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Prioritizing Infrastructure Investments in Panama: Pilot Application of the World Bank Infrastructure Prioritization Framework

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Introduction

Infrastructure services are significant determinants of economic development, social welfare, trade, and public health. As such, they typically feature strongly in national development plans. While governments may receive many infrastructure project proposals, however, resources are often insufficient to finance the full set of proposals in the short term. Leading up to 2020, an estimated US\$836 billion - 1 trillion will be required each year to meet growth targets worldwide (Ruiz-Nuñez & Wei, 2014; World Bank). Global estimates of infrastructure investments required to support economic growth and human development lie in the range of US\$65-70 trillion by 2030 (OECD, 2006), while the estimated pool of available funds is limited to approximately US\$45 trillion (B20, 2014).

The past twenty years have also seen a shift towards decentralized infrastructure planning. Many subnational governments, regional entities, and sector agencies have been delegated responsibility for infrastructure planning promote local responsiveness, but responsibility for allocating funds often remains with a centralized finance agency (CFA). While constituencies may propose numerous projects, governments often have insufficient financial resources to implement the full suite of proposals.

As such, government must make difficult decisions about which projects to select for implementation within a given investment period. This implies grappling with the relative efficiency and effectiveness of investments as well as project costs and benefits. The multiple considerations of project selection demand improved decision support frameworks that are sufficiently rigorous to accommodate multiple facets, yet practical to implement.

Good practice suggests that economic and strategic project appraisals and feasibility studies provide a good basis for project prioritization via highest societal net present value as a ranking metric. The reality, however, is that capacity, resources, and time are often too short in supply to support extensive economic analysis across full project sets. Decision-makers may only have partial information on project costs and benefits, particularly since many are difficult to quantify and monetize. Thus, there is a need for evidence-based infrastructure decision support that is consistent and data-driven but pragmatic and responsive to the needs and current capacities of a government.

The World Bank's Infrastructure Prioritization Framework (IPF) responds directly to these demands by offering a systematic approach to infrastructure prioritization that places financial-economic and social-environmental factors at the forefront of decision-making. The framework is transparent and objective, following a clear step-wise approach, but allows space for deliberation in order to remain responsive to policy priorities.

The IPF framework is differentiated in four ways from other approaches to infrastructure decision-making. First, it incorporates national policy goals, social and environmental sustainability considerations, and long-term development aims alongside financial and economic indicators. Second, it is predicated on parsimony and pragmatism. Third, it makes space for policy debate via criteria identification and the selection of projects from mid-priority categories. Fourth, it provides decision-makers with an intuitive, graphical interface upon which to compare alternative investment scenarios.

IPF is not intended to replace traditional planning or policy analysis, which remain critical to identifying problems, assessing their relative importance or urgency, and selecting from amongst alternative solutions. These remain important pre-prioritization activities. IPF also

does not propose to substitute extensive economic analysis with more basic appraisal in the long term, or for major projects. Rather, IPF can be used employed as a catalyst to improve data collection in order to progress more sophisticated and extensive appraisal methods, including social cost-benefit analysis (SCBA).

This report presents the IPF methodology and results of the pilot application to a select set of transport and water and sanitation projects in Panama. The report first gives background information on infrastructure prioritization in Panama, then follows with a description of the IPF in technical and implementation terms. Next, we present the results of the pilot and close with recommendations for implementing IPF to a wider set of proposed projects.

Background

In Panama, the current economic outlook and institutional supports spurred pilot application of the IPF. First, GDP growth and economic buoyancy in 2014 motivated an ambitious public investment program, accompanied by a high number of infrastructure project proposals to the Ministry of Economics and Finance. This was coupled with political commitment to narrow the deficit, and thus demanded that Government select some projects and postpone others for implementation during the following five-year strategic period.

Institutionally, the application of a prioritization methodology was endorsed via the *Government Strategic Plan 2015-2019*, which called explicitly for systematic prioritization of public investments and consideration of socio-economic and environmental indicators. In keeping with the 2008 Social Fiscal Responsibility Law, the *Government Strategic Plan* sets forth action areas for investments in economic sectors, social, infrastructure, developments of people, environmental and governability over a five-year period. The 2015-2019 Plan is premised on achieving social equity, better standards of life for all Panamanians, and sustainable economic growth. The indicative plan is to be reviewed and updated annually to account for changes in forecasted income and expenses and the availability of capital to service project costs. As such, it recognizes that project execution is dependent on the availability of sufficient finance.

The *Strategic Plan* accounts for public investments of approximately US\$19.5 billion for the following five-year period. Of this planned total, 15.2% (US\$2.96 billion) is marked for road projects, whereas 18.9% (US\$3.69) is designated for water and sanitation. The Strategic Plan is also linked to the Five-Year Investment Plan, which specifies allocations to various Government ministries, agencies, and corporations for public expenditure.

The 2014 World Bank *Panama Country Partnership Framework* (CPF) also calls for technical assistance to Panama on infrastructure prioritization (p. 19). In keeping with the Strategic Plan and CPF, in April 2015, the Ministry of Economy and Finance of Panama engaged the World Bank to undertake a technical advisory project to prioritize a select set of projects in the transport and water and sanitation sectors. Nineteen projects in transport and 35 in water and sanitation are the purview of the IPF pilot application herein.

Developing Panama's Infrastructure

Infrastructure features heavily in Panama's Government Strategic Plan 2015-2019, based on (a) an aim to reduce infrastructural constraints on per capita GDP (see Loayza et al, 2004, and Araujo, et al, 2014); and (b) recognition that national growth has stemmed largely from the

transport, commerce, and construction sectors. Construction has become a key economic driver due to investment (public and private) in residential and non-residential infrastructure (1.9% contribution over the past five years). The sectors also created most of the new employment from 2007 to 2012, particularly for low-skill workers (World Bank, 2015).

While there is evidence of economic constraints from infrastructure, Panama has been ranked highly in international comparisons: it is one of the most competitive countries in the region on infrastructure developments, according to the Global Competitiveness Ranking prepared by the World Economic Forum, and the country has positioned itself as a key trade and logistics hub, naturally centered around the Panama Canal. Nevertheless, certain infrastructure subsectors have lagged, including urban connectivity and energy.

With respect to the decision processes for infrastructure funding, a medium-term fiscal framework sets the budget ceiling for the central government, decentralized institutions, public companies and financial intermediaries. Institutions register programs and projects that require budgetary resources into a project bank (BP) maintained by the Ministry of Economy and Finance (MEF). The BP links pre-investment activities (e.g., proposal and appraisal) to budget execution. Assessments of proposed projects take into account the budget ceiling and the physical and financial performance of each institution. Based on this, the Directorate of Investment Programming (DPI) of the Ministry of Economy and Finance (MEF) provides a preliminary recommendation. This is then reviewed and modified by another MEF directorate, the Directorate of National Budget (DIPRENA), which assigns the final figure for each institution.

Transport

Roads are Panama's weakest link with respect to trade infrastructure. Contrary to the country's elevated position on international rankings for port and air transport infrastructure, Panama ranks 44th in the quality of road infrastructure (WEF, 2015), and road density is amongst the lowest in Central America. Rectifying this is particularly important, as Central America has yet to take full advantage of potential gains of regional integration and trade connectivity. The physical trade network limits bilateral trade, and logistics costs can be as much as 50% of the final price of traded goods. Estimates suggest that exports stand to double with integration (Marcelo, et al, 2010).

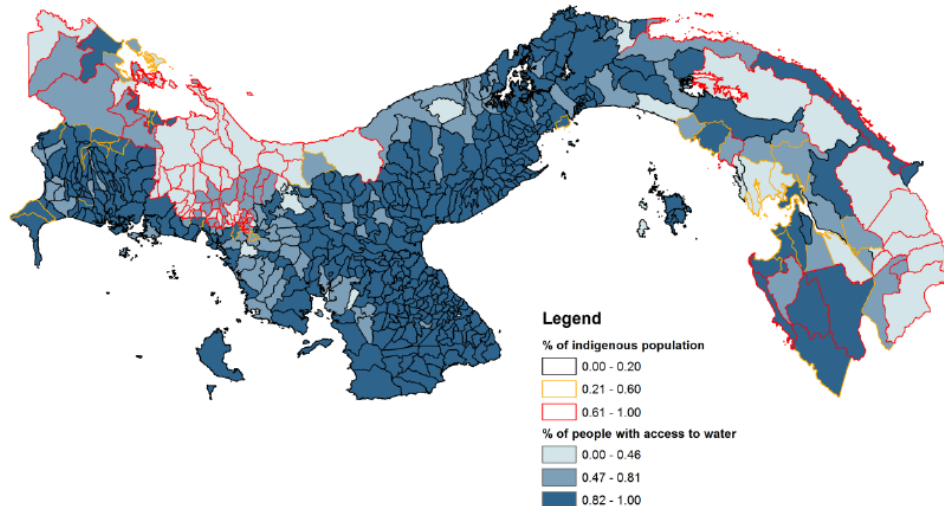
Water

In the water sector, three government bodies are responsible for policy and investment: (a) the Ministry of Health, via the Directorate of Water and Sanitation (DISAPAS), oversees sector planning and service delivery in towns and rural areas; (b) the National Water and Sewerage Institute / Instituto de Acueductos y Alcantarillados Nacionales (IDAAN) is responsible for urban areas and rural communities with over 1,500 inhabitants; and (c) the National Authority for Public Services (ASEP) supervises and regulates urban provision (World Bank, 2015).

There are observed coordination problems, as infrastructure investments may be made in parallel, with no integrated sector investment plan. In this way, a structured prioritization process has much to offer in the way of organizing project selection, both within and across water agencies. One move towards better coordination, however, is in the development of a new Interagency Commission for Drinking Water and Sewerage (CIAPAS), involving the three agencies responsible for water and sanitation policies and investments. Regular meetings of working committees are held to address water and sanitation policy issues and disaster risks.

Whereas 94% of Panama’s population has access to an improved water source, only 73% have access to improved sanitation (World Bank b, 2015). Development needs in the sector are concentrated in the comarcas,¹ where many residents have little or no access to improved water supplies and sanitation. While public service quality, coverage, and reliability is generally lower in dispersed rural areas, services are particularly poor in the comarcas (World Bank, 2015). Poor water and sanitation coverage has major implications for child health, including the prevalence of diarrheal illness, and life expectancy overall. As such, if improving access to water and sanitation in the comarcas is identified as a key policy goal, this can be coded into future analysis via the inclusion in the social-environmental indicator.

Figure 1. Access to running water in the dwelling, by concentration of indigenous peoples



Source: World Bank, 2015

Poverty

The concentration of poverty in rural indigenous areas has important implications for infrastructure development.² Indigenous residents of comarcas have markedly low access to basic services and infrastructure, and, whilst needs are also evident in urban areas and amongst other segments of the population, slow development and particularly low conditions in these areas cannot be overlooked. This requires that decision-makers deal with the inherently different economic performance of proposed projects in rural areas in some sectors in a way that does not penalize the communities where needs are greatest.

Infrastructure Prioritization Framework

The Infrastructure Prioritization Framework is a quantitative approach that synthesizes and displays financial and economic as well as social and environmental indicators at the project level and considers these alongside the public budget constraint for a sector. Results are displayed graphically to map comparative performance along these dimensions.

While the IPF is quantitative in nature, it employs knowledge that is practice-based or political and opens space for deliberation in criteria and project selection. The approach recognizes

1. *Comarca indígena* or ‘comarcas’ in Panama are five indigenous regions, representing 20% of the national territory, which hold special administrative status alongside provinces. The comarcas are Ngobe-bugle and Campesino, Kuna Yalar, Embera-Wounan, Kuna de Madugandi, and Kuna de Wargandi.
2. 42% of Panama’s extremely poor residents live in the comarcas.

that project selection cannot be entirely dissociated from the political economy of a sector. Particular projects may be chiefly valued by governments and other stakeholders due to key policy goals which are non-economic in nature, or due to considerations that objective indicators cannot measure, such as upholding election promises, promoting social cohesion, or honoring culture. As such, the IPF accommodates policy and political responsiveness in two ways: through the selection of criteria (indicators) for assessment and by leaving a degree of freedom in decision-making through provision of two references for judgment (the indices).

The IPF was created in response to observed government demand, including a needs for (a) improving infrastructure planning at national and sector levels; (b) considering large projects sets with scarce planning resources; (c) meaningfully addressing environmental and social factors; and (d) balancing analytical efficiency, derived from standardization, with policy and political responsiveness. Institutionalizing a systematic approach to prioritization is further justified by public demand for evidence, value, and legitimacy in infrastructure decision-making. These logics are detailed in Marcelo, et al, 2016. To be deemed legitimate and comprehensive, prioritization must be based on sound evidence that affords meaningful comparison. Many project comparisons are inherently technical; thus, IPF is designed to employ quantitative measures to the greatest extent possible to limit subjectivity.

