Improving performance of infrastructure projects in developing countries: an Ecuadorian case study

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**ABSTRACT**

Improving the quality of infrastructure is crucial for sustainable development. Providing infrastructure faces many challenges – both financially and in terms of how projects are delivered. This is particularly apparent for developing countries. This research aims to (a) determine the key factors influencing the successful delivery of infrastructure projects, (b) provide an example of these factors as manifested on an important Ecuadorian flood control and irrigation infrastructure project and (c) identify key learnings for future projects in similar contexts. Many of the key failure factors identified in the literature were evident on the example project, validating the literature findings and indicating that the learnings may be relevant to the context of developing countries more widely. These factors included insufficient planning, unrealistic estimates, poor stakeholder communication, bureaucracy, insufficient ground investigation and an inadequate project delivery system. Addressing these issues is an important step towards improving infrastructure delivery in developing countries.

**KEYWORDS**

Infrastructures; project management; project performance; developing countries; Ecuador

**Introduction**

There are 123 developing countries in the world, which contribute most to global growth (in terms of gross domestic product and population) (United Nations 2017). Boyd (2017) cites estimates from the United Nations that around 3 million people migrate into cities each week, requiring the equivalent of 20,000 football fields to be paved every day. As a result, 40% of future urban expansion is expected to be in the form of slums and infrastructure-impoverished areas, increasing social and economic discrepancies and facilitating the spread of disease (World Economic Forum 2015). Failure to meet the resulting infrastructure demand will worsen social and economic disparities in these areas and lead to the entrenchment and spread of poverty.

The need for infrastructure to promote economic growth and reduce poverty is well understood. However, there is no clear agreement on the most effective form of infrastructure to support this, whether it be transport, power, telecommunications, etc. (Seethanah et al. 2009; Ramessur et al. 2010; United Nations 2017; World Economic Forum 2016, 2017). Gunawansa (2012) estimates that every 1 km extension of road in India would lift 10 people out of poverty. Similarly, Ali and Pernia (2003) estimate 3.2 persons are lifted out of poverty for every 10,000-yuan spent on rural roads in China. Additionally – and of particular relevance to this research – the authors found substantial poverty differences when comparing irrigated and unirrigated areas.

Latin America is a developing region with 62.8% of the population (approximately 365 million people) living in poverty or in danger of falling into poverty (United Nations Development Programme 2016). Lardé (2016) declares that ‘Latin American countries suffer from a significant scarcity of infrastructure’ (p. 3) due to having the lowest growth and public investment of any region (Lardé 2016; United Nations 2017; World Bank Group 2017). Fay et al. (2017) attribute this to a systemic bias among regional governments against capital spending. Emblematic of this, Ecuador has become increasingly reliant on international investment for infrastructure development, with some estimates suggesting that China provided loans for 61% of the government’s financial requirements in 2013, including this case study project (Schneyer and Perez 2013; Rodrigues and Schipiani 2014).

Developing countries spend most of their annual budgets (~70%) simply meeting the basic needs of their people (Ali and Pernia 2003; World Economic Forum 2016). However, this figure is likely to change as they will have to fund up to two-thirds of their infrastructure spending from government revenue by 2030 in the face of reduced investment (Garemo et al. 2015; World Economic Forum 2016). In view of this fact, the UN (2015) has promoted comprehensive reform of infrastructure policies and planning to reduce the cost of infrastructure and improve its efficiency, quality and affordability.

Rather than focusing on the quantum of investment, this paper presents strategies to improve value for money and maximize infrastructure development by increasing the effectiveness of project delivery, emulating examples from other developing countries such as Jordan (Odeh and Batainehe 2002), Vietnam (Long et al. 2004) and Chile (Serpell et al. 2013), to name just a few. The McKinsey Global Institute (2013) estimates that 40% of current infrastructure spending could be saved by adopting proven best practice in the planning, delivery, operation and financing of infrastructure, with the greatest benefit predicted to accrue
Improving the performance of infrastructure projects has been a major focus of research for decades. A significant portion of this research presents factors that authors suggest are key contributors to the success or failure of projects. The literature was comprehensively reviewed and summarized to determine which factors for project success and failure occur most commonly. The aim of this exercise was to identify the most significant trends identified as leading to project success and failure around the globe, highlighting which practices project managers should seek to emulate and which to avoid. These factors are summarized in Table 1; more detailed descriptions and sources can be found in Supplementary Tables S1 and S2 in the Supplemental data for this paper.

### Most common success and failure factors

The most common failure factor identified in the literature is insufficient planning (F1). The opposite of this (sufficient up-front planning (S2)) is the second most common success factor identified from the review of relevant literature. The importance of careful planning is supported by Mišić and Radujković (2015), who argue – partly based on a study by the World Bank – that focusing on the initial phases is even more important than management of the execution. The World Bank study, which evaluated over 1000 projects from all continents but North America, showed that 80% of projects that exhibited sufficient up-front planning (S2) performed well, whereas only 35% of projects with insufficient planning (F1) were successful.

Given the range of project steps included in the planning phase, there are countless potential remedies for insufficient planning (F1). In the simplest terms, Garemo et al. (2015) suggest that spending 3%–5% of total project capital in planning will produce significant cost and time savings. Similarly, a study performed by the Construction Industry Institute (CII) identifies increased execution input (e.g. construction contractor) into the front-end planning as the number one factor in improving the planning and execution processes, followed by increased resources and improved risk assessment and mitigation at number three and four respectively (Taylor 2015). According to Jergeas and Ruwanpura (2010), effective planning includes early involvement of the contractor, clear definition of decision-making responsibilities and a comprehensive execution plan. Hromadka et al. (2015) consider a detailed risk analysis one of the most important documents of the planning phase (prior to investment) and recommends it include scenario analysis or Monte Carlo simulation, depending on the importance and size of the project.

The second most common failure factor was lack of appropriately skilled workers (F2). This factor encompasses a general lack of competency in the industry (in both public and private sectors) hampering project performance, particularly in developing countries. Evidence of this was found in Pakistan (Gardezi et al. 2014), Benin (Akogbe et al. 2013), Canada (Jergeas and Lozon 2015), Jordan (Odeh and Bataineh 2002), Vietnam (Le-Hoai et al. 2008) and Colombia (Gonzalez et al. 2013), among others. Fay et al. (2017) affirm that state and local governments in Latin America have a clear lack of human and technical competency, resulting in an inability to effectively manage large-scale projects.

Emuze and Smallwood (2013) identify competency-related issues as the number one cause of ‘non-value-adding activities’ on infrastructure projects in South Africa, and the most detrimental. As a result, they recommend that procurement and management responsibilities be granted to competent experts within government, and that contractors emphasize academic and professional development of their employees. The key theme throughout these through the studies is the need to raise the competency of human resources in the construction industry (particularly in project management), rather than adding more competent people into the industry (i.e. train more workers, rather than hire or import more highly trained people).

