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"Aerosols, land-use changes may greatly weaken monsoon"

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The South Asian Monsoon has been weakening since the 1950s. Mohammed Yousuf

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The South Asian Monsoon has been weakening since the 1950s with an increased incidence of extreme rainfall events. Now, a paper in the journal *Climate Dynamics* lead authored by Dr. R. Krishnan attributes this weakening to increased greenhouse gas (GHG) emissions, atmospheric aerosols and land-use changes. Dr. Krishnan is a scientist at the Indian Institute of Tropical Meteorology, Pune.

The monsoon is mainly driven by thermal contrast between the Indian subcontinent and the adjoining ocean. As the land warms up the air above the land surface is heated and rises up and is less dense than the cool air over the ocean. This contrast in temperatures and densities causes the cool moisture bearing winds from the western Indian Ocean to move into the land mass and bring monsoon rains to the subcontinent.

This scenario, however is changed due to the presence of greenhouse gases, aerosols in the atmosphere or if the land has been subjected to increased deforestation. Greenhouse gases trap the heat over land and sea and result in both the land and sea being warm, that is the thermal contrast is greatly reduced. This leads to a weakening of the monsoon circulation and the result is a weakened monsoon.

However, a warmed up atmosphere can hold more moisture and this situation can result in heavy rainfall over some regions.

Anthropogenic atmospheric aerosols, including sulphates, black carbon, nitrates and dust accumulate over the Indo-gangetic plains. These reduce incoming solar radiation over northern India and the northern Indian Ocean and lead to cooling on both land and sea resulting in a lowered thermal contrast.

Hence, monsoon winds and circulation are weakened as both land and sea are cooled. Evaporation is also suppressed. Over South Asia, over 50 per cent of aerosol emissions are caused by biomass and agricultural burning. There is mounting evidence of the emissions from South Asia and China in changing the timing, spatial distribution and strength of the monsoon.

However, negative impacts of these aerosols can be reduced quickly as they have a short lifetime of few weeks compared to GHGs which can stay in the atmosphere for up to 80 years.

A third, and nevertheless important, contributor to monsoon weakening is the albedo effect of deforestation by humans. Reduced land cover increases the reflectivity (albedo effect) which leads to cooling of land in contrast to the ocean and results in a weakened monsoon circulation.

This could be particularly important over south Asia as tree fraction has decreased by 30 per cent and crop cover increased by 45 per cent in the past century. But what happens to the south Asian monsoon if say, both aerosols and GHGs are present in the atmosphere and if land-use effect (albedo, cooling of land) is present along with say, GHGs?

"It would be difficult to explain the combined effect of any of these forcings," said Dr. Deepti Singh, Postdoctoral Fellow, Lamont Doherty Earth Observatory, Columbia University and the author of a News & Views article in *Nature Climate Change* in an email to this Correspondent. "There is still more to do in understanding how these will individually affect the monsoon so I can only really speculate without data about how they would interact. We can turn to models to simulate the combined effects of these forcings. Few modelling studies have done so. The net effect of these different forcings depends on their relative magnitudes."

According to her, the study shows that in the absence of GHG forcing, the monsoon circulation would have strengthened and some regions would experience enhanced rainfall. However, since there were aerosol, land-use and GHG forcing that have opposite effects on the monsoon circulation and rainfall, the overall response of the monsoon has been muted. "Just aerosol and land-use changes would likely lead to a greater weakening of the monsoon than has been observed in recent decades," she underlined.

Keywords: Climate Dynamics, Nature Climate Change

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