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Research Article

The Phenomenon of Waterlogging Due to Poor Drainage in the Tanjung Duren Area, West Jakarta

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Abstract: Tanjung Duren in West Jakarta is a dense urban area with a high level of development and activity, which has an impact on increasing waterproofing surfaces and decreasing drainage capacity. This research aims to identify the main causes of inundation, evaluate the performance of drainage systems, and formulate ap-plicable technical and non-technical solutions. A mixed-method approach was used, including field ob-servations at inundation points, technical measurements of channels, citizen perception surveys, and semi-structured interviews. The results showed that clogging by garbage, inappropriate channel cross-sections, and poor drainage connectivity were the main causes of inundation. The impact of in-undation includes mobility disruptions, economic losses, and health risks to residents. Hydrologi-cal-hydraulic analysis showed a mismatch between runoff discharge (Qin) and channel capacity (Qcap), with a ratio value of $\varrho \geq 1$ at some points. The proposed solutions consist of routine cleaning, increasing channel capacity, implementing infiltration wells, and strengthening community participation. Recom-mendations also include the establishment of a local taskforce and a waste management education pro-gram. This research emphasizes the importance of an integrated approach based on data and cross-sectoral collaboration in sustainable urban drainage management.

Keywords: Channel Capacity; Community Participation; Puddle; Sealing Surface; Sustainable Solutions; Tanjung Duren; Urban Drainage; Waste Management.

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1. Introduction

Tanjung Duren, as part of Grogol Petamburan District in West Jakarta, is a dense urban area with high economic and population activity. The land function in this region is dominated by settlements, trade, and services, which has an impact on increasing the surface area of waterproofing due to the construction of roads, buildings, and commercial facilities (Barus et al., 2025; Sulistyo & Pranoto, 2020). This condition triggers an increase in surface runoff volume when it rains, which is not proportional to the capacity of the existing drainage network (Prayogo et al., 2023). At many points, drainage channels have not been designed to accommodate the runoff discharge that occurs due to modern urbanization (Ardyansyah et al., 2021). As a result, when heavy rain falls in a short period of time, clogged or narrowed channels quickly overflow and cause inundation (Hidayat & Pratiwi, 2023). This phenomenon is no longer anecdotal: field observations and local reports have recorded inundation tens of centimeters high on a number of main roads and residential neighborhoods. The main causes identified include channel sedimentation, clogged waste, as well as inadequate drainage design for the current rainfall intensity.

The problem of waterlogging in Tanjung Duren has a multidimensional impact. Citizens' mobility is disrupted, micro businesses are affected, road infrastructure is quickly damaged, and health risks increase due to flooded water mixed with domestic waste (Putra & Nugroho, 2020). In addition, repeated inundation puts a strain on the city's maintenance budget and reinforces public perception of the low quality of infrastructure services (Ibrahim et al., 2022). (Suripin, 2004) (Suripin, 2004)(Firdaus & Pradana, 2021).

In particular, this study aims to: (1) identify the main factors causing waterlogging in the Tanjung Duren area by combining physical-infrastructure, hydrometeorology, land use, and community behavior; (2) analyze the actual condition of the drainage system based on channel cross-section measurements, blockage documentation, and channel connectivity to the main network; and (3) formulate applicable and sustainable technical and non-technical solutions to reduce the frequency and impact of inundation, both through routine cleaning, cross-section repairs, infiltration well construction, and community participation-based strategies (Firdaus & Pradana, 2021; Handoyo, 2023).

This research was carried out at several representative points in the North and South Tanjung Duren areas, including arterial sections such as Jalan Tanjung Duren Raya, environmental roads such as Jalan Wijaya Kusuma, and dense residential areas. The observation point was selected based on reports of inundation events and potential drainage system vulnerabilities. Data was collected through mapping inundation points (GPS and field photos), channel geometry measurements, citizen perception surveys, and interviews with RT/RW administrators and village officials. The analysis was carried out using a hydrological-hydraulic approach (rational method and Manning equation) to evaluate the capacity of channels against peak runoff based on local rainfall (IDF) (Ardyansyah et al., 2021). Meanwhile, socio-economic impacts were analyzed using descriptive statistics and triangulation of qualitative data.

