sustainability

MDPI

Article

Analysis of the Capital Structure in Sustainable Infrastructure Systems: A Methodological Approach

Juan David González-Ruiz [1,*], Sergio Botero-Botero [2] and Alejandro Peña [3]

1 Grupo de Investigación en Finanzas y Sostenibilidad, Departamento de Economía, Universidad Nacional de Colombia, Sede Medellín, Medellín 050034, Colombia
2 Departamento de Ingeniería de la Organización, Facultad de Minas, Universidad Nacional de Colombia, Sede Medellín, Medellín 050034, Colombia
3 Grupo de Investigación en Información y Gestión, Escuela de Administración, Universidad EAFIT, Medellín 050022, Colombia
* Correspondence: jdgonza3@unal.edu.co

Abstract: Many countries require financial mechanisms, leading to increasing coverage through sustainable infrastructure systems (SISs). However, establishing such mechanisms demands innovative approaches and analyses that contribute to the development of financial schemes by providing a new vision for private investors and public entities promoting sustainable development and, therefore, the creation of new eco-financial assets. To address this need, this paper proposes a methodology for analyzing capital structure in sustainable infrastructure systems, which is validated in a case study. Thus, a mathematical model that identifies the impact on the final capital structure according to an investment plan and capital structures per period is developed. Additionally, this proposal integrates a financial framework that involves sustainable financing, capital markets, and public–private sectors. The results of the case study show that debt-service capacity was always higher than 1.0×. Hence, this study provides a better understanding of financing processes for SISs. Additionally, this contributes to the debate on infrastructure financing and its implications for main stakeholders.

Keywords: capital structure; infrastructure; project finance; public–private partnerships; sustainability; sustainable financing

check for updates

Citation: González-Ruiz, J.D.; Botero-Botero, S.; Peña, A. Analysis of the Capital Structure in Sustainable Infrastructure Systems: A Methodological Approach. *Sustainability* **2022**, *14*, 12662. https://doi.org/10.3390/su141912662

Academic Editors: Rui Alexandre Castanho and Daniel Francois Meyer

Received: 23 August 2022
Accepted: 28 September 2022
Published: 5 October 2022

1. Introduction

Infrastructure systems are characterized by requiring a large amount of financial capital for their construction [1,2]. A holistic definition of infrastructure systems indicates that they have environmental, social, and governance impacts on project stages, such as planning, building, and operating [3]. In this way, understanding the social components is critical for increasing resilience [4]. Additionally, they can be integrated into a combination of two or more infrastructure systems [5]. In this context, infrastructure systems, such as buildings, bridges, facilities, energy, transportation networks, among others, play a pivotal role in providing vital services to mankind [5,6]. According to ref. [7], by 2030, Latin America and the Caribbean will need to invest USD 2,220,736 million in developing infrastructure systems, particularly water, sanitation, energy, transportation, and telecommunications, in order to meet the Sustainable Development Goals (SDGs). Of that total, 59% is required for developing new infrastructure systems, while 41% for maintaining the existing assets and replacing assets that are obsolescent [7]. According to the Inter-American Development Bank [7], investments by countries can be grouped as follows: Central America: USD 612.8 billion; Caribbean: USD 19.6 billion; Andean: 457.9 billion; Southern Cone: USD 1130.4 billion. In this way, private and public sectors have a great opportunity to join efforts for closing both investment gaps and reaching SDGs.

These are typically structured using project finance (PF) and public–private partnerships (PPPs). Regarding capital structure, the study conducted by [8] found that infrastructure systems structured under PPPs are usually financed by a combination of equity and debt in different proportions, with debt generally exceeding 70%, although sometimes reaching 100%. Similar findings were also found by [9], who indicated that the percentage of debt was between 65% and 90%, compared to 25% and 35% for typical companies. Likewise, [10] indicated that the capital structures of most PPPs developed through PF were highly leveraged, with equity financing covering between 10% and 30% of capital expenditures (Capex) and debt between 90% and 70%. Additionally, although studies have been conducted by analyzing infrastructure systems from a financial perspective, they include neither sustainable nor convertible debt. These studies have mainly focused on the optimization [11–13], financing [14–18], and analysis of risks [19–23].

Considering all the above-mentioned points, ref. [24] indicated that infrastructure system financing is an open field for academic researchers. However, empirical studies remain limited, despite their importance in professional and academic arenas. Thus, areas of knowledge from different perspectives could be indicated, particularly in risks [25–28] and capital structure [1,2,29–31], thus, further encouraging extended studies. This could also provide insights for stakeholders in order to encourage private sector investments [32].

Given that infrastructure systems could be financed by equity and/or debt, it is important to consider that some debt mechanisms can convert into equity shares. This is the case in mezzanine debt [3]. Thus, given that convertible debt has a contingent claim from lenders, this could cause capital structure to change once during a project's life-cycle when the outstanding debt is converted into equity shares [33]. When this happens, equity investments would increase participation in the capital structure [3].

Thus, lenders could convert outstanding debt into equity shares based on criteria or parameters. This study deals with the capital structure evolution when infrastructure systems are financed with convertible financial mechanisms indexed with sustainable criteria and exercised by an American-type option. In this scenario, capital structure could change if goals or covenants related to sustainability are accomplished, and the option is exercised. It is important to note that financial options are classified as American and European. The former can be exercised at any time during the life of the option, while the latter can only be exercised at a specific time [34]. In this case, debt must be a sustainable financial mechanism and infrastructure systems must have sustainability impacts. In this way, it is important to impact investors' behavior and, thus, shift the investment industry mindset concerning SISs. That means that higher financial returns could result from better operation performances, lower financial costs, and an adequate financing strategy, which should include sustainable financial resources. In this way, SISs could reduce operational costs by focusing on efficiency [35].

In this regard, [36] argued that it is necessary to change traditional shareholders' maximization of sustainable value creation as only the viable way forward. Likewise, [37] provided a remarkable description of financial and sustainable investments, indicating no difference between the two, given that both types of investments create social, financial, and environmental value, which [38] confirmed.

Although empirical studies have mainly focused on analyzing the capital structure of infrastructure investments [31,39–41], to the best of our knowledge, no elements in the current literature have analyzed the capital structure evolution. Therefore, to fill this gap, this study proposes a methodology for analyzing capital structure in sustainable infrastructure systems. Thus, a mathematical model that identifies the impact on the final capital structure according to investment plans and capital structures per period is developed. Additionally, this proposal integrates a framework that involves sustainable financing, capital markets, and public–private sectors.

The current study provides a two-fold contribution to the literature. First, the present study allows for a better understanding of how capital structure changes, even if debt is converted to equity shares, from a mathematical perspective. Its analysis provides critical new evidence and insights on this topic. Second, this study integrates the main stakeholders into a framework, allowing for a complete outline at all stages of an infrastructure system.

In this way, this study provides a roadmap that researchers and professionals can use to improve their understanding of how infrastructure could be financed.

The remainder of the paper is organized as follows: In Section 2, we present the materials and methods used in this study. In Section 3, we explain the methodological proposal. In Section 4, we apply the methodological proposal in a case study. In Section 5, we conclude the study.

2. Materials and Methods

This research proposes an integrated framework that involves sustainable financing, capital markets, and public–private sectors. Consequently, it presents a mathematical model that identifies the impact on the capital structure according to investment plans and capital structures per period. In order to apply the methodological proposal, the wastewater treatment plant "Aguas Claras" was used as a case study. This plant is located in the municipality of Bello, Colombia, and is managed by Aguas Nacionales. In this way, the research was considered exploratory with a post-positivist approach, since the object under investigation (research problem) had been little studied thus far, especially in situations with limited information [42]. Our objective was to formulate generalizations in the form of laws, although the scope was limited and provisional in time (but with potential for application) [43]. In this way, the spatial delimitation was the Aguas Claras project, and the temporality of the study had a horizon of 30 years based on Colombian Law 1508/2012 [44].

The design and establishment of the methodological proposal considered the main findings in developing the theoretical framework and the main difficulties of developing SISs. These theoretical and practical findings constituted the basis of this methodological proposal. Figure 1 shows the methodological scheme used.

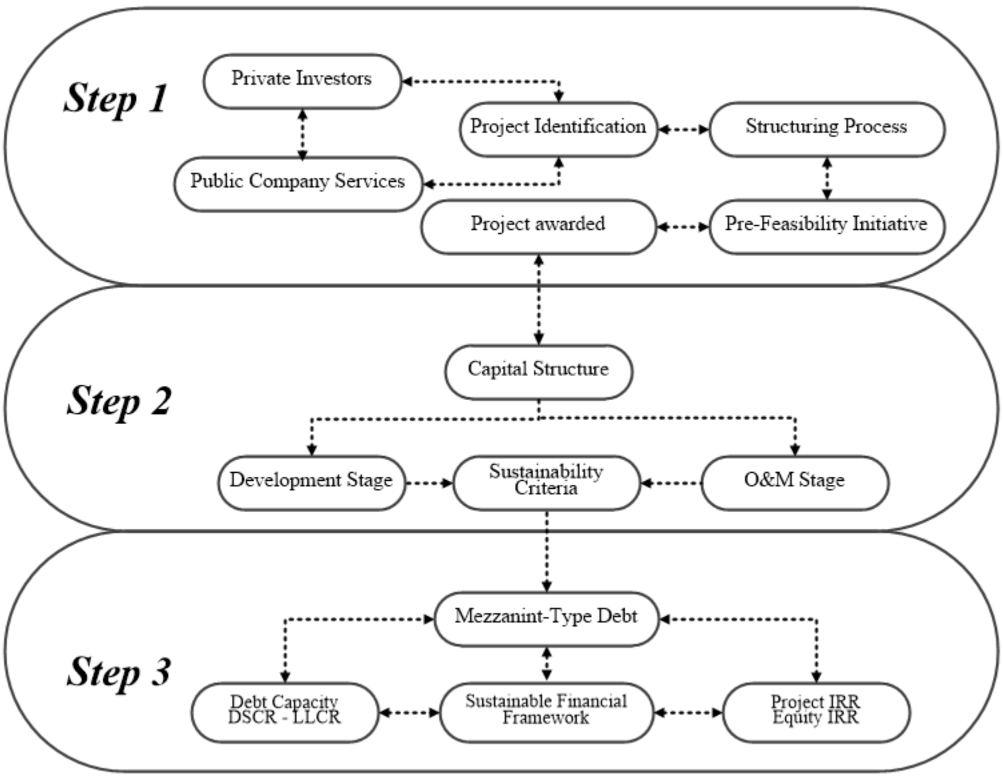


Figure 1. Methodological scheme. Source: authors' own.