Furthermore, comprehensiveness requires that project comparisons make space for multiple policy goals and facets of project selection. This lends support to employing multi-criteria approaches, with criteria selected to reflect considerations of effectiveness and value, as well as sector and national policy goals. The IPF captures the strengths of multi-criteria decision approaches, but also allows use of inputs from cost-benefit analysis (CBA).³

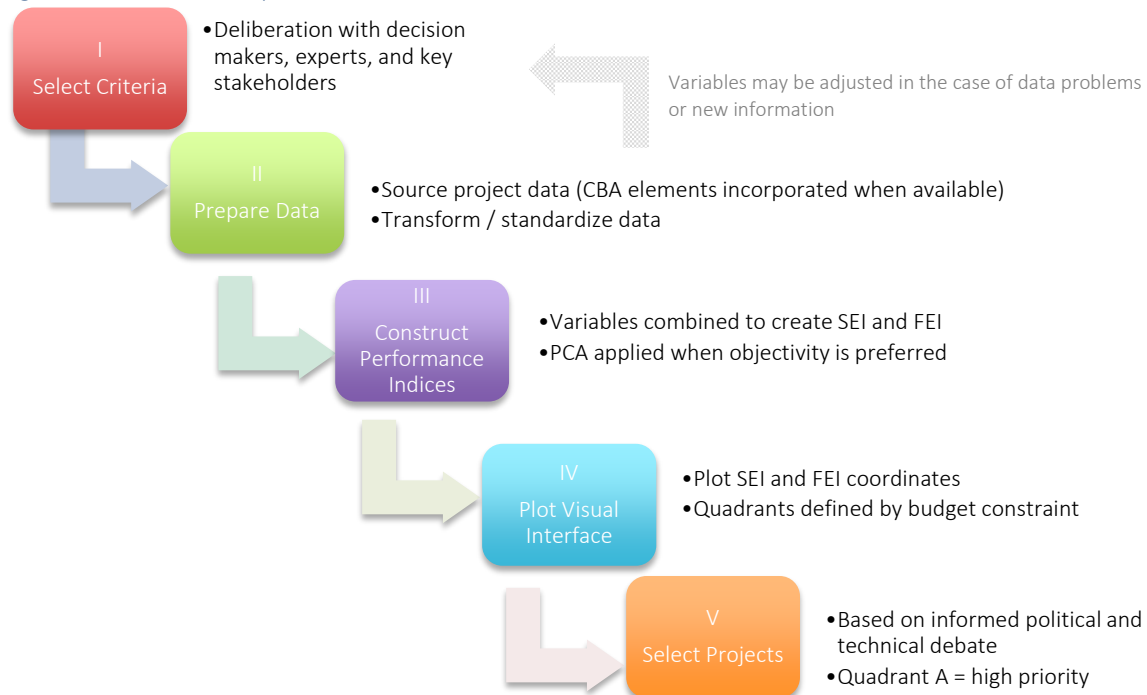
The process by which infrastructure is prioritized must also be administratively and politically feasible. This suggests that governments adopt the principle of parsimony – using the least amount of relevant information needed to inform a decision. Administrative feasibility means that approach can be implemented within limits of institutional capacity, cost, time, and data availability. And political feasibility accepts that prioritization cannot be totally unresponsive to political factors. In summary, most infrastructure policy contexts demand the reconciliation of highly technical and objective policy analysis with more political and practice-based inputs, all within the resource means of government.

The IPF Process

Implementing the IPF is relatively straightforward, following five steps: (1) selecting decision criteria; (2) gathering project indicator data; (3) calculating social-environmental and financial-economic indices; (4) plotting projects and budget limits; and (5) selecting projects (see Figure 2). In this section, we describe implementation in terms of these steps, with direct reference to the Panama pilot. An extensive technical description of the IPF methodology is also detailed in Marcelo, et al, 2016.

3. We recognize multiple approaches to investment decision-making, including social cost-benefit analysis (SCBA). For an extensive discussion of alternative approaches, see Marcelo, et al, 2016. Whereas SCBA requires fully monetized information on costs and benefits, IPF makes use of available inputs (e.g., financial CBA). IPF's value-adds to CBA are in (a) directly treating non-marketed impacts in 'natural' units; (b) relieving the burden of making and justifying assumptions required to monetize benefits and costs; and (c) dealing directly with issues like equity and social justice.

Figure 2. IPF Process Map



Source: Marcelo, et al, 2016

One important pre-analytical step is the delineation of proposed projects to which the IPF will apply. This may include the full universe of projects proposed to Government, or a select set. In the case of the Panama pilot, experts from the Ministry of Economy and Finance (MEF), in consultation with participants from the Ministry of Public Works / Ministerio de Obras Públicas (MOP), Ministry of Health / Ministerio de Salud (MINS), and the National Water and Sewerage Institute / Instituto de Acueductos y Alcantarillados Nacionales (IDAAN), a consultant in charge of the Government’s Strategic Plan, and experts from the World Bank, randomly selected 34 and 19 projects in the water and urban mobility sectors, respectively.

Basic information for these projects was obtained from the Banco de Proyectos, the platform of the National Public Investment System (SINIP), where all public investments carried out by state agencies are recorded at the national level. Only projects above US\$ 5 million were included in this exercise, as they are bound to meet the data requirements of Article 12 of Law 25 (amending Article 23 of Law 34 on Social and Fiscal Responsibility). This law indicates that investment projects with proposed costs equal to or greater than 0.1% of the General State Budget must include studies on costs and social benefits, whereas projects less than 0.1% but more than five million dollars (US\$ 5,000,000) require at least prefeasibility studies.

The 19 transport projects included in the analysis are listed in Annex 1, along with project costs and the raw data on indicator values. The 35 water and sanitation projects included in the analysis are listed in Annex 2, along with project costs and the raw data on indicator values. Participants from the Institute of Aqueducts and Sewers (IDAAN), Ministry of Public Works (MOP), and Ministry of Health (MOH) were included in the implementation stages.

Step 1. Identifying criteria

The first step in applying the IPF is to select the criteria used to compare projects. The selection of variables seeks to preserve the principle of parsimony. Accordingly, this methodology

requires a minimum level of relevant information to assess the various expected outcomes of proposed infrastructure projects. The selection of variables may differ amongst application contexts, based on government policy goals (e.g., particular sectorial, social, and environmental aims) and stakeholder consultations, but will generally include indicators of value, efficiency, and social and environmental impact.

This step is an opportunity to leverage professional knowledge and allow policy-makers, experts, and other key stakeholders to reach consensus on the decision factors most important to project selection. In this way, the step crystallizes the Government’s agreed goals of infrastructure development. In the Panama pilot, the initial list of variables was agreed during a technical workshop including participants from the World Bank team, Ministry of Economy and Finance (MEF) technical staff, National Water Supply and Sanitation Administration / Institute of Aqueducts and Sewers (IDAAN), Ministry of Health (MOH), Ministry of Public Works (MOP), and Ministry of Government (MINGOB).

The variables are organized into two categories: social-environmental and financial-economic. The indicators originally selected were as follows:

Social-Environmental Indicators	Financial-Economic Indicators
<ul style="list-style-type: none"> • Beneficiaries (people served) • Jobs created • Negatively affected (people and costs) • Poverty (coverage map) • Environmental footprint (positive, neutral, negative) 	<ul style="list-style-type: none"> • Internal rate of return • Multiplier effects • Externalities (e.g., avoided diseases) • Implementation risks

Infrastructure projects are meant to improve quality of life. A number of direct social and environmental benefits are relevant, including improved access to public services and job and income opportunities created during construction and operation. These benefits come at a cost, however. Engineering works may require clearing forested areas, polluting and endangering natural environments, or resettling communities. The IPF directly considers relevant social and environmental benefits and costs via indicators used to construct a social and environmental index (SEI). In Panama, the SEI initially consisted of five indicators: the number of direct beneficiaries; direct jobs created; people affected by repurposing of land use; poverty; and the environmental footprint (categorized as negative, neutral, or positive).

The financial and economic viability and fiscal burden of a project is a central issue in all infrastructure decision-making. Four indicators were initially selected to comprise the financial-economic index (FEI): the internal rate of return, economic multiplier effects, monetizable externalities, and implementation risk.

Adjusting criteria variable specification

One key lesson drawn from the Panama pilot was that a need to adjust some of the original indicators may arise. An indicator may be found to be analytically problematic due to lack of sufficient data, calculation problems, or other issues such as imprecision in the variable specification or specifications that do not capture policy goals. This is an iterative process, and indicator problems are likely to be discovered during data collection (Step 2) or index calculation (Step 3). In the case of Panama, the major constraints that emerged were (1)

variable incalculability, (2) unavailability of data, (3) insufficient precision in variable specification, and (4) sector-specific needs. These are described in the following table.

Table 1. Indicator variable adjustments

Indicator change	Reason for adjustment
1. 'Number affected' eliminated from SEI	No data available
2. 'Environmental footprint' eliminated from SEI	Indicator found too imprecise (1-3) to reflect scale of differences between projects.
3. Transport SEI variables controlled for project size (cost); original SEI variables transformed and expressed as ratios of cost (e.g., number of beneficiaries / jobs created per dollar)	Beneficiaries and jobs created per dollar gives an indication of relative efficiency of projects. In contrast, SEI variables for water projects were not adjusted, as doing so would have privileged urban projects over rural.
4. Absolute number of potential poor receiving service used instead of poverty ratio (%) to calculate SEI	Poverty rates are higher in less densely populated areas, but in absolute terms, poor are mainly concentrated in urban areas. The use of poverty rates could favor projects with lower impacts to poor when using PCA. Using absolute values corrected the problem.
5. FEI for both sectors limited to benefit-cost ratio	Insufficient data for multiplier effects, externalities, and implementation risk IRR not mathematically calculable in many cases due to very low monetized benefits

An important adjustment was made to the calculation of FEI. The FEI was originally expected to include the internal rate of return (IRR) and/or economic rate of return (ERR) of projects, depending on data availability, in addition to several other indicators. Since many of these investments were proposed for projects with no direct monetary benefits and largely indirect economic effects (i.e. mainly projects with a large public good component), however, the calculation of IRR would have produced unrealistic or incalculable results.

The alternative would have been to account for all indirect positive effects and estimate benefits. This would require data on monetized benefits for such effects, which was not available. For these reasons, we relied on the NPV (assuming given discount rates) of available information to calculate benefit-cost ratios (BCRs). The BCRs also allowed us to control for project size and avoid penalizing projects with higher costs but possibly higher benefits.

Step 2. Gathering and transforming data

The second step is to gather and transform data to calculate social-environmental and financial-economic scores for each project. A team of six local consultants with sectorial expertise gathered data under the supervision of World Bank staff (Table 2). Consultants gathered information from existing project information sheets and made additional calculations based on research.

Table 2. Summary of consultant time for Panama pilot

Consultant	Sector	Days
1	Urban Transport	33
2	Urban Transport	20
3	Operations/Transport	7
4	Water/Sanitation	40
5	Water/Sanitation	20
6	Water/Sanitation	15
Total		135
Average days per consultant		22.5

Data was entered into an Excel environment, which recorded raw project data associated with each variable, for each project under study.⁴ A simple Excel environment could be constructed in the future to assist the population of a prioritization database. An example data entry form

4. For analytical purposes, we also coded some projects as 'outliers', since their extreme values would have distorted the calculation of weight via PCA.

is included in Annex 3, and an example populated data table for Water and Sanitation Projects is shown in Table 3 below.

Table 3. Water and Sanitation Project Excel Data Table

ID	Cost	PCA Weighting						Equal Weighting			
		BEN	EMP	POOR	BEN STD	EMP STD	POOR STD	SIE STD	SEI	SIE STD	SEI
Project 1	17,650,597	206481	125	74333	0.47	-0.91	1.10	0.87	36.76	0.38	40.33
Project 2		874935	138	166238	3.76	-0.65	3.35			3.73	84.08
Project 3	5,887,649	315019	156	63004	1.01	-0.29	0.82	1.19	41.43	0.89	46.97
Project 4	5,991,593	67265	156	36996	-0.21	-0.29	0.19	-0.09	22.93	-0.18	32.97
Project 5	7,450,110	36512	98	13144	-0.36	-1.46	-0.40	-0.86	11.66	-1.28	18.64
Project 6	5,971,133	43939	98	8348	-0.33	-1.46	-0.52	-0.92	10.85	-1.33	18.03
Project 7	30,000,000	53247	208	13844	-0.28	0.75	-0.38	-0.28	20.12	0.05	36.06
Project 8	6,800,000	3723	191	1378	-0.53	0.41	-0.69	-0.74	13.49	-0.46	29.35
Project 9	5,250,000	6813	189	1363	-0.51	0.37	-0.69	-0.74	13.50	-0.48	29.16
Project 10	5,000,000	206481	153	74333	0.47	-0.35	1.10	1.00	38.67	0.70	44.58
Project 11	15,300,000	16636	152	4658	-0.46	-0.37	-0.61	-0.82	12.28	-0.83	24.52
Project 12	60,000,000	116000	148	25520	0.03	-0.45	-0.09	-0.15	21.97	-0.30	31.45
Project 13	9,000,000	47401	103	25123	-0.31	-1.36	-0.10	-0.60	15.45	-1.02	22.01
Project 14	5,000,000	3905	102	1406	-0.53	-1.38	-0.68	-1.15	7.46	-1.49	15.87
Project 15	50,000,000	156698	239	86184	0.23	1.38	1.39	1.43	44.96	1.73	57.95
Project 16	9,980,000	161470	103	41982	0.25	-1.36	0.31	0.07	25.16	-0.46	29.36
Project 17	40,000,000	31223	238	21544	-0.39	1.36	-0.19	-0.08	22.96	0.45	41.21
Project 18	5,000,000	9788	186	5579	-0.50	0.31	-0.58	-0.67	14.47	-0.44	29.59
Project 19	10,000,000	15339	208	4142	-0.47	0.75	-0.62	-0.57	15.89	-0.19	32.87
Project 20	8,000,000	7006	203	1962	-0.51	0.65	-0.67	-0.66	14.61	-0.30	31.40
Project 21	7,000,000	2890	203	1329	-0.53	0.65	-0.69	-0.68	14.25	-0.32	31.13
Project 22	20,000,000	20420	234	11231	-0.44	1.28	-0.44	-0.31	19.64	0.22	38.30
Project 23	50,000,000	220779	243	50779	0.54	1.46	0.52	1.07	39.73	1.46	54.41
Project 24	50,000,000	161470	243	41982	0.25	1.46	0.31	0.72	34.67	1.16	50.58
Project 25	5,000,000	5181	186	2901	-0.52	0.31	-0.65	-0.73	13.59	-0.49	28.92
Project 26	18,000,000	7980	184	3032	-0.51	0.27	-0.65	-0.73	13.63	-0.51	28.75
Project 27	60,000,000	64856	234	17511	-0.23	1.28	-0.29	-0.06	23.35	0.44	41.11
Project 28	42,825,811	50694	210	10139	-0.29	0.80	-0.47	-0.34	19.22	0.02	35.59
Project 29	24,397,000	47401	208	25123	-0.31	0.75	-0.10	-0.11	22.59	0.20	37.93
Project 30	5,413,130	2313	118	1411	-0.53	-1.05	-0.68	-1.08	8.47	-1.31	18.23
Project 31	12,674,150	31537	162	11669	-0.39	-0.17	-0.43	-0.61	15.40	-0.57	27.88
Project 32	9,000,000	7364	125	2651	-0.51	-0.91	-0.65	-1.01	9.50	-1.20	19.71
Project 33	5,500,000	7602	98	2129	-0.51	-1.46	-0.67	-1.15	7.55	-1.52	15.53
Project 34	5,000,000	31223	103	21544	-0.39	-1.36	-0.19	-0.72	13.79	-1.12	20.75
Project 35	5,000,000	64856	148	17511	-0.23	-0.45	-0.29	-0.46	17.51	-0.56	28.08

The Social and Environmental Index (SEI) and the Financial and Economic Index (FEI) are each built on sets of quantitative variables combined into one index via an additive model. To condense disparate data types and scales of measurement into indices, three data transformations are required. One must (a) transform ordinal qualitative data into usable quantitative scalar data; (b) standardize criteria to isolate the various units of measure; and (c) establish weights for each criterion in the additive model.

