Bihar	45.9	114.3	55.7	16.7
Chandigarh	NA	1.4	0.0	0.0
Chhattisgarh	110.7	15.6	15.5	0.0
Delhi	13.5	0.0	0.0	0.0
Goa	5.2	0.5	3.8	0.8
Gujarat	5.1	88.7	39.7	0.5
Haryana	102.1	0.1	10.0	80.6
Himachal Pradesh	971.6	533.5	1565.7	1171.9
Jammu and Kashmir	22.1	0.0	0.0	1300.9
Jharkhand	0.0	0.0	0.1	0.3
Karnataka	4.1	183.3	887.1	164.1
Kerala	89.8	1.3	49.9	70.2
Madhya Pradesh	1.5	19.0	0.2	20.1
Maharashtra	0.4	3.1	0.0	0.0

Manipur	52.5	65.9	86.3	300.9
Meghalaya	7.3	171.5	0.0	1012.1
Mizoram	NA	0.0	0.0	4.0
Nagaland	NA	0.0	0.0	64.3
Odisha	115.1	199.3	331.0	14.8
Puducherry	0.0	0.0	0.0	473.5
Punjab	2.3	0.4	25.4	42.7
Rajasthan	95.5	15.5	0.0	87.0
Sikkim	0.4	0.1	0.0	1.0
Tamil Nadu	3.1	2.2	0.5	0.2
Telangana	NA	NA	NA	NA
Tripura	72.9	23.2	14.6	210.5
Uttar Pradesh	47.9	7.8	22.9	2.3
Uttarakhand	0.0	0.0	0.0	7719.2
West Bengal	236.8	33.0	31.4	561.6

Source: Flood Forecast Monitoring Directorate, Central Water Commission, Government of India (2018) State Wise Flood Damage Statistics

6.2 Inferences from SDRF Estimates

Starting from 1999-2000, the Union government has been providing financial assistances to the states for mitigating the losses of natural disasters. As per the National Disaster Management Policy, the primary responsibility for disaster management rests with the States. The concerned State Governments undertake relief activities according to the magnitude of the ground situation, in the wake of notified natural disasters from the State Disaster Response Fund (SDRF) already placed at their disposal in accordance with Government of India approved items and norms without any discrimination. For calamity of a severe nature, additional assistance is supplemented by Government of India from the National Disaster Response Fund (NDRF) by following the laid down procedure.

The corpus of SDRF is contributed by the Government of India and the State Government in the ratio 75:25 for General Category States and 90:10 for Special Category States. NDRF is fully funded by the Government of India. Under the prevailing guidelines, the first charge of relief expenditure is always on the SDRF. Allocation of

SDRF for each State Government is done by the Finance Commission (set-up under the Article 280 of constitution from time-to-time), for the Award period. In addition, 10% of the annual fund allocation of the SDRF may be used for localized State specific natural disaster. No calamity-wise allocation is made under the SDRF to State.

The allocation to the SDRF by Finance Commission is done after a thorough assessment of the cost of disaster across states and consultation with the state governments. Therefore, analysis of allocation of SDRF to various states will provide an indicative scenario of the cost of disasters across states. Figure 2 presents the state wise SDRF allocation recommended by the Finance Commission XIV. Maharashtra state receives the maximum SDRF allocation followed by Rajasthan, Madhya Pradesh, Odisha and Gujarat. However, we cannot compare the cost of disaster with the total sum of allocation because of the wide variation in the size of the states in terms of geography and population. Therefore, we should compare the per capita SDRF allocation.

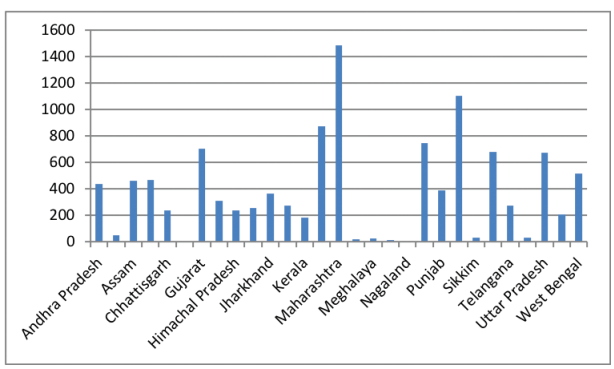

Figure 2 State Wise SDRF Allocation Recommended by FC XIV (Rs. Crore) for the year 2015-16

Figure 3 presents the per capita SDRF allocation to all states of India. Sikkim received the maximum per-capita SDRF allocation from the fourteenth Finance Commission followed by Arunachal Pradesh, Himachal Pradesh and Uttarakhand. Among the major states Odisha has received the maximum per capita SDRF allocation in 2015-16. The all India average per capita SDRF allocation made is 91 rupees.