3. Methodological Proposal

The methodological approach to financing SISs was structured in steps. Figure 1 shows a scheme that summarized, in a general way, the proposed methodology. Subsequently, each step was systematically integrated into a sustainable financial framework. This methodology could provide a better description of the SIS structuring process and how to improve strategic decision making, particularly in regard to financing issues. Although this proposal was designed for the Colombian case, it can be applied to any country or sector, considering the application of specific tax benefits. In this way, the methodology proposed can become a financial tool that strengthens the financing process, helping boost the development of SISs and close the coverage gap.

3.1. Structuring Process

In Colombia, private investors can present two types of proposals to carry out projects: (1) with public resources and (2) without public resources. The main difference between the two is based on the public funding issue. In the first type of proposal, the private initiative with public resources (PIPR), the amount of public financing cannot be more than 30% of the value of the original contract. Such proposals would be conditioned on infrastructure availability. For example, operating projects must comply with service levels and quality standards. In the second type of proposal, the private initiative without public resources (PIWPR), there is no public funding; therefore, projects must be financed exclusively by operating income. Figure 2 is a flowchart showing what private investors must do to propose an infrastructure project. According to the Colombian PPPs Law, this process takes no more than 18 months.

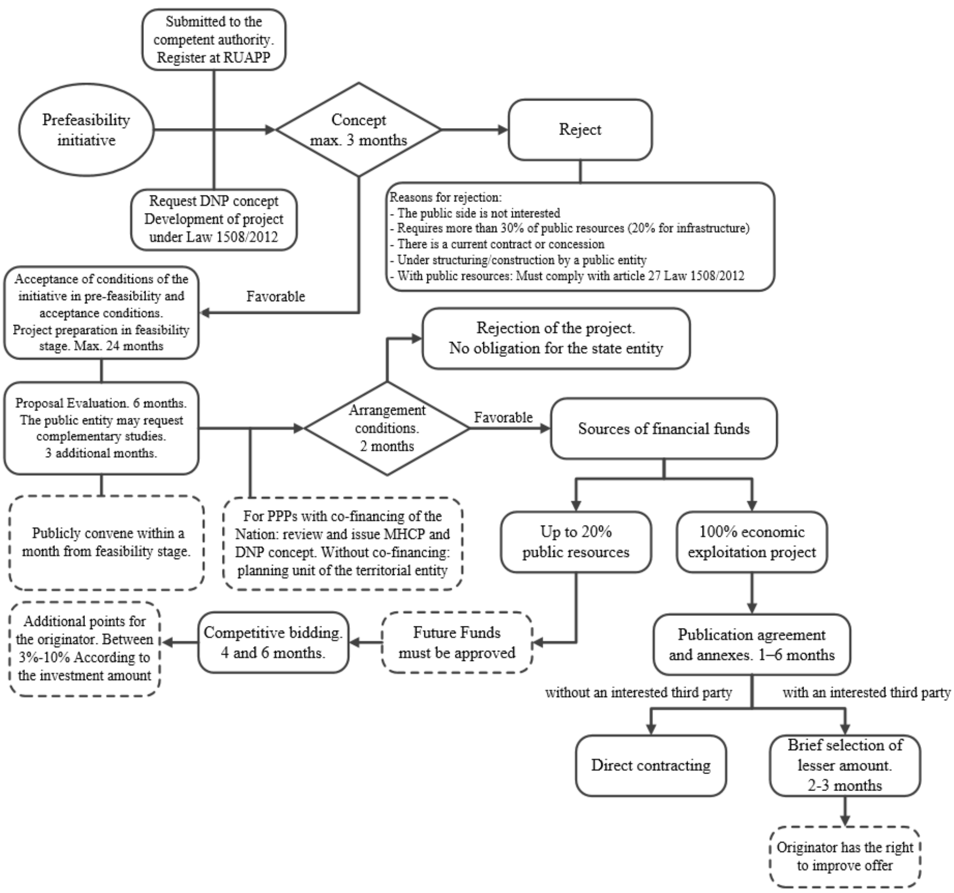


Figure 2. Flowchart of a private initiative under the Colombian PPPs law. Source: authors' own based on [45].

Considering that almost all financial models adopt a bottom-up approach to PPP projects [46], this proposal used a strategy that prioritized input identification. Thus, this proposal considered two stages in implementing infrastructure projects to present an approach to a sustainable financial scheme that incorporates sustainability criteria into a financial model. The first had two stages, preparation and construction; they were unified for practical effects at the development stage. The second was the operating and maintenance (O&M) stage. The two stages were explained as follows.

3.2. Development Stage

Intending to keep track of the capital structure's evolution during the development stage, which includes both the preparation and the construction stages, this work presents a mathematical model that enables the identification of impacts on the final capital structure based on an investment plan and capital structure per period. As shown in Table 1, this proposal used three financial sources: equity, senior debt, and mezzanine debt.

Table 1. Capital structure evolution described as a mathematical model. Source: authors' own.

Financial Mechanism		Development Stage		Final Capital Structure
		Preparation → *x* Periods	**Construction → *k* Periods**	
Equity		$\sum_{i=0}^{x+k}(I_i.(1+\%SF_i)+S_{i-1}.Kd_{s_i}+M_{i-1}.Kd_{m_i})$ (1)		$\%E_i = \frac{E_{x+k}}{E_{x+k}+D_{x+k}}$ (4)
Debt	*Senior*	$\sum_{i=0}^{x+k}(I_i.(1+\%SF_i)+S_{i-1}.Kd_{s_i}+M_{i-1}.Kd_{m_i}).\%S_i$ (2)		$\%D_i = \frac{D_{x+k}}{E_{x+k}+D_{x+k}}$ (5)
	Mezzanine	$\sum_{i=0}^{x+k}(I_i.(1+\%SF_i)+S_{i-1}.Kd_{s_i}+M_{i-1}.Kd_{m_i}).(1-\%E_i-\%S_i)$ (3)		
$\%E_i+\%D_i=1$ (6)	$Capex_i = E_i + D_i$ (7)	$Kd_{mi} > Kd_{si}$ (8)	D_{x+k} = (2) + (3) E_{x+k} = (1)	$\frac{Total\ Capex}{(1)+(2)+(3)}$

I_i—investment at period *i*. $\%E_i$—% equity at period *i*. $\%D_i$—% debt at period *i*. S_i—accumulated senior debt at period *i*. $\%S_i$—% senior debt at period *i*. Kd_{si}—interest rate of senior debt at period *i*. M_i—accumulated mezzanine debt at period *i*. Kd_{mi}—interest rate of mezzanine debt at period *i*. $Capex_i$—capital expenditures at period *i*. SF_i—sustainability factor at period *i*.

This proposed mathematical approach can be adjusted to any financing process, which includes equity, senior debt, and/or mezzanine debt. The main elements were as follows, and, based on the proposal, assumptions were raised in items four, five, and six.

1. The investment plan could be divided into two stages. The first stage (preparation) has a duration of *x* periods and the second stage (construction) has a duration of *k* periods. Thus, the development stage, which combines the above stages, has a duration of *x* + *k* periods. This way, each investment can be given by I_i, where *i* indicates each period and, thus,

$$\sum_{i=0}^{x+k} I_i = \text{investment plan} \tag{9}$$

This equation enables an investment curve according to the construction plan; therefore, it does not use the distributed cost uniformly. In addition, O&M would have a duration of *n* periods and not have an investment plan. In this manner, the project's total duration would be given by *x* + *k* + *n* periods, which includes the preparation, construction, and O&M stages. Additionally, the sustainability factor is also included in the investment plan.

2. Each period can have a different capital structure. Thus, equity investment, given by $\%E_i$, could be different at each period *i*; therefore, the total debt provided by the senior and mezzanine debt would be the complement $(1 - \%E_i)$. As a result, Equation (6) is mandatory. This model can be used in any scenario. For example, lenders can limit

the sponsors' investment strategy through guarantees, covenants, or letters of credit; thus, project debts could be disbursed after a 100% equity investment or pari passu. The final capital structure would be given by the participation of the total equity and debt between the total Capex, which is shown in the "Final Capital Structure" column in Equations (4) and (5), respectively. Another method can calculate the weighted average between total equity and total Capex per period (Equation (10)). Similarly, the weighted average could be used, as shown in Equation (11).

$$\%\ Equity = \frac{\sum_{i=0}^{x+k} \%E_i\ Capex_i}{\sum_{i=0}^{x+k} Capex_i} \tag{10}$$

$$\%\ Debt = \frac{\sum_{i=0}^{x+k} \%S_i Capex_i + \sum_{i=0}^{x+k} (1 - \%E_i - \%S_i) Capex_i}{\sum_{i=0}^{x+k} Capex_i} \tag{11}$$

3. Interest rates in senior debt (Kd_{si}) and mezzanine debt (Kd_{mi}) could be different at each period *i*. Therefore, according to the project's risk and development stage duration, it would be possible to have an interest rate arrangement per each period *i*. Due to intrinsic risk, the relation between these interest rates follows Equation (8). The average cost of debt funding, which includes both senior and mezzanine debt, could be calculated as shown in Equation (12).

$$Weighted\ average\ cost\ of\ financing = \frac{\sum_{i=0}^{x+k} kd_{si} S_i\ +\ \sum_{i=0}^{x+k} kd_{mi} M_i}{\sum_{i=0}^{x+k} Debt_i} \tag{12}$$

4. Interest generated at each period *i* by accumulated debt, which includes senior and mezzanine debt, must be paid according to the capital structure of each period *i*.
5. The investment plan, which includes both the construction contract and inflation, would be signed by sponsors through a SPV with a construction company. The total interest paid during the development stage can be calculated as the difference between the total Capex and the investment plan, which are given by

$$\sum_{i=0}^{x+k} Capex_i \tag{13}$$

and Equation (9), respectively. Therefore, if the project is financed only by sponsors, this difference must be equal to zero, and if there is debt at the development stage, the total Capex must include the investment plan plus interest.
6. A sustainability factor (SF) is defined as an increase in the investment at each period *i*. According to [47], this could be approximately 5%.

