Yes, construction cost, time and scope are important, but there is more: a new action plan for infrastructure success

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Abstract

Purpose – During the planning and delivery, iron triangle criteria, are essential for internal stakeholders (e.g. owner, sponsors and delivery company), mostly ignoring external stakeholders such as local communities (often perceived as inconvenient) or end users. In the medium-long term, infrastructure cost and benefit are far more important for external stakeholders and the environment.

Design/methodology/approach – The iron triangle criteria, i.e. delivering on time, budget and quality/scope, is the traditional perspective to assess the success of infrastructure projects. Delivering on cost and time is significant, but particularly for infrastructure, there are more relevant success criteria. The authors argue which criteria are important, and explain why.

Findings – The authors challenge the traditional view of judging projects based on respecting time, budget and quality/scope. The authors explain that discussing the social value and contribution to achieving the UN Sustainable Development Goals (SDGs) is extremely relevant. Crucially these metrics keep changing, even after the project is terminated.

Originality/value – The authors provide a new seven-step action plan for decision-makers to improve infrastructure provision by reflecting on SDGs and engaging with external stakeholders, particularly minorities and the weaker members of their communities. Such an action plan is focused on the cost and value for different stakeholders on different timeframes and progress toward social value and achieving SDGs.

Keywords Project management, Sustainable development, Social sustainability, Net zero, Sustainable infrastructure, Sustainable project, Non market stakeholders, Social cost

Paper type In motion

Why it matters

Over the next 20 years, global investment in infrastructure is estimated between $79 and $94 trillion, i.e. 3.5% of the world GDP (GiHub, 2022), requiring new technologies, management strategies, and delivery models. These infrastructures will reshape our cities and communities, impacting the environment, diversity, equity, and inclusion for centuries. This article introduces an action plan for managers to improve infrastructure provision.

Let us start with a vignette. Once upon a time, a bishop decided to build a bell tower for his cathedral. The construction, initially planned for 30 years, lasted two centuries. The colossal

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delay and extra cost were due to several reasons, including inadequate foundations and the Black Death pandemic during construction. Once completed, the tower was visibly leaning. We can only imagine the outrage! Can you guess the tower? Yes, it is the Leaning Tower of Pisa, built between 1172 and 1372. Only 500–600 years later became a worldwide attraction, millions of tourists visiting Pisa to see it. They use hotels, shops, and dine in restaurants, creating jobs and boosting the economy. Surely nobody expected this incredible success, particularly considering that the tower "was wrong", or a "project failure".

The case of Pisa's Tower is extreme, but we often read that infrastructure, such as bridges or power plants, has been delivered late and over budget. Politicians, managers and decision-makers are hasty to judge these projects as failures. They are (often) wrong. We will explain where this mistake comes from, why it is a mistake, and provide an action plan for managers and decision-makers to discuss infrastructure success.

The problem: your thinking about infrastructure success is flawed

If you have taken a class or read a book on "project management", you learned the so-called "iron triangle," summarizing the three traditional criteria for assessing a project:

(1) Respecting the agreed/signed budget (cost criteria).

(2) Respecting the deadlines/schedule (time criteria).

(3) Deliver what was agreed at the agreed quality (scope criteria).

This idea is often traced to the early 50s when the US Department of Defence needed to procure weapon systems from its suppliers (Morris, 1994). If the Department needs a new rocket, these three criteria are adequate, making the "Iron triangle" popular and widely adopted.

However, modern research in project management moved forward (Locatelli *et al.*, 2023). Project scholars have recognized over the last 20 years (Atkinson, 1999; Ika and Pinto, 2022; Pinto *et al.*, 2022; Sabini *et al.*, 2019) that framing the narrative across cost-time-scope criteria is a huge limitation in assessing project success. For example, the infrastructure might be built according to a contract where the construction company builds for a fixed price. Extra costs might be an issue for the contractor, but not for the customer or community. But let us be a bit more open-minded. Suppose we are building a bridge to link A to B because we want people to travel from A to B, saving time and fuel over a longer route, boosting the economic exchange between A and B, creating jobs, etc. The traditional iron triangle does not capture any of this. Over the years, managers understood this point and introduced a further dimension: "benefit" e.g. "100,000 people per day should use the bridge", making the "cost-benefit analysis" popular, see, e.g. European Commission (2014).

