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Does participation lead to on-going infrastructure maintenance? Evidence from Caribbean landslide mitigation projects

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Abstract

Donor-funded infrastructure projects may focus on construction and neglect longer-term sustainability. Engaging local communities has been proposed as way of inducing on-going maintenance by facilitating co-ordination and a sense of ownership, but there is little evidence on its effectiveness in practice. We analyse data from inspections of 103 landslide hazard mitigation drains in Saint Lucia several years after construction. We conclude that community participation at the beginning of the project, by accessing local knowledge, is associated with improved construction quality, but appears to have no impact on subsequent maintenance, suggesting that contractual provision for maintenance may be required.

1. Introduction

The idea of community participation has become increasingly prominent in international development. The World Bank has been instrumental in promoting such approaches; contributing $85 billion in funding for participatory development projects over the last ten years, followed by other major lenders and donors. Support for community-based development, over the alternative of 'top-down' development initiatives, comes from the

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view that it can lead to better outcomes across a number of dimensions, including improved local services, accountability in the use of public funds, empowerment of local people and social cohesion (Mansuri and Rao, 2013). In particular, participatory approaches are often cited as a means of encouraging a sense of ownership of new infrastructure, resulting in higher levels of maintenance. Such maintenance is important for extending the operational lifespan of infrastructure projects, but is often overlooked by donors who prefer to provide funds for new investments rather than pay recurrent costs (Therkildsen and Buur, 2010). Project plans often claim to be 'sustainable', but this tends to rely on local communities to undertake or finance maintenance after donors have financed the capital costs of infrastructure (Kremer and Miguel, 2007).

Participation in infrastructure projects involves challenges and costs to communities. This has been shown with respect to water supply projects in South Asia and Africa (Burr and Fonseca, 2013), rural community infrastructure projects in Pakistan (Khwaja, 2009), and schools and roads in Jamaica (Rao and Ibáñez, 2005). It is therefore not a given that communities will undertake maintenance as expected, even when the project is widely perceived to be beneficial. In fact, the extent to which local communities will take over such projects remains largely untested, and very few studies assess their long-term sustainability (Mansuri and Rao, 2013, p188). Our study seeks to address this shortfall in evidence.

We present new evidence on the relationship between community engagement and the long-term condition of infrastructure projects. The projects we look at are government- and World Bank-funded hillside drainage networks in ten informal urban communities in Saint Lucia, Eastern Caribbean. We look at whether engagement with local communities at the design and construction stages is associated with on-going, post-construction maintenance of the drainage networks. We also ask two specific research questions that relate to potential causal mechanisms. *First*, with reference to Mansuri and Rao's (2013) findings, what are the potential mechanisms by which community participation during the design and construction phases affects project quality and the long-term condition of infrastructure projects? In particular, we consider Khwaja's (2004) assertion that participation is more likely to be beneficial when it relates to decisions that require local knowledge compared with those that necessitate more technical decisions. *Second*, given that project resources must be allocated between a number of inputs, what is the effect on project quality of investing in community engagement compared with construction inputs such as materials, contractor ability and supervision by engineers? The analysis takes account of community-level factors, including both objective characteristics of the communities, such as income, and survey-based indicators of community cohesion.

We analyse data from 103 surface-water drains constructed in Saint Lucia between 2004 and 2011. The purpose of the drains was to improve slope stability, and they were delivered using a community-based disaster risk reduction approach (Anderson and Holcombe, 2013a, 2013b; Anderson et al., 2013). The degree of community participation and the level of initial build quality are based on structured interviews with the original project managers and site supervisors. The current state of a drain is quantified by estimating the cost of cleaning and repair required to bring it back to as-new condition.

Compared to Khwaja (2004, 2009), who investigated 132 infrastructure projects across multiple infrastructure categories and 99 communities, our sample is more homogeneous: we focus on a single project type, analysing data on 103 drains in ten similar low-income informal urban hillside communities in a Small Island Developing State. Our paper is related to Rao and

Ibáñez (2005) in that we study participatory infrastructure projects in the Caribbean, but their focus is on elite capture and satisfaction with outcomes, rather than with the long-term maintenance and condition of the projects.

Overall, our results indicate that community engagement at the design and construction stages is associated with lower estimated cost of repair years later. We interpret this as improved project quality due to being able to draw on local knowledge, and specifically, to avoid the locations of previous landslides where the slope is weakened. However, we find no evidence that upfront investment in community participation leads to more on-going maintenance by the community. We conclude that communities respond to attempts to engage them by getting involved at the design and construction stages, but that on-going community action may require on-going investment in participation.

2. A community-based approach to landslide risk reduction

Like many other developing countries in the humid tropics, Saint Lucia is increasingly affected by rainfall-triggered landslides. The main hazard and risk drivers are rapid unplanned urbanisation and changing rainfall patterns. Low-income urban communities are particularly at risk due to their occupation of low-value landslide-prone slopes, the high density of informally constructed dwellings and decreased slope stability due to changes in topography (slope cuts and fills), loading by construction, surface cover and unplanned drainage. Even moderate rainfall (one-in-1-year to one-in-5-years events) can result in numerous small-scale landslides causing damage to property and livelihoods and the loss of life. The highly localised scale of landslide mechanisms calls for an equally localised approach to risk mitigation.

A carefully aligned and connected network of drains can be highly effective in increasing slope stability. Such drainage projects are, however, rarely implemented by local governments due their non-standard nature (retaining walls are favoured, but expensive), the political sensitivity of intervening in unauthorised settlements, the highly localised nature of slope destabilising mechanisms and the difficultly in assessing their impacts (potential landslide locations, magnitudes and frequencies). Residents may have detailed local knowledge of slopes to overcome some of these challenges, but independent community action can be hindered by the cost of construction materials, land ownership issues and the need for co-ordination and engineering expertise.

In this section we describe the community-based approach to landslide hazard reduction that was taken in the ten project communities. We highlight the role of local residents in providing information and contributing to project implementation. The associated conceptual framework (section 3) guides our investigation into how community participation might affect infrastructure project quality and maintenance.

