

# Consequences of sea level rise due to Greenhouse effect for coastal Archaeological monuments

RAJIV NIGAM, PATHAK M.C. and N.H. HASHIMI

It is evident that the fluctuating sea level and related climatic phenomenon were responsible for extinction of many ancient port - cities and places of cultural heritage. Lothal, Kaveripatnam and Dwarka are the glaring examples of destruction due to sea level rise in the past and thus became the well known objects of modern marine archaeology.

It is well known that sea level is on the rise for the last 11,000 years (Holocene sea level changes) and there are evidences to believe that there will be an accelerated rise in sea level in near future due to greenhouse effect. The increased concentration of greenhouse gases in the atmosphere will be responsible for thermal expansion of sea water and the melting of ice from high latitudes. Consequently the sea level will rise. It has been inferred that the sea level rise will vary between 23.8 cm to 116.7 cm by the year 2050 and 56.2 cm to 345.9 cm by the year 2100. Such a rapid rise in sea level will cause inundation of many modern ports and cities and also monuments of cultural importance and thus become a subject of study for future marine archaeologists. The seriousness of the problem may be explained with a case study, for example, the famous shore temple at Mahabalipuram in Tamilnadu which was built far from the coast. In course of time sea has gone up and now shoreline is touching the base of the temple. This has caused severe problem of erosion. In the past To check further damage to the temple due to erosion a protection wall was constructed (1944-45). Now it will again face a fresh danger due to future sea level rise. The gradient of land in this region is 1:500. Therefore, the anticipated rise of 1 or 2m may cause the shore line retreat by 0.5 to 1.0 km. This may put the temple right into the sea and thus get subjected to damage from all the four sides. This all may happen in the next few decades. Therefore, a precautionary measure has to be planned immediately and implemented.

This is only one example, there may be many more cases of this type all along the west and east coasts of India. Geologists are already on the job to identify the 'danger zone' along the Indian coasts which is going to face consequences of sea level rise due to greenhouse effect. The need of the hour is that archaeologists should come forward to join the geologists to catalogue the monuments of archaeological importance falling in the 'danger zone' and plan the strategy in advance before the disaster occurs.

## INTRODUCTION

Marine Archaeology is the study of human interaction with the ocean environment. Unfortunately for archaeologists, 18,000 years ago world sea level was much lower and the coast line was located many kilometres out towards sea from its present locations. The continental shelf was a part of the terrestrial environment. Thus most of the evidences of the origin and early development of marine culture is submerged (Flemming, 1985). It is evident that the fluctuating sea level rise and related climatic phenomena were responsible for drowning of many ancient port-cities and places of cultural heritage. Lothal (Nigam, 1988), Kaveripatnam (Rao, 1990) and Dwarka (Rao, 1988) are the glaring examples of destruction due to sea level rise in the past and thus became the well known subjects of modern marine archaeology. References to consequences of sea level fluctuation are available in religious, archaeological and oceanographic records (Nigam, Hashimi and Pathak, 1990). Figure 1 shows the generalized curve for the sea level rise which indicates that about 11,000 years B.P. sea level was 60-90 m below the present one (Nair, 1974; Nair and Hashimi, 1980) along the west coast of India. If we assume the same trends (i.e. rise in sea level) will continue in future also, anticipated sea level will submerge the low lying areas of present coast along with valuable monuments of archaeological importance. But con-

sidering the natural trend by this rate, 1 m rise will take about 1000 years.

However, these estimates for natural trend are under threats due to man's indiscriminate interference with the environment. As Goddy (1982) said "This is a unique time, when one species, humanity, has developed the ability to alter its environment on the largest (i.e. global) scale and to do so within the life time of a single species number". In view of this, whatever natural changes are likely to happen in the next 1000 years may happen now in only 100 years. For example, Scientists predicted that sea level may rise upto 1 metre by 2050 (Hoffmann et al., 1983). The phenomena responsible for this alarming situation is known as "Greenhouse Effect". The objective of this paper is to bring the facts about likely climatic changes to the notice of the archaeologists and indicate the consequences of such changes in the field of archaeology.

## WHAT IS GREENHOUSE EFFECT

Over the last couple of years, the Greenhouse Effect has become one of the world's hottest topics.