However, the idea of benefit can be tricky; let us take space exploration. What is the benefit of *"wasting billions of dollars to bring few men to the moon when so many poor people in the world struggle to get the next meal?"* That was the legitimate question for NASA managers from Sister Mary Jucunda, a nun taking care of starving children in Zambia, in 1970. You can read the long and intelligent answer of Ernst Stuhlinger, an Associate Director of Science at NASA (Siegel, 2017). Nowadays, NASA estimates that 444,000 lives have been saved from the technologies originally developed for space exploration (Schwerin *et al.*, 2012). Space exploration gave us several technologies, including wireless headsets, artificial limbs, and the laptops we used to write this piece (NASA, 2016). Therefore the cost-benefit analysis is appropriate for simple short-term decisions but can be misleading for complex projects. Let us elaborate on this. What is the benefit of the long bridge linking A to B? Yes, moving people from A to B, but why? Maybe A is an affluent

area, and B is a depressed one, so by linking A to B, we hope to reduce the commuting time and develop B. So, people in B can get jobs, increase their quality of life, etc. However, house prices in B might increase and lead to gentrification. Benefits are hard to predict, and infrastructure "can be used" in ways that are difficult to predict. Let us think about the Sydney opera house.

"*The original cost estimate to build Sydney Opera House was $7mn. The final cost was $102mn, and it was largely paid for by a State Lottery"* (SOA, 2021). Another "failure project" over budget (and late)! However, about 11mn people each year visit the Opera House. In 2018–2019, the total audience attendance for Performing Arts events was "just" 1.4mn, while 9.5 million visitors went to take tours costing $30 for adults and $15 for children. The performance generated 77.617mn, costing 67.681mn (profit of about 10mn), while precinct activities (tours, food shops etc.) generated 30.396 million, costing only 7.777mn, therefore, making more than double the profit of the performances (SOA, 2020). Moreover, *"The precinct's total economic contribution was $1.2bn in 2016–17 [supporting] 8,700 full-time equivalent jobs, and for every person directly employed by the Opera House, 14 others are employed throughout the economy; and The Opera House's social asset value was $6.2bn in 2018"* (SOA, 2020). Was all this expected (or possible to estimate) in the 1950s when the opera was planned? Moreover, if, on one side, tourism is great for the economy, is a source of greenhouse gas emissions contributing to climate change and a vehicle to spread viruses.

So, managers should consider that costs (construction and operations) are hard to predict and benefits even harder. But brace yourself; there is more. Let us consider the case in Figure 1, depicting a new high-speed railway linking cities X, Y, and Z.

Let us assume this is a state-owned infrastructure; the traveling time from X to Z now takes 4 h and can be reduced to 2 h and 45 min. The new infrastructure cost is 20 billion dollars (3% of the country's GDP), and the high-speed ticket is three times the price of a regular ticket. Would it be worth building this infrastructure? A professional living in X and often going for business in Z would love it. Managers building the infrastructure might be very supportive; job positions will be created, etc. However, commuters using regional trains might want the money spent to improve their old trains or reduce fares. People in cities A, B, C, D, E, and F might be annoyed seeing their tax money spent elsewhere. People living in beautiful villages across the line will vividly protest against it because this noisy infrastructure will cause huge discomfort and reduce their house value. Bottom line: cost and benefits are not beheld by projects but by people, and each person sees a different cost-benefit analysis (Locatelli *et al.*, 2021).

