Relative Sea Level Rise Scenarios

Cauvery delta zone, Tamil Nadu, India

Rev.3

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Executive Summary

This report documents the data, methodology, and the outcome of the analyses undertaken for developing sea level scenarios based on different climate change (CC) scenarios and provides a set of scenarios for sea level for the Cauvery delta of Tamil Nadu, India. The document consist of four main sections : i) Determining the current trends in local relative sea level rise (Baseline); ii) Developing the scenarios for local relative sea level rise by the year 2100; iii) Determination of storm surge statistics; and iv) recommendations on using the presented relative sea level rise projections within the CASDP.

Sea level projections for the Cauvery Delta Zone (CDZ)

The current trend of relative sea level rise (RSLR) was determined by analyzing available tide gauge data in the study area. Tide gauge data for Cochin, Chennai and Vishakapatnam obtained from the PSMSL were used in this study. The RSLR rates estimated by the National Oceanic and Atmospheric Administration of USA (NOAA) for the same locations were also considered. Based on this analysis the most appropriate rate of local relative sea level rise for the Cauvery delta was considered to be the same as the closest PSMSL station, CHENNAI: 0.29 ± 0.56 mm/year (Figure E1). The extrapolation of this rate of RSLR provides one RSLR scenario for the future.

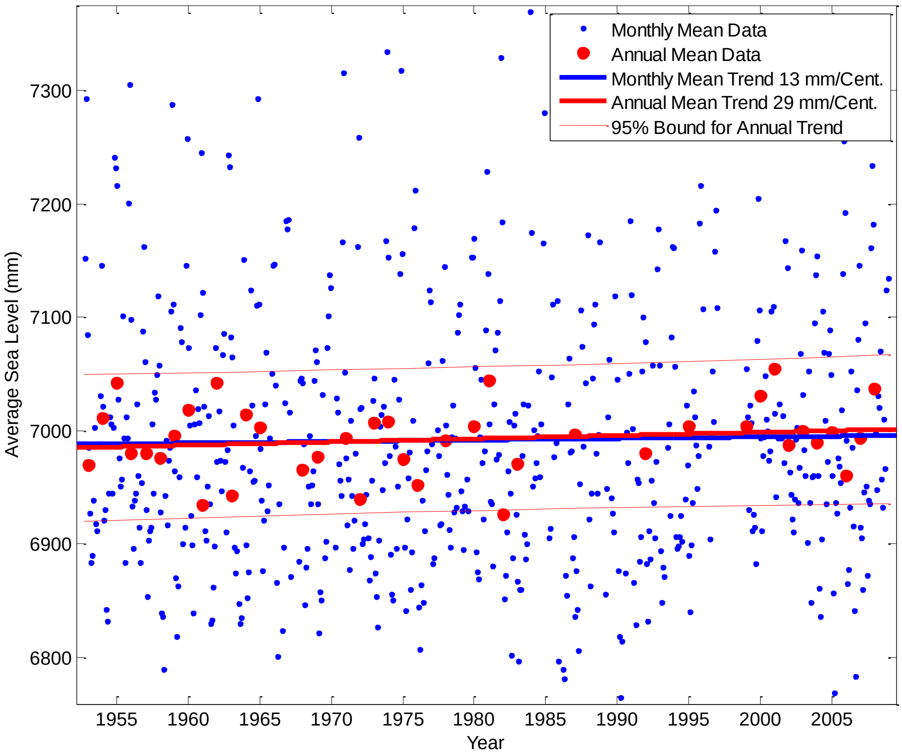

Figure E1. Monthly and annual mean seal level and corresponding trends at CHENNAI

