An Envision Rating System Approach to Sustainable Infrastructure in Latin American and the Caribbean. Infrastructure 360 Awards, Lessons Learned.

Citation

Contreras Casado, Cristina. 2016. An Envision Rating System Approach to Sustainable Infrastructure in Latin American and the Caribbean. Infrastructure 360 Awards, Lessons Learned.. Master's thesis, Harvard Extension School.

An Envision Rating System Approach to Sustainable Infrastructure in Latin American and the Caribbean. Infrastructure 360 Awards, Lessons Learned.

,

Cristina Contreras Casado

Thesis in the Field of Sustainability
for the Degree of Master of Liberal Arts in Extension Studies

Harvard University
November 2016

Abstract

The infrastructure spending required to supply global demand (the infrastructure gap) has been estimated at US$3.7 trillion annually worldwide. Considering this demand and the vast amount of social and environmental capital invested in closing the gap, it is especially important to create more sustainable infrastructure projects. In order to define the criteria to be applied, it is crucial to answer questions such as: (i) What are the best practices to apply in a project for a more sustainable outcome? (ii) What is the current state of sustainability integration in infrastructure projects?

To narrow the scope, this research will focus on the Latin American and Caribbean (LAC) region, and will be framed by the initiative of the Infrastructure 360 Awards. This initiative was promoted by a partnership of the Inter-American Development Bank and Harvard University to identify, evaluate, and reward sustainable practices implemented in infrastructure projects developed in the LAC region. This initiative provides an unparalleled body of knowledge by the uniform application of the same methodology (the Envision rating system) to a total of 38 projects, making it possible to draw conclusions about the current sustainability performance of an infrastructure project and opportunities for improvement. To participate in the Infrastructure 360 Awards initiative, projects had to be privately funded, with a budget of more than US$30 million, and had to be in a current phase of construction during the year of the award or recently completed.

The Envision rating system data on these projects was used to test the following hypotheses: (1) larger-scale infrastructure projects in Latin America have incorporated better practices than smaller-scale projects; (2) projects located in more developed countries have stronger regulatory frameworks in social and environmental requirements and therefore more sustainable outcomes; (3) projects financed by multilaterals, such as the World Bank, Investment Financial Institution (IFC) or the Inter-American Development Bank (IDB), will have more sustainable practices, and score higher in the assessment, than projects financed by other sources; and (4) project typology plays an important role in determining the sustainability outcome of the projects. To test these hypotheses, a statistical analysis was conducted using R3.3.1 software, as well as spreadsheet analysis. According to the statistical analysis, and taking an alpha level of 0.05, the project typology- hypothesis 4- was statistically significant. The other three hypotheses would require a larger sample size of 139 projects to achieve enough explanatory power to reject or fail to reject the null hypothesis testing 64.30% of the possible variables correlations. The spreadsheet analysis conducted took two different views: (i) analysis by Envision category and (ii) analysis by project typology. This showed that project leadership is a key matter to ensure high sustainability, that projects have low scores in issues related to infrastructure resiliency, and that water and waste projects have overall high performance vs. transportation or energy ones.

Besides advancing the state of knowledge in the field of infrastructure sustainability, this research also provides a framework of preferable practices to be applied for decision makers, developers or policymakers for improving the sustainability performance of infrastructure projects.

Dedication

I dedicate this master’s thesis to

My mom, Marisol Casado & my dad, Mariano Contreras – who returned to be energy in this universe – and both made me the person that I am today.

Acknowledgements

I would like to thank my thesis director, Dr. Thomas P. Gloria, for his help during this process. He has provided not just excellent guidance but also much-needed encouragement when necessary. I would also like to thank all the members of the Zofnass Program for Sustainable Infrastructure, Research Program at the Graduate School of Design (GSD) at Harvard University, where I have been working for the last four years. This thesis would not have been possible without them and the research conducted during this time. A special thanks to my mom Marisol and her unconditional support. To my sister Lydia and her willingness to help when necessary, to my niece Brianda who made me realize the importance of the future, and to the rest of my family who always encouraged me to pursue my goals and dreams and were with me in moments of adversity. Thanks also to my friends and especially to Dr. Dahianna Lopez de Fausto, who has always been a source of inspiration to me, and will remain so in the future.

Table of Contents

List of Tables

List of Figures

Chapter I

Introduction

Infrastructure is a key pillar of modern society. The satisfactory provision of infrastructure projects causes big differences among nations' level of development and their economic competitiveness worldwide. Infrastructure projects have an average lifespan of 50–100 years, and therefore a substantial impact on the surrounding communities, the development in the region, and the quality of life of the population. Infrastructure projects are also big users of materials and resources; therefore, it is important to take into consideration the environmental impact that some developments may have on biodiversity, water quality, or environmental services. The construction of certain large-scale infrastructure projects has become a key strategy to combat climate change and increase resiliency.

Research Significance and Objectives

Given the consensus on the importance of building sustainable infrastructure – not just infrastructure – the following questions arise: What are the characteristics of a sustainable infrastructure project? How can projects be built in a more sustainable manner? And how far is it from achieving this goal? To address this broad topic in a more manageable way, this research will focus on the Latin American and Caribbean (LAC) region, and it will be framed by the initiative named the Infrastructure 360 Awards. This initiative was developed by a partnership of the Inter-American

Development Bank (IDB) and Harvard University. The completion of this research will advance the state of knowledge in the field of sustainability in infrastructure and the current stage of implementation in the LAC.

The significance of this research will be to filter out the best practices of the projects evaluated in the Infrastructure 360 Awards during the last three years (2013–2015), in order to identify opportunities for improvement to be applied to other projects in the region. Some questions guiding the identification of these best practices are: How can the project impact the growth and development of the communities located nearby? What type of long-term monitoring is planned to guarantee the sustainable performance in the long run? Is there some strategy in place to minimize the use of materials in this infrastructure? What is the impact of the project on biodiversity? Is this development integrating strategies to promote a more resilient outcome? More than 60 factors are measured in the 38 projects assessed in this thesis. Similar research to the Infrastructure 360 Awards has not been previously conducted, and the analysis of the information gathered will provide a means to critically examine future projects to highlight their differences and identify best practices. One of the limitations identified in using a single methodology to assess the sustainable performance of these projects is that it may fail to measure some criteria that could be significant in the context where these projects are located. A critical analysis of the Envision rating system framework and how it applies to the LAC context, however, is considered beyond the scope of this thesis, though it could be addressed in future research.

The research objectives are:

- To analyze the best practices applied to sustainable infrastructure projects in Latin America and the Caribbean (LAC) to identify opportunities for improvement.
- To create guidelines of best practices, following the Envision rating system framework that can be applied or replicated in other infrastructure projects in the future.
- To identify the main drivers that could influence the incorporation or failure to incorporate best practices in a given infrastructure project.

Background

The term infrastructure has traditionally covered a wide variety of services, from telecommunications and water and power supply to sanitation and waste collection, among others. Infrastructure also includes types of projects such as roads, dams, urban transportation, railways, ports, and airports. All of these infrastructure projects have the capacity to address some of the most pressing issues in our society, such as by alleviating poverty, providing access to clean water, sanitation and a reliable energy supply, and mitigating effects of climate change, among others. There are several challenges that make it extremely difficult to understand what sustainable infrastructure is and how to measure it in a systematic manner. Some of these challenges are the disaggregation of information, the lack of a common framework to measure against, as well as the large number of stakeholders involved. Some of the stakeholders identified are the finance sector, planning ministries, regional and municipal governments, private developers, multilateral financial institutions, and civil society, among others (Watkins, 2014).

In recent years, more projects have started to incorporate sustainable practices in large-scale infrastructure developments. This is especially relevant considering the fast pace of infrastructure construction and attempts to bridge the global infrastructure gap (lack of infrastructure required to meet the existing demand). It is estimated that it will take US$3.7 trillion annually to bridge that gap (World Economic Forum, 2013). In developing countries, the need for infrastructure is driven by the increase in population, changing trends in urbanization, and economic growth. In contrast, the needs of infrastructure in developed countries are focused on maintenance and rehabilitation, more strict regulations, and globalization of supply chains (World Economic Forum, 2013).

In the LAC context, where this research is focused, the increase in development and population mobility from rural areas to cities in recent decades have generated an increasing demand for services such as energy and water supply, efficient transportation, and waste management (Tissot, 2015). Besides providing the services required, these interventions can serve different purposes, such as reducing GHG emissions (Gonzalez Diez, 2015). In recent years the energy sector in the LAC region has focused on meeting international emissions reduction agreements and therefore moving towards a low-carbon economy. The integration of efficient energy systems is also seen as a strategy to reduce vulnerabilities and dependence on external resources such as oil, as well as to diversify the energy matrix of the different countries (Gonzalez Diez, 2015). As a result of these recent developments, the energy demand in the region increased at a rate of 3.1% a year from 2001 to 2009. It is expected that following the same business-as-usual approach, the demand will increase to 3.7% annually between 2008 to 2030 (Tissot, 2015). For this reason it is key not just to focus on satisfying this energy demand, but also to explore opportunities to reduce energy consumption by implementing more efficient procedures or new technologies. The IDB has estimated that energy demand could decrease approximately 10% in the coming decades by the implementation of preferable practices (Gonzalez Diez, 2015).

The increase in transportation infrastructure has been identified as a key factor for economic growth and has an important impact on the quality of life of the population (Bleviss, 2013). Notable opportunities have been identified in the role that sustainable transportation can play in the Latin American region, including improvement in connectivity. Such improvements can also play a key role to define better strategies towards GHG reduction. This is relevant considering that transportation is the biggest source of GHG emissions, with 35% of total emissions in the LAC region, while energy and heat represent 29% and manufacturing and construction 21% (IDB, 2014). In addition, risks such as traffic congestion or air and noise pollution should also be considered as potential hazards of transportation infrastructure development (Bleviss, 2013). For this reason, a better understanding of how transportation projects are built, as well as identifying opportunities for improvement, are key for a sustainable future.

When looking at the water supply in the region, extensive droughts together with deficient water management are some of the main challenges faced. Poor governance practices on the use of potable water for industrial purposes or low quality farming procedures have been identified as key aspects to be addressed to promote efficient water use (United Nations, 2015). The rapid increase in population in some of the biggest cities in the region such as Mexico City, São Paulo, or Lima, and the inefficiencies of the infrastructures in place, have put more pressure on limited water resources in these areas.

Lack of water availability, proper water treatment, or sanitation particularly affects the most vulnerable population. The identification of this increasing need has been the driver to promote innovation in the region to provide drinkable water and high-quality water for irrigation, and to guarantee compliance with national or international standards before discharging treated water into other water bodies. Due to the complex challenges associated with water systems and their importance as a basic resource, this research will identify the main gaps in order to integrate sustainable practices in water infrastructure.

The last key infrastructure service that this research will focus on is waste infrastructure, and the main challenges to promoting sustainability in this sector. Latin America and the Caribbean are one of the most urbanized developing regions in the world, with 80% of the total population of 525 million living in cities (United Nations, 2014). Waste management systems are deficient in many of the cities in this region. This poor or in some cases nonexistent service represents a serious health concern, primarily due to land and water contamination, and an environmental concern due to considerable amounts of methane released to the atmosphere. In response to this need, big investments and policies are being mobilized towards building some of the largest and most advanced waste management facilities in the region. Some of these projects provide synergistic solutions by not just solving the waste management problem but also collecting biogas with the goal of generating energy.

In response to these needs in the energy, transportation, water, and waste sector, most LAC countries have worked hard to achieve the standards of developing economies. The main goal is to move from lacking or deficient infrastructure towards high-technology ports, airports, wind farms, and solar or hydropower plants. Even in this scenario, the questions remain: Are these infrastructure projects sustainable? What criteria should be taken into consideration to balance the impacts that a large-scale project can place on the environment? Is there some other project applying different practices to learn from?

Previous Research on Sustainable Infrastructure

No comprehensive research-based analysis has been conducted on the current state of implementing sustainable practices in infrastructure projects in the LAC region. Several multilateral financial institutions such as the World Bank, IDB, and International Finance Corporation (IFC) have been working in this region for decades trying to promote sustainable development. It is estimated that these institutions provide support for 10–15% of infrastructure projects in the LAC annually (Serebrisky, 2014). In the existing literature, sustainable infrastructure is commonly included as part of a broader concept – sustainable development. This concept takes into consideration topics such as poverty alleviation, equity, education and literacy, living conditions, and levels of crime, as well as some other institutional frameworks such as international cooperation or disaster preparedness. The areas that the World Bank, IFC and IDB look at when defining sustainability are integrated within their Social and Environmental framework, and are aligned with the principles listed in Table 1 below.

Due to the broad spectrum of topics covered under sustainable infrastructure, certain information also overlaps with other internal policies used by IDB such as the Involuntary Resettlement Policy, the Indigenous Peoples Policy, the Gender Equality

Policy, and the Disaster Risk Management Policy (Watkins, 2014), making difficult to have a clear understanding of the requirements to be applied.

International organizations such as the United Nations and its Commission for Sustainable Development have also created a framework for sustainability indicators. These indicators are very broadly targeted to promote sustainable development, rather than sustainable infrastructure in particular.

Table 1. Social and environmental criteria used by multilaterals.

<table>
<tr><th colspan="2">Social Considerations</th></tr>
<tr><th>World Bank and IFC</th><th>IDB</th></tr>
<tr><td>1) Assessment and management of social risks and impacts.
(2) Labor and working conditions.
(3) Community health and safety.
(4) Resettlement.
(5) Indigenous peoples.
(6) Cultural heritage.
(7) Information disclosure and stakeholder engagement.</td><td>(1) Compliance with local laws.
(2) Consultations and stakeholder engagement.
(3) Assessment of social concerns beyond the project.</td></tr>
<tr><th colspan="2">Environmental and climate change considerations</th></tr>
<tr><th>World Bank and IFC</th><th>IDB</th></tr>
<tr><td>(1) Assessment and management of environmental risks and impacts.
(2) Resource efficiency and pollution prevention.
(3) Land acquisition, restrictions on land use.
(4) Biodiversity conservation and sustainable management of living natural resources.</td><td>(1) Compliance with local laws.
(2) Environmental assessment and management of projects.
(3) Hazardous materials.
(4) Transboundary impacts.
(5) Natural habitats and cultural sites.
(6) Pollution, including greenhouse gas emissions.
(7) Assessment of risk factors beyond the project, such as sector-related risks, vulnerability to disasters, and sensitive environmental concerns.</td></tr>
</table>

Other well-known frameworks such as the Millennium Development Goals (MDGs) and the Sustainable Development Goals (SDGs), look at issues of poverty alleviation, inequality, education, or climate change. Apart from the overlap with some indicators applicable to sustainable infrastructure, the consideration of these international criteria to measure sustainable development is outside of the scope of this thesis. Other systems to quantify infrastructure include Green Roads, a sustainability rating system for roads, and the Hydropower Sustainability Assessment Protocol (HSAP), designed to assess hydropower plans. These rating systems are targeted to specific project typologies, and therefore not suited to assess the wide diversity of projects used for this research.

Envision Rating System

The methodology used for this research is the Envision rating system. Envision is a holistic framework for evaluating the social, environmental, and economic benefits of any given infrastructure project. There are other methodologies besides Envision that have a more integrated approach. Some of them are: the Civil Engineering and Environmental Quality Assessment and Award Scheme (CEEQUAL), created in 2003 by the Institution of Civil Engineers in the United Kingdom, and the IS Rating System, a rating scheme developed and administered by the Infrastructure Sustainability Council of Australia.

The Envision Rating System was created by a partnership of the Zofnass Program for Sustainable Infrastructure at the Harvard University Graduate School of Design (with the collaboration of the Center for the Environment and the School of Public Health), the Institute for Sustainable Infrastructure of the American Public Works Association, the American Council of Engineering Companies, and the American Society of Civil Engineers (Georgoulias, Allen, & Farley, 2010). This methodology has been widely applied in the USA, Latin America, and some other regions such as the Middle East and China. The tool can be applied to a wide variety of project typologies, and can look at different parameters of progress based on the different stages of an infrastructure project, such as planning/design, construction, operation, and decommissioning phases of the project life cycle.

Currently there is no recognized research-based study conducted over a long term to track the outcomes of sustainable infrastructure not just in the design phase but also during construction and after completion. To fill that gap, the Infrastructure 360 Awards initiative has been running for the last three years trying to identify the best sustainable practices in the region.

Background to Proposed Research: The Envision Database

The main objective of this research was not to compare the different methodologies available, but to create a set of best practices backed up by the lessons learned from the analysis of the scores achieved on the 38 projects evaluated at the moment. The common features of the infrastructures assessed were: (i) the projects were located in Latin America and the Caribbean; (ii) the budgets of the projects ranged from US$30 million to US$8 billion; (iii) most information gathered to conduct this assessment comes from projects that were in the late phase of construction or early phase or operation; and (iv) at least 50% of the investment in the projects comes from private funding. The common denominator for the evaluation of these projects has been the use of the Envision rating system.

The Envision rating system looks at five main aspects of infrastructure projects: Quality of Life, Leadership, Resource Allocation, Natural World, and Climate and Risk. The social impact of the project, summarized under Quality of Life, assesses parameters such as the creation of local employment in the area, promotion of growth and development, improvement of mobility, or preservation of cultural assets in the community. The governance and management aspects of sustainability are measured in the Leadership category. This looks at the different strategies such as stakeholder engagement or long-term maintenance in order to incorporate sustainability as part of the life cycle of the project, as well as the procedures to manage it. Resource Allocation promotes practices to optimize the use of materials, energy, and water, as well as the identification of strategies that encourage appropriate monitoring. The analysis of the environmental impact of the project comes under the category of Natural World. This category rates the type of land where the project is located and the project's impact on water bodies and biodiversity, among other environmental factors. The last section, Climate and Risk, measures emissions and the resilience strategies integrated into the project (Envision™, 2015).

The Zofnass Program research team developed a comprehensive case study in each of these projects selected. The information available in these case studies was used as the base for this thesis. The 38 projects to be used for this research were selected from a total number of 147. These 38 projects were considered the most sustainable ones among all the candidates. Some of the 38 projects assessed have been financed by Multilateral Development Banks (MDBs) while others rely in different sources of funding. The typologies of projects assessed are also very diverse, ranging from energy to transportation, water, and sanitation or waste management. The analysis of the outcome of this research will help understand which project typologies have a more sustainable outcome, and the degree to which the location of the country, the source of funding and the level of development of that country influence the integration of sustainable practices.

Research Questions, Hypotheses and Specific Aims

This research will address a series of questions and specific hypotheses:

Research question 1: What are the current practices applied to infrastructure projects in the Latin American and Caribbean (LAC) region?

Research question 2: What are the best sustainable practices that could be applied to a given infrastructure project in order to have a more sustainable outcome?

Hypothesis 1: Larger-scale infrastructure projects in Latin America apply better practices to the project than small-scale infrastructure projects. Large-scale projects tend to have more comprehensive studies of their impacts as well as mitigation measures in place. Small-scale projects sometimes lack the budget or the technical knowledge to conduct this detailed assessment.

Hypothesis 2: Projects located in more developed countries have stronger regulatory frameworks in social and environmental requirements and therefore better sustainable outcomes.

Hypothesis 3: Multilateral Development Banks (MDBs) have more sustainable practices, and therefore a higher score, than privately funded projects. MDGs require the application of certain protocols as a requirement to provide loans. Therefore, a higher sustainable performance by these projects could be expected.

Hypothesis 4: The typology of the project, i.e., energy, transportation, water, and waste, is one of the main drivers in determining its sustainability outcome. Besides the protocols applied at the project level, the nature and strengths of the different project have a significant impact on the final score.

Specific Aims

In order to test the hypotheses previously stated, my research:

1. Identified the statistical significance of the data set, by running different scenarios on R 3.3.1 software.

2. Created a spreadsheet to analyze the best practices used by the 38 projects previously assessed for the Infrastructure 360 Awards.

3. Determined the relationship between the scale of the project and the level of compliance with the preferable practices identified.

4. Analyzed what location/countries have higher indexes of development and identify to what extent this can impact the final outcome of the evaluation of the projects.

5. Determined the number of overall projects financed by MDBs, for the purpose of this research the World Bank, IFC, and IDB will be considered. This will help identify if these projects have a more sustainable outcome that the ones financed by other sources.

6. Analyzed the different typologies of projects to determine if there are specific trends in the inclusion of more sustainable practices based on project type.

Chapter II

Methods

Several different approaches were used to address the hypotheses and aims stated above. The first one was statistical analysis of the data using R 3.3.1. This provided the first step in identifying the sustainability trends of the projects assessed. The second approach was qualitative, and examined the main drivers at the project level that influence the final score. Looking at specific projects and the causes of high and low scoring will help identify the preferable practices to be promoted and less favorable practices to be avoided to influence the sustainability outcome of the project.

Statistical Analysis

To conduct the statistical analysis, the project typology, human development index (HDI) of the country, project budget and source of finance, were identified as the predictive variables. For the first variable – project typology – the projects have been divided into four categories (energy, transportation, water, and waste). This classification was chosen following some of the main infrastructure sectors defined by institutions such as the IDB that could fit the project typology available on the data set used for this research. Each of these four project typologies has several project sub-typologies (Table 2). The energy typology had the biggest sample size (20 projects), representing 53% of the total data set. As a result, an additional evaluation was conducted at the sub-typology level, looking at the main differences in score between wind farms, hydropower plants, photovoltaic facilities and the scores of the projects assessed.

Table 2. Distribution of project typology and sub-typology.

Project type	Sample size	%	Subtype	Sample size
Energy	20	53	Wind farm	7
			Hydroelectric	6
			Photovoltaic	4
			Transmission Line	1
			PV/Solar tower	1
			Biogas	1
Transportation	11	29	Airport	3
			Port	4
			Road	3
			Mass transit	1
Water	4	10	Water treatment	3
			Desalinization plant	1
Waste	2	8	Waste to energy	2
			Landfill	1

The second independent variable was the level of development of the country where the project is located. The data set used contains projects from 12 different countries: Argentina, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Honduras, Mexico, Peru, Trinidad and Tobago, and Uruguay. The information on national development, used to determine how level of development affects the final sustainable outcome of infrastructure projects, comes from the Human Development Index (HDI) published by the United Nations Development Program. The information related to this second variable is shown in Table 3.

Table 3. Distribution of HDI according to the country.

Country	# Projects	HDI
Mexico	6	0.915
Argentina	1	0.836
Chile	5	0.832
Uruguay	2	0.793
Trinidad and Tobago	1	0.772
Costa Rica	1	0.766
Brazil	7	0.755
Peru	7	0.734
Ecuador	2	0.732
Colombia	3	0.72
Dominican Republic	1	0.715
Honduras	2	0.606

The third variable used refers to the scale of the project and the relationship between the project budget and the integration of sustainable practices. Budget was considered a continuous variable, ranging in these projects from US$31 million to US$8.59 billion. The budget of each of the projects evaluated is shown in Appendix 2. Analyzing the correlation between the scale, represented by the budget and the sustainability score achieved, can provide an indication about how budget influences the sustainability performance of the project. It was expected that projects with more resources available, have stronger sustainable management and social responsibility plans, and more environmental and social mitigation measures in place. The data used for this analysis is the overall project budget, since there is no information on the specific percentage invested in sustainable strategies and environmental management.

The last variable examined was the effect of funding source, comparing how multilateral-funded projects perform on the integration of sustainable practices vs. other non multilateral-funded projects. This analysis looks at the significant differences in the sustainability outcomes based on who is financing the project and therefore the level of demand to integrate sustainability practices to obtain project funding. The analysis was divided in projects financed by multilaterals (12 projects) or not (26 samples) (Table 4). For a detailed overview of which projects were financed by MDBs see Appendix 2.

The statistical analysis was modeled using the score of the project evaluation as response variable, and typology of the project, human development index, and budget as predictive variables.

Table 4. Summary of predictive variables used for the statistical analysis.

Typology		Development (HDI)	Budget	Financier (Multilateral)	
Subcategory	# Samples	Coefficient	US$ million	Subcategory	# Samples
Energy	20	0.915–0.606	31–8,590	Yes	12
Transportation	11	-	-	No	26
Water	4	-	-	-	-
Waste	3	-	-	-	-

Spreadsheet Analysis

The second method used to identify the main trends in scoring was spreadsheet analysis. The information evaluated is the same as shown in Appendix 2, and the analysis was divided into two different approaches. The first approach looks at the performance of the central tendency by Envision categories, the second approach does it by project typology.

In the first case, the methodology assessment is divided into five categories (Table 5): Quality of Life (QL), Leadership (LD), Resource Allocation (RA), Natural

World (NW), and Climate and Risk (CR). These categories break down into 14 subcategories, which are composed in turn of a total of 60 credits. The number of credits in a subcategory ranges from two to seven according to the complexity of the matter assessed. Once the highest- and lowest-scoring credits were identified, a deeper analysis was conducted to highlight the good practices applied to these specific projects.

Table 5. Categories and subcategories according to Envision rating system.

Category	Subcategory	# credit	Information assessed
Quality of Life	Purpose	3	Impact of the project on growth and development in the area, as well as job creation.
	Community	3	The integration of context-sensitive design to minimize the alterations to the views, cultural heritage, and local character.
	Well-being	6	Identification of comfort conditions, health, and mobility in the area and the encouragement of alternative modes of transportation.
Leadership	Collaboration	4	The level of leadership and commitment to integrate all the stakeholders to contribute ideas and perspectives.
	Management	2	A synergistic approach to the project as a whole in order to reduce costs, expand the project's lifespan, and increase sustainability overall.
	Planning	3	A long-term approach as a way to promote sustainability, along with understanding other regulatory issues.
Resource Allocation	Materials	7	Integration of practices and protocols in order to minimize the amount of material used on the project and the impact of its disposal.
	Energy	3	Enhancement of the use of renewable energy sources in the

			project, and adequate monitoring of the process.
	Water	3	Minimization of the water used as well as repurposing of water for other uses.
Natural World	Siting	7	Reduction of the impacts of locating the projects in areas of high ecosystem value or areas that serve diverse habitats.
	Land and water	3	Minimization of impacts on existing hydrologic and nutrient cycles, with special attention to avoiding the introduction of contaminants in the system.
	Biodiversity	4	Minimization of habitat fragmentation as well as prevention of the introduction of invasive species in the area.
Climate and Risk	Emissions	2	Reduction in the emission of dangerous pollutants, including greenhouse gases and others.
	Resilience	5	Understanding of long- and short-term risk originating from changing weather patterns, as well as minimization of overall vulnerabilities.

In the second case, the spreadsheet analysis identified the main trends in the results by project typologies, dividing the assessment into energy, transportation, water, and waste. The highlights and opportunities for improvement will be identified in each of the project types. The last section provides a list of best practices identified in the projects evaluated that can be used as a recommendation to follow for future infrastructure projects.

Data Collection

The data set available consists of the results gathered during the last three years (2012–2015) through the Infrastructure 360 Awards initiative promoted by Harvard University (Graduate School of Design) and the Inter-American Development Bank, and is publicly available at both of their websites. The Zofnass Program research gathered information from 38 different infrastructure projects, and wrote a comprehensive case study in each of them. The information required for the completion of the case studies was directly provided by the project teams. These 38 projects were selected as the best-performing ones from a pool of 147 projects in total. The detailed assessment of each of these 38 case studies looks at the practices applied in the project in terms of each of the 60 credits evaluated according to the Envision Rating System. The final score of each of the projects results from the sum of the points attained in the 60 credits based on the practices applied on that project. For the purpose of this research, and in order to simplify the identification of findings, the projects with higher scores according to the Envision rating system have been considered more sustainable than the ones with lower scores. To be able to compare among projects, the assessment methodology has been applied in a systematic manner regardless of the specific characteristics of the project.

Research Limitations

Several limitations have been identified in this research. The first of these is the different conditions, regulations, and levels of expertise of the projects due to the big geographic area addressed (Latin America and the Caribbean region). The 38 projects were analyzed based on the information self-reported by the project teams, acknowledging that the level of involvement, knowledge, or time available for the collaboration with our team could have been different according to the project.

