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Community-Based Production of Precast U-Ditch Using a Semi-System Mold to Improve Environmental Drainage in Cipayung Jaya, Depok

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Abstract

Purpose: This program aimed to improve environmental drainage in Kelurahan Cipayung Jaya, Depok, by developing, together with residents, the capacity to produce and install precast U-Ditch channels using a reusable semi-system steel mold. The program contributes primarily to SDG 6.b (local participation in water and sanitation management), SDG 11.5 (reducing water-related disaster impacts) and SDG 11.b (resilient settlements), with SDG 9.1 as a secondary contribution.

Method: A participatory approach following one plan–act–observe–reflect cycle was applied from March to July 2026 in four stages: joint problem assessment, mold design and fabrication, hands-on production training, and collaborative installation and evaluation. Evaluation combined compressive strength testing, field observation and a 10-item, four-point questionnaire completed by 10 participating residents.

Practical Applications: Fifteen U-Ditch units (internal section 0.30 × 0.30 m, length 1.0 m, wall and base thickness 0.05 m) were produced and installed, replacing 15.0 m of eroding open earth channel. The concrete met the K-225 target (≈ fc′ 18.7 MPa). The mold and a documented production procedure remain with the community for further production.

Conclusion: All technical targets were realized and all respondents were satisfied (79% strongly agree, 21% agree; mean 3.79 of 4). Limited funding and difficult demolding constrained the scale; mold redesign and a resident-led production and maintenance group are needed to sustain the results.

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Introduction

Inadequate drainage remains a persistent problem in rapidly urbanizing residential areas, where increasing impervious surfaces and limited channel capacity lead to waterlogging, local inundation and poor sanitation. Indonesian regulation on urban drainage explicitly assigns a role to communities in the planning, construction, operation and maintenance of drainage systems (Kementerian PUPR, 2014). In practice, however, community participation is often limited: Sari et al. (2025) found that four of six participation indicators in drainage maintenance remained below 40% among 90 surveyed households, indicating that physical infrastructure alone does not guarantee functioning drainage.

Cipayung Jaya is a sub-district (kelurahan) of Cipayung District on the southern urban fringe of Depok City, West Java (Figure 1). The partner community consists of residents of Kelurahan Cipayung Jaya living along the affected channel. The neighbourhood is drained by an open earth channel along the residential lane (Photo 1). Field observation during the initial assessment showed that the channel had unstable side slopes, accumulated sediment and household waste, and an irregular cross-section that reduced its capacity, so that water overflowed onto the lane during heavy rain. In discussions with the service team, residents identified this channel as a priority problem for their neighbourhood and expressed the need for a lined channel that would remain stable and be easier to clean.

Precast concrete U-Ditch is a widely used solution for such channels. Comparative studies show that precast U-Ditch shortens construction time and lowers cost compared with conventional river-stone masonry (Dilianto et al., 2024) and cast-in-situ concrete (Sidiq et al., 2024), and its design and field application have been documented for urban roads (Rahman et al., 2022; Tama et al., 2024). Product quality, however, depends on the production process: flexural capacity is governed by section geometry and reinforcement (Wagola et al., 2020), porosity depends on the compaction method (Safri & Sutantiningrum, 2023), and dimensional consistency depends on the formwork system (Kusnadi et al., 2026). In residential neighbourhoods, U-Ditch units are normally purchased from manufacturers and installed by contractors, so residents remain passive beneficiaries.

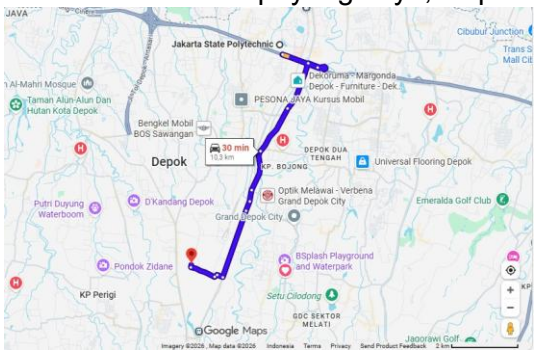
Studies of community-based water infrastructure point to a recurring gap. Residents frequently understand the function of drainage but do not maintain it, because responsibility for a public asset is diffuse (Sari et al., 2025). Engagement in infrastructure projects is often “token” consultation rather than shared decision-making (Arnstein, 1969; Starkey et al., 2025). Conversely, communal infrastructure is sustained where residents are involved from planning to maintenance and where local institutions and mutual cooperation (gotong royong) are present (Brontowiyono et al., 2022; Ostrom, 1990). Community-led learning from floods also strengthens resilience (Auliagisni et al., 2022). Previous U-Ditch studies have focused on cost, time and structural performance in contractor-built projects, while community service on precast formwork has mainly taken the form of socialization (Kusnadi et al., 2026). To date, little has been reported on residents producing the drainage components themselves.