Since the mid of nineteenth century there have been warnings about how increased level of Greenhouse gases [Carbon dioxide (CO<sub>2</sub>), Methane (CH<sub>4</sub>), Nitrous Oxide (N<sub>2</sub>O) and

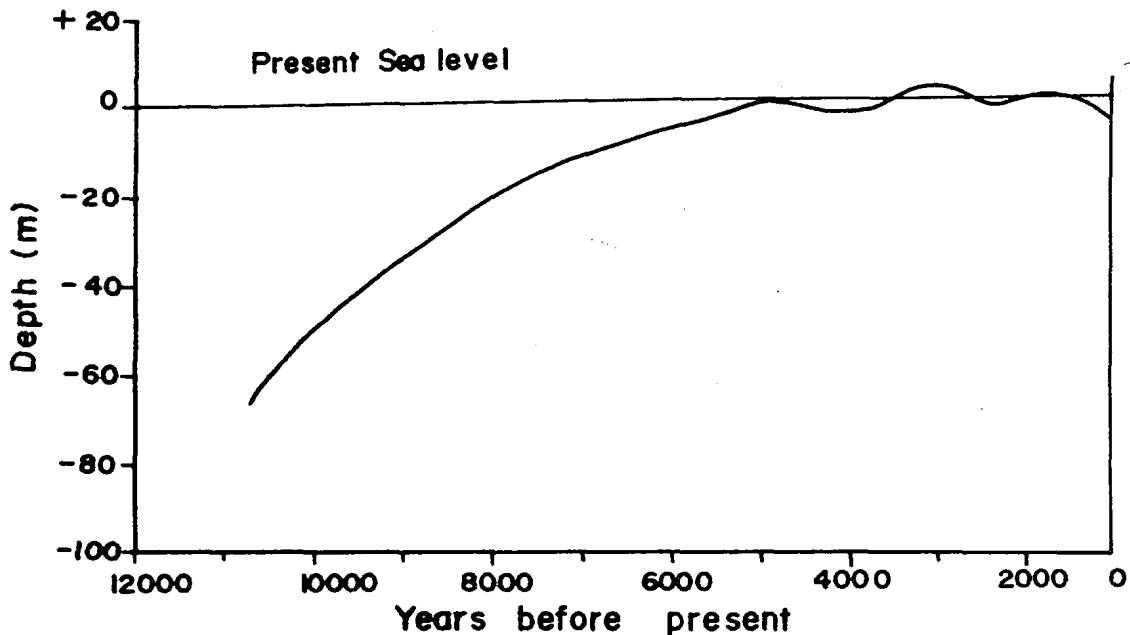


Fig. 1 Generalized sea-level curve for Indian region.

Chlorofluorocarbons (CFC) in the atmosphere can effect our climate. These gases in the atmosphere act in a similar way, as the glass walls and roof of a greenhouse, in trapping heat from the sun that would otherwise be radiated back into the space. Any departure from equilibrium of these gases in atmosphere (natural or man made) creates problem. Too little greenhouse gases in atmosphere and we freeze, and too much we get overheated.

In the last 100 years the earth has warmed up by more than half a degree centigrade (Jones et al., 1986). This warming (0.4–1.1°C) is compatible with what might be expected to have resulted from the increase in atmospheric concentrations of carbon dioxide and other greenhouse gases. Some 65-90% of the increase of carbon emissions in the atmosphere today is believed to come from the burning of "fossil fuels" (coal, oil, gas) (Bolin et al., 1986; Warrick et al., 1988).

The net result of warming is thermal expansion of sea water and melting of ice on polar regions. As a consequence of these, sea level is also rising (Report by Common Wealth Group of Experts, 1989). The best estimates is that the global mean sea level has risen by 10-15 cm over the past century. There are reasons to believe that these trends will continue in future also. There are a range of estimates of future warming and related would be sea level rise based on different modelling assumption. Figures 2 and 3 give the most recent projections drawn for 2030 AD. Another set of estimates was given by Hoffman et al. (1983) for a period upto 2100 AD by which as per high scenario, sea level may go upto 3.45 metres.

While there is a reasonable agreement about global average increase, there is much less agreement about what these could mean for the climate of particular regions, let alone individual countries. Here in this paper we are concerned about the consequence of accelerated sea level rise for India in general and for archaeologist in particular.

#### CONSEQUENCES FOR INDIA

Nigam (1989) indicated the possible implications of sea level rise for coastal zone management for Indian region. Such implications include inundation of low lying coastal areas and some islands, migration of human population, loss of agricultural and forest land, destruction of industries, buildings in coastal areas and tourism, problem of drinking water due to salt water intrusions, change in precipitation pattern etc. Shetye et al. (1989) presented a general scenario which shows that east coast of India is more vulnerable as compared to the west coast (Figure 4). One thing is certain that whatever be the scenario, rapid rise in sea level will cause inundation of many modern ports and cities and also monuments of cultural importance and thus become a subject of study for future marine archaeologists. To show the seriousness of the problem two case studies are given below, one each from east and west coasts of India.