Risk sharing (S1) was the most common success factor identified through the literature review. While the literature suggests that public–private partnerships (PPPs) are a successful project delivery method, Rajan et al. (2014) note that they may perform poorly if the contractual structure does not discourage cost and time overrun. Similarly, Heravi and Hajhosseini (2012) suggest that there is considerable evidence of poor risk allocation on PPP projects. Ameyaw and Chan (2015) advocate proper risk identification prior to awarding of contracts, to assist in risk allocation in the contract. Proper allocation of risks is not always simple, however; the private sector is not always willing to accept risk, especially when quality of governance, regulations and institutions is poor or corruption is high, both of which are typical of developing countries (Percoco 2014). This leads to the
government typically bearing most of project risk in developing countries (Gunawanwa 2012).

Another common success factor, *early and continuous involvement of stakeholders* (S3), includes regular coordination with utilities, early involvement of key contractors and aligning all teams to the project plan, inter alia. Transparency in all actions (within reason), and listening to stakeholders concerns increases cooperation and can lead to identification of solutions or risks that would not have been considered with a less open/consultative approach (Slootman 2007; Hassanain 2009; Forcael et al. 2011; Gharaibeh 2014; Jergeas and Lozon 2015). Stakeholder management, which requires adequate communication, is critical to avoiding conflict which can lead to delays and litigation (Hassanain 2009; Gharaibeh 2014). Early and continuous involvement of stakeholders (S3) encompasses many communication-related aspects of a project and, unsurprisingly, is ranked third in terms of success factors in the literature.

### Change in improvement strategies over time

The literature review for this research focused on the most recent research to ensure any conclusions drawn were up to date. As a result of this research methodology, drawing robust conclusions on how success and failure factors have developed over time is outside the scope of this study. The date of references for success factors range from 2002 to 2016 with an average publication date of 2012 and 97% of papers published in 2007 or later. Failure factors references range between 1998 and 2016 with an average publication date of 2012 and 95% of papers published in 2008 or later. The average date of the success factors is evenly distributed over the period 2011–2014, with failure factors falling between 2011 and 2013 except for insufficient ground investigation/consideration (F10) which is skewed by having fewer references and including the oldest reference. As noted above, it is difficult to draw meaningful conclusions when the factors are so evenly and closely distributed.

Despite this, some basic trends were apparent in the literature. Firstly, research into infrastructure project success and failure is more prevalent than ever, indicating the importance of improving project delivery is recognized and yet to be solved – evidenced by the repeated failings of projects of all shapes and sizes (Flyvbjerg et al. 2002; Flyvbjerg 2014). Secondly, research based on developing countries is increasing, as these countries increase their research capabilities and their importance to the global economy is more widely recognized.

### Developing country trends

There does not appear to be much peer-reviewed literature focusing on the performance of infrastructure projects in developing countries; representing less than 15% of all literature reviewed during this study. There are more papers that focus on residential/commercial building construction (Sweis et al. 2008; Le-Hoai et al. 2013; Sha’ar et al. 2016), and others more concerned with how projects are financed and contracted in developing countries rather than their performance (Khasilnabi et al. 2010; Umar et al. 2011; Badu et al. 2013; Percoco 2014).

Of the performance-focused literature that was discovered, less than 10% was based on projects from Latin America – although there are likely more sources in Spanish databases not translated to English. Over 80% of this literature was based on projects from Africa (33%), Asia (28%) and the Middle East (22%). Therefore, on top of the general shortage of performance-focused literature for infrastructure in developing countries, there is a severe lack of such literature relevant to the contextual factors of Latin America (in English). Moreover, literature in Spanish pertaining to project performance in Latin America relies mostly on press reports or opinion articles, rather than peer-reviewed journals. Although literature based on other developing countries contains useful lessons for practitioners in Latin America, if the performance of infrastructure projects in Latin America is to reach the desired level, greater dissemination of lessons learned from infrastructure projects in the region needs to occur.

When reviewing the literature concerned specifically with developing countries, some interesting trends were noticed. It is difficult to draw meaningful conclusions on success factors as the sample size is only 15 papers and the top factor (risk sharing) has only 4 references, as shown in Table 2. In contrast, while the sample for failure factors is only 19 papers there is significant agreement between the sources. Lack of appropriately skilled workers (F2) is the most common factor with 11 references, while insufficient planning (F1) – which is the equal most common factor in the wider literature – drops to the fourth most common factor, with 6 references. The relatively small sample size of research on developing countries supports the choice of a case study to uncover real project learnings and develop a greater understanding of the topic.

Odeh and Battaiheh (2002) found issues regarding labour productivity, contractor quality and experience among the most significant causes of delay when surveying contractors and consultants involved in a range of projects in Jordan. Similarly, El-Gohary and Aziz (2014) found a lack of labourer experience and skill, and incompetent supervision and construction management to be three of the five most significant factors affecting construction productivity in Egypt. Research by Le-Hoai et al. (2008) continued this trend, finding poor site management/supervision and poor project management assistance to be the two most significant causes of delays and cost overruns in large construction projects in Vietnam. A lack of appropriately skilled workers (F2) appears to be the most critical issue affecting performance of infrastructure projects in developing countries, although it can manifest in many forms.

*Ill-defined project scope* (F4) and *insufficient cashflow* (F6) are the second most common factors for developing countries. Based on the literature reviewed, it appears *ill-defined project scope* (F4) typically manifests in the form of design errors or changes throughout construction. These are cited as raising substantial impediments to project success in Iran (Heravi and Hajihosseini 2012), Pakistan (Gardezi et al. 2014), Benin (Akogbe et al. 2013).

| S1 | Risk sharing |
| S2 | Choosing the correct project delivery method |
| S3 | Early and continuous involvement of stakeholders |
| S5 | Procurement models that reward good performance (not just contractor) |
| S6 | Shared goals/collaborative approach/Transparency |

| Top success factors (15 papers) | References | Top failure factors (19 papers) | References |
|-------------------------------|----------------|-------------------------------|----------------|
| S1 Risk sharing | 4 F2 Lack of appropriately skilled workers | 11 | |
| S7 Choosing the correct project delivery method | 4 F4 Ill-defined project scope | 8 | |
| S3 Early and continuous involvement of stakeholders | 3 F6 Insufficient cashflow | 8 | |
| S5 Procurement models that reward good performance (not just contractor) | 3 F1 Insufficient planning | 6 | |
| S4 Shared goals/collaborative approach/Transparency | 2 F3 Unrealistic estimates | 5 | |
Colombia (Gonzalez et al. 2013) and Vietnam (Le-Hoai et al. 2008), among others.

As expected, insufficient cashflow (F6) is a more important issue in developing countries than in developed nations, as budgets are inherently more stretched. This is illustrated by 8 of the 11 references citing this factor being studies in developing countries. Cashflow problems, such as payment delays, insufficient funding and budgeting and financial difficulties of project owners and contractors, are cited as important factors leading to project failure in developing countries throughout Asia, Africa, the Middle East and South America (Odeh and Battaineh 2002; Le-Hoai et al. 2008; Heravi and Hajijosseini 2012; Akogbe et al. 2013; Gonzalez et al. 2013; Gardezi et al. 2014).