Fiscal benefits could play a pivotal role in encouraging eco-innovations in the financial area [48]. Thus, based on the mathematical approach presented, the following consideration was considered in the proposal. Private investors, validated by competent authorities, who invest in improving the environment, would have the right to deduct the value of such investments from their annual income in the appropriate tax year; this deduction cannot be more than 20% of taxable income. Thus, since corporate income tax payments must be paid one year later, the benefits can be considered one year after the investment.

However, given that projects only have investment expenses in the development stage, the projects would not have either income or expenses, and, therefore, would not have taxable income. This proposal suggests that tax benefits obtained at this stage could be used as fiscal credit at the O&M stage. Similarly, this assumption was evaluated in the case study. In this way, Capex invested by private investors during the development stage for developing water and sanitation projects, particularly for improving the quality of wastewater discharges to rivers, could be transformed into cash benefits during the O&M stage. Therefore, the total benefits provided by this regulation can be calculated as follows.

$$Fiscal\ credit_i = (Taxable\ income_i)(20\%) \tag{14}$$

$$\sum_{i=x+k+1}^{n} (Taxable\ income_i)(20\%) \leq \sum_{i=1}^{x+k} Capex_i \tag{15}$$

Recently, the average involvement of equity investment and debt in Colombian water-sector projects, with more than 5000 users, was 67% and 33%, respectively [49]. This indicates that the water sector requires new strategies for increasing its financial resources, especially debt instruments. Additionally, the average weighted average cost of capital (WACC) in these projects was 12.76% [49]; this indicated that benefits could be obtained by achieving less expensive financial resources than debt, improving corporate value.

3.3. Operating and Maintenance Stage

Having modeled the evolution of the capital structure during the development stage, in the O&M stage, the model must incorporate the sustainable criteria into cash flows, particularly in free cash flow, debt cash flow, and equity cash flow. This project was carried out using financial engineering techniques as one of the main supports for PF schemes. In addition, it was structured as a PIPR project and based on the BOT (build, operate, and transfer) method for PPP projects. Accordingly, sponsors must create a SPV for developing infrastructure projects, and when the concession duration is over, they must transfer the assets (infrastructure projects) to the government. Therefore, the terminal value was not considered in the financial valuation process. In the Colombian case, according to PPP law 1508/2012, the maximum duration is 30 years, including extensions [44].

To begin the mathematical modeling of the O&M stage, this stage was divided into two parts: operational and financing. Figure 3, based on the cash flow waterfall, shows the first part with the main drivers for encouraging the involvement of private investors in the water sector, aiming at increasing regional coverage through sustainable infrastructure projects.

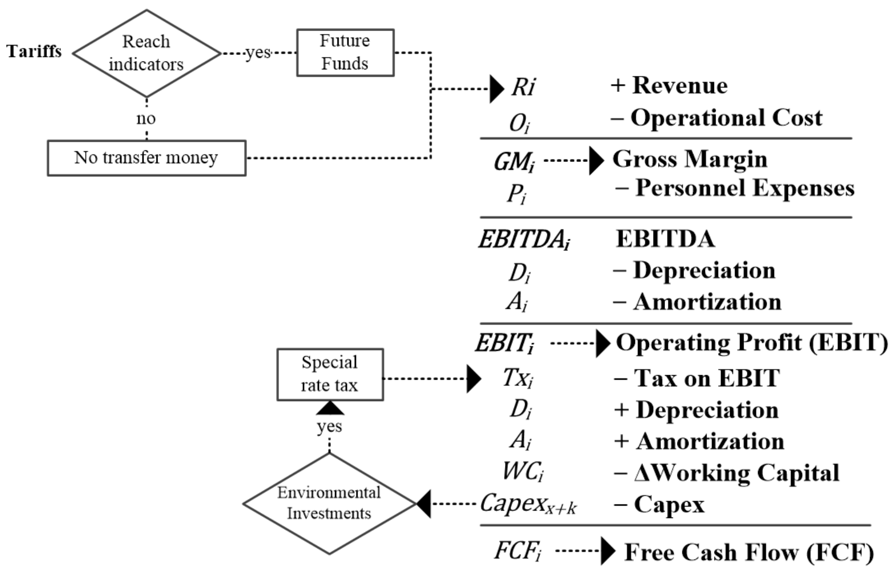


Figure 3. Operational section. Source: authors' own.

The main assumptions were presented below:

1. According to PPP law 1508/2012 [44], PIPR projects can obtain financial resources from the Colombian Government. These resources are called "Future Funds", and

are conditioned by their availability, service levels, quality standards, and service continuity. These funds may not exceed 30% of the contract's originally agreed value and are delivered only at the O&M stage. This scheme assumed that fee structure subsidies given to users were not part of the "Future Funds".

2. Private investors using legal entities would be able to take annual deductions from their taxable income for environmental control and improvement investments. This value cannot exceed 20% of taxable income.
3. Income tax can be established per section.

From a programming perspective, Algorithm 1 shows how the capital structure can be calculated at the O&M stage, which can occur when the criteria are achieved; therefore, the debt–equity conversion could be executed.

Algorithm 1. Capital Structure Programming. Source: author's, based on Table 1.

Conversion Debt-Equity = False
For *i* = 1 to n − 1
If Criteria$_i$ = Certify and Conversion Debt-Equity = False Then
  % Debt$_i$ = (Debt$_i$ − Mezzanine$_i$)/Asset$_i$
  % Equity$_i$ = (Equity$_i$ + Mezzanine$_i$)/Asset$_i$
  Conversion Debt-Equity = True
Else
  % Debt$_i$ = (Debt$_i$ − Amortization$_i$)/Asset$_i$
  % Equity$_i$ = Equity$_i$/Asset$_i$
End if
Next *i*

As mentioned above, the return expected by lenders could take the form of interest, given by the Kd_m interest rate, and in the case of changing debt per equity share, dividends or profits obtained by lenders selling their equity shares before the concession is over. In this last scenario, creating a primary and secondary financial market for assets indexed to infrastructure projects is mandatory. This enables private investors to have a diversified project portfolio and, therefore, manage trades of equity shares of different projects, generating liquidity in the capital market. Accordingly, it would be possible to build a new infrastructure by creating more eco-innovative mechanisms and developing financial instruments to encourage sustainable infrastructure [50]. In addition, financing should be more innovative and adapted to the SIS's needs [51].

This work suggests that if private investors finance projects using financial mechanisms indexed with sustainable criteria, the capital structure could change if goals and covenants related to sustainability criteria are accomplished and if an American-type option or warrant is exercised. In short, the conversion of outstanding debt per equity share would be sub-ordinated to sustainability criteria. In this way, this condition must be included in the deal.

This study did not intend to identify or propose a method for finding an optimal capital structure approach in infrastructure systems. On the contrary, this proposal intended to show how capital structure changes during the O&M stage. In this way, Figure 4 shows not only how operational, but also financial sections can be integrated into the capital structure when outstanding debt is transformed into equity shares.

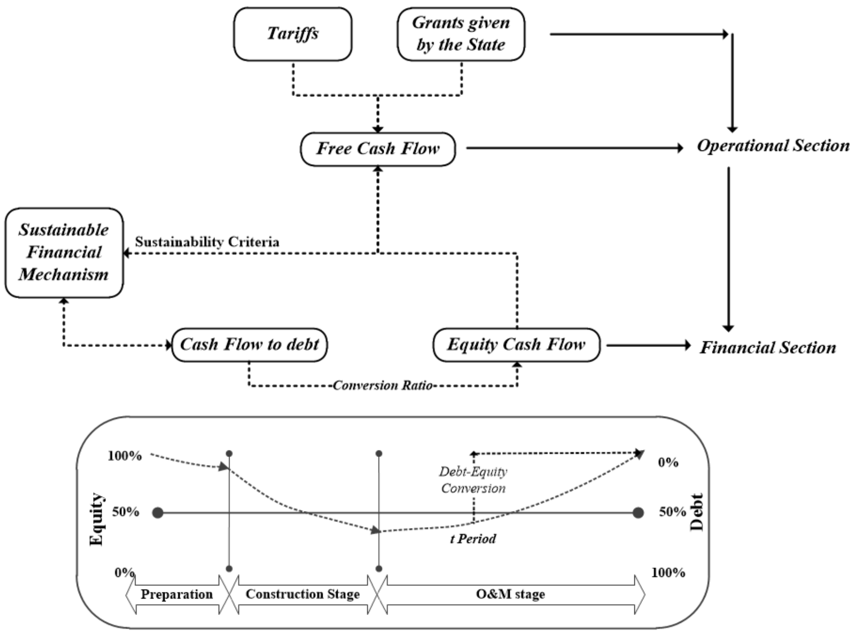


Figure 4. Operational and financial section. Source: authors' own.

3.4. Proposal for Validating Debt Pay Capacity

The importance of the control and monitoring mechanisms implemented by sponsors, lenders, and governments led to the use of indicators able to measure a project's capacity to pay for debt service and compliance with the infrastructure's quality and service levels. In practice, the primary mechanisms used by financial institutions are the debt service coverage ratio (DSCR) and the loan life coverage ratio (LLCR) [52], which measure the coverage of free cash flow (FCF) on debt services (interest plus repayment) during the credit period. Figure 5 shows how the indicators explained above are related. Table 2 indicates the DSCR and LLRC average for different sectors.

These indicators can help evaluate default situations. In this regard, [53] stated that the PF default event occurs when specific indicators related to debt service and project flows drop below a certain level. In project monitoring, an auditing SPV can be used to validate compliance with fundamental indicators or conditions of projects so that financial institutions can require the issuance of certificates [54].

