United Nations Climate Change
Technology Executive Committee

© Pexels / Ahmad Syahrir

# Urban flood management in Jakarta

## Case study.

**This document is part of a collection of six case studies selected from the work conducted by the Technology Executive Committee (TEC) on "Good practices and lessons learned on the setup and implementation of National Systems of Innovation". It specifically focuses on the urban flood management strategies in Jakarta.**

The Summary for Policymakers of the TEC's work presented in June 2023[1] explains that the primary objective of an innovation system is to produce, diffuse, and use innovations. To accomplish this objective, the Summary for Policymakers document identifies specific activities or functions that should be carried out to facilitate the innovation process. Based on empirical evidence, innovation studies identify seven main functions as outlined in Table 1. Evaluating to what extent an innovation system can perform these functions is necessary to identify and assess the innovation system's achievements, failures and gaps or barriers. The functions assessment found that the functions of knowledge development and diffusion (F1), and resource mobilization (F5) are key functions to the Indonesian study case.

**Table 1. Indonesian case of innovation system**

| | | | |
|---|---|---|---|
| **Country** | **Indonesia** | **Focus** | **Adaptation** |
| **Scope** | Urban flood management | **Innovation system functions (F)**[a] | **Key functions:**<br>F1 Knowledge development and diffusion<br>F5 Resource mobilization<br><br>**No-Key functions:**<br>F2 Entrepreneurial experimentation<br>F3 Market formation<br>F4 Influence on the direction of the search<br>F6 Legitimation<br>F7 Development of positive externalities |
| **Approach** | Top-down and bottom-up | **Starting year** | 1970s |

[a] See the Summary for Policymakers of "Good practices and lessons learned on the setup and implementation of National Systems of Innovation",[2] and table 2 for the description of functions.

1 TEC, 2023, Summary for Policy makers: Good practices and lessons learned on the setup and implementation of National Systems of Innovation, UNFCCC Technology Executive Commission, Bonn. Available at https://unfccc.int/ttclear/tec/NSI.html.

2 TEC (2023).

This document begins with a general introduction of the case study, followed by a description of the legislative framework and an examination of its context within the national innovation system. This provides a foundation for a more detailed exploration of the case. These sections serve as the basis for assessing the case by analysing its functions. The last sections include additional analysis of the case's role within the national system of innovation, key success factors and lessons learned, and good practices.


© Pexels / Tom Fisk

# 1. Introduction of the case

**The aim of urban water management is to establish a sustainable urban water system that provides safe drinking water, handles wastewater treatment, protects against floods and alleviates the effects of pollution.[3] Urban flooding, namely flooding in urban centres, is caused by rainfall overwhelming the capacity of drainage systems.**

While it can result from disastrous events such as flash floods, it is usually repetitive in nature, causing systemic impacts on local communities.[4] Overflows can damage infrastructure, including public and private buildings, seeping through walls and floors or backing up into buildings through sewage pipes. For coastal cities, flood management can include protection against flooding due to rising sea levels caused by climate change and to land subsidence caused by excessive extraction of groundwater. The soft soil beneath the city is held together by the pressure of groundwater; however, extreme extraction of the underground water reduces this pressure and, consequently, the land above it subsides.[5]

Urban flooding can pose severe challenges to national development. Although flooding can be disastrous for both rural and urban areas, flooding in urban regions has more far-reaching consequences and is more expensive to manage because of the greater concentration of population and assets.[6] The problem is particularly significant in some fast-developing South Asian cities, where burgeoning populations, strong economic growth and unplanned urban development interferes with the natural flow of water and various structural, natural and socioeconomic factors. Many South Asian cities become severely waterlogged (and flooded) during short-duration, high-intensity rainfall episodes.[7] The problem is amplified in coastal cities where intense rainfall events are frequent and occur together with local land subsidence and sea level rise, leading to coastal land loss. Some coastal regions in which booming South Asian cities are located, such as Ho Chi Minh City (Viet Nam), Chittagong (Bangladesh), Ahmedabad (India) and Jakarta (Indonesia) are sinking faster than most other regions in the world.[8]

Jakarta is a clear example of a city facing the risk of urban flooding. As the capital of and largest city in Indonesia, with a population of over 11.1 million (as at 2022), it is one of the most populous coastal cities in the world.[9] Frequent flooding has been a critical challenge for Jakarta for hundreds of years,[10] and this is only expected to worsen over time (see box 1). As a result, flood management has been on the agenda of the national Government and local governments since the 1970s.[11] This case study assesses key strategies adopted by Jakarta to manage recurring floods, including infrastructure-focused initiatives such as the National Capital Integrated Coastal Development (NCICD) and Giant Sea Wall Jakarta projects, the normalization[12] and naturalization of rivers, and the relocation of communities. Non-structural community-centred initiatives are also described, including early warning systems (EWS) and flood control systems using the Internet of Things and artificial intelligence (AI).

3 Larsen, T. A., Hoffmann, S., Lüthi, C., Truffer, B., & Maurer, M. (2016). Emerging solutions to the water challenges of an urbanizing world. *Science, 352*(6288), 928–933.

4 Center for Neighborhood Technology, Chicago IL, "The Prevalence and Cost of Urban Flooding", May 2013.

5 Sakdapolrak, P., Butsch, C., Carter, R. L., Cojocaru, M. D., Etzold, B., Kishor, N., Lacambra, C., Reyes, M.L. & Sagala, S. (2008). The megacity resilience framework. Resilience and Social Vulnerability, 10. https://www.researchgate.net/profile/Hans-Georg-Bohle/publication/305391391_Megacities_Resilience_and_Social_Vulnerability/links/578ca19608ae254b1de843d4/Megacities-Resilience-and-Social-Vulnerability.pdf#page=12.

6 Jha, A. K., Bloch, R., & Lamond, J. (2012). Cities and flooding: a guide to integrated urban flood risk management for the 21st century. World Bank Publications.

7 Pervin, I. A., Rahman, S. M. M., Nepal, M., Haque, A. K. E., Karim, H., & Dhakal, G. (2020). Adapting to urban flooding: a case of two cities in South Asia. Water Policy, 22(S1), 162–188.

8 Tay, C., Lindsey, E. O., Chin, S. T., McCaughey, J. W., Bekaert, D., Nguyen, M., ... & Hill, E. M. (2022). Sea-level rise from land subsidence in major coastal cities. Nature Sustainability, 1-9.

9 See https://worldpopulationreview.com/world-cities/jakarta-population.

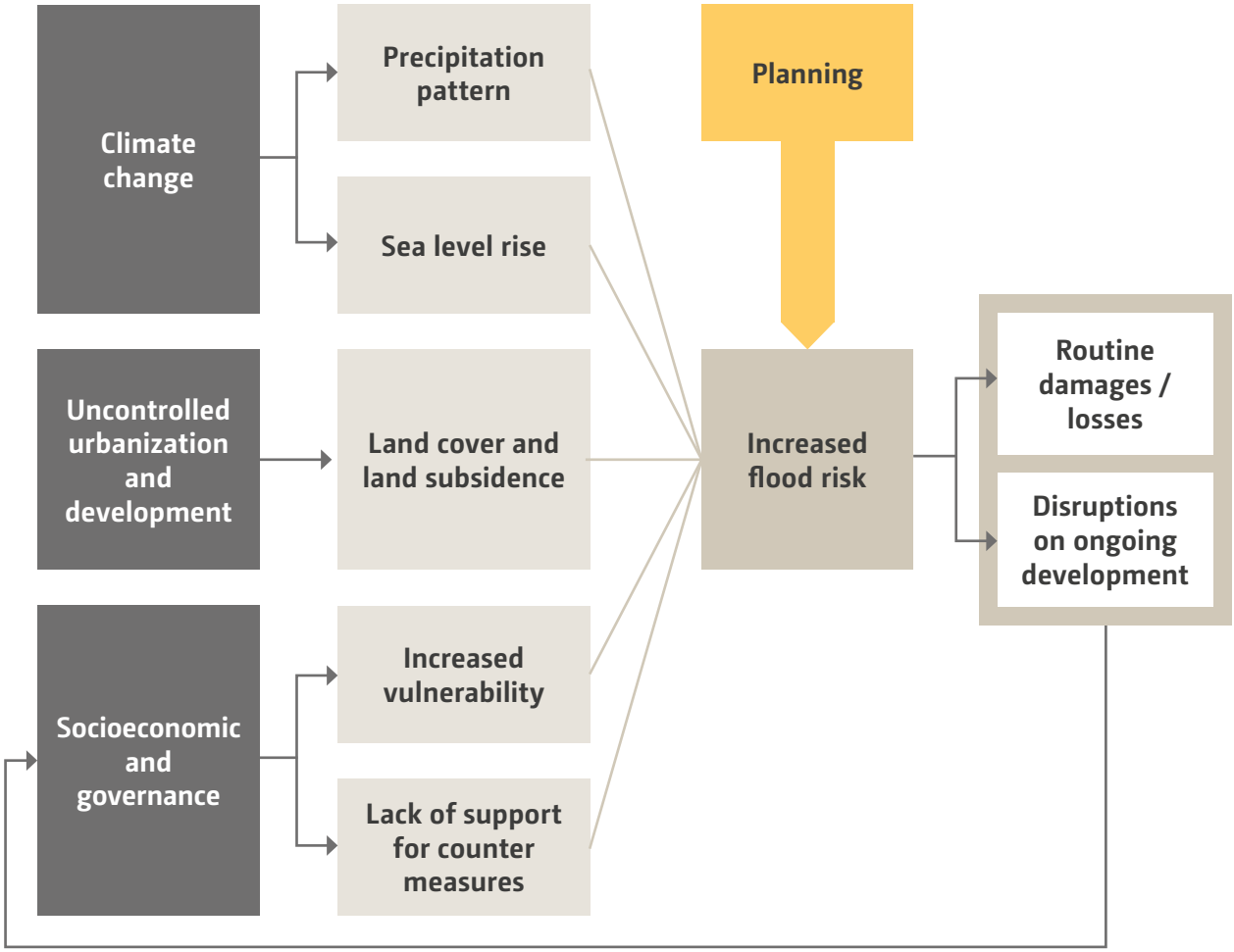
10 See https:// www.nationalgeographic.com/environment/article/indonesias-giant-capital-city-is-sinking-can-the-governments-plan-save-it#:~:text=Jakarta%20 is%20now%20sinking%20at,of%20an%20inch%20a%20year.

11 Simanjuntak, I., Frantzeskaki, N., Enserink, B., & Ravesteijn, W. (2012). Evaluating Jakarta's flood defence governance: the impact of political and institutional reforms. *Water Policy, 14*(4), 561–580.

12 Normalization is the process of restoring rivers, ponds, canals, etc., to their original capacity or design standards by dredging and relocating squatters from their banks (see Octavianti, 2019).