The relative drop in importance of insufficient planning (F1) in developing countries is likely due to the three more important factors – lack of appropriately skilled workers (F2), ill-defined project scope (F4) and insufficient cashflow (F6) – being directly related to a lack of human and financial capital, which is known to be a key issue in developing countries (Le-Hoai et al. 2008; Gardezi et al. 2014; Fay et al. 2017; United Nations 2017). Insufficient planning (F1) naturally takes a back seat to these more prominent issues.

**Developed country examples**

In terms of performance improvement literature based on projects in developed countries, much of it is concerned with megaprojects, which are becoming an increasingly preferred option for infrastructure delivery in developed countries (Flyvbjerg 2014). Accordingly, the most useful performance improvement literature found from developed countries were all concerned with megaprojects. Haidar and Ellis (2010) studied several megaprojects from the USA and outlined some key practices to improve performance. Han et al. (2009) performed a case study on the Korea Train eXpress project, highlighting the key lessons learned. As another example, Mišić and Radujković (2015) provided many megaproject success and failure factors based on their research from Europe. More recently, Li et al. (2019) studied the impact of megaproject governance on project performance, based on a case study that analysed the dynamic governance of the Nanning Transportation Hub in China. It is recognized that the vast scale of megaprojects does not lend itself perfectly to this small-scale case study, but there are certainly some transferable lessons from megaprojects that can be applied to all types of projects.

**Methodology trends**

Surveys and questionnaires have been widely implemented in construction engineering and management research, particularly with regards to project success and failure factors (Molenaar and Scott 2003). The benefit of this method is experts with in-depth knowledge of construction projects can provide valuable opinions on project uncertainties (Choi et al. 2004; Forcael et al. 2018). However, it seems researchers rarely have access to actual project data for analysis. As this study had access to such information, it provides insight into the inner workings of a major infrastructure project in a developing country. This detailed perspective is expected to further the body of knowledge on improving delivery of infrastructure projects in developing countries, as it can detect problems that less detailed methods such as surveys cannot (Marrelli 2007).

**Case study trends**

From the literature reviewed, there are few case studies that delve into the detail of individual projects. Such articles represent only 10% of the literature cited in this paper and showed no significant bias towards case studies of successful versus unsuccessful projects. These case studies seem to either be detailed descriptions of project events/approaches written by authors with first-hand involvement for the purpose of knowledge sharing, or analyses of projects from an external perspective based on literature and interviews/surveys. The papers in the latter category (as with the wider literature) seem to have little access to detailed project data for analysis, while papers in the former category typically did not compare their experiences with the literature, except for studies by Han et al. (2009) and van Marrewijk and Smits (2016), which most closely align with the format of this study.

**Overall literature gaps**

The literature review highlighted two interesting points about the overall state of the literature. Firstly, there is more agreement between sources on factors that lead to failure than on factors that lead to success (which is evident when comparing Supplementary Tables S1 and S2 in the Supplemental data); and, secondly, there is more research focused on failure factors than success factors. This is likely due to a known cognitive bias whereby positive outcomes (tailwinds) attract little attention after the fact, while negative circumstances (headwinds) demand attention (Davidai and Gilovich 2016). Davidai and Gilovich (2016) label this phenomenon the headwind/tailwind asymmetry. This highlights the need for more detailed discussion of solutions to improve project performance, rather than simply describing failures.

**Research method**

To determine the relevance of the Ecuadorian case study to a more general theoretical context, an extensive literature review was undertaken to identify the most frequently cited factors for project success and failure on civil infrastructure projects from across the globe. These factors framed the analysis of the case study and the associated literature formed the basis of the recommendations.

Due to the large number of factor terminologies and descriptions across the reviewed literature, there was some generalization to translate the differing wording across the sources into common terms. For transparency, Supplementary Tables S1 and S2 in the Supplemental data for this paper show the wording from the articles themselves. This grouping was largely subjective and would likely lead to a different outcome if done by another. This was not considered critical for the purposes of this exercise. Where the source listed many factors but ranked them in importance, the most important factors were recorded.

For example, the presence of ‘uncertainty’ was grouped under insufficient planning (F1), as uncertainty reduces as more resources are invested in up-front planning (although uncertainty cannot be completely eradicated) (Giezen 2012). Similarly, failure factors such as ‘rushing the project’ and ‘unresolved design issues’ were also grouped into the ‘insufficient planning’ category, as were other factors. Additionally, clear scope and client requirements (S8) include factors such as unambiguous contract documents; clear project brief and client outcomes; setting clear,
fully articulated business objectives for the team; nailing down the scope, schedule, budget and funding early and sticking to it, etc. Finally, in some cases, factors noted in a specific source were included in two categories. For example, El-Gohary and Aziz (2014) cite ‘procurement methods that allow the involvement of contractors during the design stage’ as a key success factor. This was included under early and continuous involvement of stakeholders (S3) and choosing the correct project delivery method (S7).

As noted earlier, this case study was made possible through access to detailed project data. Documents such as work breakdown structures (WBS), estimates, cost analysis and progress-tracking spreadsheets and project schedules were made available through Escuela Superior Politecnica del Litoral (ESPOL) and the Empresa Pública del Agua (Public Water Company) (EPA-EP). The remaining information was sourced from the publicly available Ecuadorian National Government website (compraspublicas.gob.ec), which is helpful to encourage transparency in public works. This included the project contract, monthly invoices and third-party auditor reports.

As all the project data were in Spanish, translation of documents was required throughout analysis. Due to the quality of the data, many issues were easily identifiable but the deeper interpretation was still required. Data on actual resource usage each month were not available, so Figure 2 (presented later in the paper) showing estimated resource usage was based on an interpretation of the monthly invoices and planned productivities. Although this method is unlikely to be completely accurate, the broad trends this figure illustrates are useful.

The various documents were reviewed and compared to each other to identify any deficiencies in project management. The identified issues were then grouped under their respective project management aspects (e.g. scheduling, estimation, design, etc.) to target these specific areas in researching remedies from best practice literature. The third-party auditor reports were very helpful in highlighting the causes and consequences of some of the project management deficiencies identified in the data. This paper presents these issues in conjunction with discussions of potential solutions from relevant literature. Only the issues considered to have the most impact on the outcome of the project were included in the final version of this paper. Relating the problems identified in the case study to the success and failure factors from the literature is intended to indicate transferability of the findings of this case study to other projects (Rowley 2002).

Case study: flood control of the Bulubulu River, Ecuador

Background

The flood control of the Bulubulu River project was one of six projects in a US$688 million programme of flood control and irrigation projects completed between 2013 and 2016 by Ecuador’s Secretaria Nacional del Agua (National Water Secretariat, SENAGUA). The project was situated on the Bulubulu River near the towns of La Troncal and Cochancay in the Cânar province of Ecuador. This area lies within the Guayas River basin, which is of high importance to Ecuador due to its agricultural potential. The primary factor restricting this potential is the periodic flooding the area faces and the El Niño–Southern Oscillation (ENSO) phenomenon, which causes heavy rains and droughts (Bureau of Meteorology 2018). For these reasons, the project had both a flood control and irrigation function. It involved construction of 20 km of earthen embankments and a 2.8 km concrete wall to protect against overflows from the river, a diversion/discharge structure (coinciding with a 180 m long bridge), a 16 million cubic metre dam over 305 ha, irrigation outlets and other complementary works (Empresa Pública Agua Ecuador 2015).