(a) The Management of Slope Stability in Communities (Mossaic) participatory approach

The drains studied here were delivered using the Management of Slope Stability in Communities (Mossaic) approach (World Bank, 2009; Anderson and Holcombe, 2013a; Holcombe et al., 2013). Mossaic aims to combine community knowledge of local slope features with engineering know-how, and community participation with government funds, to construct cost-effective landslide-mitigation drainage networks. The projects involved the construction of a network of open drains designed to capture surface water in all forms, including roof water, grey water and overland flow of rainwater.

The Mossaic project steps are as follows:

i. *Decision by government* to deliver community-based landslide risk reduction in informal urban settlements, often using Disaster Risk Reduction funding from an international organisation.

ii. *Identification of implementing agency*. Commissioning of a multi-disciplinary Mossaic core unit comprising a senior project manager, civil engineer, community development practitioner and representatives from other relevant agencies; and identification of task teams to deliver the technical components of the project on the ground.

iii. *Selection of suitable urban communities* based on the degree of landslide hazard, exposure and vulnerability. Confirmation of the selected communities includes initial discussions with residents and identification of an existing or new 'community task team' (comprising community residents and leaders) to liaise with government teams.

iv. *Detailed assessment of localised landslide hazard* using a community-based mapping approach, jointly led by the community task team and a landslide assessment team that includes a civil engineer or slope stability expert, a mapping technician and a community development practitioner to guide the participatory process. Community residents are involved through a house-by-house survey of slope stability and a series of open community meetings in which the evolving hazard map and potential drainage solutions are discussed (see step v). Local knowledge of the slopes elicited from residents is interpreted by the engineer or slope stability expert to determine the dominant instability mechanisms and most effective means of reducing the landslide hazard. Involving community residents in the conversations on landslide causes and solutions allows them both to contribute and to gain insights into the localised slope processes that are vital for understanding the landslide hazard.

v. *Design of a drainage network* to reduce surface water infiltration and improve slope stability. This is led by the engineer but informed by residents who may provide vital local knowledge on issues affecting drain alignment. The design is refined by means of further walk-through surveys and community meetings before final approval by the community and the project management team.

vi. *Construction of the drains* that form the network is undertaken by small teams of community residents who have experience in the formal or informal construction sector, such as contractors, masons, carpenters and labourers. Potential community contractors are guided through a tender process by the implementing agency and, if successful, are awarded petty contracts for constructing specific drains. Unskilled labourers from the community may be selected by community leaders for short-term employment as part of the contractors' teams. Construction is overseen on-site by an experienced supervisor or engineer from the implementing agency. Additional on-site training may be given to contractors during implementation of the works. External skills input during drain construction depends on the pool of locally available labour, the selection of contractors and workers from that pool and any training given to them.

vii. *Post-project maintenance* typically falls outside Mossaic project delivery and funding time-scales. However, on-going drain cleaning is one of several slope-management good practices promoted in the community as part of the Mossaic framework. Decisions on post-project maintenance rest with funders and local government stakeholders. The hitherto prevailing assumption was that community participation will lead to residents 'owning'—and thus maintaining—the drains.

Between 2004 and 2011, sixteen Mossaic projects were implemented in Saint Lucia, Dominica, Saint Vincent and the Grenadines and Tortola. Because the details of implementation vary somewhat across countries, this paper focuses on the ten projects, comprising 103 individual drains, implemented in Saint Lucia and funded by the government of Saint Lucia and the World Bank.

The Mossaic approach has been shown to be effective in reducing landslide hazard (World Bank, 2009). The project slopes in Saint Lucia remained stable despite a one-in-500-years rainfall event during Hurricane Tomas in 2010. Prior to the interventions, these hillside communities experienced landslides in response to rainfall events with two- to five-year return periods. Analysis of a typical project estimated a benefit-cost ratio of 2.7 based on a 20-year design life (Holcombe et al., 2012). The long-term condition of the drains is crucially important, however; shortening the project lifetime to seven years reduces the benefit-cost ratio to 1.7. This makes it important to consider what affects the long-term operation of the drains.

(b) Project implementation decisions and community participation

Mossaic funders, implementing agencies and the multi-disciplinary project management team must decide how best to implement each project with the available funding. Top-level project implementation decisions concern the selection of the implementing agency, the selection of communities, the approach to involving community residents, and the method of engaging local contractors to build the infrastructure. This sub-section provides a brief overview of how the ten community-based projects in Saint Lucia were implemented.

The projects studied here were delivered by two different implementing agencies. In 2004 the Mossaic pilot project was implemented by the Poverty Reduction Fund (PRF) – a social fund accountable to the Government of Saint Lucia (GoSL) and initially funded by the World Bank. The broad remit of the PRF was community development through participation. Staff included project managers, community development practitioners and social scientists, a civil engineer and two technicians. After the pilot project, six further Mossaic-PRF projects were directly funded by the GoSL between 2005 and 2008. The pilot project and four of the subsequent projects are included in this study (communities 1–5 in section 4). The remaining five projects in this study (communities 6–10) were implemented by the Ministry of Communications, Works, Transport and Public Utilities (MCWTPU; now the Ministry of Infrastructure); staffed by civil engineers, project managers and technicians, and funded under a World Bank loan for disaster risk reduction. Both the PRF and MCWTPU were accountable to the GoSL, and budgetary considerations did not influence the funder's choice of implementing agency. Both implementing agencies also collaborated with relevant ministries to ensure that the full range of necessary technical and community development aspects of project delivery were covered.

The focus of Mossaic is to reduce landslide hazard in the most vulnerable hillside communities. The community selection process (step iii above) therefore targets landslide-prone slopes (high hazard), where the exposure to, and impact of, landslides is likely to be significant (high vulnerability); and where the human actions and natural mechanisms that affect slope hydrology and stability can be mitigated. These criteria lead directly to low-income informal communities, typically in urban areas, with high housing density and poor quality construction. Nine of the ten communities in this study are located on the densely populated hillsides surrounding Castries, the capital of Saint Lucia, and several are contiguous with one another along the same slopes. The communities range in size from about 20 to 120 households, with housing densities of 40% to 70% land surface cover, on slopes of 20- to 40-degree angles. Road access and other formal infrastructure is limited (for example. street lighting, mains water and electricity) or non-existent (for example. sewerage), and most houses are reached by narrow unpaved or concrete paths and steps.

