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Economic modelling for selection of flood measures in Jakarta: an optimization approach

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Background

Jakarta suffers from both river and coastal flooding. In order to reduce flood risk in the downstream area of the *Ciliwung* River, the flood peak discharge should be reduced. Due to the ineffectiveness of a single flood measure, Indonesian authorities have proposed to integrate different flood measures to control the discharge to achieve better flood risk management.

Objective

To develop an economic model to select the optimal strategy for implementing flood measures to reduce the risk of flooding in Jakarta by applying an economic optimization approach.

Methods

- The objective function of the model is to minimize the net present value of total expected costs (*NPV*), i.e.

$$\min_{M_{i,j,t}} NPV = PVCM + PVCD$$

Where:
PVCM : present value of measure costs, which depends on the construction level of measures *i* in area *j* at year *t* ($M_{i,j,t}$)
PVCD : present value of expected flood damage, which depends on the land subsidence rate

- We show how the optimization model can be formulated for four strategies under different combinations of measures implemented in upstream, midstream, and downstream of the *Ciliwung* River to reduce the risk of flooding in Jakarta.
- The model is numerically solved using the General Algebraic Modelling System (GAMS). Results for the four strategies are compared to identify the optimal strategy.

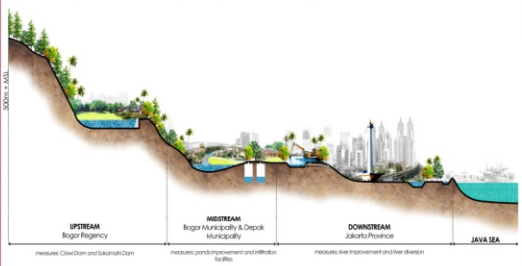

Figure 1. Flood measures along the *Ciliwung* River, Jakarta, Indonesia

Results

Table 1. The values of objective function under the baseline and four strategies

Baseline and strategy options	*PVCM*	*PVCD*	*NPV*
	(million USD)		
Baseline. Only midstream and downstream measures	90.58	1,581.03	1,671.61
Strategy 1. Baseline and *Ciawi* dam in upstream	197.65	1,067.61	1,265.25
Strategy 2. Baseline and *Sukamahi* dam in upstream	158.23	1,442.53	1,600.76
Strategy 3. Baseline and both *Ciawi* and Sukamahi dams in upstream	265.29	929.10	1,194.40
Strategy 4. Strategy 3 without river diversion	230.08	1,144.36	1,374.44

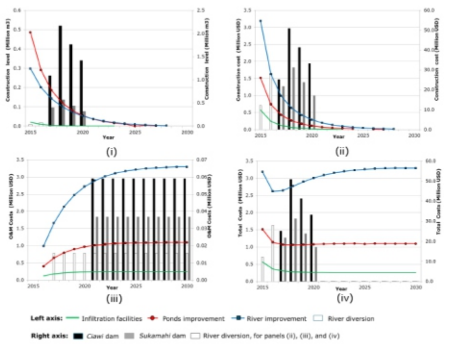

Figure 2. The construction levels (i), construction costs (ii), operational costs (iii), and total costs (iv) for the implementation of measures under Strategy 3

Conclusions

- Based on a planning horizon of 50 years and a discount rate of 8%, a strategy of constructing two dams upstream, infiltration facilities and ponds improvement midstream, and river improvement and river diversion downstream provides the best result, reducing the present value of total expected costs by 71%.
- This strategy can be accelerated if a lower discount rate is used, and decelerated if a longer planning horizon is taken.
- A higher growth of land subsidence and postponing of dam construction significantly increase the present value of expected flood damage and the total expected costs.

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