Next, the guidelines provided by NICHOLLS et al. (2011) were used to derive RSLR scenarios linked to six (6) IPCC SRES scenarios (B1, B2, A1B, A1T, A2 and A1FL). The 'intermediate' assessment methodology suggested by NICHOLLS et al. (2011) was adopted herein. In this approach, RSLR projections for a specific location take into account the different contributions from the components at the global, regional and local scales, as relevant to the study area. These components are then integrated using following equation:

$$\Delta \mathrm{RSL} = \Delta \mathrm{SL}_{\mathrm{G}} + \Delta \mathrm{SL}_{\mathrm{RM}} + \Delta \mathrm{SL}_{\mathrm{RG}} + \Delta \mathrm{SL}_{\mathrm{VLM}}$$

Where :

- ΔRSL is the change in relative sea level
- ΔSL_G is the change in global mean sea level
- ΔSL_{RM} is the regional variation in sea level from the global mean due to meteo-oceanographic factors
- ΔSL_{RG} is the regional variation in sea level due to changes in the earth's gravitational field
- ΔSL_{VLM} is the change in sea level due to vertical land movement

Note that in these calculations 0.2m was added to the upper range values of the IPCC global average SLR values to account for the uncertainty in climate-carbon cycle feedback and ice sheet flow, as suggested by IPCC (2007). The ranges of RSLR thus calculated for the six SRES scenarios are shown in Figure E2.

The same information plus the scenario developed based on the rate of RSLR from observed data are tabulated in Table E1 for 4 different points in time. The highest and lowest values of RSLR by 2100 relative to 1990 projected for the study area are 0.87m and -0.03m respectively.

Table E1. The ranges of RSLR (m) at CDZ calculated for the six SRES scenarios at different times

CC Scenarios								
		B1	**B2**	**A1B**	**A1T**	**A2**	**A1FI**	**Extrapolated historical data**
2025	lower	0.07	0.06	0.07	0.08	0.07	0.08	-0.01
	upper	0.19	0.18	0.20	0.21	0.16	0.17	0.03
2050	lower	0.13	0.10	0.12	0.15	0.13	0.14	-0.02
	upper	0.33	0.33	0.36	0.37	0.32	0.35	0.05
2075	lower	0.18	0.15	0.17	0.21	0.18	0.21	-0.02
	upper	0.48	0.50	0.54	0.53	0.53	0.58	0.07
2100	lower	0.24	0.18	0.21	0.27	0.24	0.29	-0.03
	upper	0.63	0.69	0.74	0.70	0.78	0.87	0.09