Indicators of community poverty levels, cohesion and inequality are given in section 4(b). There are no statistically significant differences between the ten communities that might affect community capacity and initial project construction quality. This is unsurprising given the proximity and physical similarity of the nine urban communities. The remaining community (community 9 in section 4b) is in a fishing village and, as is typical of rural areas in Saint Lucia, it has lower income levels and higher unemployment than Castries.

The structure of land ownership varies among the communities; from cases where land is rented from a single landlord and residents are permitted to build new, or extend existing, houses; via those which are comprised of parcels of family land that is sub-divided with each generation; to those where government or privately owned land has been illegally built upon. Types of ownership may vary within a single community. Part of the community selection process involves the implementing agency ensuring that a community-wide drainage construction would be both legal and acceptable to landowners; and that all safeguard policies are in place (World Bank, 2016). Following the pilot project in 2004, funding proposals for each community were based on an average per-house unit cost estimated from previous project costs. The comparable size of the potential project communities meant that budget constraints did not affect community selection. Anderson and Holcombe (2013a) describe the communities in more detail.

The final two project decisions relate to the implementing agency's allocation of the project budget in support of two areas of activity – community participation and construction inputs. The 'ladder of participation' (Arnstein, 1969; Pretty, 1995) describes different levels of community engagement in projects that can be summarised, from low to high participation, as follows: manipulation by the implementing agency, passive receipt of information, providing information, being consulted, receiving material incentives, providing in-kind contributions, interacting in decisions, and initiating and running the project independently. Within the fully defined Mossaic framework (Anderson and Holcombe, 2013a), project implementing agencies are directed to take a collaborative approach in which they should aim to both build the capacity of the community and learn from it (in accord with ALNAP, 2003). Mossaic project activities align with the middle rungs of the ladder of participation: communities provided information, tendered for contracts, volunteered their time during mapping and meetings, and interacted on selected project decisions such as drain alignments or identification of manual labourers to join the contractors' teams. The iterative knowledge sharing between residents and engineers promotes action-learning for *all* stakeholders as opposed to traditional top-down technology transfer (Holcombe et al., 2013).

(c) Community engagement in practice

In translating the participatory approach into practice, it is important to take account of local circumstances. We discuss how this was done, drawing on field experience and anecdotal evidence. To understand implementation, it is helpful to think of two stylised types of communities. Type A, is characterised by relatively dense housing and the presence of an informal leader and their close supporters, who can have a high level of influence within the community. While community-based decisions were still the norm in the drains projects, in these communities the overall progress of the project relied on the implicit or explicit support of the leader. In Type B communities, housing tends to be less dense and there are no strong hierarchies or sub-groups. In these communities decisions therefore tend to be consensus-based at all levels, and different leaders or teams might emerge for different aspects of the project. It should be noted that these community types represent the ends of a spectrum rather than exclusive categories, and the two types do not map easily to any quantifiable factor. However, we find these community types are more helpful than standard markers such as ethnicity and gender in understanding what happened on the ground.

When the project teams first approached a community of Type A, they would generally be introduced to the unofficial community leader at an early stage, who would inquire about the purpose and nature of the work. In all cases the proposed landslide mitigation projects were welcomed and engagement with the wider community would then proceed. In Type B communities, upon first approach, the project team would often be met by a group of people who were curious as to the purpose of a group of outsiders. Introductions would then be made to other residents who may have information on past landslides or current slope stability issues. While participation changed organically, the people who first approached the team would often continue to play important roles in the projects as they progressed.

In all communities there was invariably enthusiasm about the prospect of installing the drains, and so the project team always felt welcome to enter the communities and talk to residents – both informally on site, or at community meetings. Communities were quick to recognise that, in addition to landslide hazard reduction, the drainage projects offered other significant benefits that could improve their daily life. These co-benefits included: the removal of excess surface water that would have previously made the footpaths within the community muddy and difficult to negotiate; a reduction in stagnant water that might have become contaminated with unsanitary waste water from leaking septic tanks, or provided a breeding-ground for mosquitoes; and the provision of roof-guttering and water-tanks for some households (to capture rainwater and connect to the drains). Thus, while landslides were also recognised as a risk, their relative infrequency made them less salient to the community than restricted access via the footpaths and poor environmental health, which would affect them after every heavy rainfall (Holcombe et al., 2012).

While the drains would indeed help with these other issues, the main purpose of the project was the prevention of landslides, and this informed the design of the drain alignments and network. In the early stages of the projects it was therefore important to manage the communities' expectations of what the drains could be expected to achieve and why they may be constructed in certain locations and not others.

The competitive tendering process for drain construction work packages proceeded smoothly, by and large. This was probably in part due to the skill of the government team members in identifying eligible local contractors from the communities in the invitation to tender, operating a transparent process, managing expectations and ensuring fairness. Though the implementers' approaches differed, there was also generally an emphasis on involving as many locals in the construction work as possible, whether as contractors or labourers.

One of the characteristics of the projects noted by the authors was the need for transparency and trust. A marker of the extent to which the projects were accepted by the community was the fact that building materials rarely if ever went missing. During the construction of the drains, materials of significant value were stored in each of the communities. While these were stored close to the dwellings of key participants rather than at the sites, they were in most cases not securely locked. Keeping the construction materials safe can itself be regarded as a key contribution from the communities into the participatory process.

There were few apparent problems relating to land ownership due to the projects having already been approved by Government and therefore deemed compliant with such safeguarding issues. Where the land was subdivided into smaller family holdings, consent would be obtained as part of the process of community engagement. In every case, as well as the advantages they brought to the communities, landowners generally saw the drains as improvements that would increase the value of the land.

It is likely that residents with jobs outside the communities may have had less contact time with project implementers than the unemployed, elderly, or those working at home. Still, project implementers endeavoured to consult all householders and residents during the house-to-house slope mapping and drain design phase. Care was taken to visit the community at different times of day and on different days of the week, including Saturdays and Sundays. Community meetings were held in the evenings or at weekends to maximise the opportunities for residents to attend.

All ten communities are dominated by people of black Afro-Caribbean or mixed descent. Because of this homogeneity, ethnicity did not play a major role in the participatory processes.