Secondly, the evaluation of the different projects should be considered a screenshot of the practices used by a specific project at a specific time when the assessment was conducted. Thus, some of the conditions identified in this research may have changed over time without notification to our team.

Thirdly, when defining the participation of MDBs on the project finance, the institutions considered for this research are the World Bank, IFC, and IDB. Some other local or international financial institutions may have participated in the funding process of other projects. Nevertheless, the sustainable requirements applied by other entities may be very different, that the ones above, and therefore are not considered at this point.

Finally, due to the different profile of the data used and the numerous variables tested, the level of significance at the moment is considered low. This research therefore represents the first steps in a longer-term assessment in which a larger data set will be required to identify conclusive trends for infrastructure sustainability in Latin America.

Chapter III

Results

The analysis of the results is divided by the two primary methods. The first is the statistical evaluation of the data set using the software R 3.3.1. This approach looks at the statistical significance of the variables in the sustainability performance. The second method uses spreadsheet analysis to identify trends in the project scoring based on Envision category and project typology. The last part of this chapter consists of the identification of the best practices observed in the 38 projects evaluated.

Statistical Analysis Using R

Simple and multiple regression models are fit to understand the correlation of the different hypotheses (predictive variables) on the final score achieved (response variable). A total of six different models were designed as shown in Table 5 below. Each model represents the scores obtained in the five Envision categories plus the overall score obtained in the 38 projects combined, and its goal is to analyze the correlation between the different variables (adjustedhdi, log_budget, finance, energy, transportation, water, waste) and the final score achieved. An alpha level of 0.05 was used for all statistical tests.

Table 6. Models to determine the statistically significance of the predictable variables.

	Simple regression	Multiple regression
Model 1_QL	mod1 = lm(ql~ trans + water + waste, data= dat) mod1 = lm(ql~ log_budget, data= dat) mod1 = lm(ql~ adjustedhdi , data= dat) mod1 = lm(ql~ finance , data= dat)	mod1 = lm(ql~ adjustedhdi + log_budget + trans + water waste + finance , data= dat)
Model 2_LD	mod2 = lm(ld~ trans + water + waste, data= dat) mod2 = lm(ld~ log_budget, data= dat) mod2 = lm(ld~ adjustedhdi , data= dat) mod2 = lm(ld~ finance , data= dat)	mod2 = lm(ld~ adjustedhdi + log_budget + trans + water + waste + finance , data= dat)
Model 3_RA	mod3 = lm(ra~ trans + water + waste, data= dat) mod3 = lm(ra~ log_budget, data= dat) mod3 = lm(ra~ adjustedhdi , data= dat) mod3 = lm(ra~ finance , data= dat)	mod3 = lm(ra~ adjustedhdi + log_budget + trans + water + waste + finance , data= dat)
Model 4_NW	mod4 = lm(nw~ trans + water + waste, data= dat) mod4 = lm(nw~ log_budget, data= dat) mod4 = lm(nw~ adjustedhdi , data= dat) mod4 = lm(nw~ finance , data= dat)	mod4 = lm(nw~ adjustedhdi + log_budget + trans + water + waste + finance , data= dat)
Model 5_CR	mod5 = lm(cr~ trans + water + waste, data= dat) mod5 = lm(cr~ log_budget, data= dat) mod5 = lm(cr~ adjustedhdi , data= dat) mod5 = lm(cr~ finance , data= dat)	mod5 = lm(cr~ adjustedhdi + log_budget + trans + water + waste + finance , data= dat)
Mod. 6_Total	mod6 = lm(total ~ trans + water + waste, data= dat) mod6 = lm(total ~ log_budget, data= dat) mod6 = lm(total ~ adjustedhdi , data= dat) mod6 = lm(total~ finance , data= dat)	mod6 = lm(total ~ adjustedhdi + log_budget + trans + water + waste + finance , data= dat)

The results of the linear regression of the six different models are shown on the Table 7 below. This results have been defined by two different parameters the R^2, which represents the percentage of variability of the results in the response variable, and the p-value representing the significance of the results.

Table 7. Results of the simple regression by Envision category.

Models by Envision Category	Correlation by predictive variable (simple regression)							
	Project typology (energy/ trans / water / waste)		Scale of the project (log_budget)		Human Development Index (adjusted hdi)		Source of funding (finance)	
	Adj r^2	p-value (<0.05)	Adj r^2	p-value (<0.05)	Ad r^2	P-value (<0.05)	Adj r^2	P-value (<0.05)
Model 1_QL	-0.01978	0.524	0.1312	0.01456	-0.02774	0.9717	-0.01823	0.5648
Model 2_LD	-0.02039	0.528	0.05901	0.07675	0.01475	0.2206	-0.015	0.5051
Model 3_RA	0.1398	0.04384	0.0114	0.2401	-0.007941	0.4055	0.02241	0.6663
Model 4_NW	0.2502	0.004992	-0.01548	0.5134	-0.0255	0.7792	0.01143	0.2399
Model 5_CR	0.5281	2.474e-06	-0.002682	0.3488	0.03217	0.1441	-0.02215	0.6589
Mod. 6_Total	0.007625	0.3646	0.02907	0.1552	-0.02469	0.7439	0.007625	0.2646

The outcome of the simple and multiple regression models show high variability of the results due to a small R^2, and a low level of significance due to high p-values (>0.05). Nevertheless, some of the results in the Resource Allocation, Natural World, and Climate and Risk categories are considered statistically significant.

Correlation between Project Scale and Sustainability Outcome

One of the questions to be answered through this research is the impact of project scale on the sustainable outcome of the infrastructure developed. Thus, hypothesis 1 proposes that: Larger-scale infrastructure projects in Latin America apply better practices to the project than small-scale infrastructure projects. Large-scale projects tend to have more comprehensive studies of their impacts as well as mitigation measures in place. For the purpose of this analysis, the size of the project was considered as a continuous variable defined by its budget, covering a wide range from US$ 31–8590 million. The data set has been logarithm-transformed due to the existence of an outlier.

The result of the simple regression models determined that the predictive variable “log_budget” is not statistically significant in influencing the scores of the five Envision categories or total overall performance (response variables); as a result, the null hypothesis cannot be rejected in all the models analyzed.

Correlation between Location and Sustainability Outcome

Hypothesis 2 of this research proposes that the level of development of the country where the infrastructure project is located affects its sustainability outcome. For this purpose the hypothesis presented is: Projects located in more developed countries have stronger regulatory frameworks in social and environmental requirements and therefore better sustainable outcomes. The United Nations Development Program publishes the coefficients associated with the Human Development Index (HDI) of each of the countries. These coefficients “adjustedhdi” were used as a continuous variable in the statistical analysis conducted. The results obtained from the simple regressions show non-statistical significance between the level of development of the country and the sustainability outcome of the project. As a result, the null hypothesis cannot be rejected in all the models analyzed.

Correlation between Sources of Funding and Sustainability Outcome

Hypothesis 3 looks at the impact of the financing on the sustainability of the project. To prove or refute this effect, the hypothesis presented is: Projects funded by

Multilateral Development Banks (MDBs) have more sustainable practices, and therefore a higher score, than projects financed by other sources. Of the 38 projects evaluated, 12 are financed by MDBs and 26 by other entities. As in the previous two cases, non-statistical significance was identified proving a positive effect of projects funded by Multilateral Development Banks, in this our context, World Bank, IFC, and IDB, and their correlation on the sustainability outcome in any of the models designed. Based on the results, the null hypothesis cannot be rejected. A bigger sample size is required to increase the explanatory power of some of the variables that show no significance at the moment.

Correlation between Project Typology and Sustainability Outcome

Hypothesis 4 is defined as: The typology of the project –energy, transportation, water and waste- is one of the main drivers in determining its sustainability outcome. To prove or refute this statement, six simple regressions models are fit according to the six response variables (five Envision categories and the overall score). Three of the six simple regressions conducted show statistical significance. As a result, the null hypothesis is rejected in Model 3_ Resource Allocation, Model 4_Natural World, and Model 5_Climate and Risk, and the null hypothesis is failed to be rejected in Model 1_Quality of Life, Model 2_Leadership, and Model 6_Total. From the models with statistical significance, Resource Allocation and Natural World show a moderately positive correlation while Climate and Risk shows a stronger correlation.

Looking closely at the Resource Allocation (RA) category (p-value = 0.04384 / R^2 = 0.1398), and the distance of the different project types from the intercept, project typology shows a positive effect on the RA score. Water has the strongest correlation followed by waste, energy, and transportation. It was identified that most of the water and waste projects are developed in facilities where the standards in place and the level of control of the external outputs may be considered higher than in energy and transportation projects. The nature of the water and waste projects analyzed also plays an important role in resource management. In both cases most of the projects examined used by-products from other processes – solid waste or gray water – to run the project.

In the Natural World (NW) category (p-value = 0.004992 / R^2= 0.2502), the project typology with the largest positive effect on the final result is waste, followed by transportation, water, and energy. All the waste projects and most of the transportation projects – especially ports, airports, and other developments located in an urban context – have been built in previously disturbed areas. As a result and in general terms, a lower environmental impact has been observed compared to other project types such as energy. Hydropower plants, wind farms, and photovoltaic projects are commonly located farther away from urbanized areas and sometimes in greenfield or farmland. As a result, the environmental impacts are considered to be greater.

In the Climate and Risk (CR) category, the level of significance of the results is higher than in any other model (p-<.0001; R^2= 0.53. In this case, the positive effect of the project type on the final result follows this order: energy, water, waste, and transportation. Of the energy project analyzed, most involve renewable energy sources. As a result, the exceptional performance in emission reduction plays a major role in the overall score of the Climate and Risk category. No significant efforts were identified in emission reduction or promotion of resilience strategies in other project types such as transportation.

Multiple Regression Model

Multiple regression models are fit to predict the cumulative effect of all the predictive variables. The null hypothesis in Models 1, 2, 3, and 6, cannot be rejected due to the low levels of statistical significance (Table 8). However, the null hypothesis can be rejected in Models 4 and 5 based on a stronger correlation.

Table 8. Results of the multiple regressions by Envision category.

Models by Envision Categories	Multiple regression (adjusted hdi / log_budget / energy / trans / water / waste / finance)	
	Adj r^2	P-value(<0.05)
Model 1_QL	0.05	0.27
Model 2_LD	0.09	0.18
Model 3_RA	0.16	0.08
Model 4_NW	0.30	0.01
Model 5_CR	0.56	<.0001
Model 6_Total	0.12	0.12

As previously identified, there is a moderate positive correlation between all the predictive variables and the final score in the Natural World category (p = 0.01; R^2 = 0.30), and a stronger positive correlation with the climate and Risk category (p,.0001; R^2 = 0.56).

Conclusions of the Statistical Analysis Using R

Taking an alpha level of 0.05 for all statistical tests, most of the simple regression models, as well as the multiple regression models, are considered non-significant. The only predictive variable with statistical significance is project´s typology. Based on the results, this variable is proven to have a positive effect on the final results of the RA category (p-value = 0.04 ; R^2 = 0.14), NW category (p-value = 0.01; R^2 = 0.25), and CR category (p-value <0.000002 ; R^2 = 0.53).

After determining the statistical significance of the 38 projects used for this study, and having identified that the small sample size is one of the main challenges at the moment, the next question to answer is: What would be the sample size required to reject or fail to reject the null hypothesis with enough statistical confidence? To answer this question, different scenarios were ran using G*Power for Statistical Power Analyses to compute statistical power analyses and compute effect sizes.

The common parameters imputed were: [t tests]; [Linear multiple regression: Fixed model, single regression coefficient]; [Analysis: Post hoc: Compute achieved power]; [two tails]. The minimum Power (1-β err prob.) considered explanatory = 80%.

According to the parameters above several tests are ran to determine the explanatory power of the different predictable variable assessed according to the current sample size (Table 9).

Table 9. Power of the text with the current sample size (38 projects).

		Model 1_QL	Model 2_LD	Model 3_RA	Model 4_NW	Model 5_CR	Model 6_Total
Predictable variables		Power (1-β err prob)	Power (1-β err prob)	Power (1-β err prob)	Power (1-β err prob)	Power (1-β err prob)	Power (1-β err prob)
log_budget		56.58%	41.63%	20.19%	16.61%	11.26%	21.02%
adjustedHDI		10.66%	97.22%	70.74%	40.11%	97.23%	31.31%
Finance		20.59%	21.54%	11.41%	29.45%	14.11%	19.69%
Type	Energy	94.82%	95.18%	86.79%	85.90%	92.44%	91.34%
	Transport.	30.01%	22.95%	30.13%	55.60%	82.01%	5.76%
	Water	55.76%	47.95%	42.95%	34.56%	40.15%	34.64%
	Waste	17.51%	51.31%	26.51%	82.92%	56.21%	31.81%

As shown in the table above, Energy has an explanatory power above 80% in all the models, while transportation, waste, and adjustedhdi, just in some specific models. The rest of the variables have a low explanatory power for the current sample size. Several scenarios were run to identify the sample size required in each of the predictable variables in the different models (Table 10). The samples needed for an 80% power will vary according to the correlation between variables, ranging from 38 (current size) to 4277 in the case with very low or almost inexistent correlation.

Table 10. Sample size required for an 80% Power in the different models.

		Model 1_QL		Model 2_LD		Model 3_RA	
Predictable variables		Power (1-β err prob)	Sample size	Power (1-β err prob)	Sample size	Power (1-β err prob)	Sample size
log_budget		80.32%	65	80.26%	95	80.06%	227
adjustedHDI		80.64%	600	97.22%	38	79.13%	46
Finance		80.18%	222	80.05%	209	80.07%	524
Type	Energy	94.82%	38	95.18%	38	86.79%	38
	Transportation	80.05%	139	80.18%	193	80.24%	139
	Water	80.25%	66	80.33%	80	80.14%	91
	Waste	80.06%	273	80.03%	73	80.23%	162

		Model 4_NW		Model 5_CR		Model 6_Total	
Predictable variables		Power (1-β err prob)	Sample size	Power (1-β err prob)	Sample size	Power (1-β err prob)	Sample size
log_budget		80.13%	295	80.04%	536	80.12%	216
adjustedHDI		80.13%	99	97.23%	38	80.19%	133
Finance		80.18%	143	80.02%	372	80.15%	235
Type	Energy	85.90%	38	92.44%	38	91.34%	38
	Transportation	80.09%	66	82.01%	38	80.00%	4277
	Water	80.20%	118	80.28%	99	80.31%	118
	Waste	82.92%	38	80.05%	65	80.14%	130

Based on the different scenarios conducted 139 is the lowest sample size required to achieve enough explanatory power to reject or fail to reject the null hypothesis in 64.30% of the variables. In order to explain the variables with lower correlation the number of samples required increase significantly (Table 11).

Table 11. Optimal sample size to achieve them most explanatory power.

Sample size	38	100	139	200	250	300	400	600	4277
Variables >80% explanatory power	10	21	27	30	35	37	38	41	42

Spreadsheet Analysis: Main Trends by Envision Categories

The results presented below (Figure 1) are based on an Excel spreadsheet analysis of the 38 projects evaluated. This analysis was done following a multi-layer approach, using the Envision rating system as a framework. First the main trends at the category level are identified, then at the subcategory level and finally to the credit level.

QUALITY OF LIFE
13 Credits

1 PURPOSE
QL1.1 Improve Community Quality of Life
QL1.2 Stimulate Sustainable Growth & Development
QL1.3 Develop Local Skills & Capabilities

2 WELLBEING
QL2.1 Enhance Public Health & Safety
QL2.2 Minimize Noise and Vibration
QL2.3 Minimize Light Pollution
QL2.4 Improve Community Mobility & Access
QL2.5 Encourage Alternative Modes of Transportation
QL2.6 Improve Site Accessibility, Safety & Wayfinding

3 COMMUNITY
QL3.1 Preserve Historic & Cultural Resources
QL3.2 Preserve Views & Local Character
QL3.3 Enhance Public Space

QL0.0 Innovate or Exceed Credit Requirements

LEADERSHIP
10 Credits

1 COLLABORATION
LD1.1 Provide Effective Leadership & Commitment
LD1.2 Establish A Sustainability Management System
LD1.3 Foster Collaboration & Teamwork
LD1.4 Provide for Stakeholder Involvement

2 MANAGEMENT
LD2.1 Pursue By-Product Synergy Opportunities
LD2.2 Improve Infrastructure Integration

3 PLANNING
LD3.1 Plan For Long-Term Monitoring & Maintenance
LD3.2 Address Conflicting Regulations & Policies
LD3.3 Extend Useful Life

LD0.0 Innovate or Exceed Credit Requirements

RESOURCE ALLOCATION
14 Credits

1 MATERIALS
RA1.1 Reduce Net Embodied Energy
RA1.2 Support Sustainable Procurement Practices
RA1.3 Use Recycled Materials
RA1.4 Use Regional Materials
RA1.5 Divert Waste From Landfills
RA1.6 Reduce Excavated Materials Taken Off Site
RA1.7 Provide For Deconstruction & Recycling

2 ENERGY
RA2.1 Reduce Energy Consumption
RA2.2 Use Renewable Energy
RA2.3 Commission & Monitor Energy Systems

3 WATER
RA3.1 Protect Fresh Water Availability
RA3.2 Reduce Potable Water Consumption
RA3.3 Monitor Water Systems

RA0.0 Innovate or Exceed Credit Requirements

NATURAL WORLD
15 Credits

1 SITING
NW1.1 Preserve Prime Habitat
NW1.2 Protect Wetlands & Surface Water
NW1.3 Preserve Prime Farmland
NW1.4 Avoid Adverse Geology
NW1.5 Preserve Floodplain Functions
NW1.6 Avoid Unsuitable Development on Steep Slopes
NW1.7 Preserve Greenfields

2 LAND + WATER
NW2.1 Manage Stormwater
NW2.2 Reduce Pesticide & Fertilizer Impacts
NW2.3 Prevent Surface & Groundwater Contamination

3 BIODIVERSITY
NW3.1 Preserve Species Biodiversity
NW3.2 Control Invasive Species
NW3.3 Restore Disturbed Soils
NW3.4 Maintain Wetland & Surface Water Functions

NW0.0 Innovate or Exceed Credit Requirements

CLIMATE AND RISK
8 Credits

1 EMISSIONS
CR1.1 Reduce Greenhouse Gas Emissions
CR1.2 Reduce Air Pollutant Emissions

2 RESILIENCE
CR2.1 Assess Climate Threat
CR2.2 Avoid Traps & Vulnerabilities
CR2.3 Prepare For Long-Term Adaptability
CR2.4 Prepare For Short-Term Hazards
CR2.5 Manage Heat Island Effects

CR0.0 Innovate or Exceed Credit Requirements

Figure 1. Envision credit list (Institute for Sustainable Infrastructure, 2015).

Each of the five Envision rating system categories is composed of a different number of credits, with a different number of maximum total points. The scores assigned to every category and subcategory, as well as the percentage that these points represent in the overall evaluation (Table 12).

Table 12. Score distribution by categories and subcategories.

Category	Subcategory	# Credits	Max. score by subcategory	% On the overall assessment	Max. points in this category	% On the overall assessment
Quality of Life	Purpose	3	56	6.92%	181	22.37%
	Well-being	6	82	10.14%		
	Community	3	43	5.32%		
Leadership	Collaboration	4	60	7.42%	121	14.96%
	Management	2	31	3.83%		
	Planning	3	30	3.71%		
Resource Allocation	Materials	7	80	9.89%	182	22.50%
	Energy	3	49	6.06%		
	Water	3	53	6.55%		
Natural World	Siting	7	99	12.24%	203	25.09%
	Land and Water	3	48	5.93%		
	Biodiversity	4	56	6.92%		
Climate and Risk	Emissions	2	40	4.94%	122	15.08%
	Resilience	5	82	10.14%		
Total			55+ 5 Innovation cr.	100%	809	100%

It is worth mentioning that, due to the lack of normal distribution of the results, and in order to avoid outliers that could potentially interfere with identifying the true tendency of the results, all the percentages have been calculated using the median. The total percentage by category was calculated by adding all the credits that are part of a category. The results obtained across the five categories evaluated indicate that the percentage of achievement of each of them can vary significantly, ranging from 16.8% to 34.4% (Figure 2).

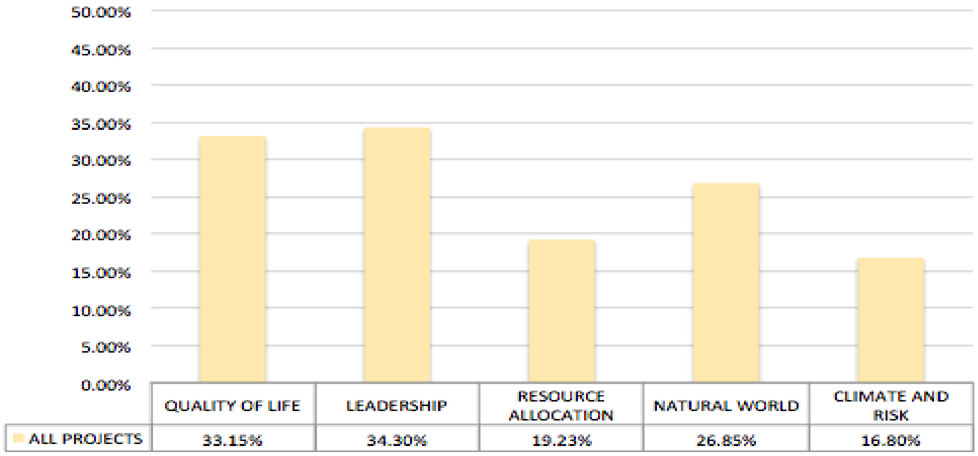


Figure 2. Percentage of achievement by category of all the projects assessed.

The highest-scoring category out of the five evaluated is Leadership, followed closely by Quality of Life and Natural World. The two lowest-scoring categories are Resource Allocation and Climate and Risk. To identify the key trends of the evaluation, it is essential to know which credits are driving the results as well as which ones tend to score very low, or not at all.

Quality of Life: Main Trends of the Overall Scores

This category identifies the social impact of the project in the communities located nearby, as well as the integration and alignment of the communities to achieve a common goal among the different parties involved. Looking at the overall performance of the central tendency (Figure 3), it is observed that the distribution of scores among credits has a wide variation.

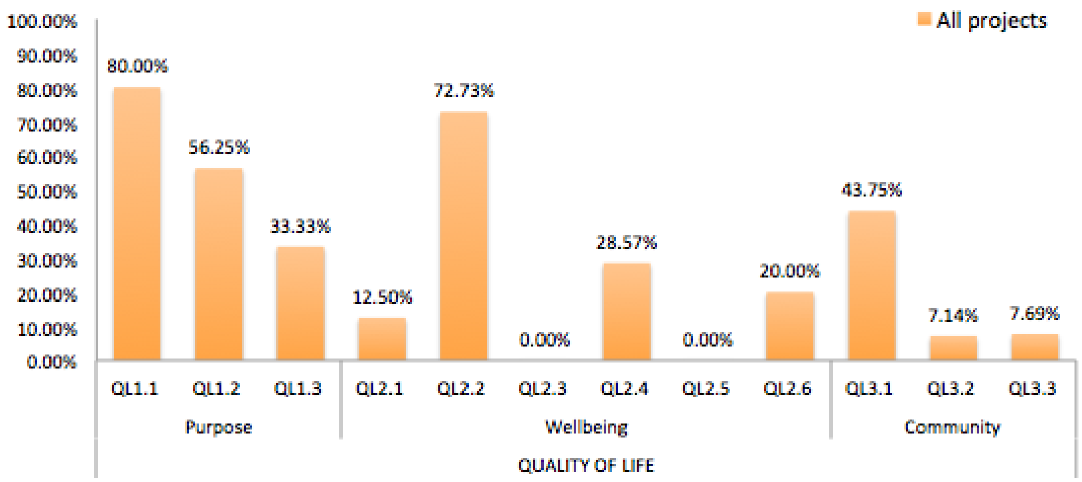


Figure 3. Score of the Quality of Life category by credit. Median of the 38 projects.

In most of the projects evaluated, there are credits such as QL1.1 Improve Community Quality of Life (80.0%), QL2.2 Minimize Noise and Vibration (72.7%), QL1.2 Stimulate Sustainable Growth and Development (56.2%), or QL3.1 Preserve Historic and Cultural Resources (43.8%) scored high or very high (above 40%). According to the results, this performance shows a positive impact of most projects on local development as well as job creation. The scores related to noise mitigation and identification of cultural resources or archaeological remains are influenced by common practices or specific standards applied in certain sectors, which is why these matters have been take into consideration in most projects. To judge by the lower-scoring credits such as QL2.3 Minimize Light Pollution (0.0%), QL2.5 Encourage Alternative Modes of Transportation (0.0%), QL3.2 Preserve Views and Local Character (7.1%), or QL3.3

Enhance Public Space (7.7%), and base on the detailed information provided on the 38 case studies evaluated, most project fail to incorporate the above mentioned practices into their projects design. As a result, stronger emphasis and training programs are recommended to address matters related to the impacts of light pollution, and advantages of promoting alternative modes of transportation. At the moment most of the practices used in these matters, are done following the projects needs and not always the minimization of other impacts in the communities nearby.

Leadership: Main Trends of the Overall Scores

The Leadership category has a more homogeneous performance than some of the other categories evaluated (Figure 4). In this case, most of the credits scored between 25% to 65%, with the best-performing credits being LD3.1 Plan for Long-Term Monitoring and Maintenance (65.0%), LD1.1 Provide Effective Leadership and Commitment (52.9%), and LD1.2 Establish a Sustainability Management System (50.0%). Based on the practices described on the case studies evaluated, one of the main reasons for this performance is the integration of most companies of a sustainability strategy at the project and company level. As an example the Galapagos international airport included on the contract signed with the Ecuadorian government, the integration of sustainability features on the projects design (Contreras, 2014). Also, according to the high score in these credits, several of the projects have a long-term view of the project lifecycle, putting monitoring and maintenance plans in place to guarantee efficient operations (Galan, 2014).

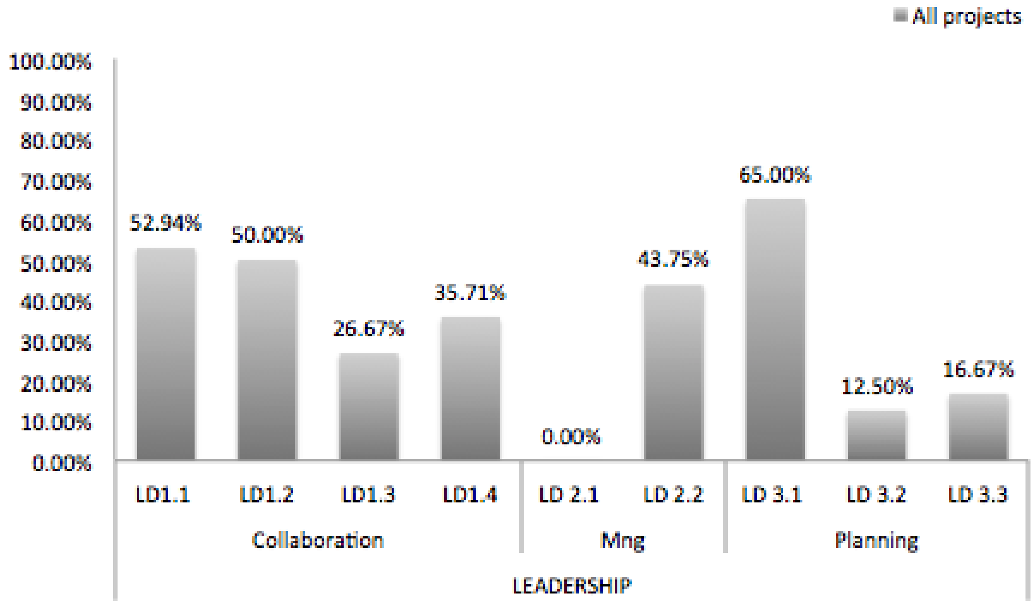


Figure 4. Score of the Leadership category by credit. Median of the 38 projects.

