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Soil Erosion as an Underlying cause of Disasters Case of North Indian Floods, and Rio de la Plata, Spain

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ABSTRACT: Soil erosion is a slow-onset disaster, and results into various other forms of disasters. Finding out these overlooked results of soil erosion is a must for a planner, so as to study the land suitability for various proposed activities.
The paper aims at finding out this relationship, using 2 cases: Rio de la Plata, Spain and Uttarakhand. In Rio de la Plata, anthropogenic activities (symbolized using GDP) has resulted in increase in frequency of water-triggered disasters like floods, droughts etc. The author identifies complete lack in literature relating soil erosion in context of Uttarakhand June 2013 disaster. Therefore, in a much detailed study of the region, soil erosion's role in the disaster has been explained in this paper. Thus, this paper focuses on detailing out how erosion can act as an underlying cause of other primary disasters, and that planners should take these into account in any disaster management planning.

Keywords: erosion, landslides, bank erosion, toe erosion, GDP, geology, degradation, sediment

I. INTRODUCTION

Disasters can result in failed development, but failures in development planning can also lead to disaster risk. (Kamat R., 2015). At its current pace of consumption, world is running out of useable topsoil. In fact, about a third of the world's soil has already been degraded. Soil Erosion in India is amongst the leading areas of concern for the Government of India. In India, almost 130 million hectares of land, that is, 45 % of total geographical surface area is affected by serious soil erosion through gorge and gully, shifting cultivation, cultivated wastelands, sandy areas, deserts and water logging. It affects cultivation and farming in the country in adverse and unfavorable ways. In response according to UN, only 60 years of farming is left if the current practices continue.

One of the major concerns at current time is soil erosion as a slow-onset disaster. Type of soil in terms of percolation of water from the surface is a major factor of concern in urban flooding. It largely depends on the built-up cover of the area (Kamat R. 2017). Because of the rapid rate of soil erosion, various disasters like floods, landslides, avalanches etc are increasingly occurring. If the damage is assessed before the occurrence of a disaster, measures can be taken before hand to minimise the damages (Kamat R. 2009). Therefore, this paper attempts at studying whether soil erosion can be termed as an underlying cause of other disasters, by taking cases of North Indian Floods, 2013, and Rio de la Plata, Spain.

II. SOIL EROSION

The word erosion is of Latin origin being derived from the verb *erodere*- to eat away, to excavate. The term erosion has evolved from describing the wearing away of solid material by action of river water (Penck, 1894), to express geomorphological processes caused by wind and water like corrasion, corrosion, abrasion and denundation. Many authors now use the term erosion to ecompass any form of destruction of soil or Earth's surface by water, and will be thus used in this paper, unless stated.

A. Causes

The cause of soil degradation and erosion differs from place to place. Oceania's erosion is mainly because of overgrazing, while Europe's heavy deforestation is unbalancing the soil, and is eroding it.

In Asia, the major cause is agricultural practice (40%), followed by industrialization (27%) and overgrazing (26%). Overexploitation of trees for fuelwood (6%) also poses danger of erosion in Asia. Throughout the world, overgrazing (35%) is the major cause of soil erosion, followed by deforestation (30%), and agricultural activities (28%) (L.R Oldeman, 1990).

Therefore, human interventions on land are playing a very bad role in soil degradation, and results in various issues and concerns, as discussed below.

B. Issues and Concerns

Half of the topsoil on the planet has been lost in the last 150 years, and it can take decades, if not centuries, to regenerate. This is of great ecological concern as one inch of topsoil can take between 500 (Smolka, 2001) and 1,000 years (Scientific American, 2014) to form naturally. Numbers suggest only 60 years of viable topsoil left at the current rate of degradation and increased usage. Some 40% of soil used for agriculture around the world is classed as either degraded or seriously degraded – the latter means that 70% of the topsoil, the layer allowing plants to grow, is gone. Because of various farming methods that strip the soil of carbon and make it less robust as well as weaker in nutrients, soil is being lost at between 10 and 40 times the rate at which it can be naturally replenished.

The United States alone loses almost 3 tons of topsoil per acre per year (NRCS, 2009).

Soil is a living material and there are millions of microorganisms that play a part in the constitution of soil. These microbes recycle organic material, which underpins the cycle of life on earth, and also engineer the soil on a tiny level to make it more resilient and better at holding onto water. Microbes need carbon for food, but carbon is being lost from the soil in a number of ways. Human activities take too much from the soil and don't put enough back. Carbon is lost by too much disturbance of the soil by over-ploughing, mining and by the misuse of certain fertilizers. Thirdly, overgrazing results in soil erosion and degradation, as one of the most important ways of getting carbon into the soil is through photosynthesis.