This program addresses that gap by placing residents in the production chain. The term semi-system mold is used here for a reusable steel mold consisting of prefabricated outer side panels, an end frame and a removable inner core that are assembled and dismantled manually with pins and bolts (Figure 4). Unlike conventional timber formwork, which is built for each casting and produces variable dimensions, the semi-system mold fixes the geometry and can be reused many times. Unlike full-system factory molds, it needs no vibrating table, crane or hydraulic demolding equipment, so it can be operated by a small group of residents with hand tools. This choice reflects the principle of appropriate technology—technology at a scale that local people can own, operate and maintain (Schumacher, 1973).

Cipayung Jaya was selected because the open earth channel in the partner neighbourhood was identified during the preliminary assessment as a pressing drainage problem, and residents expressed their willingness to take part in the production and installation activities. The program had three objectives: (1) to replace a priority segment of

the open earth channel with precast U-Ditch (target: 15 units, 15 m); (2) to enable residents to produce U-Ditch units of K-225 quality using the semi-system mold; and (3) to lay the foundation for resident involvement in maintaining the channel and continuing production. The intended social change is a shift in the residents' position from recipients of infrastructure to co-producers and custodians of it, in line with SDG 6.b, 11.5 and 11.b, with SDG 9.1 as a supporting contribution (United Nations, 2015).

Figure 1. Location of Cipayung Jaya, Depok City



Source: Google Maps, 2026.

Photo 1. Existing open earth drainage channel in Cipayung Jaya before the program



Source: Private Documentation, 2026.

Method

The program used a participatory approach informed by the Participatory Action Research (PAR) cycle of planning, acting, observing and reflecting (Kemmis et al., 2014; Siswadi & Syaifuddin, 2024) and by participatory appraisal principles that treat local knowledge as a primary source of problem definition (Chambers, 1994). Because the program completed one full cycle within one funding period, it is not claimed as a multi-cycle PAR. The reflection of the first cycle was used to define the improvements planned for the second cycle (mold redesign and institutional strengthening), which is reported as a recommendation.

Activities took place in Kelurahan Cipayung Jaya, Cipayung District, Depok City, West Java, from March to July 2026. The program was carried out collaboratively by lecturers, students and technical personnel of the Civil Engineering Department, Politeknik Negeri Jakarta, together with local residents. Community participants were residents living along the affected channel who were willing to take part; ten of them completed the training and the evaluation questionnaire. Their roles covered identifying the problem and the installation location, preparing materials, mixing, casting and compacting concrete, demolding, curing, and installing the units, as well as providing feedback on the program.

The drainage problem and the installation location were identified on the basis of field observations and interviews with residents during the preliminary assessment. The geometry of the mold was proposed by the service team on the basis of the channel survey and introduced to the participants before production. This division of roles—residents shaping where the channel was improved, the team shaping the production tool—is reflected upon in the Discussion.

The program was implemented from March to July 2026 in four sequential stages, mapped to the PAR cycle as summarized in Table 1.

Table 1. Stages of the Program (March–July 2026) and their Correspondence with the PAR Cycle

	Stage	PAR Step	Main Activities and Residents' Role
1.	Preliminary assessment	Plan	Field observation and interviews with residents; identification of the drainage problem, needs and installation location
2.	Mold design and fabrication	Plan	Mold design and fabrication by the team based on the required U-Ditch dimensions
3.	Training and production	Act	Hands-on training; participants involved in reinforcement fabrication, mixing, casting, compaction, demolding and curing of 15 units; specimen preparation and compressive strength testing
4.	Installation and evaluation	Act–Observe–Reflect	Transport and installation of 15 units (15.0 m); field observation, participant questionnaire and evaluation of constraints

Source: Author's Work, 2026.