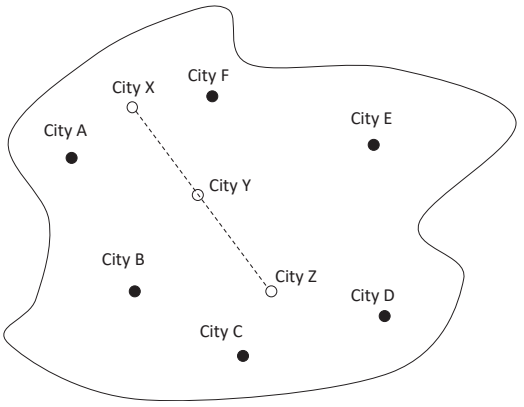

Figure 1.
The case of a new multi-billion railway

A fresh way to think about infrastructure (and project) success

How can we better assess infrastructure success? Our answer is to study how infrastructure creates benefits in terms of value, particularly social value, and contributes to or hinders the UN Sustainable Development Goals (SDGs) achievement. Social value is ideal for initiating a broad discussion about the infrastructure, understanding which problems we are trying to solve, which are the stakeholders, and which stakeholders are "gaining" or "losing" from the infrastructure. The SDGs support more structured and detailed discussions for comparing different design solutions.

Social value

Social value refers to the social benefit created, delivered, and captured for a given population (Kroger and Weber, 2014), and has three characteristics 1) Social value is subjective (Simpson, 2004). External stakeholders have different value perceptions (Haass and Guzman, 2019). Therefore, the infrastructure may create value for some and destroy value for others (Jones *et al.*, 2018). E.g., building a metropolitan may improve sustainable urban mobility, reducing air pollution and traffic, but also reducing jobs for taxi drivers. 2) Social value is assessable (Raymond *et al.*, 2014), for example, by measuring the tons of carbon emission reduction and the number of jobs for taxi drivers. 3) Social value is multidimensional as it includes the individual perspective (Saebi *et al.*, 2019) and the societal one (Lehtinen *et al.*, 2019). For example, an infrastructure could create new job opportunities for an unemployed individual or society.

Considering the "social value" of infrastructure offers a good advancement of the traditional "success" metrics (Gil and Fu, 2022). Several methods and tools have been developed to measure social value (Paravano *et al.*, 2023), such as Cost-Benefit Analysis (McWilliams and Siegel, 2001), Social Accounting (Gray, 2002), Social Return on Investment (Fernandez-Izquierdo and Matallin-Saez, 2008), SDGs impact assessment (Markkanen and Anger-Kraavi, 2019). No single method has been universally recognized as the industry standard for measuring social value. Nevertheless, embracing the social value perspective provides an inclusive understanding of the benefits created by the infrastructure, especially for external stakeholders (Kroger and Weber, 2014), as for the example in Table 1.

Let us go back to the bridge example to appreciate the bigger picture. The key question is how can we enable internal and external stakeholders to capture value from this infrastructure?

As for the internal stakeholders, the (temporary) project organization generally has a clear structure, where organizations create, deliver and capture value according to contractual conditions. Outside the project organization, the situation is far more chaotic, with heterogeneous external stakeholders, mixing individual people with groups, which seldom have any formal links between them or the project organization. Also, the value mechanisms are more complex. For instance, we might want to make the bridge free to use for people using low-emission vehicles or, before building the bridge, plan to have areas for parks, shops, and

Table 1.
Social value creation
Data from https://ec.europa.eu/transport/themes/its/road/action_plan/ecall_en https://www.euspa.europa.eu/newsroom/news/ecall-emergency-alert-system-launched

Project name	eCall
Issue	Every year 1.3 million people are killed in car accidents. Road traffic injuries are expected to become the sixth biggest cause of mortality by 2030
Infrastructure	eCall is an EU initiative to bring rapid assistance to motorists involved in a collision. eCall automatically connects the occupants of the affected vehicle to the nearest emergency centre while sending their precise position (through Galileo and EGNOS)
Social value created	According to the European Commission, eCall will save up to 800 lives per year in Europe while dramatically reducing the severity of injuries in 15% of all incidents involving actual injury. This would reduce the social costs for society by EUR 130 billion per year

places where people can socialize and not leave the lend to the "shark developers", planning for value creation and distribution. In doing so, managers need to give up some old and narrow (reductionist) ideas of economics (e.g., utility-maximizing individuals), such as looking at people as emotionless calculating robots but people with feelings and biases. People use infrastructure differently, for instance, according to their available income, gender, age, education, etc. Building a modern art museum or a stadium provides for (mostly) two different population segments. These infrastructures are not in a vacuum but would affect other infrastructures such as hotels or subways.

