

INFRAVISION COMPETITION 2026: INFRASTRUCTURE AS A SYSTEM

INTEGRATING MULTI-SCALAR WATER,
WASTE AND SANITATION SYSTEMS IN
KAMPUNG CANGKOL, INDONESIA

Jayden Holmes

University of Sydney
Master of Urban Design



THE CHALLENGE

According to current UN estimates, over 1 billion people globally live in informal settlements – a number that is continues to grow in rapidly urbanising centres like Cirebon, Indonesia. These communities typically lack basic water, sanitation, and waste infrastructure, leaving residents exposed to communicable (i.e. gastroenteric) diseases and climate hazards, while their unrecognised legal status leaves them perpetually vulnerable to eviction or neglect.

These urban environments present a critical infrastructure turning point: climate constraints intensify risk, yet conventional planning (designed for formal, stable, legally-secure contexts) cannot simply be scaled down and applied here. Kampung Cangkol in Cirebon demands infrastructure that performs under deep uncertainty: uncertain tenure, uncertain funding, uncertain climate trajectories. The challenge is delivering essential services today while remaining adaptable to whatever recognition, regulation, or resources tomorrow brings.



PROJECT VISION AND VALUE CREATION

This project proposes an integrated infrastructure upgrade of Kampung Cangkol, an informal settlement of approximately 9,000 residents in Cirebon, Indonesia, addressing intersecting water, sanitation, and waste challenges that will intensify under climate change, particularly coastal flooding and sea-level rise.

Rather than introducing a single discrete asset, the project works with what already exists – strengthening community networks, informal water and drainage systems, and existing service infrastructure – while strategically filling critical gaps. Modular wetland systems for blackwater treatment exemplify this approach: low-cost, decentralised, and scalable interventions that can be implemented incrementally and adapted as the settlement evolves. This flexibility is essential given the precarity of informal settlements, which often exist in a legally ambiguous space subject to shifting government recognition. Infrastructure in these contexts must be resilient to political as well as environmental change.

Critically, the project connects physical works to policy and governance, embedding local interventions within regional and catchment-scale integrated water management strategies. This ensures upgrades are not isolated fixes but contribute to citywide water security and climate adaptation planning.

The value created is multi-scalar. For residents, it delivers improved sanitation, reduced flood exposure, and better public health outcomes, offering a pathway out of poverty and unsafe living conditions. For Cirebon more broadly, addressing wastewater and solid waste at the source reduces plastic and waste dumping along the Java Sea shoreline, improving coastal water quality. This, in turn, supports the revival of traditional fishing livelihoods, linking urban upgrading directly to environmental restoration and regional economic resilience and demonstrating that informal settlement infrastructure investment generates benefits well beyond the settlement's boundaries.

PROJECT CONTEXT



This project is based on field work and analysis undertaken for PLAN9049 'Global Foundations of Informal Urbanism', also known as 'Global Studio Indonesia', as part of the Master of Urban Design at the University of Sydney.

The program was offered as a collaborative intensive between University of Sydney and Institut Teknologi Bandung (ITB) from 8 to 18 November 2025.

Direct site visits were undertaken in Kampung Cangkol, Cirebon, as part of the program. Methods of data collection included transect walks to map patterns, geotagged photos, and conversations with community members and leaders, as well as government officials.

While data collection occurred in groups, the findings and ideas presented in this proposal are my own (unless otherwise credited). I acknowledge the deep community knowledge, as well as insights from the teaching team at ITB and the University of Sydney, which has informed my approach.



• Metro
Bandar
Lampung

Java Sea

Tangerang • Jakarta

BANTEN

• Bandung

WEST JAVA

• Cirebon

• Tegal

• Jepara

• Semarang

CENTRAL JAVA

• Tuban

Madura Island

• Surabaya

Sidoarjo

EAST JAVA

Madiun

SPECIAL REGION
OF YOGYAKARTA

• Cilacap

• Purwokerto

• Kediri

Tulungagung

• Malang

• Situbondo

• Jember

• Banyuwangi



DEMOGRAPHICS

- Area = 8.56 km²
- Population = 8,959 residents
- Relatively high population density compared to the broader Kota Cirebon.
- Comprises local neighbourhood units known as *rukun warga* (RW) 5, 6 and 7.

