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FLOOD DAMAGES IN INDIA: A TEMPORAL ANALYSIS

Omvir Singh
Manish Kumar

Abstract

In this paper a temporal analysis of flood damages in India for a period of 55 years (1953 - 2007) has been attempted on the basis of data published by Central Water Commission, New Delhi. A close examination of the data revealed that flood affected area in India exhibited a discernible increasing trend with time. It has been found that about 0.014 million hectare area per year has increased under floods in the country. These results support the widespread belief that the floods and associated damages in the country are progressively increasing. Moreover, flood affected population in the country is also increasing with a slope of 0.15 million people per million hectare flood affected area per year. The increasing trend in the flood affected population in India is in agreement with those reported in World Water Development reports and findings of the impacts of the global flood disasters. About 88875 human lives were lost due to flood disasters in India during 1953-2007. This loss has progressively increased year after year during the study period. Total loss per million hectare flood affected area during 1953 to 2007 was found to be about Rs. 1584.9 billion with an average of Rs. 28.8 billion per year. In this study, therefore, an effort has been made to highlight the various types of damages by floods in the country during last 55 years so that a suitable strategy may be formulated to solve this problem which is increasing with time.

Introduction

Among all the disasters afflicting India, floods are most frequent and often the most devastating meteorological hazard. Existing literature shows that several disastrous floods hit India particularly in 1971, 1973, 1976, 1977, 1978, 1980, 1984, 1988, 1993, 1995, 2006 and 2010 (Kayastha, 1983; Kale, 2004; CWC, 2010). India is one of the most flood prone countries in the world after Bangladesh and about 40 million hectares of land, roughly one-eighth of the country's geographical area, is prone to floods. The nature and hydrology of flooding varies according to Geography and physiography in India (Gupta et al., 2003). Floods in the country assume gigantic dimensions because of large river system. Generally, floods in India are caused due to extreme spatial and temporal variations in rainfall. The flood-generating rainstorms are confined to Ganga basin, plains of Punjab, central India, northern half of Indian Peninsula and areas drained by Brahmaputra and its tributaries (Pisharoty and Asnani, 1957; Nandargi, 1996; Rakhecha and Pisharoty, 1996; Starkel et al., 1998; Kale, 2002). Flash floods are also most common destructive type of floods which occur mostly in hilly areas

destroying bridges, buildings, roads, crops and human lives most frequently (Dhar and Nandargi, 2003). The Vamsadhara and Kedarnath flash floods of September 1980 and June 2013 are well known examples causing huge loss of life and property in Orissa, Andhra Pradesh and Uttarakhand. Floods also occur due to dam or reservoir failure or improper management of high water level conditions in reservoirs and consequent sudden release of the water especially during the periods of high intensity rainfall (Dhar et al., 1975; Nandargi and Dhar, 2003). Exceptionally high floods have also occurred due to the breaching of dams, e.g. the Machhu dam in Morvi town of Rajkot district in Gujarat breached on August 11, 1979, washing away about 1500 people, damaging about 8000 houses completely and tremendous destruction of livestock, property and agricultural lands (IMD, 1979; Dhar et al., 1981). Collapse of Khadakwasala-Panshet dams in July 1961, in Pune is another example of dams giving way due to heavy rush of flood waters (Dhar et al., 1980; Dhar and Nandargi, 2003). In addition, other factors include landslides leading to obstruction of flow and change in the river course, retardation of flow due to tidal and back water effects, poor natural drainage in the flood prone area, cloud bursts, snowmelt and glacial outbursts flow also cause floods (Mohapatra and Singh, 2003). The changes in river courses and erosion of riverbanks are one of the major problems associated with floods (Bhan, 2001).

Floods may also occur due to anthropogenic activities. The extensive urbanization and consequential increase in built up area in cities causes increased flood water flow in the drains leading to floods especially in the streams near to the cities. Besides, deforestation and shifting cultivation in the catchment areas of rivers results in increased direct runoff and resultant floods. Consequently, these floods cause damages to life and property, industry, agriculture, public utilities etc. almost every year but the enormity varies from year to year depending upon the frequency, magnitude and intensity of floods and the extent of flood affected areas. On an average, floods affect the normal lives of 35 million people annually in different parts of the country and displace them from their place of residence (CWC, 2010). Moreover, the damages related to floods are direct and indirect. Death of people and animals, damage to house and properties, standing crops, public utilities like transport and communications are the result of direct consequences of floods whereas, change in ecosystem, spreading of diseases, dislocation of agricultural operations, waste of manual labour, disruption of rail and road traffic etc. are the indirect losses due to floods.

On the whole, the physical and socio-economic impacts of floods are complex, depending on the vulnerability of the place of occurrence and as well as the mitigation measures adopted. Although, the damages and vulnerability of the people to flood events seems to be increasing every year yet, the damages and vulnerability associated with flooding have been studied, to a limited extent in India. Therefore, to fill this research gap, the present study has been taken in hand. It may help in establishment of early warning systems, proper management options and policy directives.

Objective of the Study

Major objective of the study is to highlight the trends of floods and associated damages that have occurred in India from 1953 to 2007.

Database and Methodology

The present study is primarily based on secondary data collected for the period of 1953 to 2007 from the published records of Water and Related Statistics of Water Resource Information System Directorate, Central Water Commission (CWC), New Delhi. The report published by CWC is only reliable and official sources of data in India for flood related studies.

Based on the above database, simple numerical calculations such as ratio between flood affected area and various damages were made and subsequently information was summarized in the form of simple bar graphs using Microsoft office based spread sheet. The possible presence of any trend in the occurrence of damages in time can be useful to understand flooding and to protect lives and properties. Therefore, to determine yearly variations in various flood damages and the identification of the highest and lowest flood affected years, technique of simple linear trend was adopted. For the better understanding of the observed trends in various flood damages (maximum, minimum and average) anomalies of annual average were also computed.