Achievement of UN Sustainable Development Goals

The second point concerns achieving UN SDGs (UN, 2021). There are two relevant debates around SDGs.

The first debate discussed the effectiveness and alignment of SDGs with sustainable transition. In some contexts, SDGs can fail to account for long-term sustainability outcomes since SDGs do not consider the limitation of physical resources (Wackernagel *et al.*, 2017). Also, policies based on the SDGs framework are effective in advancing equality and fostering economic growth, but there is no clear evidence on how SDGs help to address the different sustainable transition challenges (Leal Filho *et al.*, 2019).

The second debate discusses the possibility of achieving multiple SDGs in the same context, focusing on synergies and trade-offs among the SDGs goals. On the one hand, some articles demonstrate that SDGs present some contradictions and sit in tension with each other, pushing policy-makers to prioritize one at the expense of the other (Kassouri and Altıntaş, 2020) or to implement incompatible policies (Agbaitoro and Oyibo, 2022). In particular, trade-offs arise when policy-makers aim at contributing to economic- and social-oriented SDGs with environmental-oriented SDGs (Spaiser *et al.*, 2017). On the other hand, some articles argue that synergies between SDGs outweigh the trade-offs (Pradhan *et al.*, 2017), showing how particular technologies and infrastructures aiming at achieving specific SDGs can contribute to other SDGs (Fader *et al.*, 2018).

While the extant literature mainly focuses on policies promoting SDGs, we can flip the question to the infrastructure. The key question is: how is this infrastructure promoting (or harming!) the achievements of SDGs? Famous is the case of modern slavery and death tools in building infrastructure (Alzoubi *et al.*, 2023). We can also assess to what extent an infrastructure is aligned with the Net-zero transition goal (SDG 13) and consider it a success, depending on its impact on the climate. Using the Bridge example, to what extent are the greenhouse gasses avoided by reducing the distance from A to B, not counterbalanced by the rising volume of traffic resulting from more people willing to commute (or go on weekends) from A to B? What about, instead of building this bridge, developing high-speed Internet to facilitate remote working avoids the need for commuting?

Infrastructure takes years or a few decades to build but last centuries and has a central role in achieving Net-zero transition goals. Indeed, most of the budget pledge for the Net-zero transition will be spent on infrastructure (UNCC, 2021). The key question is, "How does infrastructure, over its life cycle, impact SDGs?" For instance, we know that men and women work different hours at different times of the day in different places. Is the infrastructure promoting gender equality (SDG 5), or is it increasing the divide? Is the infrastructure promoting affordable and clean energy (SDG 7) or increasing greenhouse gas emissions?

Let us be practical! an action plan for improving infrastructure provision

This section presents a seven-step action plan to support managers in making better decisions when planning infrastructures. The decision-makers should follow the action plan

below, firstly independently (steps 1 and 2), then together in a collaborative exercise inspired by design thinking (Hölzle and Rhinow, 2019). This action plan does not substitute an economic-financial analysis or a cost-benefit analysis but integrates them. To be practical, we will use the case of the railway mentioned above (Figure 1).

STEP 1 – identify external stakeholders

Managers can identify the external stakeholders by leveraging these four questions.

(1) Who will be positively or negatively affected during construction, operation, and decommissioning?

(2) Which are the leading organizations (including NGOs) concerned with the nature of this infrastructure?

(3) Looking at similar infrastructure delivered in the past in a similar context, which stakeholders protested or were negatively influenced?

(4) What is this infrastructure doing for minorities, the poorer, and, generally, the most disadvantaged groups?