Because all of the variables selected were already quantitative, we did not have to perform the first transformation. We did, however, standardize the numerical values via a typical standardization formula. The standard score z of a raw score x is

$$z_{ij} = \frac{x_{ij} - \mu_j}{\sigma_j},$$

where μ is the sample mean and σ is the standard deviation of the variable j . The standardization formulas are coded into the Excel platform.

Step 3. Constructing the SEI and FEI

Indices are used to combine information from multiple variables into one composite indicator. In IPF, there are two variable classes that comprise the social-environmental index (SEI) and the financial-economic index (FEI). In the case of Panama, since the FEI was comprised of a single component (the standardized benefit-cost ratio), its calculation was based on the standardization and normalization steps (see Step 2) only.

The SEI, on the other hand, was constructed by an additive model that combined variables with associated weights. The function may be expressed as

$$SEI = w_1 \times (BEN) + w_2 \times (POOR) + w_3 \times (JOBS),$$

where weights, w_i , are associated with each of the social-environmental indicators.

Principal Component Analysis (PCA) was used to determine the weights w_i of each variable in the additive function. PCA is an information reduction procedure that seeks redundancies in a set of variables. These redundancies can be expressed as linear combinations or 'principal components' of the variables comprising the set, where each principal component is a weighted average of the original indicators.⁵ The first principal component corresponds to the linear combination of variables that retains the maximum information of the original data set (Pearson, 1901). One of the main characteristics of PCA is the ability to calculate coefficients based solely on the statistical relationship between variables. This is particularly useful when there is a preference to objectively assign weights. Nevertheless, other methods such as equal weighting or expert-decided weighting may also be employed for reference.⁶

After the SIEs and FIEs are calculated for each project, they are normalized and rescaled to generate scores between 0 and 100 for each project's index score. The rescaled z_i score is

$$Rescaled(z_i) = \frac{z_i - Z_{min}}{Z_{max} - Z_{min}} \times 100$$

where Z_{min} is the minimum value for variable Z and Z_{max} is the maximum value. These rescaled scores are used as the SEI and FEI scores for plotting in Step 4.

5. The coefficients, or weights, associated with variables in each principal component are those that maximize the variance of each. The notation for the first principal component y is:

$$y = w_{1i}x_{1i} + w_{2i}x_{2i} + \dots + w_{ni}x_{ni},$$

where i denotes each observation and w_n denotes the weight for the n^{th} variable x . The coefficients w_n of each 'first principal component' are taken as the weights associated with each variable x .

6. The simplest mode of weighting is equality, where all criteria are equally considered. An alternative method is negotiated expert guidance, where a panel of decision-makers decides weights based on experience.

Transport Index Scores

The SEI index scores were based on PCA-determined weights of .650, .439, and .633 associated with beneficiaries per dollar (BEN_COS), employment per dollar (EMP_COS), and poor people served per dollar (POOR_COS), respectively. The results are shown in Figure 3.

Figure 3. Transport Social-Environmental Index, PCA weighting

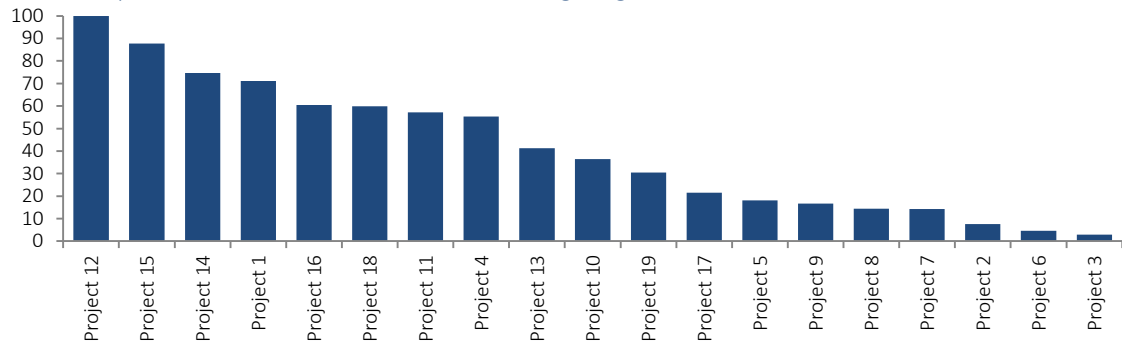
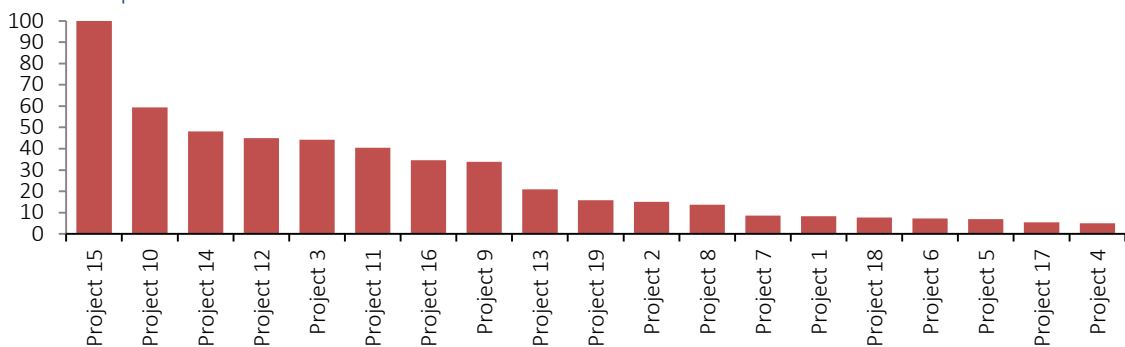


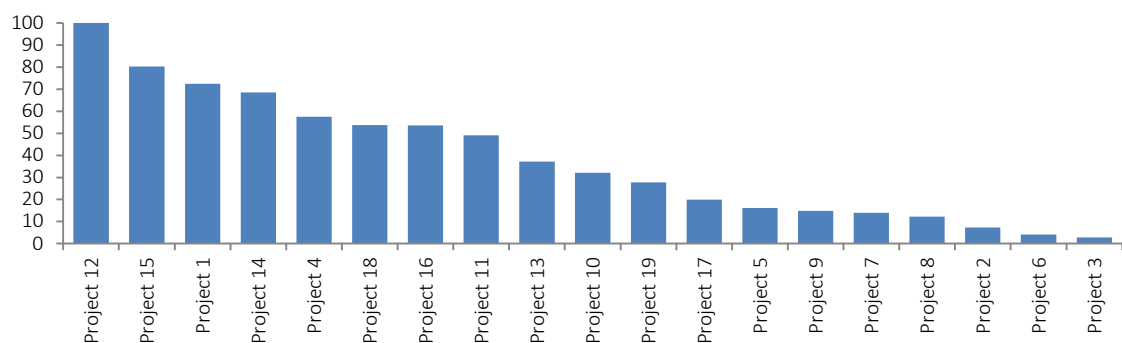
Figure 4 shows results of the transport sector FEI calculations. Note that the FEI reflects the relative importance of projects in terms of the benefit-cost ratio.

Figure 4. Transport Financial-Economic Index



Finally, a sensitivity analysis was performed on the SEI to determine the effect of using other weighting schemes besides PCA on the calculated SEI scores for each project. This is described in Step 4. The alternative tested for Transport was equal weighting of SEI variables. Figure 5 shows that project rankings by SEI changes very minimally.

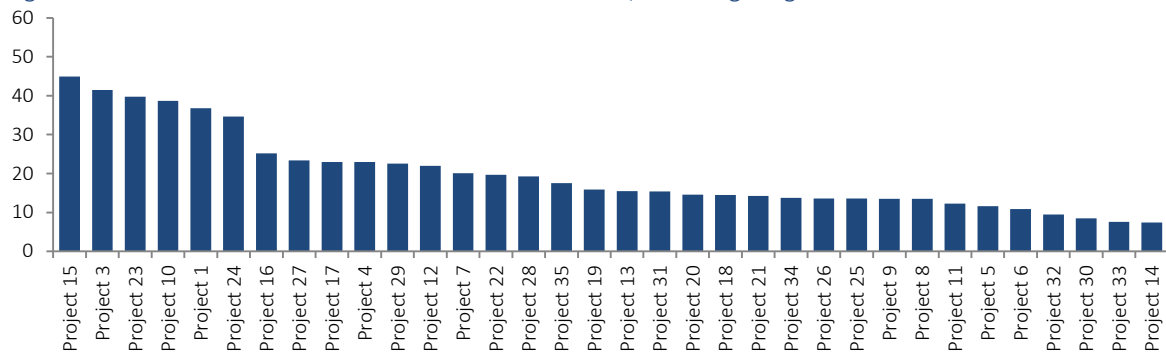
Figure 5. Transport Social-Environmental Index, Equal Weighting



Water and Sanitation Index Scores

Similarly, SEI scores for water and sanitation projects used PCA weights of .687, .233, and .688, respectively, for beneficiaries (BEN), jobs created (EMP), and poor served (POOR).

Figure 4. Water and Sanitation Social-Environmental Index, PCA weighting



As with transport, an alternative SEI calculation based on equal was used for sensitivity analysis (Figure 7). In this case, the ordering of projects changed more than with transport, but high scoring projects remained high, and low scoring ones remained low.

Figure 5. Water and Sanitation Social-Environmental Index, Equal Weighting

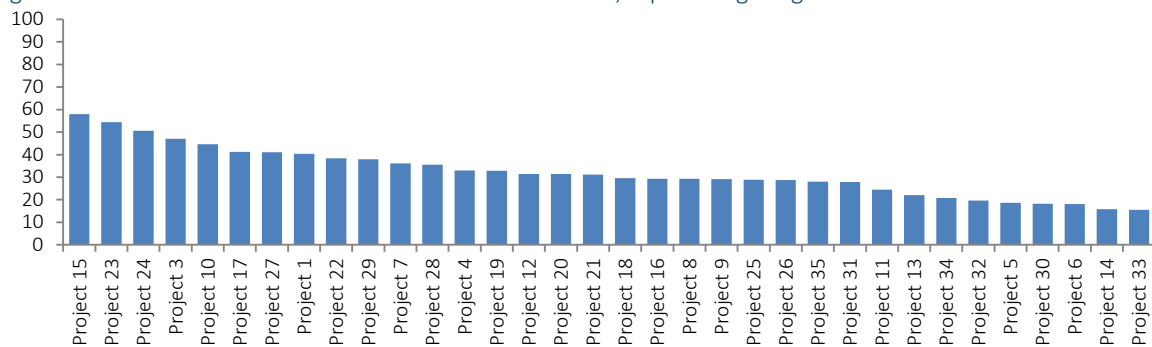
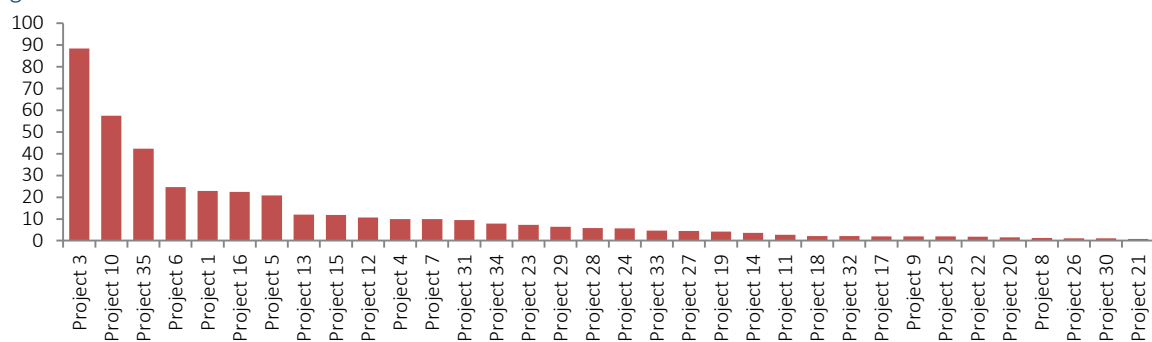


Figure 6. Water and Sanitation Financial-Economic Index

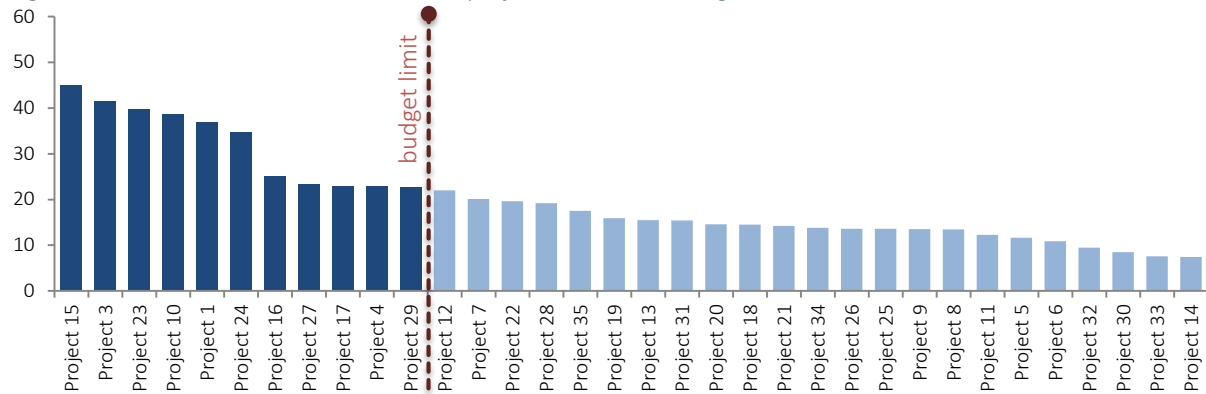


Determining the Budget Limit

The SEI and FEI rankings are used to determine the set of projects fundable under the budget limits for the visual interface to follow in Step 4. Budget limits are mapped separately for SEI and FEI rankings, but using the same budget limit value. In other words, the limits are imposed on each index ranking, according to the hypotheticals that projects would be entirely selected according to SEI or to FEI, respectively.