Study Area

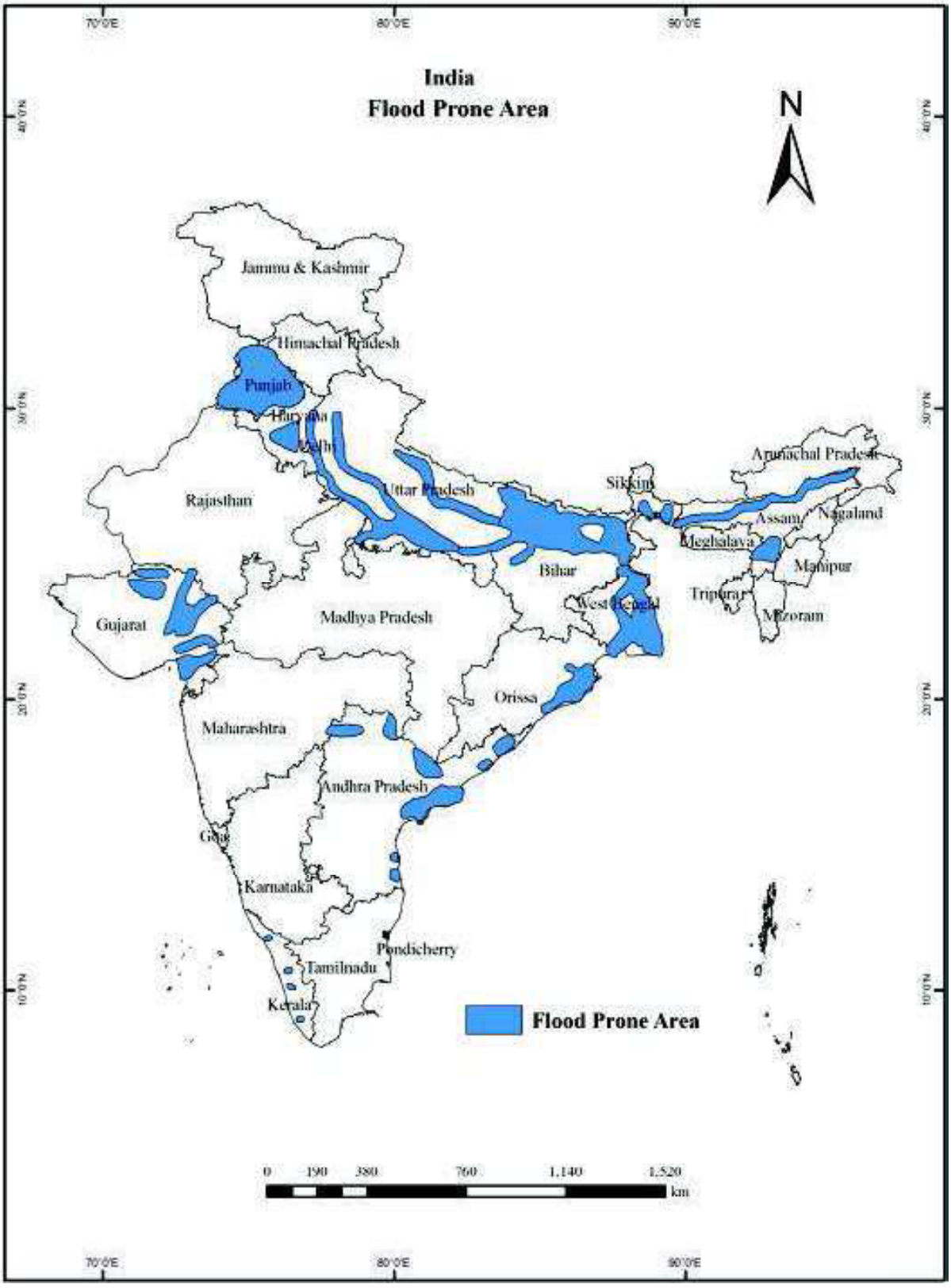
India being the seventh largest country of the world spreads over an area of 3.29 million km^2. The prosperity and well being of its people largely depends upon the rainfall received during its summer monsoon. It is well known that summer monsoon rainfall is not uniformly distributed over the Indian region and there are large seasonal as well as annual variations of rainfall in both space and time. Some parts get heavy to very heavy rainfall while others get little rainfall. This unequal distribution of monsoon rainfall is one of the major causes of floods in the Indian rivers. India can be broadly divided into four zones of flooding, viz. (a) Brahmaputra river basin (b) Ganga river basin (c) North-west rivers basin, and (d) Central India and Deccan rivers basin. The bulk of India's population is concentrated in these river basins and consequently, very large number of people and their livelihoods are seriously affected. In recent times, flooding has claimed more lives than any other natural disaster in these basins. The area liable to floods in the country has been shown in Fig.1.

Results and Discussion

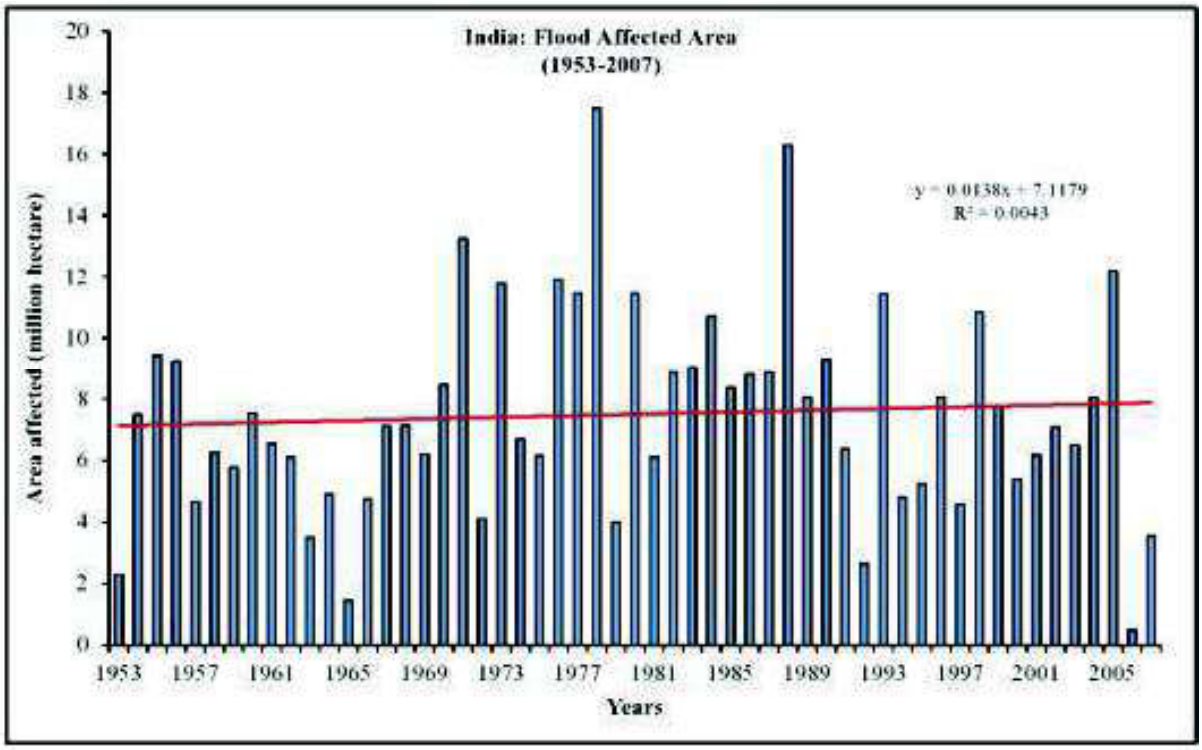
The floods affect the lives of millions of people annually in the country. It causes loss of life, damages to property and public utilities. The amount of damage varies from year to year depending upon the magnitude of flood and extent of flood affected area. The cumulative damages associated with floods in India during 1953-2007, are presented as under:

Flood Affected Area

The area affected by floods each year for the second half of the last century and initial phase of the present century has been demonstrated in Fig. 2. Flood affected area exhibited an increasing trend with time and about 0.014 million hectare area per year has increased in the country. These observations are in agreement with studies conducted by Dogra, 1997 and Mohapatra and Singh, 2003. Flood affected area varied from year to year in the last 55 years and it was as low as 0.50 million hectare in 2006 and as high as 17.5 million hectare in 1978. The analysis further demonstrated that the number of years when the flood affected area was more than10 million hectares was high during 1970s and 1980s and the year 1971, 1973, 1976, 1977, 1978, 1980 crossed the 10 million hectare landmark (Fig. 2). Flood affected area varied closely with the variation in the rainfall distribution in the



Source: Mohapatra and Singh, 2003 Fig. 1



Source: CWC, 2010

Fig. 2

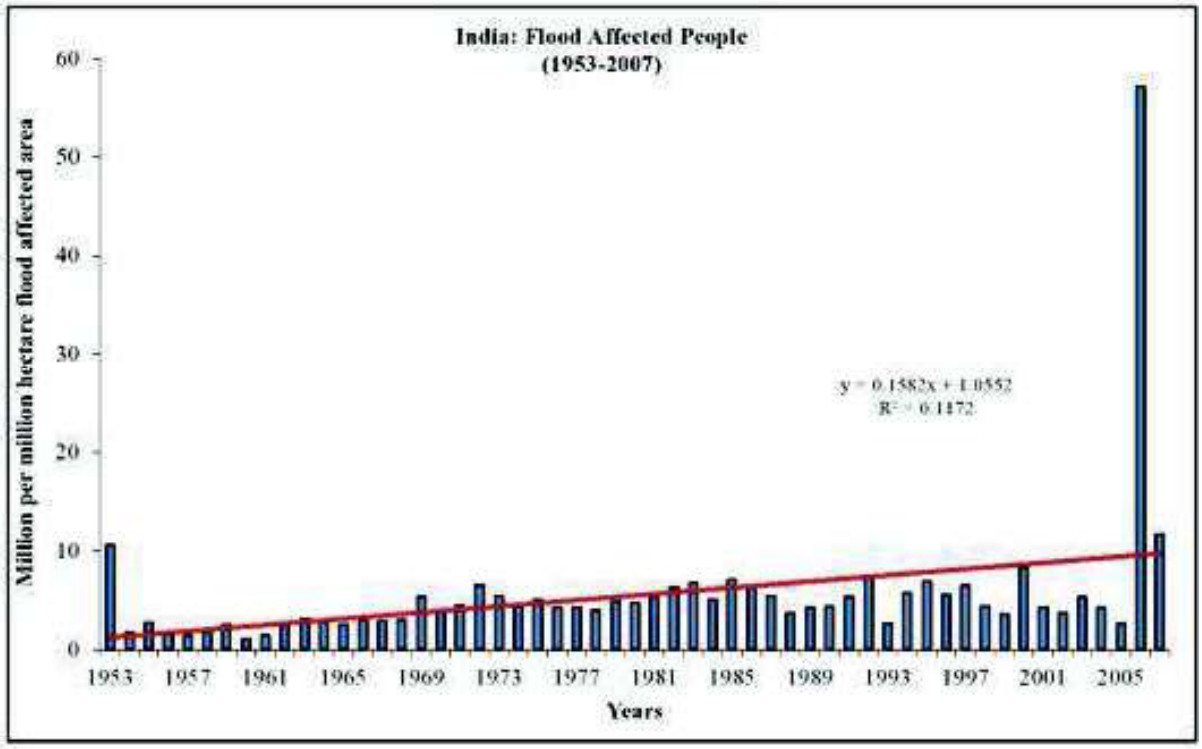


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Fig. 3

country. In general, the years of excessive or high intensity rainfall had higher area under floods. Also, the deposition of silt and gravel in large quantities in the river channels is the major reason for bringing more area under floods in the country. The flood affected area showed higher coefficient of variability (45%) during 1953-2007 period. However, it must be mentioned that the assessment of flood prone area is not done scientifically in India. Often higher figures are reported and the actual area submerged may reduce if a careful scientific assessment is carried out (Jain et al., 2007).

Flood Affected People

The number of people affected by floods per million hectare of flood affected area in India during 1953-2007 has been shown in Fig.3. This figure exhibits large fluctuations in the flood affected population. The overall trend of flood affected population in the country is increasing with a slope of 0.15 million people per million hectare flood affected area annually. The increasing trend in the flood affected population in India is in agreement with those reported in World Water Development reports and the findings of the impacts of the global flood disasters reported by Jonkman (2005). The total number of flood affected people in India during the study period is about 1814 million accounting to an average of 33 million people per year. There is a high correlation (0.67) between flood affected area and the number of people affected. Also, a high coefficient of variability (51%) was observed annually in the number of people affected by floods. The flood affected population has risen from an average of 3 million people per million hectare flood affected area in 1950's to about 13 million people per million hectare flood affected area in the first decade of 21st century. The flood affected people per million hectare flood affected area in the country has increased substantially after 1990s and the increase was observed to be more than 1.5 times in comparison to previous decades, whereas it was observed to be 2.5 times more during the first decade of 21st century. The maximum flood affected people per million hectare flood affected area in country were observed in the year 2006 (57.14 million people per million hectare flood affected area) while it was observed lowest in the year 1960 (1.1 million people per million hectare flood affected area). In addition, flood affected people per million hectare of flood affected area have demonstrated a rising trend in the country. This may be presumably attributed to compensation rendered by the Central and State governments to flood victims in recent years.