Shortage of food is a major concern, as under a business as usual scenario, degraded soil will mean that we will produce 30% less food over the next 20-50 years. Water will reach a crisis point, as moderately degraded soil will hold less than half of the water than healthy soil in the same location. And, without topsoil, little plant life is possible. The estimated annual costs of public and environmental health losses related to soil erosion exceed $45 billion (Pimentel *et.al,* 2005).

Apart from these issues, one of the major related issues is soil erosion becoming a reason behind various other disasters. This has been discussed using 2 cases in this paper. The scenario study is the basic ingredient for development of disaster management plan for vulnerable area (Kamat R., 2007).

III. SOIL EROSION: CATALYST OF OTHER DISASTERS

Accelerated soil erosion are said to be slow-onset disasters. Because of its slower pace, it is often overlooked upon as a disaster. But, at worse times, it turns out to be a prime reason behind loss of life and property, and often are underlying reasons for onset of other disasters.

A. Case Sudy: Rio de la Plata, Spain

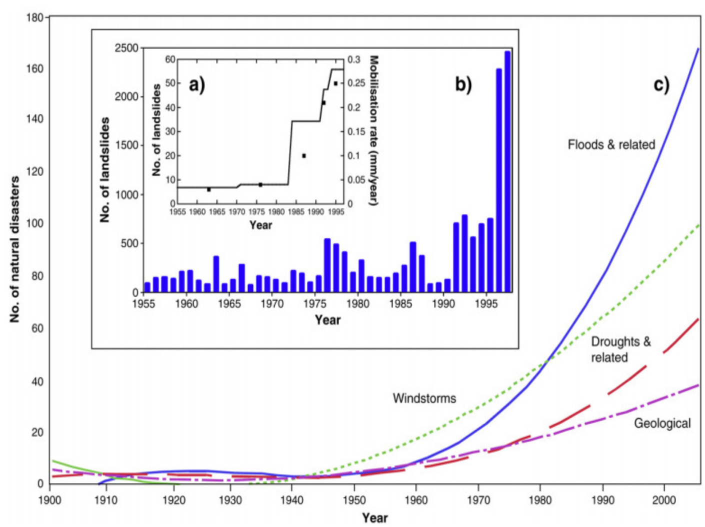


Fig. 1. Landslide frequency in the Deva valley, Spain (a) and in Italy (b). Frequency of natural disasters in the world (c). Source: (Bonachea *et. al,* 2010).

As evident from Fig. 1, in Spain the number of yearly floods and related disasters around the world has jumped more than 9 times since the 1950s —to more than 180 per year— and that the trends in rainfall attributed to climate change are not enough to explain such a rise. Unregulated development in urban area makes the people in many countries to occupy the hazardous area, thus, making them vulnerable to disasters (Kamat R. 2013).

The dramatic rise of water-related disasters seems to follow GDP. *As GDP increased in northern Spain, so did the rates of sediment production and also the number of water-triggered disasters in the region* (Bonachea *et. al,* 2010).

Therefore, this case depicts how human interventions to increase GDP has resulted in erosion, and has finally resulted in increasing the number of water-triggered disasters. Here, erosion has been the underlying cause behind various disasters, and can be termed as a slow-onset disaster.

IV. CASE STUDY: NORTH INDIAN FLOODS

In June 2013, a multi-day cloudburst centered on the North Indian state of Uttarakhand caused devastating floods and landslides becoming the country's worst natural disaster since the 2004 tsunami. Though some parts of Himachal Pradesh, Haryana, Delhi and Uttar Pradesh in India experienced the flood, some regions of Western Nepal, and some parts of Western Tibet also experienced heavy rainfall, over 95% of the casualties occurred in Uttarakhand. As of 16 July 2013, according to figures provided by the Uttarakhand government, more than 5,700 people were "presumed dead." This total included 934 local residents.

The National Institute of Disaster Management (NIDM) has blamed "climatic conditions combined with haphazard human intervention" in the hills for the disaster (Parkash, 2013). Deforestation in the region for socio-economic growth like unplanned construction of buildings, hotel, roads etc. also accounted for flood and landslides. This is because deforestation caused soil erosion, which shows that depletion of these natural resources was the basic cause of this tragedy.

Therefore, soil erosion caused by Uttarakhand's soil character, unplanned development, and river erosion were the major causes of the extent of the disaster.

