

Monsoons in Bygone Era

Vijay B. Tuljapurkar

Abstract

The seers of vedic age, seafarers and intrepid explorers, traders, civil servants, poets, historians, geographers and many others studied, interpreted and wrote about the rainy season in Indian sub-continent. Since the vedic age till today we are seeking answers to questions like - Has it been seasonal in the past as it is now? Has it been adequate all the time? Were there periods of aridity or heavy rains spanning over extended time? Have the strings of rain left any records of their frequency and quantum? When did the inhabitants of India realize its importance in their life? The present paper attempts to find answers to these and similar questions.

The earth has been blessed with showers from heaven for millions of years. The sun, the raging winds, the blue oceans, the mighty mountains and many other factors play an important role in perpetuating life on the planet. The elements, Prithvi, Aap, Tej, Vayu and Akash constantly interact with each other. As a part of this dynamic activity, the vast saline oceans provide fresh water for the plants and animals through the medium of rain. Many a countries in the world depend on rainwater to grow crops that feed their population and having an agro based economy India is no exception to that.

Since the rains are so very important to the sub-continent, a few interesting questions come to mind. Has it been seasonal in the past as it is now? Has it been adequate all the time? Were there periods of aridity or heavy rains spanning over extended time? Have the strings of rain, which raced from heaven to earth few thousand years ago, left

any records of their frequency and quantum? When did the inhabitants of India realize its importance in their life? What methods did they adopt to study this phenomenon? How did they document their observations and used this knowledge? What effect did the rains have on the geography of the land, lives of people and various cultures that thrived and perished in the sub-continent? Did the summer rains in India interest people from other lands as well? Why would the winds and rains in a distant part of globe be a subject of their study?

The answers to these and many such queries are not easy to get. The records of the annual rainfall and its fluctuations in last few millennia are preserved in nature at various locations. In addition, the seers of vedic age, seafarers and intrepid explorers, traders, civil servants, poets, historians, geographers and many others studied, interpreted and wrote about the rainy season in Indian sub-

continent. To understand the evolution of summer rains in India one has to begin at the beginning.

Development of Monsoon Mechanism

Millions of years ago there were two huge landmasses on earth. The one in the northern hemisphere has been named as Laurasia and the other, which was south of equator, is called Gondwana. A vast ocean, Sea of Tethys, separated the two. Around 140 million years ago the plate that is Indian sub-continent separated from Gondwana and commenced its northward drift through the immense expanse of water that we now identify as Indian Ocean. It crossed the equator and continued its northward journey at a speed of 18 to 19.5cms/year. In Cenozoic era, 60 to 65 million years ago India collided with Asian mainland, continued its northward thrust and both were joined around 55 million years ago. This cataclysmic event caused shrinking of Sea of Tethys and the mountain range of Himalayas was borne as gentle elevations along the meeting points. As the sub-continent pushed further, tectonic events of various magnitude occurred frequently and the Great Himalayan range or Himadri was created around 20 to 25 million years ago.

Born merely 60 million years ago Himalaya is indeed a very young mountain. However, it is because of the Nagadhiraj, the Indian sub-continent enjoys a unique cycle of three seasons, which are, the hot summer, the wet monsoon and the cold winter. The orogeny of Himalayas has been responsible in the development and stabilization of monsoon that has moulded her destiny. Though the greater Himalayas were formed about 20 million years ago, another 10 million years had to pass before its major

uplift as well as that of Tibetan plateau began and continued further. This progressive change in the geography probably modified the climate in India's favour.

It is difficult to prove what might have happened in such remote times; however, studies by An Zhisheng and others (2001) based on a numerical model throw some light on this subject. These studies suggest that around 8 to 9 million years ago the interior of Asia was arid but possibly this was also the time when the southwest monsoon rains started in Indian sub-continent. Five million years later, in East Asia, there was a period of heavy rainfall during summer as well as winter. At the end of this phase, that is 2.6 million years ago, the rains fluctuated and became scanty. From these experimental models it was inferred that the stages in the evolution of monsoon were linked to the phases of Himalayan-Tibetan plateau uplift.

As deduced from this experimental model and from other studies it was learnt that the rainfall in the sub-continent fluctuated in cycles of thousands of years causing major upheavals from time to time. It is known that the pattern and quantum of rain in any given period leaves its signature in some form or the other, be it in ocean beds or lofty mountains. These cryptic climatic writings can be deciphered with the help of technologies developed in the field of geology, paleontology, paleo-botany, archeology, chemistry and isotope studies. Over the years research in these disciplines of science provided information about the climate that was eons ago.