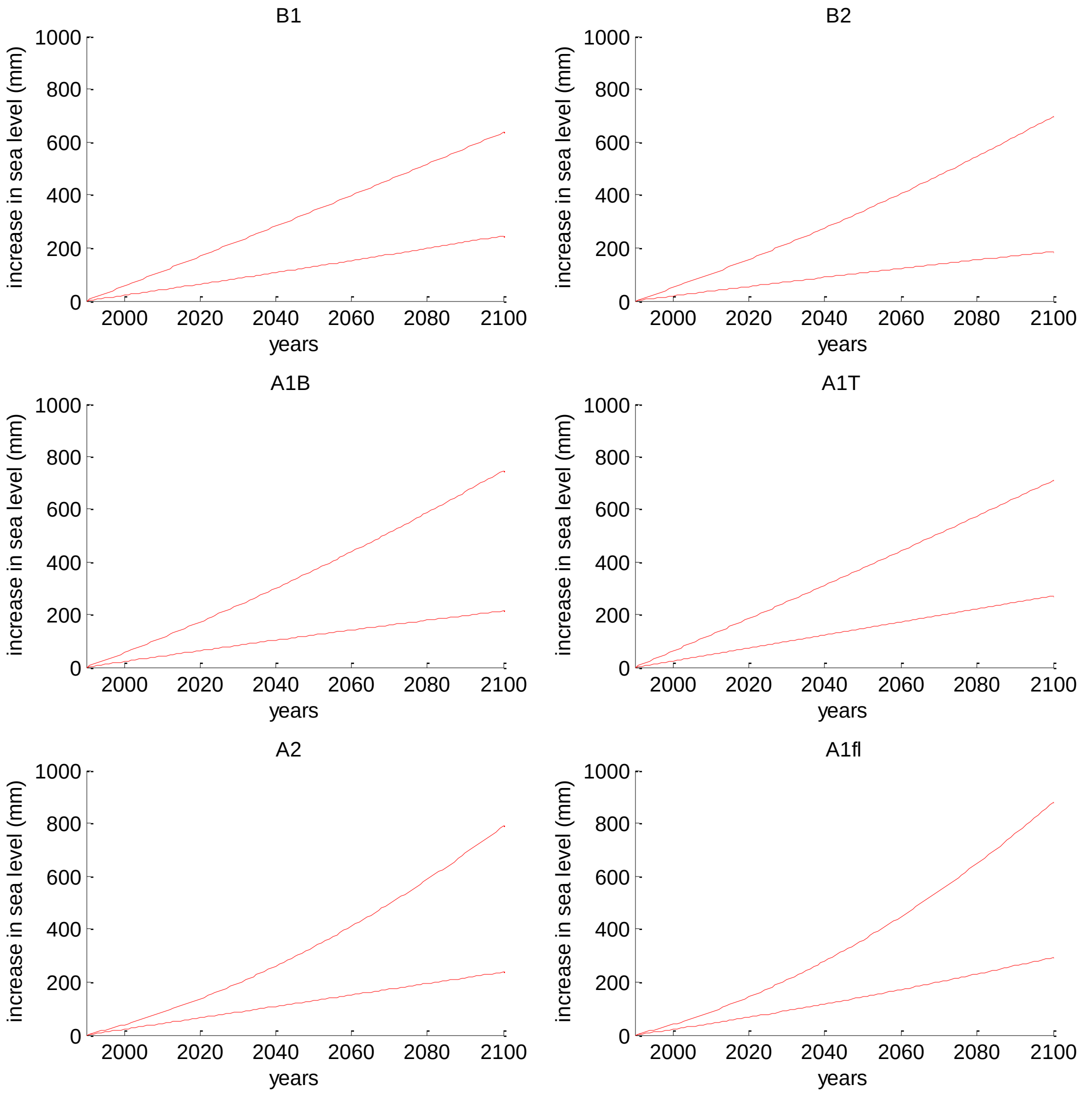

Figure E2. The ranges of RSLR at CDZ calculated for the six SRES scenarios.

Recommendations

The CASDP intends to implement improved drainage facilities, flood control measures and land use strategies (among others) to mitigate the potential impacts of climate change in the Cauvery Delta Zone (CDZ). In designing these interventions, the precautionary principle would advocate the use of the highest projected sea level rise value (including the 1:100 yr storm surge) of 1.61m obtained in all designs/strategies. However, this may, on occasion come at a significant and unwarranted cost and thus be not the most cost-effective approach. Therefore, the following simple approach is recommended to ensure a balance between safety and cost effectiveness.

Before deciding on a higher or lower RSLR scenario to work with, stakeholders need to make a decision to take on board climate change projections at all. Therefore, the cost of not incorporating any climate change projections needs to be estimated, in most cases, to inform this decision. Assuming that this leads to a decision to indeed consider RSLR, at the design stage of all interventions, two separate designs for the highest and mid-level projected sea level scenarios (RSLR plus storm surge) relevant for the planning horizon of the interventions may be developed. For example, if the design lifetime of a planned flood protection measure is until 2100, then develop two separate designs to accommodate RSLR values of 0.87m and 0.29m, plus at least the 1 in 100 yr storm surge estimate (0.74 m) (i.e. sea level scenarios of 1.61m and 1.03m by 2100). In this example both the highest and mid-level RSLR values are associated with the A1Fl projections, but this need not always be the case. Then evaluate the costs associated with both design options as well as the costs of damage if either design were to fail by overtopping. The way in which damage costs are estimated differ widely from country to country and local governance unit to local governance unit, but would ideally account for not only property (or economic) damage but also environmental, and societal damage and loss of life, or any combination thereof. Say, for example:

Cost of highest sea level design = C1

Cost of mid-level sea level design = C2

Cost of damage due to failure of highest sea level design = D1

Cost of damage due to failure of mid-level sea level design = D2

Then (D1-D2) is the value of additional protection gained by investing (C1-C2). If (D1-D2) is significantly greater than (C1-C2) then the decision should be to adopt the higher sea level design. However, if this is not the case the lower sea level design maybe taken under consideration. Nevertheless, the choice to adopt the less safe option is not only a matter for managers and planners but one for multi-stakeholder (including politicians and special interest groups) deliberation.

Flood risk maybe more elegantly optimized by balancing the cost of the intervention versus the potential damage using advanced probabilistic calculations such as those used in flood management spheres. In the presence of efficient risk-sharing arrangements, investments in risk mitigation can be evaluated through net present value computations with the cost of risk mitigation on the one hand, and *expected loss* (or: the actuarially fair insurance premium) on the other. This approach has been used in the Netherlands since the 1950s to inform decisions about flood protection (Figure E3).

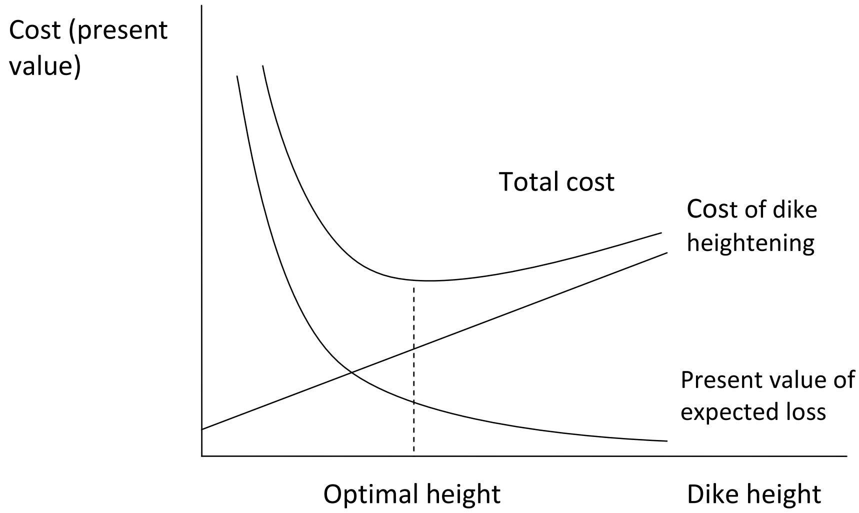

Figure E3. The optimization of flood protection: total cost equals the cost of dike heightening plus the present value of expected loss (assuming stationary conditions: no sea level rise, economic growth or degradation).

However, such an approach requires estimates of the exceedance probability of RSLR (which the IPCC do not provide at present) and detailed spatial information on the damage function. While a Gaussian distribution maybe assumed for the probability of occurrence for values lying between the lower and higher RSLR projections per SRES scenario, the availability of sufficiently detailed spatial data is often the stumbling block when attempting this type of risk optimization approach. However, if such data can be provided for the CDZ, it is possible to optimize flood risk due to future RSLR (as part of a separate project).

A further point to note is coastal recession due to RSLR. When the mean sea level rises the coastline position will move landward due to erosion. A rule of thumb for such RSLR driven recession dictates a recession of between 50-100 times the RSLR over a 100yr period. Thus, it is also crucial that any interventions take this recession effect also into account. For example, major new developments or infrastructure should not be placed within this recession zone. However, the same principle discussed above for flooding also applies for coastal recession: while the potential damage due to coastal recession can be large, so can be the forgone land use/commercial opportunities in the coastal zone. In recent years numerical modeling methods have been developed to assess the coastal erosion risk and determine optimal coastal setback lines (a setback line is defined as the position seaward of which developments should be restricted or prohibited). An example application of these models to a site in Australia is shown below in Figure E4 .