**Flooding in urban regions has more far-reaching consequences and is more expensive to manage because of the greater concentration of population and assets**

Figure 1. Underlying causes and problems contributing to the increase in flood magnitude in Jakarta[13]




Jakarta's experience in managing floods shows the country's strengths and weaknesses in this regard and, as such, there are useful lessons to be learned. Its flood management projects have had significant material and political effects and an analysis of them can lead to enriching insights into the related policymaking processes.[14]

13 Based on a study by Rahayu, H. P., & Nasu, S. (2010). Good practices of enhancement early warning system for high populated cities: a case study for Jakarta flood) (Adapted from Rahayu, H. P., Haigh, R., Amaratunga, D., Kombaitan, B., Khoirunnisa, D., & Pradana, V. (2020). A micro scale study of climate change adaptation and disaster risk reduction in coastal urban strategic planning for the Jakarta. International Journal of Disaster Resilience in the Built Environment, 11(1), 119–133.

14 Colven, E. (2020). Thinking beyond success and failure: Dutch water expertise and friction in postcolonial Jakarta. *Environment and Planning C: Politics and Space, 38*(6), 961–979.

### Box 1. Factors behind Jakarta's recurrent and severe flooding

Jakarta experiences both riverine (pluvial) and coastal flooding during the rainy season.[15] The frequency and intensity of the floods and the scale of direct and indirect socioeconomic impacts[16] have increased significantly in the past few decades[17,18,19] and such floods are expected to multiply in future years.[20,21] The surge in flooding is driven by several natural and socioeconomic factors, as follows.

#### Natural factors

The geography and topography of Jakarta play a key role in flooding.[22] The city is situated in an alluvial, low-lying, flat coastal region[23] at the mouth of the Ciliwung River, which flows into the Java Sea.[24] The Ciliwung River is a canalized river stretching over 100 km that traverses the city and ultimately flows into Jakarta Bay, and is predisposed to backwater flows from the Java Sea during high tides or in the case of raised sea level.[25] The deltaic plain of Jakarta is crisscrossed by 13 natural and artificial rivers, which form the main drainage system of the city.[26] Owing to the passage of so many rivers, the city has historically been swampy.[27] In addition, sediments from upstream are deposited here, resulting in limited drainage and storage capacity in Jakarta's rivers. Moreover, the relentless dumping of city waste has further congested the river systems.[28] Jakarta has a tropical monsoon climate with an annual rainfall of more than 1,700 mm[29], increasing to over 3,000 mm in the Ciliwung watershed, particularly in the upper tracts. Extreme rainfall events are rampant.[30] The increased frequency of extreme rainfall events due to climate change has compounded the problem further.[31] The topography of the city is almost flat, with a height gain of only around 25 m between the highest and lowest points across the city.[32]

While climate change induced sea level rise has made the situation worse for many major coastal cities, Jakarta is especially vulnerable[33] owing to the problem of land subsidence.[34] Jakarta is the fastest-sinking city in the world,[35] losing 3–10 cm/year, with even higher rates for northern Jakarta.[36] Around 40% of the city is already lower than the high tide mark.[37,38] Escalating concerns about the sustainability of Jakarta led to a controversial proposal to move the capital.[39,40]

15 Betteridge, B., & Webber, S. (2019). Everyday resilience, reworking, and resistance in North Jakarta's kampungs. *Environment and Planning E: Nature and Space, 2*(4), 944–966.

16 The first major flooding event in recent times was in 1996, resulting in 20–30% of Jakarta being flooded, and the second was in 2002, resulting in 40–50% of the city being flooded. The 2007 floods were the most severe in recent years; around 75% of the city was inundated, leading to a severe loss of life and property. Around 450,000 people were displaced, and the economic losses were to the tune of USD 900 million.Sources: Texier, P. (2008). Floods in Jakarta: when the extreme reveals daily structural constraints and mismanagement. Disaster Prevention and Management: An International Journal. Asdak, C., & Supian, S. (2018). Watershed management strategies for flood mitigation: A case study of Jakarta's flooding. Weather and climate extremes, 21, 117–122.

17 Budiyono, Y., Aerts, J. C., Tollenaar, D., & Ward, P. J. (2016). River flood risk in Jakarta under scenarios of future change. Natural hazards and earth system sciences, 16(3), 757–774.

18 Hellman, J. (2015). Living with floods and coping with vulnerability. *Disaster Prevention and Management.*

19 Asdak and Supian (2018).

20 Budiyono et al. (2016).

21 Januriyadi, F., N., Kazama, S., Riyando Moe, I., & Kure, S. (2018). Evaluation of future flood risk in Asian megacities: A case study of Jakarta. Hydrological Research Letters, 12(3), 14–22. https://doi.org/10.3178/hrl.12.14.

22 See https://www.jbarisk.com/flood-services/event-response/a-retrospective-view-of-floods-in-jakarta/.

23 Martinez, R., & Masron, I. N. (2020). Jakarta: A city of cities. *Cities, 106*, 102868. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7442427/.

24 Martinez and Masron (2020).

25 Asdak and Supian (2018).

26 Abidin, H. Z., Andreas, H., Gumilar, I., & Wibowo, I. R. R. (2015). On correlation between urban development, land subsidence and flooding phenomena in Jakarta. *Proceedings of the International Association of Hydrological Sciences, 370*, 15–20.

27 Martinez and Masron (2020).

28 Budiyono et al. (2016).

29 See https://www.britannica.com/place/Jakarta.

30 Asdak and Supian (2018).

31 Wihanesta, R., Sulaeman, D., Pradana, A., S. Pribadi Y. (2021). The reasons for Jakarta's frequent flooding and how nature-based solutions (NBS) can help reduce the risk. Insights. WRI Indonesia. https://wri-indonesia.org/en/insights/reasons-jakartas-frequent-flooding-and-how-nature-based-solutions-nbs-can-help-reduce-risk.

32 Hurford, A. P., Maksimović, Č., & Leitao, J. P. (2010). Urban pluvial flooding in Jakarta: applying state-of-the-art technology in a data scarce environment. *Water Science and Technology, 62*(10), 2246–2255.

33 See https://www.wired.co.uk/article/jakarta-sinking.

34 Shatkin, G., & Soemarwi, V. (2021). Risk and the dialectic of state informality: Property rights in flood prone Jakarta. *Annals of the American Association of Geographers, 111*(4), 1183–1199.

35 See https://populationstat.com/indonesia/jakarta.

36 Abidin et al. (2015).

37 Shatkin and Soemarwi (2021).

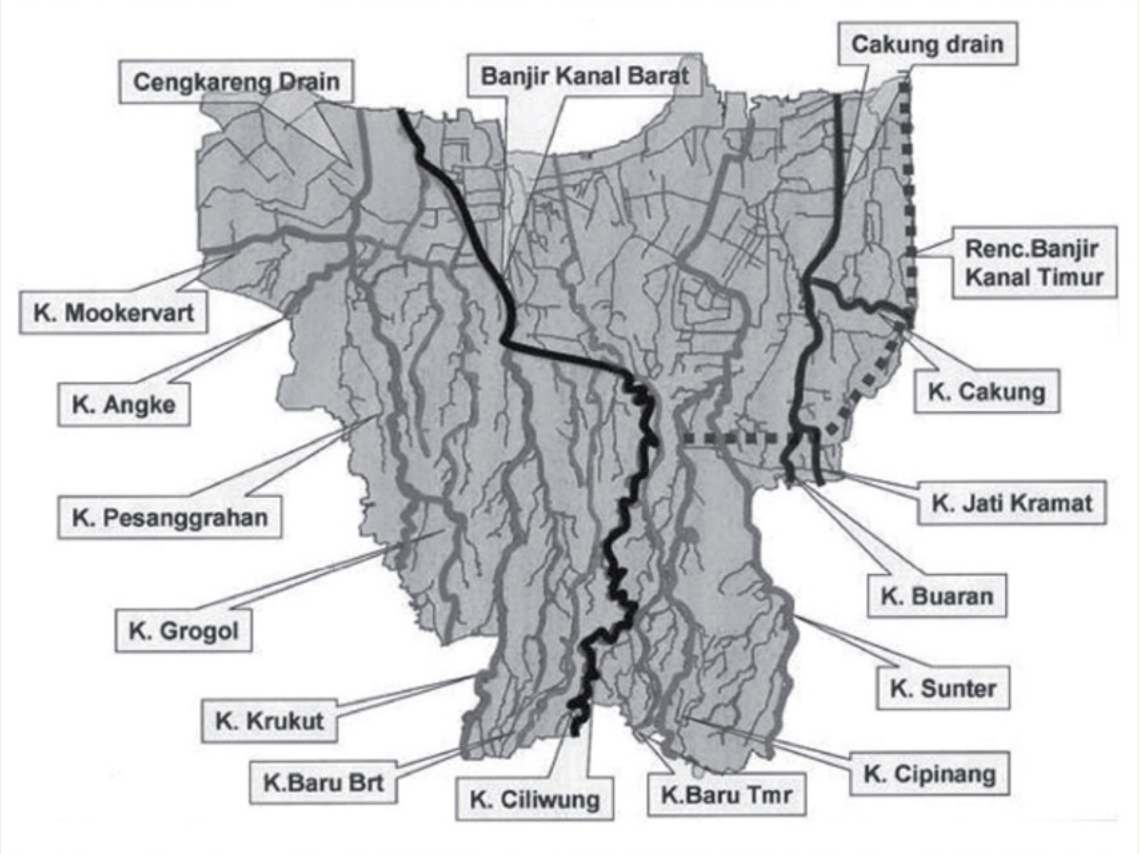
38 Azhar, H. N., Fatima, H. H. P., & Tamas, I. N. (2020). Preliminary study of Indonesia capital city relocation based on disaster mitigation principle with mental model approach. In *E3S Web of Conferences* (Vol. 148, p. 06002). EDP Sciences.

39 The Indonesian Government proposed moving the capital to a new city to be built on the island of Borneo. However, many sections of society have opposed this move, claiming that setting up a new city with modern infrastructure would lead to unnecessary expenditures (at an estimated cost of over USD 30 billion), deforestation and environmental degradation. See https://sdg-action.org/sustainable-development-in-the-face-of-floods-and-rising-sea-levels-jakarta-case-study%EF%BF%BC/.