Loss of Human Lives

About 88875 human lives were lost due to flood disasters in India during the study period and this loss has progressively increased in absolute figures and as well as per million hectare flood affected area during 1953-2007 (Fig.4). These results are in agreement with various other studies carried out in India (Rosenfeld, 1994; Kale, 1997). A similar increasing trend in loss of human lives has been observed globally, in South Asia and Europe (Jonkman, 2005; Shrestha, 2008). This increase in flood related death toll has been attributed to improved information and communication technology (ICT), leading to increase in reporting activities (Shreshtha, 2008). On an average, about 1620 people died every year due to flood disaster. In other words, every year about 270 people lost their lives per million hectare flood affected area. There was unprecedented loss of lives in the year 1977 when 11316 persons lost their life due to floods followed by 1988 (4252), 1979 (3637), 1968

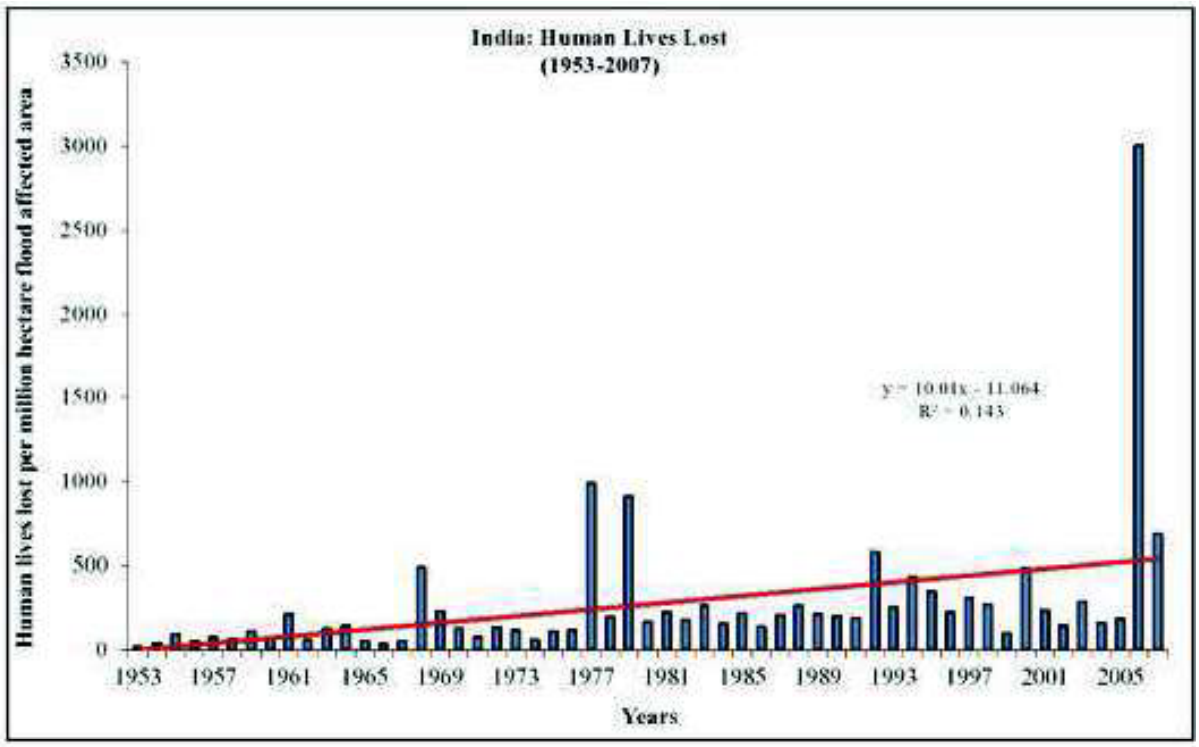

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Fig. 4

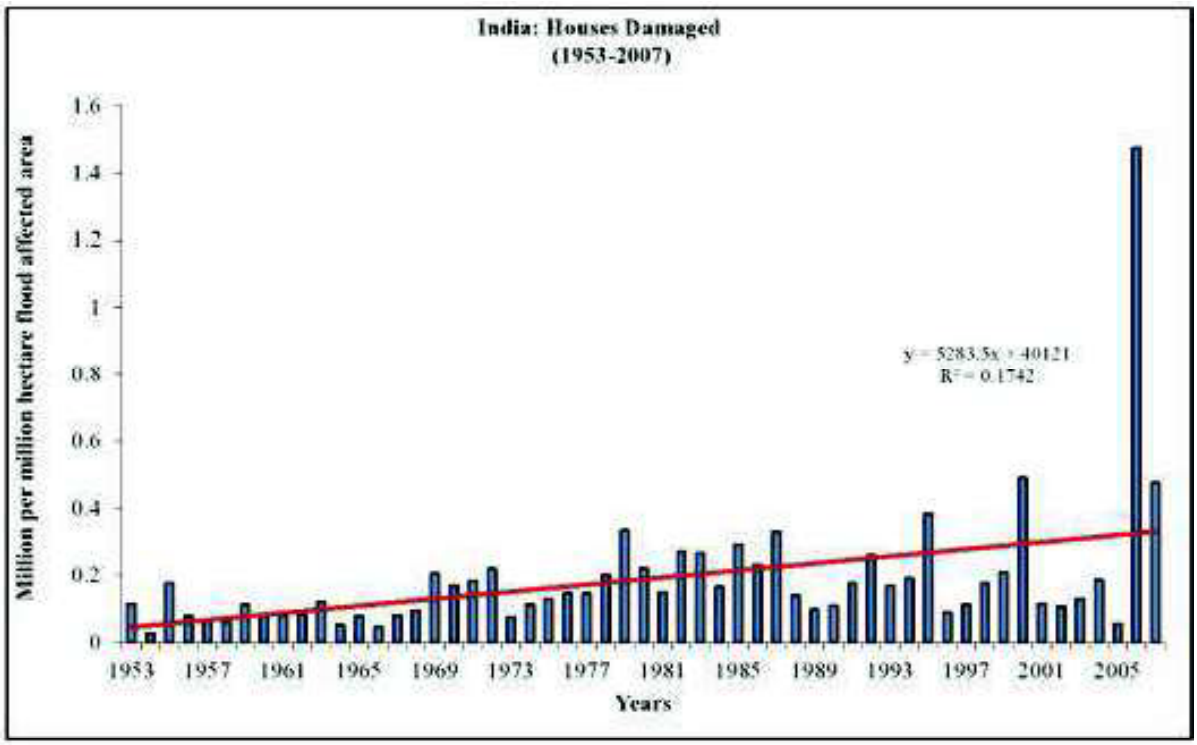

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Fig. 5

(3497) and 1978 (3396). The average death toll per million hectare flood affected area has increased more than 11 fold in the 21st century in comparison to the mid of the twentieth century. The loss of lives was only 16 persons per million hectare of flood affected area in 1953 while it was observed as high as 3000 persons per million hectare of flood affected area in 2006. It may be due to gradual expansion of urbanization and encroachment of flood prone lands/areas by the human settlements.

Damage to Houses

Every year floods damage large number of houses and other buildings in India. The pattern of house damage per million hectare flood affected area in the country has increased progressively during 1953-2007 (Fig. 5). The analysis revealed a loss of about 10.3 million houses per million hectare flood affected area during the study period and on an average about 0.2 million houses were annually affected by floods. The minimum (0.03 million) and maximum (1.4 million) houses were damaged per million hectare flood affected area in the year 1954 and 2006, respectively. The study reveals high correlation (0.61) between damaged houses and area affected by the floods in India. The analysis revealed that the damage of houses per million hectare flood affected area in the country was more after 1980 and it is presumably attributed to urbanization process and increasing population.

