Research Brief

Urban flood risks and mitigation measures under future climate change scenarios

January 2026[1]

Highlights

- Kalu Oya and Mudun Ela are densely populated sub-basins of the Kelani River Basin and are prone to recurrent floods.
- The Japan International Cooperation Agency (JICA), in collaboration with the Sri Lanka Land Development Corporation (SLLDC), published a stormwater drainage master plan in 2023.
- JICA Ogata Research Institute conducted an evaluation analysis of the proposed measures in light of uncertain future climate impacts and socioeconomic changes.
- The analysis revealed that flood damage in the region could significantly increase under future climate change, while the measures proposed in the master plan could substantially reduce these impacts.
- Under various future climate scenarios, the benefit-cost ratios of the proposed measures were generally above 1, indicating that investments in flood mitigation measures were economically worthwhile.

1. Background

The Sri Lanka Land Development Corporation (SLLDC) and the Japan International Cooperation Agency (JICA) jointly implemented a technical cooperation project, “The Project for Storm Water Drainage Plan in Selected Areas in the Colombo Metropolitan Region,” (hereafter referred to as “the Project”) and developed a Storm Water Drainage Plan (hereafter referred to as the “Master Plan”) for the Kalu Oya/Mudun Ela and Bolgoda basins in the Colombo Metropolitan Region.

A research team from the JICA Ogata Sadako Research Institute for Peace and Development undertook the “Study on Quantitative Evaluation of Climate Change Adaptation Benefits of Urban Flood Management” to develop a new approach to evaluating climate change adaptation projects. As part of its research activities, the team has been conducting an analysis of the effectiveness of measures proposed in the Master Plan under diverse future climate change and socioeconomic scenarios, in collaboration with SLLDC. Although the effects of future climate change have, to a certain extent, already been taken into account in the development of the Master Plan, this study further complements the analysis by expanding the breadth and time horizon of possible future scenarios. This allows us to explore the effects of uncertain future changes in climate and socioeconomic conditions. Figure 1 shows the worst-case scenarios of inundation depth distributions in 2050 and 2070 under future climate conditions if no additional flood mitigation measures are taken. A corresponding map under the historical climate conditions is also shown to allow comparison with the 2050 and 2070 projections.

[1] This Research Brief was prepared by the research team of JICA Ogata Sadako Research Institute for Peace and Development (Ogata Research Institute). The views expressed in this Research Brief are those of the research team and do not necessarily represent the official positions of either JICA, JICA Ogata Research Institute or any other stakeholders.