At the other extreme, low-scoring credits such as LD3.3 Extend Useful Life (16.7%), LD3.2 Address Conflicting Regulations and Policies (12.5%), and LD 2.1 Pursue By-product Synergy Opportunities (0.0%) are observed. To understand the reason for this low performance, closer attention is put on the practices needed to score well in these credits, as well as the information provided in the case studies and project documentation previously assessed. It would appear that, several of the projects are centered in fulfilling contractual agreements. This will cause to miss opportunities that go beyond business as usual practices, or require either a longer view or a further collaboration with other entities, such as government agencies or other facilities located nearby. A more collaborative approach is recommended with other indirect stakeholders that may also have an input in the project and its leadership.

Resource Allocation: Main Trends of the Overall Scores

The Resource Allocation category evaluates the efficient use of resources needed for an infrastructure project as well as the characteristics of those resources. The scores obtained in the Resource Allocation category, after calculating the median of the 38 projects assessed, are strongly disaggregated. Therefore, high-scoring credits vs. low- or non-scoring credits, can be easily identified as shown in Figure 5.

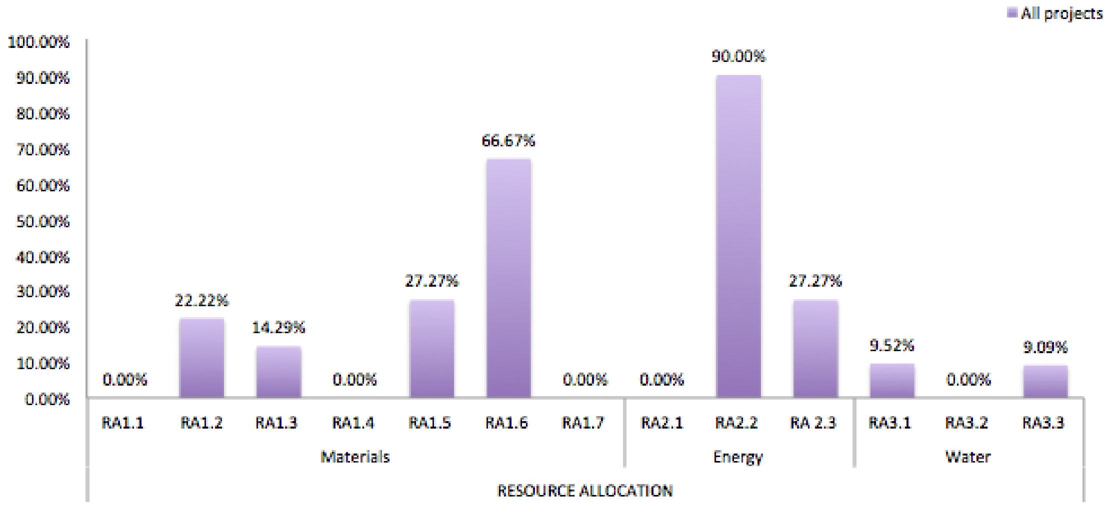


Figure 5. Score of the Resource Allocation by credit. Median of the 38 projects.

The two highest-scoring credits in this category are RA2.2 Use Renewable Energy (90.0%) and RA1.6 Reduce Excavated Materials Taken Off Site (66.7%). In both cases, the higher performance is related to the intrinsic aspect of the project. Around half of the projects in the data set are renewable energy projects, which in most cases score high in the Use Renewable Energy credit. As for the reuse of excavated material, this is a common practice in certain project typologies, especially when the development is located far from populated areas and the space availability on the site is not a constraint.

The non-scoring credits in this category are RA1.1 Reduce Net Embodied Energy (0.0%), RA1.4 Use Regional Materials (0.0%), RA1.7 Provide for Deconstruction and Recycling (0.0%), RA2.1 Reduce Energy Consumption (0.0%), and RA3.2 Reduce Potable Water Consumption (0.0%). The lack of information or of evidence that certain efforts were made in these matters is among the biggest challenges faced in the evaluation. The integration of the practices identified above are still not used by most companies, which is thus the primary driver of the low performance in these credits. It is recommended that infrastructure developers create stronger protocols to identify the origin of the materials used on infrastructure projects as well as a strong emphasis at the project design phase on prescribing the utilization of materials with recycled content.

Natural World: Main Trends of the Overall Scores

The Natural World category looks at the environmental impacts of the projects. The primary goal of this section is to understand infrastructure integration within the project context as well as the identification of positive synergistic approaches. The evaluation of the performance in this category, as with the other categories, is well divided, with half of the credits scoring between 40.0% and 80.0% and the other half scoring between 0.0% and 20.0%, as shown in Figure 6.

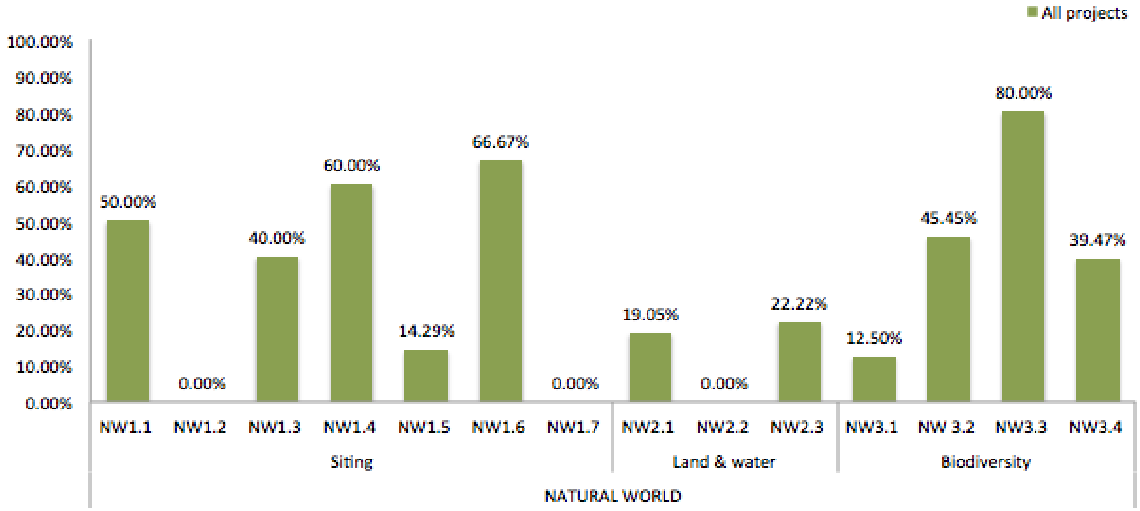


Figure 6. Score of the Natural World by credit. Median of the 38 projects.

The highest-scoring credits in this category are NW3.3 Restore Disturbed Soils (80.0%), NW1.6 Avoid Unsuitable Development on Steep Slopes (66.7%), and NW1.4 Avoid Adverse Geology (60.0%). In most cases the high scores in these credits are the result of good practices applied during the construction process, such as revegetation to guarantee the restoration of the soil to a predevelopment stage. An example of this process, the metro line 1 project in Lima conducted a study to classify the characteristics of the soil extracted to guarantee the restoration of the ecological and hydrological function in later phases. The soil typologies were determines as bare soil, vegetated soil and high urban impact soil (Rodriguez, 2013). Some of the other high scores are the outcome of comprehensive studies conducted to guarantee that the project is located in a safe area far from hazards such as landslides, erosion, (Neves Lejeune, 2015) or areas with geologic formations (Arroyo, 2013). At the other extreme, the lowest or not scoring credits are NW1.2 Preserve Wetlands and Surface Water (0.0%), NW1.7 Preserve Greenfields (0.0%), and NW2.2 Reduce Pesticides and Fertilizer Impacts (0.0%). Some of the main problems faced when scoring in these credits are, first, the lack of information related to some of the above credits, together with the high standards required to score in some of these credits, considering the difference in practices used in developed countries vs. those used in the Latin American region; and second, differences in determining what type of land the project is located on due to different considerations between the land classifications used in the USA and those applied in other countries in the region.

Climate and Risks: Main Trends of the Overall Scores

This category evaluates the minimization of emissions as well as the long- and short-term risks that the project may face during its life cycle. In this case, there is a big difference between the two first credits (belonging to the Emissions subcategory) and the last five (which look at resilience strategies), as shown in Figure 7.

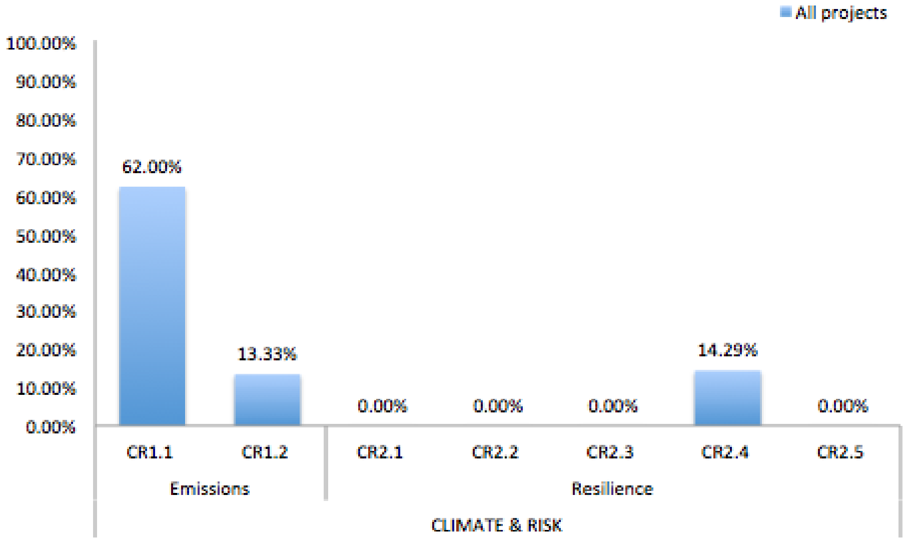


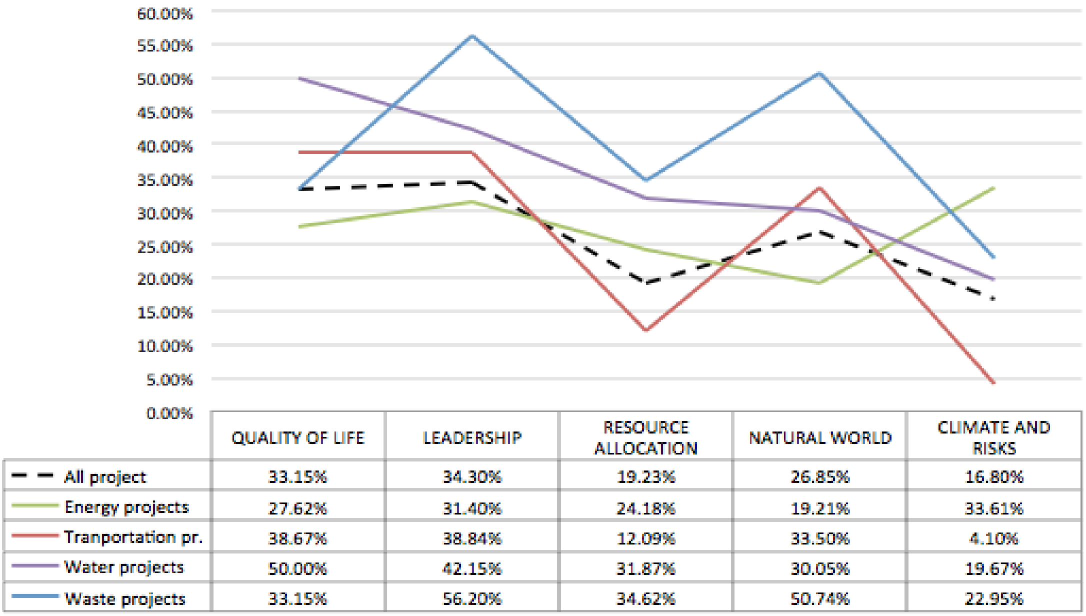
Figure 7. Score of the Climate and Risk by credit. Median of the 38 projects.

The highest-scoring credits in the Climate and Risk category are: CR1.1 Reduce Greenhouse Gas Emissions (62.0%), CR1.2 Reduce Air Pollutant Emissions (13.3%), and CR2.4 Prepare for Short-Term Hazards (14.29%). Many of the projects evaluated, especially the renewable energy ones, have an excellent performance in CR1.1 and the reduction of greenhouse gases (GHG) overall, which is why the performance in this credit is well above that in the rest of the category. On the other side, just a small percentage of all the projects have some strategy in place to reduce GHG, which also accounts for different types of dangerous pollutant such as CO, SO_x, or NO_x among others. When evaluating the protocols integrated to promote project resilience, it is important to recognize that this is the lowest performance subcategory over all with a total percentage of achievement of 3.7%. The only measures implemented towards a more resilient performance, looks at the short-term hazards and the mitigation measures to be applied in order to prevent man-made risks. The hazards identified are related to oil spills or another risk of contamination as well as potential threats due to natural factors such as earthquakes or tsunamis for 1 in 100 year's hazards (Guzman, 2013).

When looking at other practices considered within the resilience category, such as (i) the development of a comprehensive Climate Impact Assessment and Adaptation Plan, (ii) identification of vulnerabilities affecting the community or (iii) changes in design to prepare infrastructure projects for long-term climate effect, there were very few project that took this alternatives into consideration. As a result the median of most credits in this category is 0.0%. These credits are: CR2.1 Assess Climate Threat (0.0%), CR2.2 Avoid Traps and Vulnerabilities (0.0%), CR2.3 Prepare for Long-Term Adaptability (0.00%), and CR2.5 Manage Heat Island Effects (0.0%). As a result, a more aggressive strategy needs to be integrated in the infrastructure projects built in the region at the moment. This is especially important considering that the LAC region has been identify as a region with evident increase to extreme weather events (Magrin, 2007).

Spreadsheet Analysis: Results by Project Typology

The statistical analysis conducted indicated that project typology is one of the main factors affecting the outcome of the sustainability performance and ultimately the score obtained by the projects. Therefore, besides identifying trends by Envision categories, a detailed evaluation was done looking at the main differences in performance based on project typology. The data set evaluated contains 38 samples divided among: energy projects (20 samples), transportation projects (11 samples), water projects (4 samples), and waste projects (3 samples).



	QUALITY OF LIFE	LEADERSHIP	RESOURCE ALLOCATION	NATURAL WORLD	CLIMATE AND RISKS
All project	33.15%	34.30%	19.23%	26.85%	16.80%
Energy projects	27.62%	31.40%	24.18%	19.21%	33.61%
Tranportation pr.	38.67%	38.84%	12.09%	33.50%	4.10%
Water projects	50.00%	42.15%	31.87%	30.05%	19.67%
Waste projects	33.15%	56.20%	34.62%	50.74%	22.95%

Figure 8. Percentage of achievement by category base on project typology.

Comparing the significant score variations by category, it is evident that the project typology is an important driver of the results (Figure 8). Analyzing the main trends identified, the water and waste projects score well above the central tendency in most of the five categories. On the other side energy and transportation varies, depending on the criteria evaluated. The best performance categories in the transportation projects are Quality of Life, Leadership, and Natural World, while in energy projects are Resource Allocation and Climate and Risk (Table 13).

Table13. Percentage of achievement of the different project typology by subcategory.

ALL PROJECTS		ENERGY PROJECTS		TRANSPORTATION PROJECTS		WATER PROJECTS		WASTE PROJECTS	
PURPOSE	60.71%	EMISSIONS	92.50%	PURPOSE	50.00%	PURPOSE	73.21%	MNG	90.32%
EMISSIONS	43.75%	ENERGY	63.27%	PLANNING	50.00%	WATER	55.92%	ENERGY	72.22%
ENERGY	42.86%	PURPOSE	48.21%	COLLAB.	41.67%	ENERGY	50.56%	EMISSIONS	62.50%
COLLAB.	41.67%	COLLAB.	45.00%	WELLBEING	40.24%	BIODIV	49.11%	SITING	57.58%
BIODIV	40.18%	BIODIV	25.89%	SITING	38.38%	PLANNING	45.00%	BIODIV	57.14%
PLANNING	31.67%	MNG	22.58%	BIODIV	37.50%	COLLAB.	43.33%	COLLAB.	50.00%
SITING	24.24%	WELLBEING	20.73%	MNG	22.58%	COMMUN.	40.70%	PURPOSE	46.43%
MNG	22.58%	SITING	20.20%	COMMUN.	20.93%	WELLBEING	39.02%	WELLBEING	39.02%
COMMUN.	20.93%	COMMUN.	13.95%	MATERIALS	19.75%	MNG	37.10%	PLANNING	33.33%
WELLBEING	20.73%	PLANNING	13.33%	L&W	18.75%	SITING	22.73%	MATERIALS	32.06%
L&W	16.67%	MATERIALS	12.50%	WATER	12.55%	L&W	22.92%	L&W	29.17%
MATERIALS	13.75%	L&W	9.38%	ENERGY	9.09%	RESILIENCE	24.39%	WATER	18.61%
WATER	5.66%	WATER	5.66%	EMISSIONS	5.00%	MATERIALS	14.84%	COMMUN.	4.65%
RESILIEN.	3.66%	RESILIEN.	4.88%	RESILIEN.	3.66%	EMISSIONS	10.00%	RESILIEN.	3.66%

Here the scores received in the 14 subcategories are organized from the highest percentage of achievement to lowest. Comparing the significant score variations by subcategory, it is clear that project typology is an important driver of the results. (Table 12 is color-coded following the Envision methodology, helping to identify that subcategories belong to which categories. The colors used are orange for the Quality of Life subcategories, gray for Leadership, purple for Resource Allocation, green for Natural World, and blue for Climate and Risk.). To better understand the differences between project typologies and their scores, a target diagram is shown in Figure 9. For a more detailed quantification of the differences between the percentage of achievement and the central tendency, see the tables in Appendix 5.

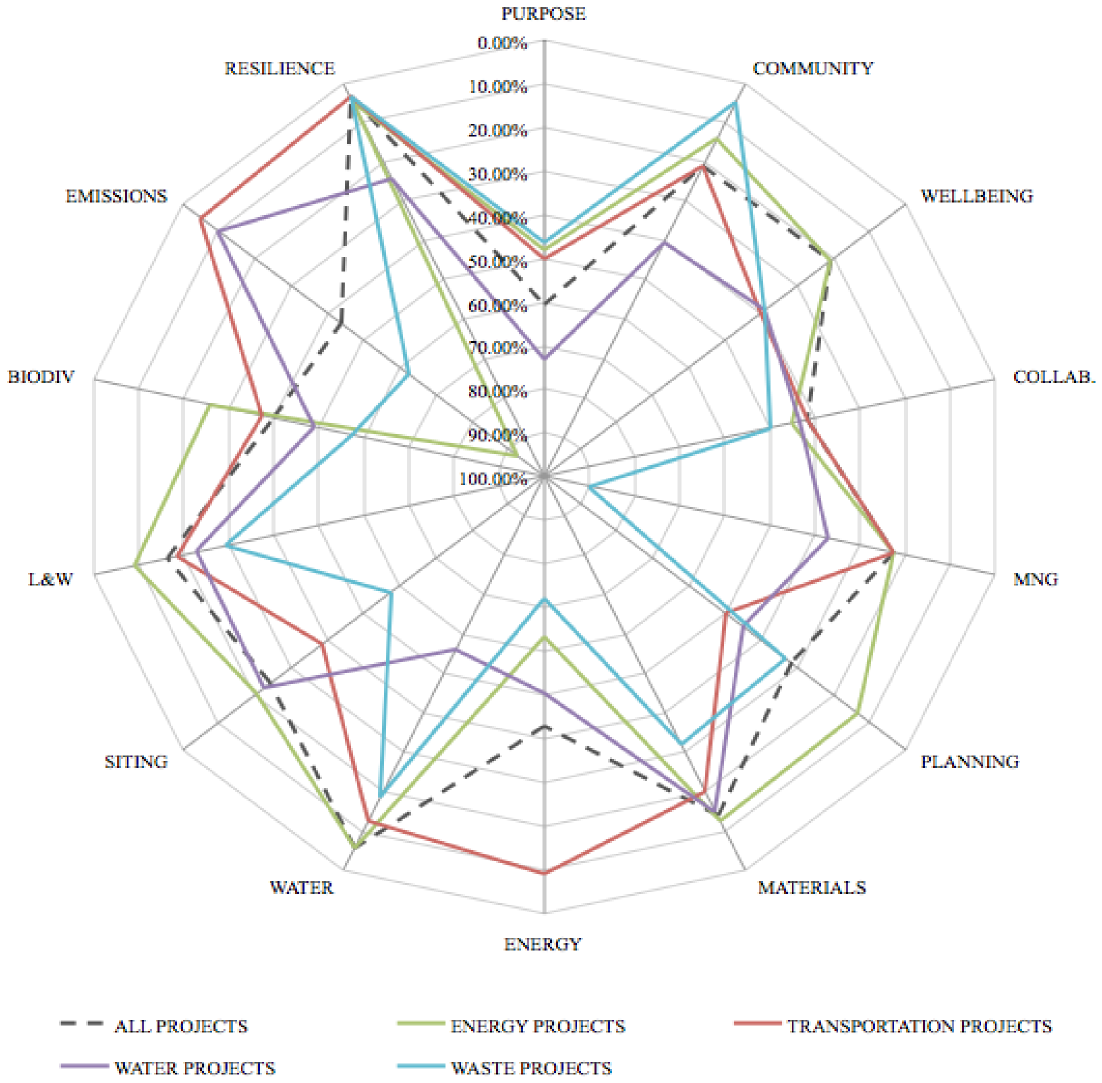


Figure 9. Achievement by subcategory of the four project types vs. central tendency.

Analysis of the Energy Projects Performance

Within the total pool of projects analyzed, there are 20 energy projects assessed, representing 53% of the total sample. These 20 energy projects are divided into three main groups: wind farms (7 samples), photovoltaic (4 samples), and hydropower plants (6 samples). Three other energy projects are also included in the data set: a transmission line, a solar concentration plant, and a combined cycle facility. The scale of the projects ranges from US$32 million to US$8.590 billion, and the projects belong to a variety of locations such as Uruguay, Brazil, Mexico, Chile, Dominican Republic, Honduras, Colombia, and Peru.

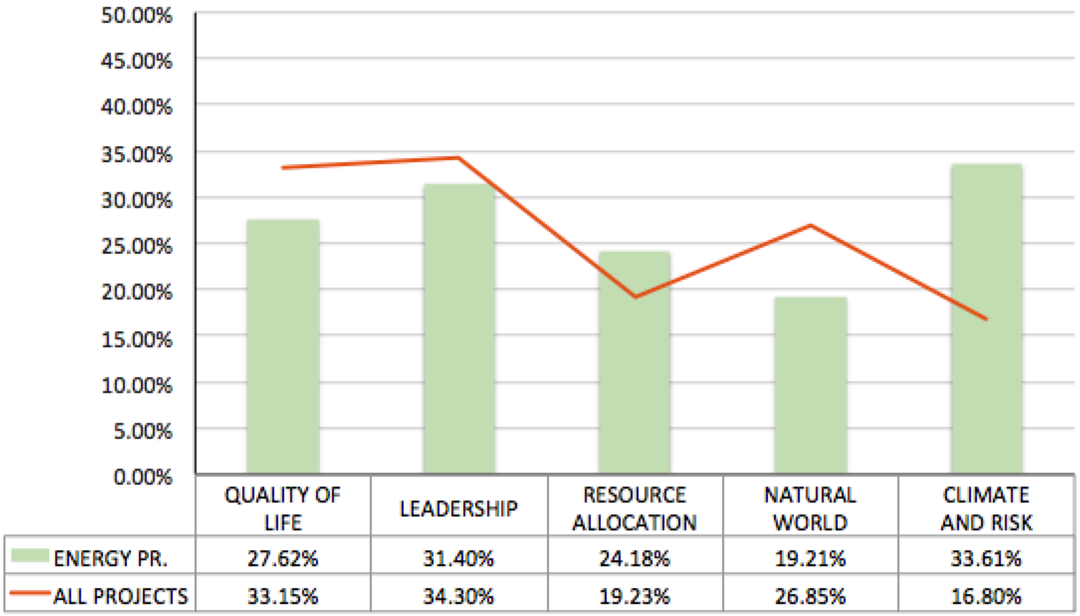


Figure 10. Scores of the energy projects by category vs. central tendency.

At the macro level of their performance (see Figure 10), the best-scoring category for the energy projects is Climate and Risk with 33.6%, followed by Leadership with

31.4%, then Quality of Life with 27.6%, Resource Allocation with 24.2%, and lastly Natural World with an achievement of 19.2%. Nevertheless, looking at the differences from the central tendency, the results are slightly different, with Climate and Risk and Resource Allocation being the only categories that score above the overall median, while the other three score below it. To understand the drivers of these scores, a deeper assessment is conducted, identifying the main trends and the material differences at the subcategory level.

Figure 11. Target diagram of the energy projects’ scores vs. central tendency.

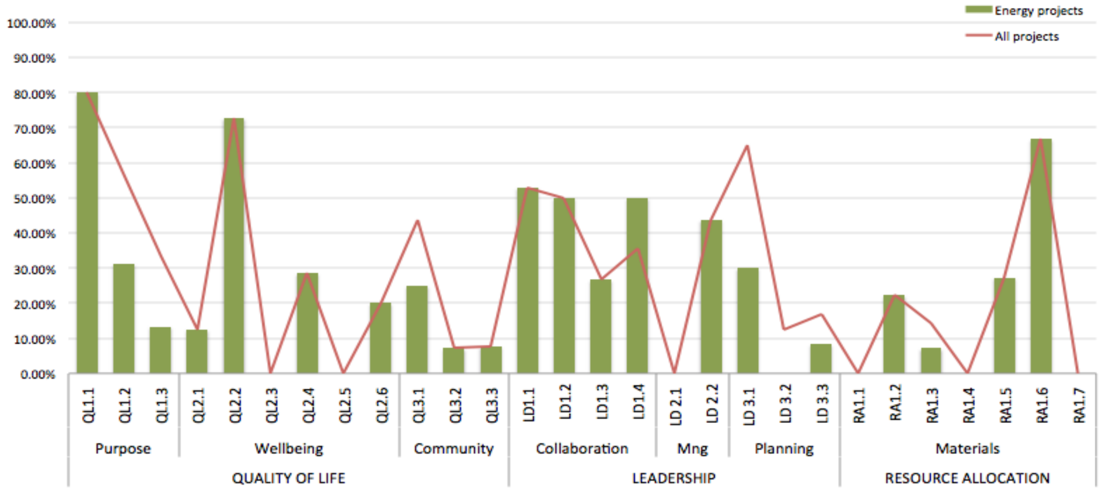
Highlights of the energy projects. Due to the nature of the energy projects assessed – all of which involved the development of renewable energy – one of the highlights of these infrastructure projects is the reduction of greenhouse gas (GHG) emissions, a reason why their performance in the Emissions subcategory and therefore the Climate and Risk category obtained a high score. Several of the projects evaluated qualified under the UNFCCC Clean Development Mechanism (CDM) framework, within the context of the Kyoto Protocol. As a result, the Certified Emission Reductions (CERs) can be commercialized on the carbon market, and therefore become part of the finance strategy of the project. The project teams conduct detailed emission calculations and monitoring processes in the context of the CDM. Due to this circumstance, most renewable energy projects reported detailed information about their long-term plan for GHG reduction and mitigation measures during the evaluation process.

In the second-highest-scoring category, Leadership, is identified that regardless of the energy projects' good performance. The projects did not have a substantial amount of credits scoring above average, but instead different independent efforts that relate to several credits. An example of committed leadership in the stakeholder engagement process is the one conducted in the Santo Antônio hydropower plant, a project located in the Amazon region near Porto Velho, Brazil. In this case, an extensive consultation process was conducted in the area of influence as well as outside it (Rodriguez, 2014). Even after obtaining approval for the project, the project team summoned the stakeholders to 64 meetings and six public hearings where more than 2,000 people participated. The groups represented in these meetings were diverse, including members of communities directly impacted, indigenous communities outside of the reservoir area, opinion leaders from Porto Velho city, and the press (Rodriguez, 2014). In addition to the success of the collaboration processes, special efforts were required to improve the results of the planning process as well. This helped promote a long-term view of the development as well as the regulatory environment affecting the project's life cycle.