A. Uttarakhand Landscape and Geology

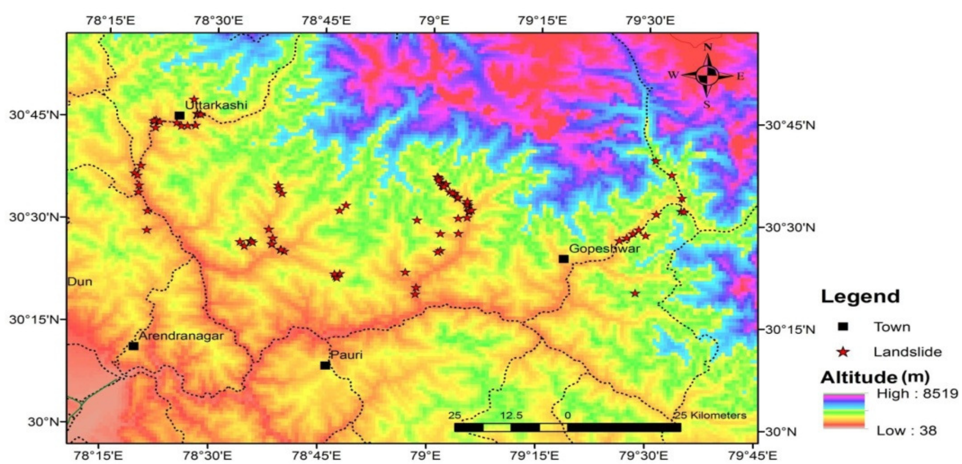


Fig. 2. Uttarakhand Landscape.

The State of Uttarakhand, due to its complex terrain and ongoing tectonic activities, is highly prone to hazards like earthquakes, landslides, cloud bursts, and flash floods. (CAG, 2010)

The Uttarakhand Landscape has the following

Characteristics

-Rugged mountain chain: hilly topography

-Dominance of erosional & gravitational processes

-Lies in Zone IV & V of Seismic Zoning map of India

-Known to be one of the most landslide prone states in India

-Rainfall & Earthquake are the main triggering factors for slope failures (Sundaramoorthy, 2013).

Uttarakhand has a total area of 53,484 km^2 of which 93% is covered by mountains and 64% is covered by forest. Most part of the Uttarakhand is covered by High Himalayan Peaks and glaciers. Uttarakhand is the originating point of two of India's largest rivers, Ganga and Yamuna from the glaciers.

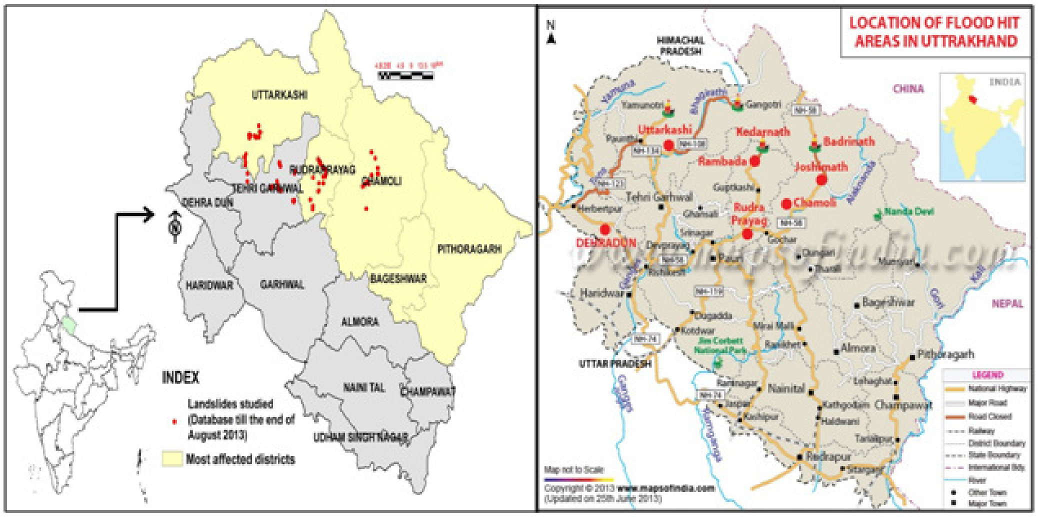


Fig. 3. Landslide Profile of Uttarakhand (Left), and Flood Hit areas in Uttarakhand (Right) Source: CAG, 2010 and www.mapsofindia.com.