CONTEXT

- Functions as a fishing village with enduring cultural and economic ties to the sea.
- Experiencing progressive land reclamation, often using plastic and textile waste as fill material.
- Most downstream point of the Cimanuk River, which exits to the Java Sea at RW6, shaping local hydrology and land use.
- Prone to flooding due to flat topography, sinking soil, seawater ingress and drainage issues.
- Highest open defecation rate in Kota Cirebon.

KEY STRENGTHS

- Evidence of existing communal water infrastructure such as communal water tanks connected to bore wells (one tank generally connected to five households).
- Evidence of existing communal sanitation infrastructure such as communal septic tanks recently installed by ITB.
- 'Takakura' system - household scale composting and urban farming practices in place.
- Household and communal aquaculture practices - replacing traditional fishing which is no longer possible due to coastal pollution.



KEY CHALLENGES

- Design failures such as broken water pumps and septic tanks installed without access manholes.
- Open sewage systems connected to general drainage network, which is regularly blocked due to excessive litter (exacerbating impacts of flooding and exposure to disease-causing pathogens in human excrement).
- Maladaptive land reclamation practices using plastic and textile wastes are exacerbating climate vulnerabilities and environmental contamination, resulting in loss of local livelihoods and cultural practices (i.e. fishing).
- Downstream impacts from Kota Cirebon and other kampungs on the Cimanuk River, such as Kampung Kasepuhan.



Extensive land reclamation is occurring at the coastline of Kampung Cangkol using plastic and textile waste to create new land for informal housing. This maladaptive practice is exacerbating environmental contamination and climate change risks.



Low-lying land in Kampung Cangkol retains water long after rainfall events, exacerbating flash-flooding and coastal inundation risks.



SCENARIO 1 – EXPANDING CANGKOL

Business as usual. Unplanned growth continues unchecked, as land and housing pressures in Cirebon push more residents into the settlement. Infrastructure investment lags behind population growth, deepening overcrowding, contamination, and flood exposure. Without regularisation, informal service provision remains ad hoc and fragile, leaving residents increasingly vulnerable to compounding health and climate hazards.

SCENARIO 2 – DISAPPEARING CANGKOL

Accelerating sea-level rise and subsidence render the settlement uninhabitable, or shifting government priorities trigger forced clearance of 'illegal' settlements. Residents face displacement with little compensation or resettlement support, severing community networks. Infrastructure investments are abandoned mid-transition, representing a stranded-asset risk (unless designed for relocation or repurposing).

SCENARIO 3 – STABLE CANGKOL

Coordinated policy shifts recognise informal settlements as legitimate urban fabric. Land regularisation grants tenure security, unlocking investment. Reclamation practices cease, shoreline rehabilitation restores coastal ecosystems to prior states, and a combination of centralised and decentralised infrastructure approaches are scaled alongside managed population growth. Cangkol becomes formally integrated into Cirebon's spatial strategic plans and provides a model for inclusive urban transition.

CURRENT STATE

Incomplete and fragmented waste, sanitation and drainage systems are impacting the health of residents and the local environment, including waterways. This is resulting in the loss or partial re-adaptation of local cultures and place-based ways of life (i.e. fishing practices).