Resource Allocation is considered the fourth-highest-scoring category (in absolute value) out of five; nevertheless its performance is one of two above the central tendency. This category evaluates criteria related to efficient use of materials, energy, and water. The high performance on credits related to the use of renewables as well as the commissioning and monitoring of the power systems is one of the main drivers positively affecting the energy projects' overall performance in this category. An example of the enhancement of the use of renewable energy sources in a project and the adequate monitoring of the process is seen in the Florida wind farm, located in Uruguay. This wind farm includes sub-meters as part of the control system, as well as support from an independent commissioning authority (García-Rincón, 2014). The project team also provided a precise quantification of the budget invested in monitoring and maintenance on a yearly basis.

Opportunities for improvement of the energy projects. Quality of Life is the third-highest-scoring category for the energy projects; nevertheless its performance is slightly below the central tendency in some specific matters. Even though it is known in a general way that the construction of new energy projects will improve the standards of living of the population located nearby, some of the projects evaluated did not provide evidence of how they are collaborating to stimulate sustainable development and growth in their region as well as the training and skills of the population. Several social programs have been identified as initiatives to promote development in the area of influence of the projects; the biggest challenge is to guarantee the long-term effect of the programs as well as to quantify their real impact in the future.

Natural World is the lowest-scoring category for the energy projects assessed. In most cases, the low score for some of the credits related to environmental impact stems from a failure to report some of the project's initiatives related to biodiversity and land or water contamination, rather than from actual negative impacts. Thus there is a big opportunity for better reporting protocols and data gathering in order to more effectively communicate some of the environmental impacts caused by energy projects. It was identified that a large number of wind farms, photovoltaic plants, and hydropower projects are located in either greenfield or farmland. As a result, preservation was not achieved for any of the land categories by the projects.



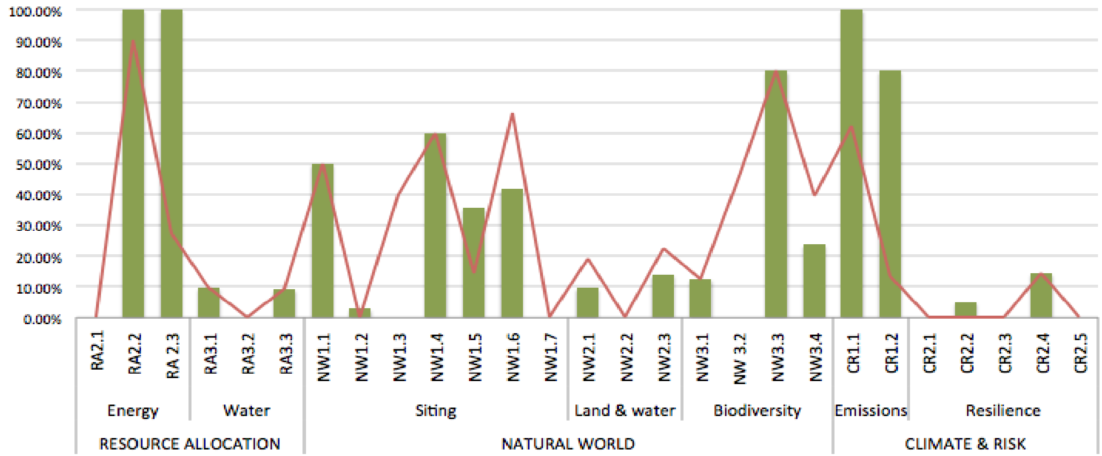


Figure 12. Performance of the energy projects by credit vs. central tendency.

To identify whether there are key differences in performance among the three main types of energy project, a further analysis is conducted looking into wind farms, photovoltaic, and hydropower plants independently (Table 14).

Table 14: Score of the three main energy projects types by category.

ENERGY PROJECTS		WIND FARMS PROJECTS		Diff.	PV PROJECTS		Diff.	HYDRO PROJECTS		Diff.
QL	27.62%	QL	34.81%	7.18%	QL	24.31%	-3.31%	QL	28.73%	1.10%
LD	31.40%	LD	30.58%	-0.83%	LD	32.64%	1.24%	LD	32.64%	1.24%
RA	24.18%	RA	26.37%	2.20%	RA	24.18%	0.00%	RA	22.80%	-1.37%
NW	19.21%	NW	20.20%	0.99%	NW	19.70%	0.49%	NW	22.41%	3.20%
CR	33.61%	CR	34.43%	0.82%	CR	35.66%	2.05%	CR	29.10%	-4.51%

Although the differences between these projects are not large, several trends can be highlighted: The wind farms are the project type with the biggest positive impact on the growth and development of their area and on job creation – measured in the Purpose subcategory – while hydropower plants have the lowest score in this matter. (See Figure 13 and Appendix 7). In both cases, the projects will have a positive impact on the communities where the infrastructure is located; but hydropower projects, besides promoting employment during the construction phase, do not always clearly identify contribution to sustainable growth and capacity building in the long run.

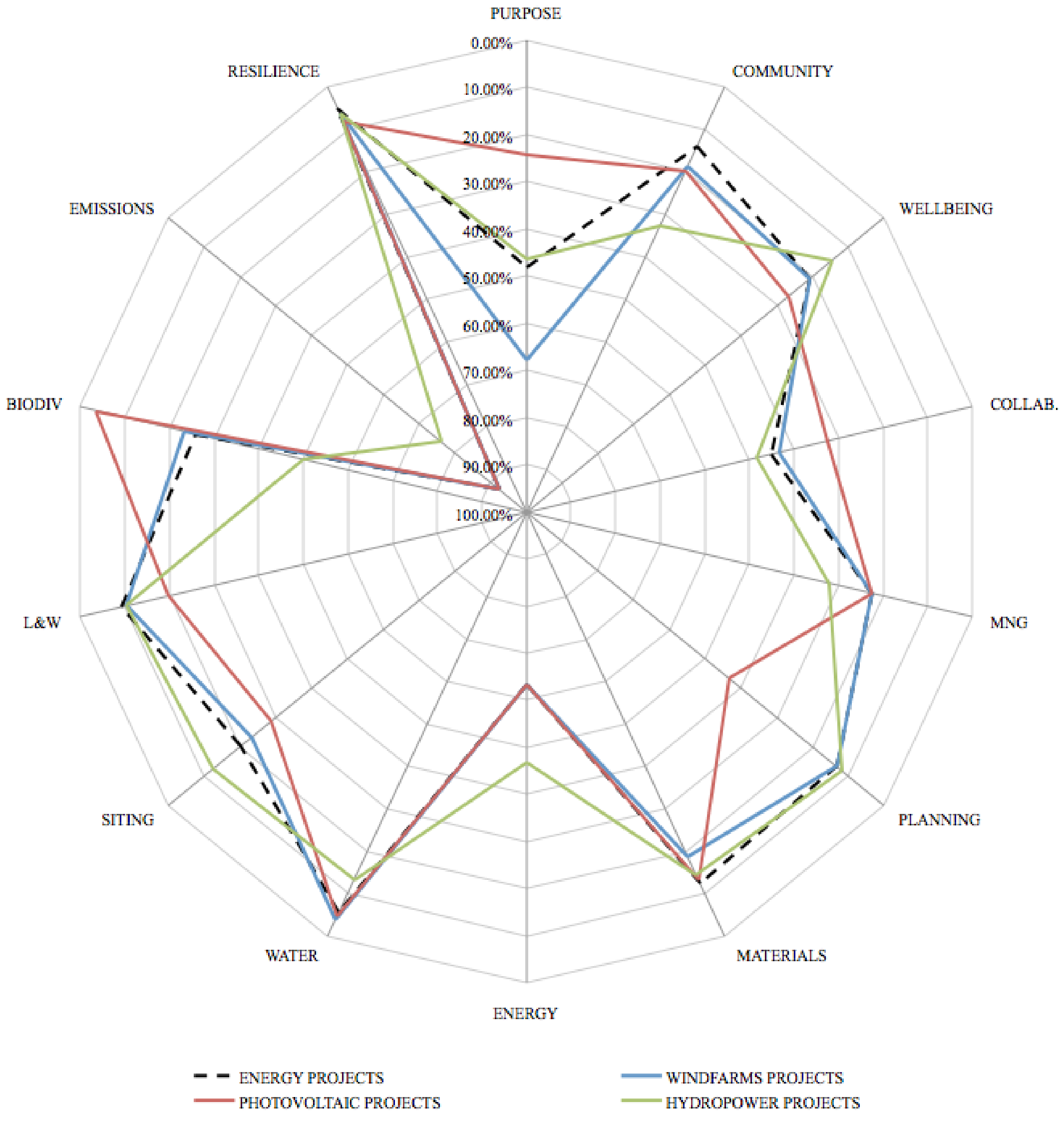


Figure 13. Score of the three main energy projects by subcategory

In matters related to the integration of context-sensitive design to minimize alterations to views, cultural heritage, and local character – measured in the Community subcategory – the hydropower plants have the higher scores among the different energy projects. According to the assessments conducted, it is a common practice in hydropower projects to do a detailed analysis of the landscape surrounding the project, the project´s effect on the land, archaeological studies, and identification of landmarks that the project will need to preserve.

To achieve a sustainable outcome, it is important to take a long-term view and plan appropriately for the project's life cycle – measured in the Planning subcategory. Essential to this approach is understanding regulatory issues and monitoring processes. In this respect, the photovoltaic projects scored three times higher than the other energy project types. Long-term surveillance and maintenance protocols were reported in the photovoltaic projects evaluated, which was not the case for the other energy project types. In certain scenarios, the variations in the scores can be attributed to the difference in the level of rigor in reporting the practices implemented or planned for the future. An example of efficient planning and monitoring for the long term is the one used on the Choluteca I & II photovoltaic plant, where digital control systems such as SunEdison Energy and Environmental Data System (SEEDS) monitor the environmental impacts as well as the facility's performance during the project lifespan (Galan, 2015).

In water-related matters, the performance observed overall in the energy projects is very low, due to the lack of information or protocols to reduce consumption, guarantee availability, and encourage proper monitoring. In the hydroelectric projects, contrary to what one might intuitively expect, the performance observed was higher than in the other energy project typologies. Despite greater potential impacts on water quality and quantity, the information gathered, studies conducted, and mitigation measures put in place greatly exceed those of some of the other energy projects. The precautionary approach taken by some of the hydropower projects to minimize their impact on water bodies has resulted in a higher achievement in water-related evaluations.

Infrastructure projects have the potential to affect biodiversity negatively in areas where the project team has not assessed the possible disruption carefully. The scenario in biodiversity matters is similar to the one seen in the Water subcategory. With the ultimate goal of mitigating the potential impact caused by the hydropower facility, the studies and compensatory processes in place exceed those implemented by other energy project typologies. As a result, contrary to what could have been expected, the performance of hydropower facilities in biodiversity-related matters is higher than that of other energy projects such as wind farms or photovoltaic plants.

Analysis of the Transportation Projects Performance

Transportation infrastructure includes the second largest group of projects analyzed, after energy. In this case, our data set contains 11 projects in total, consisting of three airports, three roads, four ports, and one subway project. The diversity of location is also wide, with the projects placed in six different countries: Costa Rica, Ecuador, Mexico, Peru, Colombia, and Brazil. The scale of the projects varies widely, from a budget of US$35 million to one of US$749 million.

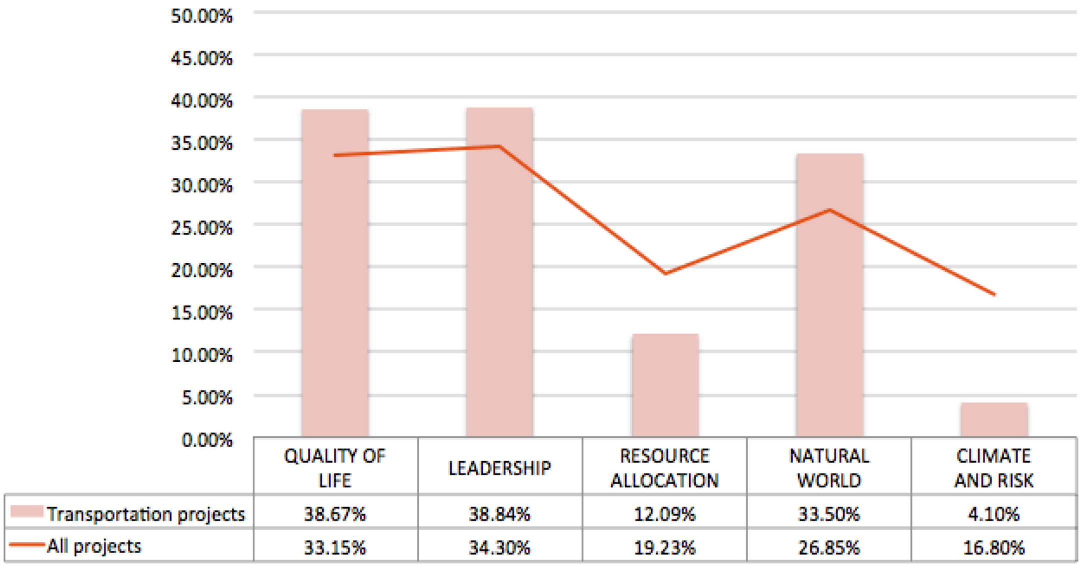


Figure 14. Scores of the transportation projects by category vs. central tendency.

Looking at the results at the macro scale, it is observed that Quality of Life, Leadership, and Natural World score higher than the median of all the projects (see Figure 14), while Resource Allocation and Climate and Risk are considerably below the baseline. There is an apparent difference between the score achieved on different credits as well as the central tendency and the median for the transportation projects, as shown in Figure 15 and Appendix 8.

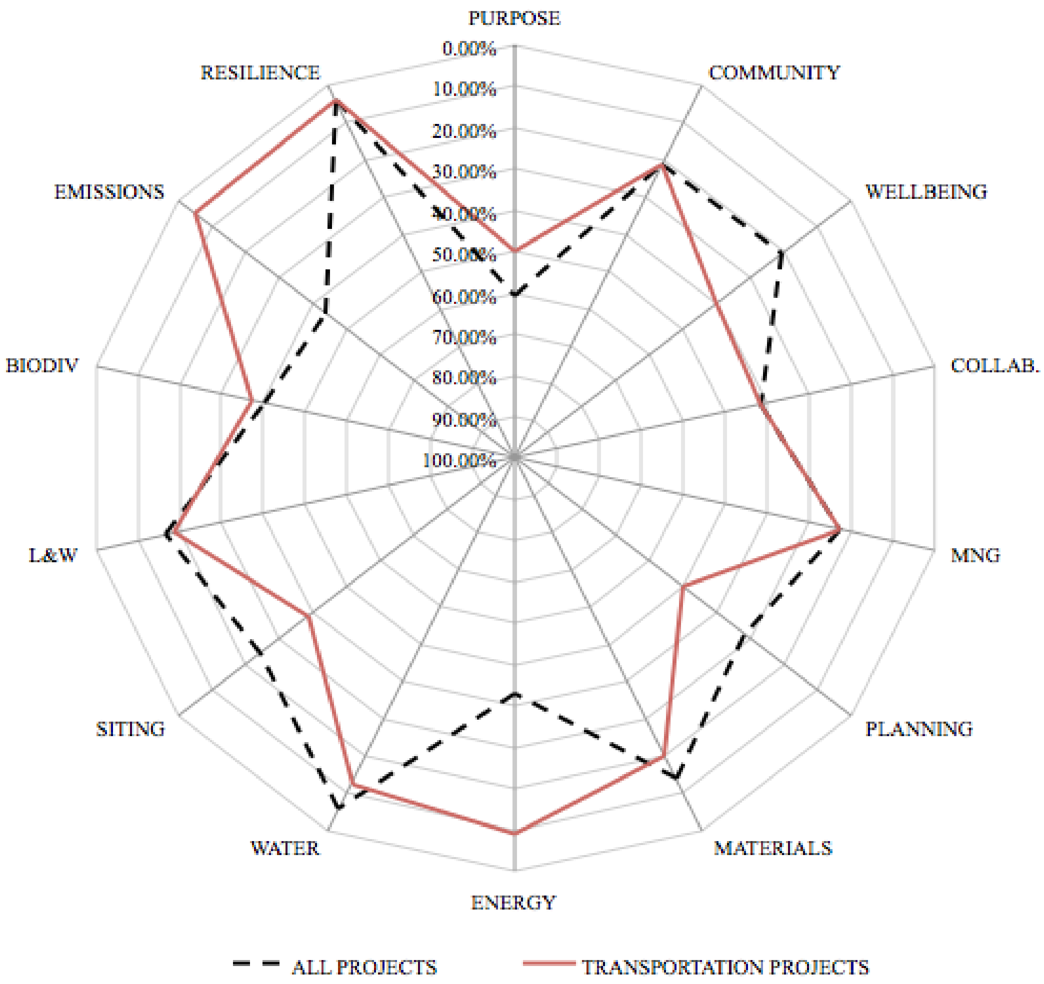


Figure 15. Target diagram of the transportation projects' scores vs. central tendency.

Highlights of the transportation projects. One of the highlights of the transportation projects in social matters is their positive impact on health and safety, as reflected in their scores above the median in these areas. Some of the leading causes of this sound performance are detailed demographic studies of the areas of influence and identification of the population's needs, as well as proper training at the project site following strict safety protocols to minimize risks for workers. These detailed standards are especially present in port and airport projects. An example of preferable practices observed in a transportation project is the Necaxa-Avila highway in Mexico. This development went beyond the project scope and identified how the construction of the road could have a positive impact on the region. Specific programs in health and education together with efforts to transform health conditions in the community encouraged the project team to create vaccination campaigns, aiming to achieve a long-term effect on the population and not just during the time frame of the project (Lee, 2013). It is also notable that the Planning subcategory scores higher than the overall performance. Long-term plans for maintenance and monitoring have been established in several of the projects evaluated.

In the environmental performance of the transportation projects, the largest departures from the median are related to the preservation of land considered as greenfields or prime farmland. In the majority of cases, high performance is evident for the expansion of pre-existing transportation systems, as opposed to new projects built from scratch. The latter are expected to create greater disturbance to non-developed land than are infrastructure projects located on previously developed land. An example of restorative effort in a transportation project is the Juan Santamaría airport in Costa Rica. In this case, part of the project was located on land previously polluted by hydrocarbon spills. Before proceeding with the terminal expansion, a soil remediation process was conducted by the project team. This project has not only minimized its environmental impact on the area, but has restored degraded conditions already existing at the project site (Contreras & Castaldo, 2013a).

A project that illustrates several of the main highlights identified in the transportation typology is subway Line 1 in Lima, Peru. This is the first subway line in the city, and its main achievement is not just to improve the quality of life of the population through community integration and more efficient mobility, but also to have a material impact by stimulating development in the area of influence. Environmental disturbance was minimized by locating the project in previously abandoned areas, while long-term comprehensive plans were developed to guarantee maintenance and ecological protection (Rodriguez, 2013).

Opportunities for improvement of the transportation projects. Among the 14 subcategories analyzed, the main difference between the transportation projects' scores and the overall score is seen in the reduction of greenhouse gas emissions (GHG) – measured in the Emissions subcategory. While renewable energy projects tend to have sophisticated procedures for GHG emissions accountability, transportation projects lack proper protocols to track their impact on the emissions produced during the construction as well as the life cycle of the project. In most cases, a reduction of GHG has been identified as a side effect of the technological improvements implemented in several projects. Nevertheless, no quantitative assessment of the emissions reduced has been provided. An example of the technological improvements that will help reduce emissions is the replacement of the gasoline-powered cranes in some of the port expansions by electric ones.

Resources in transportation projects were not used very strategically. Lack of traceability on where the resources are coming from is common, as it happens in most of the other project typologies. The lack of initiatives to enhance the use of renewable energy sources in the transportation projects is the main reason for the low score obtained in the Energy subcategory, as shown in Figure 16. An achievement 33.8% below the central tendency in this subcategory (Appendix 5) highlights the need to implement new practices that promote the use of renewables energies in ports, airports, or highways and its proper monitoring. Some project teams have reported the exploration of small initiatives such as the installation of solar panels or wind turbines. Nevertheless, this is an anecdotal practice that does not have a major impact on the overall use of energy of the project; therefore the projects do not reach the minimum percentage – at least 10% of energy supply coming from renewable energy resources – required to score in this credit.

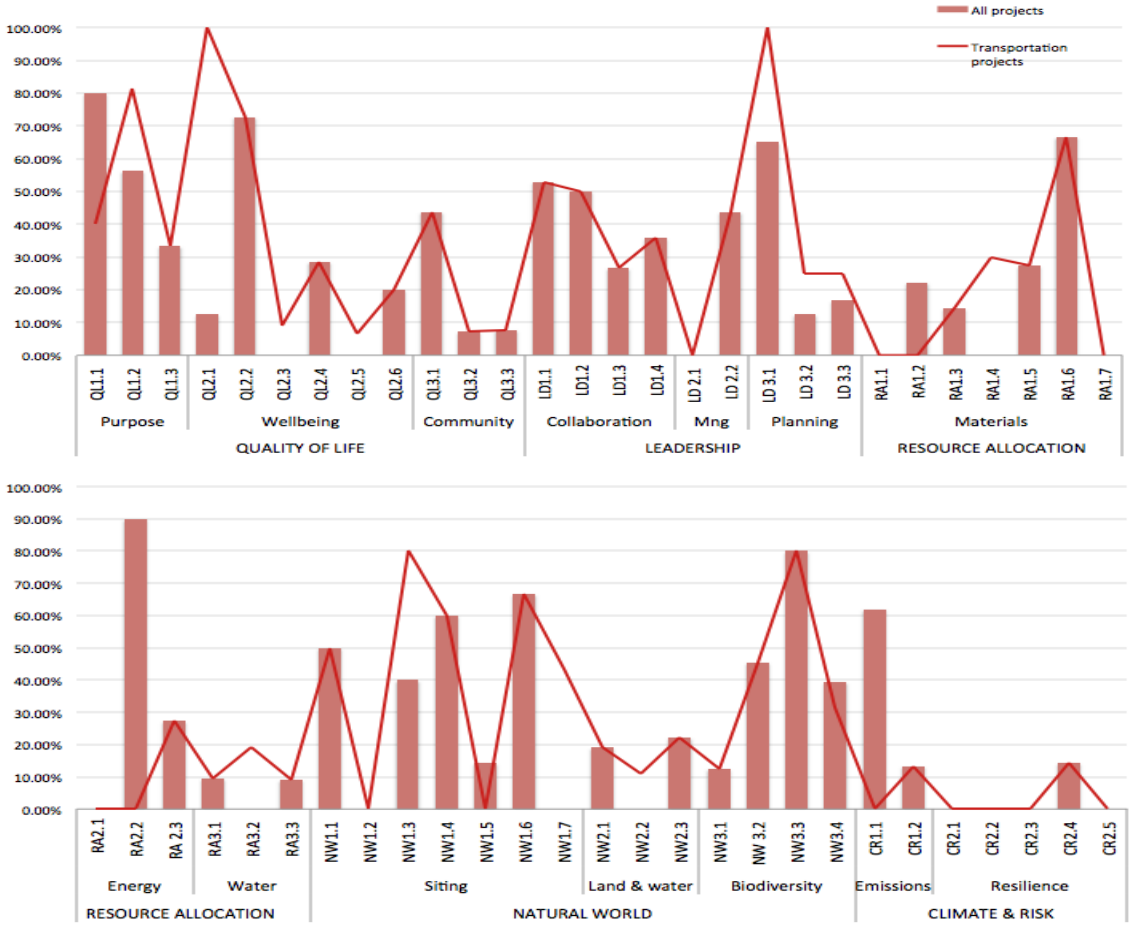
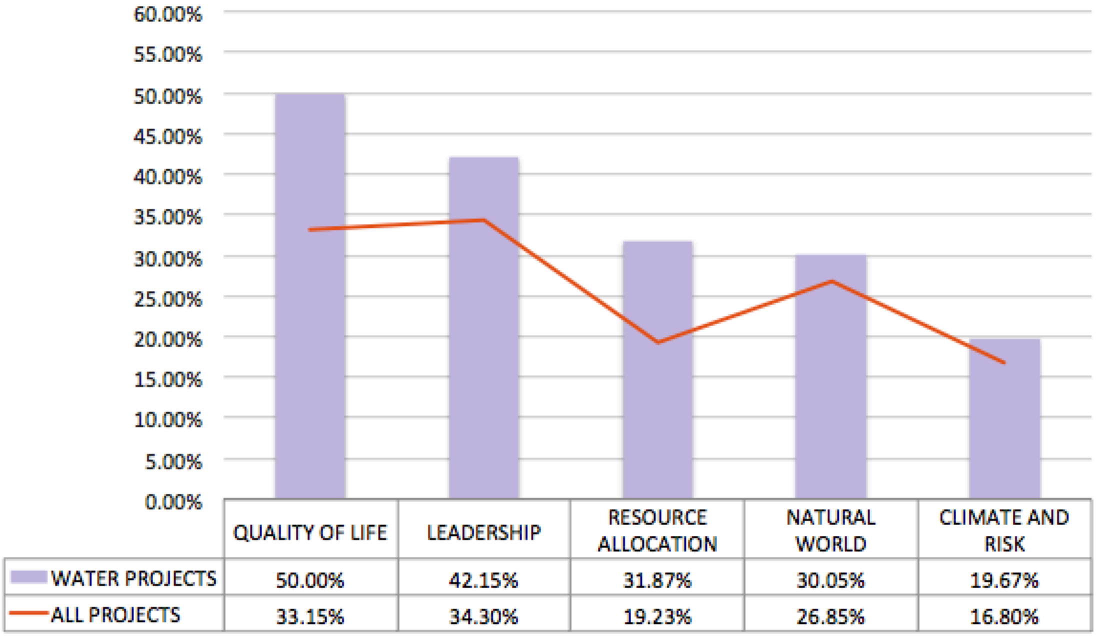


Figure 16. Performance of the transportation projects by credit vs. central tendency.

Analysis of the Water Projects Performance

Water projects constitute one of the smallest sample sizes among the projects assessed (followed by waste). The water projects represented in this study are water treatment facilities in Peru, Brazil, and Mexico and a desalination plant in Trinidad and Tobago. In terms of budget, the projects range from US$55 million to US$686 million.



	QUALITY OF LIFE	LEADERSHIP	RESOURCE ALLOCATION	NATURAL WORLD	CLIMATE AND RISK
🟪 WATER PROJECTS	50.00%	42.15%	31.87%	30.05%	19.67%
— ALL PROJECTS	33.15%	34.30%	19.23%	26.85%	16.80%

Figure 17. Scores of the water projects by category vs. central tendency.

It is apparent that the water projects score higher than the central tendency in all categories, with the largest difference in the Quality of Life category, followed by Resource Allocation, Leadership, Natural World, and Climate and Risk. A more detailed analysis at the subcategory level was conducted to identify where the primary differences lay between project typologies, and thus to understand the main trends of the results.