#### EAST COAST OF INDIA

The immediate victim of accelerated sea level rise on the east coast will be the famous shore temple of Rajasimha's

time at Mahabalipuram (Pl. 37) in Tamilnadu. In Tamilnadu region, it is already inferred by Rao (1990) that after 11-12th century A.D. there has been gradual transgression of sea. Now sea is just touching the base of temple. This has caused severe problems of erosion. In the past (1944-45) to check further damage to the temple due to erosion a protection wall was constructed (Shivaramamurti, 1978). Now it will again face a fresh danger due to future sea level rise. The gradient of land in this region is 1 : 500. Therefore, even 1 metre rise will put the temple right into the sea as its horizontal extent on the land will be about 0.5 km. Thus the temple will be subjected to damage from all sides. All This may happen in the next few decades only. The problem may

be compounded to increase intensity and frequency of storm surges, which is also one of the consequences of greenhouse effect. The damaging power of storm surge can be visualized from the recent cyclone along the Madras coast when the famous Kasi Viswanathar temple at Ennore was destroyed by storm surge on 7-10th May, 1990 (Pl. 38).

**WEST COAST OF INDIA**

The six episodes of transgression and regression (Negi and Tewari, 1988) of sea in just last 3500 years destroyed the legendry city of Dwarka (Rao, 1988) 6 times. Decline of Lothal (Nigam, 1988) and Sopara (Dhavalikar, 1988) ports