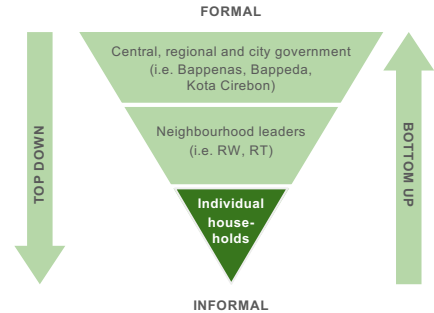
PREFERRED FUTURE STATE (SCENARIO 3)

Addressing system failures from the household (bottom-up) to catchment (top-down) scale, and preventing untreated waste from entering local waterways, will improve living conditions for Kampung Cangkol residents and allow local cultures and practices to thrive into the future. Rather than a single 'asset', the infrastructure intervention is multi-dimensional and multi-scalar, reducing the risk of single point failure in an uncertain future and recognising the need for a mix of formal and informal approaches to address the unique challenges of kampung contexts.

PROPOSED INFRASTRUCTURE INTERVENTION DIMENSION 1: HOUSEHOLD

Proposed household scale strategies for improving water, sanitation and waste conditions in Kampung Cangkol involve scaling up successful micro-infrastructure systems and practices already in place.

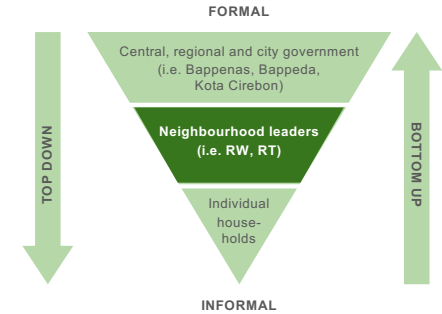
Examples: home composting, separation of non-organic waste streams at designated collection points, urban farming and aquaculture practices, installation of private septic tanks (where connection to communal systems is not possible)



PROPOSED INFRASTRUCTURE INTERVENTION DIMENSION 2: NEIGHBOURHOOD

Proposed neighbourhood scale strategies include connecting and improving upon fragmented systems and practices for water, waste and sanitation management already in place within *rukun warga* areas.

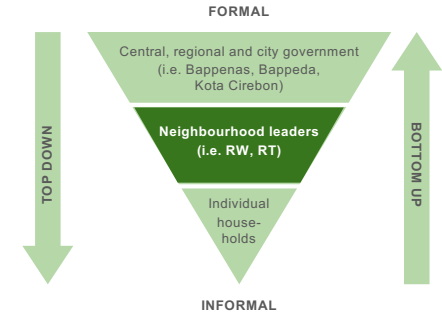
Examples: communal septic tanks, pressure sewers, closed sewer drains (separated from stormwater drainage network where possible)