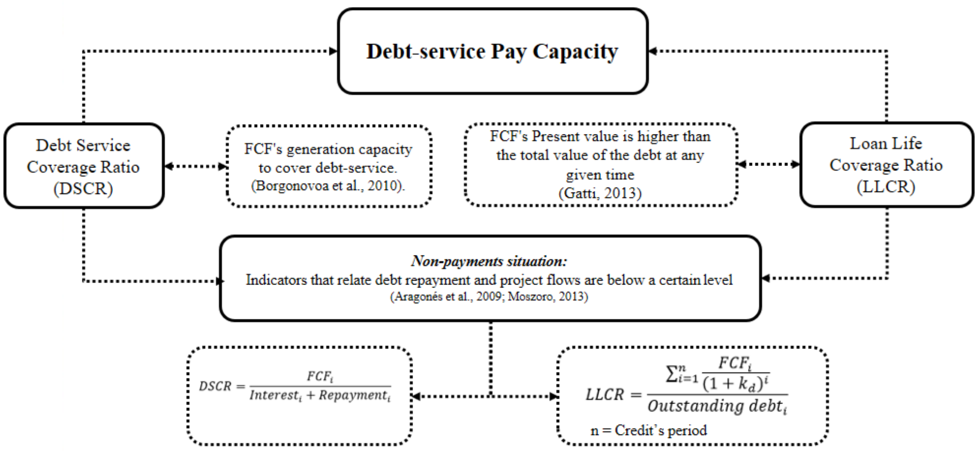


Figure 5. DCSR and LLCR as indicators of debt service capacity. Source: authors' own based on Aragonés et al. [53], Borgonovoa et al. [52], Gatti [55], and Moszoro [56].

Table 2. DSCR and LLRC average for sectors. Source: Gatti [55].

Sector	DSCR	LLRC
Power		
Merchant plants	2.00x–2.25x	2.25x–2.75x
With a tolling agreement	1.50x–1.70x	1.50x–1.80x
Regulated business	1.40x–1.45x	1.40x–1.45x
Transportation	1.35x–1.50x	1.40x–1.60x
Telecommunication	1.35x–1.50x	1.35x–1.50x
Water	1.20x–1.30x	1.30x–1.40x

A financial model's primary objective is to test the project's financial viability [46]. For that reason, considering that both indicators must be higher than one, both in a graphical way and as an extension to the DSCR and LLCR indicators, this proposal also contributed to the construction of a new method for monitoring debt-service capacity, as shown in Figure 6. Zone A indicates that the project does not have the debt service capacity to pay; therefore, the operating or capital structure would have to be reconsidered. Zone B shows that the project can service its debt during a specific calculated period; however, it would not generate enough future FCF to pay the debt service. In Zone C, current and future debt service payments can be conducted with the FCF. Zone C is the ideal zone for any project. Finally, in Zone D, the project cannot service its debt during a specific period; however, the project would generate enough future FCF to service its debt, unlike in Zone B.

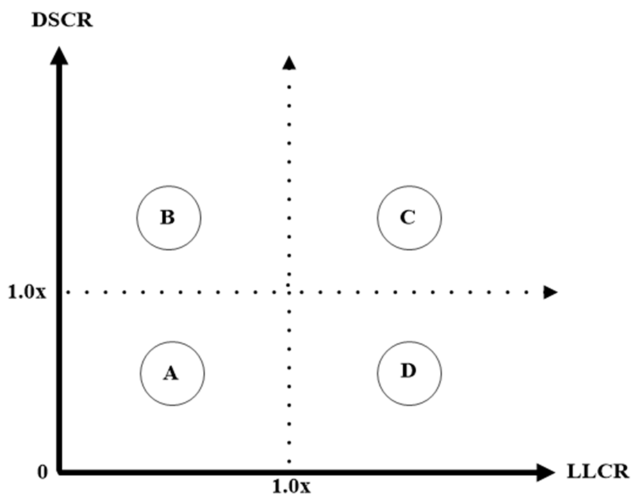


Figure 6. Proposal for validating debt service capacity. Source: authors' own.

Other indicators identified in the literature and used to analyze the financial viability of infrastructure projects included the adjusted net present value, modified internal rate of return, self-financing capacity, equity ratio in risk [57], decoupled net present value [58], and the project life coverage ratio [25–59].

3.5. Financing Sustainable Infrastructure Projects through Capital Markets

Promoting the implementation of innovative models, particularly in the social infrastructure sector (where coverage gaps are wide) would articulate the environmental variables related to sustainable development. As a result, supporting the Colombian capital market and investing in mitigating climate change has become the most important challenges in Latin America, particularly in Colombia.

Due to there being a historic window of opportunity to develop a sustainable financial system [60], a complete funding framework for SISs should be based on a clear understanding of the complementary roles of public and private funding and how the two of them can work together to achieve complex, long-term social objectives [61]. In this way, many public financial institutions work with private financing to close the viability gap for investors in green projects [62].

As a proposal for financing SISs, Figure 7 allows for the identification, under a systemic approach, of prominent participants in a sustainable financial framework. This proposal was based on PPP and PF schemes, and incorporated the Colombian capital market to raise sustainable financial recourses provided by special investors. Therefore, the primary objective of a sustainable financial framework should be to create value by implementing financial assets in ways that shape real wealth to support the long-term demand of a sustainable economy [60]. Consequently, a revision of the financial regulations would be required to remove constraints on sustainable infrastructure investments, especially by institutional investors such as pension funds and insurers, and to create a rollover mechanism for sustainable infrastructure assets through debt and equity markets [60]. In this way, creating a sustainable financial framework would be a great opportunity to defeat restrictions that avoid a complete recognition of environmental and social criteria in financial decision making.

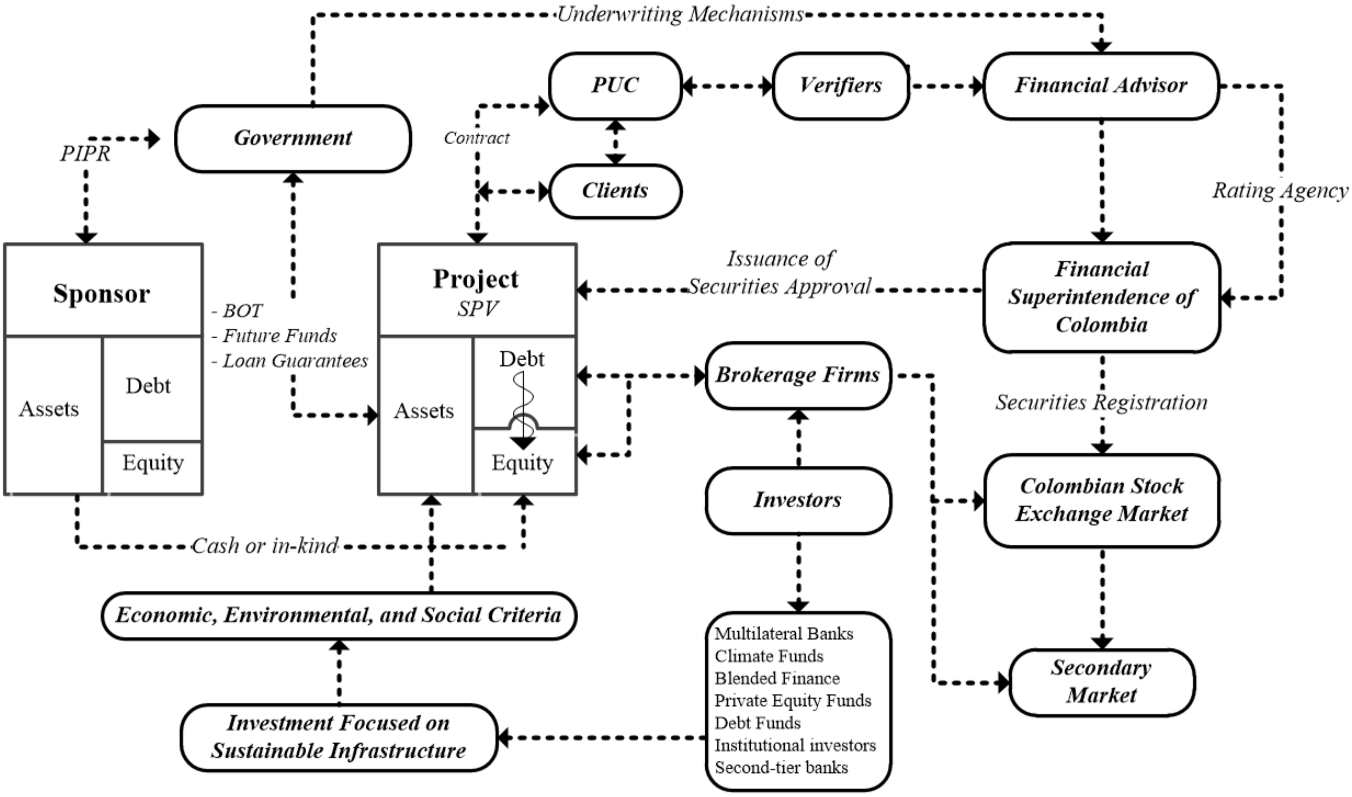


Figure 7. Proposal of a sustainable financial framework for financing SISs. Source: authors' own based on how the Colombian capital market works and the debt-for-equity conversion proposal developed in this study.

Additionally, the generation of new market rules leading to long-term investment can help reduce GHG (greenhouses gas) emissions by improving quality of life. This initiative mobilizes financial and technological resources, requiring PPP schemes that link players in the private sector, prompting them both to develop public infrastructures and to provide financial strategies aligned with sustainable interests.

In the Colombian case, Decree 1385/2015 allowed both pension funds and insurance companies to finance PPP projects [63]. Additionally, with the growth of infrastructure investments, specialized investors such as private equity funds are increasingly using mezzanine capital as a mechanism of investment in this area [64]. However, sustainability criteria are not completely considered in the financial decision-making process. According to [27], it is important to align the design of investment plans for this kind of investor with sustainability criteria as the essential first step.

In this framework, the sponsor must create a SPV, which is the investment vehicle. If the sponsor is not a public utility company (PUC), the SPV must establish a contract with one. The SPV has a BOT (build–operate–transfer) contract with the Colombian government, which could provide it with loan guarantees. The SPV is financed by both the sponsor (cash or in-kind) and the sustainable infrastructure market through sustainable mezzanine-type debt. There, investors with a high credit rating, such as institutional investors, could centralize funding requests into groups for financing SISs. A sustainable mezzanine-type debt could be, thus, structured as proposed in this work, which aims to incorporate social, environmental, and economic criteria into financing decisions. Thus, the project would help attract financial resources from private investors, such as pension funds, multilateral banks, and investment funds, dedicated to encouraging sustainable project development.

Since private investors invest to provide public utilities (a state responsibility), the Colombian government could provide financial guarantees that would make it cheaper than usual to raise financial resources. Although this argument could represent a good approach at the theoretical level, it would not work at the practical level.