With the increase in number of damaged houses, the value of houses damaged by floods also increases. Fig. 6 shows the trend in the value of houses damaged per million hectare flood affected area in India. The value of damage to houses per million hectare flood affected area has increased since 1953. The total value of damaged houses during 1953-2007 was found to be Rs. 1537 billion amounting to the average of Rs. 28 billion per year. The years 2007 and 1995 witnessed the highest monetary loss due to damaged houses per million hectare flood affected area while the year 1965 recorded the lowest loss.

Damage to Crops

About 413 million hectare area was observed to be flood prone in India during the study period and on an average more than half of the flood affected area is under agriculture (CWC, 2010). The standing crops are being destroyed by floods every year in India. This amounted to substantial financial losses due to the submergence of standing crops. Crop damage with respect to area and value has shown increasing trends during 1953-2007 (Fig. 7 and Fig. 8). Normally, floods in India destroy already matured or nearing maturity crops during the second half of monsoon season, particularly during the month of August and September when unprecedented rainfall occurs in the catchment areas. The total cropped area damaged per million hectare flood affected area during 1953-2007 was found to be about 28 million hectare accounting for an average of about 0.5 million hectare per year. A minimum of 0.09 million hectare and maximum of 1.8 million hectare of cropped area was affected by floods in 1957 and 2007, respectively. The huge damage to crops in India can be attributed to poor structural measures undertaken in the floodplains of India. There is a substantial flow reduction in most of the rivers of India due to impacts of climate change and construction of reservoirs and dams. This subsequently resulted in shrinkage of channel width and these abandoned portions of channels were found rich in productive alluvial soils. Therefore, farmers invariably tend to cultivate these alluvial soils once occupied by