The U-Ditch geometry, mold and concrete specifications are listed in Table 2. The concrete mix targeted quality K-225 (characteristic cube strength 225 kg/cm², approximately equivalent to a cylinder strength fc′ of 18.7 MPa), proportioned according to SNI 7394:2008 (Badan Standardisasi Nasional, 2008); structural requirements followed SNI 2847:2019 (Badan Standardisasi Nasional, 2019).

Table 2. Technical specifications of the U-Ditch, Mold and Concrete

Parameter	Specification
Internal section (width × height)	0.30 × 0.30 m
Unit length	1.0 m
Wall and base thickness	0.05 m
External section (width × height)	0.40 × 0.35 m
Mold	Reusable steel mold: outer side panels, end frames and removable inner core, joined with pins/bolts
Reinforcement	Steel reinforcement fabricated by participants (Figure 5)
Concrete quality (target)	K-225 (≈ fc′ 18.7 MPa)
Mix proportion per m³ (SNI 7394:2008)	Cement 371 kg; sand 698 kg; coarse aggregate 1,047 kg; water 215 L (w/c ≈ 0.58)
Casting and compaction	Cast in layers and compacted
Demolding and curing	Demolding after initial hardening, followed by curing
Quality control	Concrete specimens tested for compressive strength

Source: Author's Work, 2026.

Evaluation covered three dimensions. (1) Technical: compressive strength tests on concrete specimens to verify the K-225 target. (2) Hydraulic: field observation of the channel after installation and a theoretical comparison of the conveyance capacity of the U-Ditch with that of the original earth channel using Manning's equation (Chow, 1959). (3) Social: a satisfaction questionnaire of 10 statements (Table 4) covering the relevance of the activity, its physical and environmental outcomes, the usefulness of the mold, the clarity of the training, the management of the mentoring process and overall satisfaction, on a four-point scale—strongly agree (SS = 4), agree (S = 3), disagree (TS = 2) and strongly disagree (STS = 1)—completed after installation by the 10 residents who completed the training, supplemented by

direct observation during the activities. Questionnaire data were analysed descriptively as frequencies, percentages and mean item scores.

Result

The existing channel was an unlined earth ditch with eroded banks and sediment deposits (Photo 2). The priority segment for installation was determined on the basis of field observations and interviews with residents. The internal section was set at 0.30 × 0.30 m so that the units would fit the existing channel and could be lifted manually.

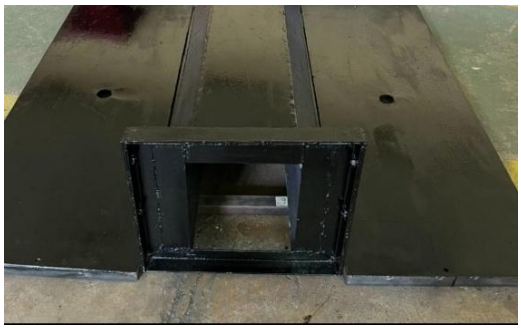
Photo 2. Existing Condition of The Residents' Drainage Channel: An Open Earth Channel



Source: Private Documentation, 2026.

The semi-system steel mold (Photo 3) was fabricated by the team and introduced to the participants. Production followed a fixed sequence that residents practised directly under supervision: fabrication of the steel reinforcement (Photo 4); cleaning, assembly and oiling of the mold; batching and mixing of concrete; casting in layers with compaction (Photo 5); surface finishing; preparation of test specimens; demolding (Photo 6); curing; and lifting, transport and installation of the units on a compacted bedding (Photo 7).

Photo 3. Semi-System Steel Mold for the U-Ditch with Removable Inner Core



Source: Private Documentation, 2026.

Photo 4. Fabrication of Steel Reinforcement by Participants



Source: Private Documentation, 2026.