A more structured approach, useable by mature organizations, is the Q-method, as applied in (Cuppen *et al.*, 2016) for large infrastructure.

STEP 2 – look for value/benefit created (see the questions)

Managers and decision-makers should discuss the social value of the infrastructure, and how it is created, distributed, and captured:

(1) Social Value creation andand destruction:

o Which social value is created? (e.g., new jobs, air pollution reduction)

o For which stakeholders is value created (commuters, new businesses etc.)?

o For which stakeholders is value destroyed or lost? (e.g., people with house prices reduced because of noise and pollution) and how this will be counterbalanced for them?

(2) Social Value delivery: How is the value delivered to stakeholders? (e.g., through policies of fair access)

(3) Social Value capture: How can we enable stakeholders to capture value from this infrastructure?

To follow a more holistic process (Bayliss *et al.*, 2020), provides the "system of provision" approach.

STEP 3 – design thinking exercise part 1

Stakeholders are invited to a collaborative workshop prepared following the design thinking method (Liedtka and Ogilivie, 2011) to provide a complete overview of the method; key elements are:

(1) Diversity in the workshop is essential, and that is the reason to go back to the answers from step 1, including stakeholders such as minorities. It is necessary to find places and timeslots accessible for these stakeholders and support their presence, for instance, by reimbursing expenses (Babaei *et al.*, 2023).

(2) Being inclusive means people with different skills and expertise participate in the workshop. The vast majority will not be engineers. A key idea of design thinking is prototyping, so to be inclusive, the infrastructure can be 3D printed at scale and used for discussion. Tools based on virtual reality and metaverse may support an immersive experience for participants, even if online.

(3) Use techniques such as the "world café" (Fouché and Light, 2011) to capture the perspective of the groups involved, including those that are often silenced and not just the voice of the "white alpha male".

(4) Focus on possibilities. Traditional engineers (and managers) start their design process from constraints (e.g. budget, passenger demands, train speed etc.). This approach kills the creative process and the possibility of developing more innovative (and valuable) solutions.

STEP 4 – classify value

Decision-makers should complete Tables 2 and 3 alone, then come together to discuss differences and similarities. Table 2 captures that organizations and people are distinct stakeholders who perceive different costs and values (Locatelli *et al.*, 2021). This table pushes decision-makers to reflect on actions aimed at value creation, distribution and capturing for the stakeholders. The physical design of the infrastructure (e.g. tunnels and noise protection barriers) and its business model (e.g. pricing mechanisms for different users) are updated accordingly.

STEP 5 – assess sustainability

Table 3 relates to the SDGs pushing decision-makers to consider sustainability aspects at different scales and times. Following Pradhan *et al.* (2017), decision-makers should map synergies and trade-offs in their project context. The results of these two tables can be used to communicate the value and sustainability to the wider public. Finally, the infrastructure's physical design and business model are updated accordingly.

STEP 6: design thinking exercise part 2

A second design thinking workshop is organized. Here a new version of the infrastructure with features incorporating the results from steps 3, 4 and 5 is presented and discussed with the support of the new 3D models (or virtual reality models). Feedback from the participants is collected and incorporated into a new version. Steps 3, 4, 5, and 6 are iterated until the stakeholders are satisfied with the value creation, distribution, and capture, and there is a clear advantage in terms of the achievements of SDGs.

STEP 7: close out and handover

In this final step, the entire process is documented and these documents are shared among the participants, including external stakeholders. Lessons learned are collected and a committee of external stakeholders, including minorities and the more vulnerable community members, is created. Such committees support the project organization along the detailed design and construction process, being involved in the inevitable discussions about scope change. The detailed engineer and site preparation can start.

Concluding insights and remarks

We draw six final insights for decision-makers involved in assessing infrastructure by combining what emerges in the extant literature with our experience as researchers and consultants.