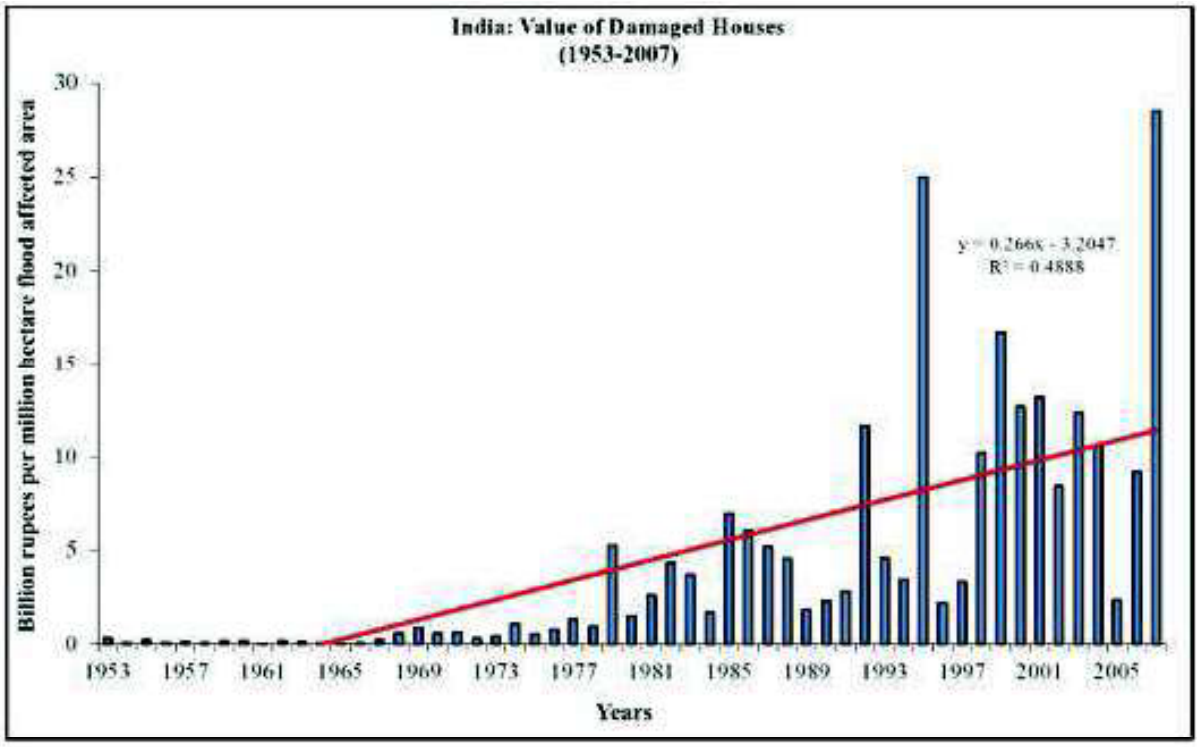

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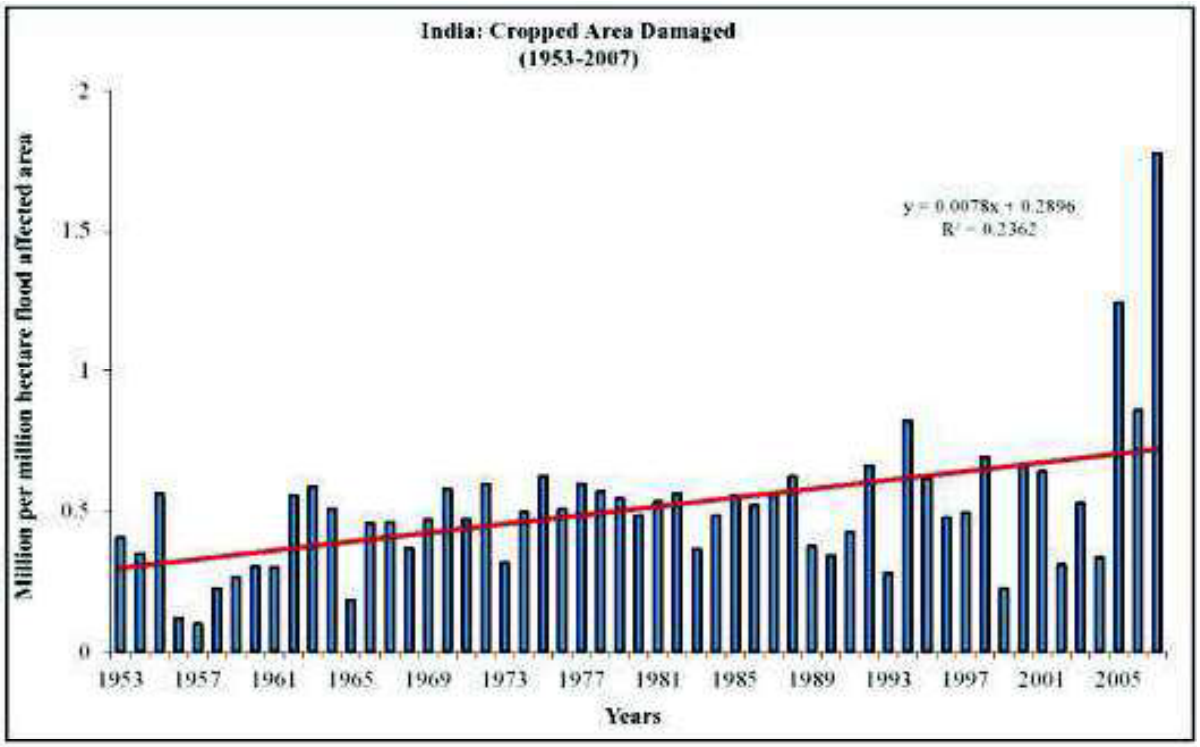
Fig. 6



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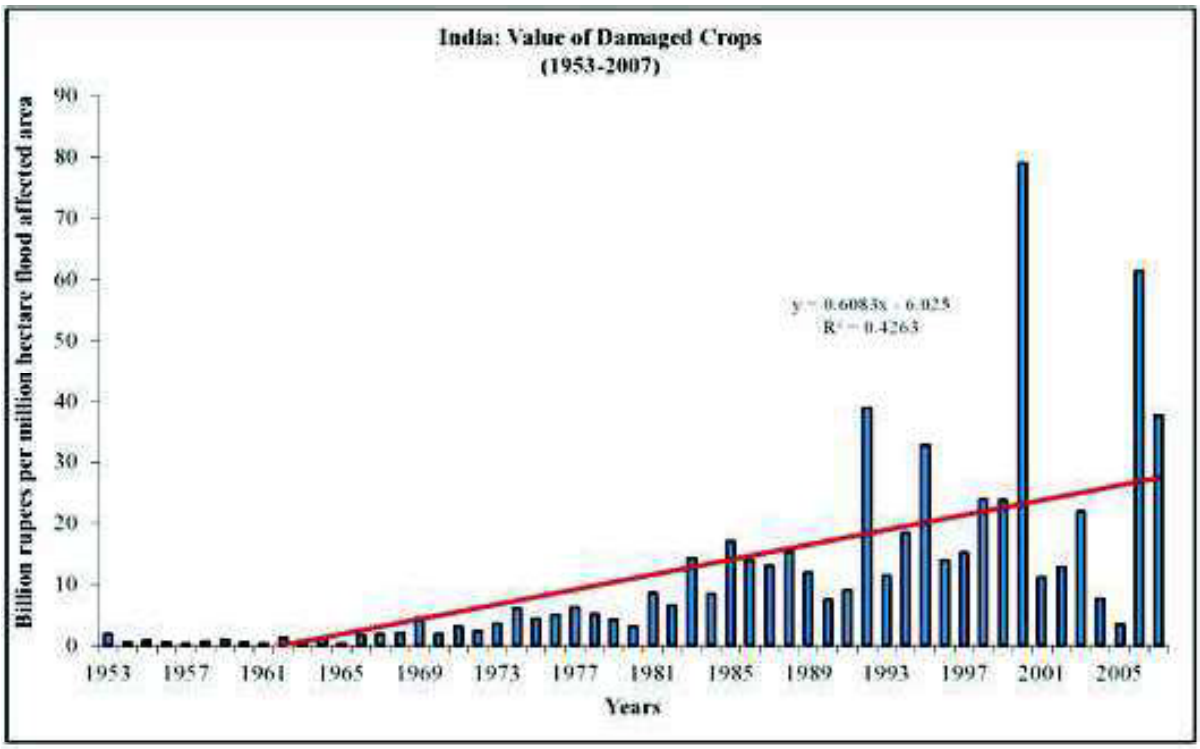