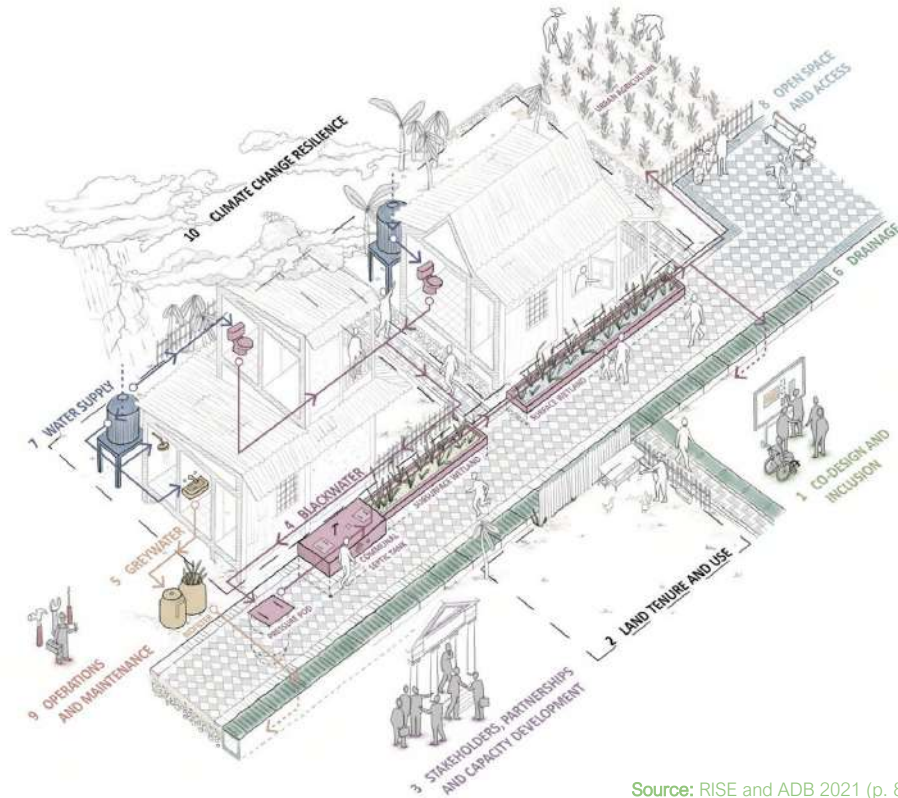
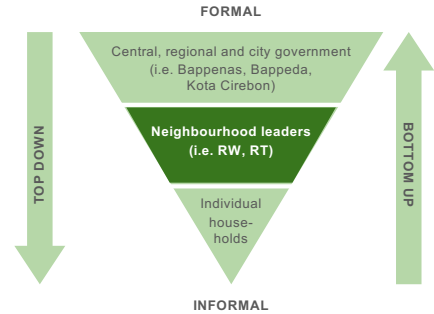
PROPOSED INFRASTRUCTURE INTERVENTION DIMENSION 2: NEIGHBOURHOOD

Once existing systems have been improved, neighbourhood scale strategies also include:

- Connecting communal septic tanks to modular wetland units to treat water before it enters Cimanuk River, such as examples below from RISE Program (ADB and RISE 2021).
- Connecting placemaking and beautification initiatives to water and sanitation infrastructure that will improve living conditions for kampung residents (rather than standalone aesthetic treatments that do not address underlying issues).



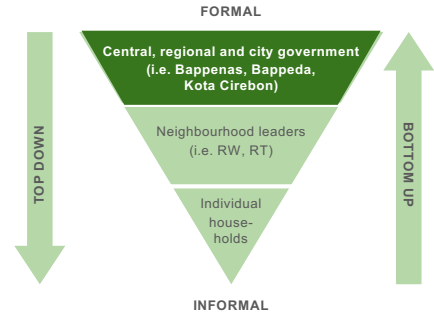
PROPOSED INFRASTRUCTURE INTERVENTION DIMENSION 2: NEIGHBOURHOOD



Source: RISE and ADB 2021 (p. 8)

PROPOSED INFRASTRUCTURE INTERVENTION DIMENSION 2: CITY CATCHMENT

The proposed city catchment scale infrastructure intervention involves different levels of government – such as local (Kota Cirebon), regional (Bappeda) and central (Bappenas) – working with neighbourhood *rukun warga* (RW) leaders to co-develop an Integrated Water Management Plan for the Cimanuk River through *musrenbang* style forums. Musrenbang is a nationally regulated (law 8/2008) participatory planning process in Indonesia, through which RW leaders meet with government officials to establish bottom-up development priorities (Anindito et al 2022).



RESILIENCE AND ADAPTIVENESS

Key vulnerabilities include reliance on neighbourhood RW leadership continuity, risk of decentralised wetland systems failing without proper operation and maintenance programs, and the general insecurity of land tenure in informal settlement contexts. The resilience and adaptiveness of the proposed infrastructure systems are stress-tested against the three future scenarios previously established. In all scenarios, household and neighbourhood scale systems work together to provide redundancy if one system is more poorly maintained (removing single points of failure). Reversibility is also built in, through use of modular septic tank and wetland components that can be added, relocated, or removed as settlement boundaries shift, ensuring the system remains functional and financially viable regardless of which future materialises. At the city-scale, the development of a catchment scale Integrated Water Management Plan further helps to respond to uncertain futures through better coordinated planning for future water resources.