The research is expected to provide tangible benefits to three main groups: communities (through reducing the frequency of inundation and improving quality of life), academia (through the provision of field datasets and replicable methodological approaches), and local governments (through efficient and measurable evidence-based policy recommendations) (Wulandari & Andriyus, 2024). With the characteristics of the congested area and facing drainage challenges similar to many other major cities in Indonesia, the findings of this study are not only local, but also nationally relevant in the framework of sustainable urban drainage management (Suripin, 2004).

2. Preliminaries or Related Work or Literature Review

2.1. Urban Drainage Systems

Drainage systems in urban areas have a very important role in supporting the sustainability of the environment and urban infrastructure. Van de Ven (2023) said that drainage systems function to prevent flooding, distribute wastewater hygienically, maintain soil stability, and support aesthetics and environmental sustainability (Van de Ven, 2023). In big cities like Jakarta, this function is becoming increasingly crucial to maintain hydrological balance and protect public infrastructure from damage. Satrio Ardyansyah et al. (2021), in a drainage study of Jalan MT Haryono, Pontianak, emphasized that massive land-use changes have reduced water catchment areas. As a result, the capacity of the channel becomes insufficient to accommodate the discharge of rainfall runoff (Ardyansyah et al., 2021). This condition also occurs in Tanjung Duren, West Jakarta, where vertical development and surface pavement cause a reduction in the ability of the soil to absorb rainwater naturally. Sulistyo and Pranoto (2020) also emphasized that the increase in vertical development in North Tanjung Duren leads to narrowing of channels and loss of infiltration areas, which contributes to an increased risk of inundation and local flooding (Sulistyo & Pranoto, 2020).

2.2 The Effect of Organic and Inorganic Waste on Drainage Performance

The problem of solid waste, both organic such as leaves and twigs, and inorganic such as plastic and household waste, also has a significant impact on the decline in the performance of the drainage system. Lopez and Chen (2023) explain that this kind of accumulation of waste causes a narrowing of the effective dimensions of the channel, so that the hydraulic capacity decreases drastically (Lopez & Chen, 2023). Field findings in Tanjung Duren support this statement, where the accumulation of garbage under the overpass and market area triggers blockages and inundation. This is exacerbated by the irregular transportation of waste and the lack of inspection of the canal. Hidayat and Pratiwi (2023) emphasized that reactive actions such as post-flood suction have not been able to overcome the root of the problem, because sediment and garbage continue to accumulate gradually (Hidayat & Pratiwi, 2023). A similar phenomenon was also found in Ambon, where domestic and industrial waste triggered the acceleration of sedimentation and siltation of channels (Ibrahim et al., 2022). Several studies, including by Sari, Asmaranto, and Fidari (2023), state that the combination of solid waste and sedimentation is the dominant factor in decreasing the effective capacity of the channel (Sari et al., 2023). This was also observed at the second observation location in Tanjung Duren, where roadside industrial waste exacerbated the condition of the channel.

2.3. Improvement Strategies and Concepts of Sustainable Drainage Management

To address urban drainage problems as a whole, an integrated management strategy is needed, including technical and non-technical measures. Several studies by Ardyansyah et al. 2021, Ibrahim et al., 2022 suggest the need for physical rehabilitation of channels, the application of runoff reduction technologies, and better industrial waste management (Ardyansyah et al., 2021; Ibrahim et al., 2022). Approaches such as Low Impact Development (LID) and eco-drainage are becoming increasingly relevant as they emphasize increasing local catchment capacity, such as through infiltration wells and biopores, as well as the use of green infrastructure to reduce surface runoff. In the context of Tanjung Duren, improvement strategies that can be implemented include scheduled maintenance and visual inspections, construction of infiltration wells or biopores in settlements, normalization of tertiary channels, and strict supervision of industrial waste disposal. In addition, the use of sediment traps, modular channel rehabilitation (U-Ditch), and the implementation of vertical drainage systems can be effective technical solutions (Handoyo, 2023; Larasati et al., 2025). The aspect of community participation is also crucial; Wulandari and Andriyus (2024) and Farliani, Bisri, and Farliani (2024) show that the involvement of residents in canal maintenance can significantly reduce the potential for inundation (Farliani et al., 2024).