40 Azhar et al. (2020).

## Box 1. (continued) Factors behind Jakarta's recurrent and severe flooding

### Major canals and rivers of Jakarta




Source: Padawangi and Douglass, 2015[41]

### Socioeconomic factors

Jakarta has undergone rapid urbanization and land-use change in the past few decades; housing, industry, transport and other economic assets have been created at a large scale in potentially flood-prone areas of the city.[42,43] Large-scale conversion of agricultural lands into residential and industrial areas has led to increasingly waterproofed surfaces (soil compaction), limiting water infiltration during floods.[44] This increases the volume of direct run-off to the city's rivers, further aggravating the risks of overflowing rivers and drainage systems. In addition, although Jakarta is naturally prone to land subsidence, excessive groundwater extraction[45] has further lowered the city's foundations.[46,47] About a third of Jakarta's population still relies on groundwater to meet daily needs. Currently, groundwater extraction, especially for industrial use, is the primary cause of land subsidence in Jakarta.[48] The lack of permeable surfaces in the city also prevents groundwater recharge.[49] This has severely depleted groundwater levels and the storage capacity of aquifers.[50]

41 Padawangi, R., & Douglass, M. (2015). Water, water everywhere: Toward participatory solutions to chronic urban flooding in Jakarta. *Pacific Affairs, 88*(3), 517–550.
42 Budiyono et al. (2016)
43 Abidin et al. (2015)
44 In the last four decades, urban land use in Jakarta has increased by 276%. Source: Garschagen, M., Surtiari, G. A. K., & Harb, M. (2018). Is Jakarta's new flood risk reduction strategy transformational?. *Sustainability, 10*(8), 2934.
45 See https://news.detik.com/berita/d-5306804/35-warga-dki-masih-gunakan-air-tanah-pam-jaya-aspek-lingkungan-terganggu.
46 Wihanesta et al. (2021).
47 Shatkin and Soemarwi (2021).
48 Takagi, H., Esteban, M., Mikami, T., & Fujii, D. (2016). Projection of coastal floods in 2050 Jakarta. *Urban Climate, 17*, 135–-145. https://doi.org/10.1016/j.uclim.2016.05.003.
49 See https://www.wired.co.uk/article/jakarta-sinking.
50 Renaldi, A. (2022). Indonesia's giant capital city is sinking. Can the government's plan save it?. Environment. National Geographic. (July 29, 2022). https://www.nationalgeographic.com/environment/article/indonesias-giant-capital-city-is-sinking-can-the-governments-plan-save-it#:~:text=Jakarta%20is%20now%20sinking%20at,of%20an%20inch%20a%20year.

# 2. Legislative framework

**This section aims to highlight some of the key aspects of the national and local regulatory framework encompassing Jakarta's flood management strategies and the science, technology and innovation landscape.**

The Government of Indonesia operates at three levels, covering provinces, cities and regencies (rural local governments).[51] Governance at each level has specific functions, with the national Government as overarching entity, issuing general directions for plans and policies at the lower levels.[52] The administrative structure of Jakarta[53] is unique: as the city is also an autonomous province, it has the authority to define its own policies and budget allocations.

Indonesia's relevant planning processes primarily focus on development and spatial planning, with the latter also encompassing water management issues.[54] Most planning documents in the country explicitly include sustainable development objectives.[55] The country's governments at the various levels are required to prepare socioeconomic development plans under the National Development Planning System Law (law 25/2004) and spatial plans under the Spatial Planning Act (26/2007).[56] The overarching 2005–2025 Long-Term National Development Plan[57] aims to promote the creation of a developed, self-reliant, democratic and just society with a specific focus on the promotion of agriculture, mining, manufacturing and human resources.[58] It comprises four separate medium-term plans, each with a duration of five years. Currently, the fourth plan (for 2020–2024) is under way,[59] integrating the 17 Sustainable Development Goals (SDGs) and their indicators to shape the country's development agenda. Its primary focus is to promote sustainable infrastructure, human development and better public services and welfare standards.[60]

All provinces must develop a new spatial plan every 20 years. The spatial plans at various levels of government are evaluated on the basis of the three dimensions (economy, environment and society) of sustainability.[61] The Jakarta 2030 Regional Spatial Plan, enacted in 2012,[62] is an ambitious and inclusive plan focusing on rigorous urban planning principles such as protecting green spaces and transit-oriented development.[63] Its goal is to create a safe, pleasant, productive and sustainable city. The spatial plans for the city set out strategies for economic development, a sustainable environment (sustainable transport, energy management, water management, waste management, green areas and biodiversity) and sustainable societies (sustainable housing, inclusive communities, safety and security).[64]

51 See https://www.mlit.go.jp/kokudokeikaku/international/spw/general/indonesia/index_e.html.
52 Sunarharum, T. M., Sloan, M., & Susilawati, C. (2016). Managing Jakarta's Flood Risk after Hyogo: Policy & Plan Analyses. https://www.researchgate.net/profile/Tri-Mulyani-Sunarharum/publication/344442685_Managing_Jakarta's_Flood_Risk_after_Hyogo_Policy_Plan_Analyses/links/5f75f67ca6fdcc00864cf041/Managing-Jakartas-Flood-Risk-after-Hyogo-Policy-Plan-Analyses.pdf.
53 Daerah Khusus Ibukota, or Jakarta Special Region. Source: Sunarharum et al. (2016).
54 Sunarharum et al. (2016).
55 Drestalita, N. C., & Saputra, R. T. (2019). The Jakarta Detailed Spatial Plan evaluation based on sustainable development principles. In *IOP Conference Series: Earth and Environmental Science* (Vol. 340, No. 1, p. 012032). IOP Publishing.
56 See https://www.mlit.go.jp/kokudokeikaku/international/spw/general/indonesia/index_e.html.
57 See https://policy.asiapacificenergy.org/sites/default/files/LONG-TERM%20NATIONAL%20DEVELOPMENT%20PLAN%20OF%202005-2025%20%28EN%29.pdf.
58 See https://www.indonesia-investments.com/projects/government-development-plans/national-long-term-development-plan-rpjpn-2005-2025/item308.
59 See https://policy.asiapacificenergy.org/sites/default/files/LONG-TERM%20NATIONAL%20DEVELOPMENT%20PLAN%20OF%202005-2025%20%28EN%29.pdf.
60 See https://perpustakaan.bappenas.go.id/e-library/file_upload/koleksi/migrasi-data-publikasi/file/RP_RKP/Narasi-RPJMN-2020-2024-versi-Bahasa-Inggris.pdf.
61 Drestalita et al. (2019).
62 Hasibuan, H. S., & Mulyani, M. (2022). Transit-Oriented Development: Towards Achieving Sustainable Transport and Urban Development in Jakarta Metropolitan, Indonesia. *Sustainability, 14*(9), 5244.
63 World Bank. (2011). JAKARTA- Urban Challenges in a Changing Climate. Mayors' Task Force on Climate Change, Disaster Risk and the Urban Poor. https://documents1.worldbank.org/curated/en/132781468039870805/pdf/650180WP0Box360ange0Jakarta0English.pdf.
64 Drestalita et al. (2019).

Flood risk is also addressed in the National Action Plan for Disaster Risk Reduction 2010–2012 by the National Development Planning Agency (Bappenas) and UNDP. Indonesia has initiated linking climate change adaptation, DRR and flood management. In 2017, the Ministry of Environment and Forestry and the National Disaster Management Agency introduced a convergence framework pertaining to adaptation and DRR. This aims to build convergence between DRR and adaptation in five dimensions: policy, institutions, budget, project management and methodology.[65,66] Efforts have also been taken to integrate disaster plans into development and spatial plans,[67] for example by combining hazard and vulnerability maps to evaluate spatial plans to take decisions on land allocation.[68]

The national Government also issues general directions for plans and policies framed at the lower levels for DRR.[69,70] It ratified the Disaster Management Law (DML) in 2007,[71] drawing its approach and principles from the Hyogo Framework for Action (HFA),[72] which elaborates the roles and responsibilities of national Governments and local governments and the obligations of local communities, non-governmental organizations (NGOs), the private sector and donor agencies. In Indonesia, local government bodies must follow DML norms to frame disaster management regulations and systems. The DML also aims to democratize disaster management in the country by engaging diverse actors, making the process more transparent and efficient, and developing and strengthening the country's institutional structure for disaster management.[73] Accordingly, the DML allows local agencies and actors to participate in disaster management by preparing site-, hazard- and vulnerability-specific management systems in addition to enhancing lower-level governance capabilities.[74] It stipulates that disaster financing is the responsibility of both national governments and local ones.[75] Local regulations must also be based on guidelines issued by the National Disaster Management Agency or the Minister of Home Affairs, including guidelines 46/2008, which established the Jakarta Regional Disaster Management Agency.[76]

The national policy agenda prioritizes technology and innovation to strengthen the national system of innovation.[77]

Policies pertaining to science, technology and innovation under the medium-term plan for 2020–2024 are framed under two pillars. Pillar 1 focuses on human development and excellence in science and technology, while pillar 2 emphasizes sustainable economic development.[78] In order to promote downstream innovation and commercialization in the priority economic sectors, the Government is setting up science and technology parks (STPs). The STPs are designed to promote cooperation on research and development between tertiary institutions, research institutions and industry, support innovation-based industry, and develop quality learning services.[79,80] It is not clear whether flood management is a focus area for the STPs.

65 With help from UNDP. See Dwirahmadi, F., Rutherford, S., Phung, D., & Chu, C. (2019). Understanding the operational concept of a flood-resilient urban community in Jakarta, Indonesia, from the perspectives of disaster risk reduction, climate change adaptation, and development agencies. *International journal of environmental research and public health, 16*(20), 3993.

66 The adoption of international frameworks such as the Hyogo Framework for Action, the Sendai Framework for Disaster Risk Reduction 2015–2030 and the SDGs has further helped in mainstreaming DRR and adaptation in development planning (Dwirahmadi et al., 2019).

67 Putra, D. I., & Matsuyuki, M. (2019). Disaster management following decentralization in Indonesia: Regulation, institutional establishment, planning, and budgeting. *Journal of Disaster Research, 14*(1), 173–187.

68 Sutanta, H., Rajabifard, A., & Bishop, I. D. (2010). Integrating spatial planning and disaster risk reduction at the local level in the context of spatially enabled government. *Spatially enabling society: Research, emerging trends and critical assessment, 1*, 56–68.

69 Sunarharum et al. (2016).

70 The introduction of decentralization post-1999 led to the distribution of powers and responsibilities among the national Government and regional and local governments (Putra and Matsuyuki, 2019), including in relation to DRR (Djalante et al., 2017).

71 Mardiah, A. N., Lovett, J. C., & Evanty, N. (2017). Toward integrated and inclusive disaster risk reduction in Indonesia: Review of regulatory frameworks and institutional networks. *Disaster risk reduction in Indonesia*, 57–84.

72 HFA 2005–2015 is a global blueprint for DRR efforts adopted in January 2005 by 168 Member States of the United Nations at the World Conference on Disaster Reduction. Its overarching goal was to build the resilience of nations and communities in relation to disasters. The successor instrument to the HFA is the Sendai Framework for Disaster Risk Reduction 2015–2030, adopted in 2015.

73 Putra and Matsuyuki (2019).

74 Mardiah et al. (2017).

75 Putra and Matsuyuki (2019).

76 Putra and Matsuyuki (2019).

77 Zhongming, Z., Linong, L., Xiaona, Y., Wangqiang, Z., & Wei, L. (2020). Innovate Indonesia: Unlocking Growth through Techno-logical Transformation.