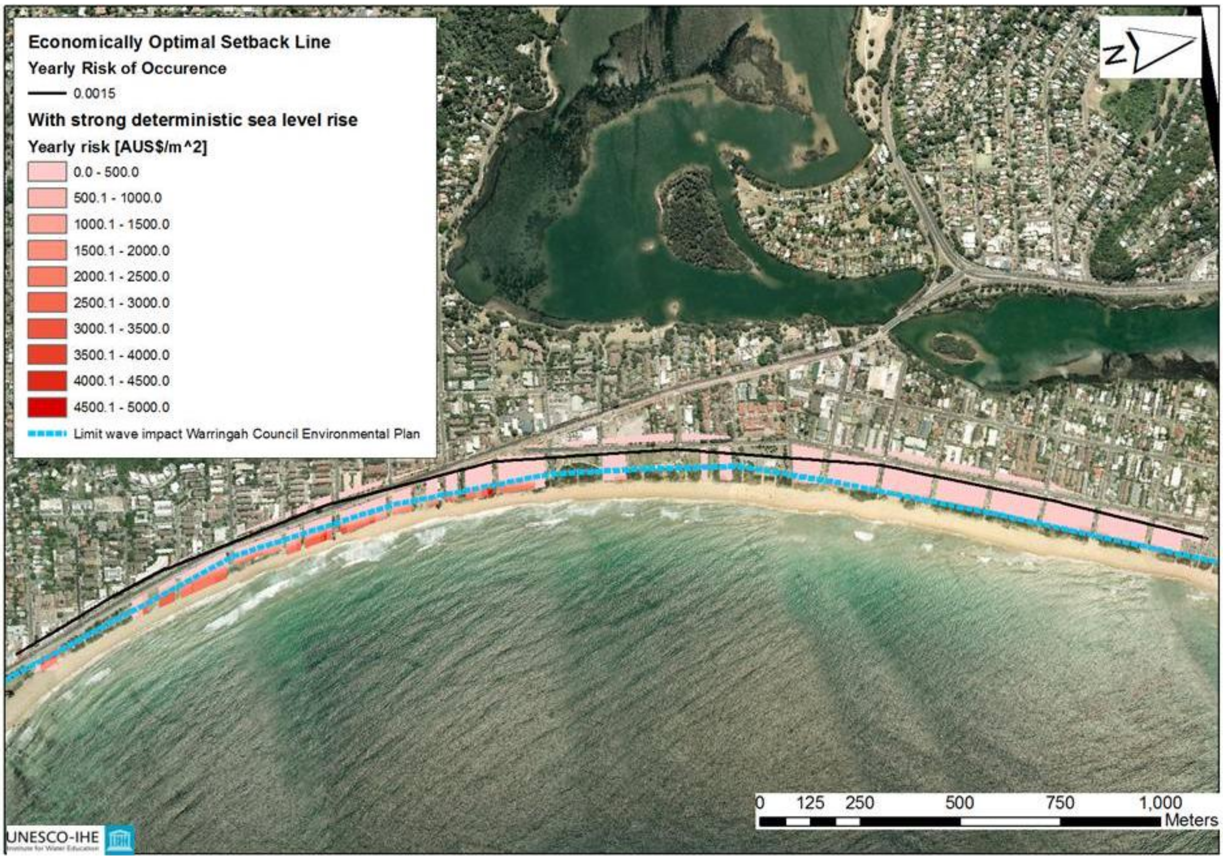

Figure E4. Coastal erosion risk due to sea level rise by 2100 at Narrabeen beach, Sydney, Australia. The economically optimal setback line is shown in black while presently adopted setback line is shown in blue.

If sufficiently detailed spatial data can be provided, it is possible (as part of a separate project) to produce similar output for the CDZ which would be of critical value for determining the appropriate placement of CASDP intervention measures and/or developing land use policies for the future.