Uttarakhand's upper terrain reaches is most prone to landslide, as evident from Fig. 4 (left). 7 out of 8 flood hit areas were in landslide prone areas of Uttarakhand. Therefore, landslide was a major factor behind flooding of these areas. But, it has been found that there is a high correlation in landslides and soil erosion in context of Asia. (Pradhan, 2011).

This fact cannot be kept without relating with the soil type profile of Uttarakhand, as it can be used in finding out whether soil erosion had any hand in the Uttarakhand tragedy.

B. Soil Profile

Based on FAO's soil classification, India has 8 major types of soil, out of which North Indian flood hit area majorly has 3 classes of soil: Alfisols, Mollisols, and Histosols, as evident from Figure. (SOE Atlas, 2011).

Alfisols have low structural stability and are susceptible to surface crusting, soil compaction and erosion. (Kang B.T, 1992) As Alfisols constitute the highest percentage of soil type in Uttarakhand, the state is very prone to soil erosion. Histosols and Mollisols also have characteristics of wind erosion linked with them. (Sommers, 1984)

The soil constitution of the flood-hit area was prone to soil erosion. This was worsened by its geology, and landslide profile, as discussed in the upcoming sections.

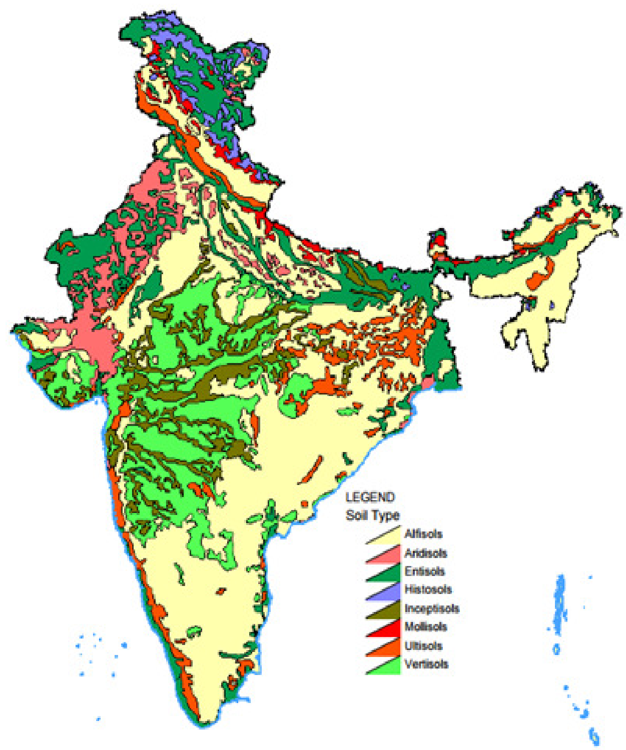
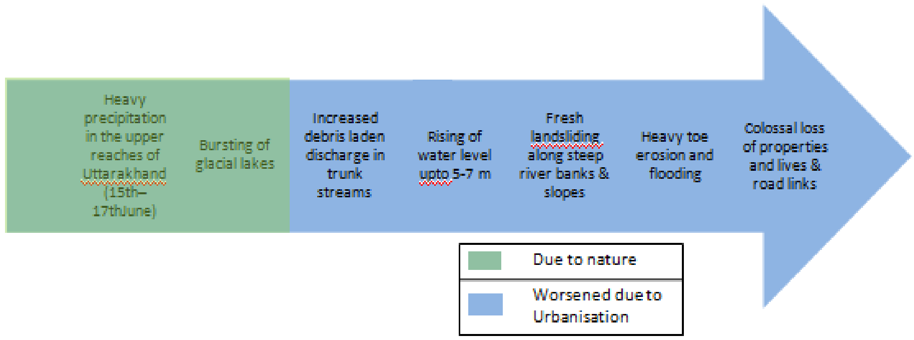


Fig. 4. Soil Type in India. Source: SOE Atlas

C. Sequence of Events



1. Heavy Rainfall. A sudden increase in rainfall was observed in June, 2013, as compared to the amount of rainfall in the past 3 years. The rainfall was 375% more than the benchmark rainfall during a normal monsoon.