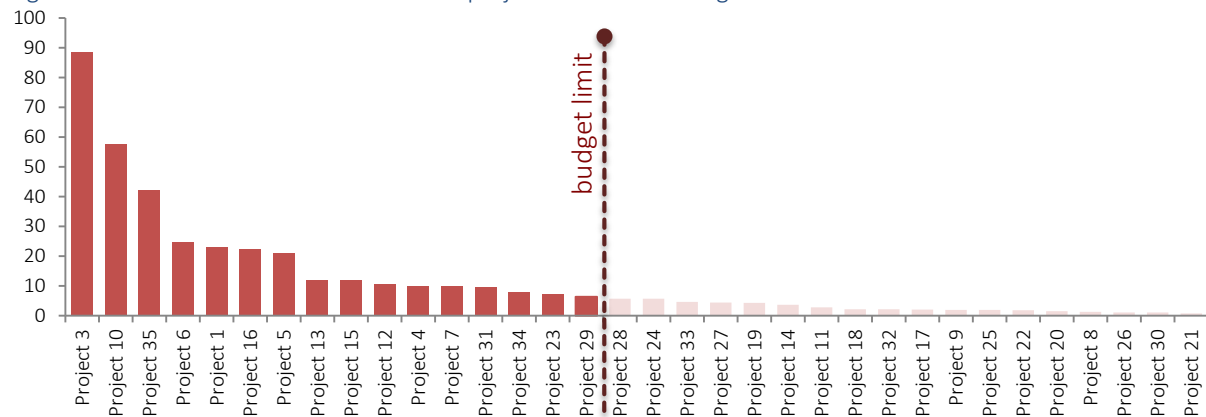
The process is simple: the available budget is ‘allocated’ to the top-ranking project on the SEI, followed by the second, third, and so on, until the available resources are exhausted. For example, the total cost of proposed water and sanitation projects (excluding Project 2) was US\$622,091,173. Based on recommended figures from the MEF (DIPRENA and DPI), in turn based on the Draft Annual Budget, the limit for water and sanitation was assumed to be 55% of the total cost of proposed projects, equaling \$342,150,145. Considering the costs of the top-ranking SEI projects 15, 3, 23, and so on, the budget would be exhausted after Project 29, at which the cumulative expenditure would be \$318,906,839. Since Project 12 costs \$60,000,000, there is insufficient funding to include it.

Figure 7. SEI-ordered water and sanitation projects within the budget limit



The same is done for the FEI. For water and sanitation, the last project that could be funded was also Project 29, with a cumulative expenditure of \$304,002,232. The cumulative totals are different because the ranking of projects according to each index are different.

Figure 8. FEI-ordered water and sanitation projects within the budget limit



For transport, the budget constraint was estimated based on historical allocation of about 60% of requested funding. This resulted in an estimated \$139,586,000 budget limit.

Step 4. Using the Visual Interface: Plotting Results on the Investment Frontier

A 'good' project, in terms of financial and economic performance, may nevertheless be undesirable from a social and environmental perspective, and vice versa. As such, decision-makers must consider projects along both dimensions. Projects can be compared by their respective SEI and FEI scores on a visual interface called the Infrastructure Prioritization Matrix. Step 4 involves plotting each project on a Cartesian plane, with axes defined by the SEI and FEI. In Figure 9, each point represents a proposed transport project, whose location on the plane is determined by (x,y) coordinates defined by the (FEI, SEI) score pair.

Once projects are plotted, the budget limit described above is imposed onto the plane, perpendicular to each axis, at the point where the budget would be exhausted if project funding was determined solely according to each index. Since this is done along each axis, four quadrants are formed. In Figures 9 and 10, the red dotted lines represent the budget constraint for the sector that delineates the four quadrants.

Projects that fall inside the budget constraint along each axis (i.e., above the dotted line, relative to the y or SEI axis, and to the right of the dotted line, relative to the x or FEI axis) represent the Investment Possibilities Set for each dimension. The set of projects in Quadrant A are those that fall in the Investment Possibilities Set for both SEI and FEI. These are categorized as 'High Priority' projects. Projects in Quadrant B are categorized as 'High Priority SEI' projects, and Quadrant C projects are categorized as 'High Priority FEI' projects.

For transport, an estimated budget of \$139,585,800 is available. If the high priority projects are implemented first, totaling US\$77,430,000 (see Table 4), a remainder of US\$62,155,800 is available for other proposed projects that may be selected from quadrants B or C depending on policy priorities.

In the case of the water sector, the budget available for water and sanitation projects is US\$342,150,145. Table 5 shows that, after funding high priority projects for a total of US\$144,509,839, a remaining \$197,640,306 is available for other prioritization categories.

Figure 9. Transport Infrastructure Prioritization Matrix

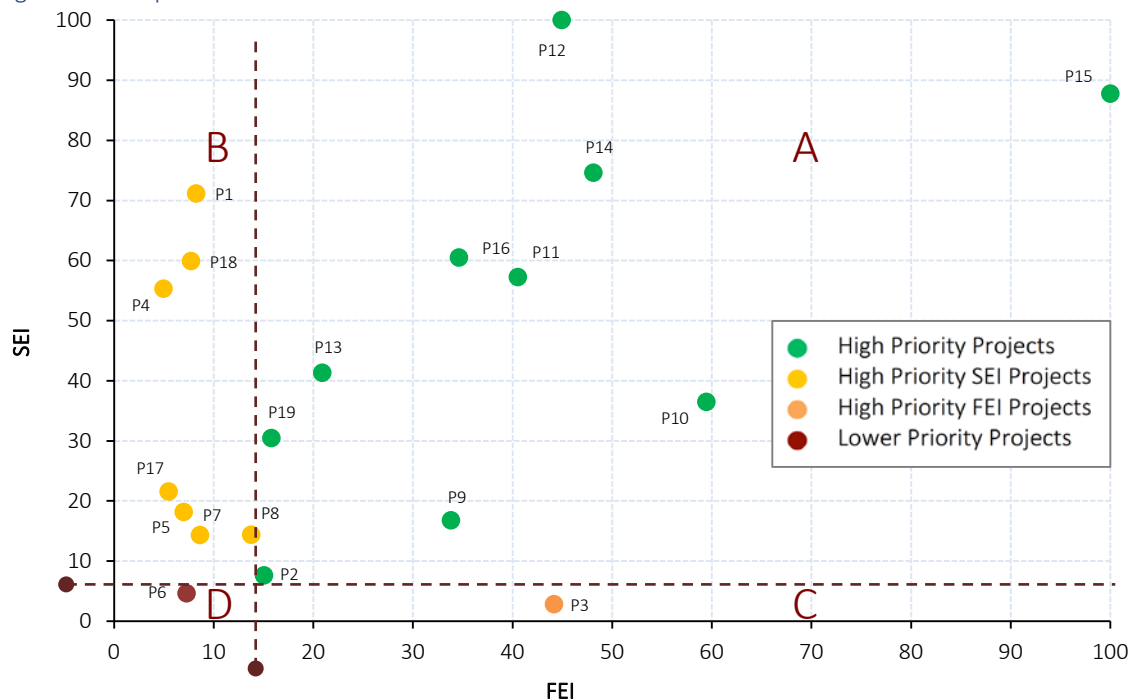


Table 4. IPM Transport Project Categorization

High priority projects		Cost
Project 2	Rehabilitación Camino Tortí-Chimán-Gonzalo Vásquez	45,000,000
Project 9	Rehabilitación Calles de Penonomé (Vista Hermosa)	4,880,000
Project 10	Rehabilitación Calles de Playa Leona (La Mitra hacia Peñas Blancas y Paso Arenas)	4,720,000
Project 11	Rehabilitación Calles de La Chorrera	1,600,000
Project 12	Rehabilitación Calles de Chilibre	4,500,000
Project 13	Rehabilitación Calles del Distrito de Aguadulce	4,200,000
Project 14	Rehabilitación Calles de Colón (Casco Antiguo y Arco Iris)	4,000,000
Project 15	Rehabilitación Calles del Distrito de Bugaba	2,000,000
Project 16	Rehabilitación Calles de Santiago (2015)	4,050,000
Project 19	Rehabilitación Carretera Lagarterita-Los Hules-Las Pavas -Lagartera Grande y Mejora del Puente	2,480,000
TOTAL		77,430,000
High priority social-environmental projects		
Project 1	Rehabilitación Carretera de Anachucuna	1,800,000
Project 4	Rehabilitación carretera de Irgandi (para llegar a la Comunidad de Playón Chico)	2,997,000
Project 5	Rehabilitación Carretera CPA-Calabacito	4,800,000
Project 7	Rehabilitación Carretera Tambo-Las Marías y Construcción de Puentes Vehiculares (5)	8,948,000
Project 8	Rehabilitación Carretera Loma Del Naranjo-Tres Quebradas	5,400,000
Project 17	Construcción Camino Quebrada Honda	8,000,000
Project 18	Rehabilitación Carretera Juay-Quebrada del Loro -Cañazas	1,600,000
TOTAL		33,545,000
High priority financial-economic projects		
Project 3	Rehabilitación Carretera Las Tablas-Los Asientos-Cañas-Cacao	58,668,000
TOTAL		58,668,000
Lower priority projects		
Project 6	Rehabilitación Carretera Circunvalación Garachiné-La Palma	63,000,000
TOTAL		63,000,000

Figure 10. Water and Sanitation Infrastructure Prioritization Matrix

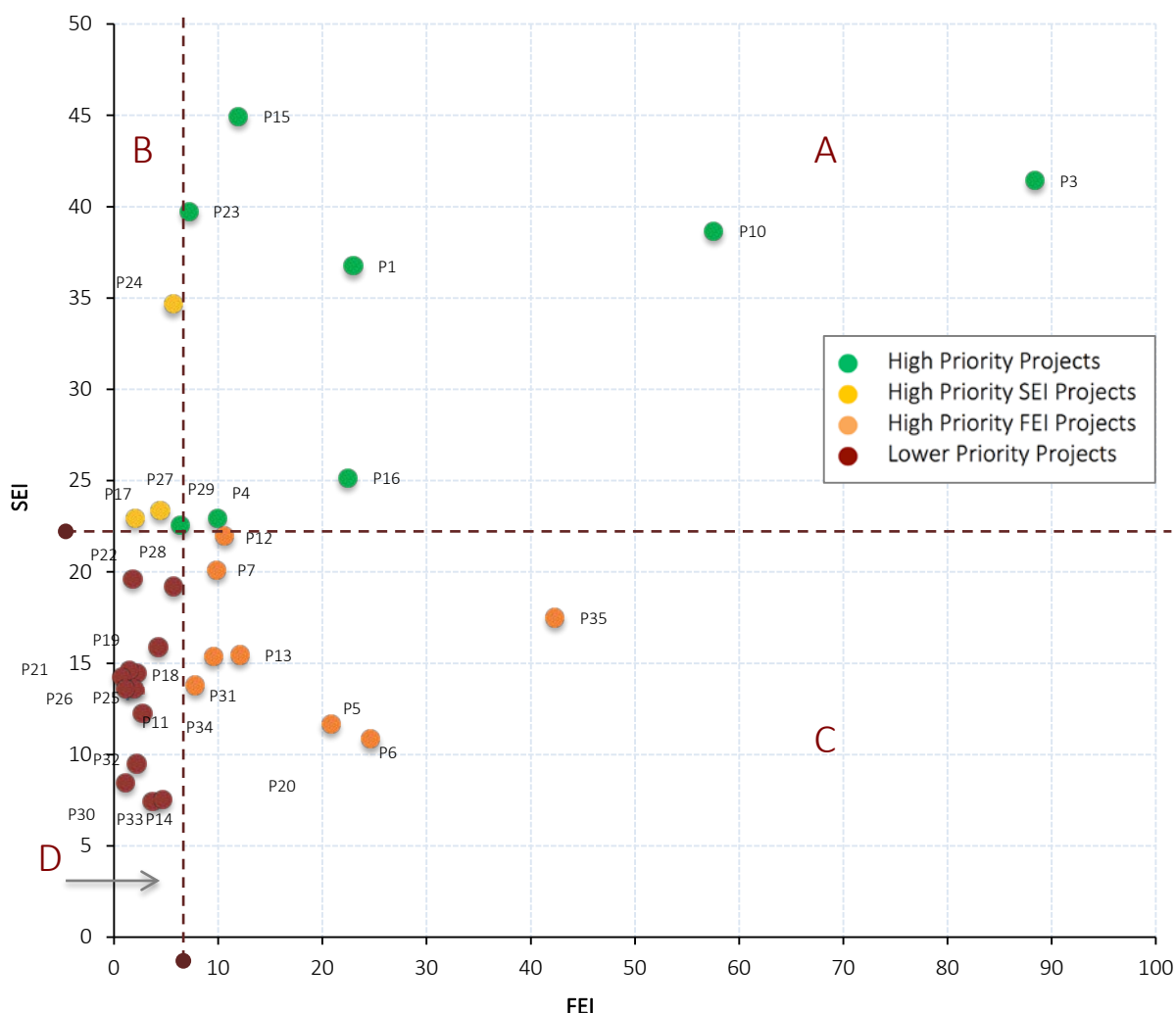


Table 5. IPM Water and Sanitation Project Categorization

High priority projects		Cost
Project 1	Mejoramiento sistemas de agua potable y saneamiento- distrito de Colón	17,650,597
Project 3	Construcción de línea de conducción del Tanque Ameglio - Red de distribución del Sector 3	5,887,649
Project 4	Mejoramiento obras complementarias red de distribución - Área Metropolitana (Línea de Conducción Pacora - Tanara - Tataré	5,991,593
Project 10	Construcción de línea paralela Sabanitas, Planta - Cuatro Altos	5,000,000
Project 15	Estudio, diseño y construcción para una nueva planta potabilizadora del Río Bayano -	50,000,000
Project 16	Construcción de obras complementarias para red de distribución de La Chorrera (Estación de bombeo y proyectos complementarios La Chorrera)	9,980,000
Project 23	Diseño y construcción del sistema de alcantarillado sanitario de Arraján	50,000,000
Project 29	Ampliación y mejoras al sistema de alcantarillado sanitario de Puerto Armuelles - CAF - II FASE	24,397,000
TOTAL		144,509,839
High priority social-environmental projects		
Project 17	Construcción Sistema de alcantarillado de Changuinola -	40,000,000
Project 24	Mejora Integral del sistema de alcantarillado sanitario de	50,000,000
Project 27	Santiago Construcción del sistema de alcantarillado sanitario (Sistema de recolección y tratamiento de aguas residuales) CAF - II FASE	60,000,000
TOTAL		150,000,000