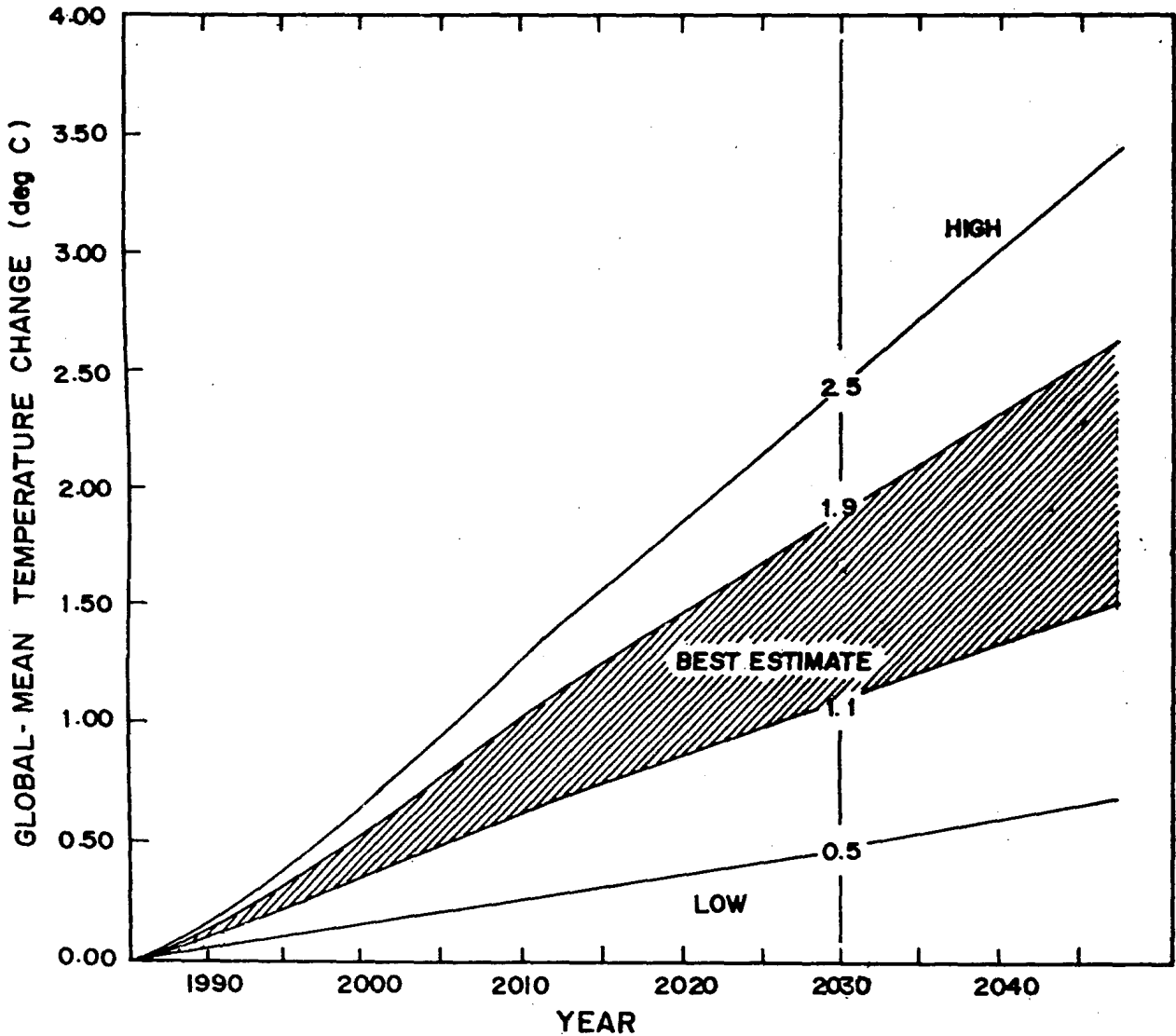


Fig. 2 Projected temperature rise, 1985-2050 (After T. Wingley 1989 in Commonwealth Secretariat Report Climate Change: Meeting the Challenge, 1989).

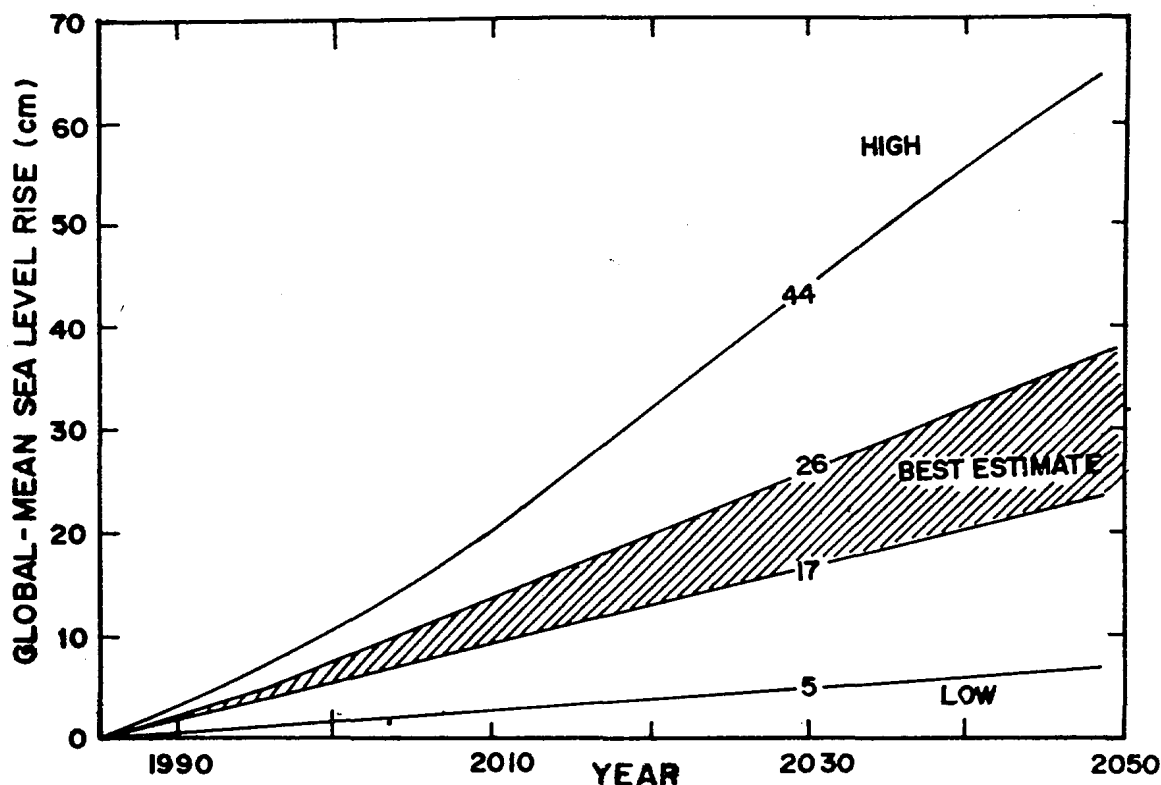


Fig. 3 Projected sea-level rise, 1985-2050.

were also attributed to fluctuations of sea levels. Now similar type of event will take place on shorter time span (few decades) and many establishments will be adversely affected. One such good example is the Samudra Narayana temple (Pl. 39) at Dwarka. The sea is touching the base of this temple and any further rise in level will be too costly to the survival of temple.