78 See https://www.adb.org/sites/default/files/project-documents/55063/55063-001-rrp-en.pdf.

79 See https://www.adb.org/projects/55063-001/main.

80 Five HEIs have been identified to set up the STPs: Bogor Agricultural University, Bangung Institute of Technology, Gadjah Mada University, University of Indonesia, and Sepuluh Nopember Institute of Technology.

# 3. The Indonesian national system of innovation

Indonesia recognizes the significance of strengthening the elements of the national innovation system and the impacts it could have on national competitiveness.[81]

However, the national innovation system is still in the initial stage of development. It comprises a network of relevant government authorities, private firms, universities, research centres and public institutions that develop, disseminate and deploy new knowledge and technologies[82] for three primary technology users: individuals, industry and government institutions. To promote innovation, the Government mainly focuses on improving human resources, creating facilities, providing institutional and network support, and developing new STPs.[83]

The Ministry of Education, Culture, Research, and Technology is the central ministry responsible for managing education, cultural, research and technology affairs within the Indonesian Government.[84] It formulates policies in science and technology and coordinates the implementation of science and technology policies in higher education institutions (HEIs).[85] The ministry was formed in 2021 by merging the Ministry of Education and Culture with the Ministry of Research and Technology, with the latter responsible for promoting activities in the field of research, science and technology and its powers and responsibilities given to the National Research and Innovation Agency (BRIN). Accordingly, in the present day, BRIN is the principal agency responsible for research and innovation in the country. Following presidential regulations 33 and 78 of 2021, different research institutes[86] and research agencies operating within various ministries have been merged with BRIN, transforming it into a "super-government agency" with an "overarching" role to promote science and technology in the country.[87]

The research and development activities in the country are mainly supported by government funds[88] and undertaken by HEIs, government research agencies and private sector organizations.[89] However, several studies show that the HEIs play the most crucial role in research and development initiatives[90,91] as they have the mandate to manage government and other research funding and allocate it to specific research proposals. They generally also have their own innovation units, such as STPs, to support downstream research and development.[92] While private firms undertake in-house research and development, universities, research institutes and private firms only collaborate on research projects on rare occasions.[93] In addition, while HEIs and public research institutes have access to funds, most of their research and development projects are academic in nature.[94] There are very few Indigenous technologies, and their contribution to industrial development or improved social welfare is limited. Further, spending on research and development activities, both at the macro and the micro level, is seen as inadequate.[95,96]

81 Aldianto, L., & Agustini, E. S. (2011, July). Innovation in Indonesia: The types, the necessary factors, and the national innovation system. In *2011 Proceedings of PICMET'11: Technology Management in the Energy Smart World (PICMET)* (pp.1–10). IEEE.
82 Zhongming et al. (2020).
83 See https://www.nesta.org.uk/report/understanding-innovation-policymakers-indonesia/indonesias-innovation-system-at-a-glance/.
84 See https://www.kemdikbud.go.id/main/tentang-kemdikbud/visi-dan-misi.
85 See https://www.adb.org/projects/55063-001/main.
86 The Indonesian Institute of Sciences, the National Nuclear Energy Agency of Indonesia, the National Institute of Aeronautics and Space and the Agency for the Assessment and Application of Technology.
87 Burhani, A. N., Mulyani, L., & Pamungkas, C. (2021). The National Research and Innovation Agency (BRIN): A new arrangement for research in Indonesia.
88 Lakitan, B. (2013). Connecting all the dots: Identifying the "actor level" challenges in establishing effective innovation system in Indonesia. *Technology in society, 35*(1), 41–54.
89 See https://www.adb.org/projects/55063-001/main.
90 Lakitan (2011).
91 Lakitan (2013).
92 See https://www.adb.org/projects/55063-001/main.
93 Lakitan, B. (2011, June). National Innovation System in Indonesia: present status and challenges. In *Annual Meeting of Science and Technology Studies* (pp.10–12).
94 Lakitan (2013).
95 See https://www.eria.org/uploads/media/5.ERIA_Innovation_Policy_ASEAN_Chapter_4.pdf.
96 See https://www.adb.org/sites/default/files/publication/575806/innovate-indonesia-unlocking-growth.pdf.

On flood-related issues, Indonesia has a long and rich history of undertaking international collaboration to learn and draw resources from global systems of innovation. The Indonesian Government and agencies mobilize both funds and technical expertise from international governments (Kingdom of the Netherlands, Japan, Australia, etc.), agencies (World Bank, Japan International Cooperation Agency, Asian Development Bank, etc.)[97] and the private sector (primarily Dutch firms) to enhance the efficiency of ongoing and proposed flood management projects in the country.[98]

97 See https://www.worldbank.org/en/country/indonesia/brief/jakarta-emergency-dredging-initiative-project-overall-project-scope-and-implementation.

98 Netherlands Water Partnership (NWP). (2020). The Netherlands and Indonesia continue cooperation on coastal protection and urban resilience. https://www.netherlandswaterpartnership.com/news/netherlands-and-indonesia-continue-cooperation-coastal-protection-and-urban-resilience.

# 4. Description of the case

Indonesia is implementing a range of flood risk reduction and management strategies, both at the city and the national level.[99]

Jakarta's strategies can be categorized into three main types:

- Structural/infrastructural/engineering measures, for examplee.g., construction of sea walls and embankments;
- Non-structural measures, such as EWS e.g., early warning systems;
- Initiatives by community organizations, such as e.g., awareness- building and, rescue operations

These are each described in more detail in the sections below.

## 4.1 Structural measures

Most planned flood management initiatives in Indonesia in general, and in Jakarta in particular, have focused on structural or engineering solutions, including building sea walls, dikes, floodgates and canals, as well as dredging and normalizing rivers. Here, the focus is on the NCICD project, including the Giant Sea Wall Jakarta project, and the normalization and naturalization of the local rivers.

### National Capital Integrated Coastal Development and Giant Sea Wall Jakarta projects

The Giant Sea Wall Jakarta project is the city's primary engineering solution for mitigating floods. The initiative is part of the NCICD project, designed to address flooding events in the northern parts of Jakarta.[100] The basic plan of the latter is to close off Jakarta Bay from the sea by constructing a large sea wall.[101] The project was developed by a Dutch consortium led by engineering and consultancy firms[102] and is a collaborative effort between the Indonesian Government and the Ministry for Public Works and Human Settlements at the national level, Jakarta, Banten and West Java at the provincial level, and the Dutch Government (with support from the Dutch embassy in Jakarta).

The main components of the NCICD project are constructing a sea wall in the north of Jakarta Bay, as well as large lagoons as water reservoirs along this wall to store the water from the 13 rivers flowing through Jakarta.[103] In addition, the NCICD project has provisions for creating new land for a new city called the Great Garuda for 1.5 million people through planned seaward expansion and addressing connectivity challenges in West Java and Banten.[104] The initial aim was to complete the works in 30–40 years, with an original planned completion date of 2025.[105] The primary technology used for the project was developed using Dutch expertise in integrated water management systems. In addition to the creation of new land and water reservoirs, the project also aims to address Jakarta's challenges related to drinking water quality, sewage systems and water pollution.[106]

99 Garschagen, M., Surtiari, G. A. K., & Harb, M. (2018). Is Jakarta's new flood risk reduction strategy transformational? *Sustainability, 10*(8), 2934.
100 Climate Policy Initiative. (2021). Assessing Jakarta's Climate Investments. https://www.climatepolicyinitiative.org/wp-content/uploads/2021/11/Assessing-Jakartas-Climate-Investments.pdf.
101 Garschagen et al. (2018).
102 Witteveen+Bos and Grontmij, https://www.dutchwatersector.com/news/groundbreaking-event-starts-work-on-jakartas-ambitious-40-billion-coastal-development-ncicd.
103 See https://kppip.go.id/en/priority-projects/water-sanitation/national-capital-integrated-coastal-development-ncicd-phase-a/.
104 See https://www.witteveenbos.com/projects/ncicd-jakarta/.
105 The project is estimated to cost around USD 41.2 billion (or IDR 598.6 trillion) (see Climate Policy Initiative (2021)).
106 See https://www.dutchwatersector.com/news/details-dutch-seawall-and-development-plan-for-jakarta-bay-well-received-by-indonesian.

The NCICD project was launched after the massive floods of 2013, with plans to implement it in three phases:

- The first phase primarily focuses on strengthening and developing existing coastal dams and constructing 17 artificial islands along Jakarta Bay. It also includes water treatment projects to address local river pollution.[107] This phase was launched in 2014, with construction beginning in 2016
- The second phase was aimed at constructing the West Outer Giant Sea Wall during 2018–2022; however, the project has been facing interruptions[108]
- The third phase involves the construction of the East Outer Giant Sea Wall to mitigate problems due to land subsidence in the east of Jakarta Bay. It also includes the expansion of the port and the development of a new airport.[109] This phase is foreseen to take place after 2023

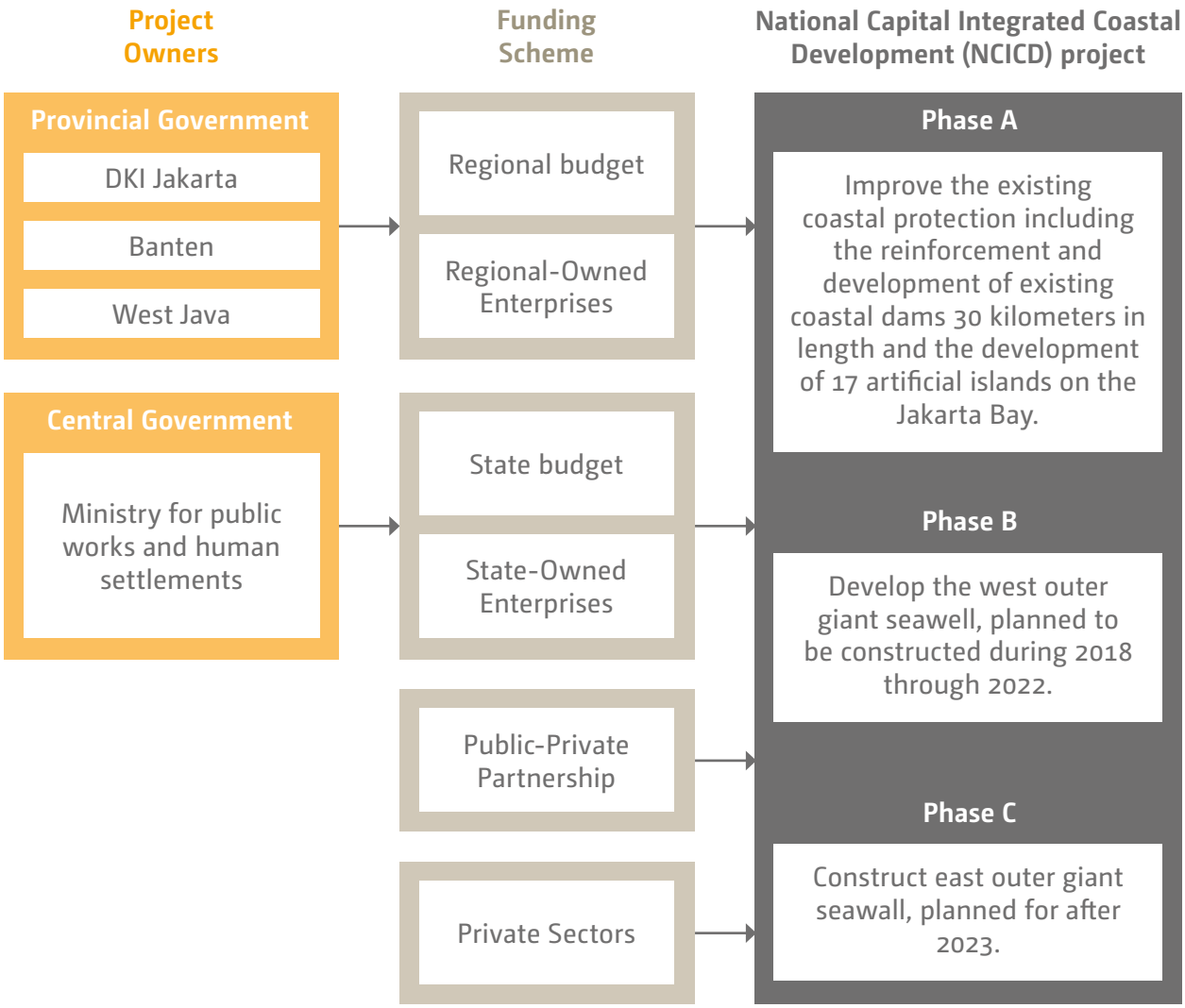
**Figure 2. Three phases of the National Capital Integrated Coastal Development (NCICD) plan.**