High priority financial-economic projects		
Project 5	Construcción de mejoras a la red de distribución de Chorrillo y Santa Ana	7,450,110
Project 6	Mejoramiento al Acueducto de San Francisco	5,971,133
Project 7	Construcción de línea de conducción de La Chorrera - Capira, (Sectores 7 y 8)	30,000,000
Project 12	Mejoramiento integral al abastecimiento de agua de David	60,000,000
Project 13	Mejoramiento al sistema de agua potable de Puerto Armuelles	9,000,000
Project 29	Ampliación y mejoras al sistema de alcantarillado sanitario de Puerto Armuelles - CAF - II FASE	24,397,000
Project 31	, Construcción del sistema de abastecimiento de agua potable de Chorro Blanco, Alanje - Boquerón II Etapa	12,674,150
Project 34	Nueva toma de agua cruda en Bonyic, Changuinola	5,000,000
Project 35	Ampliación de la planta potabilizadora - Santiago	5,000,000
	TOTAL	159,492,393
Lower priority projects		
Project 8	Construcción del sistema de alcantarillado sanitario de Parita	6,800,000
Project 9	Construcción del Sistema de Alcantarillado Sanitario de Chilibre Centro	5,250,000
Project 11	Construcción de nueva planta potabilizadora de 10 MGD de Dolega y sectores aledaños	15,300,000
Project 14	Mejoras al sistema de abastecimiento y distribución de agua potable de Santa Marta, Santo Domingo	5,000,000
Project 17	Construcción Sistema de alcantarillado de Changuinola	40,000,000
Project 18	Construcción de mejoras al Sistema de Alcantarillado Sanitario de Antón -	5,000,000
Project 19	Construcción del sistema de alcantarillado sanitario de Boquete	10,000,000
Project 20	Construcción del sistema de alcantarillado sanitario de Ocú -	8,000,000
Project 21	Construcción de alcantarillado sanitario de Macaracas	7,000,000
Project 22	Diseño y Construcción Sistema de alcantarillado sanitario de Chepo	20,000,000
Project 25	Diseño y construcción del sistema de alcantarillado sanitario de Capira	5,000,000
Project 26	Construcción del sistema de alcantarillado sanitario de Bejuco - Chame	18,000,000
Project 28	Ampliación y mejoras del sistema de alcantarillado sanitario de Chitré y alrededores - (Ejecuta el PAN)	42,825,811
Project 30	Construcción del sistema de alcantarillado sanitario de Metetí.	5,413,130
Project 32	Captación y ampliación de la planta potabilizadora de Isla Colón - CAF - II FASE	9,000,000
Project 33	Mejoramiento al sistema de agua potable de El Valle de Antón	5,500,000
	TOTAL	208,088,941

Considering Subsectors: Separating Water and Sanitation

A look at the project rankings and Figure 10 shows that water projects tend to score higher on FEI than sanitation projects. As such, the ranking of projects together results in a matrix that classifies no sanitation projects as 'High Priority' nor 'High Financial-Economic Priority'. The three 'High Social-Environmental Priority' projects, conversely, are all sanitation projects.

This observation reaffirms the need to target investments specifically to sanitation to ensure that much-needed resources are secured for implementation of sanitation improvements. By allocating resources by subsector, the government can identify the sanitation projects that are positioned in the high priority space and carve out budget specifically for the subsector.

To determine additive weights for SEI, we again performed Principal Components Analysis, but separately for the water and sanitation project sets. This would be done for FEI also, if more than one input variable was involved.

Table 6. Revised Water and Sanitation Project SEI PCA Weights

	BEN	EMP	POOR
Combined water and sanitation PCA weighting	0.687	0.233	0.688
Water only PCA weighting	0.625	0.42	0.657
Sanitation only PCA weighting	0.598	0.516	0.613

Next, we estimated separate subsector budget constraints based on 55% allocation of total subsector project costs for each. And finally, we created separate Infrastructure Prioritization Matrices that identified two sets of High Priority projects based on the separate analysis.

Whereas no sanitation projects were classified as High Priority in combined analysis, separating the subsectors promotes sanitation Projects 23 and 24 to High Priority status. The analysis does not change the ranking of projects *within* each subsector.

Figure 10. Water Projects: Infrastructure Prioritization Matrix

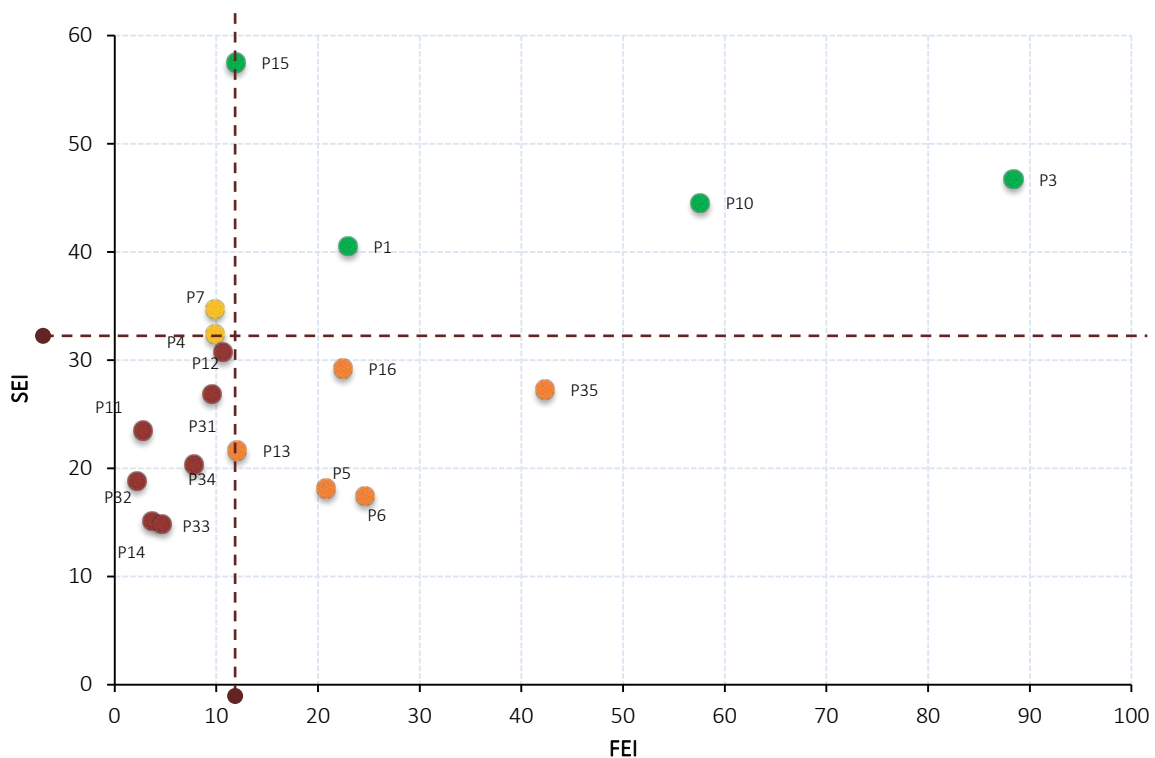


Table 7. IPM Water Project Categorization

High priority projects		Cost
Project 1	Mejoramiento sistemas de agua potable y saneamiento- distrito de Colón	17,650,597
Project 3	Construcción de línea de conducción del Tanque Ameglio - Red de distribución del Sector 3	5,887,649
Project 10	Construcción de línea paralela Sabanitas, Planta - Cuatro Altos	5,000,000
Project 15	Estudio, diseño y construcción para una nueva planta potabilizadora del Río Bayano -	50,000,000
TOTAL		78,538,246
High priority social-environmental projects		
Project 4	Mejoramiento obras complementarias red de distribución - Área Metropolitana (Línea de Conducción Pacora - Tanara - Tataré	5,991,593
Project 7	Construcción de línea de conducción de La Chorrera - Capira, (Sectores 7 y 8)	30,000,000
TOTAL		35,991,593
High priority financial-economic projects		
Project 5	Construcción de mejoras a la red de distribución de Chorrillo y Santa Ana	7,450,110
Project 6	Mejoramiento al Acueducto de San Francisco	5,971,133
Project 13	Mejoramiento al sistema de agua potable de Puerto Armuelles	9,000,000
Project 16	Construcción de obras complementarias para red de distribución de La Chorrera	9,980,000
Project 35	Ampliación de la planta potabilizadora de Santiago	5,000,000
TOTAL		37,401,243
Lower priority projects		
Project 11	Construcción de nueva planta potabilizadora de 10 MGD de Dolega y sectores aledaños	15,300,000
Project 12	Mejoramiento integral al abastecimiento de agua de David	60,000,000
Project 14	Mejoras al sistema de abastecimiento y distribución de agua potable de Santa Marta, Santo Domingo	5,000,000
Project 31	Construcción del sistema de abastecimiento de agua potable de Chorro Blanco, Alanje – Boquerón - II Etapa	12,674,150
Project 32	Captación y ampliación de la planta potabilizadora de Isla Colón - CAF - II FASE	9,000,000
Project 33	Mejoramiento al sistema de agua potable de El Valle de Antón	5,500,000
Project 34	Nueva toma de agua cruda en Bonyic Changuinola	5,000,000
TOTAL		253,268,229

Figure 11. Sanitation Projects: Infrastructure Prioritization Matrix

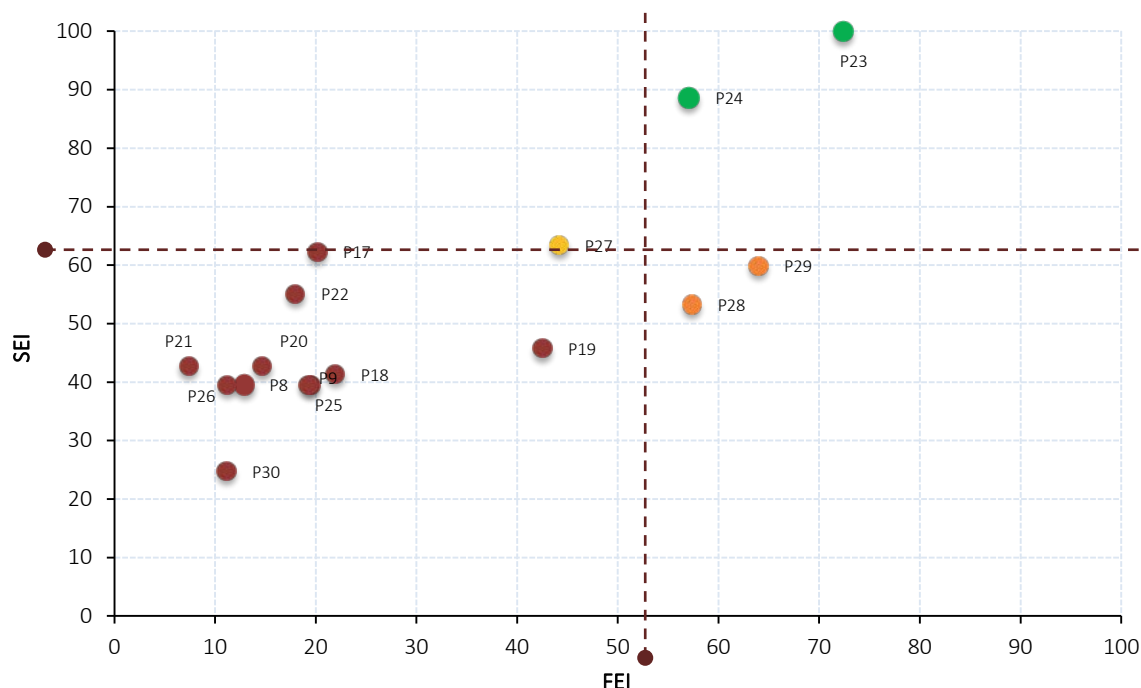


Table 8. IPM Sanitation Project Categorization

High priority projects		Cost
Project 23	Diseño y construcción del sistema de alcantarillado sanitario de Arraiján	50,000,000
Project 24	Mejora Integral del sistema de alcantarillado sanitario de La Chorrera	50,000,000
TOTAL		100,000,000
High priority social-environmental project		
Project 27	Construcción del sistema de alcantarillado sanitario de Santiago (Sistema de recolección y tratamiento de aguas residuales) CAF - II FASE	60,000,000
TOTAL		60,000,000
High priority financial-economic projects		
Project 28	Ampliación y mejoras del sistema de alcantarillado sanitario de Chitré y alrededores - (Ejecuta el PAN)	42,825,811
Project 29	Ampliación y mejoras al sistema de alcantarillado sanitario de Puerto Armuelles - CAF-II FASE	24,397,000
TOTAL		42,825,811
Lower priority projects		
Project 8	Construcción del sistema de alcantarillado sanitario de Parita	6,800,000
Project 9	Construcción del Sistema de Alcantarillado Sanitario de Chilibre Centro	5,250,000
Project 17	Construcción Sistema de alcantarillado de Changuinola	40,000,000
Project 18	Construcción de mejoras al Sistema de Alcantarillado Sanitario de Antón	5,000,000
Project 19	Construcción del sistema de alcantarillado sanitario de Boquete	10,000,000
Project 20	Construcción del sistema de alcantarillado sanitario de Ocú	8,000,000
Project 21	Construcción de alcantarillado sanitario de Macaracas	7,000,000
Project 22	Diseño y Construcción Sistema de alcantarillado sanitario de Chepo	20,000,000
Project 25	Diseño y construcción del sistema de alcantarillado sanitario de Capira	5,000,000
Project 26	Construcción del sistema de alcantarillado sanitario de Bejuco - Chame	18,000,000
Project 30	Construcción del sistema de alcantarillado sanitario de Metetí -	5,413,130
TOTAL		130,463,130

Sensitivity Analysis

To improve the robustness of prioritization results, a sensitivity analysis was introduced. The sensitivity analysis tested how much the ranking of projects change when using alternative weighting schemes on the SEI scores for transport, water, and sanitation projects. Again, the weights assigned to variables in the SEI may be determined by PCA, or other methods, including equal weighting or a weighting scheme that reflects particular policy goals. For example, if there is an emphasis on extending services to the poor or creating employment, these factors in the SEI may be weighted more heavily. However, PCA is best when there is a preference to objectively assign weights. A prioritization scheme where decisions rely on subjective judgment may reduce legitimacy to government decisions, especially in environments with low institutional capacity.