Photo 5. Casting Concrete Into The Semi-System Mold



Source: Private Documentation, 2026

Photo 6. Demolding: Lifting The Inner Core of The Mold



Source: Private Documentation, 2026

Evaluation of the activities identified two main constraints. First, the inner core of the mold was difficult to remove and required several people and levers (Figure 7), which slowed production. Second, the available funding was lower than proposed, which limited the number of units to 15 and the intervention to the priority segment. These findings form the basis of the recommendations for the next cycle.

Photo 7. Installation of Precast U-Ditch Units at The Priority Channel Segment



Source: Private Documentation, 2026

Table 3 summarizes the technical outputs. Fifteen U-Ditch units were produced and installed, forming a continuous 15.0 m lined channel. Each unit contains 0.05 m^3 of concrete, so the program used about 0.75 m^3 of concrete in total; at a density of about 2,400 kg/m^3,

each unit weighs about 120 kg and can be carried by four people without lifting equipment. The compressive strength tests showed that the concrete met the K-225 target. According to the implementation report, all main technical activities (mold fabrication, production, testing, transport and installation) were 100% realized, while supporting outputs (journal article, technical report and video) were about 70% complete at the time of writing.

Table 3. Technical Outputs of The Program

Indicator	Result
U-Ditch units produced and installed	15 units
Length of lined channel	15.0 m
Concrete volume per unit / total	0.05 m³ / 0.75 m³
Approximate mass per unit	≈ 120 kg (four-person manual lift)
Concrete compressive strength	Met the K-225 target
Theoretical capacity (y = 0.25 m, S = 0.5%, n = 0.013)	≈ 0.084 m³/s (84 L/s); v ≈ 1.1 m/s
Realization of main technical activities	100%
Realization of supporting outputs	≈ 70%

Source: Author's Work, 2026

For a flow depth of 0.25 m (0.05 m freeboard), the U-Ditch section has a flow area of 0.075 m² and a hydraulic radius of 0.094 m. With Manning's n = 0.013 for finished concrete, the theoretical capacity is $Q \approx 1.19\sqrt{S}$ m³/s, i.e., about 84 L/s at an illustrative longitudinal slope of 0.5% (velocity ≈ 1.1 m/s, above the usual self-cleansing velocity of 0.6 m/s). An earth channel of the same section with n ≈ 0.025 (Chow, 1959) would carry only about 52% of this flow, before accounting for bank collapse and sediment that further reduce its section. Field observation after installation showed that the lined segment formed a continuous and stable channel for surface runoff from the surrounding houses; quantitative flow measurement was not carried out and is recommended for future monitoring.

Table 4 and Figure 2 present the questionnaire results of 100 responses (10 respondents × 10 items), 79 (79%) were strongly agree and 21 (21%) agree, with no disagree or strongly disagree responses. The overall mean score was 3.79 of 4. The highest scores (4.0) were given to item 7 (increased knowledge or skills) and item 8 (management of the assistance and partner involvement), followed by items 5 and 9 (3.9), indicating that residents particularly valued the learning process, the way the activity was managed, the usefulness of the mold and the environmental benefit. The lowest, though still positive, scores were for item 3 (improved water flow, 3.5) and item 6 (clarity of the explanation of the production process, 3.6). The lower score for water flow is consistent with the limited extent of the intervention, which covered only a 15.0 m priority segment, while the score for item 6 suggests that the technical explanation of production needs to be simplified, for example through step-by-step visual guides.

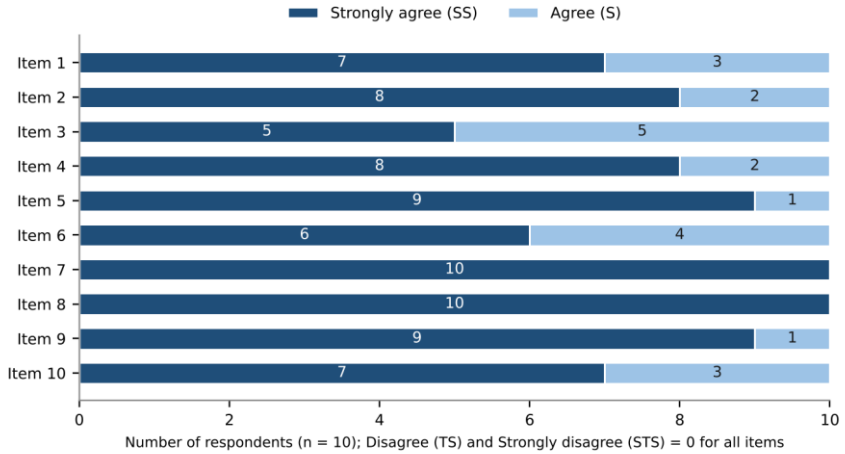
Table 4. Results of The Participant Satisfaction Questionnaire (n = 10)