The total value of the contract at construction commencement was US$55.6M. The Chinese Development Bank (CDB) provided 65% of the project funds through an existing financial agreement with the Ecuadorian Government. The project was approved under a Special Regime (meaning the tender was only open to Chinese companies) and the contract was awarded in May 2012 to a partially government owned Chinese contractor as the sole tenderer for the project.

This project was chosen for the case study as this research had a focus on developing countries, the project had an interesting development story and the authors had access to a greater amount of project data than is usually available for research. A key area of failure for the project (at a superficial level) that triggered further investigation was the significant delays in completion. Another component initially expected to be a cause of failure worth further investigation was that the project was undertaken by an internationally based contractor; this is a growing global trend (particularly in Latin America) shown to have mixed results (Peters et al. 2018). As the project served its intended purpose in the end, the failures were more in the project management – the research topic of interest to the authors – than in the overall project.

Project progress

As stipulated in the contract between SENAGUA (now the EPA-EP) and the contractor, the project was planned for completion in 390 days, from 8 February 2013 to 4 March 2014. However, based on the progress made in the early months of construction, it quickly became clear that this timeframe would not be achieved. Eleven percent of the works were planned for completion in February to April 2013, of which only 0.43% was achieved. By March 2014 (the original completion date), only 34% of the works were complete. The project was eventually completed in February 2015 (with only 94% of the planned work complete), experiencing an almost 100% extension of completion timeframe. Figure 1 shows the initial programme (based on the planned completion date), the amended programme completed in October 2013 when a project extension was agreed and the actual progress of the project. The wet season is also highlighted on this figure, the impact of which will be discussed later in the paper. According to the case study analysis, the delays in the project were a result of several factors, including poor project management practices, which are further discussed in the following sections.

Third-party auditor

A key element of the contract was the appointment of a third-party project auditor (known as the fiscalización). This is a requirement to ensure lack of technical competency and human capital among government organizations in Latin America does not impede projects (Fay et al. 2017). The requirement for an auditor also had significant cost implications for the project. The initial auditor contract was awarded to an external consultancy for a period of 15 months at a value of US$2.3m. This third-party auditor was responsible for the technical supervision of...
The project, measuring quantities of executed work, certifying the accuracy of payment claims, adjusting the designs, preparing the detailed design, verifying compliance with the contract, designs, technical specifications and standards by the contractor.

The monthly audit reports did not contain all the information stipulated by the contract. Specifically, the reports were not sufficiently detailed to fully describe the project activities during the month, reducing SENAGUA’s awareness of how the project was progressing. Additionally, the reports did not provide an evaluation of the contractor’s personnel or equipment, which implies the performance of the contractor was not regularly evaluated and, thus, that key areas for improvement were not identified. Further, reasons given for delays in the project remained the same across the reports; while this is partly due to the problems being consistent through the project, it also highlights a lack of specificity in the reports. Finally, the reports presented unchanged observations and recommendations in the relevant section each month. Examples of repeated statements include:

SENAGUA has taken the necessary steps to advance the payment of land acquisitions ... it is recommended the land acquisition processes are completed to permit other fronts of work ... the contractor is increasing the pace of the works ... the contractor has complied with the technical specifications.

Discussion

Contract award, structure and governance

As the contractor was the sole tender for the project, no comparison between bids was available, and therefore no reason for the contractor to offer competitive prices. The lack of a competitive tender process reduces the likelihood of the best available contractor being awarded the job; more efficient project execution; and more competitive overall price (Fay et al. 2017). Similarly, other authors have emphasized the impact of appropriate contracting methods in the success of construction projects (Forcael et al. 2011; Clough et al. 2015; Zhang et al. 2018).

A key aspect for a successful project is choosing the correct project delivery method (S7) to ensure the best engagement method for the principal contractor and risk allocation (i.e. risk sharing (S1)) (del Puerto and Shane 2014; Ameyaw and Chan 2015). This contract was only for the construction, one-year operation and maintenance period of the project; the project design was updated and finalized prior to the tender request. This meant that the contractor had no input into the design, even though their design process and work methods likely differ from those typical in Ecuador. This is an example of an inadequate project delivery system (F11). The contractor should have been involved in the design process for such a technically complex and unique project (e.g. in a Design and Construct (D&C) delivery model). Similarly, land acquisition issues and difficulties securing quarries and dump sites may have been identified earlier as part of due diligence prior to execution.

There is evidence D&C delivery can result in faster completion (del Puerto and Shane 2014). However, achieving full success with a D&C contract requires clear scope and client requirements (S8), early involvement of the contractor (early and continuous involvement of stakeholders (S3)) and effective communication, among other factors (Seng and Yusof 2006; Doki 2008). It is likely that earlier engagement of the contractor would have resulted in identifying communication issues early and improved the effectiveness of a D&C contract.

Procurement models that reward good performance (S5) and penalties for poor performance for all parties involved are key components to encourage effective delivery (Fei and Da-Wei 2009; El-Gohary and Aziz 2014). Rajan et al. (2014) assert that if the contractual structure does not discourage overruns, poor performance will be more likely. While financial penalties for project delays were included in the contract (i.e. US$1 fine per day for every US$1000 of outstanding work), there was no provision for cost overruns or quality, nor any compensation for outstanding performance, as found in other projects as an added incentive for success in all facets of time, cost and quality (Forcael et al. 2011).

Proper risk sharing (S1) is not always simple in developing countries and typically the government bears most of the risk (Gunawan 2012). There are many reasons for this but when quality of governance, regulations and institutions are poor, or corruption is high – which are typical for developing countries – this phenomenon is more common (Percoco 2014). Ecuador ranks poorly in all these respects (BMI Research 2017). The Ecuadorian Government accepted most project risks, including the financial risk. Additionally, the design consultant seemingly

![Figure 1. Project progress overview.](image-url)
escaped all liability for numerous design inaccuracies, nor was the contractor fined for delays.

**Construction planning and design**

All project tasks undertaken prior to construction commencement are grouped under the ‘planning’ umbrella. This includes geotechnical investigations, design, land acquisition and permits required for the project. The following sub-sections discuss examples of insufficient planning (F1) in the case study project.

**Geotechnical issues**

Several sources show that unexpected geotechnical conditions represent a risk that must be handled properly in construction projects (Black 2017; del Puerto et al. 2017; Forcael et al. 2018). The project design was completed by a government-appointed design consultant prior to the tender process. Given the nature of the project, the geotechnical investigations were a key component of the design process. However, this does not appear to have been fully considered by the design consultant – as is evident in the numerous geotechnical issues that arose during the project.

- Soil density was substandard, and this was not discovered until test pits were dug two months into construction.
- Three months of cement-bentonite injection tests were undertaken for the impermeable screen for the diversion channel (during construction), only for the results to be discarded due to a change of heart by the design consultant.
- SENAGUA, the principal on the project, requested additional boreholes seven months into construction.
- Re-analysis of the soils in the foundation of the dike of the dam was undertaken nine months into construction.