SCENARIO 1: EXPANDING CANGKOL

Under Expanding Cangkol, modular wetland units can be replicated incrementally as new clusters form, avoiding costly retrofits.

SCENARIO 2: DISAPPEARING CANGKOL

Under Disappearing Cangkol, modularity enables physical relocation or decommissioning without stranding capital assets (unlike fixed centralised treatment plants).

SCENARIO 3: STABLE CANGKOL

Under Stable Cangkol, the same units can be networked and upgraded as formal infrastructure once land regularisation occurs.

COST VS. COMMUNITY BURDEN

Community-led construction and maintenance lowers capital costs and builds ownership, but risks overburdening residents in already income-stressed households. A hybrid model is instead proposed, incorporating paid community labour schemes (cash-for-work) that build skills and income while distributing responsibility fairly, rather than relying on unpaid volunteerism.

SPEED VS. COMMUNITY BUY-IN

Rapid, top-down infrastructure delivery is faster but risks replicating past failures of solutions imposed without community buy-in. The project proposes slower co-design processes, accepting delayed implementation timelines in exchange for infrastructure residents will actually use and maintain. This is critical given the settlement's precarious legal status, where trust between community and government is fragile.

CENTRALISED CONTROL VS. COMMUNITY OPERATION

Modular wetland systems are flexible and low-cost but perform less predictably than centralised treatment, and are vulnerable to poor maintenance and inconsistent regulation. The project accepts this performance trade-off deliberately, pairing decentralised systems with simplified monitoring protocols and local operator training, recognising that decentralisation is essential for adaptability given uncertain tenure and future settlement change. Resilience matters more than optimised efficiency under fixed assumptions that may not hold.

BOLD BETS AND QUICK WINS

QUICK WINS (short term)

BOLD BETS (long term)

SOFT APPROACHES
(social, community, policy,
etc.)

Activate existing *kerja bakti* community clean-up culture as the delivery mechanism for waste separation and to help reduce waste debris in stormwater and sewage drainage system (fast, low-to-no cost, and community-owned).

Connect integrated water management planning to land tenure processes, creating a sense of long-term stewardship for local environment.

HARD APPROACHES
(physical infrastructure,
financial systems, etc.)

Fix existing decentralised infrastructure, such as water and septic tanks that are currently out of service.

Pilot a credit financing system, where collected plastic waste can be sold to recyclers or offset buyers, generating household income and revenue that subsidises wetland operation and maintenance, while helping to address maladaptive coastline reclamation and waste dumping practices.



Community *kerja bakti* clean up program taking place on top of a communal septic tank and public space in Lebak Siliwangi, Bandung.

Stakeholder engagement – particularly with respect to the proposed Integrated Water Management Plan for the Cimanuk River – will follow a participatory co-planning approach. Through this approach, the community is treated as an active participant in planning, design and decision-making processes, rather than as a recipient of externally-led ‘solutions’.

Co-planning is aligned with the *musrenbang* (*Musyawarah Rencana Pembangunan*) process in Indonesia, that involves the identification of community aspirations and needs by *rukun warga* (RW) leaders with government, and translation of these into development priorities in accordance with the concept of bottom-up planning (Anindito et al 2022).

Proposed engagement with RW leaders from Kampung Cangkol and other upstream settlements will include:

1. Identification of points of system failures within individual kampungs, that are contributing to degradation of the Cimanuk River catchment.
2. Identification of common experiences and challenges between kampungs that would benefit from government intervention.
3. Co-development of tangible actions for the Cimanuk River, through ‘musrenbang’ style forums - in line with Indonesian Government Regulation 8/2008 (Anindito et al 2022).
4. Implementation of actions through mixed-funding sources (including government and development funding), with incentives for community involvement.