(d) Participation and gender

Saint Lucia 2010 census data show that 27% of households have a female head, and 'a female-headed household often means substandard housing, weak social capital and a home located in a disaster-prone area' (CDB, 2016, p34). Women are also somewhat more likely than men to be unemployed, with a national unemployment rate of 22% for women compared to 19%

for men. However, Saint Lucian culture is characterised by strong women taking on leadership roles within their families, business and wider community.

Demographic data on those engaging with the Mossaic projects were not collected, so the following is again based on anecdotal evidence. In Type A communities, the participatory process was primarily driven by young, unemployed men. There were fewer formal community meetings, and while the implementing agencies adhered to funding safeguards to ensure that a representative number of women and the unemployed were given short-term employment as unskilled labourers, it was more challenging to engage women and the elderly in these communities.

In Type B communities, participation was more demographically balanced in terms of both age and gender, and if anything, women were more active than men. Women were often among the most vocal participants in the community meetings and the terrain walk-throughs, and were frequently employed as labourers. However, only in the case of community 8 were women also awarded work packages as contractors — perhaps because of a lack of experience in construction. That said, leaders of the committees in charge of the unskilled labour rota (a very influential role during the construction phase) were often female in these communities.

In both types of communities, the possibility of obtaining paid work appeared to be particularly attractive to young men, who in many cases have few other job opportunities.

Anecdotal evidence suggests no particular pattern in those engaging in post-construction drain cleaning – both men and women, particularly heads-of-household, were known to have cleaned sections of drain or worked with neighbours to do so.

3. Conceptual framework

Figure 1 presents the conceptual framework that we use to frame our analytical approach. While not a formal model, it helps to guide and interpret the empirical analysis.

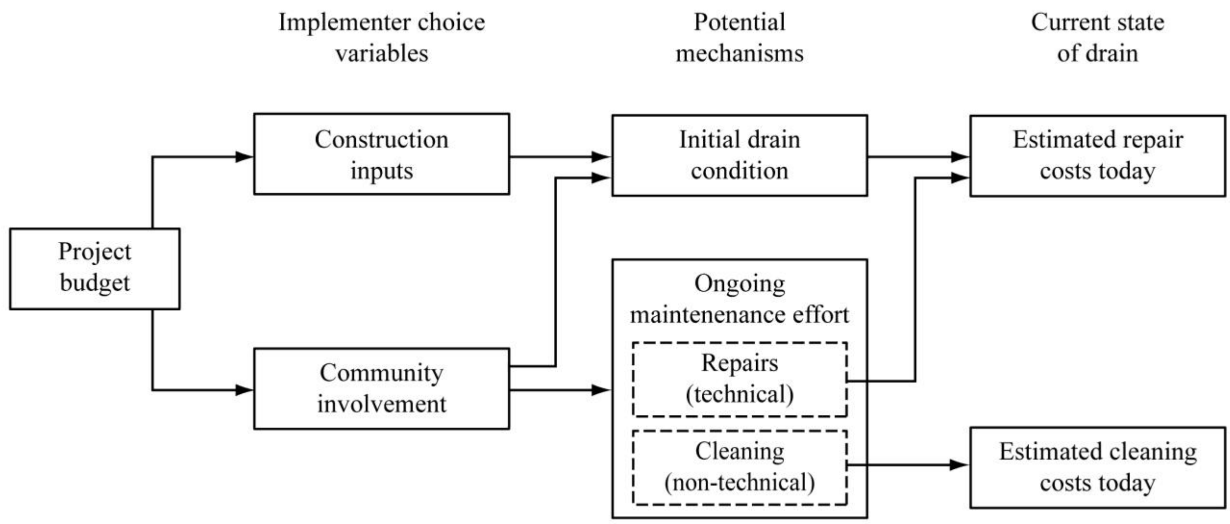

Figure 1. Conceptual framework

At the project design stage, a fixed budget is made available per project to design and construct a community-wide drainage network. The implementing agency must allocate this budget between two broad types of inputs: community engagement and construction inputs.

Measures to engage the community include: time-intensive group walk-through slope surveys, house-to-house visits and open community meetings to elicit local knowledge and involve the community in decision-making; training for community leaders; and public awareness activities to encourage good slope management practices and drain maintenance. The cost of involving communities depends on how much time the implementing agency spends on site in the community, the level of participation in project decisions and construction delivery that residents are afforded, and the associated capacity-building effort required.

Construction inputs include contractors' fees along with the costs of materials and site supervision. Note that in practice, the cost of materials required per metre of drain is largely fixed. But the implementing agency has a choice between maximising local short-term employment and participation within the community or opting for a smaller number of more experienced contractors, potentially from outside the immediate project area. The first approach can necessitate close supervision, including on-site training, while the second may be less time-intensive. The PRF typically selected of a small number of experienced local contractors to implement the works, supported by a large number of unskilled labourers drawn from the community (often selected by community residents and leaders). Supervision of the work by the PRF engineers was not necessarily continuous and depended largely on the expertise of the contractors. Conversely, the MCWTPU tended to focus on building the capacity of local contractors with little or no prior experience of tendering for formal projects. Training was provided for the tender process and a large number of petty contracts were awarded to small teams of labourers from the communities. Where there were inexperienced contractors, a MCWTPU supervisor was available on site most of the time to provide guidance and ensure quality of construction.

In principle, both community engagement and construction inputs may contribute positively to the long-term condition of the project in ways we describe below. As proxy measures of this long-term condition, we use current estimated repair and cleaning costs. Since there is no established standard for evaluating drain performance (Kolsky and Butler, 2002), we use an expert surveyor to determine and document the extent of repair and cleaning required to restore the drains to an 'as-new' level of functionality. These costs were estimated during drain inspections in 2013, several years after construction.

Figure 1 shows the pathways through which spending on the two broad types of inputs (community engagement and construction inputs) can affect long-term project condition (proxied by estimated repair and cleaning costs). Crucially for our analysis, it is assumed that the two inputs work through different pathways: A higher level of spending on construction inputs is assumed to improve initial drain condition, and hence reduce the need for subsequent repairs. Contractors' fees are an increasing function of their skill and experience, so, in general, paying more is expected to be associated with higher construction quality. Also, other things equal, increasing the level of site supervision is also expected to increase initial construction quality. However, it is assumed that higher spending on construction inputs will not reduce the need for on-going cleaning. Drain cleaning is mainly a matter of removing vegetation, debris and silt, and in tropical conditions these will tend to accumulate at a rate that is independent of the quality of the construction. From experience we do not expect that the level of cleaning will affect the state of repair, or that the state of repair will have an impact on the level of cleaning required.