This lack of understanding of the subsurface conditions in the area (due to insufficient ground investigation (F10)) resulted in a substandard design that required numerous amendments throughout the construction period when adverse ground conditions were encountered. Based on a study of highway projects in the Niger Delta region (a similarly geotechnically challenging environment), Amadi (2019) suggests that selecting a contractor without considering their capability to deal with the geotechnical risks is a near-ensure of failure. This is another aspect where having a sole tenderer hindered the project. del Puerto et al. (2017) determined that adopting a D&C project delivery method helps to mitigate and manage geotechnical risks by shifting responsibility to the contractor. However, it is acknowledged that even extensive geotechnical investigation is not a guarantee of zero geotechnical risk (Forcael et al. 2018). A geotechnical risk assessment undertaken early in the project planning stage may have helped further alleviate these issues (Black 2017; Forcael et al. 2018).

**Design changes**

Numerous other design changes were required, highlighting a lack of detail and accuracy in the design process. For example, few surveys of the site were undertaken, leading to extensive surveying during construction and resulting design changes; inconsistencies were identified between plans; quantities of work to be executed were miscalculated; elements of the design (e.g. formwork) were omitted from the budget; and the diversion channel was designed with an insufficient slab thickness. A further illustration of the poor quality of the design was that a concrete wall had been inadvertently designed to go through an existing house, which required realignment of the excavation and wall six months into construction. These observations are indicators of insufficient planning (F1), ill-defined project scope (F4) (and thus a lack of clear scope and client requirements (S8)), inefficient change control (F8) and a lack of accountability in decision-making (F12) – some changes requested by the contractor took months to be decided.

Senaratne and Sexton (2011) support the notion that most changes during construction are due to errors or omissions at the design stage. Walewski and Sadatsafavi (2010) suggest appointing a design review board to ensure the accuracy of the design, based on analysis of the successes of the Hoover Dam project in the 1930s. Coupled with effective change management (S10), they assert that this will lead to reduced rework and delays. Jergeas and Lozon (2015) believe effective change management (S10) is about defining a clear scope for the project and restricting changes, whereas Parrish (2010, p. 340) thinks the key is to ‘make adjustments quickly for unforeseen obstacles and for new and better ideas’. Senaratne and Sexton (2011) agree that time is of the essence when assessing project changes. Perhaps assigning a design review board, which was successfully implemented for London Olympic construction projects (Hone et al. 2011), is not necessary for a project of this size; however, there is agreement in the industry that adoption of a formal procedure with prompt approval timeframes, clear assignment of staff responsibilities and evaluation of cost and schedule implications would reduce the cost of changes (Zou and Lee 2008; Lester 2014). Additionally, Sinesilassie et al. (2018) suggest indecisiveness in taking day-to-day decisions and holding back key decisions have a significant impact on cost performance.

**Land acquisition and approvals**

Land acquisition of the whole or part of more than 90 private properties was required to complete construction, with few of these secured prior to construction commencing. The potential risk to the project of delays in land acquisition was not sufficiently considered. Data from neighbouring Peru and India have shown that land acquisition delays can result in significant project completion delays and substantial cost increases (Rajan et al. 2014; Fay et al. 2017). The key common issue between these countries appears to be the lack of clear timeframes for cases of disagreement or dispute resolution, to avoid protracted negotiations (El Peruano 2013).

Land acquisition was ongoing throughout the entire 24-month construction period, with properties still not fully secured in the final months. The contract stipulated that the contractor would ‘give SENAGUA a schedule of sites required for the works and the dates they are required and SENAGUA will ensure they are available when indicated’. Twenty-nine properties remained unsecured in August 2013 (seven months into construction), with 15% outstanding in February 2014 (the original completion date for the project). This was one of the major causes of delay in the project and was raised in formal correspondence by the contractor and auditor numerous times during the project.

The land acquisition laws of Ecuador are not particularly detailed or clear and require valuation and payment of compensation prior to the government taking possession (except when compensation cannot be agreed, at which point the matter is resolved in the civil courts) (Lalama 2018). Difficulty in agreeing compensation with the many landholders was, therefore, likely the major cause of the delays in land acquisition. Earlier
communication and more transparency with the landowners, and more efficient government regulation processes (e.g. negotiating compensation after acquisition, as is required for compulsory acquisition in Australia) can ease the land acquisition processes and thereby reduce delays (Tang et al. 2012; Queensland Government 2018). Land acquisition issues are evidence of poor stakeholder communication (F5), cost of bureaucracy (F9) and insufficient planning (F1).

The cost of bureaucracy (F9) and lack of accountability in decision-making (F12) (as well as insufficient planning (F1) and poor stakeholder communication (F5)) were also evident in delayed approvals to use the quarries and dump sites, the first of which was not secured until September 2013, seven months into construction. Further agreements and tests of the quarry materials were ongoing throughout construction, leading to significant delays during the project. This came to a head in August 2013 when the contractor again formally raised their frustrations, reminding the parties of their responsibilities under the contract (which stated the quarries would be available when required by the schedule) and recommending the project cease due to the issues preventing completion of the works (land acquisition, securing the quarries and dump sites, poor design detail and payment delays). Additionally, the contractor requested an extension in October 2014 (20 months into construction) due partly to the insufficient availability of material in the approved quarries.

According to the World Bank’s report Doing Business 2018, Ecuador ranks 118th out of 190 countries in terms of ease of doing business and is ranked 105th for the efficiency of obtaining construction permits (World Bank Group 2018). Garemo et al. (2015) recommend streamlining approvals and land acquisition as one of the most important elements of improving project performance. Furthermore, Forcael et al. (2018) state that excessive delays in approval processes by government entities are one of the most critical factors influencing project risk management performance.

Weather

The climate in this region has distinct wet and dry seasons, with the wet season approximately five to six months long (from December to May) with precipitation on most days. Since this was a flood control and irrigation project centred on the Bulubulu River, the wet season was problematic; not only was the rainfall around the project itself an issue, but the rainfall in the upper reaches of the catchment in the Andean highlands (La Sierra) flowed down the mountains, raising the levels of the river near the project. This hindered construction of the flood bunds and levees, which were major work items. Based on the audit reports, the levels of precipitation around the project or in the upper parts of the catchment limited progress of the works in 18 of the 21 months for which data are available. This significant impact on progress was due to most of the works consisting of importing and placing earthen materials or pouring concrete, and a lack of all-weather roads around the project work sites.

There is no evidence of a risk assessment, nor of the potential delays due to rain being factored into the schedule, despite significant work being planned for the wet season. No difference in activity timeframes compared to the dry season was observed. The contractor, however, declared in the contract that they had considered the climate and geotechnical conditions of the project. This is another example of insufficient planning (F1), unrealistic estimates (F3) and a lack of a structured and thorough risk management approach (S11).

Ballesteros-Pérez et al. (2015) report that weather is rarely considered when planning construction projects, despite often being reported as one of the main reasons for delay; additionally, where it is considered there is no consistency in how it is managed (Ballesteros-Pérez et al. 2015). The authors propose a relatively simple mathematical model for accounting for weather effects on a project and conclude that avoiding project delay through proper consideration of weather can lead to savings of 5%–20%.