The streams, rivers and lakes depend on the rain or melt water of snow. It is obvious that heavy precipitation causes expansion of

their banks and low rainfall has the opposite effect. If the aridity spans over centuries, huge lakes become ponds and mighty rivers either reduce to rivulets or dry up totally. Observations on ancient shorelines of lakes in Africa and northwest India, coupled with radio carbon dating, provided valuable information of monsoon over last 20,000 years in Indian subcontinent This data was correlated with studies of sediments from lakes in Rajasthan desert and Arabian Sea to gain a better understanding.

Past Climates of Indian Sub-continent

It is known that the flora of any geographic zone depends on the environment of that area. As climate changes, so do the plants. Existing species vanish and new ones appear on the scene. The petals and calyces of the flowers decompose but the pollens may remain for centuries. This observation has provided important clues about paleo-climate in northwest India.

Rajasthan in the northwest part of the country was a green and fertile land few thousand years ago. Now it is a dry desert. Amidst this arid zone are found saline lakes such as Lunkaransar, Didwana, Sambhar etc. Core samples from the bottom of these lakes were taken and the age of the different layers was established. Singh, Joshi, *et al.*, studied pollens from these sediments and determined their type and age. His research showed that these lakes were fresh water bodies about 10,000 years ago. The pollens from these deposits indicated plant species that grow in or near fresh water. The desert shrubs were either absent or very few in numbers in this environment suggesting a wetter climate. This situation changed around 4000 years ago and an extended period of aridity dominated later centuries.

An interesting observation was that of the relationship of floods of River Nile in Egypt and the monsoon rainfall in India. The river has two tributaries, the White Nile and the Blue Nile. The former has its origin in south and flows northwards. The Blue Nile begins her journey in Ethiopia. The southwest monsoon that causes rains in the Indian sub-continent also drenches the land of Ethiopia. The floods of Nile are thus dependant on the rainfall that is derived from monsoons. Egyptians have kept the records of this flood since 2900 B.C. and from 621 A.D. to 1521 A.D. these have been meticulously maintained every year. Sir Gilbert Walker studied monsoon in India and the floods of River Nile. His research revealed a remarkable correlation between the two. The years when the floods were heavy, the Indian sub-continent received good rains and vice versa.

It was not only lakes, rivers, deserts and mountains which provided answers to few queries, but the oceans surrounding the Indian peninsula have also contributed to our knowledge about monsoon in past. Summer in northern hemisphere causes southwesterly winds to blow over Arabian Sea resulting in upwelling along the coasts of Somalia, Oman and southwest coast of India. This process brings the cold nutrient rich waters of the deep sea to surface, thereby enhancing the biological productivity in these zones. On the other hand, the reversing northeasterly winds suppress upwelling and reduce the yield. Specific varieties of planktonic flora and fauna thrive in the upwelling waters and are eventually deposited into the sediments on the sea floor when the organisms die. The study of core samples thus reveals the record of past upwelling and has a link to the intensity of monsoon in Indian subcontinent

Though there are several species that are found in the sediments of seabed, the planktonic foraminifera species commonly studied is *Globigerina bulloides*.

These and several other research works present a glimpse of past climate in Indian sub-continent. It has been observed that periods of heavy and scanty rainfall alternate in cycles of thousands of years. The period between 19 ka and 16 ka (ka=1000 years ago) was of strong monsoon. Thereafter, for next 4 thousand years i.e. up to 12 ka, the precipitation was consistently low. During this period the glaciation in northern hemisphere was maximum. The situation started changing after that and subsequent millenia witnessed a steady increase in summer rains. In early Holocene period, intense upwelling took place in Arabian Sea and with exceptions of brief intervals the span from 10 ka to 5 ka had very heavy rains. Rajasthan, in northwest India, received a rainfall of 45 cms about 5000 years ago and was green during this phase. The land was bedecked with diverse flora and huge fresh water lakes supported aquatic vegetation. At present the state receives meager showers and the average rainfall is 16 cms per annum

The later centuries covering 5 ka to 3 ka received scanty precipitation and the period around 3.5 ka experienced lowest amount of rainfall. The longstanding aridity caused major changes in the geography of Indian sub-continent and consequently the lives of people. As a result of poor rains and prolonged dry spells the green and fertile land of Rajasthan turned into a barren desert. Ancient civilizations such as that of Harappa and Mohenjodaro, which prospered on the banks of River Indus in northwest India, went into a steady decline