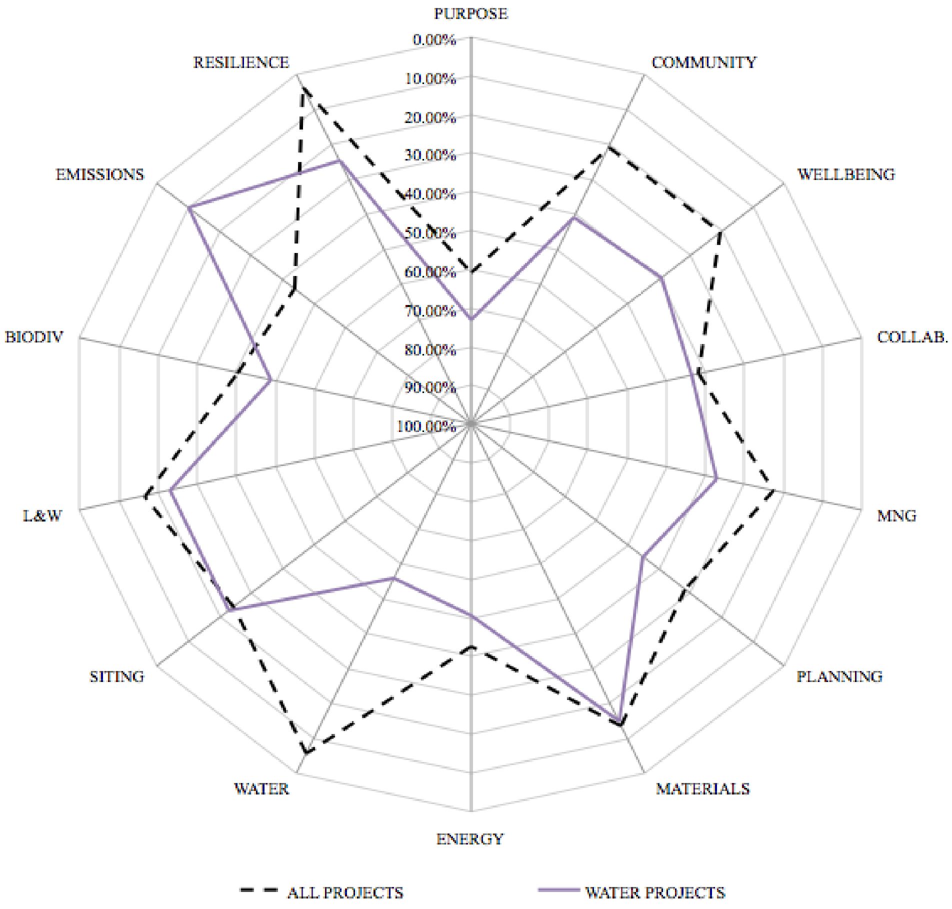


Figure 18. Target diagram comparing the water projects' scores vs. central tendency.

Highlights of the water projects. As expected, the best performing subcategory in this project typology is Water –belonging to RA. The Water subcategory exceeds the central tendency by 50.3%, as shown in Appendix 9. The development and operations of the water projects studied – water treatment and desalinization plants – are conducted in industrial facilities; as a result of this controlled environment, the protocols established to monitor utilization of resources such as energy and water are followed more closely. The nature of the water treatment facilities and their well-acknowledged positive impact – due to their improvement in water sanitation – create an intrinsic indirect benefit in the reduction of water and soil contamination. The reduction of sources of pollution or the identification of potential hazards are some of the criteria measured when looking at the environmental impact of a project. The impacts on biodiversity have also been considered, based on this same reasoning and the detailed analysis performed on the water bodies before the discharge of the byproduct generated.

In the Climate and Risk category, by contrast, the water projects have a relatively poor performance. The Emissions subcategory scores around 33.8% lower than the central tendency, while the Resilience subcategory scores 20.7% higher, as shown in Appendixes 5 and 9. This performance is driven by the practices incorporated by some of the projects to prepare for long-term adaptability. These projects have identified the possible climate impacts they could face during their lifespan and have incorporated mitigation measures to minimize the risk. An excellent example to illustrate climate adaptability measures over the long term is the Atotonilco water treatment plant, located in Mexico. Special drainage systems were built around the facility together with other barriers to mitigate the risk of flooding in case of torrential rains. These strategies will prevent disruptions, not just in the operations but also in adjacent properties (Bello, 2015). Besides the mitigation measures implemented to reduce or avoid direct risks created by weather events, the resilience of the project has been strengthened by the on-site energy generation strategy. The sludge extracted from the water treatment process is used to generate biogas, which is recovered to produce 70% of the facility's energy demand (Bello, 2015). This strategy has increased the resilience of the project as well as its independence from external energy supply.

The positive social impact achieved by the water projects evaluated is also remarkable. Two specific parameters score well above the central tendency in the Quality of Life category, as shown in Figure 19. The first is the stimulation of the growth and development in the area, where business attractiveness and livability are taken into consideration. The second is related to the enhancement of public health and safety. Considering that water is a resource needed to cover the basic needs of the population, the capacity to supply potable water or to treat wastewater has a positive impact on several different levels, and certainly on the quality of life of the population living nearby. In some cases, there is a direct benefit, such as more water availability; in other cases, these benefits are indirect and therefore more difficult to quantify, such as avoiding polluting water bodies by treating wastewater before disposal.

One of the last remarkable strategies to be highlighted in the water projects is the high performance in the identification of byproduct synergies. Synergies identification is one of the lowest-scoring credits overall, a reason why is relevant in this case. Based on the nature of some of the projects assessed, the utilization of a by-product such wastewater provides a positive consideration of the outcome achieved. The performance has also been positive in the long-term planning of the water facilities studied.

Opportunities for improvement of water projects. Keeping in mind that water projects are one of the project types with higher scores, it is still important to identify opportunities for improvement, or areas where the performance is systematically lower than the median.

As identified before, in the Climate and Risk category water projects score notably differently from the other project types evaluated. In this case, the performance in emissions is lower than the average. The main reasons are either that the project teams provided no information on this matter, or that the projects took into consideration just the emissions generated during the construction process, not necessarily during the life cycle of the project. The use of renewable energy for these projects' industrial processes is a clear opportunity to consider. As previously explained, the Atotonilco water treatment plant is one of the few projects that has implemented measures towards GHG reduction. In the rest of the water projects, the energy is obtained from the grid and no consideration of using renewable energy generation is evident. In certain cases, the low performance of some credits stems from a lack of documentation, for example regarding preservation of prime habitat, reduction of excavation material taken off site, or climate-related issues.

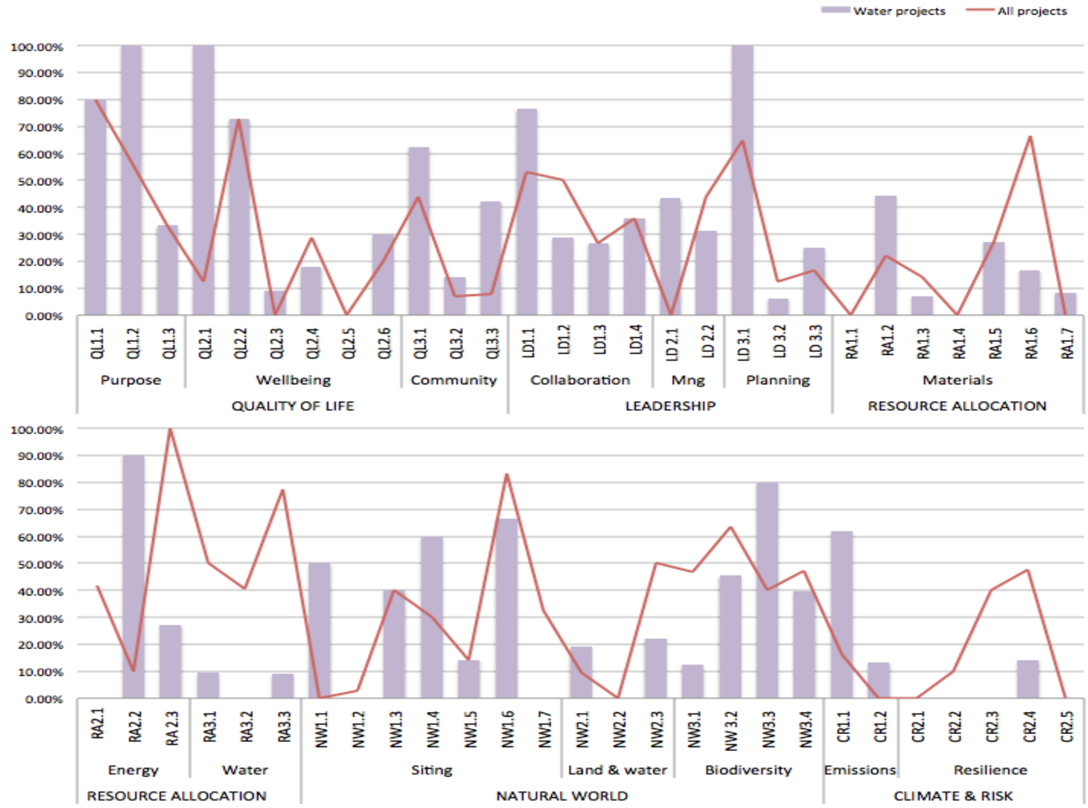
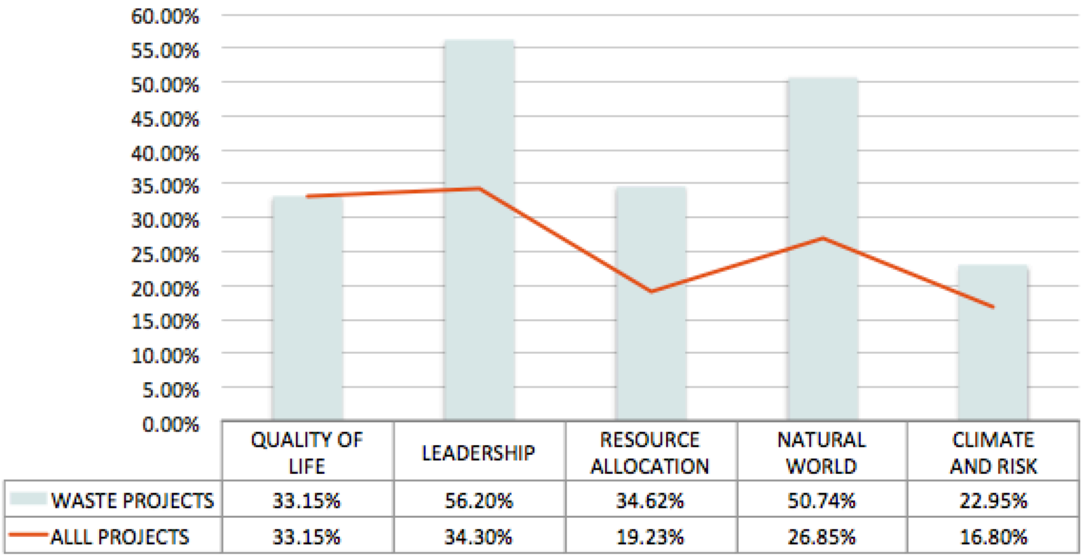


Figure 19. Performance of the water projects by credit vs. central tendency.

Analysis of the Waste Projects Performance

The waste-related projects are the smallest group evaluated, with just three examples. Despite the limitations of such a small sample size, this analysis provides the first steps in building a more robust evaluation and identification of trends in waste-related projects. The waste projects represented in this study are two waste-to-energy facilities (one in Argentina and one in Brazil) and a waste treatment center also located in Brazil. The scale of these projects is small compared with some other project types in this study, the waste-to-energy facilities having budgets of US$31 million and US$37 million, the waste treatment center having a budget of US$80 million.



	QUALITY OF LIFE	LEADERSHIP	RESOURCE ALLOCATION	NATURAL WORLD	CLIMATE AND RISK
▨ WASTE PROJECTS	33.15%	56.20%	34.62%	50.74%	22.95%
— ALLL PROJECTS	33.15%	34.30%	19.23%	26.85%	16.80%

:

Figure 20. Scores of the waste projects by category vs. central tendency.

Similar to the water-related projects, the waste facilities studied have an excellent performance overall, scoring equal to the central tendency in the Quality of Life category and above it in the other four categories. The biggest differences from the overall median are found in the Natural World, Leadership, and Resource Allocation categories, while Climate and Risk represents just a slight increase.

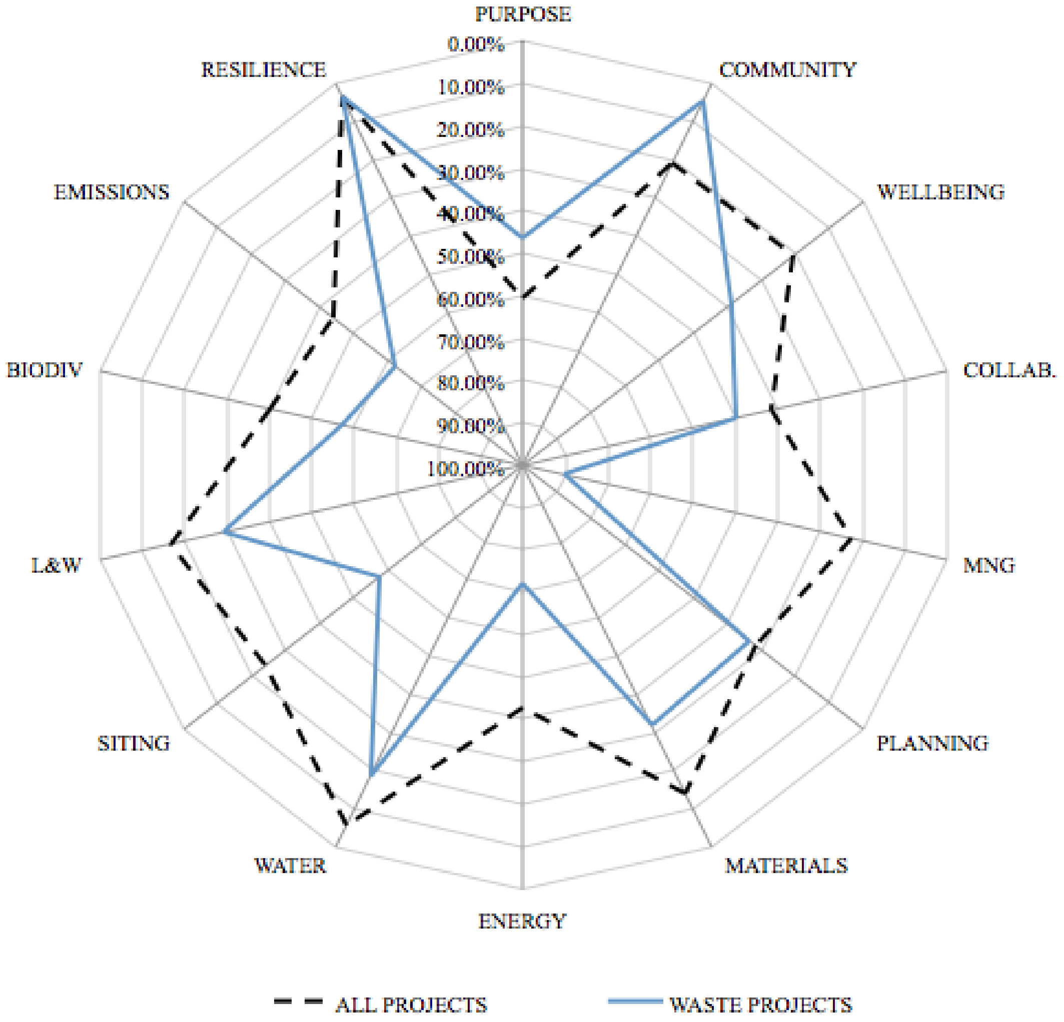


Figure 21. Target diagram comparing the waste projects' scores vs. central tendency.

Highlights of the waste projects. One of the most noteworthy highlights of the waste projects is found in the Leadership category and is related to the exploration of by-product synergies. This credit looks at the reduction of waste through the identification of new opportunities to use unwanted materials from other nearby facilities. It is important to stress that due to the nature of these waste projects, they were conceived following a synergistic approach from the beginning. The operation of these facilities is centered on the utilization of sub-products from other processes, which are repurposed to achieve a more sustainable and efficient outcome.

For the optimization of resource use, one of the most common practices identified is the utilization of excavated material within the project site. The CTR waste treatment facility, for example, reduces the amount of excavation material disposed of off-site, reducing the need for transportation and therefore emissions. A large portion of all the sand and clay extracted was reused on site. Some of the primary uses have been to cover the waste, to pave roads, and to create embankments on the site (Neves Lejeune, 2015). The synergistic nature of the waste projects also has a positive impact on infrastructure integration due to the location of the facilities close to existing and accessible infrastructure. This represents an overall improvement in project efficiency. When it comes to long-term monitoring of energy systems, some preferable examples are identified in the Termoverda Calleiras waste treatment facility. The commissioning and systems control is carried out by an independent third party that guarantees the perfect functioning of the project. Individual meters account for the consumption and generation of energy by the plant.

Individual factors play a fundamental role in the environmental impact of the waste projects. In all cases evaluated, the waste treatment project has been built in previously developed land or within the perimeter of a bigger waste facility. As a result, the projects have had limited impact (if any) on the natural environment or on land of high ecological value. Their placement in brownfield areas instead of greenfield, when possible, illustrates a preferable practice to be followed by other infrastructure projects.

Besides having the important task of managing residues, these waste facilities also make a contribution to the reduction of greenhouse gases. The treatment and utilization of waste gas to generate energy produces a double benefit, since the methane produced by organic matter decomposition would otherwise be released into the atmosphere. Two of the three projects qualify under the UNFCCC Clean Development Mechanism framework (CDM), for which reason a very detailed emissions assessment is planned to be generated over time. Better tracking of emissions has also made it possible to set goals for their reduction. The CTR Rio project is committed to reducing GHG emissions by 41% by 2018 (Neves Lejeune, 2015).

The waste projects' performance in the Resilience subcategory does not show notable differences from the average score of all the projects studied, since no specific strategies towards more resilient projects were implemented.

Opportunities for improvement in the waste projects. Besides the excellent performance on some of the criteria evaluated in the waste projects, further studies and evaluations are recommended to be conducted in the future. The credits looking into the stimulation of sustainable growth and development, and the creation of local skills and capabilities, have a lower score than the rest of the categories (see Appendix 10). The low performance is due in the first place to the location of the projects far from populated areas, so that it was difficult for the project teams to provide evidence of the positive impact in these communities. In the second place, the low score in enhancing local skills and capabilities is related to the lack of local expertise required to manage and operate some of the facilities. On the other side, the highest-performing credit in the Quality of Life category is related to the enhancement of public health and safety. Well-established health and safety protocols were identified in the waste projects evaluated. An example of this is the CTR waste treatment center, where new technologies have been implemented to identify leakages or accidental contamination that could create a risk for the employees, communities, and the environment in general.

Other opportunities for improvement refer to the identification of historical and cultural resources, long-term planning of the project, or more local capacity building.

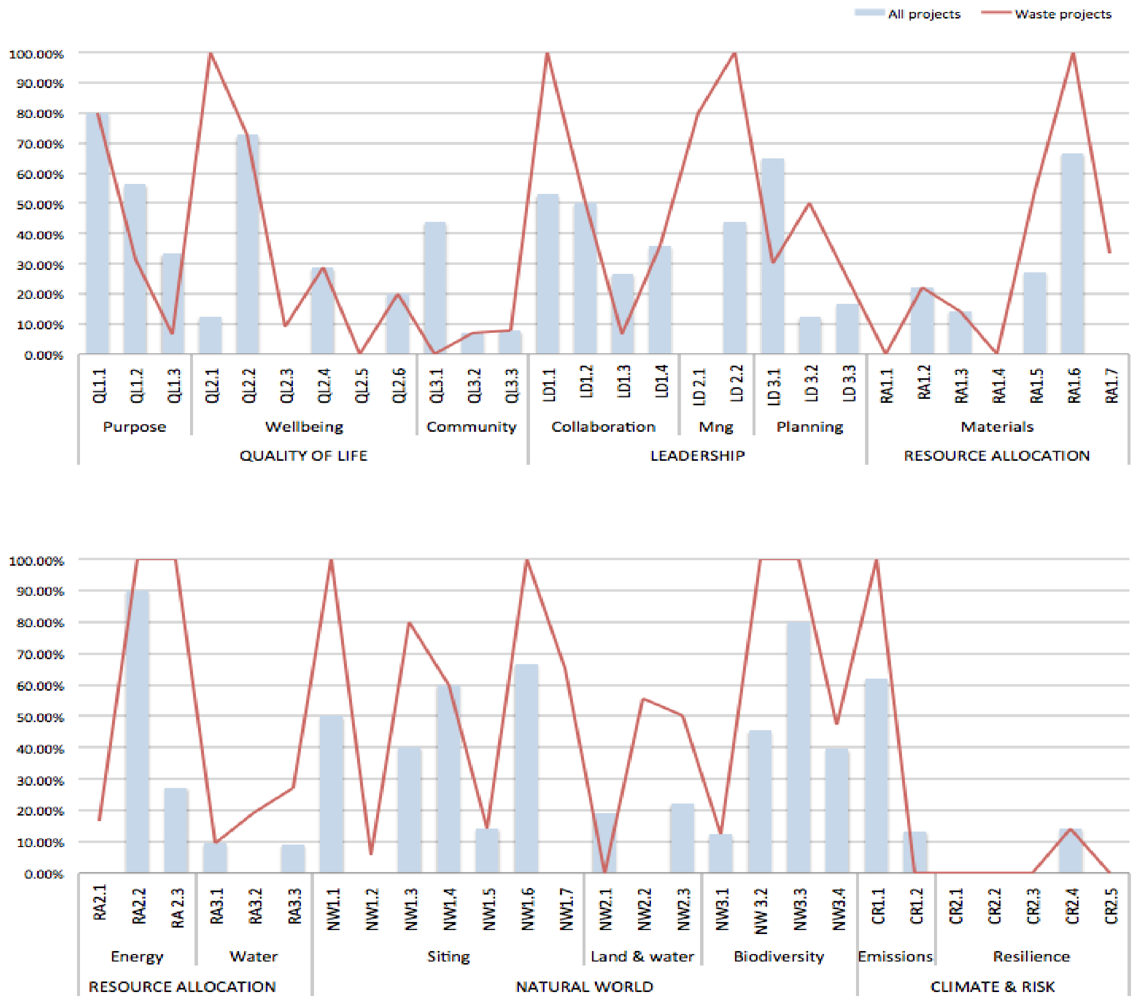


Figure 22. Performance of the water projects by credit vs. central tendency.

Identification of Preferable Practices by category

The detailed analysis of the projects assessed leads to the identification of preferable practices, categorized by Good, Better, Best qualitatively determined levels of contribution. These categories are based on parameters such as the sustainability performance achieved or the innovative approach of the solution provided in order to advance the project's sustainability outcome (Tables 15-19).

Table 15. Preferable practices in the Quality of Life category.

Outcome	Level	Applied practice	Project name
Improvements in health and sanitation	Good	Identification of health and safety plans and programs for the project's employees, and for its users, as well as, communities nearby. These informative sessions should be adapted to the target audience in order to achieve higher effectiveness.	-Lima metro Line 1, Peru -Desalination plant. Trinidad & Tobago
	Better	Health and safety protocols established at a company above the local regulations, setting up public targets for injury reduction when using specific technologies.	-Santo Antônio hydroelectric project, Brazil
		Integration of new technologies that report and monitor any health risks, and exposures to dangerous substances during construction and subsequent phases.	Center for solid waste treatment, Seropédica (Ctr Rio), Brazil
	Best	Programs focused on improving the health conditions such as vaccination of newborns, infants, and children to prevent respiratory diseases. General check-ups for adults and support with family planning are expected to have an impact on the community's long-term quality of life.	-8 de Agosto hydroelectric plant, Peru. -Nuevo Necaxa–Àvila Camacho highway, Mexico
		Specific attention to fulfill the health needs of vulnerable groups. Example: A Hydropower plant in Sto. Antonio. In this case, specific agreements have been signed by the Special Indigenous Sanitary District in Porto Velho and Santo Antônio Energia, to develop a comprehensive Plan for Indigenous Health.	-Santo Antônio hydroelectric project, Brazil

Increased social resilience and promotion of education	Good	Specific training programs implemented to train communities in how to act in case of risks such as flooding or fire.	-Nuevo Necaxa–Avila Camacho highway, MX
	Better	Training for local communities to encourage better practices in farming, cattle grazing, or traditional fishery, to minimize the environmental impact and increase local revenue. Example: An initiative called Molinos de Maguey whose central objective is to train locals to use Nopal (also known as Opuntia ficus-indica) and Maguey (known as Agave). These are two types of plants used as an alternative for livestock feed in periods of drought - increasing animals' survival rates.	-Dominica I and II wind farm, Mexico -Los Cocos wind project, Dominican Republic -Bahía multipurpose port, Colombia
	Best	Community rebirth and integration of new business opportunities through the recovery of previous traditions that were obsolete or were forgotten in the area. Example: Escamoles harvesting (ant larvae that had a substantial economic value as a pre-Hispanic food). Reviving this tradition can have economic benefit and improve food security and variety in the area.	-Dominica I and II wind farm, Mexico -Desalination plant. Trinidad & Tobago
		Capacity building at the country level through the promotion of high level education programs to guarantee knowledge transfer. Example: Agreement signed between the Fundación Chile and Abengoa Solar to create a master's program in solar technology at local universities.	- Cerro Dominador concentration plant, Chile
Identification of community needs	Good	Establishment of a community participation process in which all stakeholders are involved at an early phase of the project. Early participation helps identify community needs and resources required to achieve the project's goals.	-Lima metro Line 1, Peru
	Better	To identify long-term community which will require ongoing collaboration (rather than a one-time interaction). The collaboration should engage all the agents involved such as community representatives, government organizations, as well as non-profit organizations. This will facilitate the success of the project in the long term.	-Los Cocos wind project, Dominican Republic
	Best	Creation of neighborhood organizations to ensure transparency, and to establish a clear line of communication with the project team.	-Lima metro Line 1, Peru

Enhancement of community assets	Good	Investment in a new education center through the provision of school materials, furniture, and facility upgrades such as the installation of solar panels or wind turbines or other types of investment that will improve the existing conditions of the communities.	-Los Cocos wind project, Dominican Republic -Florida wind farm, Uruguay
	Better	Coordination of campaigns to build awareness on the importance of the preservation and enhancement of community assets. Example: Organization of special events to promote waste management through a community participation process to clean beaches or neighborhoods near the project site.	-Los Cocos wind project, Dominican Republic -Lima metro Line 1, Peru
	Best	Creation of common spaces in the area for a specific purpose. This will not only enhance community assets, but, with the proper guidance, will create spaces for social and economic empowerment.	-Eurus wind farm, Mexico
Minority groups	Good	Clear mapping of entire minority groups in the area, which might influence the project.	-Bahía multipurpose port, Colombia
	Better	Identification of needs or challenges to be faced by these minority groups. Example: Sponsoring of an education center for low-income kids with no access to schooling.	-Los Cocos wind project, Dominican Republic
	Best	Promote empowerment of minority and disadvantaged groups in new managing skills such as the development of small businesses to enhance long-term development in the area.	-Bahía multipurpose port, Colombia

Table 16. Preferable practices in the Leadership category.

