Economics of Flood Damage Prevention Investment in Colombo Metro Area: Strategic Perspectives Explored through a Viability Threshold Analysis

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Introduction

Colombo is situated in a flood plain, and therefore faces frequent floods. Being the most populated and most built-up city in Sri Lanka, such incidences of flooding in the Colombo Metro area are associated with significant socio-economic costs.[2] This is why many flood prevention measures were implemented in the past, including the erection of bunds along the river. Recently, a comprehensive flood prevention project was proposed in 2002 with the support of Japan International Cooperation Agency (JICA), and another project was implemented with Word Bank assistance in 2012.

Flood levels, expressed in their "return periods" are indicative of their degree of severity. Floods with a two-year return period, for instance, mean that this type of flood occurs almost every other year, and thus are much less severe than, say, a flood with a 100 year return period, which is rare and generally occurs once in a century. Needless to say therefore not all flood damage can be prevented through flood control investment; any such designing of flood control measures for rare but severe occurrences are bound to be extremely costly, and thus unviable.

This paper summarises the findings of a recently conducted research to appraise flood prevention economics for the Colombo Metro Area (CMA),[3] with a view to ascertain viable levels of investment, and to propose strategies for the consideration by the Government.

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[2] Population density in the area is 16 times that of the national average. Almost 50% of the country's GDP is estimated to be generated within the Western Province, of which a large majority comes from Colombo.

[3] For the purposes of this study, the CMA is defined as the Colombo, Thimbirigasyaya, Kotte, Kolonnawa Divisional Secretariat Divisions, and the Dehiwala-Mount Lavinia Municipal Council area.

Materials and Methods

Flood control benefits correspond to avoided costs of flood damage. Such benefits in Colombo, a highly urbanised and commercialised setting, would stem largely from the prevention of damage to residential and commercial properties, urban infrastructure and economic livelihoods.

The research used the probabilistic distribution of flood damage cost estimates, initially prepared by the JICA study sources (Nippon-Koei, 2002) and updated for 2011 by the Metro Colombo Urban Development Project study team (World-Bank, 2012), as basic data required for the analysis. Expected flood damage was estimated by working out the area under the flood damage cost curve expressed as a function of flood retention periods (Vojinovic, et al., 2008). The expected flood damage so estimated was cross-checked by conducting a Monte-Carlo simulation exercise.

Deviating away from the conventional means of viability assessment where investment estimates are known, the study examined the variability of Economic Net Present Value as a function of Investment, in order to suggest rational investment caps. The study also analysed the behaviour of the investment requirements to prevent flood damage, from average flood damage level to flood damage mitigation with increasingly greater degree of confidence.

Analysis and Results

Table 1: Flood Damage Costs corresponding to Flood Intensity in CMA

Flood Return Period (Years)	Damage to CMC Area (Rs Mn)	Damage to Non-CMC area (Rs Mn)	Total Damage to CMA (Rs Mn)
2	124	807	931
5	178	1342	1520
10	234	1869	2104
25	333	3552	3884
50	436	6305	6740

Source: JICA estimates, updated for 2011 by World Bank study team

The probabilistic distribution of flood damage cost estimates, summarised in Table 1, was used to estimate the expected flood damage, firstly by calculating the area under the probabilistic distribution curve, and thereafter by Monte-Carlo simulation of flood incidences with 5000 iterations. Table 2 summarises the comparative results obtained.

Table 2: Expected Flood Damage Estimates and Standard Deviations

Parameter	Calculating the area under the probabilistic curve	Monte-Carlo simulation (5000 iterations)
Expected Flood Damage cost (Rs Bn)	1060	890
Standard Deviation	1134	1220

Source: Author's estimates

The two estimates yielded quite closer estimates. It was noted, however, that the simulation exercise only could handle a discrete set of probabilistic occurrences, whereas the area under the curve calculation could account for the continuum of probability distribution, which could explain the marginal difference of results.