Using pre-fabrication of the concrete structures for the project would have been one potential solution to the persistent rain experienced. However, the precast concrete industry in Ecuador was still developing at the time of construction, following recognition of its importance to help to alleviate low productivity and high accident rates typical in the industry (Echo Precast Engineering and Tecnocom 2016). Twenty-nine percent of the total cost of the works (approximately US$16m) consisted of concrete structures, which were mostly cast in situ. If some of the concrete structures were precast in a nearby workshop, they would have been unaffected by the rain and less susceptible to land acquisition delays. This would have significantly reduced the risk of delay on up to 29% of the project, although it is noted some structures may not have been viably precast.

Estimation

The unit prices were the only source of information on compensation for the works in the contract, which may have simplified the verification of claims as completed quantities were the only input required. However, this led to the contractor simply adding 41% to every unit price – 40% to cover ‘indirect costs and profits’ and 1% for ‘other overheads’. Project indirect costs and overheads vary greatly and there is little agreement on them in the literature, but they typically increase with the complexity of the project (Assaf et al. 2001). Higher overhead costs would be expected for an international contractor in Ecuador, but the 41% used on this project still seems high when compared to other values in the literature (14.3% plus project-specific overheads in Saudi Arabia, 11.1% in Palestine and 8%–15% more generally in the literature) (Assaf et al. 2001; Enshassi et al. 2008). The all-encompassing unit prices meant the actual cost of the work was hidden, a clear disadvantage from a project management perspective as it nullifies the value of one of the two parts of earned value management (EVM). Due to the way, the contract was structured, and how the contractor estimated the prices, unrealistic estimates (F3) were almost unavoidable.

The cost, and especially the productivity estimation for this project, is a key reason for the poor project performance. In terms of schedule estimation, there were productivity rates offered for a small percentage of activities, but these differed from the performance rates (hours/unit of work) used to form the contract, the origin of which is unclear. However, they appear to be calculated from costs, rather than a reasonable estimate based on robust and relevant data (Department of Transport and Main Roads 2017).

How to improve construction estimates is a question that has persisted in the industry for decades (Flyvbjerg et al. 2002; Odeh and Battaineh 2002; Forcael et al. 2018; Siemiatycki 2018). Flyvbjerg (2006) claims reference class forecasting (S9), which involves taking an ‘outside view’ of estimation by utilizing knowledge about actual performance of similar projects, has been proven to provide more realistic estimates (S9). In addition, having cost estimates reviewed by an external expert...
prior to approval is suggested to increase the likelihood of success (Siemiatycki 2018).

Another important element of good estimation is to record any assumptions made during the estimation process so that they can be interrogated against actual performance during execution and learnings carried forward for future estimates (Carson et al. 2014; Gharabibeh 2014; Department of Transport and Main Roads 2017). At a wider scale, Grushka-Cockayne (in Dubner 2018) recommends tracking historical performance of projects, providing data to improve future estimates, and raising awareness of the issue of poor performance. Stochastic estimation is another key approach that has been shown to produce more realistic estimates (S9) than a traditional deterministic approach, as it quantifies the impact of risks (Moret and Einstein 2016; Shahtaheri et al. 2016). Many government clients in developed countries now require stochastic estimation using probabilistic risk evaluation tools (e.g. Monte Carlo simulation) to manage risk. For example, the Department of Transport and Main Roads (2017) in Queensland, Australia, requires this approach for all complex, high-risk or high-value (greater than A$25m) projects.

Scheduling

In the case study, the WBS did not cover 100% of the work to be done (including only the physical construction works) nor did it include an allowance for approvals (e.g. land acquisition, quarries, etc.) (Carson et al. 2014). This reflected an uninformed assumption and lack of appreciation of these aspects’ importance. If land acquisition was identified in the schedule presented by the contractor as a key task for construction to occur, all parties would have likely been more aware of the importance of the task. Similarly, had there been some understanding of how long it would take was known, and had allowance been included in the schedule, this major cause of delay would have been clear to all.

As shown in Supplementary Table S2, the term unrealistic estimates (F3) is taken to also include over-optimistic scheduling. There were two types of schedule produced throughout the project. One was a typical Gantt chart produced in Microsoft Project, which contained only a portion of the activities and showed a timeframe of almost three years for the project. The other ‘schedule’ (produced in Microsoft Excel) appears to have been created by simply nominating how many units of each activity would be completed each month, with no justification documented. The schedules did not align, and both were based on an activity list/WBS with insufficient detail, which hindered progress tracking and activity sequencing. Many of the activities (e.g. riprap slope protection for the dikes, placement of reinforcing steel for the diversion channel) span almost the whole duration of the project as a single item. Furthermore, activity sequencing was not fully understood, nor was which activities were on the critical path. This prevented prioritization of these activities to expedite the project. A sufficiently granular WBS (all activities must be unique, only involve a single trade, and be no longer in length than the reporting period of one month) and a clearly defined critical path are key elements of an optimized schedule (Carson et al. 2014).

Financing

Delayed payment of the advance sum and invoices from the contractor, demonstrating what has been classified as insufficient cashflow (F6), also contributed to the poor performance of the project. Ecuador’s Law of the National Public Procurement System requires advance payments to be made in no more than 30 days (Ley Orgánica Del Sistema Nacional De Contratación Pública (Ecuador) 2014 Art. 71) and the contract required invoices to be paid within 15 days of being received. The advance payment of US$16,682,573 (30% of total cost), however, took eight months to be received, and the contractor issued formal notice several times throughout construction warning that delayed payment of invoices was affecting the execution of the works. The delay in the advance payment caused the project to commence in the wet season, which had a significant impact on the duration of the works.

Other issues

Lack of appropriately skilled workers

The contractor also demonstrated poor project management practices at times, in addition to the evidence noted previously. They were responsible for environmental breaches that caused two work stoppages, safety issues at quarries and quality issues. A lack of appropriately skilled workers (F2) may have been an antecedent to these environmental, safety and quality issues as the workforce did not have the requisite skills in environmental control, safety and concrete construction procedures. Ecuador does not have systems in place to certify competency or provide licences for construction personnel, where labourers and operators develop their skills from experience. The government required that 70% of labourers and operators for the project be Ecuadorian citizens.

Stakeholder management

The contractor was also responsible for stakeholder engagement and consultation as part of the Environmental Management Plan (EMP), which was underfunded given the level of public interest. This is further evidence of poor stakeholder communication (F5) and insufficient public outreach (S12) on the project. The final audit report stated, ‘the issue of social management of the project [could have been improved], because conflicts were created due to the lack of transmission of information to the people involved in the project’. Fay et al. (2017) identify social risk management as lacking in infrastructure projects in Latin America, based on an extensive study of the continent for the World Bank. Social risks include difficulties with land acquisition, and they suggest that adequate social risk management should be considered as early as the feasibility studies, thereby giving the project a ‘social licence’ and reducing costs, delays and reputational risk to investors. Developing standard guidance for how to manage social and environmental risks as a requirement for all projects may help improve this element of infrastructure projects in developing countries.