The financial assistance received by the state from the Union Government, however, falls short of the expenditure incurred by the states. Table 5 presents the relief expenditure of states as percentage of receipts for the period 2002-09. For most of the

states and for most of the years, the relief expenditure far exceeds the receipt. The relief expenditure of states ranges from 22% of the receipts (West Bengal) to 540% for Bihar in some years. This implies that for maximum number of states, the relief expenditure incurred falls short of the receipt of assistance from the Union Government. The relief expenditure, however, does not reflect the actual cost of the disaster. Most of the states submit a memorandum to the Union Government and Finance Commission of India with the estimated economic loss due to different natural disasters and demand financial assistance from the same. In response to such demands the Union Government releases money to the states. However, the financial assistance provided by the Union government is far less than the demand placed by the states (NIDM, 2009).

Table 5: Relief Expenditure as Percentage of Receipts

		2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	Average
1	Andhra Pradesh	256	34	237	120	145	116	144	150.3
2	Arunachal Pradesh	101	100	101	100	98	100	99	99.9
3	Bihar	89	113	37	5	21	540	40	120.7
4	Chhattisgarh	111	123	70	42	62	166	76	92.9
5	Gujrat	213	137	91	69	160	146	130	135.1
6	Haryana	93	9	21	72	80	115	57	63.9
7	Himachal	100	100	100	100	100	100	100	100.0
8	Karnataka	69	90	156	80	192	105	102	113.4
9	Kerala	60	100	57	119	96	133	76	91.6
10	Madhya Pradesh	129	189	133	66	71	192	99	125.6
11	Maharashtra	100	188	74	107	245	96	129	134.1
12	Manipur	61	15	114		253	0	95	89.7
13	Meghalaya	74	58	26	116	23	41	57	56.4
14	Mizoram	100	100	100	100	100	100	100	100.0
15	Orissa	152	130	148	79	111	136	117	124.7
16	Rajasthan	94	87	40	88	121	72	87	84.1
17	Sikkim	113	73	98	79	163	100	102	104.0
18	Tamil	190	224	206	224	163	284	210	214.4
19	Tripura	70	58	125	38	21	193	51	79.4
20	Uttarakhand	387	-	100	-	100	-	114	175.3

21	Uttar Pradesh	123	47	77	23	15	187	65	76.7
22	West Bengal	22	43	39	49	124	241	65	83.3

(Source: Statement 25 furnished by the States to the Thirteenth Finance Commission as cited in NIDM (2009) "FINANCING DISASTER MANAGEMENT IN INDIA: *A Study for the Thirteenth Finance Commission*". National Institute of Disaster Management. August 2009)

In absence of the latest data, we have used the data available in a research report submitted by the National Institute of Disaster Management, (NIDM, 2009) to the 13th Finance Commission of India. In this report NIDM had compiled the data provided by the state governments in their memorandum to the 13th Finance Commission on the demand for financial assistance for natural disasters during 2000-01 to 2008-09. The disasters included, flood, cyclone, hailstorm, and drought. We took the GSDP and NSDP data for all major states from the RBI's Hand Book of Statistics on Indian States. We used the GSDP and NSDP data in 2004-05 constant price for the period 2000-09. The economic losses due to natural disasters were obtained from the NIDM (2009) report. We used GDP deflator to convert the economic loss due to disasters into 2004-05 constant prices. Using 2001 census data and the economic loss due to disaster we calculated average per capita cost of disaster for the period 2000-09. Similarly, we have also calculated the average per capita NSDP for the period 2000-09 and per capita disaster cost adjusted NSDP (Per capita NSDP minus per capita economic cost due to natural disaster). At the end we have also estimated per capita disaster cost as a percentage of per capita NSDP (Table 6). Arunachal Pradesh witnesses the maximum per capita cost of disaster as percentage of per capita NSDP (6.8%) followed by Jammu and Kashmir (3.5%), Bihar (3.1%) and Himachal Pradesh (2.7%). 14 states have reported more than 1% of per capita NSDP as cost of disaster.