Outcome	Level	Practice applied	Project name
Identification of synergies to increase efficiency	Good	A synergistic approach to drainage systems to promote safety on-site and to minimize interruption of the processes.	- Aquapolo, industrial water production, Brazil
	Better	A well-designed strategy to identify and use existing infrastructures (such as roads or other type of access among others) which will increase the efficiency of the project and improve its sustainability performance.	-Ecological airport in Galapagos. Ecuador
	Best	The use of existing infrastructure during its off-season, to not just reduce the amount of infrastructure built but almost eliminate it. Example: Irrigation canals on Los Hierros hydropower plant are used to generate electricity during the farming off-season. As a result, no additional infrastructure is required.	-Los Hierros hydroelectric plant, Chile
Raise sustainability awareness	Good/ Better	Train and educate the population on the importance of sustainability practices to raise awareness regarding sustainability and its benefits for the community as well as at the country level. Example: Training courses regarding the reduction of energy consumption, recycling processes, minimizing of water use, and utilization of earth-friendly products are targeted for the employees as well as members of the community.	-Florida wind farm, Uruguay -Wastewater treatment plant and marine outfall of La Chira, Peru
	Best	Establishment of environmental training programs as a requirement to become a member of the project team. This proves a basic knowledge in sustainability matters for the employees as well as identification of possible risks.	-Ecological airport in Galápagos, Ecuador
Statement of the sustainability strategy	Good	Publicly identify the integration of sustainability practices as a core value of the company within defining specific targets.	-Nuevo Necaxa–Avila Camacho highway, Mexico
	Better	Public identification of sustainability commitments and goals to be achieved through social responsibility programs. Example: Reduction of GHG emissions by 40% in 2018.	-Solid Waste (Ctr Rio), Brazil - C. Dominador concentration plant, Chile
	Best	Integration of a sustainability strategy as a contractual commitment with the developer/owner.	-Ecological airport in Galapagos. Ecuador

Identification of sustainability actors at the project and company level	Good	Clear identification member's responsibilities for the development of the sustainability strategy, as well as, the resources available to achieve that target.	-Wastewater treatment plant and marine outfall of La Chira, Peru
	Better	Long-term strategy for the implementation of sustainable practices during the lifecycle of the project.	-Expansion of port capacity and logistics in the container terminal in Cartagena, Colombia
	Best	Third party evaluation. Creation of a Sustainability Committee to implement a strategic plan which will increase the chances of achieving the objectives set and will guarantee transparency.	
Mapping of stakeholders involved	Good/ Better	Precise identification, engagement, and involvement of the stakeholders is a key factor for their integration into the decision-making process. Example: A multidisciplinary team, composed of a psychologist, an industrial engineer, sociologists, and anthropologists to implement a detailed method for social diagnosis at the Line Metro 1 project.	-Lima metro Line 1, Peru -Santo Antônio hydroelectric project, Brazil
	Best	The identification of stakeholders in early project phases, will not just minimize possible conflict during the process, but also create platforms to fulfill common interests. Example: Stakeholder of Dominica wind farm created a US$ 200,000 shared funding plan to invest in the community.	-Dominica I and II wind farm, Mexico
Comprehensive long-term monitoring and maintenance programs	Good	Identification of the targets aiming to achieve during the lifecycle of the project	-Florida wind farm, Uruguay
	Better	Detailed definition and line of action to be followed when integrating long-term monitoring and maintenance strategies. Some of the more comprehensive programs have defined the following features: Costs, goals, responsible people, execution schedule, location, benefits to the population, monitoring indicators, and strategies for community participation.	-Bahía multipurpose port, Colombia
	Best	Third party identification of the sustainability monitoring and maintenance protocol as well as periodic reporting of the achievement of the targets.	-Desalination plant. Trinidad & Tobago
Identification of possible regulatory conflicts	Best	Working with the different agents involved in project design, construction, and operation can help identify future problems within the regulatory framework. Example: Identification of land overlaps between the expansion of Juan Santamaría International Airport and the urban development of communities located nearby.	-Expansion Phase II, Juan Santamaría International Airport, Costa Rica

Table 17. Good practices in the Resource Allocation category.

Outcome	Level	Practice applied	Project name
Sustainable procurement practices	Good	Adherence by the subcontractors to the Plan of Sustainability and Social Responsibility of the main contractor to guarantee compliance with these principles.	-Palmatir wind farm, Uruguay
	Better	Define protocols to select subcontractors based on the sustainability practices applied at the corporate level (not solely to follow economic interest.)	-Los Cocos wind project, Dominican Republic
	Best	Implementation of procurement strategies with a particular focus on greenhouse gas (GHG) monitoring or other high-sustainability protocols in place. Example: A continuous evaluation of subcontractor performance through several evaluations over time to guarantee they achieve the targets set.	- Cerro Dominador concentration plant, Chile
Materials traceability	Good/ Better	Mapping of the materials locally available and analysis of their compliance with the local or international regulations to be applied to the project.	-Expansion and upgrade project, international (ecological) airport in Galápagos, Ecuador
	Best	A detailed inventory of the percentage and cost of regional materials used is provided in individual projects. This inventory would provide information about the manufacturer, the distance between the project and the provider, the distance between the project and the source of extraction, the product cost, and the percentage and value of regionally extracted materials. This information will help calculate the footprint of the project and reduce inefficiencies.	
Reuse of materials	Good	Prescription at the design stage of use for recycled and reused materials to be incorporated into the project construction phase. These practices will improve the sustainability performance of the project and will reduce the amount of raw material required.	-Ecological airport in Galápagos, Ecuador
	Better	The identification of potentially recycled materials	-Expansion and upgrade project,

		such as natural soil, deconstruction debris, or structural elements coming from other construction sites to minimize the utilization of raw materials of the new project and reduce the amount of waste. Example: 15.34% of the material use for the construction of the new terminal building in the Galápagos international airport was reused from the previously existing building.	international (ecological) airport in Galápagos, Ecuador
	Best	Identification of a future reuse of the materials integrated into the project, to provide a second life after the lifecycle of the project is over.	-Vias Nuevas de Lima highway, Peru
Energy third-party commissioning and monitoring	Best	Independent control of the project performance will increase transparency in the information reported.	-Termoverde Caieiras biogas thermoelectric plant, Brazil
Use of renewable energy supply	Best	Set goals (entirely or partially) to supply the project with green renewable energies. Example: To achieve the targets, a strategy to provide the Galápagos international airport was implemented. First, with the provision of 40% of the energy from solar, and several months later when several wind turbines installed on the site were connected.	-Expansion and upgrade project, international (ecological) airport in Galápagos, Ecuador
Efficient water use	Good	Use of recycled water (when possible) to minimize the use of potable water in the cases when is not necessary.	- Cerro Dominador concentration plant, Chile
	Better	Integration of monitoring processes to guarantee, water quality and minimize the risk of water contamination. Monitoring systems should apply to the entire lifecycle of the project.	-Wastewater treatment plant and marine outfall of La Chira, Peru
	Best	Integration of systems to increase water efficiency by maximizing the water storage and minimize water disposal. Example: A 40% water reduction goal was set at the Galápagos International Airport. Gray water from laboratories as well as rainwater were repurposed. Recycled water was utilized in the construction phase when possible.	-Expansion and upgrade project, international (ecological) airport in Galápagos, Ecuador -Mariscal Sucre Airport, Ecuador

Table 18. Preferable practices in the Natural World category.

Outcome	Level	Practice applied	Project name
Monitoring of wildlife and habitat restoration	Good	Go beyond the industry norms and country regulations to carefully map the existing habitat and create a restoration and long-term monitoring strategy.	-Santo Antônio hydroelectric project, Brazil
	Better	A restoration program conducted with close collaboration between the project team and the community, which will enhance the sense of ownership, and will bring the ecosystem functions back to their original stage.	-Nuevo Necaxa–Avila Camacho highway, Mexico
	Best	Detailed studies of fauna distribution followed by careful monitoring of possible changes during the construction and subsequent operation. Example1: On the Santo Antônio hydroelectric project a long-term social and environmental monitoring plan (54-108 months) was put in place to account for the after-completion risks. Example2: In Puerto Bahía, several programs were developed for protection and conservation of mangrove habitats and endangered species for Cienega Honda's area. Additionally, the project team commissioned a comprehensive action plan for conserving and increasing biodiversity in the project's area of influence.	-Santo Antônio hydroelectric project, Brazil -Ecological airport in Galápagos, Ecuador -Los Cocos wind project, Dominican Republic -Bahía multipurpose port, Colombia
Comprehensive approach when siting the project	Good	At the study stage, a comprehensive analysis of project location, integrating sustainability parameters within the criteria used for the selection.	
	Better	Restoration or remediation processes applied on the project site can restore the land to a more beneficial stage than before the development. Example: the project in the port of Callao prevents future contamination by cleaning up previously contaminated land, restoring wellhead protection, and installing land use controls to prevent future contamination.	-Center for solid waste treatment, Seropédica (Ctr Rio), Brazil
		The use of previously disturbed land to minimize the impact on greenfields or farmland is a practice considered highly positive.	-Expansion Phase II, Juan Santamaría International Airport, Costa Rica -Point Fortin desalination plant,
	Best	Restoration or remediation processes applied on the	

		project site to restore the land to a more beneficial stage than before the development. Example: The project in the port of Callao prevented future contamination by cleaning up previously contaminated land, restoring wellhead protection, and installing land use controls to prevent future contamination.	Trinidad and Tobago -Modernization project of the multipurpose north terminal in the port of Callao, Peru
Preventing soil and water contamination	Good	Protection of groundwater and surface water through monitoring and identification of substances that can create a risk to water quality. Monitoring would include rainwater and any other source of contamination.	-Juan Santamaría International Airport, Costa Rica -Center for solid waste treatment, Seropédica (Ctr Rio), Brazil
	Better	Integration of third-party evaluation, which will ensure transparency in the process of risk identification. Example: An entity independent of the project team, determined that chemicals could be a source of contamination during a tsunami, earthquake, fire, or explosion in the Callao port expansion.	-Modernization project of the multipurpose north terminal in the port of Callao, Peru
	Best	Minimization of environmental impacts through use of technology. Example: A placement of sensors on the project site to determine the concentration of certain polluting by-products of a facility's operation, such as leachate from waste facilities.	-Center for solid waste treatment, Seropédica (Ctr Rio), Brazil
Implementation of a stormwater management plan	Best	Integration of programs for full stormwater monitoring and water quality assessment, as well as the installation of structures to capture and repurpose stormwater. Example: In the Mariscal Sucre International Airport, some of the strategies used for water harvesting were open ditches, culverts, and storm drains. The Stormwater Management Plan in place included parameters of frequency, location, and quality control.	-Mariscal Sucre Airport, Ecuador

Table 19. Preferable practices in the Climate and Risk category.

Outcome	Level	Practice applied	Project name
Comprehensive GHG emission measurement processes	Best	GHG inventories are introduced as a protocol to follow in each of the processes involved in the completion of a project. These inventories will account for direct emissions as well as indirect emissions.	-Palmatir wind power project, Uruguay -Cerro Dominador concentration plant, Chile
Training initiatives for subcontractors	Good / Better	Coordination of voluntary training programs to teach subcontractors to integrate GHG tracking processes in their companies.	-Palmatir wind power project, Uruguay - Cerro Dominador concentration plant, Chile
	Best	Establishment of mandatory reporting requirements of GHG emissions of the subcontractors working on a construction site. This will allow project representatives to calculate the carbon footprint of an infrastructure development, as well as, the overall company.	
Increased energy supply resilience	Good / Better	Incorporation of renewable energy generation on the site as a small-scale intervention to a 100% renewable energy generation in the future.	-Ecological airport in Galápagos, Ecuador
	Best	Reuse of operation by-products for the energy generation on the site. Example: Utilization of the CH_4 released by the sludge extracted from the water treatment plant Atotonilco. These practices will decrease external dependence and vulnerabilities of the project to outside conditions, increasing its resilience.	-Atotonilco wastewater treatment plant, Mexico
Minimized vulnerabilities on the project area of influence	Good / Better	Identification of areas with high dependence on fossil fuels and price fluctuation to quantify widespread vulnerability in areas with a poorly diversified energy matrix. The development of renewable energy projects creates a good opportunity to diversify this energy matrix and reduce emissions.	-Palmatir wind power project, Uruguay -Dominica I and II wind farm, Mexico Los Cocos wind project, Dominican Republic
	Best	Development of an action plan in conjunction with the community to account for risks and vulnerabilities in the region. Example: The Tunjita hydropower project worked with the community to evaluate resource depletion and infrastructure traps. Project risks were updated in the latest contingency plan to reflect the current risk landscape.	-Tunjita hydropower plant, Colombia

Chapter IV

Discussion

Several trends were identified from the analysis of the projects evaluated within the framework of the Infrastructure 360 Awards research. The statistical analysis reveals that the project typology (hypothesis 4) is a predictive variable considered statistically significant for the sustainability outcome of the project. This positive correlation is proven in the categories of Resource Allocation (p-value = 0.044; R^2 = 0.14), Natural World (p-value = 0.005 ; R^2 = 0.25), and Climate and Risk (p-value = <0.000002/ R^2 = 0.53), and therefore the null hypothesis is rejected in these simple regression models. The rest of the predictive variables tested – the effect of the budget on the final sustainability outcome (hypothesis 1); the level of development of the country, represented by the Human Development Index (hypothesis 2); and the financing of the project by MDBs vs. other sources (hypothesis 3) – have proven not statistically significant and, as such, the null hypothesis has failed to be rejected for these.

Using other statistical tools (G*Power for Statistical Power Analyses), it was determined that in order to achieve an 80% explanatory power, the number of samples needed varies widely according to the variable tested. This number can vary from 38 (in variables with stronger correlation) to 4,277 (in variables with low or almost nonexistent correlation). After running several scenarios, it was determined that the optimal sample size to test the largest number of variables is 139. This sample size will provide enough explanatory power for 64.3% of the variables. Due to the small data set (38 projects) currently available, and the variability of the projects' profiles, this thesis can be seen as a first step toward constructing an analytical framework for a more comprehensive study with a larger data set.

The second approach used to evaluate the information available was a spreadsheet analysis. This evaluation helped identify the main trends in terms of the percentage of achievement by Envision category and by project typology, and highlighted the preferable practices, categorized by Good, Better, Best, in the 38 projects assessed.

To identify these trends in the credit performance as well as the preferable practices, a comprehensive analysis was conducted of the efforts made in each of the case studies evaluated. The highlights of the results are as follows:

The Leadership category (LD) is the highest-scoring category, earning 34.3% of the total possible points. Most projects perform well in the identification of and commitment to a sustainability strategy, especially at the corporate level. Some of the preferable practices identified toward achieving this target related to the identification of synergies in order to increase efficiency (especially in waste and water projects). This commitment could still be improved by looking beyond the company scale, to identify further opportunities for collaboration with other agents involved in the process such as public officials or representatives from facilities located nearby. The performance observed in the LD category is more homogeneous and has less variability than in some of the other categories.

Quality of Life (QL) is the second-highest-scoring category, earning 33.2% of the total possible points. The best-scoring credits in QL are the ones linked to the identification of community needs, to the needs of minority groups, and to enhancement of community assets. Good practices in these areas, together with education efforts, had a significant impact on enhancing the social resilience of the communities and led to a good performance in these credits. Certain gaps were also found on the integration of context-sensitive design and alternative modes of transportation into the area of influence of the project. Water and waste projects had the highest performance in this category, partly influenced by the positive benefits of these project typologies. One of the most remarkable outcomes in QL was the positive impact of transportation projects on health and safety.

Natural World (NW) has the third highest level of achievement, at 26.9%. Certain projects evaluated have focused on minimizing their disturbances in high-ecological-value and biodiverse environments. Some of the best practices identified through the projects assessed were the monitoring of wildlife, habitat restoration, and full stormwater management. Based on the data set, ports and airports have shown a high performance in the preservation of greenfields or other natural land, since most of the projects assessed here are expansions or upgrades of existing facilities; as a result, they do not require any additional disruption of previously undeveloped land. On the other side, low performance was identified in implementing mitigation measures to reduce the impact on existing hydrologic and nutrient cycles and in avoiding the risk of contamination.

The Resource Allocation category (RA) has an overall score of 19.3%, ranking fourth in overall percentage of achievement. RA shows a low performance in its three subcategories of Materials, Energy, and Water. In most projects, no specific protocols have been identified or reported to minimize the use of resources or make a better use of them. Some of the preferred practices identified in RA that would be recommended for integration into other projects are sustainable procurement practices, material traceability, and reuse as well as more comprehensive monitoring programs to guarantee more efficient use of resources. Water and waste projects are the typologies with better performance in RA, partly due to their stricter monitoring processes. Most of the projects evaluated in these categories involve industrial processes where most of the inputs and outputs can be controlled.

To improve the performance in this category, more synergies are encouraged through future collaboration with other projects or infrastructures nearby. Calculation of net embodied energy and life cycle assessment (LCA) are practices not considered in most cases when creating a new infrastructure project, but could offer sustainability benefits in terms of resource allocation.

The lowest-scoring category is Climate and Risk, achieving 16.8% of the total possible points. As shown in the analysis, the overall results in climate-related matters are highly influenced by the excellent performance achieved by the energy projects in the GHG reduction credits (92.5%), while the overall score in the Resilience subcategory is very low (3.7%). See Appendix 5. As shown in the practices identified in this category, it is recommended to provide training for better accountability of GHGs in project typologies other than energy, as well as identification of vulnerabilities in the area of influence of the project and improved resilience strategies. Waste projects have also shown a good performance in the reduction of emissions, mainly CH_4, while additional efforts should be made to guarantee the traceability of emissions in transportation projects, as well as resilience solutions.

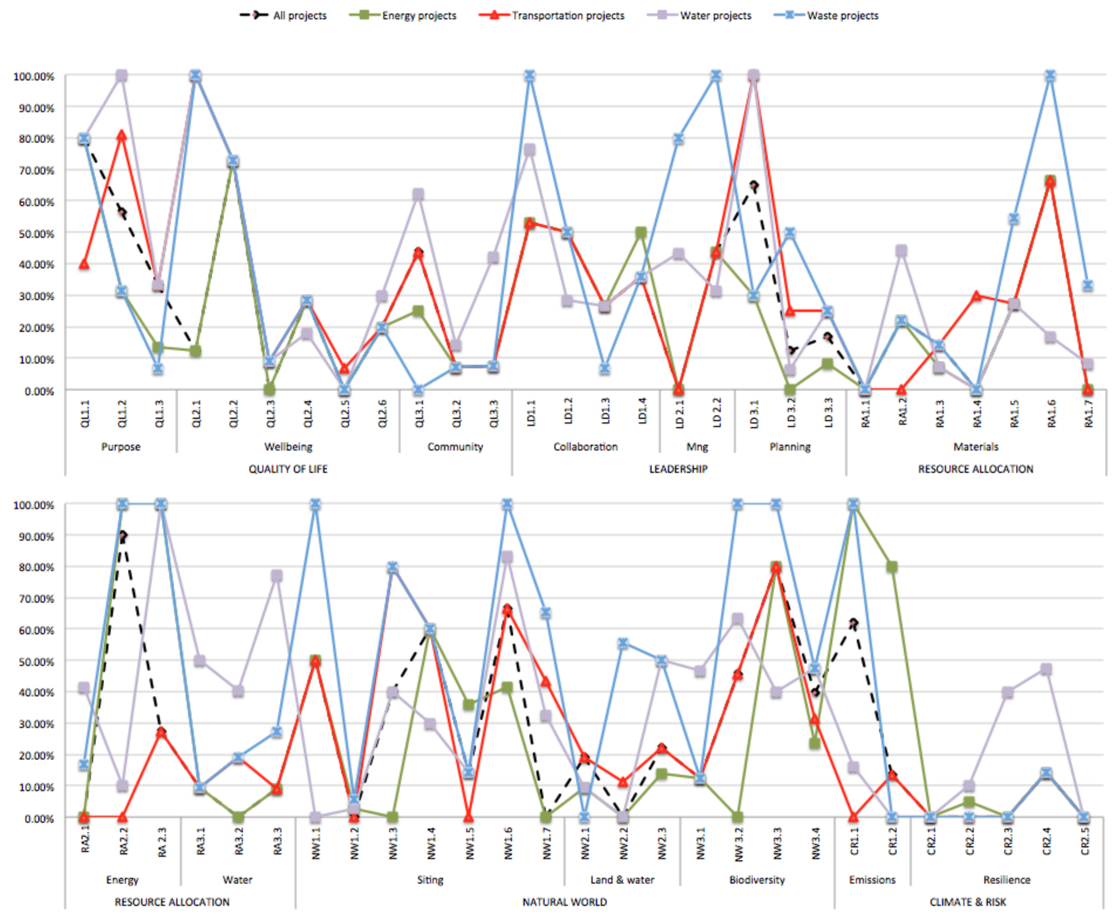


Figure 23. Performance of the different project typologies by credit.

Additional Findings

The following findings (Table 20) identify some additional trends seen in the results of the analysis, as well as future opportunities for improvement. It is important to highlight that some of the following findings are based on small sample size; therefore future research and larger data set will validate the findings with higher certainty.

Table 20. Additional findings.

Findings	Detail
High variance of the results	The final scores of the evaluation are highly polarized with some credits scoring high or very high, while others score low or very low. This is causing a distorted reality where individual credits are driving the results in some categories.
Sustainability outcome vs. impacts	Projects that seem to cause a bigger social or environmental disturbance may have a better sustainability outcome due to the protocols established to anticipate those risks and mitigate them in the long run. An example of this are the results obtained when comparing hydropower projects vs. wind farms or photovoltaic plants. In most cases to minimize larger impacts, more mitigation measures are put in place in hydropower plans and therefore better sustainability outcome are found in certain projects.
Projects operated in controlled environments	The water and waste projects evaluated score well above the average in the Resource Allocation category since the operations are conducted in industrial facilities. Being in controlled environment more detailed identification and monitoring have been conducted of the use of resources (materials, energy, and water), as well as of environmental impacts or potential hazards.
Synergistic approach	Due to the intrinsic characteristics of the waste projects, this typology has shown an excellent performance in the identification of synergies. These synergies apply to many different scales, from the use of by-products as raw material for the projects to the location of these facilities on previously developed land or near existing infrastructure systems.
Corporate sustainability	Most companies collaborating in this evaluation process have identified sustainability as one of the key values at the corporate level. Nevertheless, several projects fail to demonstrate a comprehensive strategy for the long run or the identification of the resources required to implement those practices. As a result, more efforts should be devoted to approaching infrastructure projects in a more holistic manner, as well as to providing long-term solutions.
Approach to sustainability	Most of the measures in place nowadays, still follow a business-as-usual approach having cost reduction as one of the primary drivers to minimize the use of resources, rather than approaching the project from a sustainability standpoint.

Comprehensive documentation strategy	A stronger effort should be made in most cases to integrate a systematic approach in the documentation process. A well structure documentation process will help report the good sustainability practices in place, as well as replicate them in future projects.
Long term approach to sustainability	Most projects evaluated have shown an approach to sustainability focused on construction phase or another short-term phase. To improve the sustainability outcome, in general, is key to have a strong focus on the life cycle of the project.
Climate change mitigation	The results show that most projects incorrectly identify the reduction of GHG as an effective strategy to minimize long-term climate risks, not giving enough attention to promoting resilience practices and preparedness strategies to manage risks such as floods, heat waves, etc. The resilience subcategory has scored as the lowest overall with 3.66% achievement.
Environmental impacts of energy projects	Additional effort should be devoted to improving the reporting of environmental impacts such as land and water contamination in energy projects. The fact that energy projects are mostly located on previously undeveloped land (green fields and farmland) has a notable influence on the low score of the Siting subcategory, which evaluates the avoidance of natural land for project development as a positive attribute.
Water projects performance	The water projects have shown a high overall percentage in all the categories evaluated. Some of the leading causes are the intrinsic nature of the projects assessed (water treatment and desalination plants). These projects create a positive effect on the quality of life of the population as well as establishing strong synergies within infrastructure systems.

Conclusions

The approach followed for the analysis of the information gathered through the Infrastructure 360 Awards initiative represents a first step in determining the baseline of infrastructure sustainability in Latin America and the Caribbean. This thesis has shown the need for further research on this topic, due to a low level of statistical significance in some of the issues evaluated, as well as the small sample size of the water and waste project typologies.

As identified in the results, corporate responsibility protocols acknowledge the importance of the implementation of sustainable practices in infrastructure projects; nevertheless, business as usual procedures are still widely used. A stronger commitment to sustainability –from all the agents involved into the process- will be required to drive change in how infrastructure projects are currently built. A striking finding of the research is the extremely low performance in resilience matters, since just 3.7% of the projects have reported that they take active actions to prepare their projects for weather events. This finding is especially relevant in a region that has been identified as very vulnerable to climate change (Gonzalez Diaz, 2015).

Appendix 1

Envision Rating System: Points Table

			IMPROVED	ENHANCED	SUPERIOR	CONSERVING	RESTORATIVE
QUALITY OF LIFE	PURPOSE	QL1.1 Improve community quality of life	2	5	10	20	25
		QL1.2 Stimulate sustainable growth and development	1	2	5	13	16
		QL1.3 Develop local skills and capabilities	1	2	5	12	15
	WELLBEING	QL2.1 Enhance public health and safety	2	—	—	16	
		QL2.2 Minimize noise and vibration	1	—	—	8	11
		QL2.3 Minimize light pollution	1	2	4	8	11
		QL2.4 Improve community mobility and access	1	4	7	14	
		QL2.5 Encourage alternative modes of transportation	1	3	6	12	15
		QL2.6 Improve site accessibility, safety and wayfinding	—	3	6	12	15
	COMMUNITY	QL3.1 Preserve historic and cultural resources	1	—	7	13	16
		QL3.2 Preserve views and local character	1	3	6	11	14
		QL3.3 Enhance public space	1	3	6	11	13
					Maximum QL Points:	181*	
LEADERSHIP	COLLABORATION	LD1.1 Provide effective leadership and commitment	2	4	9	17	
		LD1.2 Establish a sustainability management system	1	4	7	14	
		LD1.3 Foster collaboration and teamwork	1	4	8	15	
		LD1.4 Provide for stakeholder involvement	1	5	9	14	
	MANAGEMENT	LD2.1 Pursue by-product synergy opportunities	1	3	6	12	15
		LD2.2 Improve infrastructure integration	1	3	7	13	16
	PLANNING	LD3.1 Plan for long-term monitoring and maintenance	1	3	—	10	
		LD3.2 Address conflicting regulations and policies	1	2	4	8	
		LD3.3 Extend useful life	1	3	6	12	
					Maximum LD Points:	121*	
RESOURCE ALLOCATION	MATERIALS	RA1.1 Reduce net embodied energy	2	6	12	18	
		RA1.2 Support sustainable procurement practices	2	3	6	9	
		RA1.3 Use recycled materials	2	5	11	14	
		RA1.4 Use regional materials	3	6	9	10	
		RA1.5 Divert waste from landfills	3	6	8	11	
		RA1.6 Reduce excavated materials taken off site	2	4	5	6	
		RA1.7 Provide for deconstruction and recycling	1	4	8	12	
	ENERGY	RA2.1 Reduce energy consumption	3	7	12	18	
		RA2.2 Use renewable energy	4	6	13	16	20
		RA2.3 Commission and monitor energy systems	—	3	—	11	
	WATER	RA3.1 Protect fresh water availability	2	4	9	17	21
		RA3.2 Reduce potable water consumption	4	9	13	17	21
		RA3.3 Monitor water systems	1	3	6	11	
					Maximum RA Points:	182*	
NATURAL WORLD	SITING	NW1.1 Preserve prime habitat	—	—	9	14	18
		NW1.2 Protect wetlands and surface water	1	4	9	14	18
		NW1.3 Preserve prime farmland	—	—	6	12	15
		NW1.4 Avoid adverse geology	1	2	3	5	
		NW1.5 Preserve floodplain functions	2	5	8	14	
		NW1.6 Avoid unsuitable development on steep slopes	1	—	4	6	
		NW1.7 Preserve greenfields	3	6	10	15	23
	LAND & WATER	NW2.1 Manage stormwater	—	4	9	17	21
		NW2.2 Reduce pesticide and fertilizer impacts	1	2	5	9	
		NW2.3 Prevent surface and groundwater contamination	1	4	9	14	18
	BIODIVERSITY	NW3.1 Preserve species biodiversity	2	—	—	13	16
		NW3.2 Control invasive species	—	—	5	9	11
		NW3.3 Restore disturbed soils	—	—	—	8	10
		NW3.4 Maintain wetland and surface water functions	3	6	9	15	19
					Maximum NW Points:	203*	
CLIMATE & RISK	EMISSIONS	CR1.1 Reduce greenhouse gas emissions	4	7	13	18	25
		CR1.2 Reduce air pollutant emissions	2	6	—	12	15
	RESILIENCE	CR2.1 Assess climate threat	—	—	—	15	
		CR2.2 Avoid traps and vulnerabilities	2	6	12	16	20
		CR2.3 Prepare for long-term adaptability	—	—	—	16	20
		CR2.4 Prepare for short-term hazards	3	—	10	17	21
		CR2.5 Manage heat islands effects	1	2	4	6	
					Maximum CR Points:	122*	
					Maximum TOTAL Points:	809*	

* Not every credit has a restorative level. Therefore totals include the maximum possible points for each credit whether conserving or restorative.

