THE ALL - GIRLS ECO- PROGRAMME	ANTHROPOGENIC INTENSIFICATION OF FLOODING AND ITS DISASTROUS RAMIFICATIONS ON MUMBAI

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ABSTRACT

Floods are a common occurrence in many parts of the world. In some places, they expectedly occur annually, whereas in others, their erratic behaviour wreaks immeasurable havoc. Due to unprecedented levels of anthropogenic activity and rapid change in climatic conditions, deadly and erratic deluges have become the norm. Mumbai usually faces a flooding calamity during the monsoon season, bringing daily life to a standstill. The destruction caused has only surged in recent years. In this paper, we investigate the sources of this problem and its consequences on the population. Finally, we delve into mangrove restoration as a means to cope with this problem or similar events in the future.

INTRODUCTION

Flooding is a natural disaster exacerbated by anthropogenic actions such as increasing urbanisation and climate change [1]. Not only does it result in great economic damage, but it also has a widespread social and environmental impact, from the destruction of ecosystems, damage to livelihoods as well as health-related consequences [2], which are all detrimental to communities. This research paper focuses on Mumbai, the capital of India. Located in Western India, it is a metropolis with a population of approximately 20 million [3], and unfortunately, it is flooded by heavy rain at least once a year. Whilst monsoons are a natural occurrence for the city, climate change has intensified downpours, sometimes causing torrential rains that worsen flooding [4]. This research paper explores the causes of floods in Mumbai, the effects, and highlights how effective mangrove restoration projects can mitigate the negative impacts of these floods.

ANALYSIS

The Mumbai Floods are exacerbated by several factors, one of which is the geography of the city itself [5]. Initially, starting as a group of islands, the city was artificially developed using reclamation projects, expanding land and creating space for an increasingly urban population [6]. This means the city has many low-lying areas prone to flooding. Further, as a result of this process, alongside mangroves that were previously a natural buffer from floodwaters were destroyed. Moreover, as a result of this development, many rivers that acted as a natural drainage system have become polluted [2], exacerbating the city's vulnerabilities. The increased building of housing properties also means that vegetation is removed and replaced by materials such as concrete which slow down natural drainage processes. This means that there is a higher rate of surface run-off in heavy rain conditions, causing rivers to fill up faster leading to flooding. Another factor exacerbating flooding of the city is the faulty and inefficient stormwater drains across Mumbai [2]. The complex drainage of networks leads water to drain into the surrounding rivers, and eventually the sea and has existed since the 1860s [7]. However, since that time period, the network has not substantially improved. Under normal conditions the drains can handle 25 mm/hour, however with a greater rain intensity inundation i.e overflow or rising and spreading of water can, and often occurs. To add to this pollution is a complicating factor that has severely impeded drainage, as the storm drains can only work to their full capacity if there are no obstructions. However, with a large population, many of Mumbai's drains are severely polluted, blocking drainage and reducing the drain capacity.[2]

Mumbai is likely to increasingly suffer from flooding which will have many impacts on the local community apart from economic destruction and loss of livelihoods, there is a serious risk of contamination of clean water facilities and an increased risk of infection and water-borne diseases. Through contact with these polluted waters there is an increased risk of transmission of diseases like cholera, leptospirosis,typhoid fever, and hepatitis A and E [8]. Drowing, hypothermia and animal bites are some examples of the direct health impacts of floods [8]. The process of evacuating health patients and supplying medicine and supplies, also pose health risks [9]. Flooding can have a negative psychological effect on survivors in terms of mental illness,

who can be diagnosed with post-traumatic stress disorder (PTSD), anxiety, and severe depression. Floods cause short-term distress in people, influence their wellbeing, and affect their mental health [10].

The Municipal Corporation of Greater Mumbai (MCGM) is responsible for the management of the city and alongside the Mumbai Disaster Management Committee they have undertaken various tasks to address heavy flooding. This has included spending USD 2 million [11] on upgrading their emergency control center to include the latest technology, emergency water supplies and a reliable power source with backup generators to ensure all disasters can be responded to efficiently. Moreover, after heavy flooding in 2005, the MCGM procured automatic weather stations to provide an alarm as the rainfall was 955mm [12]. This has meant warnings can be issued to the general public sooner and responses to intense rainfall can be taken quickly.