We assume that investment in community engagement can also improve the initial condition of the drains, since it will allow local knowledge to be incorporated into their design and construction. The correct alignment of drains is of fundamental importance if such projects are to reduce the landslide hazard, since their purpose is to intercept surface water and reduce infiltration into the slope (Anderson and Holcombe, 2013a; Anderson et al., 2103). Information on the precise locations of previous landslides, areas of groundwater seepage and surface run-off and indicators of potential future instability were obtained during house-by-house mapping and community meetings. Taking such information into account when designing the drain alignments and construction specifications may reduce the risk of subsequent damage to the drains, resulting in a better state of repair years later. It is therefore expected that greater community engagement may lead to better drain placement. As with construction inputs, better placement may reduce the estimated cost of repair years later but is not expected to make a difference to the need for on-going cleaning.

A second potential pathway through which community engagement may improve the long-term condition of the drainage network is that a community that has been consulted and given a sense of ownership during the design and construction phase may be more likely to contribute to on-going maintenance activities. In principle such maintenance activities take the form of either cleaning or repair, but we expect that community members are better able to undertake cleaning than repairs. This is because repair work requires technical expertise, which most members of the community do not possess (Khwaja, 2004), and also financial resources for materials. (Our own data indicate that next to no technical repair had taken place between construction and inspection.) On the other hand, drain cleaning is an unskilled task for which the principal input is labour.

For these reasons, the estimated cost of repair at the time of inspection will be taken as an (inverse) proxy for the initial condition of the drain, including construction quality, functionality and placement, while the estimated cost of cleaning at the time of inspection will be taken as an (inverse) proxy for the level of cleaning undertaken by the community since construction. This distinction allows us to disentangle some of the potential pathways in the conceptual framework: The crucial test is whether more community engagement is associated with reduced *cleaning* costs, due to ongoing maintenance by community members. In contrast, an association between participation and *repair* costs would indicate that community engagement may improve initial build quality.

4. Data

There are 103 drains across ten communities. Drain- and community-level data are presented in turn. Some of the key variables (such as initial drain quality and functionality) are based on assessments by the senior government engineers, construction procurement and project managers involved in the original community projects. A surveyor, with no connection to the initial project construction process, inspected the networks in 2013 and recorded the current condition of each drain and estimated the repair and cleaning costs required to restore them to as-new condition. Some variables are based on interviews with residents from each community. We also draw on census data for the income and inequality variables.

(a) Drain-level data

Table 1 presents summary statistics for the 103 drains. The drains are between 5 and 130 metres long, with an average of 46.5 metres. For each drain the senior engineer responsible for the Mossaic project in that community was asked to assess, on a scale from 1 to 5 (low to high), the intensity of the implementing agency's on-site construction supervision as well as the skill of the contractor undertaking the work on that drain. We regard these variables as reflecting choices made by the implementing agency. Drain build quality and functionality, also in the range 1–5, are expert assessments of the state of the drain immediately after construction. Note that the expert was not asked to assess the suitability of drain placement, since this would require precise local knowledge of slope stability mechanisms.

Table 1. Summary statistics for drain-level variables

Variable	Mean	SDev	Min	Max
Variables pertaining to drain construction				
Length (metres)	46.5	29.4	5	130
Supervision intensity (1–5)	3.79	0.66	2	5
Contractor skill (1–5)	3.95	0.80	2	5
Build quality (1–5)	4.10	0.76	2	5
Functionality (1–5)	4.46	0.66	2	5
Variables pertaining to 2013 drain re-inspection				
Age of drain at inspection (years)	4.72	3.04	2	9
Estimated cost of cleaning drain (XCD)	203	338	0	1440
Estimated cost of repairing drain (XCD)	169	999	0	9750

Notes to table: Costs in East Caribbean dollars. 1 USD = 2.7 XCD.

In 2013, all the drains were inspected by an independent surveyor. At the time of inspection, the age of the drains ranged from 2 to 9 years. The surveyor assessed the degree of maintenance required to bring each drain back to a fully operative ‘as-new’ state. The types of maintenance considered are presented in Table 2. In each case, the length of drain requiring each type of maintenance was recorded in metres. For example, a 20-metre drain might require 15 metres of debris and vegetation removal (‘cleaning’) and 7 metres of added backfill to prevent the drain walls being undercut by erosion (‘repair’). Each type of maintenance is associated with the cost per metre used in the government procurement process, in turn based on known costs and prices around the time of inspection. The cost of *cleaning* a drain was estimated by multiplying the cost per metre of removing debris and vegetation by the length of drain requiring this form of maintenance. The cost of *repairing* a drain was estimated by multiplying unit costs by lengths of drain requiring each form of repair, and then adding together the costs of all the different categories of repair.

Table 2. Types of repairs or maintenance considered and associated costs per metre

Type of repairs or maintenance required	Cost per metre (XCD)	Repair or cleaning
Remove debris, silt and vegetation	14.40	Cleaning
Add row of blockwork to prevent overtopping	30.00	Repair
Add compacted backfill to prevent undercutting	20.25	Repair
Add new concrete invert to make water-tight	90.00	Repair
Break up damaged sidewall and patch with new blockwork	150.00	Repair
New drain required to connect with existing network	350.00	Repair
Demolish existing damaged drain and rebuild	500.00	Repair

Notes: The costs per metre are based on a typical open reinforced concrete blockwork drain, with a rectangular cross-section 0.45 m deep and 0.4m wide. The cost of removing debris and vegetation is obtained from a standard XCD 80 cost per cubic metre. The cost of adding blockwork per metre assumes the height of a single concrete block to be 0.2m, and the cost of blockwork to be XCD 150 per square metre; thus the cost adding a single layer of blockwork is 0.2 x 150 = 30 per metre run. The cost of adding backfill is based the assumption of a depth of fill of 0.45m (i.e. the height of the drain sidewall), a width at the ground surface of 0.3m and a triangular cross-section. If both sides of the drain need backfilling the area of fill per meter run is 0.3 x 0.45 = 0.135m^2. The cost of fill is XCD 150 per cubic metre, so the cost per metre run of fill is 0.135 x 150 = 20.25. Costs in East Caribbean dollars. 1 USD = 2.7 XCD.