The need for a new framework corresponds to a lack of research on new theories about innovations in financing strategic infrastructures and efforts to create new financing systems, as indicated in [65]. Moreover, the scientific literature on investment and financing that addresses climate change and sustainable development remains limited, and knowledge gaps are substantial [66]. In this context, sustainability plays a strategic role in infrastructure development. Sustainability is supported by the benefits of improving quality and coverage levels and encourages eco-friendly investments. However, developing a sustainable market project in Latin America would be a considerable challenge, particularly in Colombia [67,68].

This type of development requires increasing current levels of investment, boosting infrastructure improvements, and prioritizing the implementation of financing mechanisms related to climate change and, thus, sustainable development [67]. Therefore, a financing mechanism is fundamental to the success of an investment connecting the creation of infrastructure and economic development with sustainable development. Indeed, much of the required economic development and infrastructure financing can be found in developing countries [69]. Thus, for economic growth derived from SIS investments in Colombia, the government, the private sector, the capital market, and the research community must actively work together to establish and promote a new behavioral sustainable development model.

Therefore, creating a new business model for developing SISs would provide an opportunity to establish a market for climate derivatives. Colombia does not have an organized market or over-the-counter (OTC) derivatives related to the environment [70]. Climate change represents a development challenge; therefore, integrating sustainability criteria into generating infrastructure projects should begin with planning and integrating these elements [71].

4. Case Study

To apply the methodological proposal, the wastewater treatment plant "Aguas Claras" project was used as a case study. This project was located in the municipality of Bello, Antioquia, and was managed by Aguas Nacionales. This was a subsidiary company of Empresas Públicas de Medellín (EPM). EPM is one of the largest utility companies in Colombia. It is Colombia's largest secondary-type treatment plant. It is operated on a 45-hectare lot in Bello, treating wastewater from both Bello and Medellín and removing more than 80 percent of pollution. To stabilize the sludge, Aguas Claras had six bio-digesters with a capacity of 8700 cubic meters.

This megaproject conducts the wastewater of the municipalities of Medellín and Bello to the site; wastewater receives secondary treatment through activated sludge before being discharged into the Medellín River. The plant has a treatment capacity of 5 m^3/s and processes more than 70% of the wastewater for a total coverage of 95%. This percentage should be added to the San Fernando wastewater treatment plant, which is currently in operation. Aguas Claras is predicted to be three times larger in infrastructure and treatment capacity than the San Fernando plant.

These facilities are expected to receive 120 tons of organic matter from the wastewater produced daily by industries, commerce, and housing, with material exposed to biological, chemical, and physical processes, and then returned to the Medellín River. The goal was to cause the river to exceed the internationally accepted dissolved oxygen levels, indicating decontamination. Thus, by reducing the organic load, the river would increase its dissolved oxygen content to a minimum of 5 mg/L. This result would comply with the requirements of the environmental authority, Area Metropolitana del Valle de Aburrá. The wastewater would be transported through an interceptor 8 kilometers long and 2.4 m wide. In the future, this project is expected to serve urban developments and recreational spaces, such as the cities' Christmas lighting and parks [72].

4.1. Investment Plan

The investment plan required COP 1.47 billion and was executed for six years at the development stage, which ran from 2012 to 2017. For this project, the Inter-American Development Bank granted a USD 450 million credit to EPM (in turn, EPM provided its subsidiary Aguas Nacionales with the money). To financially evaluate the project and the proposal's implementation, the capitalized funds were the equity investments, as confirmed by [73]. Figure 8 shows the planned investment curve. This amount represented the value of the contract signed with the building company and accounted for inflation without the construction interests.

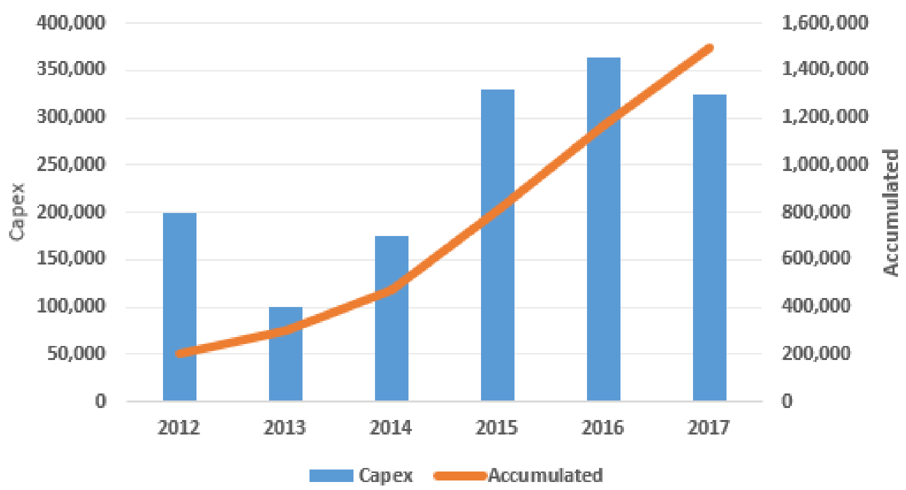


Figure 8. Planned investment curve of the wastewater treatment plant "Aguas Claras". Source: authors' own based on data from Aguas Nacionales S.A. E.S.P. Figures in COP million.

4.2. Development Stage

To validate the mathematical modeling of the capital structure's evolution, the following information was considered, as shown in Table 3.

Table 3. Input values for modeling the capital structure. Source: authors' own. Figures in COP million.

Item	Development Stage					
	2012	**2013**	**2014**	**2015**	**2016**	**2017**
Investment –> $1,493,000	200,000	100,000	175,335	330,000	364,000	323,665
Sustainability Factor	5%	5%	5%	5%	5%	5%
Accumulated Investment (9)	200,000	300,000	475,335	805,335	1,169,335	1,493,000
Capital Structure						
% Debt Mezzanine	0.0%	16.7%	36.6%	50.6%	57.0%	60.1%
% Equity	100.0%	83.3%	63.4%	49.4%	43.0%	39.9%
Interest Rate –> kd (AE)	8.7%	7.1%	7.5%	8.4%	10.9%	9.0%
IBR (AE)	5.01%	3.39%	3.84%	4.69%	7.10%	5.30%
Spread MV	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%

Assumptions:

- Planned investment curve: data based on Aguas Nacionales S.A. E.S.P.
- According to Egler and Frazao [14], the sustainability factor could be approximately 5%.
- Capital structure per period: Although the project was 100% funded by own resources, to apply the methodological proposal based on primary information, it was considered that in the event of acquiring debt, the capital structure per period would behave as presented in Table 4. The debt funds would be a sustainable financial mechanism in COP issued by the SPV.
- The interest rate: Given that the Colombian capital market (and the Latin American one) has little experience in financing sustainable development, the last green bonds emission interest rate (issued by Bancolombia S.A. in December 2016) was considered as referent; it was equal to an IBR + 2.2% at seven years (the IBR is the banking reference indicator in Colombia). This was the first time that a Latin American bank issued this type of financial mechanism [74]. Accordingly, given the project's duration and characteristics, a 3.5% spread was considered.
- IBR values were obtained from the Bank of the Republic of Colombia and Bancolombia, and projected by the authors.
- Cash flows were projected in current prices.

Table 4. Capital structure by period. Source: authors' own.

Capex	2012	2013	2014	2015	2016	2017
Debt Mezzanine (3)	0	52,500	131,635	253,370	300,882	284,561
Equity (1)	210,000	52,500	56,415	108,587	128,950	121,955
Total Capex (7)	210,000	105,000	188,049	361,957	429,832	406,516
Accumulated						
Debt Mezzanine (3)	0	52,500	184,135	437,504	738,387	1,022,948
Equity (1)	210,000	262,500	318,915	427,502	556,451	678,406
Total Capex (13)	210,000	315,000	503,049	865,006	1,294,838	1,701,354
% Debt Mezzanine (11)	0.0%	16.7%	36.6%	50.6%	57.0%	60.1%
% Equity (10)	100.0%	83.3%	63.4%	49.4%	43.0%	39.9%
Total (6)	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Interest Rate –> kd (AE) (12)		7.1%	7.4%	8.0%	9.2%	9.1%

Table 4 shows the last table's values mathematically modeled according to the proposal developed. The equations were developed in Table 1 and shown in parenthesis.

As mentioned above, it was important to include project funding strategies that provided profit to both public and private parties. Therefore, special characteristics had to be considered in this conceptual framework. This framework included a special focus on the relation among different cash flows, such as the free cash flow (FCF), debt cash flow (DCF), and equity cash flow (ECF), and was mentioned several times by [75–77] because of its importance in the financial world, especially in the areas of project investment and firm valuation. Equation (16) and Figure 9 show the relationships among the different cash flows and return rates. Additionally, Table 5 shows the projected cash flows as well as the equity internal rate of returns (equity IRR). As you can see, when the fiscal benefits were included, the equity IRR was higher.

$$\text{Free Cash Flow} + \text{Tax Shield} = \text{Debt Cash Flow} + \text{Equity Cash Flow} = \text{Capital Cash Flow} \quad (16)$$