For transport, we tested two alternative weighting scenarios to compare outcomes with the project ranking by PCA-determined SEIs. These alternatives were equal weighting⁷ and a weighting scheme that hypothesizes a government emphasis on most beneficiaries served and most jobs created. These alternative weights are summarized in Table 9.

Table 9. Transport SEI Sensitivity Analysis

	BEN_COS	EMP_COS	POOR_COS
PCA Weighting	0.638	0.439	0.633
Alternative scenario 1: Equal weighting	0.577	0.577	0.577
Alternative 2	0.650	0.650	0.394

Similarly, for water and sanitation projects (still evaluated separately), we tested alternative scenarios of equal weighting and ranking by the combined water-sanitation PCA weights. The latter (termed 'Alternative 2') can also be thought of as hypothetically representing a policy priority on overall beneficiaries and poor due to higher weights for these variables. These weighting scenarios are summarized in Tables 10 and 11.

Table 10. Water SEI Sensitivity Analysis

	BEN	EMP	POOR
PCA Weighting	0.638	0.439	0.633
Alternative scenario 1: Equal weighting	0.577	0.577	0.577
Alternative 2	0.687	0.233	0.688

Table 11. Sanitation SEI Sensitivity Analysis

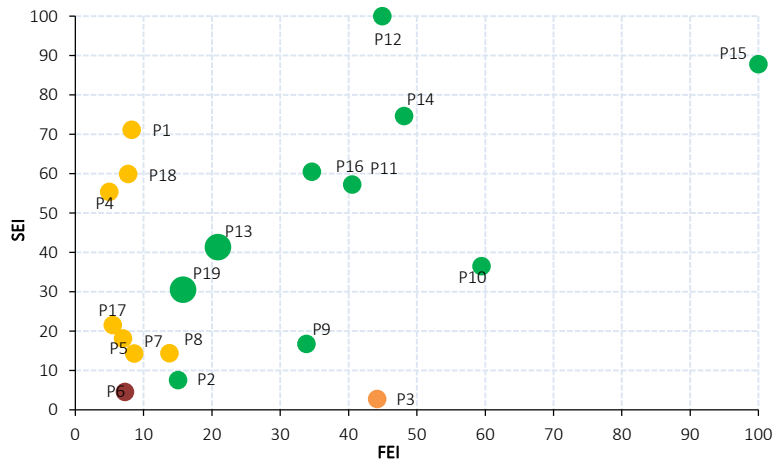
	BEN	EMP	POOR
PCA Weighting	0.598	0.516	0.613
Alternative scenario 1: Equal weighting	0.577	0.577	0.577
Alternative 2	0.687	0.233	0.688

To demonstrate the results of sensitivity analysis, we present three Infrastructure Prioritization Matrices each for transport, water, and sanitation. The results in Figures 14, 15, and 16 reveal an important finding, namely that project rankings change very little with alternative weighting scenarios. This suggests that SEI scores are much more sensitive to the values of input variables themselves than to the weighting system applied to combine them. It also demonstrates the robustness of results generated by the PCA-weighted Infrastructure Prioritization Framework. Nevertheless, alternative weighting may be still applied to meet policy requirements.

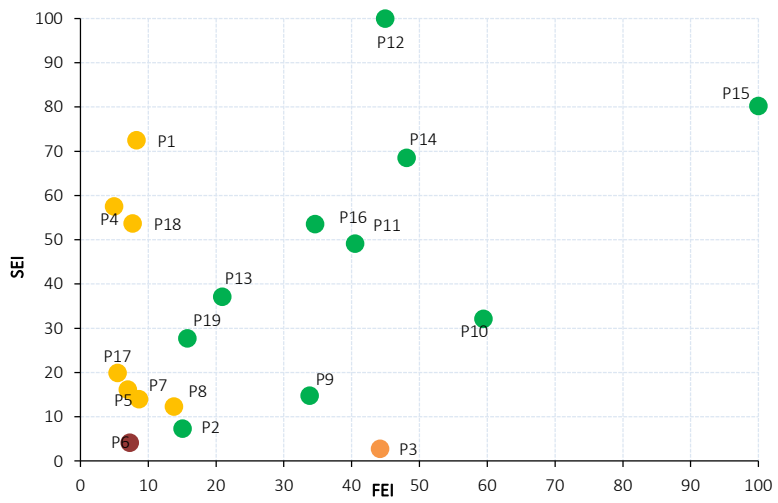
7. In keeping with PCA, .577 is used so that the sum of the square of each element equals 1.

Transport Sensitivity Analysis

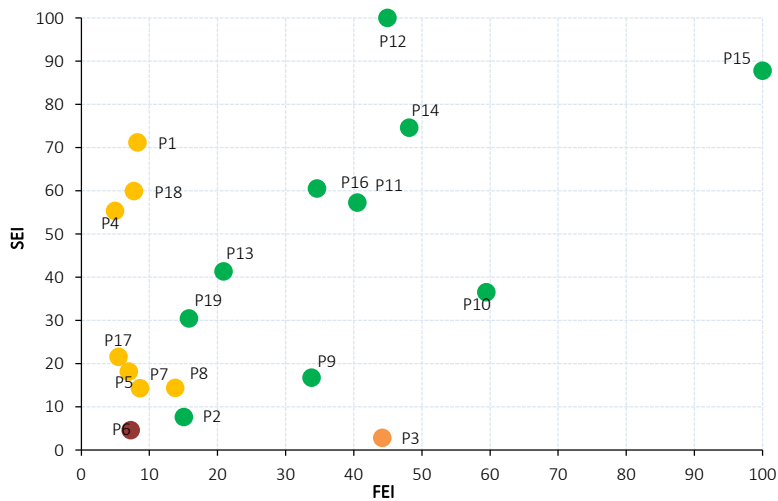
Original IPM



Alternative 1
Equal weight

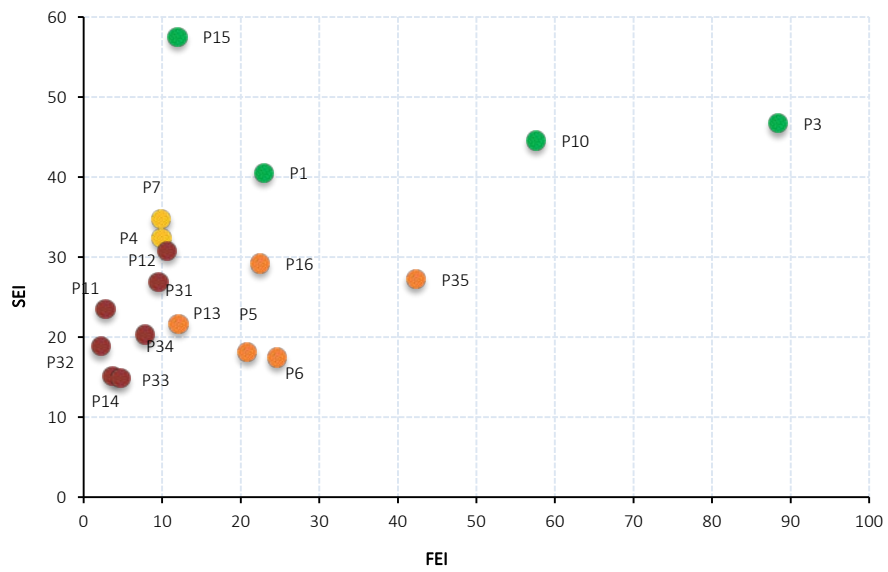


Alternative 2

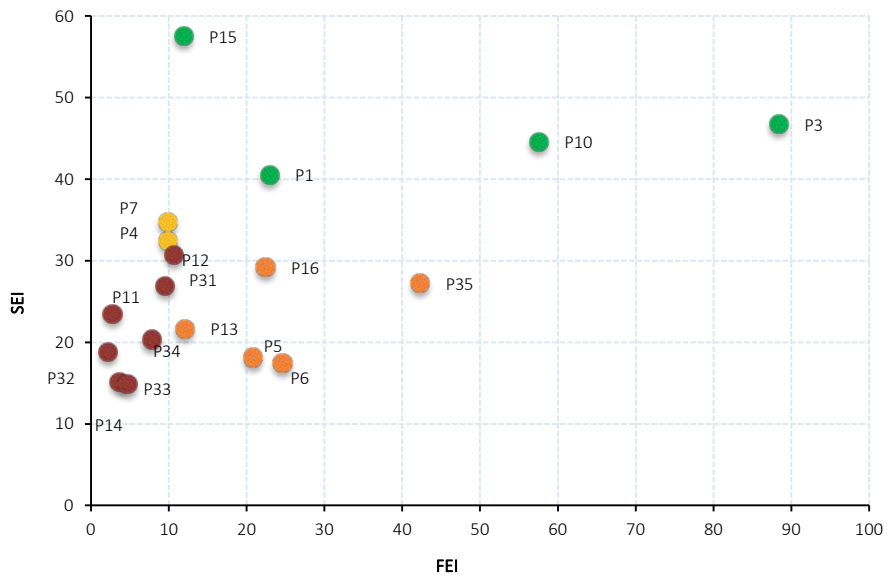


Water Sensivity Analysis

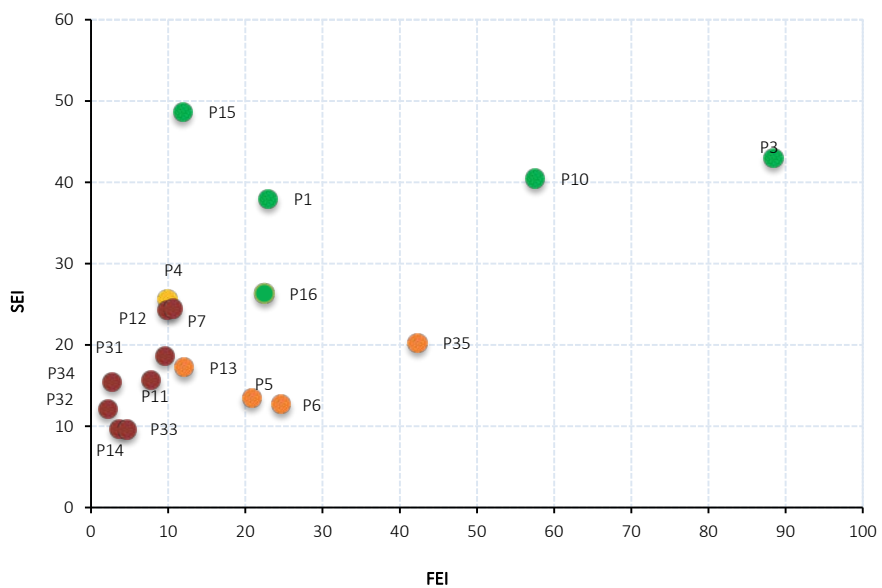
Original IPM



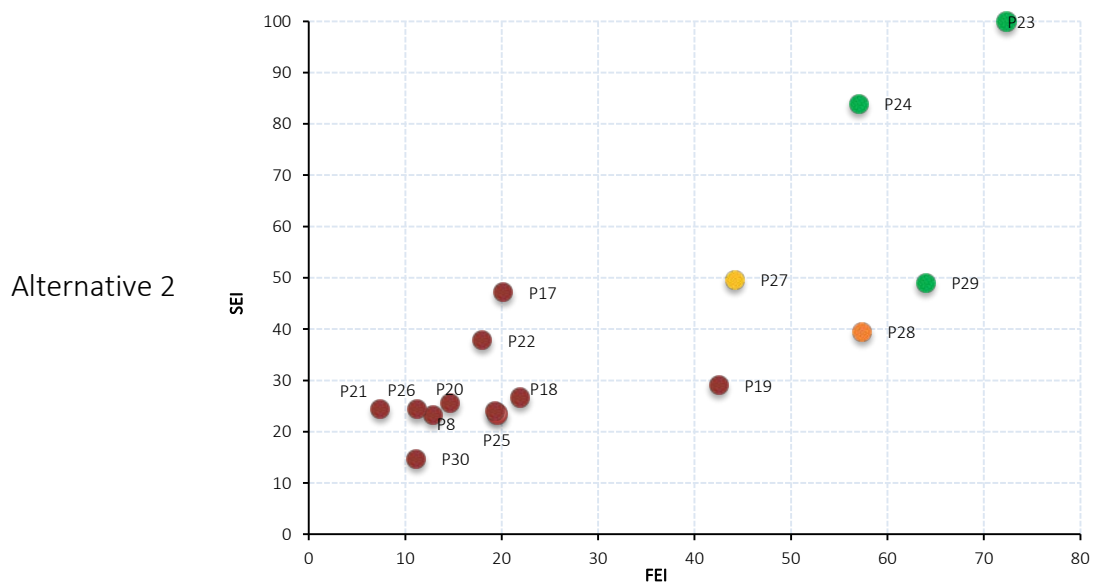
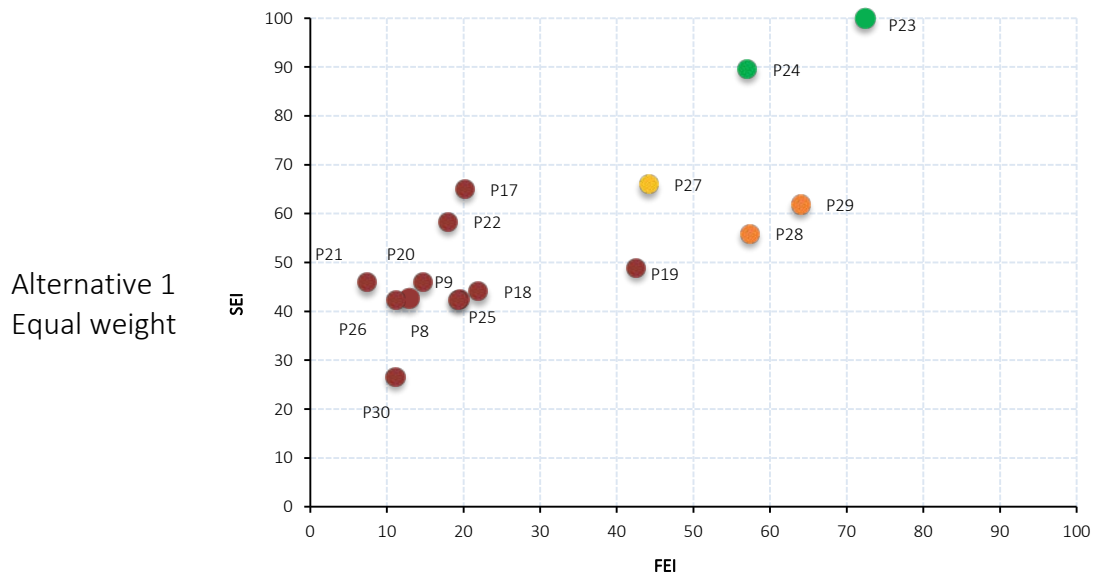
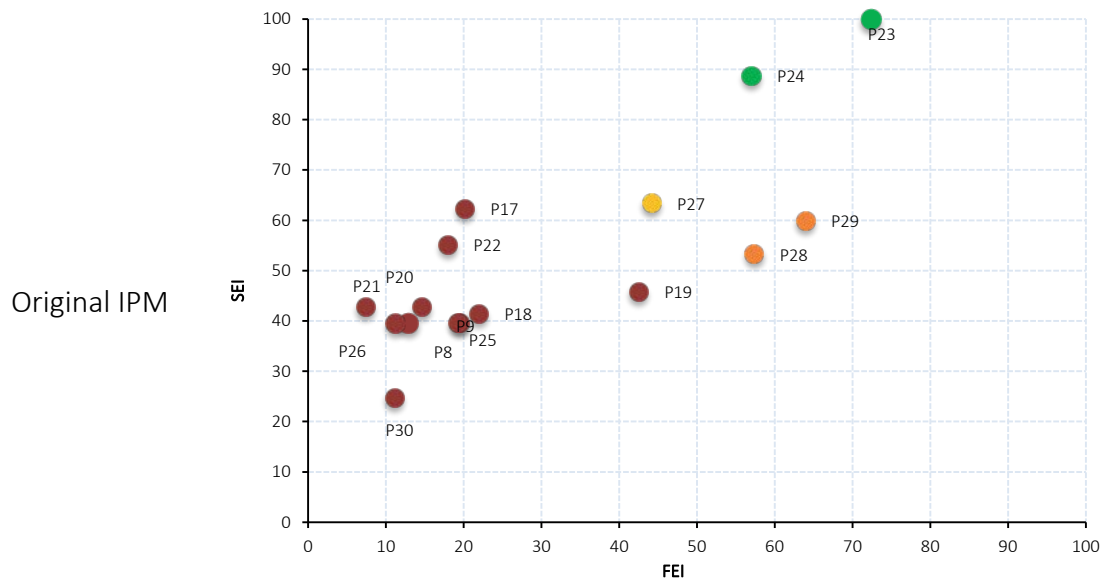
Alternative 1
Equal weight