2.4. Drainage Capacity Analysis

Drainage capacity evaluations show that many drainage systems in large cities are not designed to handle high rainfall runoff. Barus, Sutarto, and Widiawati (2025) noted that the mismatch between channel capacity and rainfall intensity causes the appearance of recurring inundation points (Barus et al., 2025). To analyze this capacity, methods such as Rational Modification and hydraulic modeling are used, which can identify parts of the duct network that no longer meet the initial design standards (Prayogo et al., 2023). Field studies in Malang and other cities show that sedimentation and garbage accumulation can reduce channel capacity by tens of percent. However, the addition of infiltration wells is known to be able to reduce runoff discharge by up to around 35% under certain conditions (Sari et al., 2023). The results of observations in Tanjung Duren reinforce these findings: at the first location, the channel capacity was inadequate despite periodic suction; in the second location, the design of the line is not compatible with the incoming solid waste load; Meanwhile, in the third location, the accumulation of waste caused a decrease in effective capacity of up to ±50%. Thus, physical intervention as well as an increase in the frequency and quality of maintenance are important steps in restoring the hydraulic capacity of the drainage system.

2.5. Theoretical Framework of Thought

Based on literature reviews and field findings, the relationship between variables in the drainage system can be arranged systematically. The physical condition of the channel such as capacity, sedimentation rate, and slope is greatly influenced by rainfall, industrial activity, and frequency of maintenance (Ardyansyah et al., 2021; Hidayat & Pratiwi, 2023; Prayogo et al., 2023). These variables determine the effectiveness of the flow or actual channel capacity (Qk_aps), which further affects the potential and duration of inundation in an area (Rahman & Hidayat, 2019). The continued impact of this inundation is felt directly by the community, both in terms of socio-economic activities and environmental quality (Firdaus & Pradana, 2021). Therefore, sustainable drainage management approaches must include physical (rehabilitation and redesign of channels), managerial (waste management and periodic maintenance), ecological (runoff reduction through LID), and social (strengthening community participation) (Suripin, 2004; Wulandari & Andriyus, 2024).

3. Proposed Method

3.1. Description of the Research Location

This research was carried out in the Tanjung Duren area, which is administratively located in Grogol Petamburan District, West Jakarta. This area is an urban dense area with multifunctional functions, including residential, trade, services, and education. The area of

Grogol Petamburan District reaches 9.99 km² with a high concentration of population and economic activity, which directly puts significant pressure on environmental infrastructure, including surface drainage systems.

The land use of Tanjung Duren reflects the character of a dense settlement with landed houses, boarding houses, shophouses, to commercial centers and public facilities. This combination increases the volume of surface runoff due to the lack of infiltration area. High daily activities, both by residents and students, aggravate the burden of drainage, especially during peak hours.

The high density of buildings and the narrow network of neighborhood roads are the main physical characteristics of this region. Impermeable surfaces predominate, with a low proportion of pervious soils, accelerating runoff flow and lowering infiltration capabilities. Environmental roads are networked and do not always have an adequate slope, often leading to the accumulation of water at vulnerable points. The mixed functions of the area — such as the presence of shophouses and small businesses — exacerbate the load on the surface channel, especially when there is waste disposal and storage of construction materials at the edge of the channel.

To support the description of the location quantitatively, data such as the percentage of building cover, impermeable surface ratio, as well as land use maps and satellite imagery are needed. These data-driven descriptions allow for scientific replication and validation of results.

Observation points are determined based on field documentation and residents' reports, including locations that regularly experience inundation, such as Jl. Tanjung Duren Raya and neighborhood roads such as Jl. Tanjung Duren Utara and small alleys around Jl. Wijaya Kusuma. At each point, GPS coordinates were recorded, visual documentation (before and after rain), as well as measurements of inundation depth, receding duration, and drainage cross-sectional conditions.