#### PLAN OF ACTION

We have discussed above, only two examples (one each from east and west) as case studies. There are many more cases of this type all along the west and east coasts of India. Since the visualised eventualities may happen in very short time, a precautionary measure has to be planned immediately and implemented.

Under the sponsored project of Ministry of Environment and Forests, Scientists are already on the job to identify the 'Vulnerable Zone' along the Indian coasts which is going to face consequences of sea level rise due to greenhouse effect. The need of the hour is that archaeologists should also catalogue the monuments of archaeological importance falling in the "Vulnerable Zone" and plan the strategy in advance before the disaster occurs.

#### ACKNOWLEDGEMENT

We are thankful to Dr. B.N. Desai for his encouragement

and permission to publish this paper, we are also indebted to Sri. R.R. Nair for critical reading of the manuscript. We also acknowledge the financial help received from Department of Environment (Grant No. 21/6/89-RE). Miss Geeta Menon deserves thanks for typing the manuscript. Last but not the least we are grateful to Dr. S.R. Rao for giving an opportunity to present this work at IInd International Conference of Marine Archaeology of Indian Ocean Countries at Bangalore.

#### References

- Bolin, B., Doos B., Jager, J. and Warrick, R. 1986. *The Green House Effect, climate change and ecosystem*. SCOPE. 29:Chichster: John Wiley.
- Common Wealth Group of Experts Report*, 1989. Climate change: Meeting the challenge. Commonwealth Secretariat, London. 116 pp.
- Dhavalikar, M.K. 1988. The decline of Sopara In. *Marine Archaeology of Indian Ocean Countries* (Ed. S.R. Rao) pp. 104-107.
- Flemming, N.C. 1985. Ice ages and human occupation of the continental shelf. *Oceanus*. Vol. 28, No. 1 pp. 18-20.
- Goddy, R.M. 1982. *In JPL Report D-95* Pasadena CA, USA.
- Hoffman, J., Keyes, D. and Titus, J. 1983. *Projecting future sea level rise methodology estimates to the year 2100 and research needs*. 2nd edition U.S. GPO No. 055-000-0236-3 Washington, D.C., Govt. Printing Office.
- Jones, P.D., Wingley, T.M.L. and Wright, P.B. 1986. *Global*