While on 14.06.13 and 15.06.13, the rainfall was 5.66mm and 15.28mm respectively, on 16.06.13 it suddenly rose up to 113.25mm. On 17.0613, 180mm rainfall was observed. 325 mm of rainfall in 24 hours between 5PM, 15th June and 5PM, 16th June at Chorabari Lake as against 272 mm in 3days (15-17 June) at Ghuttu initiated the disaster

2. Increase in River Discharge –A Trigger For Bank Erosion And Landslides. Geomorphological study of the area indicates that the surface slopes consist mostly of glacial, fluvio-glacial, or fluvial materials, which are mostly unconsolidated and loose in nature. The drainage studies indicate a migratory or shifting nature of the river systems that causes aggradations on the concave end of the river and degradation or toe erosion on the convex part of the river. Due to morphological setting of the area, the river has high sinuosity and hence, high level of erosive capacity, especially when it is loaded with sediments (the erosive power of river with sediments is almost square of the erosive power without sediments). (Parkash, 2013).

Thus, situation was then aggravated by increased and uncontrolled river discharge.

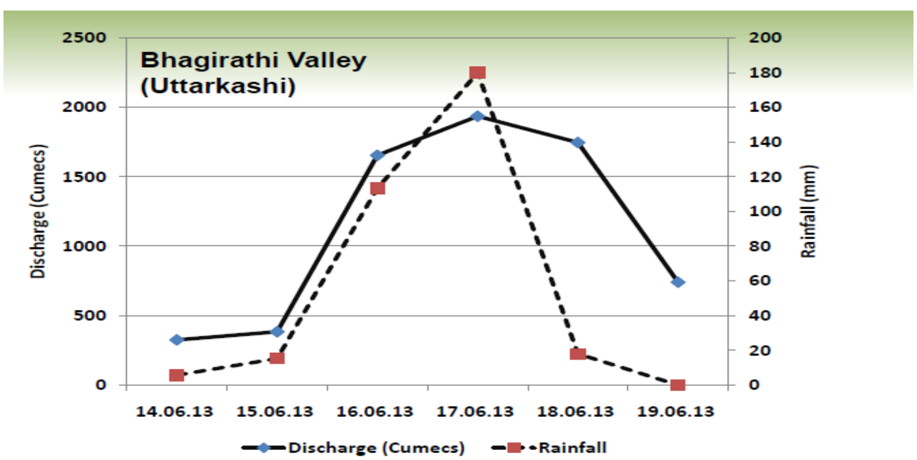


Fig. 5. Level of rainfall and discharge in Bhagirathi valley, Uttarkashi, Uttarakhand from 16th June to 19th June in 2013. Source: GSI, 2013.

As it can be seen from the graph above, in Bhagirathi Valley, Uttarkashi, there was a sudden increase in river discharge with increasing rainfall. This river discharge was mixed with huge supply of debris from upper reaches, yielding tremendous erosive power.

Because of high erosivity of the Uttarakhand soil, heavy rainfall and high flowing rovers, landslides occurred. Both bank erosion, and landslides led to an even more increase in debris in the river streams, aggravating the already aggravated matter.

Fig. 6. Land unsuitable for development (slide zone) has built up and cultivation, Uttarakhand. Picture taken before the disaster. Source: Geological Survey of India.

Such unsuitable development was not only dangerous for the houses themselves, but also led to an increase in debris in river during the disaster, which aggravated the situation. This also led to landsliding of such sloping areas near river banks.

VI. CONCLUSIONS

Using the following justifications:
(i) Similarities between landslide profile of Uttarakhand and its flood-hit areas (discussed in section IV A).
(ii) High correlation between landslide and soil erosion in context of Asia. (Pradhan, 2011).
(iii) Erosive soil type of Uttarakhand region (SOE Atlas, 2011).
(iv) Heavy bank and toe erosion during the disaster.

We can conclude that soil erosion prevailing in Uttarakhand was an underlying reason behind the 2013 Floods.

Despite the soil type being very erosive, no precautionary steps were taken to preserve the river buffer. Because of deforestation, Uttarakhand land's *water retention and porosity decreased*, and thus even Nature could not play its part in minimizing flooding. Moreover, deforestation gave home to *soil erosion*, which in turn created an ecological imbalance. This also led to a state of uncontrolled *landslide*, as trees could have helped in controlling the latter.

Moreover, with deforestation, the erosive nature of soil increased, and every time there was heavy rainfall, there were *gully formations*, which resultantly led to flash floods. Thus, the existing forest lands are unable to hold water coming down the slopes.

The unplanned development in the river buffer area are putting extra pressure on weak lithology of hill slopes, caused soil erosion, and resulted in more *landslides than before* (Das, Nov. - Dec. 2013).

Therefore, we can again conclude that in most of the reasons behind this disaster like landslides, cloudburst, flooding etc, erosion was an underlying catalyser behind these.

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