The consequences of poor stakeholder communication (F5) have been discussed throughout this paper. The key to effective stakeholder engagement, as identified in the literature, is involving (particularly primary) stakeholders early and continuously throughout a project (Sloatman 2007; Hassanain 2009). Sharing knowledge and prompt and honest communication are also key to sound stakeholder communication and should be present in alliance-type contracts, which Baharuddin et al. (2017) and Gransberg et al. (2016) propose as a valuable delivery model for large, complex projects. Baharuddin et al. (2017) highlight how the inclusion of an independent alliance manager and the
local council in the alliance, as well as nominating responsiveness and engagement quality as a KPI (key performance indicator), were keys to success in a complex transport infrastructure project in New Zealand. This model could have helped the land acquisition process, and likely avoided the associated safety issues that arose during the project. The authors also encourage involving the contractor as early as possible so they have input into the planning and design, which would likely have improved the performance of this project (Slootman 2007; Baharuddin et al. 2017).

**Reporting frequency**
Due to the contract stipulating that the audit reports and invoices from the contractor were only required monthly, progress was only measured monthly. This frequency was insufficient for a project planned to be completed in 13 months (Project Management Institute 2011). Recording progress monthly, when some months had 15% of the work planned, did not provide enough opportunity for project managers to recognize poor performance and correct in a timely manner. In two cases where over 15% of the total project work was planned in a single month, less than 2.5% was completed. This means that in each month, the project was already 12.5% behind schedule by the time the project managers were made aware by the monthly report. This is another example of poor stakeholder communication (F5).

**Resource management**
Managing resources, in general, was a problem for this project. Figure 2 shows how the resource usage planned for the remainder of the project following the first reprogramming/extension in October 2013 compared to the actual resource usage. It has been assumed the resources used generally follow value of the work completed, which paints a far-from-ideal picture of a resource-loaded schedule. The difference between the project plan and actual progress is significant, especially given that this plan was developed eight months into construction, when the issues faced by the project were well known. The figure does not demonstrate optimization of resources, with the wet season (December to May) clearly being a large factor. The inability to maintain steady resources on the project for even two consecutive months is striking. An effective schedule should consider the realistic supply available and endeavour to avoid large fluctuations in resources (Project Management Institute 2011, 2013).

**Lessons learned**
This case study identified many elements of the project that could have been better managed. Of particular interest, however, are the lessons that may be applicable to a wider context of infrastructure projects in developing countries with similar characteristics (e.g. geotechnical complexity). Below is a summary of the key literature-based factors identified in the case study that had the most significant impact on the outcome of this project. The key learnings have been arranged in terms of their causes, relation to the literature and suggested improvement strategies to potentially avoid similar issues on future projects. These causes and improvement strategies are a summary of the discussion section, in which they are discussed in more detail.

(1) Insufficient planning (F1)

**Causes**

a. Underappreciation of the wet season’s impact on construction.

b. Insufficient timeframe between contract award and construction commencement.

c. Underappreciation of potential delays due to unsecured approvals.

**Potential improvement strategies**

a. The potential impact of weather on a project should be more thoroughly considered in the project risk assessment, especially in countries where the tropical climate can bring unpredictable project changes. This could lead to mitigation through increased pre-fabrication/off-site production or simply through adjusting activity timings.

b. Although it may seem obvious, a detailed project schedule (which includes all activities required to execute the project, not just physical works) reduces uncertainty, clarifies responsibilities and deadlines and simplifies project execution.
c. A design review board, clear project scope, and an efficient change review and approval procedure will reduce the occurrence and cost of design changes.

**Literature examples**

a. Akogbe et al. (2013) cite climate as a key delay factor in Benin, and Ballesteros-Pérez et al. (2015) give examples of bridge projects in Chile that also would have benefited from better consideration of adverse weather in project planning.

b. Inadequate planning and scheduling have been shown to be major causes of delay for projects in Benin, Saudi Arabia and Jordan (Assaf and Al-Hejji 2006; Sweis et al. 2008; Akogbe et al. 2013).

(2) Unrealistic estimates (F3)

**Causes**

a. Poor estimating techniques resulted in actual cost of works being hidden.

b. Lack of understanding of productivities for many activities.

c. Not all activities included in WBS (e.g. required approvals not allowed for).

d. Lack of science behind project schedule (e.g. activities not sufficiently broken down).

**Potential improvement strategies**

a. Depending on project complexity, a combination of reference class forecasting, third-party review of estimates and stochastic estimation (e.g. Monte Carlo analysis) can improve the accuracy of estimates, enabling realistic budgeting, scheduling and performance tracking.

b. Record assumptions made during estimation for comparison against actual performance to improve future estimates (Carson et al. 2014; Gharaibeh 2014; Department of Transport and Main Roads 2017).

c. Along these lines, performance of projects should be recorded in detail to be used as a reference for estimation of future projects. This simple process is rarely performed but is key to improving estimates (Dubner 2018).

d. A sufficiently detailed WBS and clearly defined critical path to optimize the project schedule (Carson et al. 2014).

**Literature examples**

a. The Guayaquil South Viaduct road project in Ecuador is an example of inaccurate estimates, which had an initial completion timeframe of four years (Invest Ecuador 2019), but subsequent studies have estimated a timeframe of five to six years for completion (Varas Flores 2016).

b. Al-Saadi and Abdou (2016) advocate for recording performance of projects for reference in future estimation to improve PPPs in the UAE.

(3) Poor stakeholder communication (F5)

**Causes**

a. Underappreciation of social risks.

b. Contractor not involved earlier in the project.

c. Reporting period (one month) too long for project size.

**Potential improvement strategies**

a. Social impacts should be identified in the project risk analysis, especially when land acquisition is required, and a plan developed to manage them.

b. Early, continuous and open communication with stakeholders throughout the project should be established, which Baharuddin et al. (2017) and Gransberg et al. (2016) claim is best achieved through an alliance delivery model.

c. Sharing knowledge and prompt and honest communication are also key to sound stakeholder communication and should be present in alliance-type contracts.

d. Adequate social risk management should be considered as early as the feasibility studies, thereby giving the project a ‘social licence’ and reducing costs, delays and reputational risk to investors. Developing standard guidance for how to manage social and environmental risks may help improve this element of infrastructure projects in developing countries.

**Literature examples**

a. Issues with manipulated and late communication have been shown to be prevalent in large infrastructure projects in Europe (Mišić and Radujković 2015).

b. Similarly, poor communication, imposition and a lack of socialization caused issues on the Coca Codo Sinclair hydroelectric dam in Ecuador (Chen 2015).

(4) Cost of bureaucracy (F9)

**Causes**

a. Land acquisition and other approvals not completed prior to construction commencing.

b. Inefficient land acquisition laws.

c. Lack of communication between stakeholders.

**Potential improvement strategies**

a. Bureaucracy is an issue that comes in many forms across the globe. Streamlining bureaucratic processes through prioritization, clear definition of responsibilities, established timeframes and educating regulators on the significance of their actions are necessary steps to alleviate this.

b. Earlier communication, transparency with landowners and more efficient government regulation processes can simplify land acquisition and thereby reduce delays (Tang et al. 2012; Queensland Government 2018).

c. The risks associated with commencing construction prior to securing all necessary approvals should be fully considered and factored into project schedule.