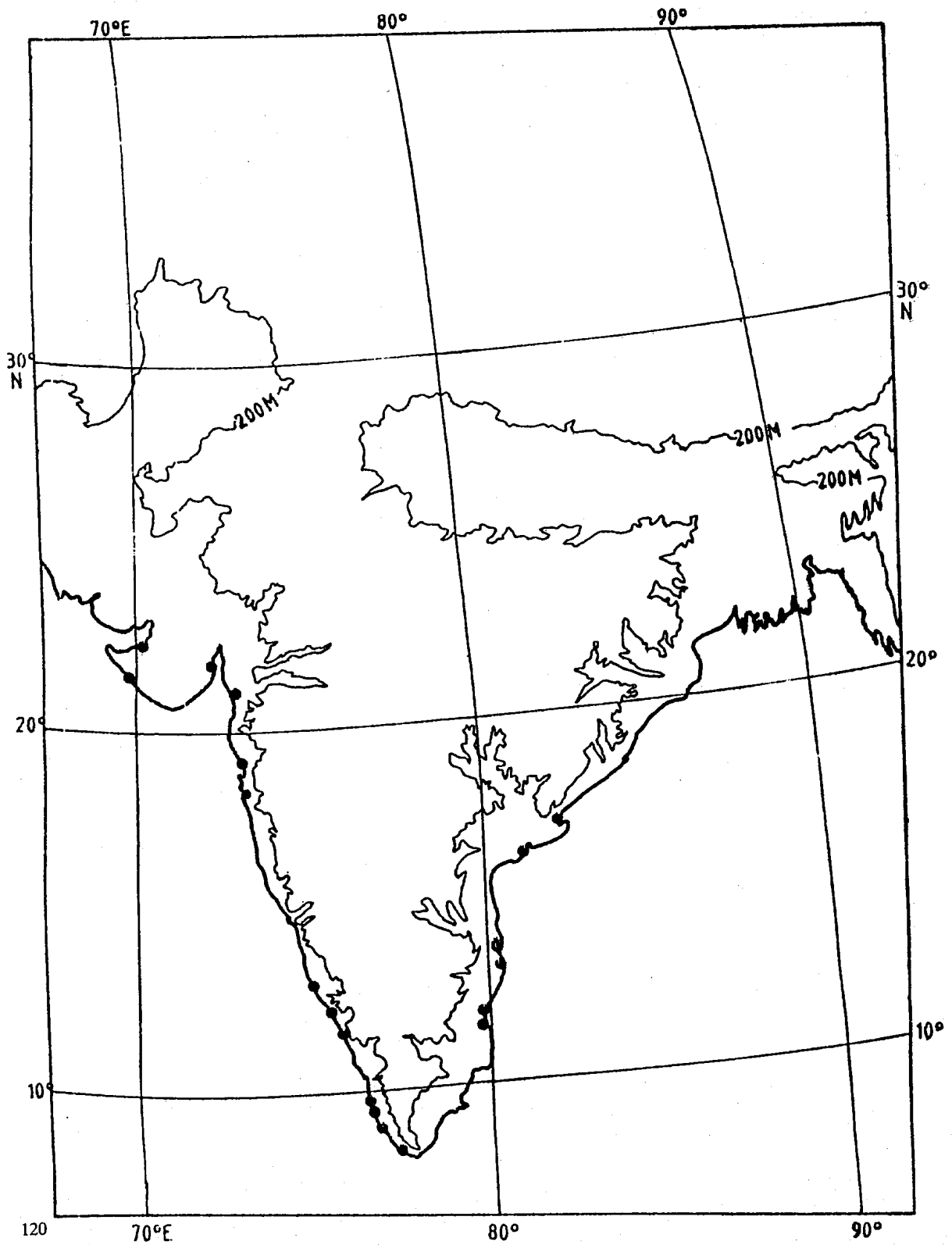


Fig. 4 Showing idea about slope of Indian coastal areas.

## CONSEQUENCES OF SEA LEVEL RISE FOR COASTAL ARCHAEOLOGICAL MONUMENTS

- temperature variations between 1861 and 1984. *Nature*, Vol. 322, pp. 430-434.
- Nair, R.R. 1974. Holocene sea-levels on western continental shelf of India. *Proc. Indian Acad. Sci.* Vol. 79 No. 5, pp. 197-203.
- Nair, R.R. and Hashimi, N.H. 1980. Holocene climatic inferences from the sediments of the western Indian continental shelf. *Proc. Indian Acad. Sci. (Earth and Planet. Sci.)*, Vol. 89, pp. 299-315.
- Negi, J.G. and Tiwari, R.K., 1988. Climate and sea level variation cycles during last 8000 years and their relationships with Global human history. *In Marine Archaeology of Indian Ocean countries* (Ed. S.R. Rao) pp. 79-82.
- Nigam, R. 1988. Was the large rectangular structure at Lothal (Harappan settlement) a 'Dockyard' or an 'Irrigation tank?' *In Marine Archaeology of Indian Ocean countries* (Ed. S.R. Rao) pp. 20-22.
- Nigam, R. 1989. *Sea level rise and expected impact on coastal zone.* In *coastal zone management in India* (Eds. Dewidi, S.N. Bhatt, V.S. and Chaturvedi, P.), Indian Association for Advan. Sci. pp. 145-147.
- Nigam, R., Hashimi, N.H. and Pathak, M.C. 1990. Sea Level fluctuations: Inferences from religious and archaeological records and their oceanographic evidences. *J. Mar. Archaeol.* Vol. 1 pp. 16-19.
- Rao, S.R. 1988. Excavation of submerged ports – Dwarka a case study. *In Marine Archaeology of Indian Ocean Countries.* (Ed. S.R. Rao) pp. 47-53.
- Rao, S.R. 1990. Keynote address. *J. Mar. Arch.* Vol. 1 pp. 6-11.
- Shetye, S.R., Gouveia, A.D. and Pathak, M.C. 1990. Vulnerability of the Indian Coastal region to the sea level rise due to green house effect. *Current Science.* 152-156.
- Shivaramamurti, C. 1978. *Mahabalipuram.* Archaeological Survey of India. 35 pp.
- Warrick, R.A., Jones, P.D. and Russell, J.E. 1988. *The Greenhouse effect and climatic change and sea level : An overview report of the commonwealth Secretariat.*