Appendix 2

Projects Included in the Evaluation and their Main Features

		Typology		Development		Budget	Finance by Multilat.
Year	Name of the project	Type	Category	Country	HDI	(mill USD)	Yes / No
2013	Palmatir wind power project	Wind farm	Energy	Uruguay	0.793	42	Yes
2014	Xingú and Macapá high tension lines	Transmission Line	Energy	Brazil	0.755	1300	No
2014	Aura Solar I photovoltaic plant	PV	Energy	Mexico	0.915	100	Yes
2014	Pozo Almonte solar photovoltaic plants	PV	Energy	Chile	0.832	80	Yes
2014	Los Hierros hydroelectric plant	Hydro	Energy	Chile	0.832	76	No
2014	Santo Antônio do Jari hydroelectric power plant	Hydro	Energy	Brazil	0.755	422	No
2014	Los Cocos wind project	Wind farm	Energy	Dominican R.	0.715	180	No
2015	Concentration Plant Cerro Dominador	PV/Solar tower	Energy	Chile	0.832	1100	Yes
2015	Moquegua photovoltaic plant	PV	Energy	Peru	0.734	49	No
2015	Cerro de Hula wind project	Wind farm	Energy	Honduras	0.606	350	Yes
2015	Florida wind farm	Wind farm	Energy	Uruguay	0.793	110	No
2015	Eurus wind farm	Wind farm	Energy	Mexico	0.915	560	Yes
2015	Carilafquen and Malalcahuello hydroelectric power plant	Hydro	Energy	Chile	0.832	54	No
2015	Tunjita hydropower plant	Hydro	Energy	Colombia	0.72	60	No
2015	Santo Antônio Hydroelectric	Hydro	Energy	Brazil	0.755	8590	No
2016	Choluteca I and II	PV	Energy	Honduras	0.606	209	Yes
2016	Chilca UNO thermoelectric plant	Biogas	Energy	Peru	0.734	320	No
2016	Dominica I and II	Wind farm	Energy	Mexico	0.915	196	No
2016	Ucuquer wind farm, phases I and II	Wind farm	Energy	Chile	0.832	32	No
2016	8 de Agosto hydroelectric plant and 138 Kv Transmission Line	Hydro	Energy	Peru	0.734	60	No
2013	Expansion, Phase II: Juan Santamaria International Airport	Airport	Transport.	Costa Rica	0.766	100	Yes
2014	Mariscal Sucre International	Airport	Transport.	Ecuador	0.732	700	Yes

	Airport						
2014	Expansion and upgrade project international (ecological) airport in Galapagos	Airport	Transport.	Ecuador	0.732	35	No
2014	Nuevo Necaxa - Àvila Camacho highway	Road	Transport.	Mexico	0.915	353	No
2014	Vias Nuevas de Lima highway	Road	Transport.	Peru	0.734	590	No
2014	Lima metro Line 1	Mass transit	Transport.	Peru	0.734	270	No
2015	Urban improvement and maintenance of the Interior Circuit	Road	Transport.	Mexico	0.915	230	No
2015	Modernization project of the multipurpose north terminal in the port of Callao	Port	Transport.	Peru	0.734	749	Yes
2015	Expansion of port capacity and logistics in the container terminal in Cartagena	Port	Transport.	Colombia	0.72	660	Yes
2016	Puerto Bahía multipurpose port	Port	Transport.	Colombia	0.72	591	Yes
2016	Maranhão grain terminal. TEGRAM	Port	Transport.	Brazil	0.755	200	No
2016	Biogas from waste, Buen Ayre plant	Waste to energy	Waste	Argentina	0.836	31	No
2016	Center for solid waste treatment, Seropédica (Ctr Rio)	Waste treatment	Waste	Brazil	0.755	80	No
2016	Termoverde Caieiras- Biogas thermoelectric plant	Waste to energy	Waste	Brazil	0.755	37	No
2014	Wastewater treatment plant and marine outfall of La Chira	Water treatment	Water	Peru	0.734	192	No
2015	Industrial water production Aquapolo	Water treatment	Water	Brazil	0.755	158	No
2016	Atotonilco wastewater treatment plant	Water treatment	Water	Mexico	0.915	686	No
2016	Point Fortin desalination plant	Desalinization plant	Water	Trinidad and Tobago	0.772	55	No

Appendix 3

Percentage of Achievement by Project Typology

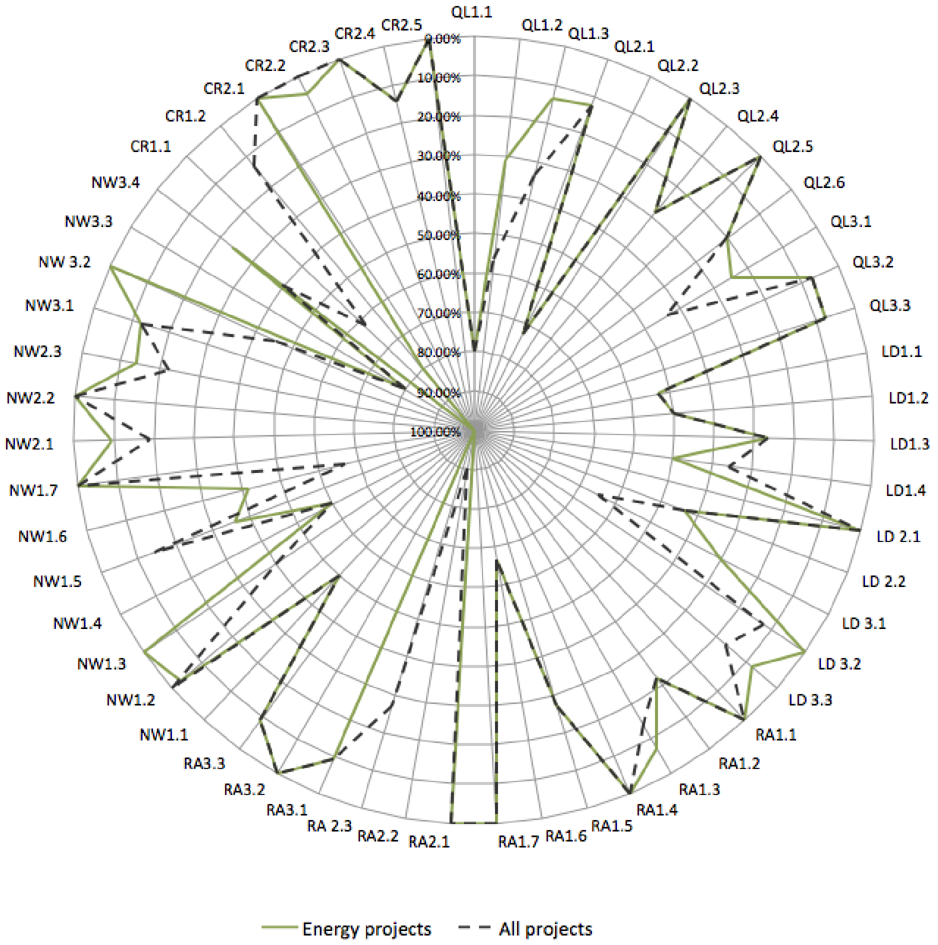
Table 21. Percentage of achievement and difference to the median by project typology

DIFFERENCE % TO CENTRAL TENDENCY BY SUBCATEGORY							
ALL PROJECTS		ENERGY PROJECTS			TRANSPORTATION PROJECTS		
SUBCAT.	**% Achiev.**	**SUBCAT.**	**% Achiev.**	**Diff.**	**SUBCAT.**	**% Achiev.**	**Diff.**
PURPOSE	60.71%	PURPOSE	48.21%	-12.50%	PURPOSE	50.00%	-10.71%
COMMUNITY	20.93%	COMMUNITY	13.95%	-6.98%	COMMUNITY	20.93%	0.00%
WELLBEING	20.73%	WELLBEING	20.73%	0.00%	WELLBEING	40.24%	19.51%
COLLAB.	41.67%	COLLAB.	45.00%	3.33%	COLLAB.	41.67%	0.00%
MNG	22.58%	MNG	22.58%	0.00%	MNG	22.58%	0.00%
PLANNING	31.67%	PLANNING	13.33%	-18.33%	PLANNING	50.00%	18.33%
MATERIALS	13.75%	MATERIALS	12.50%	-1.25%	MATERIALS	19.75%	6.00%
ENERGY	42.86%	ENERGY	63.27%	20.41%	ENERGY	9.09%	-33.77%
WATER	5.66%	WATER	5.66%	0.00%	WATER	12.55%	6.89%
SITING	24.24%	SITING	20.20%	-4.04%	SITING	38.38%	14.14%
L&W	16.67%	L&W	9.38%	-7.29%	L&W	18.75%	2.08%
BIODIV	40.18%	BIODIV	25.89%	-14.29%	BIODIV	37.50%	-2.68%
EMISSIONS	43.75%	EMISSIONS	92.50%	48.75%	EMISSIONS	5.00%	-38.75%
RESILIENCE	3.66%	RESILIENCE	4.88%	1.22%	RESILIENCE	3.66%	0.00%

ALL PROJECTS		WATER PROJECTS			WASTE PROJECTS		
PURPOSE	60.71%	PURPOSE	73.21%	12.50%	PURPOSE	46.43%	-14.29%
COMMUNITY	20.93%	COMMUNITY	40.70%	19.77%	COMMUNITY	4.65%	-16.28%
WELLBEING	20.73%	WELLBEING	39.02%	18.29%	WELLBEING	39.02%	18.29%
COLLAB.	41.67%	COLLAB.	43.33%	1.67%	COLLAB.	50.00%	8.33%
MNG	22.58%	MNG	37.10%	14.52%	MNG	90.32%	67.74%
PLANNING	31.67%	PLANNING	45.00%	13.33%	PLANNING	33.33%	1.67%
MATERIALS	13.75%	MATERIALS	14.84%	1.09%	MATERIALS	32.06%	18.31%
ENERGY	42.86%	ENERGY	50.56%	7.70%	ENERGY	72.22%	29.37%
WATER	5.66%	WATER	55.92%	50.26%	WATER	18.61%	12.95%
SITING	24.24%	SITING	22.73%	-1.52%	SITING	57.58%	33.33%
L&W	16.67%	L&W	22.92%	6.25%	L&W	29.17%	12.50%
BIODIV	40.18%	BIODIV	49.11%	8.93%	BIODIV	57.14%	16.96%
EMISSIONS	43.75%	EMISSIONS	10.00%	-33.75%	EMISSIONS	62.50%	18.75%
RESILIENCE	3.66%	RESILIENCE	24.39%	20.73%	RESILIENCE	3.66%	0.00%

Appendix 4

Performance of the Energy Projects by Credit



	PURPOSE	COMMUN.	WELLBEING	COLLAB.	MNG	PLANNING	MATERIALS
ALL PR.	60.71%	20.93%	20.73%	41.67%	22.58%	31.67%	13.75%
ENERGY PR.	48.21%	13.95%	20.73%	45.00%	22.58%	13.33%	12.50%
DIFF.	-12.50%	-6.98%	0.00%	3.33%	0.00%	-18.33%	-1.25%

	ENERGY	WATER	SITING	L&W	BIODIV	EMISSIONS	RESILIENCE
ALL PR.	42.86%	5.66%	24.24%	16.67%	40.18%	43.75%	3.66%
ENERGY PR.	63.27%	5.66%	20.20%	9.38%	25.89%	92.50%	4.88%
DIFF.	20.41%	0.00%	-4.04%	-7.29%	-14.29%	48.75%	1.22%

Figure 24. Target diagram of the energy projects scores by credit

Appendix 5:

Comparison of the Energy Projects Performance by Credit

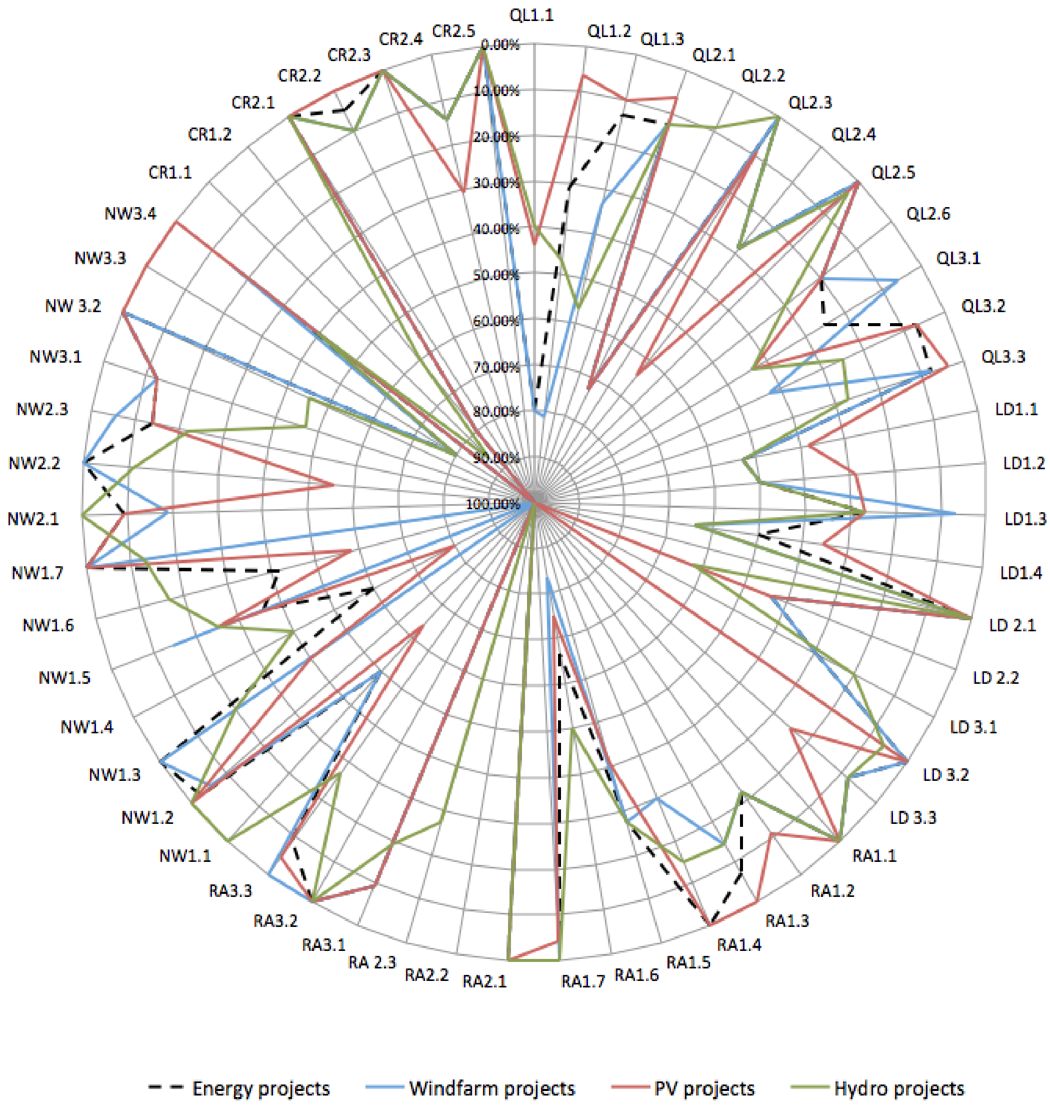
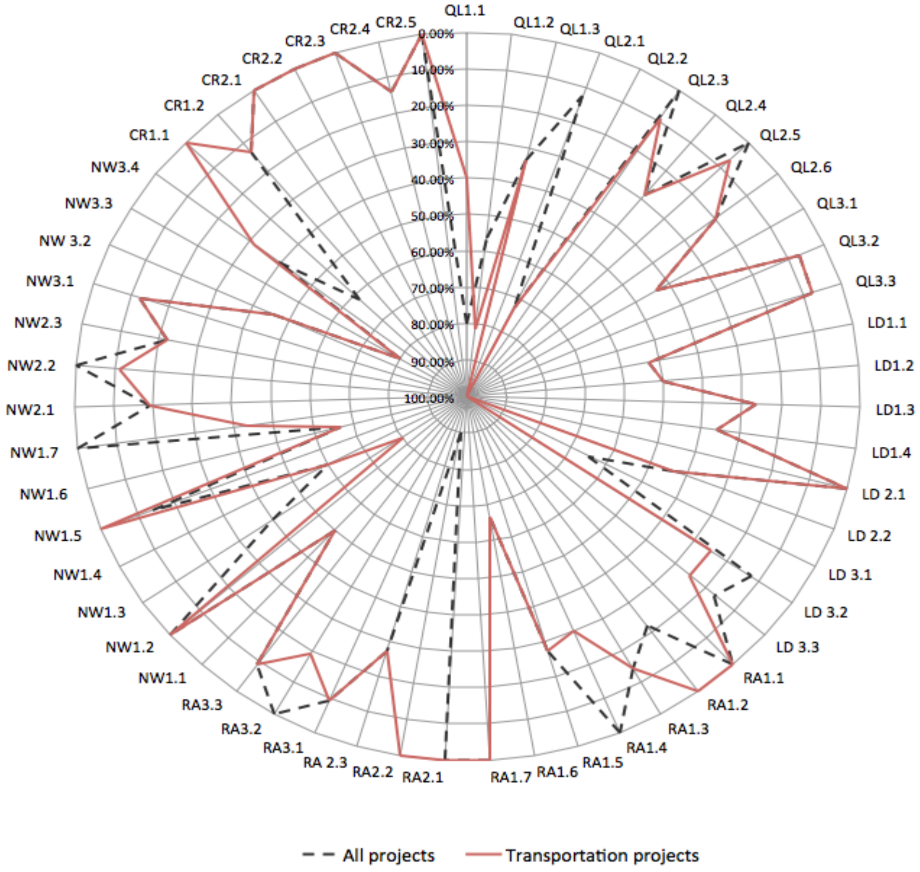


Figure 25. Target diagram comparing the performance of the energy projects vs. total. Credit by credit evaluation.

Appendix 6

Performance of the Transportation Projects by Credit



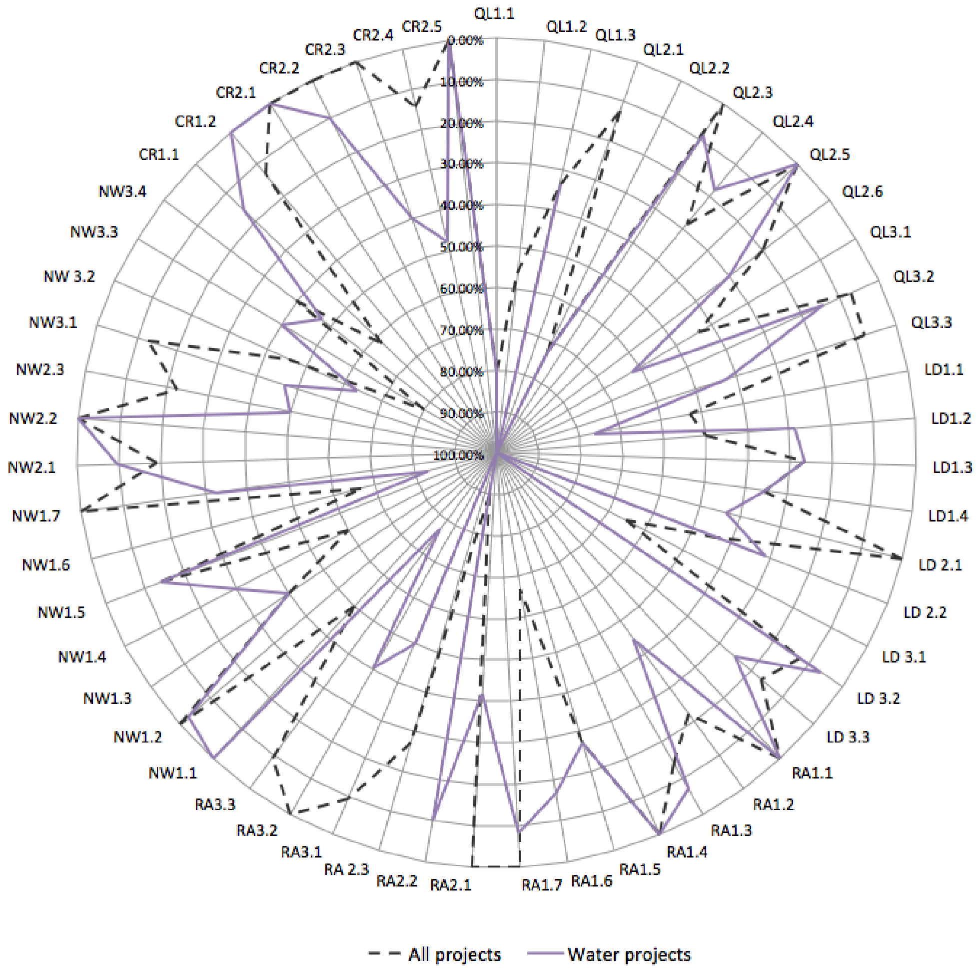
	PURPOSE	COMMUN.	WELLBEING	COLLAB.	MNG	PLANNING	MATERIALS
ALL PR.	60.71%	20.93%	20.73%	41.67%	22.58%	31.67%	13.75%
TRANSP. PR.	50.00%	20.93%	40.24%	41.67%	22.58%	50.00%	19.75%
DIFF.	-10.71%	0.00%	19.51%	0.00%	0.00%	18.33%	6.00%

	ENERGY	WATER	SITING	L&W	BIODIV	EMISSIONS	RESILIENCE
ALL PR.	42.86%	5.66%	24.24%	16.67%	40.18%	43.75%	3.66%
TRANSP. PR.	9.09%	12.55%	38.38%	18.75%	37.50%	5.00%	3.66%
DIFF.	-33.77%	6.89%	14.14%	2.08%	-2.68%	-38.75%	0.00%

Figure 26. Target diagram of the transportation projects scores by credit

Appendix 7

Performance of the Water Projects by Credit



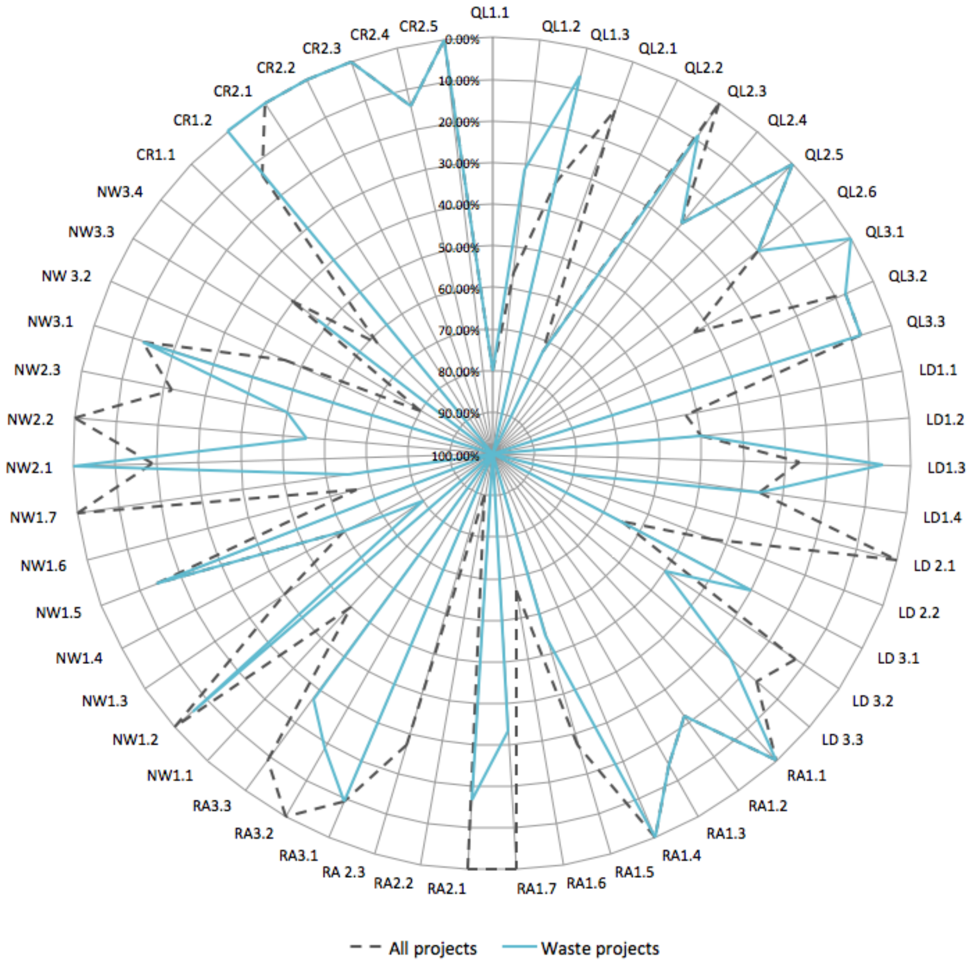
	PURPOSE	COMMUN.	WELLBEING	COLLAB.	MNG	PLANNING	MATERIALS
ALL PR.	60.71%	20.93%	20.73%	41.67%	22.58%	31.67%	13.75%
WATER PR.	73.21%	40.70%	39.02%	43.33%	37.10%	45.00%	14.84%
DIFF.	12.50%	19.77%	18.29%	1.67%	14.52%	13.33%	1.09%

	ENERGY	WATER	SITING	L&W	BIODIV	EMISSIONS	RESILIENCE
ALL PR.	42.86%	5.66%	24.24%	16.67%	40.18%	43.75%	3.66%
ENERGY PR.	50.56%	55.92%	22.73%	22.92%	49.11%	10.00%	24.39%
DIFF.	7.70%	50.26%	-1.52%	6.25%	8.93%	-33.75%	20.73%

Figure 27. Target diagram of the water projects scores by credit

Appendix 8

Performance of the Waste Projects by Credit



	PURPOSE	COMMUN.	WELLBEING	COLLAB.	MNG	PLANNING	MATERIALS
ALL PR.	60.71%	20.93%	20.73%	41.67%	22.58%	31.67%	13.75%
WATER PR.	46.43%	4.65%	39.02%	50.00%	90.32%	33.33%	32.06%
DIFF.	-14.29%	-16.28%	18.29%	8.33%	67.74%	1.67%	18.31%

	ENERGY	WATER	SITING	L&W	BIODIV	EMISSIONS	RESILIENCE
ALL PR.	42.86%	5.66%	24.24%	16.67%	40.18%	43.75%	3.66%
ENERGY PR.	72.22%	18.61%	57.58%	29.17%	57.14%	62.50%	3.66%
DIFF.	29.37%	12.95%	33.33%	12.50%	16.96%	18.75%	0.00%