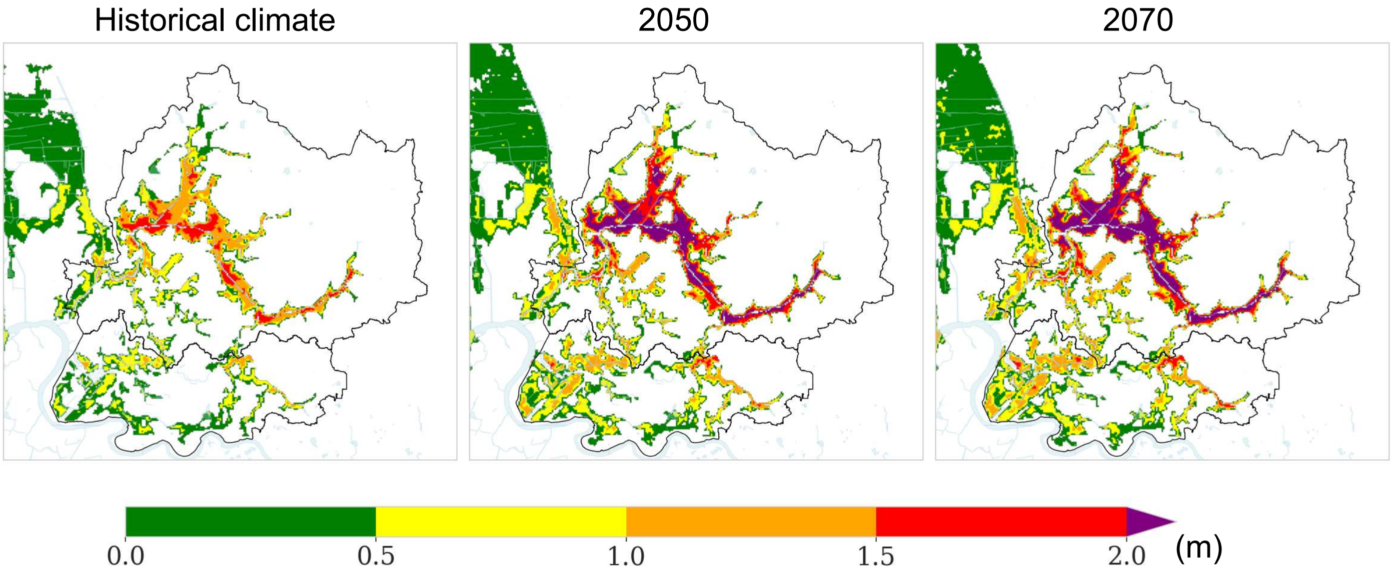

Figure 1. Inundation depth map of Kalu Oya and Mudun Ela sub-basins in 2050 and 2070 under the worst-case scenario with a 25-year return period flood if no additional measures are taken
Source: Research team

The study will continue until June 2026, and this Research Brief presents preliminary results from the analysis to highlight the significance of the flood mitigation measures proposed in the Master Plan.

2. Descriptions of the basin and the proposed measures

Kalu Oya and Mudun Ela are sub-basins of the Kelani Ganga River Basin and are located to the north of the Kelani River near the river mouth (Figure 2). Figure 3 shows the types and locations of measures proposed in the Master Plan. The list of measures proposed in the Master Plan is provided in Tables S1 and S2 in the Appendix.[2] In this Research Brief, the term **"Priority Measures"** refers to a package of measures that includes those classified as "10-year Return Period" and "25-year Return Period" in Tables S1 and S2, with the exception of "Installation of a gate structure [M4]." Similarly, the term "**Expanded Measures"** refers to the package of measures that includes all measures listed in Tables S1 and S2, apart from the "Installation of a gate structure [M4]."

[2] Although the Oliyamulla Pumping Station—shown as being "under construction" in Figure 3—currently does not have a required discharge capacity, it is treated as an existing facility for the purposes of this analysis.

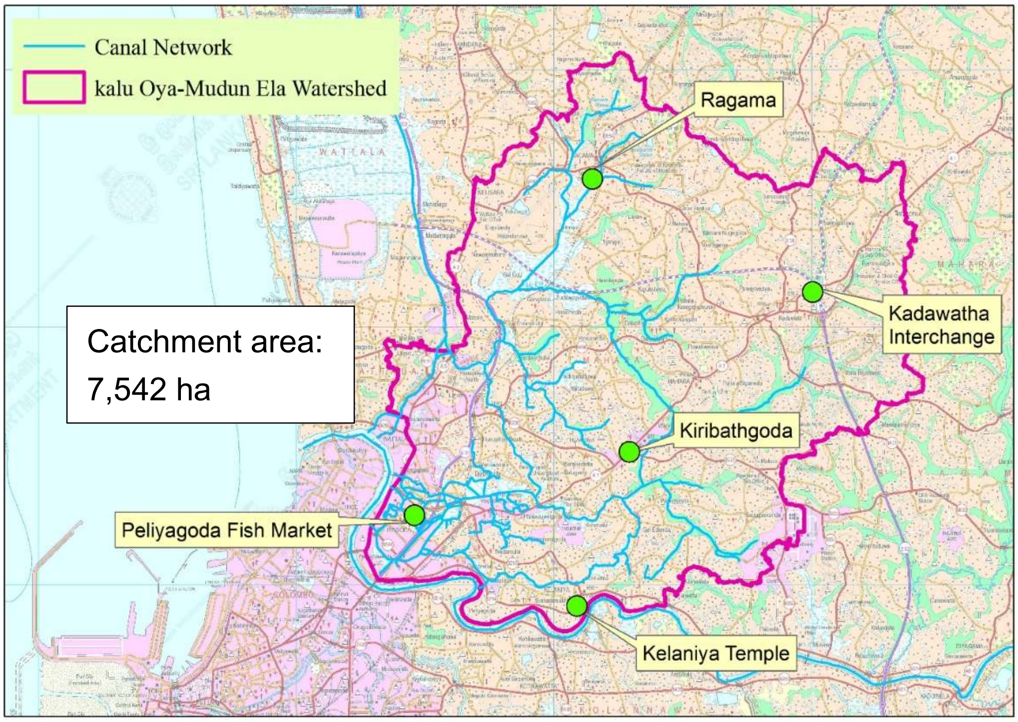

Figure 2. Location and boundary of the Kalu Oya/Mudun Ela sub-basins
Source: Map provided by the Government of Sri Lanka