Table 6: Per Capita NSDP, Cost of Disaster and NSDP adjusted for the Cost of Disaster

State	Per Capita Cost of Disaster	Per Capita NSDP	Percapita Disaster Cost adjusted NSDP	Per Capita Disaster Cost as % of Per Capita NSDP
Andhra Pradesh	156.3	16433.1	16276.8	1.0%
Arunachal Pradesh	1951.2	28678.7	26727.4	6.8%
Assam	205.3	17684.8	17479.5	1.2%
Bihar	267.7	8717.9	8450.1	3.1%

Chhattisgarh	161.9	20308.2	20146.3	0.8%
Gujarat	501.0	35542.1	35041.1	1.4%
Haryana	109.3	42162.5	42053.2	0.3%
Himachal Pradesh	960.1	35514.7	34554.6	2.7%
Jammu and Kashmir	808.8	23296.8	22488.0	3.5%
Jharkhand	139.9	18372.2	18232.4	0.8%
Karnataka	358.1	30119.2	29761.1	1.2%
Kerala	292.3	33989.3	33697.0	0.9%
Madhya Pradesh	123.1	17229.1	17106.0	0.7%
Maharashtra	226.2	41261.6	41035.5	0.5%
Manipur	198.3	19785.4	19587.2	1.0%
Meghalaya	101.8	25921.9	25820.0	0.4%
Mizoram	626.5	28185.9	27559.4	2.2%
Nagaland	16.4	28429.9	28413.4	0.1%
Odisha	214.8	18536.5	18321.7	1.2%
Punjab	202.5	36952.2	36749.7	0.5%
Rajasthan	371.4	20684.0	20312.7	1.8%
Sikkim	447.4	28597.9	28150.6	1.6%
Tamil Nadu	427.8	33723.0	33295.2	1.3%
Tripura	26.2	25984.6	25958.4	0.1%
Uttar Pradesh	128.4	14392.7	14264.3	0.9%
Uttarakhand	156.7	28453.3	28296.7	0.6%
West Bengal	0.0	24248.9	24248.9	0.0%

(Source: Calculated from the Demand submitted by states to the Finance Commission and compiled by National Institute of Disaster Management in NIDM (2009) "FINANCING DISASTER MANAGEMENT IN INDIA: A Study for the Thirteenth Finance Commission". National Institute of Disaster Management. August 2009)

Note: All Per Capita estimates are the average estimates of the specific indicator in 2004-05 constant price for the period 2000-01 to 2008-09

The money spent on the mitigation of disasters could have been invested in either new productive investment. Therefore, the part of expenditure incurred on disaster mitigation should be considered as leakages from productive expenditure of the government. Figure 4 shows the SDRF allocation as a percentage of the total expenditure of the states for the year 2015-16. At all India level the total SDRF allocation amounts

to 0.5% of the total expenditure (TE). For Assam this amounts to 1.2% of State Total Expenditures (STE), followed by Odisha (1% of STE), Arunachal Pradesh (0.9% of STE), Uttarakhand (0.8% of STE).

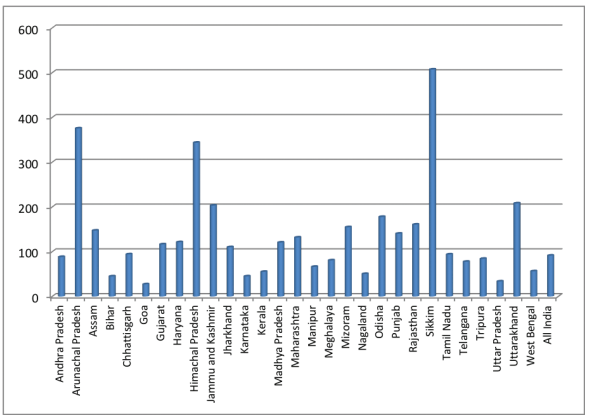

Figure 3: State Wise Per Capita SDRF for the year 2015-16

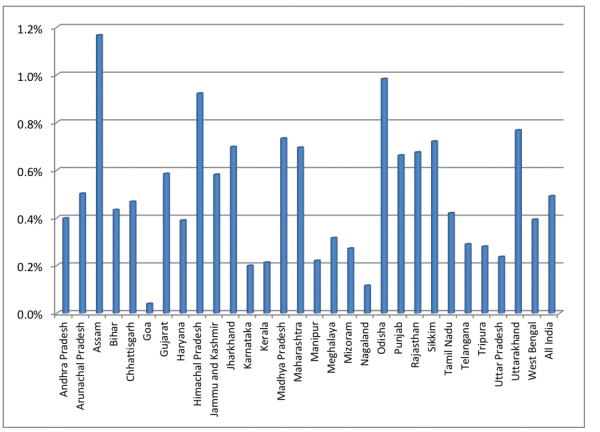

Figure 4: SDRF as a Percentage of Total Expenditure of the State for the Year 2015-16