4000 years ago. Saraswati, described in scriptures as mother of all rivers, also suffered during this period. Originating in Shivalik hills, Saraswati attained a width of 8 to 10 kms at places. The river coursed through present day Punjab, Haryana, Rajasthan and Gujarat to meet Arabian Sea at Great Rann of Kutch. Around 3.5 ka the flow of Saraswati progressively dwindled and more than one factor is responsible for her eventual drying up. Earthquakes in the Shivaliks probably deprived her of the perennial source of glacial melt-water and later it was the prolonged dry climate with scanty rains, which might have served as a death knell for this mighty river.

Such major changes took place as the cycle of nature pulsed at its own rhythm. The land convulsed intermittently. The mountains altered their size and shapes. Fertile soil transformed to desert. Tectonic events and rainfall determined the birth of rivers, their flood pattern and course. Mankind inhabited the sub-continent and progressed through various stages of evolution. Civilizations flourished and declined due to one or other reason. As centuries rolled, in the history of India, a period arrived when people realized that the rainfall, their lifeline, was neither random nor erratic. In fact, it had a definite periodicity. This understanding is mirrored in the ancient Hindu scripture, the Rig-Ved.

Monsoon in Sanskrit Literature

The ancient religious scriptures are the product of literary creativity and genius of several rishis. Though many a hymns in Rig-ved are meant for sacrificial rituals, it also has a beautiful description of rains. The seers realized the importance of rain, hence implored. Parjanya with a request

to shower the earth with life saving water that will nourish the plants and make rivers flow. Living in an ashram, Rishi Vasishtha observed the seasonal changes around him. In Mandook-sookta, he writes “ The frogs, that remain mute for most of the year, become vociferous in rainy season. They, who stay dormant and blend with the dust in summer, become active during varshakal. This reference, ‘VARSHAKAL’, when the earth is soaked with showers from heaven is worth noting as it clearly identifies a specific period in the cycle of seasons when it rains. Rig-ved, generally believed to be 3500 years to 6000 years old, is probably the earliest literary creation of man and this reference is perhaps the first written documentation of monsoon rains in Indian sub-continent.

Measurement of Rainfall in Ancient Period

A few thousand years later, in 4th century B.C., the Maurya dynasty came into power. Chandrgupta (322- 298 B.C.) subjugated his enemies and ruled over a vast region of north and central India, extending the boundaries of his empire from Arabian Sea to Bay of Bengal. His mentor and guide Vishnugupta, also known by the names Kautilya or Chanakya, wrote a treatise titled Arthashastra. This literary work of astute statesmanship and practical wisdom deals with various aspects of governance and royal duties. Chanakya also had the foresight to study the pattern and record the quantum of rain in various locations in India with the help of a rain gauge. This equipment was a simple bowl to collect rainwater that enabled people to compare rainfall at different places. This data was used to help the government to assess the revenue potential and to plan relief work as and when needed. In this way

the knowledge about rainfall over a vast region of India assisted the Emperor to take steps for the betterment of people. Ashmak, which is probably Maharashtra or Deccan of present day, has a rainfall of 13 ½ Drona (about 21 inches), Avanti receives 23 Drona (about 36 inches) and rainfall in Konkan is so plentiful that it cannot be measured, writes Vishnugupta.

It is believed that in the 1st century A.D. and even before that, seafarers from distant lands such as Rome, Greece, Egypt, and Persia visited the shores of India. Their purpose was mainly commerce. Coins, pottery, jars and other artifacts from far off places were found near ports of Gharapuri and Nalasopra in Maharashtra. Similar findings from Bhadoch (Broach) and Lothal in Gujarat prove that these harbours were thriving trade centers centuries ago. These traders and seamen coming from far off lands knew about the southwestern winds blowing over Arabian Sea in summer. However, not many from these regions seem to have traveled in the Bay of Bengal. Indian and Malay people navigated this route often and a record of this is found in the travelogue of a Chinese, Fa Hsein.

Fa Hsein, a Buddhist, visited India at the turn of 4th century A.D. to learn about Buddhism. He visited various places and also made a journey by sea from the Gangetic delta to Sinhala Dweep (Sri Lanka of present day) along the east coast of India in winter. ‘The wind was favourable’ reports Fa Hsein which indicates that the seafarers on the east coast knew about the reversed direction of winds in winter and took advantage of that when they sailed in cold season.