Alternative 2



Sanitation Sensivity Analysis



Step 5. Selecting Projects

Projects categorized as ‘High Priority’ in Quadrant A are natural targets for project selection, as they represent the set of projects that score highly with respect to both social-environmental and economic-financial considerations. Projects in Quadrants B and C, on the other hand, score relatively high on either the SEI or FEI, but not both. If all Quadrant A projects are selected, the remaining budget could be allocated to either (a) all projects in Quadrant B, if social-environmental factors are privileged over financial-economic ones, (b) all projects in Quadrant C, if financial and economic factors are most important, or (c) a combined array of select projects from each.

Selection of a mixed set from amongst Quadrants B and C makes space for expert review, flexibility, and informed political debate. The negotiated process of ordering projects within Quadrants B and C (and even those clustered around the quadrant intersection in Quadrant D) allows IPF to capture important information from the professional and political bases of knowledge amongst decision-makers. In other words, the framework informs decisions regarding projects in the medium-priority set, but leaves room for structured professional and political judgment.

Considering Projects at the Intersection

It is important to note that projects in Quadrant D are not automatically removed from consideration. While categorized as ‘Lower Priority’, they may be considered alongside High Priority FEI and SEI projects when they are clustered around the intersection of the budget line and also score relatively higher than some projects in Quadrants B or C along one dimension.

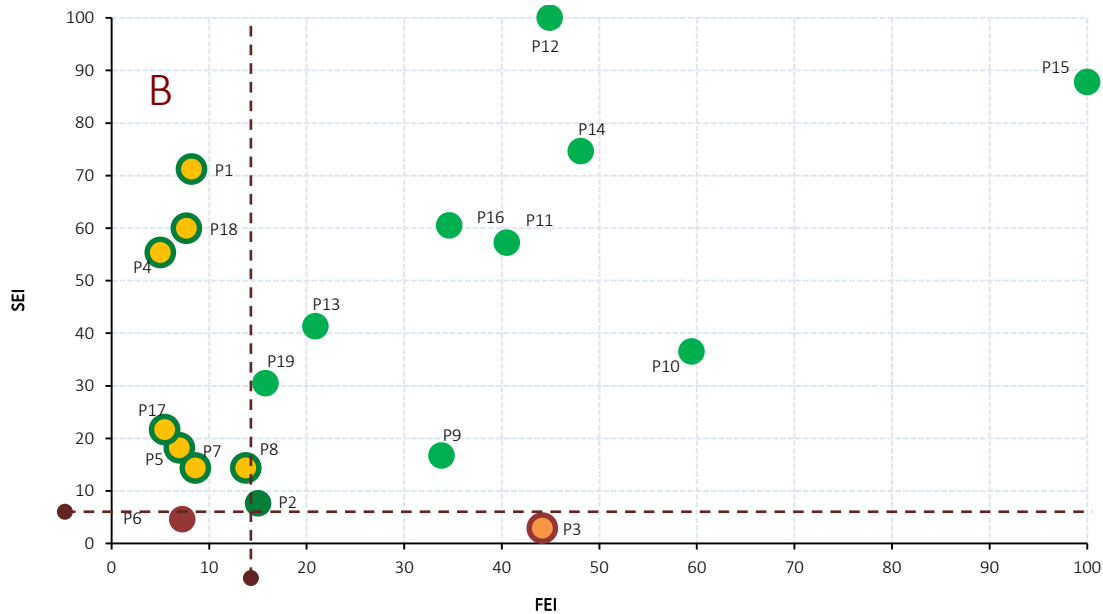
This is demonstrated in Figure 10 above, where some Quadrant D water and sanitation projects clustered around the axis score relatively higher on SEI than some projects in Quadrant C, ‘High Priority FEI’. For example, Project 12, located in Quadrant D near the axis, has a higher SEI score than Projects 5 and 13 in Quadrant C, which have a higher FEI but low social-environmental rating. If government prioritizes social and environmental considerations above financial aspects, some projects in Quadrant D may compete strongly with those ‘High Priority FEI’ projects with relatively low SEI scores. Conversely, some ‘High Priority SEI’ projects score lower on FEI than do the ‘Lower Priority’ projects clustered near the axis.

Tradeoffs: Considering High-Cost Projects

In some cases, a project with a very high cost may fall within Quadrant B or C but score low on one dimension. As such, when considering the Quadrant B and C projects, implementation of the high cost project may mean that Government must forgo funding a number of other smaller projects. In this case, it would be recommendable to acknowledge tradeoffs between one large project and many others – a decision that comes with political ramifications.

For example in Transport, Project 3 is positioned in Quadrant C, and is one of three very high cost projects (the others are Projects 2 and 6) with a total cost of \$ 58,668,000. By foregoing Project 3, the Government could instead fund seven projects (Projects 1, 4, 5, 7, 8, 17, and 18) in Quadrant B, which all score higher with respect to SEI and total only \$33,545,000 combined.

Figure 12. Considering Transport project tradeoffs, P2 versus all projects in Quadrant B



Next Steps: Implementing IPF

The following section discusses challenges to IPF in Panama, key lessons drawn from the pilot, and next steps for full implementation.

Challenges and Lessons

The main challenge to overcome in moving towards full implementation of the IPF is the limited and deficient technical, financial and economic data at the project level. Calculation of the SEI and FEI depends on the availability and consistency of indicator values for each project. At present, these are missing for some projects or of undetermined accuracy.

In 2001, the Public Investments System of Panama (SINIP) was created under the Panama Ministry of Economy and Finance (MEF) to store project-level information. One of the main institutional goals of the SINIP was to provide an information system for designing, evaluating, training and monitoring investment projects in the public sector (Executive Decree 148, December 11, 2001). While this could be a useful platform on which to base IPF, information consigned in the SINIP database is not currently sufficient to implement the framework. There are no established basic information requirements for all projects, and the definitions and consistency of variables stored vary from project to project, even within a particular sector. Moreover, this analysis has identified important data limitations in the selected sectors.

For example, between 1995 and 2005, the Panama Ministry of Public Works (MOP) carried out economic evaluations based on the Highway Development and Management Model (HDM), versions 3 and 4. Technical and economic evaluations of road projects were based on the HDM. However, this practice was suspended 10 years ago, and since then, there is no systematic production of data for proper financial and economic analyses of transport projects.

To strengthen the SINIP database and make it suitable for the IPF, we recommend adding a prioritization module to systematically gather a minimum set of relevant information to assess,

rank and select projects. This model would be used to populate the database on which to run the IPF analysis, as described in the steps above. Building this platform would require (a) a redesign or at least modification of the existing SINIP platform, and (b) a training plan to develop the institutional capacity within MEF to monitor the quality of data, interpret results and update the IPF platform.

Three main lessons have emerged from this analysis. First, although a full CBA assessment for each of the proposed infrastructure projects to the MEF is unrealistic given the information requirements, set assumptions, and extensive technical and resource needs, we recognize the value of incorporating CBA elements on the financial and economic side of the IPF. To integrate available CBA elements into the framework, we calculated Benefit-Cost Ratios (BCRs) that contrasted the net present value of observable monetary (monetized) flow of revenues against the observable flow of costs per project. While this information significantly enriched the FEI estimations, it is still insufficient to provide a comprehensive picture of the financial and economic aspects of the infrastructure projects. For a full implementation of the IPF, we recommend to combine the BCR information with other financial and economic aspects, such as externalities, multiplier effects, and implementation risks.

The second main lesson, drawn from sensitivity analysis, is that IPF is more sensitive to indicator values than the weights assigned to each variable. This finding shows that PCA weighting is a good approach to combining indicators into index values, as it is both objective and robust. The objectivity of index construction lends credibility to project selection and helps protect against over-politicization of project selection or allegations of particularistic policy making.

The third lesson is that it may be desirable to prioritize projects at the subsector level. In the separation of water and sanitation projects in the pilot, we see the benefit of prioritizing subsectors separately. This could also reasonably apply to the consideration of construction versus rehabilitation projects within a sector such as transport. The advisability of separating project analysis by subsector will depend on the number of projects to be prioritized, patterns in the results of combined analysis, and policy goals. To the first point, there should be a sufficient number of each sub-category of project to justify disaggregation. To the second point, if a certain category of project regularly scores comparatively low but is responding to a particular policy goal (e.g., sanitation projects), they may be considered separately.

There are some additional needs related to variable definitions that must be dealt with moving forward. For one, variables must be carefully defined to ensure that PCA applies as intended. In the pilot, poverty levels (in percentage terms) were inversely related to other desirable factors (e.g., jobs created, beneficiaries). This resulted in PCA-determined weights that negatively weighted poverty, which stands at odds with policy goals. This may be dealt with in several ways, but our approach was to select a different poverty metric, the absolute number of poor beneficiaries, which both reflected poverty levels and also yielded positive PCA weights.

Another variable decision, which may be made on a sector or subsector basis, is whether to choose indicators that are reflective of effectiveness or efficiency. For example, if the number of beneficiaries is known (as an input to the SEI), one could use the absolute value to help answer questions of effectiveness (e.g., expansion of service to the most people possible). On the other hand, an indicator such as 'beneficiaries per dollar spent' or 'dollars per beneficiary', would demonstrate a measure of efficiency.

Lastly, it is important for decision-makers to be aware that project outcomes tend to be better in high-income areas. In a past pilot application to Vietnam, we discovered an inherent bias towards infrastructure projects in wealthier regions attributable to better project preparation and generally better social-environmental indicator scores for direct beneficiaries or jobs created. Whilst the poverty score can counter-balance this, the issue is important to keep in mind. This can be further tested by mapping results to location and local economic and development conditions.

Implementation Requirements

Implementing the IPF to full infrastructure sectors will require the commitment of staff and resources for data collection and analysis, as well as the establishment of an institutional set-up and decision-making structure that can facilitate the IPF and translate its outputs into decision-making. In this section, we propose organizational and resource recommendations for implementation.

Recalling the IPF process map, we identify three sets of requirements for each step: participants, capacities, and resources.

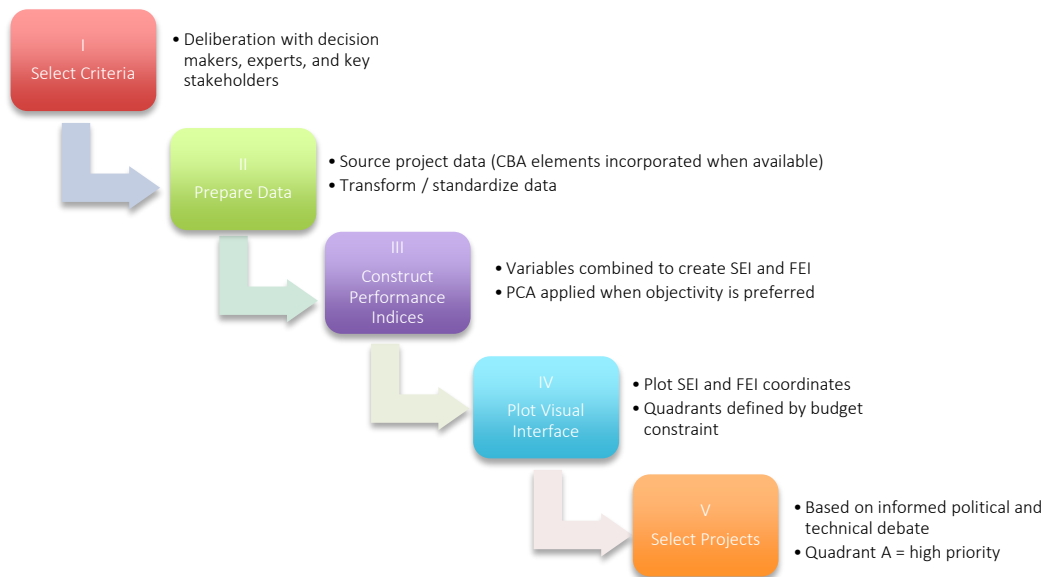


Table 12 describes the general participant, capacity, and resource requirements needed for each step of the IPF process. Naturally, the set of participants included in each stage is subject to MEF guidance, but we make some preliminary suggestions here.