Note: A: embankment, B: sea wall west and waterfront city, C: sea wall east[110]

The ambitious plans and investments under the NCICD project, however, have faced substantial delays owing to concerns from environmental and social groups[111] about a lack of required environmental and social safeguards,[112] scenarios showing possible socioeconomic and environmental implications and measures to address any implications that arise.[113] One argument by such groups is that the sea wall will not reduce flood impacts until 2040 unless land subsidence is controlled.[114] The NCICD project recognizes that halting the sinking is imperative to saving Jakarta, but the project does not include measures for addressing land subsidence.[115]

107 See https://www.dutchwatersector.com/news/groundbreaking-event-starts-work-on-jakartas-ambitious-40-billion-coastal-development-ncicd.
108 Kompas. (2019). Anies Minta "Giant Sea Wall" Dikaji Ulang.
109 See https://www.dutchwatersector.com/news/groundbreaking-event-starts-work-on-jakartas-ambitious-40-billion-coastal-development-ncicd.
110 Source: Government of the Kingdom of the Netherlands, NCICD tender document (adapted from Bakker et al., 2017).
111 Octavianti, T., & Charles, K. (2019). The evolution of Jakarta's flood policy over the past 400 years: The lock-in of infrastructural solutions. *Environment and Planning C: Politics and Space, 37*(6), 1102–1125.
112 Climate Policy Initiative (2021).
113 Bakker, M., Kishimoto, S., & Nooy, C. (2017). Social justice at bay: The Dutch role in Jakarta's coastal defence and land reclamation. *Both ENDS.*
114 Takagi, H., Fujii, D., Esteban, M., & Yi, X. (2017). Effectiveness and limitation of coastal dykes in Jakarta: the need for prioritizing actions against land subsidence. *Sustainability, 9*(4), 619.
115 Bakker et al. (2017)

**Figure 3. National Capital Integrated Coastal Development project[116]**




The National Disaster Management Agency of Indonesia has expressed concerns that the project could exacerbate flooding in Jakarta as it might slow the water flow from the drainage system to Jakarta Bay areas.[117] There is also a fear that it could result in a loss of biodiversity in the coastal and mangrove areas, as well as disturb the marine and coastal ecosystem, potentially leading to economic losses in the fishery sector.[118,119] Some of these concerns prompted Indonesian politicians to ask the project team to redesign the initiative.[120] Accordingly, the project design was revised to include five openings in the sea bay for transport and fishing activities. If the city fails to control land subsidence by 2050, the openings will be closed.[121]

Owing to intensifying concerns, the project was halted in 2017 and eventually suspended by the Governor of Jakarta after a re-evaluation in November 2021, which concluded that the negative impacts of the project could outweigh the benefits.[122] Reports suggest that construction activities will be completed as part of the first phase, including raising the existing coastal dam.[123] Despite the project's suspension by Jakarta's local government, the national Ministry of Public Works and Housing is conducting a feasibility study for the second phase of the project.

116 Based on information from the Committee for Acceleration of Priority Infrastructure Delivery website (adapted from Climate Policy Initiative, 2021).
117 Dwirahmadi, F., Rutherford, S., Phung, D., & Chu, C. (2019). Understanding the operational concept of a flood-resilient urban community in Jakarta, Indonesia, from the perspectives of disaster risk reduction, climate change adaptation, and development agencies. *International journal of environmental research and public health, 16*(20), 3993.
118 Dwirahmadi et al. (2019).
119 According to research by the Indonesian Ministry of Maritime Affairs and Fishery in September 2016, the estimated annual economic loss for the fishing communities in Jakarta would amount to IDR 137.5 billion (EUR 9.4 million) (see Bakker et al., 2017).
120 PERMANASARI, E. (2019). Reading Political Insinuation In Urban Forms: Saving The Sinking Jakarta Through Giant Sea Wall Project. *Geographia Technica, 14*.
121 See https://indonesiaexpat.id/featured/jakartas-reclamation-sea-wall-and-land-subsidence-phenomenon-continue-to-spark-debates/.
122 Kompas. (2019). Anies Minta "Giant Sea Wall" Dikaji Ulang. https://megapolitan.kompas.com/read/2019/01/16/16591041/anies-minta-giant-sea-wall-dikajiulang.
123 Climate Policy Initiative (2021).

## Normalization and naturalization of rivers and relocation of communities

The World Bank has been collaborating with the Jakarta city government since 2013 to restore flood management infrastructure (floodways, canals and retention basins) with a view to reducing flood-related losses in the short term.

This includes cooperation under the Jakarta Emergency Dredging Initiative, also called the Jakarta Urgent Flood Management project.[124] Completed in 2019, it had two main components:

- Component 1 focused on dredging and rehabilitating selected flood infrastructure.[125] Fifteen priority segments of floodways,[126] retention ponds and canals were identified for dredging. Embankments were strengthened to increase the water flow and prevent overtopping.[127] The project also included the rehabilitation of around 42 km embankments/sea walls along the canals and retention basins[128]
- Component 2 focused on providing technical assistance for, inter alia, project implementation and management, contract management, engineering design reviews, monitoring and supervision, social safeguards and resettlement plans

For the implementation of the project, the World Bank teamed up with key agencies in Jakarta: the Directorate-General for Water Resources and the Directorate-General for Human Settlements of the Ministry of Public Works. The agencies employed contractors, hired following a competitive bidding process, to carry out dredging and rehabilitation works. The project's overall implementation was coordinated by the Directorate-General for Water Resources, which hired consultants to supervise the work. In order to maintain the designed operational capacities of the flood management infrastructure, the operation and maintenance of floodways is essential. Accordingly, the authorities responsible set up drainage operation and maintenance divisions and increased the funds allocated to them.[129]

The project has led to a considerable improvement in water quality and an estimated reduction in flood-related losses for around 1.7 million people. It also helped to revive the city's flood infrastructure, mostly built in the 1920s, having lost 75% of its water-holding capacity.[130] Efforts were also taken under the project to minimize the impacts of construction and rehabilitation activities on communities, with periodic consultations on this matter undertaken. In regions where the resettlement of communities was unavoidable, land acquisition and resettlement action plans were prepared in consultation with the communities affected.[131] In addition, Jakarta's capacity for flood monitoring and assessment and the planning of measures for operating and maintaining the flood management infrastructure were addressed.[132] Besides other benefits, the project enhanced the project management capabilities of the organizations involved and strengthened coordination between project implementation units at the national and provincial level.

**Figure 4. Ciliwung River after normalization[133]**

124 A floodway is a channel designed to carry the floodwaters of a river. See https://floodlist.com/asia/jakarta-urgent-flood-management-project.
125 The estimated budget of component 1 was USD 176.1 million and the actual cost was USD 111.44 million. (See World Bank. (2019). IMPLEMENTATION COMPLETION AND RESULTS REPORT. Report No: ICR00004907. JAKARTA URGENT FLOOD MITIGATION PROJECT (P111034) https://documents1.worldbank.org/curated/en/153081567169469254/pdf/Indonesia-Jakarta-Urgent-Flood-Mitigation-Project.pdf.
126 The 15 priority regions considered under the project included 11 floodways totalling a length of 67.5 km and four retention basins covering an area of 65 ha.
127 See https://www.worldbank.org/en/country/indonesia/brief/jakarta-emergency-dredging-initiative-project-overall-project-scope-and-implementation.
128 See https://floodlist.com/asia/jakarta-urgent-flood-management-project.
129 See https://www.worldbank.org/en/country/indonesia/brief/jakarta-emergency-dredging-initiative-project-overall-project-scope-and-implementation.
130 World Bank. (2019). IMPLEMENTATION COMPLETION AND RESULTS REPORT. Report No: ICR00004907. JAKARTA URGENT FLOOD MITIGATION PROJECT (P111034). https://documents1.worldbank.org/curated/en/153081567169469254/pdf/Indonesia-Jakarta-Urgent-Flood-Mitigation-Project.pdf.
131 See https://www.worldbank.org/en/country/indonesia/brief/jakarta-emergency-dredging-initiative-project-overall-project-scope-and-implementation.
132 In 2012, a flood management information system was established with a grant of USD 0.5 million from the Kingdom of the Netherlands.
133 Bukit Duri. Napier, J. (2021). Living with Water: Infrastructure and Urbanism in Jakarta. Ecocycles, 7(1), 52–72. See http://real.mtak.hu/129385/1/NAPIER_GALLEY.pdf.

## 4.2 Non-structural and community-centred or -driven efforts

### Early warning systems

The establishment of effective EWS is an important non-structural measure for minimizing losses from floods.[134] EWS have been traditionally used in Indonesia in flood-prone regions. During flood season, communities living near the river take turns to monitor the water level and sound the alarm to nearby inhabitants using a traditional instrument when needed.[135] Currently, EWS in Jakarta operate through television and radio news, mobile phone text messages, water level sirens, warning messenger bicycles with speakers and flood information boards, among other formats. [136]

The Jakarta Regional Disaster Management Agency has introduced many early warning devices for the onset of floods and related weather conditions.[137] The city of Jakarta owns three categories of early warning devices: disaster warning systems, automatic weather systems or weather gauges, and automatic water level recorders. Disaster warning systems are primarily intended to help people living on the riverbanks and alert communities when the water level nears the danger mark.[138]

In addition to government authorities, several NGOs also use EWS.[139] In addition, international agencies and other countries have collaborated with Indonesian authorities and local communities to build the resilience of vulnerable populations to climate change impacts. For instance, the Australian Government and the Australian chapter of children's rights NGO Plan International have been collaborating with Plan Indonesia on building community resilience since 2015.[140] Plan Indonesia engages with local partners, youth and communities to conduct disaster mapping and study the socioeconomic and psychological implications of disasters such as floods. The capacity-building initiatives of Plan Indonesia also include the development of early warning tools using locally available materials (plastic pipes, loudspeakers, cables, etc.). Plan Indonesia and its local partners have also collaborated with the Agency for the Assessment and Application of Technology to augment the performance and maintenance of EWS.