STAKEHOLDER ANALYSIS

STAKEHOLDER

INTERESTS AND INCENTIVES

Residents of Kampung Cangkol

Improved neighbourhood living conditions; reduced exposure to climate hazards; long term housing security and land tenure; economic participation

Broader city residents
(including upstream settlements)

Similar to Kampung Cangkol; ensuring equitable share of government resources to other settlement upgrading efforts

City Government
(Kota Cirebon)

Integrating settlements with the broader city; cost-effective water, waste and sanitation solutions that do not further stretch municipal resources; financial sustainability (i.e. rates generation)

Regional Government
Planning Agency (Bappeda)

Ensuring integration of infrastructure strategies beyond the city-scale (i.e. Cimanuk River extends beyond Cirebon)

Indonesian Government
Ministry of National Development Planning
(Bappenas)

National prosperity; reducing urban poverty; ensuring infrastructure processes and outcomes are delivered in line with national laws (including musrenbang)

Donor agencies

Ensuring long-term impact and effectiveness of development funding; implementation of best practice for infrastructure-based international development projects, such as Gender Equality, Disability and Social Inclusion (GEDSI) considerations

SYSTEM PERSPECTIVE



This project sits within Cirebon's broader water catchment, coastal ecosystem, and urban governance systems. Proposed modular septic tank and wetland units complement centralised municipal water and wastewater management systems. Waste separation connects household practices to city-wide recycling and landfill systems, reducing maladaptive coastal shoreline reclamation with plastic waste. Placemaking initiatives link infrastructure to urban identity and city branding, whilst contributing to the 'permanence' of informal settlements.

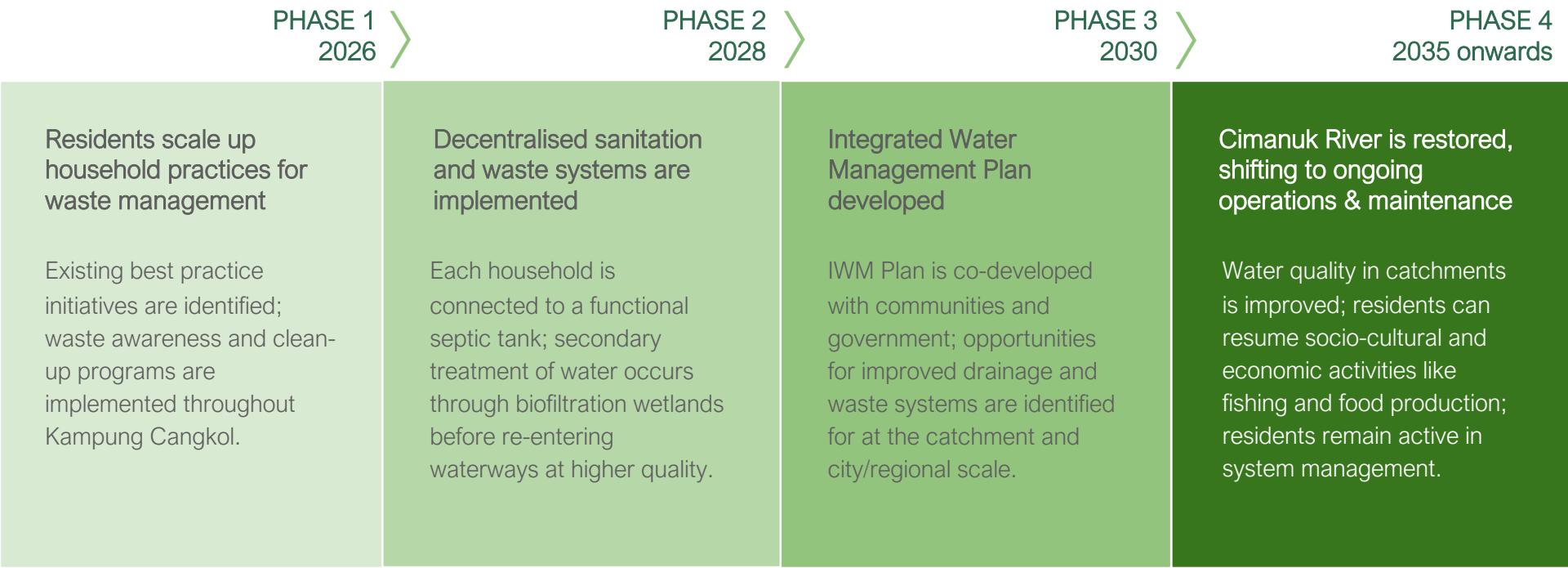
Institutionally, the project bridges informal community governance with formal municipal planning, positioning Kampung Cangkol not as an isolated slum upgrade but as an active node within Cirebon's proposed catchment-scale integrated water management plan, linking local sanitation to water quality in the Cimanuk River and Java Sea.