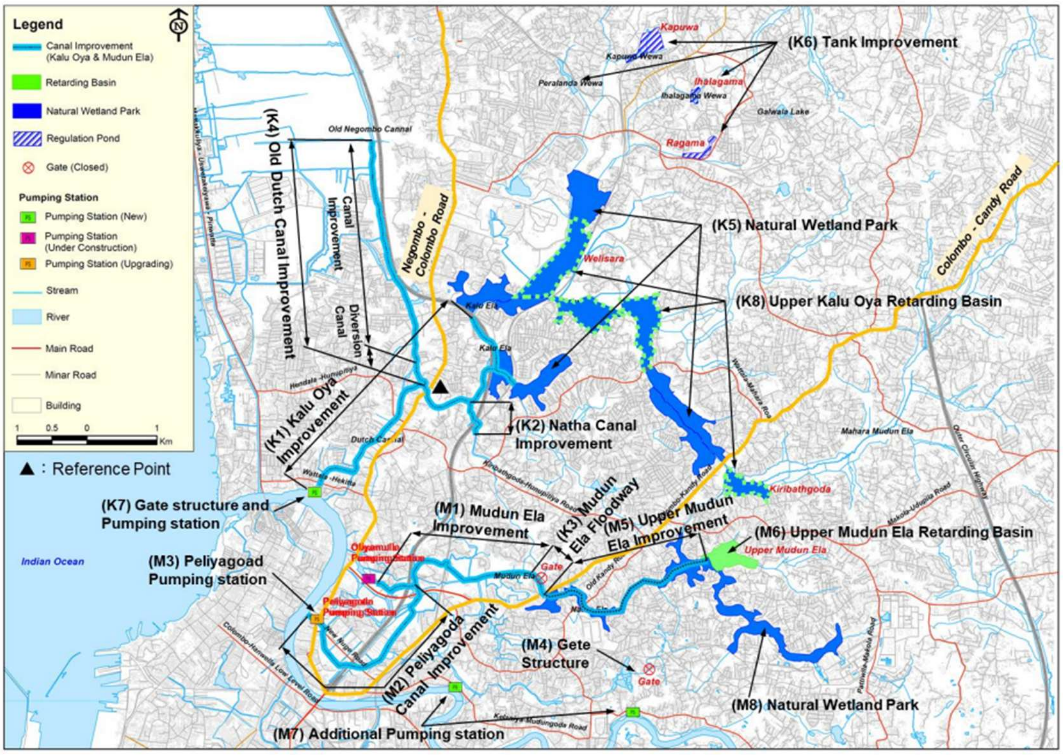

Figure 3. Type and location of proposed measures
Source: JICA et al. (2023)

3. Effectiveness of proposed flood mitigation measures against future climate change and socioeconomic uncertainties

Figure 4 shows simulated inundation maps differentiated by the severity of future climate impacts and the scale of flood mitigation measures implemented. Despite diverse future possibilities of climate change effects, the Priority and Expanded Measures will likely be effective in reducing inundation depth.