Summary statistics for estimated cleaning and repair costs for the 103 drains are presented in Table 1. Both these variables are characterised by a skewed distribution and a large number of zeroes. Only 11% and 45% of drains require repairs and cleaning, respectively. Our main outcome variables are obtained by adding 1 to the raw cleaning and repair costs and taking the logarithm. In the regressions we use a Tobit specification to account for the truncated distribution.

(b) Community-level data

Table 3 presents summary statistics for variables defined at the level of the 10 communities in which the drains are located.

Table 3. Summary statistics for community-level variables

Variable	Mean	SDev	Min	Max
Average household income (XCD per month, 2010)	2066	477	1269	2889
Income inequality (Gini coefficient)	0.39	0.05	0.31	0.51
Community involvement (1–5)	3.40	1.05	2	5

Two of these variables, average household income and income inequality (Gini coefficient), are based on binned income data from the 2010 Saint Lucia census (GoSL, 2010). Using category midpoints we estimate average household income and the Gini coefficient with respect to household income for each community.

'Community participation' is a categorical variable in the interval 1–5 based on interviews with the senior engineers and project managers responsible for the Mossaic project in each community. The variable captures the extent to which the implementer spent resources on involving the local community in the project work (see data appendix for details of indicators). We regard this, too, as a choice variable from the implementer's point of view.

In addition to the income and income inequality variables that were included in the main regressions, we collected additional information on community characteristics and indicators of cohesion (Table 4). These were obtained from census data and interviews with community residents. With only ten communities, we cannot include all these variables in the regression analysis, but they provide qualitative context for the study.

Overall, these communities are poor, with the two richest only just exceeding national mean income and, in Castries, all but community 3 falling below the average Core Welfare Index Score for Castries (GoSL, 2004). People in community 9 (the rural community) have less than half the monthly income of the people in communities 3 or 5, which are on the lower slopes of hillsides close to Castries city centre. This pattern is by and large also reflected in the employment rates.

The final column of Table 4 reports an indicator of community cohesion. Information was collected via a community-level survey, conducted by the independent surveyor at the same time as the drain inspections were undertaken. Interviews with two residents from each community involved questions concerned with neighbourly trust, fairness, friendliness, church attendance, and expectations of various types of help given amongst neighbours. Each question was associated with a scale ranging from 1 to 5, where 5 represents the highest level of community cohesion (see Appendix). We report the community-level mean. With only ten communities, it is difficult to disentangle the relationships between pre-existing community cohesion, community engagement during the project and measures of community participation in infrastructure maintenance. We have verified that our results are robust to controlling for our proxy measures of community cohesion.

Table 4. Community-level variables

Community (in order of project completion)	Income last month (USD)	Income Gini	Population	CWI score [c]	Community cohesion index
1	470	0.39	228	11.05	1.5
2	802	0.39	413	10.72	3.1
3	1,070	0.36	145	11.37	2.6
4	706	0.37	285	10.54	3.0
5	1,009	0.44	212	10.72	1.8
6	777	0.37	252	10.6	2.3
7 [a]	778	0.36	281	11.16	2.8
8 [a]	778	0.36	281	11.16	2.6
9 [b]	623	0.51	142	8.2	4.0
10	639	0.31	138	10.95	3.4
National data (SDev)	943		172,826	10.98 (1.68)	
Castries city (SDev)				11.33 (1.52)	

Notes to table:
[a] Communities 7 and 8 are in the same Census Enumeration District
[b] Community 9 is in a fishing village. It is the only non-urban community – all other communities are in Castries.
[c] Core Welfare Indicator, CWI, scores are out of a maximum of 20, and are based on 2001 census data (GoSL, 2004)

Finally, we collected subjective community-level information on the extent to which cleaning and repairs have been undertaken since construction and the general state of the drainage network. In our main analysis, we choose to focus on the more objective maintenance and repair costs since these are directly comparable across communities. However, these measures provide useful background information on the activities undertaken, and it is reassuring that these measures and the estimated costs of cleaning and repair are positively correlated.

5. Results

Following our framework in section 3, we run two sets of regressions.

First, we regress the estimated cost of repair (which proxies for initial build quality) on measures of contractor skill, supervision intensity and community engagement. We expect the estimated cost of repair to be negatively related to all three variables.

Second, we regress the estimated cost of cleaning on the same variables. We expect there to be no relationship between contractor skill / supervision intensity and the cost of cleaning. A negative relationship between community engagement and the cost of cleaning would be an indicator of the success of participatory approaches in terms of encouraging long-term maintenance, while a negative relationship between community engagement and the cost of repair would suggest that participation improves initial build quality.

(a) Estimated cost of repair

Consider first the estimated cost of repair required to bring the project back to a fully functional state. Repair costs are taken to be an (inverse) proxy for the initial build quality of the project, because survey evidence suggests that little if any repair has taken place in the interim. As with all infrastructure, there is an element of uncertainty in how fast and to what extent the drains will deteriorate; however, it is largely true that the higher the quality of the initial build, the fewer repairs will be required years later (McKinsey & Co., 2013). In the case of the repair costs summarised in Table 2, new blockwork may be required because the original drain had not been built with a sufficient flow capacity (that is, not fully functional); similarly, new backfill may be needed where the original backfill was of the wrong material or not properly compacted (a construction quality issue), or the alignment of the drain was incorrect which allowed erosion around the drain (a functionality issue). Other initial project quality issues could relate to the quality of the cement used in the drain invert, lack of weep-holes or insufficient reinforcement and mortar in the sidewall blockwork. Poor quality construction of these forms would potentially make the drain more likely to erode or be damaged. Furthermore, as argued above, the need for drain repairs is more or less independent of the level of cleaning undertaken in the intervening years.

We regress the estimated cost of repair on measures of contractor skill, supervision intensity and community engagement. Drain length and age are included as control variables. The results are presented in Table 5. In column 1 it is shown that, as expected, higher levels of supervision and skill during the construction phase are associated with lower repair costs (a better state of repair) years later. Community engagement also appears to reduce repair costs. These findings are robust to the inclusion of average income and income inequality in columns 2 and 3. Hence it appears that involving the community leads to a better initial project condition.