Section of the Cimanuk River, upstream of
Kampung Cangkol and adjacent to community
septic tank for Kampung Kasepuhan.



IMPLEMENTATION ROADMAP

The project is divided into 4 distinct phases, commencing in 2026 and moving to ongoing implementation from 2035 onwards. A budget for each phase is outlined on the next slide.

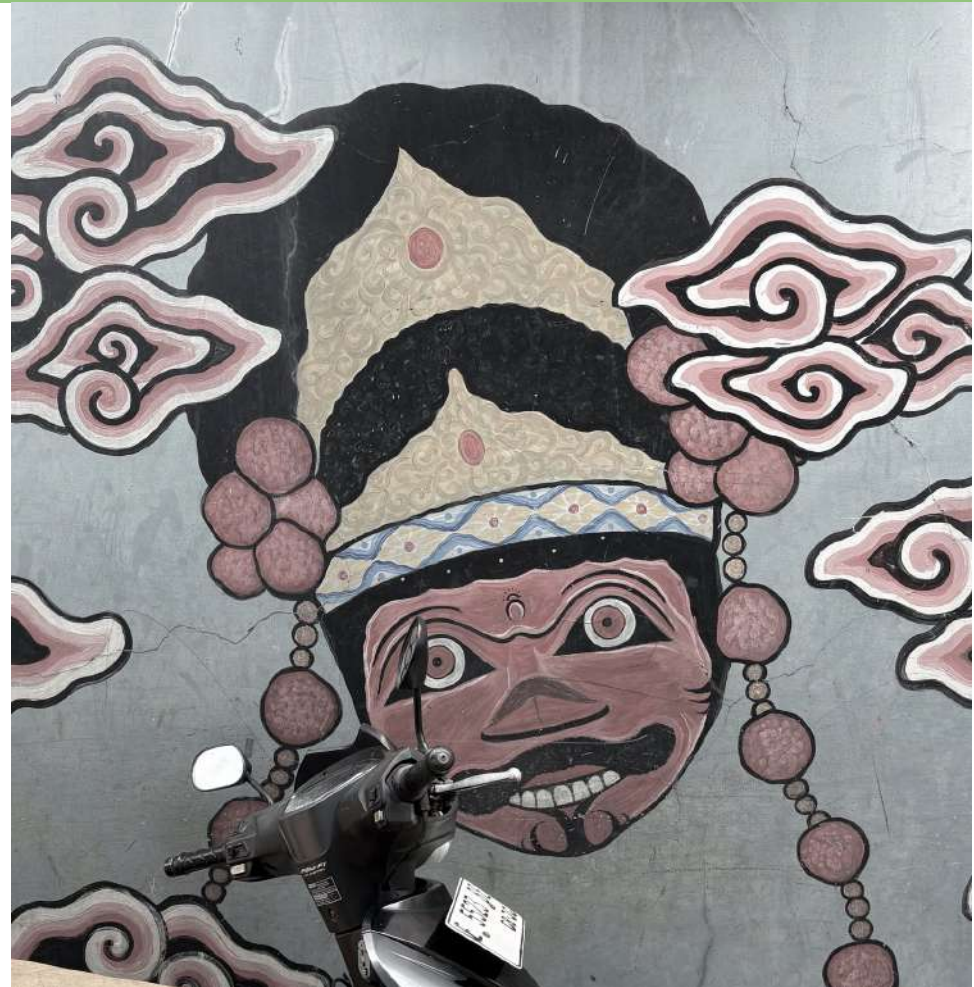


BUDGET				
PHASE	FOCUS	KEY ACTIVITIES	ESTIMATED BUDGET (EUR)	TIMEFRAME
1. Household scale	Household infrastructure scale up and quick wins	Incentives for household composting and waste separation systems, urban farming and aquaculture micro grants, installation of private septic tanks where communal septic tanks are not possible	€50,000.00	Years 1–2
2. Neighbourhood scale	Decentralised wastewater infrastructure integration	Communal septic tank upgrades, installation of up to 10 modular wetland units, placemaking tied to sanitation infrastructure, roll-out of cash-for-work schemes to incentivise clean up of waterways and coastal zones	€1,500,000.00	Years 3–4
3. City scale	Policy and institutional alignment	Development of an Integrated water management plan for the Cimanuk River catchment, musrenbang style community engagement workshops	€500,000.00	Years 5-10
4. Implementation	Ongoing operations and maintenance of modular systems	Testing and monitoring of modular systems, local operator training, community maintenance stipends	€500,000.00	Years 10+ (recurring)
Contingency & program management (15%)			€382,500.00	Throughout
Total			€2,932,500.00	10 years

IMPACT ASSESSMENT

The most important success indicator is the proportion of household blackwater treated before being discharged into the Cimanuk River and Java Sea. This one metric captures the project's full value chain: it reflects household and neighbourhood infrastructure functioning as intended, reduces gastroenteric disease burden, and directly correlates with coastal water quality improvement, enabling local economic recovery.