MARCH 1988, NASA [13] JANUARY 2017, NASA [13]

A multifaceted solution that considers both mitigation and adaptation strategies [14] is required to deal with the impact of heavy flooding. However, in this paper we will be focusing on one aspect which is the restoration of mangrove ecosystems. Moreover, within the solution process, it is essential to consider all citizens and ensure that management techniques are inclusive across different socioeconomic backgrounds [15]. Flooding is endemic to the low-lying areas in Mumbai and now with storm surges and cyclones the whole city is vulnerable. Mangroves are proven buffers against storm surge flooding [16].

IMPORTANCE OF MANGROVES

Situated in tropical and subtropical areas, mangroves are coastal forests that are usually affected by cyclones, hurricanes and storm surges. Morinda Citrifolia , Rhizophora mucronata, Avicennia Marina, Sonneratia Alba, Avicennia Alba and Avicennia Officinali are the most important types of mangroves [17]. These coastal forests bring forth many ecosystem services such as charcoal (provisioning services), provide a line of defence for storms and floods (regulating services); and provide habitats for fish (habitat services) [18]. Mangroves are extremely efficient in diminishing storm surge water levels and at lessening wind and swell wave heights. Thus, their destruction can lead to increased flooding. In Mumbai, mangroves amount to a total area of 56.40 km2 (mud flats incorporated into figure) [19]. A whopping 36.54 km2 of mangrove area was lost between 1990 to 2001 [19]. The causes for this decline were growing population pressure, increased urbanisation, land-use change, and polluting industrial wastes [19].

Using two case studies, we will demonstrate the ability of mangroves to provide coastal defence services. A city in Australia named Cains suffered cyclone Larry in 2006. When the storm hit, citizens were evacuated to mangrove creeks, and records show that zero lives were lost. This was due to the brilliant disaster mitigation strategy that incorporated an early warning, and a strategic

evacuation plan that utilised mangroves [20]. Another case study, based on three villages situated in Orissa India, demonstrated how the villages protected by mangroves after a cyclone experienced less crop damage and less economic losses [21].

FOCUS ON MANGROVES REGENERATION

Forest regeneration refers to the act of renewing a forest, and two ways exist for regenerating mangrove forests [22].

Natural: When mangrove seedlings sprout without any human intervention or aid, this process is referred to as natural regeneration. It entails creating an atmosphere that is conducive to the growth and development of local tree species. Mangrove forests need a variety of climatic factors to thrive, including high temperatures to boost productivity, precipitation, and saline water. This is the process of completely replacing old stands that have been chopped down or damaged by any kind of disturbance with new seedlings that are planted in nurseries and then transplanted to the field. It necessitates purposeful establishment of forest trees in remediated polluted sites [22].

Artificial: When new mangrove seedlings are intentionally planted in nurseries and then moved to the field, this process is called artificial regeneration. The goal of this regeneration type is to develop forests in place of a previously polluted site. The advantage of artificial regeneration is that once these seeds have been nurtured properly for 1 or 2 years, they will grow a root system that -when transferred to the field- can resist erosion, pollution and climate change [22]. This process is much faster than natural regeneration [22], and thus, we believe artificial regeneration could be utilised successfully to mitigate problems associated with mangrove loss in Mumbai.

FURTHER RECOMMENDATIONS:

- **Increase the frequency of mangrove monitoring**

  Alongside efforts of forest regeneration, mangroves must be monitored carefully to ensure they reach their optimum potential of flood alleviation. This includes recording the number of mangrove trees; measuring the growth and failure of saplings; measuring the quantity of waste levels around the coastal region.

  Commented [1]: reference needed.

- **Increase efforts in modeling and mapping floods**

  These maps should indicate different hazard zones, and can be created using remote sensing and hydrological modeling softwares to collect and analyse data on the topography, land-use and climate patterns of the study area. The models created can be used to allocate certain land uses. In addition to this, it allows for the development of mitigation strategies, such as flood warnings and evacuation plans [23].

CONCLUSION

Flooding is a hazard that will continue occuring in India, and one that might be further increased in quantity due to anthropogenic climate change. Flooding can lead to devastating impacts such as the spread of disease, injury, loss of life and damage to properties. This research paper focused mainly on the importance of mangrove regeneration, as demonstrated by two caste studies, in acting as a line of defence in flooding events. We have suggested that artificial regeneration of mangroves could serve as a quick way to mitigate mangrove loss. We have also highlighted how increased mapping efforts of flood zones, and increased efforts in mangrove monitoring could be tools in alleviating the disastrous impacts of flooding.

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