Historians, geographers and cartographers were certainly interested in Indian

monsoon for varied reasons. The poets and writers looked at Varsha ritu but with different eyes. Mahakavi Kalidas, whose period is probably 6th century A.D., resided in Ujjayini. He was not only a nature lover but described it beautifully in his literary work. In Ritusamhar, he writes about the flora, fauna and happiness of people when the life saving showers from heaven soak the earth at the end of a scorching summer. His immortal words, Ashadasya pratham diwase, in Meghdoot refer to dark rain clouds hovering in sky on the first day of Ashadh which falls on 15th June.

Kalidas looked at “Varsha’ from a literary viewpoint. Varahamihira, who lived in Ujjayini in 6th century A.D.(505 to 587 A.D.) was of a different genre. Born in the family of sun worshippers, he observed the atmospheric phenomenon as a cause and effect relationship. Brihatsamhita, authored by him is a treasure trove of meteorological information documented 1500 years ago. The fact that the solar effect on the earth causes rain was well understood and conveyed by the words ‘Adityat Jayate Vrishti’. ‘A bountiful harvest is the product of adequate showers from heaven and since the lives of people and livestock depends on this, study of rain and rainy season is important’, writes Varahamihira. He describes a variety of cloud as “Dark as elephants, adorned with flashes of lightning that causes heavy rain”. In modern meteorology these are cumulonimbus clouds (CB). Varahamihira also took interest in forecasting of rains and had developed his own methods based on the observation of diverse atmospheric phenomenon.

Contribution of Arab World

Thus the knowledge about winds, clouds, rains, weather, eclipses etc was sought, interpreted and documented since vedic times. Till 6th century A.D. the records made by Indians, Greeks and Romans were available. 7th century A.D. saw the emergence of Islam in Arabia and its spread eastwards. Travels, over land as well as maritime route, were a necessity to propagate religion and develop commerce. For this reason Islamic centers of power and academics encouraged historians, geographers and intrepid explorers to study the climate in various zones of earth and this naturally included, among other places, observations of the winds, tides, rains and storms over Arabian sea, Arabia and India. A wealth of information was collected and documented in next few centuries and the credit for this goes to seafarers, traders, scholars and civil servants in Arabia.

Some of the historians did collect a great deal of information. Abu Zayd, a scholar who lived in Siraf around 916 A.D, gave a detailed description of summer rains in India (4). Siraf, being a seaport on the eastern coast of Persian Gulf, it was easy for him to interact with sailors, navigators and traders who undertook voyages to distant lands. In Hindi, barasat or barish means rain and Abu Zayd uses the word bashara. He also mentions that, the period of monsoon in India spans over three months or so and the downpour is more or less continuous, forcing people to remain mostly indoors. The rain, however, makes the land fertile and the farmers harvest plentiful crop of rice during the season. This is the way of life for the people on the west coast and it is possible that Abu Zayd describes this region.

Monsoon Forecast

As one decade chased the next, the social structure, concepts and thinking changed. However, some thoughts and beliefs remained even though the pattern of life altered drastically. To know the future is one of the oldest desires of mankind that persists even today and to satisfy this curiosity, astrologers, palmists, crystal gazers etc occupy a niche in every society. From the cauldron of fortunetellers in ancient India emerged a group of people who prophesied about the monsoon rains. They did not use the complicated calculations with reference to positions of planets and stars, but based their forecasts on careful observation of natural phenomenon, practical wisdom and intuitive power. This class of had a strong base in the society and even in present times the rural folk patronize them.

Almost a thousand years ago, a man named Sahdev developed and propagated a way of forecasting rains of the season. Bhadali, who is presumed to be his half-sister accompanied him. Both, Sahdev and Bhadali, who lived in Maharashtra, have mentioned about clouds, winds, rainbows, rains etc and this treasure of information composed in verse form is popular in villages, though a millennium has passed by. The period of Sahdev and Bhadali is not exactly known but it is thought to be in 12th century A.D.