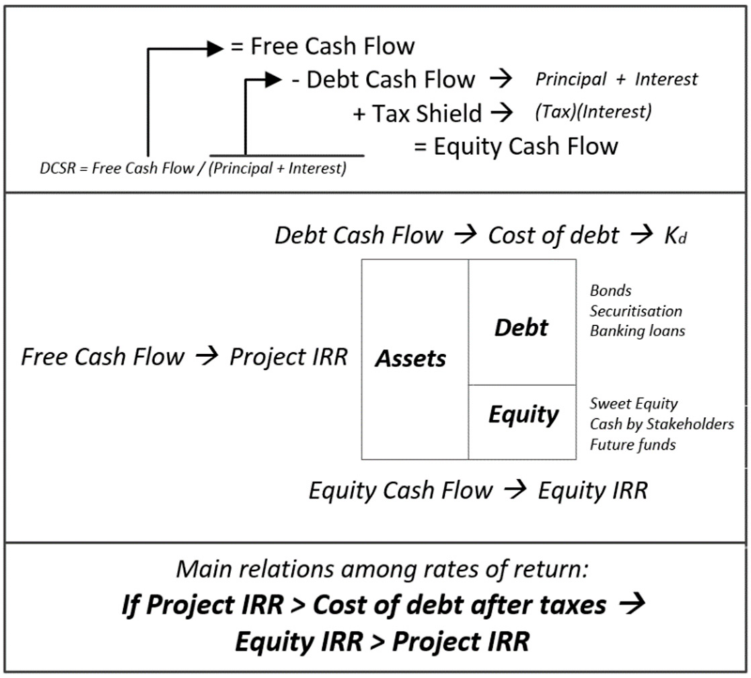


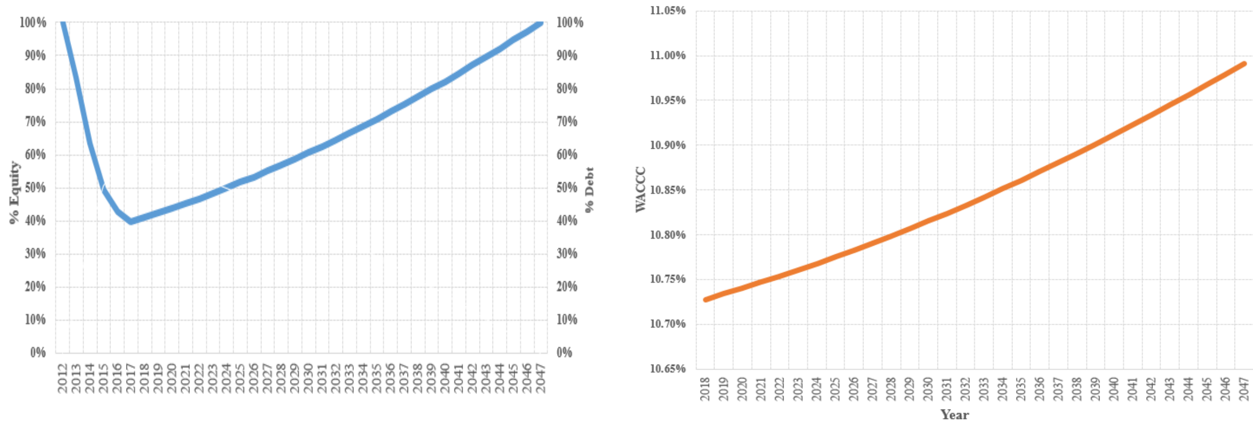
Figure 9. Relation among the different cash flows. Source: authors' own.

Table 5. Projected cash flows. Source: authors' elaboration. Figures in COP million.

Item/Year	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
(+) EBIT	208,631	212,327	220,666	227,953	235,895	243,791	251,650	260,197	268,739	277,547
(-) Operating Taxes		10,432	10,616	11,033	11,398	11,795	12,190	12,583	13,010	13,437
(=) NOPLAT	208,631	201,895	210,050	216,920	224,497	231,996	239,461	247,614	255,729	264,110
(+) Depreciation	26,713	26,713	26,713	26,713	26,713	26,713	26,713	26,713	26,713	26,713
(=) Gross Cash Flow	235,344	228,608	236,763	243,633	251,210	258,709	266,174	274,327	282,443	290,823
(-) Net Working Capital	25,174	7091	1303	1119	1196	1205	1232	1221	1226	1264
(-) Capex –> $1,567,650										
Free Cash Flow –> 13.10%	210,170	221,517	235,460	242,514	250,014	257,504	264,941	273,106	281,217	289,559
(-) Interest	92,889	89,792	86,696	83,600	80,503	77,407	74,311	71,215	68,118	65,022
(-) Principal	34,098	34,098	34,098	34,098	34,098	34,098	34,098	34,098	34,098	34,098
(+) Tax Shield		4644	4490	4335	4180	4025	3870	3716	3561	3406
(=) Outstanding Debt	988,850	954,751	920,653	886,555	852,457	818,358	784,260	750,162	716,063	681,965
Equity Cash Flow 15.56%	83,183	102,271	119,156	129,151	139,592	150,024	160,403	171,509	182,561	193,845

	Equity IRR	Project IRR	Cost of Debt
Including	15.56%	13.10%	9.08%
Excluding	14.19%	11.71%	9.08%

Figure 10a,b show the evolution of the capital structure and WACC during the project's life-cycle.



(**a**) Capital structure evolution (**b**) WACC evolution

Figure 10. Capital structure and WACC evolution, respectively.

The increasing development of the infrastructure requires not only the inclusion of new actors and the mobilization of more financial resources, but also the linking of environmental and social criteria to the structuring of projects, especially in the financing process. Consequently, concerns about constructing sustainable infrastructure resilient to climate change must transform how public–private sector policies are determined. Such policies must lead to redirecting investment and financing to market mechanisms that involve the generation of eco-innovative financial products with elements that promote sustainable development. Figure 11 shows the proposal's application for validating the debt service capacity. Zone A (in red) was highlighted in order to indicate when the project cannot pay the debt service. In any other case, the project could pay the debt service.

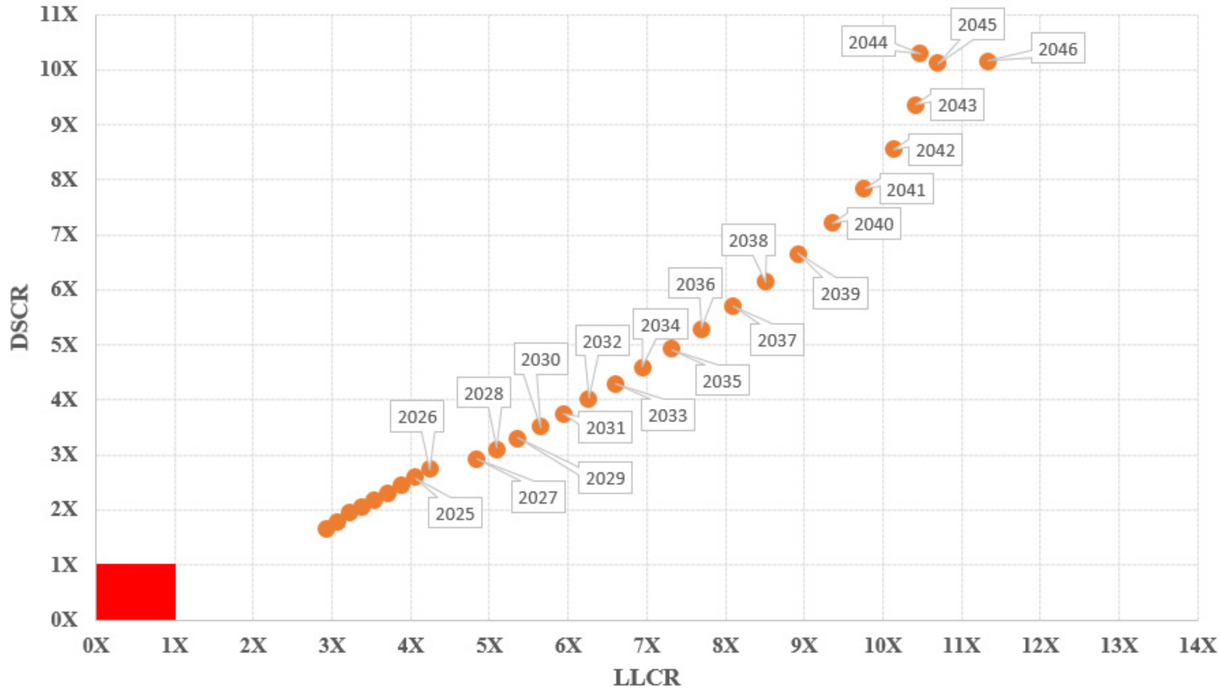


Figure 11. Application of the proposal for validating debt service capacity. Source: authors' own.

5. Conclusions

The increasing development of infrastructure requires not only the inclusion of new actors and the mobilization of more financial resources, but also the linking of environmental and social criteria to the structuring of projects, especially in the financing process. Consequently, concerns about constructing sustainable infrastructure resilient to climate change must transform how public–private sector policies are determined. Such policies must lead to redirecting investment and financing to market mechanisms that involve the generation of eco-innovative financial products with elements that promote sustainable development.

To develop an infrastructure that minimizes greenhouse gas emissions without compromising financial viability, specific financial mechanisms must be developed. This goal is supported by the SDGs, which encourage research and development that contribute to and promote sustainable development through new mechanisms and instruments [78]. Thus, Colombia is responding to the global challenge to reduce GHG emissions through a new way of developing infrastructure that should improve coverage in regions lacking infrastructure systems. If the world wants to achieve the SDGs, adequate infrastructure development is part of the answer. Therefore, a standard and clear model is crucial. Such a model would benefit project developers, lenders, and public sector institutions [47].

This research showed that factors such as financing and investment should be directly related to financial, environmental, and social criteria, allowing decision makers to analyze such factors holistically and obtain information about each process, particularly financing. In addition, market-led mechanisms, such as benefits, taxes, grace periods, debt forgiveness, duty-free machinery, and new regulations, could drive an infrastructure market based on sustainable criteria and, thus, the creation of a primary and secondary market of stocks and debts issued by sponsors or investment vehicles (SPVs). Such actions would allow the expansion of investment options through the Integrated Latin American Market (MILA). Implementing capital markets based on sustainable investments could eventually influence other sectors, such as transportation, energy, and telecommunications.

Further research on sustainable finance should involve the flexibility assessment of the creation of sustainable projects as a strategic tool for encouraging private investment through PPP schemes, in which private investors and public sector development projects consider sustainability, accessibility, and reliability in the provision of SISs. These analyses should account for the sensitivity and dynamics of the available financial resources. For this proposal, the real options theory would capture aspects related to a project's capacity that relate to sustainable financial resources. Additionally, an interesting research topic would be analyzing cost overruns/underperformance of mega-projects, which have sustainable impacts. For example, what could happen to a sub-ordination arrangement if a project is over budget or revenues are less than projected? Overruns in megaprojects were widely studied in refs. [79,80]; in this way, further research should also allow to widen the frontier of knowledge on this issue.

As a theoretical contribution, this study developed a sustainable financial framework, which included a mathematical model that allowed for an understanding of how capital structure changes during a project's life-cycle, considering a financial mechanism subordinated to sustainability criteria. This paper contributes to the project management and infrastructure literature by exploring the main financial topics that practitioners and academics involved in project assessment must consider when developing SISs

Finally, this proposal contributes to the state-of-the-art in SIS financing decisions. In addition, given the need to satisfy the requirements of SDGs, the relationships between sustainability, project management, and infrastructure are an emerging field for contributions of innovative proposals that would allow the achievement of those programs' goals. In this regard, there is a great deal of room for a better understanding of the relationship between financial market development and sustainable development.