Besides helping people evacuate flood-affected areas and building resilience to climate change impacts, this project has promoted local innovation and engaged local communities and youth in designing a simple and inclusive early warning device. Moreover, because the residents are involved in the installation and operation of EWS, they do not panic when the alarm sounds and know what needs to be done.[141] The partnership also showed that the resources, knowledge and capacities of the local communities and youth could be utilized and built upon to make DRR more inclusive and participatory.[142]

**Besides helping people evacuate flood-affected areas and building resilience to climate change impacts, this project has promoted local innovation and engaged local communities and youth in designing a simple and inclusive early warning device.**

134 Budiyono, Y., Wijayanti, P., Siswanto, S., Aerts, J. C., & Ward, P. J. (2017). Flood risk decrease resulting from Flood Early Warning System in Jakarta. https://www.researchgate.net/profile/Yus-Budiyono-/publication/350353818_Flood_risk_decrease_resulting_from_Flood_Early_Warning_System_in_Jakarta/links/605b4a03a6fdccbfea047666/Flood-risk-decrease-resulting-from-Flood-Early-Warning-System-in-Jakarta.pdf.

135 The *kentongan* (a wooden or bamboo gong). See Budiyono et al. (2017).

136 Bicycles with speakers spreading warning messages. See Lassa, J. A., Sagala, S., & Suryadini, A. (2013). Conceptualizing an established network of a community based flood early warning system: Case of Cawang, East Jakarta, Jakarta. Working Paper No. 3. http://www.irgsc.org/pubs/wp.html.

137 See https://www.preventionweb.net/files/72308_floodearlywarningsystemdevelopment.pdf.

138 See https://news.detik.com/berita/d-4857857/begini-cara-bpbd-dki-sebar-peringatan-dini-banjir-ke-warga.

139 Such as World Vision Indonesia. Source: Lassa et al. (2013).

140 See https://www.preventionweb.net/files/72308_floodearlywarningsystemdevelopment.pdf.

141 The implementation of EWS is not free from challenges. Since most of the disaster management budget is directed towards the creation of physical infrastructure, installation of EWS and building of community resilience is left with very limited financial resources. EWS are only effective when communities trust the alarms or the warnings.

142 See https://www.preventionweb.net/files/72308_floodearlywarningsystemdevelopment.pdf.

## Flood control system using the Internet of Things and artificial intelligence

In order to replace traditional manual flood monitoring and control systems and enhance the efficiency of Jakarta's flood management systems, Jakarta Smart City,[143] in collaboration with the Jakarta Water Resource Service, has developed a flood control system that is based on the Internet of Things and AI. The new system helps to predict potential floods and optimizes flood management activities during a flood, as well as raise general awareness, facilitate government actions and provide real-time flood monitoring data.[144] Various sensors, such as those measuring rainfall, waterflow, water level, temperature and vibrations, have been installed at various critical locations. The data received from the sensors are integrated into one platform, along with historical data. They are then assessed and analysed to generate information on weather conditions, the likelihood of floods and potential solutions for managing the floods, for example. The monitoring and flood prediction data help the Government make data-based decisions and optimize response mechanisms during floods. In the long term, installing these Internet of Things sensors will generate time series of data, making flood prediction and monitoring more precise and scientific. This will in turn enhance the efficiency and impact of government policies and actions.[145] This innovation has been awarded an e-science prize from the World Summit on the Information Society Forum 2022 and an IDC Smart City Asia Pacific Award 2022 for Public Safety.[146]

143 Jakarta is trying to become a smart city by 2025 by using information and communication technology to monitor, analyse and manage the city's resources and maximize public services, provide solutions and support sustainable development. The Jakarta Smart City project was started in 2014.
144 See https://www.aseanwater.net/wp-content/uploads/2022/08/Flash-Flood-System-in-Indonesia-1-2.pdf.
145 Sensor Flood Control. (2022). Smartcity. https://smartcity.jakarta.go.id/id/blog/mengintip-sensor-flood-control-system/.
146 Flood Control System Jakarta Menang Ajang Bergengsi Tingkat Dunia WSIS Prizes 2022. (2022). beritajakarta.id.


© pexels / fauxels

# 5. Assessment of the case functions

This section aims to understand how the flood management strategies in Jakarta have contributed to the establishment of systemic innovation functions and strengthened Indonesia's NSI.

The assessment of the case consists of a structure–function coupled assessment that was conducted for the strategies discussed in section 4 above to underscore how they have facilitated the delivery of systemic functions by enhancing the structural elements of the NSI. For better reference, the table 2 describes the systemic functions of systems of innovation.[147] Key and no-key functions have been included in the analysis.

**Table 2 Functions of systems of innovation[a]**

| Number | Function | Description |
|---|---|---|
| **F1** | Knowledge development and diffusion | Expansion and intensification of the knowledge base of the innovation system, dissemination of knowledge among actors in the system, creation of new combinations of knowledge |
| **F2** | Entrepreneurial experimentation | Designing business models for emergent technologies and knowledge, practices of uncertainty reduction through experimentation with new technologies, applications and strategies |
| **F3** | Market formation | Creation of a space or an arena in which goods and services can be exchanged between suppliers and buyers. Includes processes related to definition of demand and choices, positioning (pricing, segmentation) of products, regulation of standards and the rules of exchange |
| **F4** | Influence on the direction of search | Processes that influence the direction of research of firms and other actors; that is, which technologies they explore, which problems or solutions they choose to invest in, where they channelize their resources from, etc. |
| **F5** | Resource mobilization | Processes by which the system acquires the resources required for innovation, which could be financial and human resources (workforce and capabilities), complementary assets such as infrastructure, etc. |
| **F6** | Legitimation | Mechanisms by which an emergent technology, its developers and the TIS in question attain regulative, normative and cognitive legitimacy as viewed by the stakeholders concerned |
| **F7** | Development of positive externalities | Creation of system-level utilities (or resources), such as pooled labour markets, complementary technologies and specialized suppliers, which are also available to system actors that did not contribute to building them up |

[a] Adapted from Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S., & Rickne, A. (2008). Analyzing the functional dynamics of technological innovation systems: A scheme of analysis. Research policy, 37(3), 407-429.

**Knowledge development and diffusion:** Indonesia has tapped into the global innovation system, as well as international expertise and resources, to devise and implement flood management strategies. Several collaborative projects and initiatives have been or are being undertaken by bilateral or multilateral experts and donor agencies. In its efforts to manage floods, Jakarta has been generating a considerable amount of diverse data and knowledge,[148] mostly in collaboration with international partners. It is noteworthy that, for each project, efforts have been made to create specific networks of actors[149] or mini-innovation systems. Each time, this has led to new knowledge and skills development. In addition, the Government undertakes studies and surveys to assess the causes of disasters and the impacts of DRR mechanisms put in place, crediting increased awareness and preparedness among flood-prone communities.[150]

147 TEC (2023).
148 For instance, hydraulic modelling, flood hazard mapping (to predict floods and study the resulting impacts and losses), assessment of flood-related infrastructure, spatial zoning studies, land subsidence analysis, and assessment of contingency plans.
149 Such as funders, technology providers, project implementors, interfaces between communities and markets, and coordinators between institutions and agencies.
150 Djalante, R., Garschagen, M., Thomalla, F., & Shaw, R. (2017). Introduction: Disaster risk reduction in Indonesia: Progress, challenges, and issues. *Disaster risk reduction in Indonesia*, 1–-17.

This knowledge generation has led to the identification of effective strategies for better risk management, such as use of forecasting tools, EWS and raising of awareness among communities. The knowledge generated has also been continuously shared with relevant stakeholders, including local communities, as part of capacity-building and awareness-raising initiatives. The country has also augmented its institutional and technological capacity by setting up organizations and systems to provide early flood hazard warnings. Moreover, the institutions have graduated from only focusing on the material impacts of flooding to considering how people's lives are impacted socially, particularly looking at the social conflicts and challenges faced by displaced communities. However, the country still needs to develop and strengthen a culture of safety, preparedness and resilience by further improving risk knowledge, training and preparedness drills at the local level, with a focus on vulnerable communities.[151]

**Entrepreneurial experimentation:** Much entrepreneurial foresight and pragmatism have been employed to design and implement flood management projects. For instance, as part of the Giant Sea Wall Jakarta project, different private firms (local and international) were responsible for different components of the project. This resulted in transparent procedures, making the processes easier to regulate. In addition, multiple funding sources were utilized to generate significant resources for large projects such as funds from the Dutch, Australian, Japanese and Indonesian Governments as well as private sector funds from different countries. This not only helped to generate the scale of funds required but also distributed risks and ownership among actors. Furthermore, within project consortiums, partners have specific roles to play and contributions to make. For instance, for the Giant Sea Wall project, funding was sourced from the Dutch Government and technical expertise from Dutch firms, and the World Bank carried out modelling and scientific assessments. On the Indonesian side, national and provincial government agencies provided legislative backing and operational structure to the overall project and local contractors were engaged in the execution of the project. The design of the Giant Sea Wall Jakarta project included provisions for developing shopping malls, skyscrapers, luxury flats and other attractions in order to attract private investment.

**Market formation:** Market creation has not been an explicit objective of the initiatives. However, efforts have been made to create market opportunities through private sector participation in the implementation of flood management activities, including through private investments and competitive tendering procedures.

**Resource mobilizsation:** Most of Jakarta's flood management initiatives are undertaken collaboratively with national and international actors as joint projects or public–private partnerships. International partners (including international private sector actors) help to provide or mobilize funds and technical know-how, which are limiting factors in Indonesia. Nonetheless, central and provincial governments have also invested in the projects. Funds coming from international sources are in the form of loans, investments and development assistance, for example. For the NCICD project, the huge financial requirements made private sector investment indispensable, resulting in the creation of public–private partnership models. However, inadequate funds allocated to the operation and maintenance of flood infrastructure by the responsible ministries at the central and provincial level have resulted in suboptimal performance.[152] Funds could also be used more efficiently to ensure the completion of projects. The Government employs an entrepreneurial outlook when it comes to project planning and implementation and engages in projects as a trusted investment partner.