Understanding of Monsoon in Medieval Period

Monsoon interested people from Europe as well. In earlier times Romans and Greeks visited India for trading purpose. After the decline of Roman Empire, this commerce dwindled and Arab merchants dominated the

oceans in later centuries. Nevertheless, other European nations knew about the riches of India and desired to develop business relationships. Spain and Portugal were the leaders in this race in 15th century A.D. The king of Portugal, Manuel I, was very keen in sending his ships to India. In January 1497 A.D. he appointed an experienced seaman, Vasco de Gama, to command this fleet. Vasco sailed from Lisbon on 8th July 1497 with four ships named Gabriel, S. Raphael and de Berio. The fourth vessel was a cargo.

The skipper, after facing the stormy seas for several days reached east coast of Africa in December 1497 and sailed further north to touch Malindi on 14th April 1498. It was here that he engaged an Arab navigator, Ibn Majid, who had the knowledge of maritime route and the summer winds over the Arabian Sea. With his help Vasco de Gama reached Calicut in Kerala on 27th of May 1498. He stayed in India for three months before commencing his return journey to Portugal. Both these timings suggest that Ibn Majid was aware of southwest monsoon winds in summer and their reversal in winter.

Rise of Instrumentation for Weather Studies

Until this time most of the observations related to weather were made without the use of instruments and therefore were subjective up to certain extent. In 17th century and early 18th century A.D. few basic apparatus were introduced which paved the path for precise observations of weather.

In 1644 A.D. Evangelista Torricelli, an Italian scientist invented barometer, which helped to study atmospheric pressure. Ferdinand II, in late 1650 A.D., designed

a rudimentary hygrometer that measured humidity. Few years later, in 1667 A.D., British physicist Robert Hooke made the first anemometer that indicated velocity of wind. Various types of thermometers using water, alcohol etc were tried in the 17th century A.D. However, the one made by Gabriel Fahrenheit in early 18th century A.D. using mercury was the most practical instrument to record the temperature. Inventions of these instruments had an entirely different dimension and the time was now ripe to undertake scientific studies to explain atmospheric phenomenon.

Edmund Halley, a British scientist, presented a paper in 1686 A.D. in which he showed the patterns of winds over a large area of ocean. He tried to trace the relationship between the heating of seawater near the equator due to intense solar insolation and its effects on winds in tropics. Based on his observations and studies, he put forth the view that large masses of air move towards and away from the equator to equalize the air pressure gradients and this causes major wind patterns in the world. He postulated the concept of differential heating of land and sea, which in fact, is the basis of monsoon in Indian subcontinent.

In 1735 A.D. another milestone was reached with the understanding of wind movements on large scale. Halley's view of the differential heating of land and sea explained some of the observations pertaining to weather. However, it still did not provide answer to the question as to why the air masses did not travel directly to equator. George Hadley (1685- 1758 A.D.), who was a fellow of the Royal Society, provided the explanation. Hadley proposed that due to the west to east rotation of earth the winds in northern hemisphere approached equator

from northeasterly direction and those in the southern hemisphere take a southeasterly course. This deflection is termed as Coriolis force and has a relationship to the monsoon winds blowing over Arabian Sea.

Research in meteorology progressed further. Prof. Ludwig Kamtz (1801-1867 A.D.), from Germany studied Halley and Hadley's published work and added his own observations to make a statement about monsoon. He opined that the differential heating of land and sea on one hand and the deflection of winds due to rotation of earth on the other, were the two important causes that resulted in monsoon over Indian subcontinent.

Further studies revealed that monsoon has multiple facets and a systematic approach was needed to learn more about it. In 1875 A.D. a major step was taken in this direction and India Meteorological Department was established and Henry Blandford took office as the first Director of this organization.

In last 130 years research in the field of meteorological sciences progressed in leaps and bounds. Collection of atmospheric data by telegraphic mode replaced dak, that is postal communication. Balloons loaded with scientific instruments provided valuable information of upper atmosphere. Geo-stationary satellites monitored weather round the clock and computerized models developed by Indian scientists have assisted in long range forecasting of monsoons.

From a humble prayer to Parjanya in the vedic period we have come a long way in our understanding of monsoons and the quest for scientific knowledge goes on. However, emotionally speaking, the sight of dark gray clouds rolling in from southwest at the end of tormenting Greeshma fills our hearts with

joy. Varsha brings precious rain water that soaks the sun-baked land and gives relief to shriveled flora, parched throats and thirsty earth. No wonder, we have a special bond of love and affection with monsoon – The LIFE LINE OF INDIA

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Vijay B. Tuljapurkar
Shalmalee. Shivaji Nagar
MIRAJ 416 410