6.3 Case Study of Odisha

Odisha faces maximum number of tropical cyclones every year. After the devastation made by 1999 super cyclone, the state government has been maintaining systematic data to quantify the total economic loss due to cyclones only. The financial losses due

to disasters are much higher than the relief expenditure incurred by the state. Therefore, the state wise SDRF allocation will be a gross underestimation of the actual financial losses accrued to the state and individuals. Figure 5 shows the financial loss due to natural disaster and relief expenditure incurred by Odisha. Barring a few years, the relief expenditure has always remained much below the financial loss. Relief expenditure as a percentage of the total financial loss has ranged from the lowest three percent to highest 374%. Between 1994-95 and 2013-14, only in three years the relief expenditure has exceeded the assessed financial loss. In rest 15 years for which data are available total relief expenditure has remained far below the assessed financial losses. This clearly shows that use of SDRF allocation to quantify the financial losses due to disasters is a gross underestimation. However, due to unavailability of systematic data we are using this data for getting only indicative scenario.

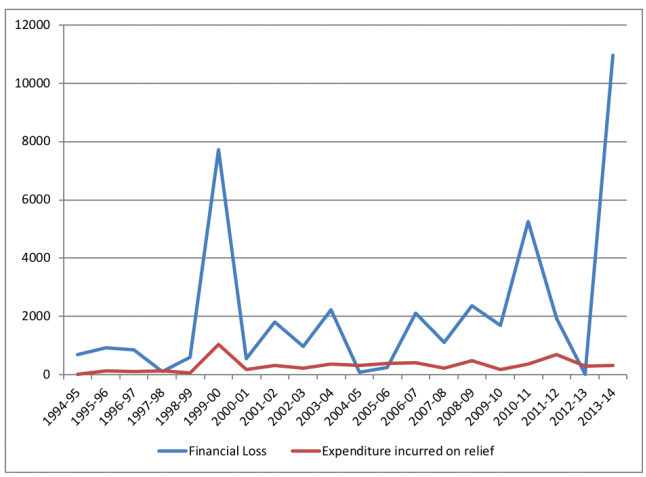

Figure 5: Financial Loss Due to Natural Calamities and Relief Expenditure of Odisha (Rs. Crore in Base Year 2004-05)

Since our primary objective is to compute the Net Domestic Product adjusted for the depreciation caused due to natural disasters it is important to compute the economic loss due to natural disaster as a percentage of GSDP. Figure 6 presents the economic loss as a percentage of GSDP. During the major cyclones the economic loss shoots up to a very high level. In 1999 the economic cost of super cyclone was as high as 13% of GSDP and in 2013 the economic cost of Phailin was eight percentage of GSDP. In most

other years the cost of natural disasters in Odisha has been estimated between one to four percentage of GSDP. Thus, for Odisha, the depreciation due to natural disaster has widely varied from as low as one percent to 13% of GSDP. This has huge negative implications for the welfare of the state. Out of one rupee earned by the state one to 13 paisa is spent every year just to remain at the same level.