Despite the contributions of this work, limitations should be acknowledged. Although the framework was designed for the Colombian context, it could also be used in other countries considering the application of specific tax benefits, which was the major limitation of this research. Additionally, in order to compare the effects and the performances of initial investment plans with those involved in the newly proposed methodology and model, it was not possible to obtain real data. Moreover, in Colombia, the convertible financial mechanism market is not fully developed. Therefore, bringing this proposal to real scenarios may take time. Consequently, this proposal may also be a further step in advancing toward developing a sustainable financial framework of convertible mechanisms that can be applied in a real-world context. In addition, it is worth mentioning that this paper was derived from the Doctoral dissertation of Juan David González-Ruiz [81].

Author Contributions: J.D.G.-R. conceived, designed, analyzed, and wrote the manuscript. S.B.-B. and A.P. analyzed the literature. Any assumptions, conclusions, findings, or recommendations expressed in this paper are those of the authors and do not reflect the views of Aguas Nacionales E.S.P. S.A. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: The study data are available on special request from the corresponding author.

Acknowledgments: The authors thank the anonymous reviewers for providing constructive comments and suggestions.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Esty, B. Why Study Large Projects? An Introduction to Research on Project Finance. *Eur. Financ. Manag.* **2004**, *10*, 213–224. [CrossRef]
2. Chen, B.; Mao, C.-K.; Hu, J.-L. The optimal debt ratio of public–private partnership projects. *Int. J. Constr. Manag.* **2015**, *15*, 239–253. [CrossRef]
3. Gonzalez-Ruiz, J.D.; Arboleda, A.; Botero, S.; Rojo, J. Investment valuation model for sustainable infrastructure systems: Mezzanine debt for water projects. *Eng. Constr. Archit. Manag.* **2019**, *26*, 850–884. [CrossRef]
4. Switzer, F.S., III; Ligato, J.; Piratla, K. Interdependent Infrastructures as a Multiteam System: Enhancing Resilience. *J. Infrastruct. Syst.* **2022**, *28*, 04022026. [CrossRef]
5. Saidi, S.; Kattan, L.; Jayasinghe, P.; Hettiaratchi, P.; Taron, J. Integrated infrastructure systems—A review. *Sustain. Cities Soc.* **2018**, *36*, 1–11. [CrossRef]
6. Vatenmacher, M.; Svoray, T.; Tsesarsky, M.; Isaac, S. Performance-driven vulnerability analysis of infrastructure systems. *Int. J. Disaster Risk Reduct.* **2022**, *76*, 103031. [CrossRef]
7. Brichetti, J.P.; Mastronardi, L.; Rivas, M.E.; Serebrisky, T.; Solís, B. *The Infrastructure Gap in Latin America and the Caribbean: Investment Needed through 2030 to Meet the Sustainable Development Goals*; Inter-American Development Bank: Washington, DC, USA, 2021. [CrossRef]
8. Akintoye, A.; Beck, M. *Policy, Finance & Management for Public-Private Partnerships*, 1st ed.; Wiley-Blackwell: Oxford, UK, 2009.
9. Esty, B. Big Deals: Financing Large-Scale Investments. Working Knowledge: A Report on Research at Harvard Business School. 2000. Available online: http://hbswk.hbs.edu/item/1690.html (accessed on 16 July 2015).
10. Kwak, Y.H.; Chih, Y.; Ibbs, C.W. Towards a Comprehensive Understanding of Public Private Partnerships for Infrastructure Development. *Calif. Manage. Rev.* **2009**, *51*, 51–78. [CrossRef]
11. Wang, X.; Wang, B.; Xu, Y.; Shi, L. A chance constrained programming method to determine optimal capital structure for privatized infrastructure. *Constr. Manag. Econ.* **2021**, *39*, 579–594. [CrossRef]
12. Soleymani, H.; Ravanshadnia, M.; Montazer, M. Transportation Infrastructure Project Financing; Highways Capital Structure Design Techniques. *Shock Vib.* **2021**, *2021*, 4988577. [CrossRef]
13. Cai, J.; Li, S.; Cai, H. Empirical Analysis of Capital Structure Determinants in Infrastructure Projects under Public–Private Partnerships. *J. Constr. Eng. Manag.* **2019**, *145*, 04019032. [CrossRef]
14. Soleymani, H.; Ravanshadnia, M.; Montazer, M. An Innovative Conceptual Model to Structure Financing Package of Infrastructure Projects. *Shock Vib.* **2021**, *2021*, 6711408. [CrossRef]
15. Pinto, J.M.; Coutinho dos Santos, M.J.; Verga Matos, P. Governance of PPP Infrastructure Projects: A Variable Capital Structure Valuation Approach. *SSRN Electron. J.* **2022**, 1–25. [CrossRef]
16. Chen, C.; Bartle, J.R. The Challenges and Opportunities of Financing Infrastructure. In *Innovative Infrastructure Finance*; Palgrave Macmillan: Cham, Switzerland, 2022; pp. 1–18. [CrossRef]

17. Regular Funding and Financing Infrastructure: The Joint-Use of Public and Private Finance*—Web of Science Core Collection. Available online: https://www-webofscience-com.ezproxy.unal.edu.co/wos/woscc/full-record/WOS:000633044400005 (accessed on 9 August 2022).
18. Pranata, N.; Firdaus, N.; Mychelisda, E.; Hidayatina, A. Crowdfunding for Infrastructure Project Financing: Lessons Learned for Asian Countries. In *Big Data, Green Growth, and Technology Disruption in Asian Companies and Societes*; IGI Global: Hershey, PA, USA, 2022; pp. 276–300.
19. Li, Y.; Xiang, P.; You, K.; Guo, J.; Liu, Z.; Ren, H. Identifying the Key Risk Factors of Mega Infrastructure Projects from an Extended Sustainable Development Perspective. *Int. J. Environ. Res. Public Health* **2021**, *18*, 7515. [CrossRef]
20. Bakhtawar, B.; Thaheem, M.J.; Arshad, H.; Tariq, S.; MAzher, K.M.; Zayed, T.; Akhtar, N. A Sustainability-Based Risk Assessment for P3 Projects Using a Simulation Approach. *Sustainability* **2022**, *14*, 344. [CrossRef]
21. Li, H.; Li, J. Risk Governance and Sustainability: A Scientometric Analysis and Literature Review. *Sustainability* **2021**, *13*, 12015. [CrossRef]
22. Ma, H.; Zeng, S.; Lin, H.; Zeng, R. Impact of Public Sector on Sustainability of Public–Private Partnership Projects. *J. Constr. Eng. Manag.* **2019**, *146*, 04019104. [CrossRef]
23. Mao, X.; Gan, J.; Zhao, X. Debt risk evaluation of toll freeways in Mainland China using the grey approach. *Sustainability* **2019**, *11*, 1430. [CrossRef]
24. Kleimeier, S. Limited and Norecourse. Project Finance: A Survey. *Estud. Adm.* **1995**, *2*, 27–67. [CrossRef]
25. Grimsey, D.; Lewis, M.K. Evaluating the risks of public private partnerships for infrastructure projects. *Int. J. Proj. Manag.* **2002**, *20*, 107–118. [CrossRef]
26. Lee, C.W.; Zhong, J. Financing and risk management of renewable energy projects with a hybrid bond. *Renew. Energy* **2015**, *75*, 779–787. [CrossRef]
27. Shrestha, A.; Chan, T.-K.; Aibinu, A.A.; Chen, C.; Martek, I. Risk Allocation Inefficiencies in Chinese PPP Water Projects. *J. Constr. Eng. Manag.* **2018**, *144*, 04018013. [CrossRef]
28. Leader, S. *Risk Management, Project Finance and Rights-Based Development*, 1st ed.; Cambridge University Press: Cambridge, UK, 2011.
29. Donkor, E.A.; Duffey, M. Optimal Capital Structure and Financial Risk of Project Finance Investments: A Simulation Optimization Model with Chance Constraints. *Eng. Econ.* **2013**, *58*, 19–34. [CrossRef]
30. Zhao, J.; Su, G.; Li, G. Financing China's unprecedented infrastructure boom: The evolution of capital structure from 1978 to 2015. *Public Money Manag.* **2019**, *39*, 581–589. [CrossRef]
31. Zhang, X. Financial Viability Analysis and Capital Structure Optimization in Privatized Public Infrastructure Projects. *J. Constr. Eng. Manag.* **2005**, *131*, 656–668. [CrossRef]
32. Kukah, A.S.K.; Owusu-Manu, D.-G.; Badu, E.; Edwards, D.J. Exploring influencing factors for private sector participation in PPP power projects: Case of Ghana. *J. Facil. Manag.* 2022; *ahead-of-print*. [CrossRef]
33. Nijs, L. *Mezzanine Financing—Tools, Applications and Total Performance*; Wiley Finance: West Sussex, UK, 2014.
34. Copeland, T.E.; Antikarov, V. *Real Options: A Practitioner's Guide*, 1st ed.; Texere: Knutsford, UK, 2001; Volume 1.
35. Bertera, B. Successful Sustainable Infrastructure. Washington, 2015. Available online: http://csengineermag.com/article/successful-sustainable-infrastructure/ (accessed on 12 February 2016).
36. Fatemi, A.M.; Fooladi, I.J. Sustainable finance: A new paradigm. *Glob. Financ. J.* **2013**, *24*, 101–113. [CrossRef]
37. Bolton, B. *Sustainable Financial Invesment. Maximizing Corporate Profits and Long-Term Economic Value Creation*, 1st ed.; Palgrave Macmillan: New York, NY, USA, 2015.
38. Martens, M.L.; Carvalho, M.M. Key factors of sustainability in project management context: A survey exploring the project managers' perspective. *Int. J. Proj. Manag.* **2016**, *35*, 1084–1102. [CrossRef]
39. Sundararajan, S.K.; Tseng, C.-L. Managing Project Performance Risks under Uncertainty: Using a Dynamic Capital Structure Approach in Infrastructure Project Financing. *J. Constr. Eng. Manag.* **2017**, *143*, 04017046. [CrossRef]
40. Demirel, H.C.; Leendertse, W.; Volker, L. Mechanisms for protecting returns on private investments in public infrastructure projects. *Int. J. Proj. Manag.* **2022**, *40*, 155–166. [CrossRef]
41. Gebhardt, J.; Ziegler, R.C.; Mourant, A. Water infrastructure financing: The experience of the United States. *Financ. Investig. Water Secur.* **2022**, 263–293. [CrossRef]
42. Hernández, R.; Fernández, C.; Baptista, M.D.P. *Metodología de la Investigación*, 5th ed.; McGraw Hill: Mexico City, Mexico, 2010.
43. Corbetta, P. *Metodología y Técnicas de Investigación Social*; McGraw Hill: Madrid, Spain, 2007.
44. Congreso de Colombia. *Ley 1508 de 2012. Por la cual se Establece el Regime n Jurídico de las Asociaciones Público-Privadas. Diario Oficial*; Congreso de Colombia: Bogotá, Colombia, 2012; p. 14.
45. Departamento Nacional de Planeación—DNP. Asociaciones Público Privadas—APP—en Infraestructura en Colombia. Presentaciones APPs. p. 86. 2016. Available online: https://www.dnp.gov.co/programas/participación-privada-y-en-proyectos-de-infraestructura/asociaciones-publico-privadas/Paginas/presentaciones.aspx (accessed on 15 December 2016).
46. Kurniawan, F.; Mudjanarko, S.W.; Ogunlana, S. Best practice for financial models of PPP projects. *Procedia Eng.* **2015**, *125*, 124–132. [CrossRef]

