GOVERNMENT OF INDIA
MINISTRY OF EARTH SCIENCES
LOK SABHA
STARRED QUESTION No. ***149**
TO BE ANSWERED ON WEDNESDAY, DECEMBER 03, 2014
(Placed at 9th Position)

WARMING OF INDIAN OCEAN

***149. KUNWAR HARIBANSH SINGH:**
SHRI GAJANAN KIRTIKAR:

Will the Minister of **EARTH SCIENCES** be pleased to state:

(a) whether as per the study published recently, the Indian Ocean has been warming consistently for over a century and at a faster rate than any other region of tropical oceans;
(b) if so, the details thereof and the reaction of Government thereto;
(c) whether ocean warming has resulted in the weakening of the south-west monsoon and is proving to be detrimental to marine bio-diversity of the country;
(d) if so, the details thereof; and
(e) whether the said study is likely to be helpful in understanding climatic changes in oceanic marine ecology and if so, the details thereof?

ANSWER
MINISTER FOR MINISTRY OF SCIENCE AND TECHNOLOGY AND
MINISTRY OF EARTH SCIENCES
(DR. HARSH VARDHAN)

(a- e) A statement is laid on the Table of the House.

STATEMENT LAID ON THE TABLE OF THE LOK SABHA IN REPLY TO (a) to (e) OF STARRED QUESTION No. *149 REGARDING "WARMING OF INDIAN OCEAN'' ASKED BY SHRI KUNWAR HARIBANSH SINGH AND SHRI GAJANAN KIRTIKAR FOR ANSWER ON WEDNESDAY, DECEMBER 03, 2014 .

(a) Yes Madam.

(b) During 1901-2012, the tropical Indian Ocean has experienced summer time warming of 0.7^{o}C. The equatorial western Indian Ocean experienced warming of 1.2^{o}C while the central-eastern Indian Ocean experienced a warming similar to that of the whole tropical Indian Ocean i.e. 0.7^{o}C. Further, warming over the North Indian Ocean was up to 0.8^{o}C and that of the South Indian Ocean remained at 0.6^{o}C. The reasons behind for such warming over the Indian Ocean and their possible impacts on the monsoon rainfall over India are still under debate.

The sea surface temperature (SST) difference between the western Indian Ocean and the eastern Indian Ocean, *known as the Indian Ocean Dipole (IOD)*, and the SST variations over the tropical eastern Pacific *(warming and cooling known as El Niño and La Niña, respectively)* and concurrent surface air pressure difference between the western Pacific and the eastern Pacific *(known as Southern Oscillation)*, whose combined effect known as *El Niño Southern Oscillation (ENSO),* are among the known influencing factors of the seasonal monsoon rainfall variability.

(c-d) No such direct link has been established so far. All India summer monsoon rainfall (AISMR), analyzed for the period 1871-2014, has a typical epochal pattern of rainfall variability with alternating periods of wet and dry, extending to 3-4 decades, viz. the 44-year period of 1921-64 witnessed just three dry monsoon (deficient rainfall) years. During such epochs, the monsoon was found to be less correlated with the ENSO*. During the other periods like that of 1965-87 which had as many as 10 dry monsoon (deficient rainfall) years out of 23, the monsoon was found to be strongly linked to the ENSO. IOD** and the ENSO* are independent climate modes, which frequently co-occur, driving significant inter-annual changes in terms of SST and circulation, within the Indian Ocean, influencing the monsoon variability.

** **El Niño Southern Oscillation** (ENSO) refers to the effects of a band of sea surface temperatures which are anomalously warm or cold for long periods of time that develops off the western coast of South America and causes climatic changes across the tropics and subtropics. The Walker Circulation was discovered by Gilbert Walker at the turn of the 20th century. The "Southern Oscillation" refers to variations in the temperature of the surface of the tropical eastern Pacific Ocean (warming and cooling known as El Niño and La Niña, respectively) and in air surface pressure in the tropical western Pacific. The two variations are coupled: the warm oceanic phase, El Niño, accompanies high air surface pressure in the western Pacific, while the cold phase, La Niña, accompanies low air surface pressure in the western Pacific.*

***Indian Ocean Dipole (IOD) also known as the Indian Niño is an irregular oscillation of sea-surface temperatures in which the equatorial western Indian Ocean becomes alternately warmer and then colder than the eastern part of the ocean.*

Studies to assess the influence of the IOD on the inter-annual variability of the AISMR for the period 1958-1997 suggests that IOD and the ENSO have complementarily affecting the AISMR. Whenever the ENSO-AISMR correlation is low (high), the IOD-ISMR correlation is high (low). The IOD plays an important role as a modulator of the Indian monsoon rainfall, and influences the correlation between the AISMR and ENSO. Despite the above, the average value of seasonal quantum of rainfall (847.5mm) did not change significantly.

Understanding impact of Indian Ocean warming on marine biodiversity needs long-term data sets covering variations in the biota of the region. Although satellite now provides over a decade of data on chlorophyll and primary productivity at high spatial and temporal resolution, the data period is still restrictive in addressing inter-annual or long-term changes as only two clear positive IODs have developed during the last 10 years. While the two events did not significantly impact surface chlorophyll in the southwestern Indian Ocean, the region did exhibit negative Net Primary Productivity (NPP) anomalies.

(e) The impact of climate change on ecosystem will vary with the processes that drive the system and the biological responses in the regional scale that are often complex to assess at the basin scale. However, IPCC-AR5 indicates that ocean warming results in surface stratification, leading to nutrient deficient regions in global oceans.

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