A Benefit-Cost Analysis was performed, first using the Expected value of flood damage cost, and thereafter by considering increased level of confidence of flood damage avoidance. A 40 year project life horizon was assumed with no residual worth of assets. Flood avoidance benefits were expected to grow at an annual rate of 4% in real terms.[4] A maintenance expenditure was assumed to be 3% of investment value. Flood prevention intervention was considered capable of preventing the entirety of damages reflected in the flood damage profile.[5] Market cost estimates were converted to economic values using the Aggregate Conversion Factor (ACF).[6] An economic rate of discounting of 10% was employed.[7]

Instead of computing the economic viability of a given investment estimate, the study adopted several scenarios of discounted investment levels to work out the corresponding economic Net Present Value estimates of expected flood damage avoidance. The results are depicted in the Figure 1.

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[4] The projection made by the World Bank study team corresponds to a 3.75% annual real growth of average flood damage costs.

[5] This assumption leads to "over-estimation" of benefits, as in reality, any finite flood prevention investment, designed for a targeted flood level, would not be capable of preventing damages that would be caused by floods with higher return periods.

[6] ACF = (X+M) in Border Prices / (X+M) after adjusting for taxes and subsidies. ACF for Sri Lanka was thus estimated to be 0.95.

[7] World Bank study team in 2012 said that 10% to 12% would be appropriate discount rates for economic analysis. They have finally resolved to use 10%.

Figure 1: Variability of Economic NPV as a function of Discounted Investment for the Expected Flood Damage Scenario
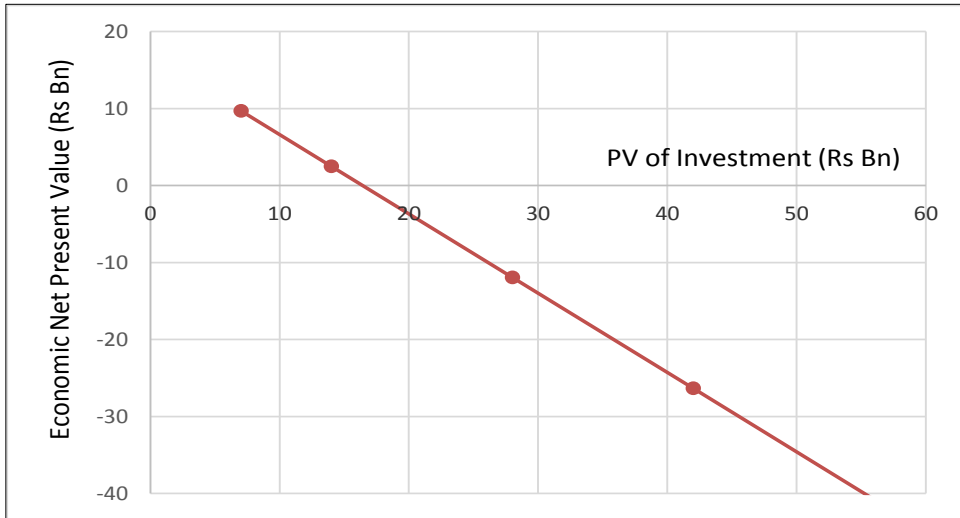
Source: Author computations

The expected flood damage being just the mean occurrence of a stochastic variable of flood damage, the study went into examine how different the Investment requirement would be for flood damage avoidance at different levels of confidence; the results are depicted in Figure 2.