No	Questionnaire item	SS	S	TS	STS	Mean
1	The activity meets the community's drainage needs.	7	3	0	0	3.7
2	The U-Ditch has made the drainage channel sturdier and more orderly.	8	2	0	0	3.8
3	The U-Ditch installation has helped improve water flow.	5	5	0	0	3.5
4	The activity has helped reduce the risk of soil collapse and blockage along the channel.	8	2	0	0	3.8
5	The semi-system mold is useful for producing U-Ditch units.	9	1	0	0	3.9
6	The explanation of the U-Ditch production process was easy to understand.	6	4	0	0	3.6
7	The activity has increased residents' knowledge or skills.	10	0	0	0	4.0
8	The assistance provided and the involvement of the community partner were well managed.	10	0	0	0	4.0

No	Questionnaire item	SS	S	TS	STS	Mean
9	The results of the activity benefit the community environment.	9	1	0	0	3.9
10	Overall, the community partner is satisfied with the activity.	7	3	0	0	3.7
	Total (%)	79 (79%)	21 (21%)	0	0	3.79

Source: Author's Work, 2026.

Figure 2. Distribution of Responses to the Participant Satisfaction Questionnaire (n = 10)



Source: Author's Work, 2026.

Changes in participation were assessed through direct observation during the activities. Residents took part not only as recipients of the infrastructure but in its production and installation—fabricating reinforcement, casting concrete, demolding and installing the units (Figures 5–8)—and thereby gained hands-on experience in precast concrete production and quality control. These observations indicate an early shift in the residents' role from beneficiaries to co-producers of their drainage infrastructure. However, a formal resident group for maintenance and continued production had not yet been established by the end of the program, and the durability of these changes requires monitoring beyond the program period.

Discussion

The physical improvement follows from two mechanisms. First, a concrete lining fixes the cross-section: unlike earth banks, it cannot be eroded or collapse, so the design capacity is maintained between maintenance events. Second, the smoother surface roughly halves Manning's roughness, nearly doubling conveyance for the same section and raising velocity above the self-cleansing range, which reduces sediment deposition. These mechanisms are consistent with the design basis of reinforced-concrete U-Ditch channels reported by Rahman et al. (2022) and with the practical application reported by Tama et al. (2024). The time and cost advantages of precast over masonry and cast-in-situ construction reported by Dilianto et al. (2024) and Sidiq et al. (2024) refer to contractor-built projects; in this program, the advantage came instead from local production, which turned the purchase of components into a learning activity for residents.

The social outcomes can be explained by how participation was organized. Learning took place through doing and through dealing with practical problems encountered during production, such as the difficult demolding, which corresponds to Freire's (2000) view of learning as action and reflection rather than the transfer of information. Measured against Arnstein's (1969) ladder, residents' knowledge shaped the identification of the problem and the installation location, whereas the mold was designed by the team and only introduced to

residents—a level closer to consultation. This difference matters: the component on which residents had least influence, the inner core, was also the one that caused the main operational problem. The relatively lower score for the clarity of the production explanation (item 6) points in the same direction. Technology transfer is therefore more than handing over equipment; its success depends on involving residents in the whole chain, including design.

The demolding difficulty has identifiable technical causes. The inner core has vertical faces without a draft angle, so the full contact area of fresh concrete resists extraction through friction and suction; adhesion increases where the release agent is applied unevenly; and the core is a single rigid box that cannot contract. Feasible redesign options include a taper of about 1:50 to 1:100 on the core faces, a split or collapsible core with hinged or wedge-released panels, chamfered inner corners, a consistent release agent, and a fixed demolding time recorded in the procedure. These modifications keep the mold manually operable and should be designed together with the residents who have used it.