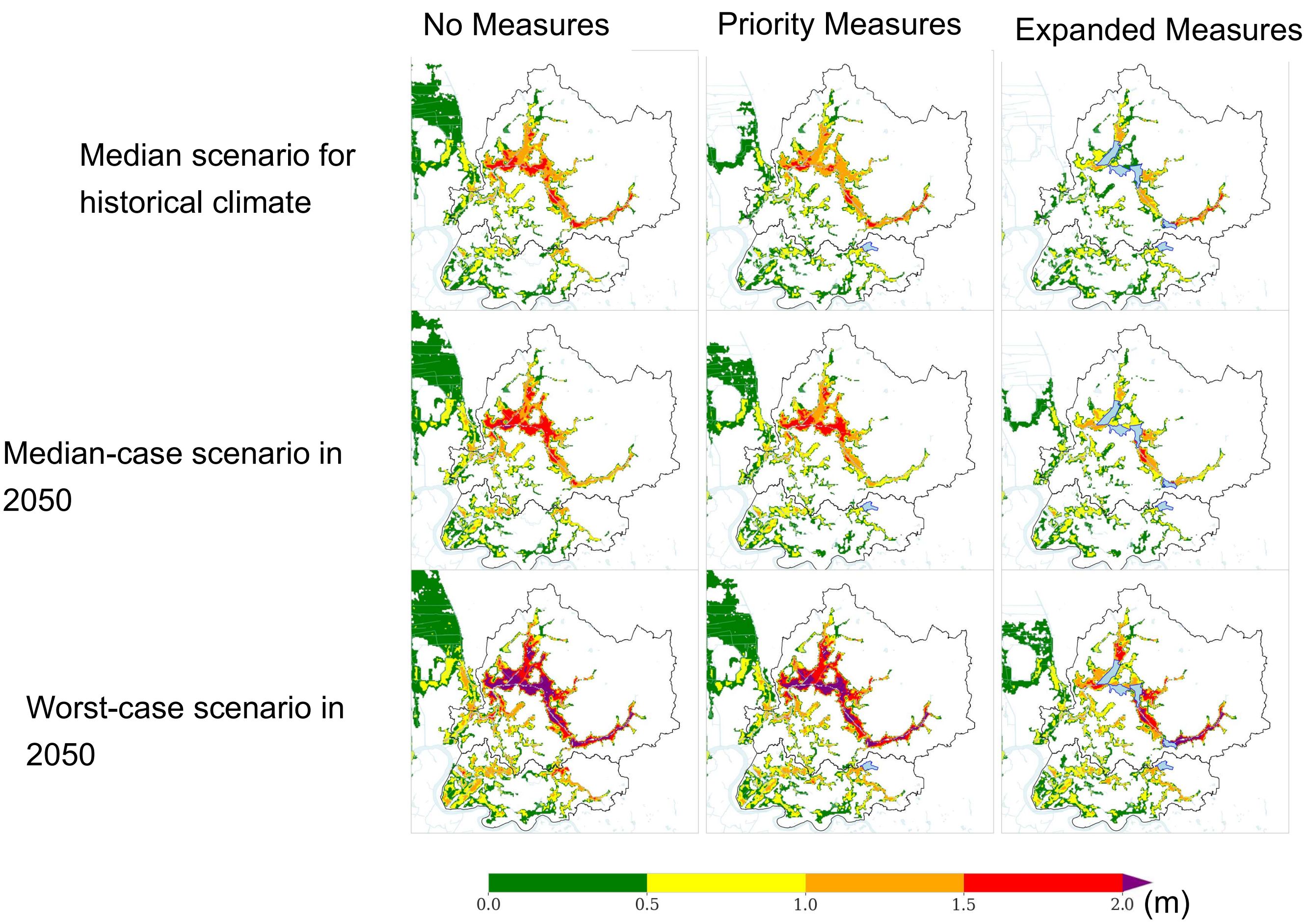

Figure 4. Inundation maps of the Kalu Oya/Mudun Ela sub-basins with a 25-year return period flood

Source: Research team
Note: "No Measures" refers to the case where no additional flood mitigation measures are taken. The median- and worst-case scenarios correspond to the median and maximum inundation areas, respectively, across the 390 future scenarios with varying assumptions regarding rainfall intensity and patterns, soil moisture, sea-level rise, and the Kelani River water level.

Figure 5 shows the distributions of estimated flood damage to assets for a 25-year return-period flood in the basins. Compared to the No Measures case, Priority Measures and Expanded Measures not only lower the overall distribution ranges of the estimated damages but also narrow the distribution ranges. This indicates that both measures are more resilient than No Measures against diverse future possibilities in terms of their effectiveness in reducing flood damage.