Figure 2: Investment requirements for varying levels of confidence in Flood Damage   Avoidance
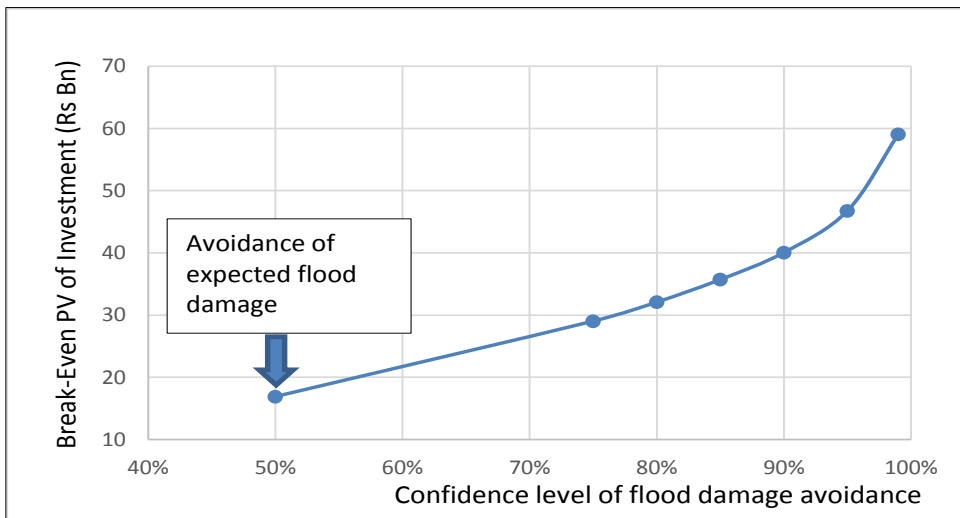
Source: Author's computations

Discussion

The results indicate that any spending of capital investments over and above Rs 17 Billion (or USD 120 Million at 2015 exchange rate) in Discounted Present Value terms for the avoidance of expected flood damage would be economically sub-optimal. This threshold limit would be slightly lower (around Rs 14 Bn, or USD 100 Mn) if expected flood damage estimates obtained through Monte-Carlo simulation method were to be used.

Nevertheless, a desire to have a greater degree of confidence in flood damage avoidance could not be ruled out; hence, the sensitivity analysis presented in the Figure 2 was performed. Accordingly, the growth of investment requirement corresponding to increased confidence levels of damage avoidance would be somewhat linear up to 75% and accelerating beyond. For instance, an investment of Rs 20 Billion would be excessive and could not be justified for the avoidance of expected flood damage, while even double that would be justified if a damage avoidance confidence level of 90% is sought.

These inferences are of high policy relevance. First, they provide a mechanism for rational bench-marking of capital expenditure on flood prevention in the Metro Colombo area, while establishing an economic analytical framework that could be used in flood prevention expenditure planning in general. Second, they demonstrate how sub-optimal and thereby economically wasteful flood prevention interventions could be, unless they are planned to satisfy rational ceilings. Third, the justifiability of high scales of investment for greater levels of confidence in flood damage prevention, might be politically relevant regardless of their economic rationality. This is because a high flood incidence, even if rare, would inundate low-lying settlements which are more likely to be substantial vote banks towards which Governments would be politically sensitive.

A strategic way out may be to relocate residents in all low-lying areas, and leave those as environmentally sensitive green patches. Under such a scenario, very high levels of confidence in flood damage avoidance could be ensured without having to spend an additional (over and above that amount justified for expected damage avoidance) sum of Rs 20 Billion, and if such savings are diverted to pay an incentive for resettlement, 20000 families could be paid Rs 1 Mn each. This amount or the number of incentivised families could be nearly doubled if the investment requirement to avoid expected flood damage also is added to such resettlement fund, enabled by the fact that low-lying areas devoid of settlements would automatically bring down even the expected flood damage to very low levels.

Conclusions and Recommendations

This study brought forward suggestive evidence to conclude that there may be more economically advantageous methods of addressing Colombo's flooding problem than the present method of trying to prevent flood damage through capital investments in engineering and technical means of damage control. Such preventive interventions are likely to be costly, and also disappointing. A better and more sustainable strategy for flood management in the Colombo area would be to remove residential houses and industrial establishments from sensitive areas and to resettle them in safer locations. As the study reveals, at least a significant share of such relocation expenses could be sourced from savings on flood prevention capital expenditure which would become unnecessary under the proposed strategy.

Key Words: Flood Damage, Economics of Preventive Interventions, Investment Viability Threshold Analysis, Colombo Metro Area

JEL Codes: C53, C54, O22, Q54, R11

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