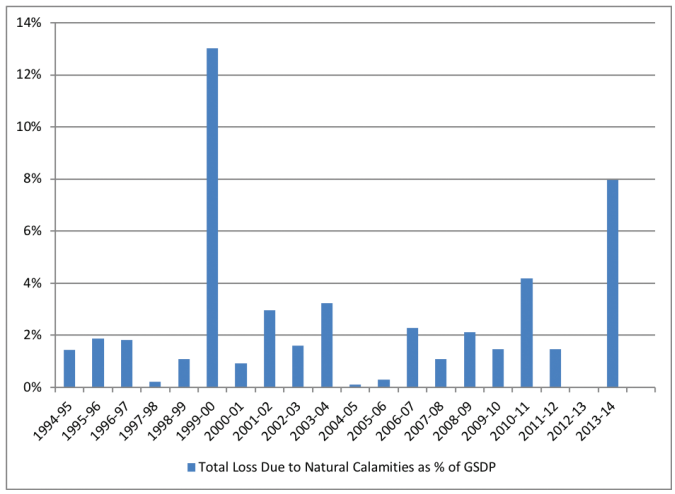

Figure 6: Total Economic Loss Due to Natural Calamities as % of GSDP in Odisha

In order to know the implications of natural disaster on the investment we had discussed in earlier section that a large amount of money is spent for repairing and reconstruction of the same physical capital. Therefore, the amount of productive investment declines signifincatly in the states that face natural disasters. Figure 7 shows the financial losses due to natural disaster and relief expenditure as a percentage of the total expenditure of the state. The total economic losses as a percentage of Total Expenditure (TE) of Odisha varies widely from a low of one percent to the highest level of 44 percent during the period 1994-95 and 2013-14. During this period, in maximum years the economic loss due to natural disaster as a percentage of TE has remained around 10 percent. In spite of this high level of economic losses, the expenditure of the state on relief has remained very low. The total expenditure of Odisha on relief as a percentage of total expenditure of the state has mostly remained between one to two percent. Only during super cyclone of 1999 this share had reached five percent. This has dampening effect on the capability

of the state and individuals. When the economic losses due to natural disaster is very high but the state fails to adequately compensate the losses, it may have wide ranging effects on the economy. In case of damage of public utilities, like roads, electricity, cold storage, drinking water, industries, without adequate expenditure on the repairing and reconstruction, this will not only affect the quality of life but also discourage the private investment. This may also ruin the Micro, Small and Medium scale industries. There are evidences that after 1999 super cyclone the MSME sector was worst hit. The film theatres in rural parts of Odisha were completely destroyed during this cyclone and they could never come back to operation. As a result of which the Odia film industry has been suffering from low level of equilibrium trap. In the extremely sever cyclone Fani, in May 2019 Raghurajpur village, which is famous for Patachitra arts has been completely devastated. Hundreds of households in this village who depended upon the art have lost their income source. Without adequate relief to these households, it may not be possible to restart their business.

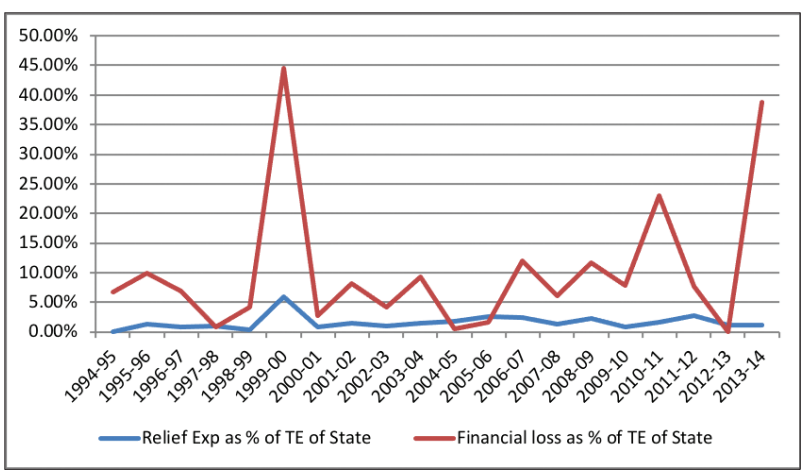

Figure 7: Financial Loss Due to Natural Disaster and Relief Expenditure of State as Percentage of Total Expenditure

6.4 Natural Disaster Adjusted NSDP for Odisha

Table 7 presents the Natural Calamity Adjusted NDP for Odisha for the period 1994-95 to 2013-14.