Table 2.
Stakeholders' costs and value. Further development of (Turner and Zolin, 2012). Costs here are "Non-economic costs" but rather social costs

		During the project				Short term [years]				Long term [decades - centuries]			
			Actions for social value				Actions for social value				Actions for social value		
		Cost	Creation	Delivery	Capture	Cost	Creation	Delivery	Capture	Cost	Creation	Delivery	Capture
Organizations	Investors/owners												
	Main contractor												
	Suppliers												
	Lenders												
	...												
People	Workers in construction												
	Workers in operation												
	Local populations												
	Users												
	Taxpayers (if public)												
	...												

(1) The "iron triangle" is important, particularly for the Project Organization (left in Figure 2), but this perspective is too narrow to fully capture the value and measure the success of an infrastructure project.

(2) Think about social value and SDGs. Most issues will come from stakeholders whose value is destroyed or lost. You need empathy to see infrastructure from their perspective. When you consider cost-value dimensions and SDGs, it becomes clear that trade-offs are needed to balance across different stakeholders' expectations.

(3) Organizations and people working in organizations are very different stakeholders who perceive cost and value differently. Cost and value for organizations are (mostly) reflected on the balance sheet. Instead, cost and value for people are (mostly) on their payrolls (if they are workers in the involved organizations) and personal perception (everyone).

(4) Consider the sustainability perspective according to the achievement of various SDGs at different levels, at least local, regional, and global. Consider the time dimension: today's good infrastructure can be bad tomorrow.

(5) Consider the transformative power: the long-term success of infrastructure comes from how it contributed to reshaping the surrounding social and economic system.

	During the project		Short term [years]		Long terms [decades-centuries]	
	Cost	Benefit	Cost	Benefit	Cost	Benefit
Micro-level (infrastructure itself)						
Meso level (infrastructure surrounding, i.e. system in which the infrastructure is embedded)						
Macro-level (global scale)						

Table 3. Costs and benefits concerning the UN SDGs. This table could be general (in a quick brainstorming) or can be replicated and used for each relevant SDG

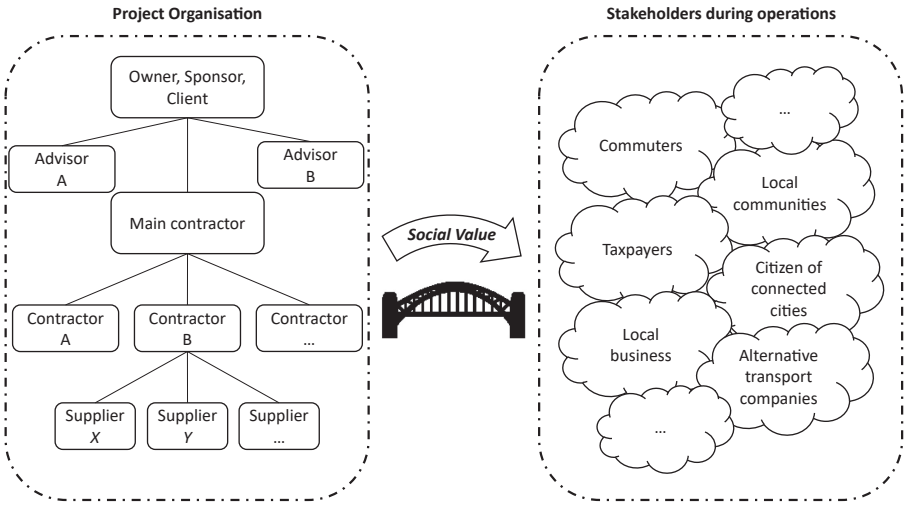

Figure 2. Project organizations, adapted from (Denicol *et al.*, 2021), vs Stakeholders during operation

(6) Use our action plan to improve infrastructure provision. Managers can start from the tools we explicitly provided and then move toward a more complex and holistic approach, such as the "system of provision".

We trust that this piece and the action plan that we provided will open managers' eyes to looking at infrastructure provision and their links with social value and SDGs. We leave our readers with a practical exercise: look at some infrastructure terminated decades ago and ask yourself, "Were they worth it? For whom? Are they sustainable? Would you do them again?"

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