Economic feasibility can be outlined from the material quantities. Following SNI 7394:2008 proportions for K-225 (371 kg cement, 698 kg sand, 1,047 kg coarse aggregate and 215 L water per m^3), one unit requires about 18.6 kg cement, 34.9 kg sand, 52.4 kg coarse aggregate and 10.8 L water, plus reinforcement; the 15 units required about 278 kg cement (about 5.6 bags of 50 kg), 524 kg sand and 785 kg coarse aggregate. A full cost comparison with commercial U-Ditch units was beyond the scope of this program. Nevertheless, because the mold is reusable and the main inputs are locally available, the marginal cost of each additional unit consists only of materials and labour. A detailed cost and time study, including mold depreciation, is recommended to determine whether small-scale production for neighbouring areas of Cipayung Jaya is economically viable.

Institutional sustainability is the critical condition. Studies of communal water infrastructure in Indonesia show that facilities are maintained where a recognized local institution, clear rules and social capital such as gotong royong exist, and decline where management groups dissolve (Brontowiyono et al., 2022). Ostrom's (1990) design principles—clear boundaries of responsibility, rules adapted to local conditions, and monitoring by the users themselves—offer a practical frame for the resident group that should be established to maintain the channel. Starkey et al. (2025) similarly argue that communities care for drainage solutions that they help to shape. For Cipayung Jaya, this implies agreeing who maintains the 15 m segment, how often it is cleaned, where the mold is kept, and how maintenance and further production are financed, for example through Kelurahan funds or a resident business group.

The program has limitations. Only one PAR cycle was completed; the questionnaire was administered once to a small group, without a pre-test, and therefore describes satisfaction rather than measured learning gains; hydraulic performance was assessed by observation and calculation rather than flow measurement; and health effects such as reduced vector breeding were not measured. Funding lower than proposed limited the intervention to 15 units, so the downstream sections of the channel remain unlined. Expanding the program to the downstream sections will require further coordination with the Kelurahan.

Replication in other neighbourhoods requires more than the mold. Based on this experience, the minimum prerequisites are: (1) a channel problem that residents themselves prioritize; (2) a core group of trained residents and a local technical contact; (3) access to cement, aggregates and a place for production and curing; (4) support from the Kelurahan and local community leaders for coordination and use of public land; and (5) an agreed scheme for maintenance and financing. Where these conditions exist, the semi-system mold provides a low-cost entry point for community-produced drainage infrastructure.

Conclusion

The program achieved its three objectives to different degrees. (1) Physical: 15 precast U-Ditch units (internal section 0.30 × 0.30 m, length 1.0 m, wall thickness 0.05 m) were

produced and installed, replacing 15.0 m of eroding earth channel with a stable lined channel whose theoretical capacity is nearly twice that of the earth channel of the same section. (2) Capacity: residents produced the units using the semi-system mold, and the concrete met the K-225 target; satisfaction was high (79% strongly agree, 21% agree, mean 3.79 of 4). (3) Institutional: a formal resident group for maintenance and continued production has not yet been established, so this objective is only partially achieved.

Theoretical reflection. The experience suggests that the success of technology transfer in community service depends on the residents' involvement across the whole production chain, including the design of the tool, not only in its use or in installation. Community ownership of infrastructure arises from participation in the decisions and the work that create it; where residents had less say, as in mold design, problems also emerged.

Recommendations. (a) Technical: redesign the mold together with residents (tapered or collapsible core, chamfered corners, documented demolding time) and monitor the hydraulic performance and condition of the channel for at least one rainy season. (b) Empowerment: establish a resident group with clear tasks for maintenance and production, train a second cohort led by the first participants, and support the group to manage its own records and funds so that it does not depend on the university. (c) Policy: the Kelurahan and the Depok City government may consider allocating Kelurahan or APBD funds to purchase materials for resident-produced U-Ditch, and recognizing the resident group as a partner in drainage maintenance, as provided for in the national urban drainage regulation (Kementerian PUPR, 2014).

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