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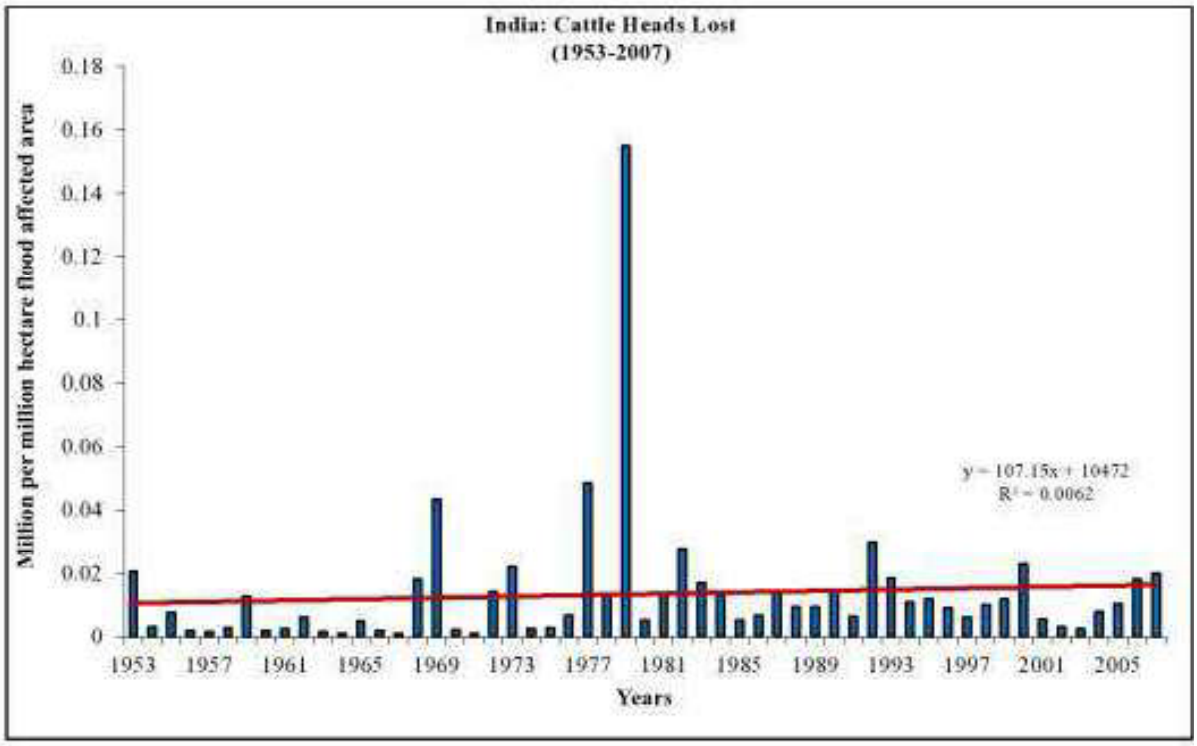

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river. Thus, there is severe damage to crops during the time of even low floods.

Annually, on an average crop of worth Rs. 11 billion per million hectare of flood affected area (at 1993-94 prices) were damaged due to floods in India. The total value of damaged crops during the last fifty five years was observed to be Rs. 605 billion per million hectare of flood affected area. The highest crop loss of Rs. 78 billion per million hectare of flood affected area was observed in year 2000 while it was found to be lowest in 1957 (Rs. 0.3 billion).

Damage to Livestock

Loss of livestock is also a common problem during floods in India. Like other flood affected damages, the loss of cattle per million hectare of flood affected area also demonstrated a discernible increasing trend during the study period (Fig. 9). Interestingly, loss of cattle per million hectare of flood affected area was almost stagnant till the year 1979 and subsequently afterwards it demonstrated an increasing trend continuously. A total of about 0.7 million cattle heads per million hectare of flood affected area were lost during the period under study and on an average about 0.01 million cattle were lost annually due to floods. The estimated loss of livestock per million hectare of flood affected area was observed to be lowest in 1967 and highest during 1979 showing about 162% variability. Analysis of livestock damages revealed a weak correlation (29%) between the area affected by floods and the loss of livestock. Such revelation may be anomalously attributed to under or over reporting of damages to livestock during various years. The under and over reporting of the loss of livestock is probably due to negligence, lack of awareness, bureaucratic hurdles and to gain the compensation (Sreekesh, 2009).

Damage to Public Utilities

Occurrence of floods also damages infrastructure and utilities. The damage to public utilities such as rail, roads, telephone, electricity etc. is very common during flood time in the country. During 1953-2007, the total damage of public utilities per million hectare flood affected area was reported to be about Rs. 732.2 billion with an average of Rs. 13.3 billion per year. The maximum damage to public utilities in the country per million hectare of flood affected area was observed in the year 2001 (Rs. 90.7 billion), while it was found to be lowest during the year 1962 (Rs. 0.01 billion). The damage to these utilities was found to be very low till the year 1980 and subsequently it enhanced exorbitantly (Fig. 10). The high loss of public utilities after 1980 is primarily attributed to the expansion and development of these facilities during the recent times.

Total Damages

Every year flooding causes loss of billions of Rupees in India (Fig 11). The total damage loss per million hectare of flood affected area during 1953 to 2007 was found to be about Rs. 1584.9 billion with an average of Rs. 28.8 billion per year. Maximum loss per million hectare of flood affected area was observed to be Rs. 164.8 billion in the year 2000, whereas it was reported to be lowest in the year 1961 (Rs. 0.47 billion). Substantial losses due to floods have been observed to public utilities, houses and crops. In addition, floods also affect the social life in the flood affected areas. Floods lead to seasonal migration of people from affected areas in search of alternative livelihood options. Also, it temporarily displaces the people from their native place to temporary shelters and makes