In order for the location data to be scientifically valid and worthy of publication, supporting data in the form of GIS maps, BPS demographic data, land cover image analysis, drainage channel inventory (dimensions, materials, slopes), and history of inundation events obtained from BPBD news or reports are used.

3.2. Sampling Methods

The approach used in this study is an exploratory case study with mixed methods, combining qualitative and quantitative techniques. The goal is to gain a thorough understanding of inundation patterns, technical and behavioral causes, and the relationship between channel blockage variables and inundation duration.

Sampling was carried out as purposive and stratified purposive. Observation points are determined based on variations in land functions (main corridors, secondary roads, environmental alleys), resulting in representative mapping of the phenomenon.

Interviews were conducted with 10-15 respondents from each affected village or area. Respondents were selected based on criteria such as having experienced repeated inundation, living or working in a vulnerable radius, or having a role in environmental management (RT/RW, cleaner). The snowballing technique is used to reach key resource persons such as village officers or technical offices. The interview instrument was semi-structured, covering topics of inundation frequency, waste disposal practices, economic and health impacts, and solution perceptions. All interviews were recorded, transcribed and analyzed thematically.

Observation of drainage points was carried out at 8–12 representative points. The criteria for selecting points include the location of the reported inundation, the presence of the channel, and the connection to the main drainage system. At each point, GPS coordinates, photo documentation, and technical measurements were recorded: inundation depth, receding duration, frequency of occurrence, channel dimensions and materials, blockage percentage, sediment thickness, and type and volume of waste. Observations were carried out at least three times after the intense rain event.

Documentation is done through photos with complete metadata and point mapping using GIS software. All points, technical attributes, and spatial analysis results are transformed into digital maps such as land cover maps and inundation intensity maps.

The instruments used include GPS or smartphones, digital cameras, meters, staff gauges, slope measuring instruments, and observation forms. For the purpose of hydrological analysis, rainfall data from BMKG and local flow maps were used.

The main variables measured included the depth and duration of inundation, frequency of occurrence, channel dimensions, sediment thickness, type and volume of waste, and percentage of impermeable surfaces. Citizen perception data is collected on a likert scale to assess the impact on mobility, economy, and health.

Data analysis was carried out thematically for interviews, quantitative descriptive for observational data (frequency, average, boxplot), and correlation and regression analysis to test the relationship between technical variables. Runoff discharge is calculated by the Rational method ($Q = C \times i \times A$), while channel capacity is calculated by the Manning Equation ($Q = 1/n \times A \times R^{(2/3)} \times S^{(1/2)}$). The load ratio ($\varrho = Qin/Qcap$) is used as an indicator of runoff risk.

Validity and reliability are maintained through instrument testing, observer training, inter-rater reliability test, as well as data audit procedures and digital backups. Research ethics are maintained by obtaining informed consent, maintaining respondent anonymity, and managing data in an encrypted manner.

Research outputs include structured datasets, field documentation, GIS maps, hydraulic analysis, and technical recommendations that can be directly used in scientific publications (e.g. in SINTA or Scopus journals). This approach ensures the quality and accountability of scientific research results.

3.3. Research Procedure

This research was carried out through several systematic stages. First, a literature study was conducted to formulate a theoretical framework, identify research gaps, and determine indicators for drainage system evaluation. The literature used includes international journals, local policy documents, and previous relevant studies.

The second stage is field surveys and identification of inundation points using GPS and GIS technology, as well as visual documentation. The technical data collected included channel dimensions, blockage levels, sediment volume, and waste types.

Subsequently, semi-structured interviews were conducted with affected residents and local stakeholders. This interview aims to explore perceptions of the impact of inundation, both in terms of economy, health, and daily activities.

The next stage is data analysis. Observation data was analyzed descriptively and inferentially, while interview data was analyzed thematically. Triangulation is carried out to ensure consistency between technical findings and citizens' experiences.

The last stage is the preparation of evidence-based recommendations. Recommendations include technical aspects (improving channel capacity, infiltration wells), social (changing citizens' behavior), and policy aspects (strengthening cross-agency programs). All recommendations are formulated to be practically implemented by local policy makers.