47. Egler, H.-P.; Frazao, R. Sustainable Infrastructure and Finance—How to Contribute to a Sustainable Future. 2016. Available online: http://unepinquiry.org/wp-content/uploads/2016/06/Sustainable_Infrastructure_and_Finance.pdf (accessed on 10 December 2017).
48. González-Ruiz, J.D.; Botero-Botero, S.; Duque-Grisales, E. Financial eco-innovation as a mechanism for fostering the development of sustainable infrastructure systems. *Sustainability* **2018**, *10*, 4463. [CrossRef]
49. Comisión de Regulación de Agua Potable y Saneamiento—CRA. Definición de la Tasa de Descuento Aplicable a los Servicios Públicos Domiciliarios de Acueducto y Alcantarillado, Bogotá D.C. 2014. Available online: http://cra.gov.co/apc-aa-files/30653965346361386366633062643033/4.-documento-de-trabajo-tasa-de-descuento_1.pdf (accessed on 10 March 2015).
50. World Bank. *Green Infrastructure Finance: Framework Report*; World Bank: Washington, DC, USA, 2012; Available online: http://www.iadb.org/intal/intalcdi/pe/2012/10331.pdf (accessed on 7 March 2014).
51. Bielenberg, A.; Kerlin, M.; Oppenheim, J.; Roberts, M. *Financing Change: How to Mobilize Private Sector Financing for Sustainable Infrastructure*; Mckinsey & Company: Washington, DC, USA, 2016; Available online: http://newclimateeconomy.report/2015/wp-content/uploads/sites/3/2016/01/Financing_change_How_to_mobilize_private-sector_financing_for_sustainable-_infrastructure.pdf (accessed on 10 June 2017).
52. Borgonovoa, E.; Gatti, S.; Peccati, L. What drives value creation in investment projects? An application of sensitivity analysis to project finance transactions. *Eur. J. Oper. Res.* **2010**, *205*, 227–236. [CrossRef]
53. Aragonés, J.; Blanco, C.; Iniesta, F. Modelización del riesgo de crédito en proyectos de infraestructura. *Innovar.* **2009**, *19*, 65–80.
54. López, J.; García, P. *Finanzas en el Mundo Corporativo*; McGraw Hill: Madrid, Spain, 2005.
55. Gatti, S. *Project Finance in Theory and Practice: Designing, Structuring, and Financing Private and Public Projects*, 2nd ed.; Elsevier: London, UK, 2013.
56. Moszoro, M. *Project Finance: Financiación de un Parque Eólico. Caso de Estudio*; IESE Publising: Barcelona, Spain, 2013.
57. Iyer, K.; Sagheer, M. Optimization of Bid-Winning Potential and Capital Structure for Build-Operate-Transfer Road Projects in India. *J. Manag. Eng.* **2012**, *28*, 104–113. [CrossRef]
58. Espinoza, D.; Morris, J. Decoupled NPV: A simple, improved method to value infrastructure investments. *Constr. Manag. Econ.* **2013**, *31*, 471–496. [CrossRef]
59. Konstantin, P.; Konstantin, M. *Financial and Economic Analysis of Projects*, 1st ed.; Springer: London, UK, 2018; Volume 1.
60. UNEP. The Financial System We Need—Aligning the Financial System with Sustainable Development. 2015. Available online: https://wedocs.unep.org/bitstream/handle/20.500.11822/9862/-The_Financial_System_We_Need_Aligning_the_Financial_System_with_Sustainable_Development-2015The_Financial_System_We_Need_EN.pdf.pdf (accessed on 15 July 2016).
61. Schmidt-Traub, G.; Sachs, J. Financing Sustainable Development: Implementing the SDGs through Effective Investment Strategies and Partnerships, Washington, 2015. Available online: http://unsdsn.org/wp-content/uploads/2015/04/150619-SDSN-Financing-Sustainable-Development-Paper-FINAL-02.pdf (accessed on 15 July 2016).
62. World Economic Forum. Blended Finance Vol. 1: A Primer for Development Finance and Philanthropic Funders an Overview of the Strategic Use of Development fi Nance and Philanthropic Funds to Mobilize Private Capital for Development. 2015. Available online: https://www3.weforum.org/docs/WEF_Blended_Finance_A_Primer_Development_Finance_Philanthropic_Funders.pdf (accessed on 15 July 2016).
63. Ministerio de Hacienda y Credito Público de Colombia. *Decreto 1385 de 2015*; Ministerio de Hacienda y Credito Público: Bogotá, Colombia, 2015; p. 8.
64. Dong, F.; Chiara, N.; Kokkaew, N.; Wu, J. Stochastic optimization of Capital Structure in Privately Funded Infrastructure Projects. *J. Priv. Equity* **2011**, *15*, 36–47. [CrossRef]
65. Mostafavi, A.; Abraham, D.M.; Sinfield, J.V. Innovation in Infrastructure Project Finance: A Typology for Conceptualization. *Int. J. Innov. Sci.* **2014**, *6*, 127–144. [CrossRef]
66. Gouldson, A.; Kerr, N.; Millward-Hopkins, J.; Freeman, M.C.; Topi, C.; Sullivan, R. Innovative financing models for low carbon transitions: Exploring the case for revolving funds for domestic energy efficiency programmes. *Energy Policy* **2015**, *86*, 739–748. [CrossRef]
67. Barbero, J.; Forteza, J.H.; Skerk, C.; Meija, A.; Katz, R.; Garcia, R.; Givogri, P.; Lleres, G.; Kohon, J.; Rodriguez, V.; et al. *IDEAL 2014. La Infraestructura en el Desarrollo de América Latina (Main Document)*; CAF: Bogota, Colombia, 2015; Available online: http://scioteca.caf.com/handle/123456789/746 (accessed on 15 July 2016).
68. González-Ruiz, J.D.; Arboleda, C.A.; Botero, S. Social Infrastructure Development: The case for Private Participation in Potable Water Supply in Colombia. *PM World J.* **2015**, *IV*, 1–15.
69. Inter-American Development Bank and Mercer. *Building a Bridge to Sustainable Infrastructure—Mapping the Global Initiatives That are Paving Way*; Inter-American Development Bank and Mercer: Washington, DC, USA, 2016.
70. Hernández, J.M. *Contratos Financieros Derivados del Clima como Estrategia de Cobertura en Colombia. Aplicación a una central de Generación Hidroeléctrica"*; Universidad Nacional de Colombia: Bogotá, Colombia, 2013.
71. Serebrisky, T. *Infraestructura Sostenible para la competitividad y el Crecimiento Inclusivo*; Banco Interamericano de Desarrollo: Washington, DC, USA, 2014.
72. Aguas Nacionales Epm S.a. E.s.p. *Informe de Sostenibilidad 2015*; Aguas Nacionales Epm S.a. E.s.p.: Medellín, Colombia, 2015.

73. Empresas Públicas de Medellín. "Planta de Tratamiento de Aguas Residuales Bello Comenzara a Operar en 2015"; Boletines Estamos Ahí. 2016. Available online: http://www.epm.com.co/site/Home/Saladeprensa/BoletinesEstamosAhi/PlantadetratamientodeaguasresidualesBelloco.aspx (accessed on 13 November 2016).
74. Bancolombia. "Bonos Verdes Grupo Bancolombia," Información Corporativa—Sostenibilidad. 2016. Available online: http://www.grupobancolombia.com/wps/portal/acerca-de/informacion-corporativa/sostenibilidad/bonos-verdes/ (accessed on 10 December 2016).
75. Mascareñas, J. *Fusiones y Adquisiciones de Empresas*, 5th ed.; Ecobook: Madrid, Spain, 2011.
76. Vélez, I. *Decisiones de Inversión para la Valoración de Proyectos y Empresas*; Editorial de la Pontificia Universidad Javeriana: Bogota, Colombia, 2013.
77. Damodaran, A. *Applied Corporate Finance*, 4th ed.; Wiley: Hoboken, NJ, USA, 2014.
78. Congreso de Colombia. Plan Nacional de Desarrollo 2014–2018 "Todos por un Nuevo País". Colombia; p. 145. 2015. Available online: https://observatorioplanificacion.cepal.org/es/planes/plan-nacional-de-desarrollo-todos-por-un-nuevo-pais-de-colombia-2014-2018 (accessed on 20 August 2016).
79. Flyvbjerg, B. What you Should Know about Megaprojects and Why: An Overview. *Proj. Manag. J.* **2014**, *45*, 6–19. [CrossRef]
80. Decision-Making on Mega-Projects: Cost-Benefit Analysis, Planning and Innovation—Google Books. Available online: https://books.google.com.co/books?hl=en&lr=&id=tenILJ-MowQC&oi=fnd&pg=PR1&dq=bent+flyvbjerg+megaprojects&ots=_CnKMFEBBJ&sig=afhl5bXQaf9ys1DvdeqF6Ld_BK8#v=onepage&q=bentflyvbjergmegaprojects&f=false (accessed on 9 August 2022).
81. González-Ruiz, J.D. *Sustainable Financing as a Mechanism to Increase Private Participation in the Development of Infrastructure Systems in the Water Sector*; Universidad Nacional de Colombia: Medellín, Colombia, 2016.