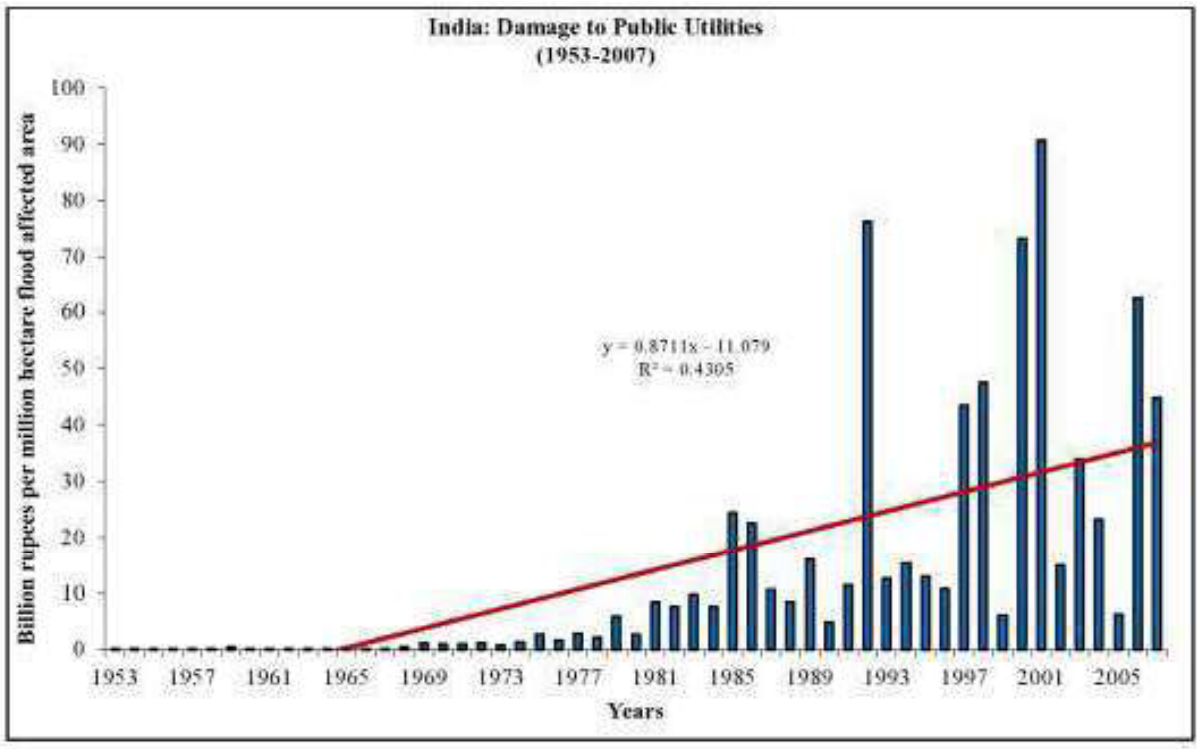

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Fig. 10

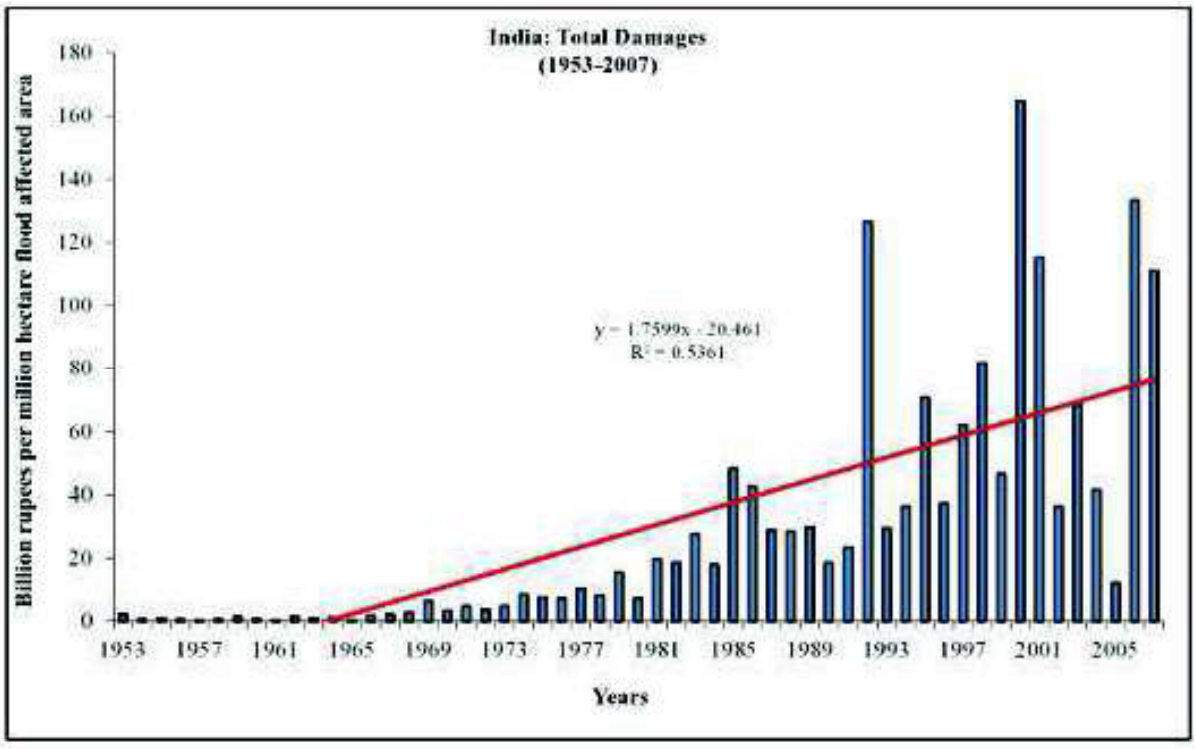

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Fig. 11

them environmental refugees. Moreover, it increases the disparities among the different sections of the society and deprives them of opportunities of growth.

Major Observations

- On an average about 270 people died per million hectare flood affected area in the country during 1953-2007.
- Annually, it affected about 5.5 million people per million hectare flood affected area and inundated about 7.5 million hectare of land.
- Maximum damages per million hectare flood affected area occurred in the year 2006.
- Nearly half of the affected area is under agriculture and average crop loss is about Rs. 11 billion per million hectare flood affected area.
- The total damage of public utilities per million hectare of flood affected area was reported to be about Rs. 732.2 billion with an average of Rs. 13.3 billion per year.
- All type of damages due to floods has exhibited an increasing trend since independence.

An increase in all sorts of damages due to floods can be attributed to i) increased pressure and concentration of the population in floodplains; ii) reduction in water-carrying capacity of the rivers due to greater floodplain occupancy; iii) encroachments in active flood plains; iv) channel alterations by human structures and v) haphazard development along the rivers. Accelerated anthropogenic activities such as changes in land use practices, road construction, mining and grazing have led to more sediment generation and subsequently its deposition into channels thereby reducing the channel efficiency. Moreover, cultivated areas have been extended into the marginalized lands and sometimes beyond the embankments constructed for the flood control.

Finally, it is suggested that area specific studies with less-interventionist approaches based on the scientific understanding should be carried out to understand flooding and to find out solutions to save flood prone areas from these reoccurring losses.

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Dr. Omvir Singh, Associate Professor
Manish Kumar, M. Phill. Student
Department of Geography,
Kurukshetra University,
Kurukshetra, Haryana