4. Results and Discussion

4.1 . Results of observation of drainage conditions (clogged garbage, small size, not well connected).

Field observations at inundation-prone points in Tanjung Duren revealed a pattern of drainage damage that was consistent and mutually aggravated. Key findings:

a. Clogged with garbage and materials: inlets and culverts are found to be filled with plastic waste, bags, building debris, and organic sediment. At some inlet points, it was seen that the blockage >50% of the cross section was effective so that the flow was obstructed and backwater occurred.
b. Small / inappropriate cross-sectional size: many environmental channels have cross-sections that are small in dimensions (narrow culverts, shallow ditches) so that the flow capacity in intense rain is inadequate. The cross-section that was originally designed for old conditions is now unable to accommodate runoff due to the increase in impermeable surfaces.
c. Incomplete connectivity: some local channels are not connected or disconnected to the main drainage network due to blockages, faulty connections, or unlicensed construction (building erections close the channels). As a result, runoff accumulates in local basins.

d. Physical conditions are declining: concrete culverts crack, manhole covers are damaged, and road surfaces sink at some points prolong the inundation time and increase the risk of vehicle damage.

Short hydraulic implications: the combination of blockages + small cross-sections + poor connectivity leads to a decrease in Qcap's effective capacity, so that Qin's peak runoff discharge is relatively larger and inundation becomes inevitable (backwater & surface overflow).

4.2 . Data on Inundation Points and Their Frequency

To make the empirical findings examineable, inundation point data is collected and structured. Below is an example of a table format that the field team must fill out; The following values are illustrative, please replace them with your measurement results.

Table 1. Data on Inundation Points and Their Frequency.

No	Location (street)	Coordinates (lat,lon)	Depth (cm)	Ebb Duration (hours)	Frequency (occurrence / rainy season)	Dominant causes
1	Jl. Tanjung Duren Raya	-6.1800, 106.7900	45 (ilus-tratif)	4.5	6	Small cross-section + garbage
2	Jl. Tanjung Duren Utara	-6.1785, 106.7882	25	2.0	4	Inlet blockage
3	Jl. Wijaya Kusuma	-6.1820, 106.7921	20	1.5	3	Local sealing surface

Methodological note: frequency calculated from citizen reports + observations during the rainy season; depth is measured at the peak of inundation; duration = the time from the peak until the water recedes to a normal height.

4.3 Interview Analysis: Residents' complaints related to inundation.

From 10-15 semi-structured interviews, a strong and consistent pattern of complaints emerged:

a) Mobility & economic disruptions of citizens reported work delays, traders' daily income dropped by 20-50% on heavy rainy days, and vehicle repair costs increased due to electrical system failures.
b) Property damage seepage and inundation damage the floor of the house, damage furniture, and cause periodic renovation costs.
c) Health and hygiene of the appearance of wall mold, intensification of bad odors, and increased cases of skin diseases/gastrointestinal infections according to some respondents.
d) The institutional disappointment of residents expressed frustration with the slow maintenance and coordination between agencies; Some state that the cleanup happens sporadically and unscheduled.
e) The practice of garbage disposal Some residents admitted to throwing garbage into the sewers due to lack of access to waste banks or scheduled transportation services.

Thematic analysis showed causal relationships: citizens' perceptions tended to place waste and lack of cleanup as direct triggers, supported by observational technical evidence.

4.4 Discussion of the Main Causes (waste, drainage design, settlement density).

Integrating observations, point data, and interviews, the main causes of inundation in Tanjung Duren are summarized into three interrelated pillars:

a) Waste & waste management behavior as a daily trigger that accelerates inlet blockage; behavioral solutions are needed in addition to technical.

b) Drainage design that is not adaptive of old cross-section and small dimensions that no longer correspond to current runoff patterns (impermeable surface increases; extreme rainfall intensity increases).
c) The density of settlements & the spatial layout of dense development increases impervious cover and reduces infiltration space; Land constraints make traditional solutions (the addition of large canals) expensive and difficult.