The results raise the question of *how* investment in community engagement acts to improve the initial project quality. In order to pursue this, we run further regressions on two, alternative expert-based measures, namely, technical build quality and functionality. Table 6, columns 1–3 show that build quality is positively related to the skill of the contractor, but not to the level of supervision nor the level of community engagement. In columns 4–6, it is

Table 5. Tobit results for repair costs

	(1)	(2)	(3)
Supervision intensity	-5.157***	-5.333***	-3.382*
	(1.929)	(1.992)	(1.936)
Contractor skill	-1.284*	-1.280*	-1.749**
	(0.747)	(0.736)	(0.811)
Community involvement	-3.518**	-4.260**	-2.959
	(1.539)	(2.108)	(1.817)
Drain length	0.053**	0.054***	0.055***
	(0.020)	(0.020)	(0.020)
Project age	-0.049	0.185	0.201
	(0.201)	(0.430)	(0.385)
Average income		-3.720	-0.091
		(6.199)	(5.945)
Income inequality			20.387
			(12.839)

Dependent variable: ln(repair costs + 1). The tobit lower limit was set just below the lowest non-zero observation.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6. Linear regression results for technical build quality and functionality

	(1) Build quality	(2) Build quality	(3) Build quality	(4) Function-ality	(5) Function-ality	(6) Function-ality
Supervision intensity	0.132	0.165	0.191	0.180*	0.252**	0.151
	(0.102)	(0.116)	(0.133)	(0.101)	(0.113)	(0.128)
Contractor skill	0.528***	0.543***	0.528***	0.407***	0.439***	0.496***
	(0.086)	(0.089)	(0.097)	(0.085)	(0.088)	(0.094)
Community involvement	-0.037	0.032	0.041	-0.030	0.117	0.082
	(0.081)	(0.136)	(0.139)	(0.080)	(0.134)	(0.134)
Drain length	-0.005**	-0.005**	-0.005**	-0.004*	-0.004*	-0.004**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Project age	0.045*	0.030	0.031	-0.024	-0.056	-0.059*
	(0.027)	(0.036)	(0.036)	(0.026)	(0.035)	(0.035)
Average income		0.320	0.370		0.684	0.490
		(0.511)	(0.528)		(0.501)	(0.510)
Income inequality			0.579			-2.237
			(1.423)			(1.377)
Constant	1.636**	-1.134	-1.820	2.547***	-3.379	-0.730
	(0.637)	(4.473)	(4.798)	(0.629)	(4.384)	(4.642)
Observations	103	103	103	103	103	103
R^2	0.388	0.390	0.391	0.209	0.224	0.245

Dependent variables: Technical quality and functionality, expert ratings in the interval 1-5.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

shown that drain functionality is positively related to skill and, to some extent, supervision, but not to investment in community engagement. These results suggest that the effect of involving the community on the state of repair years after construction does not operate through technical build quality or functionality.

Instead, the link between community participation and the cost of repair is likely to be drain placement. Drains built across failed slope sections have a greater likelihood of cracking and being displaced because the material that they are built on will be at its residual strength and could still be marginally unstable. Localised slope features relating to past landslides and current hydrology is, however, not easily discernible due to fast-growing and dense vegetation and dense housing—hence the value of detailed local knowledge. In the absence of such information, drains may be built in sub-optimal locations and hence more likely to suffer damage.

While we do not have quantitative evidence on the adequacy of initial drain placement—the experts cannot reliably assess this without detailed local knowledge—one of the core objectives of community participation in Mossaic is to document exact locations of past landslides, zones of groundwater seepage and surface water runoff convergence. This is done by undertaking community mapping exercises and house-to-house surveys (Anderson and Holcombe, 2013a). Therefore, the main advantage of involving the community in the planning phase is likely to have been access to detailed local knowledge of slope features, leading to better outcomes though better drain placement, rather than through initial construction quality and functionality.

(b) Estimated costs of cleaning

Apart from leading to better placement, investment in community participation could affect the long-term efficacy of infrastructure projects by stimulating on-going maintenance. This could happen if the investment allows the community to overcome co-ordination problems that would otherwise hinder maintenance activities, or if it increases the community's appreciation of the project's importance.

The most basic form of maintenance required to keep the drains in good working order is *cleaning* — the removal of weeds and other debris. Tropical conditions imply that drains will steadily fill with vegetation over time, so regular cleaning is necessary to keep them fully functional. Our preferred metric for on-going cleaning is the estimated cost of cleaning the drains at the time of inspection. The more cleaning the community has undertaken since construction, the less cleaning will be needed at the time of inspection.

The results are presented in Table 7. In column 1, estimated cleaning costs are regressed on the intensity of construction supervision, the skill of the contractor and community participation. As before, drain length and age are included as controls. While supervision and skill are not significant, there appears to be a negative and marginally significant relationship between community participation and cleaning costs, suggesting that greater efforts to include local people in the project are associated with a higher level of on-going drain cleaning by the community. However, this effect is not robust to the inclusion of average community income in column 2, while the coefficient on income is itself negative and significant. Our interpretation is that supervision and skill have no bearing on the extent to which the drains are cleaned after construction, and that the apparent effect of community participation on cleaning costs is driven by a negative association between income and community participation.

The negative coefficient on income may be explained if cleaning costs are higher in high-income communities. One concern might be that communities with higher average income are characterised by greater inequality, leading to more severe problems of co-ordination in drain cleaning, and that it is inequality rather than income levels that are associated with lower cleaning costs. However, the robustness of the result to the inclusion of income inequality (the community Gini coefficient based on census data) in column 3 does not support this. A more likely explanation for why richer communities do less drain cleaning is that the opportunity cost of labour is higher on average: people with higher incomes will find spending time cleaning drains more costly.