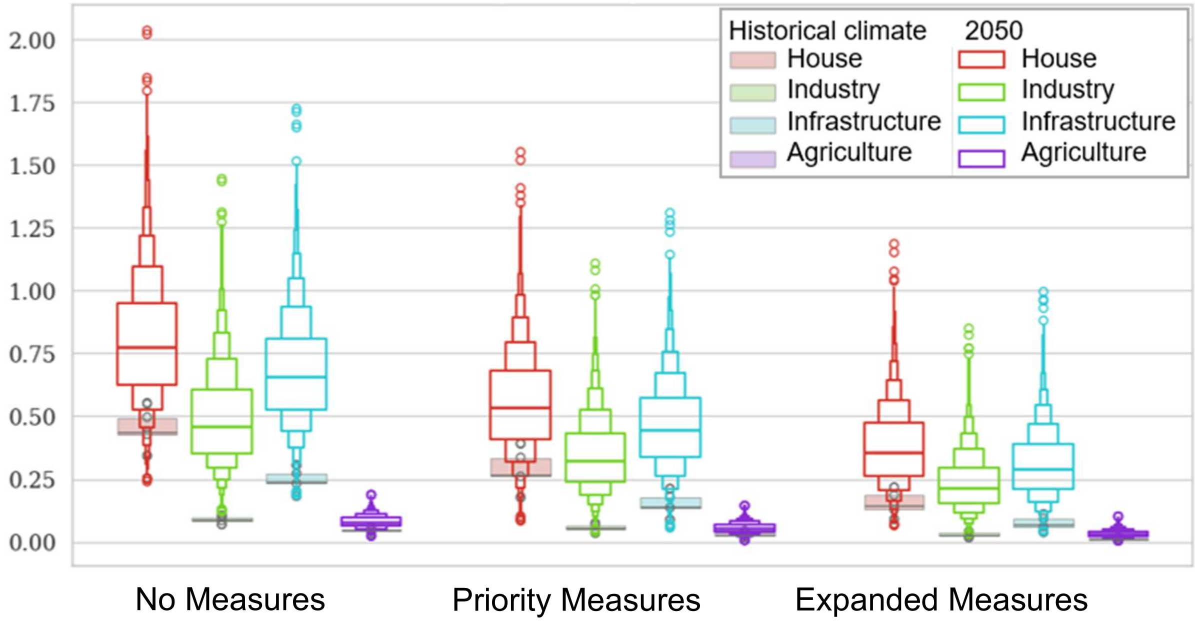

Figure 5. Distribution of the estimated flood damage to assets with a 25-year return period flood in 2050 (unit: 10 billion LKR)

Source: Research team

Note: The box plots present the distribution of estimated flood damage to assets across 3,900 future scenarios across different assumptions regarding rainfall intensity and patterns, sea-level rise, soil moisture, the Kelani River water level, GDP and population growth. The color shades indicate the distribution of estimated flood damage to assets across ten scenarios under the historical climate with different assumptions about rainfall patterns and soil moisture.

The research team calculated the benefit-cost ratio of Priority Measures under diverse future scenarios and found that it almost invariably exceeded 1.0, indicating that the net present value of benefits robustly exceeds the costs of the Priority Measures.

4. Conclusions

Our simulation study revealed that flood damage in the Kalu Oya/Mudun Ela sub-basins could increase substantially under future climate change. Across diverse future possibilities, the Priority Measures and Expanded Measures could provide effective defenses against flood risk. In addition, the distribution of the benefit-cost ratio for Priority Measures indicates that the investment would be economically worthwhile.

5. Methods

Simulation analyses of rainfall-runoff and inundation were undertaken using MIKE+ flood simulation software. Based on inundation-depth distributions calculated by MIKE+, flood damage to buildings was estimated using the locally developed damage curve generated by the Metro Colombo Urban Development Project (MCUDP). Flood damage to infrastructure was estimated using the damage curve developed by the Japanese Ministry of Land, Infrastructure, Transport and Tourism. Future climate scenarios were constructed using 11 global climate models—those selected for the Coupled Model Intercomparison Project Phase 6 (CMIP6) international model comparison—based on their ability to simulate the historical climate of Sri Lanka. Most other data on weather patterns, geography and socioeconomic conditions used in the analyses were collected from local sources in Sri Lanka.