**Literature examples**

a. The Korea Train Express project is a prime example of risks associated with commencing construction prior to securing all necessary approvals (Han et al. 2009).

b. Bureaucracy is cited as a major risk in a CA$4bn power and telecommunications project in Canada (Gharaibeh 2014); in irrigation and hydraulic projects in India (Molle et al. 2009), in the construction industry generally in Vietnam (Le-Hoai et al. 2008), and in developing countries in general (Gunawansa 2012).

(5) Insufficient ground investigation/consideration (F10)

**Causes**

a. Underappreciation of geotechnical complexity of project site.

b. Design completed prior to tender.

c. Sole tenderer restricted the ability to select most capable candidate.
Potential improvement strategies

a. For geotechnically complex projects, involving the contractor in the design phase (for example in a D&C delivery model) is likely to lead to more thorough geotechnical investigations and reduced uncertainty during construction (del Puerto et al. 2017).

b. Amadi (2019) suggests assessing the contractor’s capability to deal with geotechnical issues in geotechnically complex areas is of key importance.

c. A geotechnical risk assessment undertaken early in the project planning stage can further help alleviate geotechnical issues (Black 2017; Forcael et al. 2018).

Literature examples

a. The Korea Train Express project is an example where this factor caused numerous design changes during construction (Han et al. 2009).

b. Forcael et al. (2018) also report that unexpected geological conditions are one of the most significant risks found in the Chilean tunnelling industry.

c. Underestimation of geotechnical risks and unforeseen ground conditions causing major disruptions to construction is common to all types of projects around the world, from Canadian megaprojects (Jergeas and Ruwanpura 2010) to small-scale projects in Vietnam (Le-Hoai et al. 2008).

(6) Inadequate project delivery system (F11)

Causes

a. Funding arrangement for the project causing project owner to relinquish selection of contractor.

b. Poor governance and institutional quality causing project owner to wear most risk.

c. Decision to award contract following completion of the design.

Potential improvement strategies

a. An extensive delivery model analysis should be undertaken to determine the best model to suit the context of the project. The chosen model should provide incentives and penalties depending on performance and appropriate allocation of risks.

b. For large, complex projects, an alliance model has been shown to be effective due to how it encourages stakeholder management and risk sharing (Gransberg et al. 2016; Baharuddin et al. 2017).

c. Acceptance of international financing should be based on a robust cost-benefit analysis with potential side-effects and long-term goals in mind (as Peters et al. (2018) show, results can vary greatly) while maintaining the competitive bidding process for large projects, a process that produces well-established benefits for the owner.

Literature examples

a. Appropriate allocation of risks was shown to be the second most important factor for success of PPPs in the UAE by Al-Saadi and Abdou (2016).

b. Similarly, appropriate risk allocation was a major stumbling block in the Tehran–Chalus Toll Road project (Heravi and Hajhosseini 2012).

In terms of the positive aspects of the project, despite the project being awarded to an international contractor, the government stipulated a minimum of 70% of the project labour consisted of local workers, in an attempt to boost the local economy. Furthermore, the employment of a third-party consultant to audit the project was another positive element to attempt to improve project performance, quality and value for money. This is required by law in Ecuador, as is common in most developed countries for large public works projects. Finally, the completion of a large, multi-phase, complex engineering project, which endured decades of planning that contributed to the development of critical infrastructure for the region is a positive aspect in itself.

Although the associated key learnings from the case study are based on the unique experience of this project, they are argued to be applicable to projects of similar characteristics. The potential transferability of the key learnings to similar projects is based on: (1) support for the factors identified through the literature as being the most common issues plaguing projects in developing countries; and (2) examples of similar issues on other projects (not only in developing countries), indicating a commonality with the issues that were experienced in the case project.

Conclusion

Throughout this research, many infrastructure project success and failure factors were discovered from projects across the world, of which the 12 most important success and failure factors have been highlighted in this paper. Overall, the importance of the planning stage of the project was clearly emphasized, featuring as the top failure factor and second top success factor. Another interesting finding of this research was the relative difference in importance of factors based on developing country-specific literature; with lack of skilled workers, ill-defined scope and cashflow issues overtaking planning, estimation and communication-related problems considered more critical in the context of more developed countries.

The case study of the Flood Control of the Bulubulu River project supports the applicability of the success and failure factors identified in the literature to the Ecuadorian context: most of the identified failure factors were evident, while most of the success factors were not. Factors related to planning, estimation, communication, bureaucracy, ground investigation and the chosen project delivery system were found to have the most detrimental impact on the success of the project. As a result, it can be concluded that the project is an example of ineffective project management and delivery, and the lessons learned from its development may be applicable to a wider context of projects, particularly infrastructure projects in developing countries. These learnings, supported by existing project performance literature, provide important direction in improving the delivery of infrastructure projects in Latin America and reinforce the need to focus on solutions to these common issues to move the industry forward. This process of analysing the failure factors of completed projects is an important component of improving the delivery of future projects.

The project management failings on this project appear to stem from a lack of knowledge or clear guidance regarding what to consider when planning and managing a project. Governments in developing countries should consider developing standard guidance for project management to be followed for major infrastructure projects. This guidance need not be exhaustive, but it would provide project managers (in both the private and public sectors) with an effective starting point and raise the minimum standard of planning and project management for infrastructure.
Few case studies of infrastructure projects in Latin America with access to detailed project data exist in the literature. This research provides a rare insight into the performance of an important water infrastructure project in Ecuador, with the aim of raising awareness of the issues facing infrastructure development in Latin America and providing a detailed snapshot of their implications for an individual project. The key contributions of this research to the overall body of knowledge are to highlight the key factors that promote failure and success of infrastructure projects from relevant literature; demonstrate how these factors can manifest on a project (in the Ecuadorian context) and the effect they can have on the outcome; and provide recommendations for strategies to avoid (or at least mitigate) similar issues in future projects. Although the recommendations are based only on a single case study, they are argued to highlight significant issues restricting the effectiveness of infrastructure project delivery in developing countries.

Recommendations for future research

To build upon this research and further verify the relevance of the case study findings, similarly, detailed analysis of a broader range of projects in Ecuador is recommended to determine whether the issues experienced on the case project are endemic to infrastructure projects in Ecuador. Further, a more extensive range of case studies from various developing country contexts would further confirm the relevance of the success and failure factors, and the generalizability of the recommendations, to the general developing country context. Finally, case studies of successfully executed projects are recommended to confirm the accuracy of the literature-identified success factors and support the conclusions from this study.

Disclosure statement

No potential conflict of interest was reported by the authors.

Data availability statement

Some data used during the study (contractual documents and auditor reports) are available in a repository online at https://www.compraspureicas.gob.ec/ProcesoContratacion/comprex/PC/ informacionProcesoContratacion2.cpe?idSoliciCompra=bwq8iwc tzitzxW0Kxs-gX98G923fIExiJCIAQE40Fqu8.

The remaining data used for this study (schedule and cost analysis documents) are available on request by email to crodrigu@espol.edu.ec and used without restrictions.

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