From a cost-benefit perspective, the ~ €2.93 million investment compares favourably against avoided costs such as reduced healthcare expenditure from gastroenteric disease, avoided flood damage to homes and assets, and restored fishing income for coastal communities. These benefits accrue over decades, not years. Value is created not just for Cangkol's 9,000 residents, but for Cirebon's public health system, its coastal economy, and its climate resilience, demonstrating that investing in one of the city's poorest settlements can generate returns that extend well beyond the neighbourhood boundary.



REFERENCES

- Anindito, D., Sagala, S. and Tarigan, A. 2022, 'E-musrenbang: a digital framework for local participatory planning at the community level', *International Development Planning Review*, 44, 191–216, DOI: 10.3828/idpr.2021.5.
- Apriliani, IM, Handaka Suryana, AA, Maulina, I & Utami, RZ 2023, 'Social and cultural characteristics in the development of small-scale fisheries: Case study of Cangkol Village, Cirebon, Indonesia', *International Journal of Multidisciplinary Research and Growth Evaluation*, 4(4), pp. 842–846.
- Hidayat, I., Januar, H., Dwiyoitno, D. and Prihantini, N. 2021, 'Seasonal and Spatial Water Pollution Status at The Rivers Estuaries in Cirebon Region', *Squalen Bulletin of Marine and Fisheries Postharvest and Biotechnology*, 16(2), 76-82, DOI: 10.15578/squalen.505.
- RISE and ADB 2021, *Water-sensitive informal settlement upgrading: Description of technologies*, Asian Development Bank and Monash University, accessed 26 November 2025, from: <https://www.rise-program.org/__data/assets/pdf_file/0011/2603486/RISE_ADB-Knowledge-Products-3_FA4-hires.pdf>.
- Suhartini, N. and Jones, P. 2023, 'Beyond the Informal: Understanding Self-organized Kampung in Indonesia', *The Urban Book Series*, Springer Nature, Switzerland, DOI: 10.1007/978-3-031-22239-9.