Acknowledgments

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Reference

Japan International Cooperation Agency, CTI Engineering International Co., Ltd., Nippon Koei Co., Ltd., Earth System Science Co., Ltd. 2023. "Democratic Socialist Republic of Sri Lanka, The Project for Storm Water Drainage Plan in Selected Areas in Colombo Metropolitan Region: Final Report (Main Report)." https://openjicareport.jica.go.jp/pdf/12343448_01.pdf. .

Table S1. Proposed measures in the Kalu Oya Basin

Safety Level	Priority	Summary of Countermeasure
10-year Return Period	1	Kalu Oya improvement [K1] ● Target: Kalu Oya main canal ● Measure: Canal improvement (Widening, Dredging, Embankment) Length: 5.1 km
	2	Natha Canal improvement [K2] ● Target: From Kalu Oya to the railway bridge ● Measure: Canal improvement (Widening, Dredging, Embankment) Length: 0.5 km
	3	Mudun Ela Diversion [K3] ● Target: Near the confluence of Upstream of Natha Canal and Mudun Ela ● Measure: Canal improvement (widening, dredging, embankment), removal of the existing connecting gate, installation of new deadline facility Length: 0.3 km
	4	Natural Wetland Park [K5] ● Target: Wetlands located in the valley bottom plain in the middle and upper reaches of the main channel and tributaries ● Measure: Prevention of invasion of houses, etc. by converting existing wetlands into parks Total length of small dikes: 28.8 km
25-year Return Period	5	Old Dutch Canal Improvement and a flood diversion channel [K4] ● Target: From Upstream of Negombo Wetland to propose a new flood diversion channel ● Measure: Canal improvement (widening, dredging, embankment), excavation of the existing channel (widening, dredging, embankment) Length: Old Dutch Canal: 5.0 km, Flood diversion: 0.4 km
50-year Return Period	6	Installation of a gate structure and a pumping station [K7] ● Target: Confluence with Kelani Ganga (at the downstream end of Kalu Oya) ● Measure: Gate structure and pumping stations for the Kelani Ganga embankment project at the confluence Drainage capacity: 35 m^3/s, gate width: 30 m
	7	Improvement of natural wetland parks to retarding basins [K8] ● Target: Natural wetland parks along the Kalu Oya main channel and primary tributaries ● Measure: Excavation in natural wetland parks, surrounding dike, overflow dike Number of wetland parks: 4 nos
-	Other	Improvement of tanks [K6] ● Target: Upstream of Kalu Oya tributary, 3 locations

Source: JICA et al. (2023)

Table S2. Proposed measures in Mudun Ela basin

Safety Level	Priority	Summary of Countermeasure
10-year Return Period	1	Mudun Ela improvement ［M1］ ● Target: Mudun Ela main canal (from Oliyamula Pumping Station to Colombo-Kandy Road) ● Measure: Canal improvement (widening, dredging, embankment) Length: 3.1 km
	2	Peliyagoda improvement ［M2］ ● Target: Peliyagoda canal connected to the Peliyagoda Pumping Station ● Measure: Canal improvement (dredging) Length: 2.8 km
	3	Improvement of Peliyagoda Pumping Station ［M3］ ● Target: Peliyagoda Pumping Station ● Measure: enhancement of pump facilities (drainage capacity upgrade from 0.5 m^3/s to 1.0 m^3/s)
	4	Installation of a gate structure ［M4］ ● Target: Peliyagoda canal ● Measure: Installation of a gate structure
	5	Natural Wetland Park ［M8］ ● Target: Wetlands located in the valley bottom plain in the middle and upper reaches of the main and secondary channel ● Measure: Prevention of invasion of houses, etc. by converting existing wetlands into parks Total length of small dikes: 16.9 km
25-year Return Period	6	Upper Mudun Ela improvement ［M5］ ● Target: Upstream section from Colombo-Kandy Road ● Measure: canal improvement (dredging) Length: 3.0 km
	7	Construction of retarding basin of upper Mudun Ela ［M6］ ● Target: Natural wetland park along Mudun Ela ● Measure: Excavation and embankment in natural wetland park, surrounding dike, overflow dike Number of wetland parks: 1 nos
-	Other	Installation of small pumping stations ［M7］ ● Target: Local flooding risk area around upper Nalanmini Oya ● Measure: Installation of the small-scale pumping facility Number: 2 locations

Source: JICA et al. (2023)