**Influence on the direction of search:** Given that recurrent floods are result in a significant policy and socioeconomic challenges, and an elaborate legislative framework is already in place, the primary driver of research and innovation is flood-related legislation in the country. The direction of the search is also influenced by the involvement of international partners with specific knowledge, skills, and perceptions ideas regardingon how to deal with urban floods and their interactions with local actors. The potential massive and long-term impacts on the lives and livelihoods of the local population, especially vulnerable communities, also impacts the ongoing research in the country, directly and indirectly. For instance, the impacts of floods on people's daily lives trigger innovation at both at the informal (e.g. , local people) and the formal levels (universities, research and development R&D institutes) to devise solutions to help communities respond better to flood-related challenges and recover faster from losses incurred.

151 Djalante et al. (2017).
152 World Bank (2019).

**Legitimation:** The country's elaborate legislative framework drives and regulates Jakarta's flood management activities. In addition, government and donor agencies and other international partners undertake serious efforts to raise awareness of their activities among, and promote their acceptance by, local communities. Government agencies organize technical consultations, road shows, sessions to collect information, and focus group discussions with local communities and other relevant stakeholders to enhance credibility of and public participation in their activities. For instance, public input into the framing of the spatial plan for Jakarta to distribute people and activities was gathered over a three-month period using both traditional methods of stakeholder consultation and a dedicated website created to publicize the draft plan and seek suggestions from the public.[153] However, the extent to which public opinion was actually considered in finalizing the plan, and hence the effectiveness of the stakeholder consultations, is debated.[154] This has also turned out to be a challenge for the Giant Sea Wall Jakarta project.

Capacity-building and awareness-raising programmes being undertaken by Indonesian agencies also, directly and indirectly, lend credibility to the Government's flood management activities. Such programmes inform communities about government projects and enhance communities' adaptive capacity and preparedness, making it easier to implement projects with less resistance from local people. In many cases, when the authorities anticipate social tension or unwillingness among local actors to participate in projects, non-State actors such as NGOs, local leaders and capacity-building organizations are roped in to act as an interface between the Government and the local population. The creation of economic opportunities and benefits such as shopping malls and new housing also contributes to the legitimation of flood management projects.

**Development of positive externalities:** The various awareness-raising, community preparedness programmes, as well as measures for building the capacity of institutions, government agencies and private sector firms, have several co-benefits leading to better management of floods in the city. Interactions between different stakeholder groups have led to stronger networks for promoting innovation. Infrastructure development for flood management has to improve water management systems and the cleanliness of rivers and drinking water, for example.

The table 3 below presents the summarized findings of the structure-function analysis of Jakarta's flood management initiatives.

153 See http://indonesiaurbanstudies.blogspot.com/2010/02/the-flawed-planning-process-of-2030.html.
154 World Bank (2011).

© Yamironi Sardi / iStock

## Table 3. Structure–function coupled assessment of Jakarta's initiatives

| Function[a] | | Structural element | Jakarta's interventions |
|---|---|---|---|
| **F1** | Knowledge development and diffusion | Actors | • Studies and surveys undertaken by Indonesian agencies, independently and in collaboration with international organizations, have generated a large amount of knowledge and developed skills in flood management<br>• Capacity-building, awareness-raising and knowledge diffusion have contributed to communities becoming more informed about, aware of and capable in flood management (e.g. enhanced local forecasting of floods; improved community knowledge of what needs to be done before, during and after a flood)<br>• The urgency of managing floods has led to local innovation and development of adaptive mechanisms (e.g. EWS; coping strategies, such as storage of food and water, during floods )<br>• NGOs and local bodies have promoted local innovation in flood management |
| | | Institutions[b] | • Policy and programme implementation, and surveys and studies undertaken by institutes, have enhanced the know-how and skills of communities |
| | | Interactions | • Interaction with international partners has led to significant learning regarding institutional development, project management, stakeholder coordination, monitoring of progress, evaluation of outcomes, etc.<br>• Indonesia's multi-level governance structure has led to enhanced collaboration among organizations |
| | | Infrastructure | • Both the public and private sectors in Jakarta have enhanced their skills and know-how on infrastructure development |
| **F2** | Entrepreneurial experimentation | Actors | • Project consortiums have been formed on the basis of the types of resources and skills required for the implementation of specific projects<br>• Investment-intensive, long-term projects have been modelled on public–private partnerships<br>• Each partner and other actors have been assigned a specific role in projects |
| | | Institutions[b] | • Public sector participation in projects has ensured legislative support and addressed risks to investment by the private sector |
| | | Interactions | • Investment-intensive projects have engaged private sector actors |
| | | Infrastructure | • Not applicable |
| **F3** | Market formation | Actors | • Not applicable |
| | | Institutions[b] | • Government authorities have participated in projects to create an investment-friendly setting and encourage the use of competitive procurement procedures |
| | | Interactions | • Establishment of project partnerships and interaction with international project partners have created business opportunities for local industries, as well as firms and contractors |
| | | Infrastructure | • Some infrastructure projects have focused on market formation through competitive tendering for flood management activities<br>• Jakarta Smart City and Jakarta Water Resource Service have developed a flood control system based on the Internet of Things and AI |
| **F4** | Influence on direction of search | Actors | • Funding agencies, international project partners and others have influenced the direction of the search<br>• Local communities have come up with innovative solutions for managing flood impacts<br>• NGOs have engaged in local innovation projects |
| | | Institutions[b] | • Legislation and policies have been shown to be the primary determinant for institutional research and development and innovation in the city and country |
| | | Interactions | • Interactive learning with project partners has influenced the search |
| | | Infrastructure | • The need for constructing new infrastructure and improving existing infrastructure has guided the initiatives |

[a] See the Table 2 for the description of functions.
[b] References to institutions as a structural element in this table are to systems of formal and informal rules.

## Table 3. (continued) Structure–function coupled assessment of Jakarta's initiatives

| Function[a] | | Structural element | Interventions in the Brazilian ethanol innovation system |
|---|---|---|---|
| **F5** | Resource mobilization | Actors | • Government agencies have mobilized funds and technological support from project partners (including international agencies, foreign governments and private sector firms)<br>• International firms have provided large-scale funding, making projects financially viable and helping leverage funding from other sources |
| | | Institutions[b] | • Not applicable |
| | | Interactions | • Interaction with potential funders and technology or knowledge providers has helped mobilize resources |
| | | Infrastructure | • Not applicable |
| **F6** | Legitimation | Actors | • Capacity-building and awareness-raising activities, as well as consultation, focus group discussion and negotiation with stakeholders, have been undertaken to create credibility and acceptance of the initiatives |
| | | Institutions[b] | • Institutions have played a primary role in generating credibility for government actions |
| | | Interactions | • Interaction with local communities aimed at understanding their needs, challenges and recommendations for addressing floods has been promoted to build trust and confidence |
| | | Infrastructure | • The Giant Sea Wall project included provisions for the development of residential estates, malls, etc. |
| **F7** | Development of positive externalities | Actors | • Development of more aware and capable stakeholders<br>• Plan Indonesia has explicitly addressed youth in strengthening community resilience |
| | | Institutions[b] | • Institutions involved in flood management activities have developed capability, knowledge and experience that can be applied in their other projects |
| | | Interactions | • Interaction with international and local partners has led to more business and employment opportunities for these local partners<br>• New technologies and best practices have been employed |
| | | Infrastructure | • New infrastructure and better water management systems, including canals and drainage, have been created in the process of implementing initiatives, and these have provided co-benefits such as pollution abatement, positive health impacts and aesthetic gains<br>• The Giant Sea Wall project included provisions for the creation of new land and the development of residential estates, malls, etc., which enhanced the attractiveness of investment in the project |

[a] See the Table 2 for the description of functions.
[b] References to institutions as a structural element in this table are to systems of formal and informal rules.

# 6. Role of the Jakarta's urban flood management activities in Indonesia's nationally determined contribution

**The programmes and strategies outlined in Indonesia's nationally determined contribution (NDC) have elaborate adaptation goals, including goals related to flood risk management.**[155]

Some of the adaptation strategies listed affect flood management directly, such as sustainable agriculture, integrated watershed management, reduction of forest deforestation and degradation, and land conversion. Some of the social and livelihood resilience strategies that have a bearing on mitigating flood risks include enhancing adaptive capacities, building community capacity, facilitating communities participation in local planning processes, implementing disaster preparedness programmes and identifying highly vulnerable areas. Primary ecosystem resilience measures with flood hazard management aspects include coastal protection and ecosystem restoration measures.

Almost all strategies listed in the NDC are an integral part of Jakarta's overall flood management strategy. Building on the country's NDC, the Jakarta government is trying to minimize the risks and impacts of flooding on all development sectors by, for example, building actor capacities, generating knowledge, managing and implementing policies.[156] Some measures, such as mangrove development and integrated water management, contribute to both the adaptation and the mitigation components of the NDC.[157] Thus, Jakarta's efforts to manage floods positively contribute to the country's objectives, as stated in its NDC.

**Almost all strategies listed in the NDC are an integral part of Jakarta's overall flood management strategy.**

155 MoEF. (2021). Updated Nationally Determined Contribution Republic of Indonesia. https://unfccc.int/sites/default/files/NDC/2022-06/Updated%20NDC%20Indonesia%202021%20-%20corrected%20version.pdf.
156 https://unhabitat.org/sites/default/files/2020/06/ndc_guide_19062020.pdf.
157 Basuki, T.M.; Nugroho, H.Y.S.H.; Indrajaya, Y.; Pramono, I.B.; Nugroho, N.P.; Supangat, A.B.; Indrawati, D.R.; Savitri, E.; Wahyuningrum, N.; Purwanto; et al. Improvement of Integrated Watershed Management in Indonesia for Mitigation and Adaptation to Climate Change: A Review. Sustainability 2022, 14, 9997.

© pexels / Tom Fisk

# 7. Key success factors and lessons learned

**While Jakarta's experience shows both strengths and weaknesses in its flood management, one feature that stands out is that the various levels of government in the country have made significant efforts to develop a robust policy framework for addressing flood risks.**

However, since the decentralization of governance in the country, public-led groups have become aware of their right to question government-driven planning processes. Consequently, one of the possible explanations for observed implementation gaps and, at times, suboptimal outcomes, is that public opinion and government planning are not yet harmonized.[158]

Some of the critical success factors and lessons that can be learned from Jakarta's experience are presented in the remainder of this section.

## Integrated, collaborative governance is crucial:

Flood prevention and control is a complex issue involving several interconnected disciplines and actors operating at multiple levels of society. Consequently, the role of government in bringing together multi-level stakeholders with diverging perspectives and building synergies among them becomes crucial. The Indonesian Government recognizes this and is taking steps to foster synergies among actors and at various levels of governance through stakeholder interaction and adaptive policymaking. Flood management in the country is transitioning towards a more adaptive and integrated system.[159] Authorities realize that one of the most effective strategies to avoid project ambiguities, delays and failures is to design integrated projects that promote the collaboration of policymakers, experts and communities throughout the planning and implementation phases. Such an approach to project design can also compensate for some resource deficits and make policies more effective in the long term.[160] However, in order for this to work effectively, the Government needs to improve collaboration and coordination between agencies and authorities to enhance the effectiveness of flood governance.[161] Furthermore, although Indonesia is already decentralizing flood governance, the capacities of local agencies and the resources available to them must be boosted because it is the local authorities who best understand the local context and vulnerabilities and are the first to respond to local events.