Table7: Net Domestic Product Adjusted for the Depreciation due to Natural Disaster

Year	GSDP At Current Prices	GSDP At 2004-05 prices	NSDP At Current Prices	NSDP At 2004-05 prices	Financial Loss Due to Natural Disaster (Current Price)	Financial Loss due to Natural Disaster (in 2004-05 price)	Disaster adjusted NSDP (current price)	Disaster adjusted NSDP 2004-05 price	Percapita Disaster adjusted NSDP in current Prices	Percapita Disaster adjusted NSDP in 2004-05 Prices
	Rupees Lakh								Rupees	
1994-95	2637803	4728488	2227992	4009160	37653	67496.23	2190339	3941664	6521.88	11737.02
1995-96	3200294	4923531	2712473	4164616	59772	91956.96	2652701	4072659	7777.74	11941.37
1996-97	3162811	4684672	2633170	3913538	57700	85463.71	2575470	3828074	7439.32	11058.12
1997-98	3830064	5311965	3214665	4464813	8092	11222.9	3206573	4453590	9130.96	12682.04
1998-99	4255150	5462975	3582055	4592379	46410	59583.49	3535645	4532796	9929.66	12730.66
1999-00	4789168	5932446	4314452	5372881	624396	773452.8	3690056	4599428	10207.81	12722.49
2000-01	4841484	5830376	4325303	5223400	44523	53617	4280780	5169783	11688.43	14116.60
2001-02	5170371	6110766	4590332	5448028	153088	180931.9	4437244	5267096	11967.12	14205.02
2002-03	5480111	6105838	4873028	5432171	87140	97089.77	4785888	5335081	12761.65	14226.11
2003-04	6610014	6889860	5855462	6078415	214183	223250.8	5641279	5855164	14876.20	15440.29
2004-05	7772943	7772943	6798702	6798702	8120	8120	6790582	6790582	17628.92	17628.92
2005-06	8509649	8214472	7354959	7100497	25218	24343.25	7329741	7076154	18781.38	18131.62
2006-07	10183947	9270083	8792126	7984484	232243	211402.5	8559883	7773081	21649.62	19659.33
2007-08	12927445	10284562	11110925	8669191	140023	111396.7	10970902	8557794	27385.48	21361.93
2008-09	14849071	11081178	12751620	9320665	315781	235652.8	12435839	9085012	30638.02	22382.43
2009-10	16294643	11585113	13583679	9395723	239116	170005.9	13344563	9225717	32447.59	22432.63
2010-11	19752990	12513105	16476038	9987972	827776	524378.7	15648262	9463593	37550.59	22709.65
2011-12(3rd)	22058927	13011301	18352151	10362763	326538	192606.1	18025613	10170157	42689.67	24085.86
2012-13(2nd)	25122046	13501017	21062228	10766375	-	-	-	-	-	-
2013-14(1st)	27297992	13746828	22787686	10808072	2176600	1096101	20611086	9711971	47538.70	22400.86
2014-15	31081024	14857608	26022195	11656558						

(Source: Own estimation using the GSDP and NSDP data from Economic Survey of Odisha and financial loss due to natural disaster from the Special Relief Commission, Government of Odisha.)

7. Conclusion

The frequency of natural disasters and the extent of damages are showing an increasing trend in recent years. Per-capita GDP or NDP numbers are used to assess the level of wellbeing and backwardness of states. These are also used for fiscal transfer in India. Per-capita NDP calculation accounts for the depreciation of physical capital due to wearing and tearing effect. However, the conventional measures of Consumption of Fixed Capital do not include the damage of capital due to natural disaster. However, when the damage to physical capital due to natural disaster is substantial, it has significant implications for welfare of the people and economic growth of the state. If a state suffers massive damage to physical infrastructure due to natural disaster on regular interval, it will definitely reduce its capability to achieve fast economic growth and reduce poverty. Therefore, the damage to physical infrastructures caused by natural disasters should be accounted for in the NDP calculations. In this paper we have provided a framework for this purpose and provided the natural disaster adjusted NDP estimates for the state Odisha. We observed that the cost of disasters as percent of the per capita NSDP varied from less than one percent to about seven percent. This implies that the people living in the disaster-prone states lose seven percent of the income due to natural disaster. Due to unavailability of the appropriate data this is again gross underestimation of the damage. If we take into consideration all other natural disasters and the expenditure for preparedness, cost of damage and losses and recovery needs the value would be much higher. From the case study of Odisha, we observed that cost of only cyclones goes up as high as 13 percent of GSDP in some years. For assessing the fiscal implications of natural disasters, we have estimated the financial losses due to natural disaster as a percent of total expenditure of Odisha. The financial loss goes up to as high as 44 percent of the total expenditure of the state. Nevertheless, due to limited fiscal space of the Odisha the state is able to provide a very small fraction of the total loss as the relief/compensation. Finally, we have calculated the Natural Disaster adjusted NSDP for Odisha.

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