Table 12. IPF Implementation Requirements

IPF Step	Participants	Capacities	Resources
1. Select criteria	MEF Sector agency managers and experts	Knowledge of key policy goals Knowledge of financial and economic project indicators at sector level Knowledge of available/possible social and environmental indicators	Authority over project selection
2. Gather / prepare data	Consultants Line agency analysts	Expertise in sector Experience with basic economic and financial calculations Fluency with Excel	Data: project proposals and constructed estimates, where necessary Project feasibility and pre-feasibility study documents IPF platform (SINIP) database inputs
3. Construct performance indices	Consultants MEF analysts Line agency analysts	Experience with basic economic / financial calculations Fluency with MS Excel Familiarity with STATA or other statistical software	STATA or other statistical software Populated project variable dataset
4. Plot visual interface	Consultants MEF Analysts and sector experts	Fluency with MS Excel Familiarity with basic quantitative analysis	MS Excel SEI / FEI index outputs
5. Select projects	MEF Sector agency managers	Project experience Familiarity with political issues and sectoral policy goals	Authority over project selection and budget allocation

The table above proposes that the levels of authority required for successful implementation of each step are highest in the first and fifth steps, whereas technical analytical skills are highest in the second through fourth steps. The beginning (criteria selection) and final stage (project selection) of IPF are the most inherently political and require sufficient authority over infrastructure policy setting for IPF to be effective. In other words, the participants in Steps 1 and 5 must be actors who also have the authority to make investment decisions.

The technical steps (2 through 4) may be relegated to technical analysts or consultants with sectoral experience and familiarity with quantitative analysis. The latter is important for checking the reliability and soundness of inputs sourced from project information sheets, and specialists may also be required to perform their own estimates of projected benefits, environmental impacts, and risk, depending on the data supplied by government.

Improving Project Data

There are two areas where project data may be improved: in the SINIP system and in pre-feasibility and feasibility studies. In consultation with MEF and line agencies, the SINIP can be made to include a prioritization platform that specifically requires the submission of IPF data during project proposal. The platform should include some data points that are generally applicable to all sectors, but may also be customized to reflect particular policy goals of a sector or subsector. For example, if the reduced congestion or improved connectivity are key transport policy goals, metrics can be designed for inclusion in the platform for transport projects.

Other data may be gathered from more detailed feasibility studies. At present, the proposed projects over 0.1% of the General State Budget require feasibility studies, and projects under this amount but over \$5 million require pre-feasibility studies. The content of these studies and their basic requirements can be customized to meet the needs of implementing IPF. In particular, the feasibility studies must also be made to justify and explain the calculations or estimates of key social variables, such as number of beneficiaries and number of poor served, and important financial-economic inputs such as benefit-cost ratios, internal rates of return, or net present values. This requires better data on the streams of costs and revenues over a project's lifecycle, as well as better projections of service, which are key to ensuring that the indicators submitted for each project are comparable across projects.

In addition to improving data collection, index construction would be improved by better indicator specification. For example, the FEI would be strengthened by consideration of other important financial-economic factors, beyond the BCR, as well as by capturing other measures of benefits. For example, economic multiplier effects could be estimated with further disaggregation of national input-output tables by service sector for the construction industry. Better measures of implementation risk could help quantify the costs of potential implementation challenges. And the quantification of benefits could also be improved. To this last point, whereas transport estimates involved maintenance costs saved from rehabilitation and water estimates accounted for 'benefits' via tariff revenues, there was little data available to capture the benefits of sanitation projects, such as mitigation of health and productivity costs. Work done by the World Bank⁸ on estimating the costs associated with under provision could be useful to inform estimation of these benefits.

With respect to social and environmental indicators, measures of environmental impact (e.g., carbon footprint) may be greatly improved to reflect the environmental costs of proposed projects, and a measure of social risks should be better specified to capture potential human impacts. At present, a simple high-medium-low score was given to reflect these risks, which is too imprecise to be useful for IPF or decision-making, in general. These variable specifications need to be further developed in consultation with decision-makers.

The pilot application of IPF demonstrates the analytical power of a systematic infrastructure investment decision framework and offers an approach to improve the evidence base for infrastructure decisions. The approach is objective and data-driven yet based on the application of consensus-determined decision criteria. This allows for transparency in investment decisions alongside improved responsiveness to policy goals. Furthermore, the use of evidence is balanced by a degree of flexibility to accommodate sector-level policy and incorporate valuable practice-based, professional, and political knowledge at multiple levels of government.

8. For an example methodology, see the 2008 Water and Sanitation Program's Research Report 'Economic Impacts of Sanitation in Southeast Asia' which details their approach to estimating health, productivity, and water-related costs of sanitation.

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Annex 1. Transport Projects

ID	COST	Project Name	SEI Inputs			FEI Input		
			BEN	EMP	POOR	BCR	SEI	FEI
Project 1	1,800,000	Rehabilitación Carretera de Anachucuna	6,733	33	5,992	0.242	68	8.2
Project 2	45,000,000	Rehabilitación Camino Tortí-Chimán-Gonzalo Vásquez	16,680	108	11,676	0.442	7	15.0
Project 3	58,668,000	Rehabilitación Carretera Las Tablas-Los Asientos-Cañas-Cacao	14,056	40	5,622	1.298	3	44.2
Project 4	2,997,000	Rehabilitación carretera de Irgandi (para llegar a la Comunidad de Playón Chico)	11,644	33	8,617	0.147	56	5.0
Project 5	4,800,000	Rehabilitación Carretera CPA-Calabacito	1,718	40	1,220	0.205	13	7.0
Project 6	63,000,000	Rehabilitación Carretera Circunvalación Garachiné-La Palma	6,604	130	4,557	0.214	3	7.3
Project 7	8,948,000	Rehabilitación Carretera Tambo-Las Marías y Construcción de Puentes Vehiculares (5)	5,240	42	4,559	0.253	13	8.6
Project 8	5,400,000	Rehabilitación Carretera Loma Del Naranjo-Tres Quebradas	831	40	391	0.405	9	13.8
Project 9	4,880,000	Rehabilitación Calles de Penonomé (Vista Hermosa)	3,063	35	1,011	0.994	12	33.8
Project 10	4,720,000	Rehabilitación Calles de Playa Leona (La Mitra hacia Peñas Blancas y Paso Arenas)	8,442	70	2,026	1.747	27	59.4
Project 11	1,600,000	Rehabilitación Calles de La Chorrera	1,354	46	555	1.191	38	40.5
Project 12	4,500,000	Rehabilitación Calles de Chilibre	53,955	60	18,884	1.321	100	44.9
Project 13	4,200,000	Rehabilitación Calles del Distrito de Aguadulce	12,881	58	2,834	0.614	33	20.9
Project 14	4,000,000	Rehabilitación Calles de Colon (Casco Antiguo y Arco Iris)	39,453	57	6,312	1.414	66	48.1
Project 15	2,000,000	Rehabilitación Calles del Distrito de Bugaba	17,698	46	3,540	2.939	74	100.0
Project 16	4,050,000	Rehabilitación Calles de Santiago (2015)	31,065	58	3,107	1.017	50	34.6
Project 17	8,000,000	Construcción Camino Quebrada Honda	6,923	66	3,877	0.161	17	5.5
Project 18	1,600,000	Rehabilitación Carretera Juay-Quebrada del Loro -Cañazas	1,616	44	1,503	0.227	44	7.7
Project 19	2,480,000	Rehabilitación Carretera Lagarterita-Los Hules-Las Pavas-Lagartera Grande y Mejora del Puente	2,996	30	1,438	0.464	24	15.8

Annex 2. Water and Sanitation Projects

ID	COST	Project Name	SEI Inputs			FEI Input			
			BEN	EMP	POOR	BCR	SEI	FEI	
Project 1	17,650,597	Mejoramiento sistemas de agua potable y saneamiento- distrito de Colón	206481	125	74333	1.148	36.76	22.96	
Project 2	16,194,901	Construcción línea paralela hacia Costa del Este	874935	138	166238	10.688	<i>outlier</i>		
Project 3	5,887,649	Construcción de línea de conducción del Tanque Ameglio - Red de distribución del Sector 3	315019	156	63004	4.420	41.43	88.41	
Project 4	5,991,593	Mejoramiento obras complementarias red de distribución - Área Metropolitana (Línea de Conducción Pacora - Tanara - Tataré	67265	156	36996	0.495	22.93	9.90	
Project 5	7,450,110	Construcción de mejoras a la red de distribución de Chorrillo y Santa Ana	36512	98	13144	1.041	11.66	20.83	
Project 6	5,971,133	Mejoramiento al Acueducto de San Francisco	43939	98	8348	1.231	10.85	24.62	
Project 7	30,000,000	Construcción de línea de conducción de La Chorrera - Capira (Sectores 7 y 8)	53247	208	13844	0.494	20.12	9.87	
Project 8	6,800,000	Construcción del sistema de alcantarillado sanitario de Parita	3723	191	1378	0.064	13.49	1.29	*
Project 9	5,250,000	Construcción del Sistema de Alcantarillado Sanitario de Chilibre Centro	6813	189	1363	0.098	13.50	1.95	*
Project 10	5,000,000	Construcción de línea paralela Sabanitas, Planta - Cuatro Altos	206481	153	74333	2.879	38.67	57.57	
Project 11	15,300,000	Construcción de nueva planta potabilizadora de 10 MGD de Dolega y sectores aledaños	16636	152	4658	0.138	12.28	2.76	
Project 12	60,000,000	Mejoramiento integral al abastecimiento de agua de David	116000	148	25520	0.532	21.97	10.64	
Project 13	9,000,000	Mejoramiento al sistema de agua potable de Puerto Armuelles	47401	103	25123	0.603	15.45	12.07	
Project 14	5,000,000	Mejoras al sistema de abastecimiento y distribución de agua potable de Santa Marta, Santo Domingo	3905	102	1406	0.183	7.46	3.66	
Project 15	50,000,000	Estudio, diseño y construcción para una nueva planta potabilizadora de Río Bayano	156698	239	86184	0.596	44.96	11.92	
Project 16	9,980,000	Construcción de obras complementarias para red de distribución de La Chorrera (Estación de bombeo y proyectos complementarios La Chorrera)	161470	103	41982	1.122	25.16	22.44	
Project 17	40,000,000	Construcción Sistema de alcantarillado de Changuinola	31223	238	21544	0.101	22.96	2.02	*
Project 18	5,000,000	Construcción de mejoras al Sistema de Alcantarillado Sanitario de Antón	9788	186	5579	0.110	14.47	2.19	*
Project 19	10,000,000	Construcción del sistema de alcantarillado sanitario de Boquete	15339	208	4142	0.213	15.89	4.25	*

Project 20	8,000,000	Construcción del sistema de alcantarillado sanitario de Ocú	7006	203	1962	0.073	14.61	1.47	*
Project 21	7,000,000	Construcción de alcantarillado sanitario de Macaracas	2890	203	1329	0.037	14.25	0.74	*
Project 22	20,000,000	Diseño y Construcción Sistema de alcantarillado sanitario de Chepo	20420	234	11231	0.090	19.64	1.80	*
Project 23	50,000,000	Diseño y construcción del sistema de alcantarillado sanitario de Arraiján	220779	243	50779	0.362	39.73	7.24	*
Project 24	50,000,000	Mejora Integral del sistema de alcantarillado sanitario de La Chorrera	161470	243	41982	0.285	34.67	5.70	*
Project 25	5,000,000	Diseño y construcción del sistema de alcantarillado sanitario de Capira	5181	186	2901	0.096	13.59	1.93	*
Project 26	18,000,000	Construcción del sistema de alcantarillado sanitario de Bejuco – Chame	7980	184	3032	0.056	13.63	1.12	*
Project 27	60,000,000	Construcción del sistema de alcantarillado sanitario de Santiago (Sistema de recolección y tratamiento de aguas residuales) CAF-II FASE	64856	234	17511	0.221	23.35	4.42	*
Project 28	42,825,811	Ampliación y mejoras del sistema de alcantarillado sanitario de Chitré y alrededores - (Ejecuta el PAN)	50694	210	10139	0.287	19.22	5.74	*
Project 29	24,397,000	Ampliación y mejoras al sistema de alcantarillado sanitario de Puerto Armuelles - CAF-II FASE	47401	208	25123	0.320	22.59	6.40	*
Project 30	5,413,130	Construcción del sistema de alcantarillado sanitario de Metetí.	2313	118	1411	0.056	8.47	1.11	*
Project 31	12,674,150	Construcción del sistema de abastecimiento de agua potable de Chorro Blanco, Alanje - Boquerón - II Etapa	31537	162	11669	0.478	15.40	9.55	
Project 32	9,000,000	Captación y ampliación de la planta potabilizadora de Isla Colón - CAF-II FASE	7364	125	2651	0.109	9.50	2.18	
Project 33	5,500,000	Mejoramiento al sistema de agua potable de El Valle de Antón	7602	98	2129	0.234	7.55	4.68	
Project 34	5,000,000	Nueva toma de agua cruda en Bonyic, Changuinola	31223	103	21544	0.391	13.79	7.81	
Project 35	5,000,000	Ampliación de la planta potabilizadora de Santiago	64856	148	17511	2.115	17.51	42.31	
* Sanitation projects									

Annex 3. Example Excel Project Data Form

Project Prioritization Form

Project Name
Sector
Total Cost (US \$ dollars)
Implementation time (Years)

*The empty fields below should be populated with the data you have gathered for each project.
Once you click "Submit" this form will reset. thereafter you can enter in the data from your next project*

Social and Environmental Indicators (SEI)

- 1 Number of direct beneficiaries (BEN)
- 2 Direct jobs during Implementation (EMP)
- 3 Poor population targeted (POOR)
- 4 Region according poverty level (POV)
- 5 Social and environmental risks (SER)
- 6 Carbon Footprint (CO2)

Financial and Economic Indicators (FEI)

- 1 Internal Rate of Return (IRR)
- 2 Economic Rate of Return (ERR)
- 3 Net Present Value (NPV)
- 4 Benefit Cost Ratio (BCR)
- 5 Multiplier effects (ME)
- 6 Implementation Risks (IR)

*In the following section please make a comment on how difficult you found it to gather the various pieces of data.
If you made any adjustments to the recommended calculations, please make note of change in this section. Please provide any other info the World Bank may find helpful.*