Table 7. Tobit results for cleaning costs

	(1)	(2)	(3)
Supervision intensity	-0.123	0.227	-0.005
	(0.330)	(0.368)	(0.414)
Contractor skill	0.053	0.182	0.303
	(0.260)	(0.261)	(0.277)
Community involvement	-0.475*	0.246	0.154
	(0.246)	(0.396)	(0.400)
Drain length	0.019***	0.019***	0.018***
	(0.006)	(0.006)	(0.006)
Project age	0.061	-0.095	-0.099
	(0.082)	(0.106)	(0.106)
Average income		3.329**	2.901*
		(1.515)	(1.537)
Income inequality			-5.257
			(4.237)
Constant	4.767**	-24.022*	-17.962
	(2.009)	(13.260)	(13.906)

Dependent variable: ln(cleaning costs + 1). The tobit lower limit was set just below the lowest non-zero observation.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

6. Discussion

The main contribution of this paper is to shed further light on the mechanisms by which engaging the community in the planning, design and construction of infrastructure projects can affect the long-term condition of the projects (Mansuri and Rao, 2013, p222). Khwaja (2004) argues that participation is more likely to be beneficial when it relates to decisions that require local knowledge than to more technical decisions. Our findings are in agreement with this, since the most likely channel through which community participation reduces future repair costs is through the elicitation of non-technical local knowledge of previous landslide locations at the design stage.

But we add to this that the benefits of community participation are reaped upfront, rather than leading to on-going maintenance behaviour. In contrast to repair costs, the effect of community participation on cleaning costs disappears once community-level characteristics are controlled for. This suggests that drain cleaning—the kind of on-going, non-technical maintenance that the community could actually undertake—is not boosted by community participation in the construction phase. Instead, the results suggest that there is likely to have been selection in where the implementers have chosen to involve the community.

It is a key message of this paper that while participation has benefits, its costs, to both implementer and community, must also be considered. First, opportunity cost may explain why investing in community participation appear to have higher returns in low-income populations: people may be more willing to forego alternative activities and participate in such programmes if their opportunity cost of time is relatively low.

Second, a consideration of opportunity costs may also partly explain why the elicitation of useful information at the planning and construction stages, which represents a one-off cost to the community, may be a more realistic goal than the stimulation of on-going maintenance effort by the community.

Third, inducing community participation is costly to the implementer, too. Resources are required to engage community members in focus groups, participatory risk mapping, initial and follow-up meetings and capacity-building activities. These resources could alternatively be spent on other inputs. In particular, the return on investment in community participation should be contrasted with the return to more direct construction inputs like materials, contractor ability and site supervision. Our results confirm that greater investment in these other construction inputs also improves the long-term condition of a project, and therefore highlight the inevitable trade-off between spending money on community participation and other inputs.

Our finding that the apparent effect of community engagement goes away once we include average income also confirms that community characteristics play a role in determining the outcomes of participatory projects. With only ten communities, we cannot explore this fully in this study; not least because the communities are relatively homogeneous, a result of the criteria for the initial identification of communities for the drainage projects. Still, the results suggest that implementers chose to, or were able to, involve low-income communities more, and that it is underlying community characteristics rather investment in participation that drives on-going maintenance activity. This is in contrast to Khwaja (2009), who argues that project investment may counter-act adverse community characteristics and that ‘good’ programmes can compensate for ‘bad’ communities (see also Mansuri and Rao, 2013, p185). Like Olken (2007), we find that information elicited from participatory ‘grass roots’ meetings is useful, but that the overall impact is nevertheless limited.

Incorporating a participatory component in infrastructure plans, with the intention of creating 'ownership', is convenient from the point of view of donors. The funder's time and budget commitment is easier to control if it can be assumed that post-construction project maintenance will be 'picked up' by the community. However, our results do not support this assumption. They suggest that community participation can work, but at least in the case of the projects analysed here, it likely has the greatest value at the design and construction stages, and does not lead to on-going maintenance. We conclude that funders should consider making contractual provisions for maintenance beyond the 'hand-over'. Arguably, our findings lend support to the Easterly (2006) notion that '[…] aid donors should just bite the bullet and permanently fund [...] maintenance', or at least, ensure that a formal service-provider agreement is in place (Sohail et al., 2005).

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Data appendix

This appendix provides the questions and answer options provided to experts and local informants that underlie the categorical response variables.

Data category:	Initial project quality and community participation
Acquisition method:	Interviews
Interviewers:	Anderson and Holcombe
Respondents:	Original project engineers

Response variable:	**Supervision intensity**
Question:	'How much contact did supervisors have with the contractor per week?'
Indicators:	Time on site and guidance with construction
Scores:	1. Less than half a day 2. Equivalent of one day a week / or a couple of short visits 3. Equivalent of two whole days a week / or short visits most days 4. On site every day for a short time 5. On site all day every day
Response variable:	**Contractor skill**
Question:	'What was the level of experience and skill of the contractor?
Indicators:	Experience of contracting processes, quality of management and delivery of works
Scores:	1 – 5 ('No formal experience in contracting or constructing drains' – 'Recognised contractor with experience and skill in drainage works')
Response variable:	**Build quality**
Question:	'What was the quality of the construction?'
Indicators:	Quality and appropriate use of materials, quality of concrete mix, sufficient reinforcement, weep-holes and other design details as required, finishing, backfilling, completed as per contract
Scores:	1 – 5 ('Poor' – 'Couldn't be improved')
Response variable:	**Build functionality**
Question:	'What was the functionality of the finished drain'
Indicators:	Alignment and drain size as designed (within constraints of site conditions), smooth bends in drains (no sharp angles), sufficient gradient to prevent stagnation/back-flow, sufficient culvert size, features to prevent overtopping, connections well executed

Scores: 1 – 5 ('Drain not fully functional' – 'drain functioning as required')

Response variable: **Community participation**

Question: 'How did the implementing agency engage with the community?'

Prompts: We are interested how the government team engaged with the community. Can you describe how the government team involved residents in mapping, making decisions and construction? Did you feel that all members were engaged by the government team or just community leaders? Did meetings take place – how many, who led the meetings, was there much discussion?

Scores:

1. Instrumental approach by government: engagement of community in mapping process on a house-by-house basis, involvement of community leaders/organisations not sought, no formal meetings or communication (that is, project 'imposed' on community)
2. Informal engagement of self-selecting community leaders, no formal meetings or communication
3. Community leaders engaged, some attempts at organising community meetings
4. Collaborative approach
5. Supportive approach by government