## Complex problems require a portfolio of strategies:

Jakarta's situation makes it evident that complex problems such as urban flooding cannot be solved through magic bullet strategies. Managing flood-related challenges, especially in a developing country context, requires an assortment of measures. Accordingly, Jakarta's response has included sea wall construction, river dredging, water management, community preparedness projects and capacity-building, all operating at different levels and targeting different parts of the problem while keeping in mind the time scale needed for each intervention to produce optimal results. Agencies have been trying to strike a balance between technical and sociocultural strategies to reduce flood risk, alongside implementing measures to enhance preparedness for and recovery from the impacts when flooding does occur. Furthermore, in addition to planning for extreme flooding events, agencies are also trying to focus on 'everyday' problems and structural issues (e.g. land subsidence, excessive groundwater extraction, regular flooding of roads and residential areas, and insufficient clean water resources), which could be the underlying, root causes of extreme flooding events. Although there is a need for more urgent and comprehensive action by the authorities to avert severe losses, there is also recognition of the merits of keeping in mind the bigger picture and using major disasters as a learning opportunity to assess underlying causes, impacts and potential solutions.

158 Silver, C. (2014). Spatial planning for sustainable development: An action planning approach for Jakarta. *Jurnal Perencanaan Wilayah dan Kota, 25*(2), 115-125.
159 Wicaksono, A., & Herdiansyah, H. (2019). The impact analysis of flood disaster in DKI jakarta: prevention and control perspective. In *Journal of Physics: Conference Series* (Vol. 1339, No. 1, p. 012092). IOP Publishing.
160 Silver (2014).
161 Dwirahmadi et al. (2019).

## Future risk assessment and long-term planning is vital:

Two crucial lessons in terms of development planning can be drawn from Jakarta's experience. First, planning processes must be thoroughly synchronized with projections, scenarios and granular information on the socioeconomic and environmental trends for the present and future so as to minimize the impacts and efficiently utilize the resources. This is even more relevant given recent advancements in climate science and improvements in the precision of various socioeconomic modelling tools. The development of urban centres and infrastructure is a self-propagating process that often leads to lock-in and path dependency. The choices made regarding investment in and the design of modern cities (concerning buildings, mobility, waste management, water management, etc.) largely define their vulnerabilities and resilience in the future. Therefore, to avoid unmanageable situations where available technologies, knowledge and adaptation measures seem inadequate and ineffective in addressing the challenges, it becomes vital that development planning is based on future risk assessment.

The second lesson is that the actors involved in planning and implementing flood mitigation and adaptation strategies must have a flexible, adaptive outlook and continuously build their knowledge, skills and resource base. Learning could be based on past experience (both successes and failures), changing vulnerabilities and evolving knowledge domains (including the development of new solutions through the application of new technologies, processes and methods), as well as the acknowledgment that different kinds of capabilities are required to address flood-related challenges. Those in charge of planning and implementing strategies need to be convinced that there could be several solutions to one problem, and iterations, cancellations and adjustments are sometimes necessary and pragmatic.

## Convergence of DRR, climate change adaptation and development processes is crucial:

There is significant overlap and complementarity between DRR, adaptation and development in terms of expertise and policy goals, particularly in the context of flood risk management.[162] Integrating strategies to achieve DRR, adaptation and development avoids the duplication of expenditure, the implementation of disconnected policies, and institutional conflict.[163] Recognizing the value of inclusive and integrated management of its flood-related issues, Indonesia has launched a DRR–adaptation convergence framework and is aiming to mainstream urban planning in development processes. The idea behind this framework is to foster synergies across the DRR, adaptation and development domains with respect to policymaking, institutional involvement, budget-setting, project management and methodology development. However, achieving convergence is quite complicated as collaboration – across sectors, actors and levels of governance – must be promoted.[164] Convergence is particularly challenging at the local government level.[165]

## Community preparedness and engagement of local communities goes a long way

Communities that are aware, informed and alert with regard to flood risks are more prepared and capable of responding to those risks. Recognizing this, relevant authorities in Jakarta have been making a significant effort to enhance community preparedness and awareness. Government agencies, at times in collaboration with NGOs, are helping vulnerable communities to develop the ability to learn from previous floods, take action against flood risks, and prepare for future floods. For instance, agencies are engaged in raising awareness about flood forecasting, EWS and safe evacuation. Local communities are being engaged in developing and implementing customized EWS, which, besides leading to local innovation and capacity-building, is also helping to create trust and ownership among local people. Awareness-raising campaigns are also being run to influence community behaviour related to water quality management, and waste disposal, for example to address the dumping of solid waste into rivers, which leads to their decreased water-holding capacity.

162 Dwirahmadi et al. (2019).
163 Mardiah et al. (2017).
164 Dwirahmadi et al. (2019).
165 Putra and Matsuyuki (2019).

## Context-specificity of knowledge has implications for knowledge and technology transfer outcomes:

Indonesia has a long history of collaborating with the Dutch Government and the Dutch private sector on flood mitigation projects. The flood management strategies of Dutch cities such as Amsterdam and Rotterdam have influenced Indonesia's flood management and city planning models. However, even though there is much for Jakarta to learn from the Netherlands concerning flood management, it must be noted that the two places are climatically, socioeconomically and demographically very different.[166] They are contextually dissimilar and are at with respect to their adaptation strategies and coping mechanisms.[167] Some experts argue that attempts at replicating the Dutch flood management system (which, like the Indonesian system, has evolved over time) do not suit Jakarta's geography. Therefore, the benefits of knowledge exchange can only be maximized when the exchange takes into account the local context.

166 Al Skaff, S. (2022). Resilience Through Public Spaces:"Transforming Vulnerability into Opportunity". In *Innovations in Green Urbanization and Alternative Renewable Energy* (pp. 67-76). Springer, Cham.

167 Aerts, J., Major, D. C., Bowman, M. J., Dircke, P., & Aris Marfai, M. (2009). Connecting delta cities: coastal cities, flood risk management and adaptation to climate change.


© Cecep Rahmat / iStock

# 8. Good practices

**On the basis of the lessons learned from the Jakarta case study, the following good practices for flood (and, more broadly, disaster) management have been identified, which could lend themselves to application in other countries and contexts.**

- On the basis of the lessons learned from the Jakarta case study, the following good practices for flood (and, more broadly, disaster) management have been identified, which could lend themselves to application in other countries and contexts. The management of urban floods (and, more broadly, natural and climatic disasters) requires action at different levels of governance, across diverse sectors and by various actors, taking into account different vulnerabilities and coping capabilities. There is no magic bullet that addresses this complexity effectively and comprehensively. Rather, it requires a vision with a foundational policy buttressed by a portfolio of strategies, including those relating to impact abatement, adaptation mechanisms, community preparedness, knowledge generation, science and technology innovation, network- and partnership-building, and resource generation. The strategies could be implemented with a programmatic approach, as projects guided by the umbrella policy goal and local development priorities.

- Design and develop adaptive governance structures: Adopting a flexible, adaptive and collaborative governance approach is crucial to addressing challenges such as floods and other environmental disasters because both causes and vulnerabilities are evolving. The approach should consider emerging knowledge, data, experience, incentive mechanisms, power structures, community needs and institutional designs rather than relying on top-down, fixed structures.

- Apply long-term planning that takes into account projections and future risks: Since the causes of environmental challenges and the factors determining their impacts are evolving, it is crucial that long-term flood (and broader disaster) management strategies are based on long-term projections of demographic and socioeconomic developments, local risk and vulnerability assessments, climate change scenarios and other significant drivers of the disaster type in question.

- Ensure participatory governance is in place and engage local communities: Jakarta's experience clearly shows that participatory governance, the decentralization of roles and responsibilities across agencies, and community-based coping strategies are essential for effective disaster management. A combination of top-down with bottom-up approaches will lead to strategic processes for disaster management and enhanced stakeholder engagement. In addition, concerted efforts to build the capacities of all potential stakeholders (ranging from national institutions to local communities) and consider their diverse perspectives in the planning and implementation phases of a project will render that project collaborative and increase ownership. Tapping into the respective capabilities of different actors also makes the disaster management activities more resource-efficient and productive (e.g. development of local EWS).

- Integrate DRR, climate change adaptation and sustainable development for holistic gains and efficient governance: The management of environmental challenges and natural disasters has significant overlaps with the management of development processes. Moreover, DRR and adaptation are complex, resource-consuming processes, so it is logical and efficient to integrate them into long-term development – including sustainable development – agendas and plans. Doing so also helps address the underlying causes of environmental challenges and abate community vulnerabilities. The synergies between DRR, climate change adaptation and development can be fostered and realized through integration of specific strategies, collaboration across actors, capacity-building and innovation.

- Build networks and partnerships that are relevant to the competencies and resources required Different disaster management strategies need different skills, resources and governance tools to engage and target different actors. Therefore, it is crucial that relevant networks are created for each strategy, which will bring in the right actor groups, capabilities, funding mechanisms, policy frameworks and governance structures. Partnerships could be designed keeping in mind a project's specific needs (e.g. private actors can be brought in to meet investment requirements and share risks). Resources and capabilities can be sourced from local, national and international innovation systems.

© Pexels / Tom Fisk

TEC

## About the Technology Executive Committee

The Technology Executive Committee is the policy component of the Technology Mechanism, which was established by the Conference of the Parties in 2010 to facilitate the implementation of enhanced action on climate technology development and transfer. The Paris Agreement established a technology framework to provide overarching guidance to the Technology Mechanism and mandated the TEC and CTCN to serve the Paris Agreement. The TEC analyses climate technology issues and develops policies that can accelerate the development and transfer of low-emission and climate resilient technologies.


## Acknowledgements

The Technology Executive Committee extends its appreciation to Dian Phylipsen of SQ Consult, Heleen de Coninck and Clara Caiafa of Eindhoven University of Technology, Ambuj Sagar and Nimisha Pandey of Indian Institute of Technology Delhi, for their development of this report. It also extends its appreciation to the representative of observer organizations participating in the TEC activity group.


## Contact Details


The Technology Executive Committee may be contacted through the United Nations Climate Change Secretariat

Platz der Vereinten Nationen 1,
53113 Bonn, Germany
Email: tec@unfccc.int

Website: www.unfccc.int/ttclear/tec

UN Climate Change Technology Linkedin Group:
https://www.linkedin.com/groups/14126588/


**#climatetech #TEC tclear/tec/NSI.html**




A digital copy of this report can be downloaded from:
https://unfccc.int/ttclear/tec/NSI.html