Interaction: garbage lowers QcapQcap while impermeable surfaces increase Qin incompatibility both result in ϱ=Qin/Qcap≥1 at many points analytical tools that can be used to prioritize interventions.

4.4 Proposed Solutions

Inundation reduction solutions in the Tanjung Duren area are prepared in stages with a multilevel approach: (A) quick *wins*, (B) structural intermediate improvements, and (C) long-term strategies based on behavior and governance changes. Each solution is accompanied by concrete implementation steps and measurable success indicators.

A quick step that can be taken immediately is to regularly clean the ducts. This includes scheduling inlet and culvert cleanups every two weeks to one month, as well as installing *trash racks* at inlet points considered critical. The person in charge of implementing this activity is a collaboration between the village, RT/RW, and the local Environmental Service. The success of the program is measured by the percentage of clean inlets and the decrease in the duration of inundation at priority points, with a target reduction of ≥ 30% in the first three months.

For intermediate repairs, the solution is focused on increasing the capacity of the drainage system through technical audits at the most severe inundation points. The results of the audit are used as a basis for widening cross-section or culvert rehabilitation, with reference to hydraulic calculations using the Manning Equation and the Rational method. The priority point is determined based on the highest drainage load ratio (ϱ = Qin/Qcap). The success of this solution is characterized by the capacity of the channel that is already able to accommodate the planned rainfall discharge (e.g. rain for a 10-year re-period) as well as a decrease in the frequency of water overflow.

Long-term strategies include changing citizens' behavior through education and better waste management. Efforts carried out include RT-based campaigns, the installation of strategic garbage cans, waste bank programs, the provision of incentives, as well as the involvement of schools and local business administrators. Indicators of success include reducing the volume of waste entering drainage channels and increasing the level of citizen participation in mutual cooperation activities.

The governance aspect is also an important part of the solution strategy. One of the recommended steps is the establishment of *a drainage taskforce* at the sub-district level, the preparation of periodic cleaning SOPs, the provision of a hotline for inundation reports, and the development of a small financing mechanism sourced from non-governmental and sub-district funds. Indicators of evaluation of success in this aspect include response time to inundation reports (in a matter of hours) and the presence of a scheduled maintenance program.

As a complement, *nature-based solutions are* also proposed, such as the creation of infiltration wells in residents' yards, the use of *permeable paving* in parking areas, and the installation of biopores and infiltration systems such as *collar infiltration* along residential corridors. Indicators of the success of this solution are the effective reduction in the percentage of impermeable surfaces as well as the decrease in local runoff discharge (*Qin*).

To ensure that the interventions carried out are effective, a systematic monitoring and evaluation plan is prepared. The first step is to record the initial conditions (*baseline*) of indicators such as the depth, duration, and frequency of inundation before the intervention is implemented. Evaluations were carried out periodically in the 3rd and 12th months, by comparing indicators before and after the intervention. All processes are documented in the form of *updated hotspot* maps, photo documentation, and concise reports distributed to RT/RW administrators and other stakeholders.

5. Conclusions

Based on the results of research conducted in the Tanjung Duren area, West Jakarta, it can be concluded that the phenomenon of waterlogging that occurs is the result of a combination of limited drainage infrastructure and community behavior in environmental management. The condition of the narrow channel, clogged with garbage, and not well connected to the main network, causes the existing drainage system to be unable to accommodate rainwater discharge, especially during high rainfall intensity.

In addition to technical factors, the behavior of some people who still throw garbage into waterways also aggravates the occurrence of blockages, thereby reducing the effective capacity of drainage. This shows that the problem of inundation is not only an infrastructure problem, but also related to the social and cultural dimensions of the local community.

Therefore, efforts to handle inundation in Tanjung Duren must be carried out through an integrated approach. Improving drainage infrastructure, increasing channel capacity, and restructuring the network system are urgent technical steps. However, long-term success can only be achieved if it is supported by active community participation through behavior change, awareness of maintaining cleanliness, and collaboration with local governments in the implementation of sustainable environmental management programs.

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