Figure 28. Target diagram of the waste projects scores by credit

Appendix 9

Overall Scores: Credit by Credit Evaluation

Table 22. Achievement of all project typology vs. central tendency. Full detail

			DIFFERENCE TO CENTRAL TENDENCY													
	ALL PROJECTS		ENERGY PROJECTS		TRANSPORTATION PROJECTS		WATER PROJECTS		WASTE PROJECTS		WIND FARMS PROJECTS		PHOTOVOLTAIC PROJECTS		HYDROPOWER PROJECTS	
	Credit	**Diff.**	**Credit**	**Diff.**	**Credit**	**Diff.**	**Credit**	**Diff.**	**Credit**	**Diff.**	**Credit**	**Diff.**	**Credit**	**Diff.**	**Credit**	**Diff.**
1	RA2.2	90.00%	RA 2.3	72.73%	QL2.1	87.50%	QL2.1	87.50%	QL2.1	87.50%	RA 2.3	72.73%	RA 2.3	72.73%	CR1.2	46.67%
2	QL1.1	80.00%	CR1.2	66.67%	NW1.7	43.48%	RA 2.3	72.73%	LD 2.1	80.00%	CR1.2	66.67%	CR1.2	66.67%	NW3.1	34.38%
3	NW3.3	80.00%	CR1.1	38.00%	NW1.3	40.00%	RA3.3	68.18%	RA 2.3	72.73%	NW1.4	40.00%	NW2.2	55.56%	LD1.4	28.57%
4	QL2.2	72.73%	NW1.5	21.43%	LD 3.1	35.00%	QL1.2	43.75%	NW1.7	65.22%	CR1.1	38.00%	CR1.1	38.00%	CR1.1	24.00%
5	RA1.6	66.67%	LD1.4	14.29%	RA1.4	30.00%	LD 2.1	43.33%	LD 2.2	56.25%	QL3.2	35.71%	QL2.4	35.71%	QL1.3	23.33%
6	NW1.6	66.67%	RA2.2	10.00%	QL1.2	25.00%	RA2.1	41.67%	NW2.2	55.56%	NW1.6	33.33%	LD 3.1	35.00%	QL3.3	19.23%
7	LD 3.1	65.00%	CR2.2	5.00%	RA3.2	19.05%	RA3.1	40.48%	NW .2	54.55%	RA1.4	30.00%	NW1.4	20.00%	LD 2.2	18.75%
8	CR1.1	62.00%	NW1.2	2.78%	LD 3.2	12.50%	RA3.2	40.48%	NW1.1	50.00%	LD1.4	28.57%	CR2.4	16.67%	RA3.3	18.18%
9	NW1.4	60.00%	QL1.1	0.00%	NW2.2	11.11%	CR2.3	40.00%	LD1.1	47.06%	QL1.2	25.00%	NW1.1	13.89%	QL3.2	17.86%
10	QL1.2	56.25%	QL2.1	0.00%	QL2.3	9.09%	LD 3.1	35.00%	NW1.3	40.00%	RA1.6	16.67%	RA1.5	13.64%	RA1.4	15.00%
11	LD1.1	52.94%	QL2.2	0.00%	LD 3.3	8.33%	QL3.3	34.62%	CR1.1	38.00%	CR2.2	10.00%	NW1.5	10.71%	NW1.7	13.04%
12	LD1.2	50.00%	QL2.3	0.00%	QL2.5	6.67%	NW3.1	34.38%	LD 3.2	37.50%	RA2.2	10.00%	RA2.2	10.00%	NW2.2	11.11%
13	NW1.1	50.00%	QL2.4	0.00%	QL1.3	0.00%	CR2.4	33.33%	RA1.6	33.33%	NW1.2	5.56%	QL2.3	9.09%	NW1.5	10.71%
14	NW3.2	45.45%	QL2.5	0.00%	QL2.2	0.00%	NW1.7	32.61%	NW1.6	33.33%	QL1.1	0.00%	RA1.6	8.33%	CR2.2	10.00%
15	QL3.1	43.75%	QL2.6	0.00%	QL2.4	0.00%	NW2.3	27.78%	RA1.7	33.33%	QL1.3	0.00%	LD 3.3	8.33%	QL2.6	10.00%
16	LD 2.2	43.75%	QL3.2	0.00%	QL2.6	0.00%	LD1.1	23.53%	NW2.3	27.78%	QL2.1	0.00%	RA1.7	4.17%	RA2.2	10.00%
17	NW1.3	40.00%	QL3.3	0.00%	QL3.1	0.00%	RA1.2	22.22%	RA1.5	27.27%	QL2.2	0.00%	QL2.2	0.00%	RA3.1	9.52%
18	NW3.4	39.47%	Q L0.0	0.00%	QL3.2	0.00%	QL3.1	18.75%	NW3.3	20.00%	QL2.3	0.00%	QL2.5	0.00%	QL2.5	3.33%
19	LD1.4	35.71%	LD1.1	0.00%	QL3.3	0.00%	NW3.2	18.18%	RA3.2	19.05%	QL2.4	0.00%	QL2.6	0.00%	QL2.1	0.00%
20	QL1.3	33.33%	LD1.2	0.00%	QL 0.0	0.00%	NW1.6	16.67%	RA3.3	18.18%	QL2.5	0.00%	QL3.1	0.00%	QL2.3	0.00%
21	QL2.4	28.57%	LD1.3	0.00%	LD1.1	0.00%	CR2.2	10.00%	RA2.1	16.67%	QL2.6	0.00%	QL3.2	0.00%	QL2.4	0.00%
22	RA1.5	27.27%	LD 2.1	0.00%	LD1.2	0.00%	QL2.6	10.00%	RA2.2	10.00%	QL3.3	0.00%	QL 0.0	0.00%	QL3.1	0.00%
23	RA 2.3	27.27%	LD 2.2	0.00%	LD1.3	0.00%	QL2.3	9.09%	QL2.3	9.09%	QL 0.0	0.00%	LD1.3	0.00%	QL 0.0	0.00%
24	LD1.3	26.67%	LD0.0	0.00%	LD1.4	0.00%	LD 3.3	8.33%	LD 3.3	8.33%	LD1.1	0.00%	LD1.4	0.00%	LD1.1	0.00%
25	RA1.2	22.22%	RA 1.1	0.00%	LD 2.1	0.00%	RA1.7	8.33%	NW3.4	7.89%	LD1.2	0.00%	LD 2.1	0.00%	LD1.2	0.00%
26	NW2.3	22.22%	RA1.2	0.00%	LD 2.2	0.00%	NW3.4	7.89%	NW1.2	5.56%	LD 2.1	0.00%	LD 2.2	0.00%	LD1.3	0.00%
27	QL2.6	20.00%	RA1.4	0.00%	LD0.0	0.00%	QL3.2	7.14%	QL1.1	0.00%	LD 2.2	0.00%	LD0.0	0.00%	LD 2.1	0.00%
28	NW2.1	19.05%	RA1.5	0.00%	RA 1.1	0.00%	NW1.2	2.78%	QL2.2	0.00%	LD0.0	0.00%	RA 1.1	0.00%	LD0.0	0.00%
29	LD 3.3	16.67%	RA1.6	0.00%	RA1.3	0.00%	QL1.1	0.00%	QL2.4	0.00%	RA 1.1	0.00%	RA1.4	0.00%	RA 1.1	0.00%
30	RA1.3	14.29%	RA1.7	0.00%	RA1.5	0.00%	QL1.3	0.00%	QL2.5	0.00%	RA1.2	0.00%	RA2.1	0.00%	RA1.2	0.00%
31	NW1.5	14.29%	RA2.1	0.00%	RA1.6	0.00%	QL2.2	0.00%	QL2.6	0.00%	RA1.3	0.00%	RA3.1	0.00%	RA1.3	0.00%
32	CR2.4	14.29%	RA3.1	0.00%	RA1.7	0.00%	QL2.5	0.00%	QL3.2	0.00%	RA1.5	0.00%	RA3.2	0.00%	RA1.5	0.00%
33	CR1.2	13.33%	RA3.2	0.00%	RA2.1	0.00%	QL 0.0	0.00%	QL3.3	0.00%	RA1.7	0.00%	RA 0.0	0.00%	RA1.7	0.00%
34	QL2.1	12.50%	RA3.3	0.00%	RA 2.3	0.00%	LD1.3	0.00%	QL 0.0	0.00%	RA2.1	0.00%	NW1.2	0.00%	RA2.1	0.00%
35	LD 3.2	12.50%	RA 0.0	0.00%	RA3.1	0.00%	LD1.4	0.00%	LD1.2	0.00%	RA3.1	0.00%	NW1.3	0.00%	RA 2.3	0.00%
36	NW3.1	12.50%	NW1.1	0.00%	RA3.3	0.00%	LD0.0	0.00%	LD1.4	0.00%	RA3.2	0.00%	NW1.7	0.00%	RA3.2	0.00%
37	RA3.1	9.52%	NW1.4	0.00%	RA 0.0	0.00%	RA 1.1	0.00%	LD0.0	0.00%	RA 0.0	0.00%	NW3.1	0.00%	RA 0.0	0.00%
38	RA3.3	9.09%	NW1.7	0.00%	NW1.1	0.00%	RA1.4	0.00%	RA 1.1	0.00%	NW1.1	0.00%	NW0.0	0.00%	NW1.2	0.00%

39	QL3.3	7.69%	NW2.2	0.00%	NW1.2	0.00%	RA1.5	0.00%	RA1.2	0.00%	NW1.5	0.00%	CR2.1	0.00%	NW2.3	0.00%
40	QL3.2	7.14%	NW3.1	0.00%	NW1.4	0.00%	RA 0.0	0.00%	RA1.3	0.00%	NW1.7	0.00%	CR2.2	0.00%	NW 3.2	0.00%
41	QL2.3	0.00%	NW3.3	0.00%	NW1.6	0.00%	NW1.3	0.00%	RA1.4	0.00%	NW2.1	0.00%	CR2.3	0.00%	NW3.3	0.00%
42	QL2.5	0.00%	NW0.0	0.00%	NW2.1	0.00%	NW1.5	0.00%	RA3.1	0.00%	NW2.2	0.00%	CR2.5	0.00%	NW3.4	0.00%
43	QL 0.0	0.00%	CR2.1	0.00%	NW2.3	0.00%	NW2.2	0.00%	RA 0.0	0.00%	NW3.1	0.00%	CR 0.0	0.00%	NW0.0	0.00%
44	LD 2.1	0.00%	CR2.3	0.00%	NW3.1	0.00%	NW0.0	0.00%	NW1.4	0.00%	NW3.3	0.00%	QL3.3	-3.85%	CR2.1	0.00%
45	LD0.0	0.00%	CR2.4	0.00%	NW 3.2	0.00%	CR2.1	0.00%	NW1.5	0.00%	NW0.0	0.00%	RA3.3	-4.55%	CR2.3	0.00%
46	RA 1.1	0.00%	CR2.5	0.00%	NW3.3	0.00%	CR2.5	0.00%	NW3.1	0.00%	CR2.1	0.00%	QL2.1	-6.25%	CR2.4	0.00%
47	RA1.4	0.00%	CR 0.0	0.00%	NW0.0	0.00%	CR 0.0	0.00%	NW0.0	0.00%	CR2.3	0.00%	NW1.6	-8.33%	CR2.5	0.00%
48	RA1.7	0.00%	RA1.3	-7.14%	CR1.2	0.00%	LD 3.2	-6.25%	CR2.1	0.00%	CR2.4	0.00%	NW2.3	-8.33%	CR 0.0	0.00%
49	RA2.1	0.00%	NW2.3	-8.33%	CR2.1	0.00%	RA1.3	-7.14%	CR2.2	0.00%	CR2.5	0.00%	NW2.1	-9.52%	LD 3.2	-6.25%
50	RA3.2	0.00%	LD 3.3	-8.33%	CR2.2	0.00%	NW2.1	-9.52%	CR2.3	0.00%	CR 0.0	0.00%	RA1.2	-11.11%	LD 3.3	-8.33%
51	NW1.2	0.00%	NW2.1	-9.52%	CR2.3	0.00%	QL2.4	-10.71%	CR2.4	0.00%	LD 3.3	-8.33%	LD 3.2	-12.50%	QL1.2	-9.38%
52	NW1.7	0.00%	LD 3.2	-12.50%	CR2.4	0.00%	LD 2.2	-12.50%	CR2.5	0.00%	RA3.3	-9.09%	RA1.3	-14.29%	RA1.6	-16.67%
53	NW2.2	0.00%	NW3.4	-15.79%	CR2.5	0.00%	CR1.2	-13.33%	CR 0.0	0.00%	LD 3.2	-12.50%	LD1.1	-14.71%	NW2.1	-19.05%
54	NW0.0	0.00%	QL3.1	-18.75%	CR 0.0	0.00%	LD1.2	-21.43%	CR1.2	-13.33%	NW2.3	-16.67%	LD1.2	-21.43%	NW1.4	-20.00%
55	CR2.1	0.00%	QL1.3	-20.00%	NW3.4	-7.89%	NW1.4	-30.00%	NW2.1	-19.05%	LD1.3	-20.00%	QL1.3	-23.33%	NW1.3	-20.00%
56	CR2.2	0.00%	NW1.6	-25.00%	NW1.5	-14.29%	NW3.3	-40.00%	LD1.3	-20.00%	NW3.4	-23.68%	QL1.1	-36.00%	QL1.1	-40.00%
57	CR2.3	0.00%	QL1.2	-25.00%	RA1.2	-22.22%	CR1.1	-46.00%	QL1.2	-25.00%	LD 3.1	-35.00%	NW3.4	-39.47%	LD 3.1	-45.00%
58	CR2.5	0.00%	LD 3.1	-35.00%	QL1.1	-40.00%	RA1.6	-50.00%	QL1.3	-26.67%	QL3.1	-37.50%	NW 3.2	-45.45%	NW1.1	-50.00%
59	RA 0.0	0.00%	NW1.3	-40.00%	CR1.1	-62.00%	NW1.1	-50.00%	LD 3.1	-35.00%	NW1.3	-40.00%	QL1.2	-50.00%	NW1.6	-50.00%
60	CR 0.0	0.00%	NW3.2	-45.45%	RA2.2	-90.00%	RA2.2	-80.00%	QL3.1	-43.75%	NW3.2	-45.45%	NW3.3	-80.00%	QL2.2	-63.64%

References

Arrasate, M. I. (2013). *Case Study Mariscal Sucre International Airport. Ecuador.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=38832763

Arroyo, M. I. (2013). *Case Study Los Cocos wind project. Dominican Republic.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=38832885

Barrera, M. (2013). *Case Study Los Hierros hydroelectric plant. Chile.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=38832856

Becerra. A., Arrasate, M. I. (2015). *Case Study Modernization project of the multipurpose north terminal in the port of Callao, Peru.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=39851309

Bello, J. (2015). *Case Study Atotonilco wastewater treatment plant. Mexico.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://research.gsd.harvard.edu/zofnass/files/2016/08/05_Atotonilco_EN_FinalDocument.pdf

Bleviss, D., (2013). *The opportunities for sustainable urban transportation in medium-sized cities in Latin American and the Caribbean*.

Calderón,C., Serven, L. (2010). Infrastructure in Latin America. *Policy Research WorkingPaper, 157.* Washington, D.C.: World Bank. Retrieved from https://openknowledge.worldbank.org/bitstream/handle/10986/3801/WPS5317.pdf

Carranza, L., Daude, C., & Melguizo, A. (2011). Public Infrastructure Investment and Fiscal Sustainability in Latin America: Incompatible goals? *OECD Development Centre Working Papers,* (301), 1-32.

Carvalho Fernandes de Oliveira, J. (2015). *Case Study Maranhão grain terminal. TEGRAM. Brazil.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://research.gsd.harvard.edu/zofnass/files/2016/08/10_PORT_TEGRAM_EN_Final-version.pdf

Chavez, A. (2015). *Case Study Ucuquer wind farm, phases I and II. Chile.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://research.gsd.harvard.edu/zofnass/files/2016/08/07_Ucuquer_EN_FinalDocument.pdf

Chavez, A. (2014). *Case Study Urban improvement and maintenance of the Interior Circuit. Mexico.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=39851297

Contreras, C. (2015). *Case Study Concentration Plant Cerro Dominador. Chile.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=39851158

Contreras, C. (2014). *Case Study of the Expansion and upgrade project international (ecological) airport in Galapagos. Ecuador.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=38832777

Contreras, C., Cristaldo, J.C. (2013). *Case Study Palmatir wind power project. Uruguay.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=38203547

Contreras, C., Cristaldo, J.C. (2013). *Case Study Expansion, Phase II: Juan Santamaria International Airport. Costa Rica.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://research.gsd.harvard.edu/infrastructure360/files/2014/03/CS-Airport_Juan-Santamar%C3%ADa_Costa-Rica_EN.pdf

Cristaldo, J.C. (2013). *Case Study Xingú and Macapá high tension lines. Brazil.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=38832791

Cristaldo, J.C. (2013). *Case Study Santo Antônio do Jari hydroelectric power plant. Brazil. Zofnass.* Program for Sustainable Infrastructure, Harvard University. Retrieved from http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=38832867

Dasgupta, S., & Tam, E. L. (2005). Indicators and framework for assessing sustainable infrastructure. *Canadian Journal Of Civil Engineering*, *32*(1), 30-44. doi:10.1139/L04-101

Fantozzi, V. (2015). *Case Study Biogas from waste, Buen Ayre plant. Argentina.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://research.gsd.harvard.edu/zofnass/files/2016/08/04_PlantaCentralBuenAyre_EN_FinalDocument.pdf

Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, *41*, 1149-1160.

Fay, M., & Morrison, M. (2005). *Infrastructure in Latin America & the Caribbean: Recent developments and key challenges, 1.* (Report No. 32640-LCR). Washington, D.C.: World Bank.

Fuentes, C. (2014). *Case Study Moquegua photovoltaic plant. Peru.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=39851734

Galan, A. (2014). *Case Study Eurus wind farm. Mexico.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=39851259

Galan, A. (2015). *Case Study Choluteca I and II. Honduras.* Zofnass Program For Sustainable Infrastructure, Harvard University. Retrieved from http://research.gsd.harvard.edu/zofnass/files/2016/08/02_Choluteca_I_y_II_SP_FinalVersion.pdf

Galan, A. (2013). *Case Study Aura Solar I photovoltaic plant. Mexico. Zofn*ass Program For Sustainable Infrastructure, Harvard University. Retrieved from http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=38832817

García- Rincón, M. B (2015). *Case Study Point Fortin desalination plant. Trinidad & Tobago.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://research.gsd.harvard.edu/zofnass/files/2016/08/09_PtFortinFinal-document_EN_Final-version.pdf

García- Rincón, M. B (2015). *Case Study Dominica I and II. Mexico.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://research.gsd.harvard.edu/zofnass/files/2016/08/06_ParqueEolicoDominicaEN_Final-version.pdf

García- Rincón, M. B (2014). *Case Study Florida wind farm. Uruguay.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=39851727

Gonzalez Diez, Veronica M., Verner, Dorte, Corrales, Maria Elena, Puerta, Juan Manuel, Mendieta Umaña, Maria Paula, Morales, Carlos, . . . Redwood, John. (2015). *Climate Change at the IDB: Building Resilience and Reducing Emissions*.

Georgoulias, A., Allen, J., Farley, L.(2010). Towards the Development of a Rating System for Sustainable Infrastructure: A Checklist or a Decision-making Tool? *Proceedings of the Water Environment Federation*. 2010 (2): 379–91.

Gurley, K. (2013). *Case Study Pozo Almonte solar photovoltaic plants. Chile. Zofn*ass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=38832840

Guzman, M. (2015). *Case Study Puerto Bahía multipurpose port. Colombia.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://research.gsd.harvard.edu/zofnass/files/2016/08/01_PuertodeBahia_EN_FinalVersion.pdf

Guzman, M. (2013). *Case Study Wastewater treatment plant and marine outfall of La Chira. Peru.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=38832879

Guzman, F., García- Rincón, M. B, (2014). *Case Study,Carilafquen and Malalcahuello hydroelectric power plant . Chile.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=39851273

Institute for Sustainable Infrastructure, Zofnass Program for Sustainable Infrastructure (2015). *Envision Rating System for Sustainable Infrastructure.* Retrieved from http://research.gsd.harvard.edu/zofnass/files/2015/06/Envision-Manual_2015_red.pdf

Inter-American Development Bank. (2014) *Climate Change and IDB: Building Resilience and Reducing Emissions. Sector Study: Transportation*. Washington, D.C.: Retrieved from https://publications.iadb.org/bitstream/handle/11319/6710/Background-Paper-Sector-Analysis-of-Transportation-and-Climate-Change.pdf?sequence=1

International Finance Corporation. (2012). *Performance Standards on Environmental and Social Sustainability.* Washington, D.C.: Retrieved from http://www.ifc.org/wps/wcm/connect/115482804a0255db96fbffd1a5d13d27/PS_English_2012_Full-Document.pdf?MOD=AJPERES

Kevern, J. T. (2011). Green building and sustainable infrastructure: Sustainability education for civil engineers. *Journal of Professional Issues in Engineering Education & Practice, 137*(2), 107-112.

Kyte, R., Kaldany, R. & Wormser, M. (2015). *Transformation through infrastructure, FY 2012–2015*. Washington, D.C.: World Bank.

Lee, J. (2013). *Case Study Nuevo Necaxa - Àvila Camacho highway. Mexico.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=38832852

Llano, M. (2014). *Case Study Expansion of port capacity and logistics in the container terminal in Cartagena. Colombia.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=39851319

Magrin, G., C. Gay García, D. Cruz Choque, J.C. Giménez, A.R. Moreno, G.J. Nagy, C. Nobre and A. Villamizar, 2007: Latin America. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 581-615.

Manthey, T. J., & Goscha, R. (2013). Brief report: Conceptual underpinnings of the evidence-based practice sustainability index. *Best Practice in Mental Health, 9*(1), 83-97.

Melo, R. (2014). *Case Study Industrial water production Aquapolo. Brazil.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=39851328

Minsker, B., Baldwin, L., Crittenden, J., Kabbes, K., Karamouz, M., Lansey, K., et al. (2015). Progress and recommendations for advancing performance-based sustainable and resilient infrastructure design. *Journal of Water Resources Planning & Management, 141*(12), 1-16.

Neves Lejeune, V. (2015). *Case Study Center for solid waste treatment, Seropédica (Ctr Rio). Brazil.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://research.gsd.harvard.edu/zofnass/files/2016/08/11_CTRRio_MunicipalSolidWaste_EN_FinalFormat_2016-v.4.pdf

Orrego, K., Guerra, R., (2015). *Case Study 8 de Agosto hydroelectric plant and 138 Kv Transmission Line. Peru.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://research.gsd.harvard.edu/zofnass/files/2016/08/08_Generaci%C3%B3n-Andina_EN_Final-Version.pdf

Quiñones, F. (2015). *Case Study Chilca UNO thermoelectric plant. Peru.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://research.gsd.harvard.edu/zofnass/files/2016/08/03_ChilcaUno_EN_FinalVersion.pdf

Quiñones, F. (2014). *Case Study Cerro de Hula wind project. Honduras.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=39851228

Raye, R. (2014). *Case Study Tunjita hydropower plant. Colombia.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=39851281

Robinson, N. (2015). What is sustainable infrastructure? *Tunnels & Tunnelling International,*

Rodriguez, J. (2014). *Case Study Santo Antônio Hydroelectric. Brazil.* Zofnass Program For Sustainable Infrastructure, Harvard University. Retrieved from http://www.iadb.org/document.cfm?id=39851288

Rodriguez, J. (2013). *Case Study Lima metro Line 1. Peru Zofnass.* Program for Sustainable Infrastructure, Harvard University. Retrieved from http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=38832875

Serebrisky, T. (2014). *Sustainable infrastructure for competitiveness and inclusive growth* (1st ed.). Washington, D.C.: Inter-American Development Bank.

Shen, L., Wu, Y., & Zhang, X. (2011). Key assessment indicators for the sustainability of infrastructure projects. *Journal of Construction Engineering & Management, 137*(6), 441-451.

Takara Zanotti , A. (2015). *Case Study Termoverde Caieiras- Biogas thermoelectric plant. Brazil.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://research.gsd.harvard.edu/zofnass/files/2016/08/12_TermoverdeCaieiras_EN_Final-version.pdf

Tissot, Roger. (2015). *Latin America's Energy Future.*

Torres, E. (2013). *Case Study Vias Nuevas de Lima highway. Peru.* Zofnass Program for Sustainable Infrastructure, Harvard University. Retrieved from http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=39851341

United Nations Office for Project Services. (2012). *UNOPS policy for sustainable infrastructure* (1st ed.). Rio de Janeiro.

United Nations Office for Project Services. (2012). *Transport Infrastructure. Case Study*. Retrieved from https://www.unops.org/SiteCollectionDocuments/Factsheets/English/Services/Infrastructure/Infrastructure_Transport%20Infrastructure_EN_FINAL.pdf

United Nations Office for Project Services. (2012). *UNOPS Disaster Risk Reduction for Resilience Programme. Case Study*. Retrieved from https://www.unops.org/SiteCollectionDocuments/Factsheets/English/Services/Infrastructure/Infrastructure_DRR_EN_FINAL.pdf

United Nations Office for Project Services. (2012). *Community Infrastructure. Case Study*. Retrieved from https://www.unops.org/SiteCollectionDocuments/Factsheets/English/Services/Infrastructure/Infrastructure_Community%20Infrastructure.pdf

United Nations. (2015). *Water for a Sustainable World*. Retrieved from http://unesdoc.unesco.org/images/0023/002318/231823E.pdf

United Nations, Department of Economic and Social Affairs, Population Division (2014). World Urbanization Prospects: The 2014 Revision, Highlights (ST/ESA/SER.A/352).

Walz, R. (2007). The role of regulation for sustainable infrastructure innovations: The case of wind energy. *Int.J.of Public Policy, 2*(1)

Watkins, G. (2014). *Approaches to the assessment and implementation of sustainable infrastructure projects in Latin America and the Caribbean.* Washington, D.C.: Inter-American Development Bank.

Whitehead, C. (2015). Towards a sustainable infrastructure company. *Engineering Sustainability, 168*(1), 7-15.

Willetts, R., Burdon, J., Glass, J., & Frost, M. (2010). Fostering sustainability in infrastructure development schemes. *Proceedings of the ICE – Engineering Sustainability, 163*(3), 159–166.

World Bank. (2008). *Sustainable Infrastructure Action Plan, FY 2009-2011*. Washington, D.C.: So,J.

World Bank. (2012). *Inclusive Green Growth. The Pathway to Sustainable Development*. Washington, D.C.

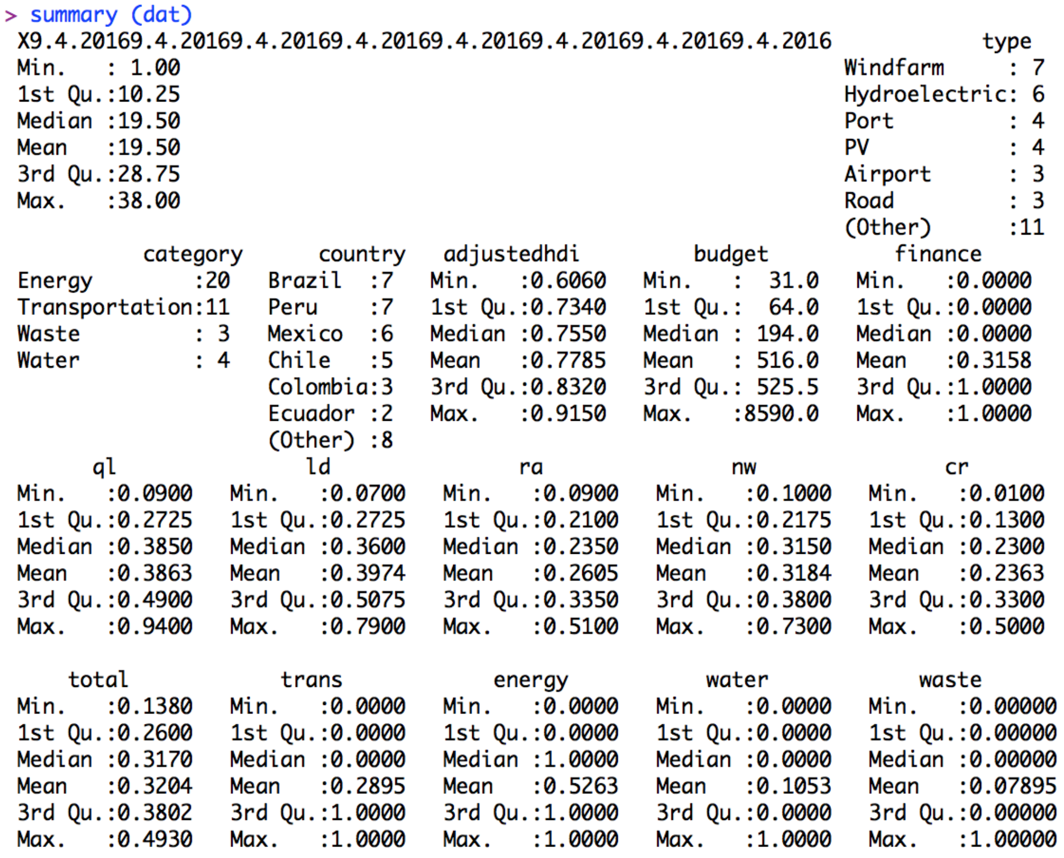
World Economic Forum. (2013). *Strategic Infrastructure: Steps to Prepare and Accelerate Public-Private Partnerships*. Geneva.

Annex 1

Statistical Analysis using R

Summary of the data:

> summary (dat)



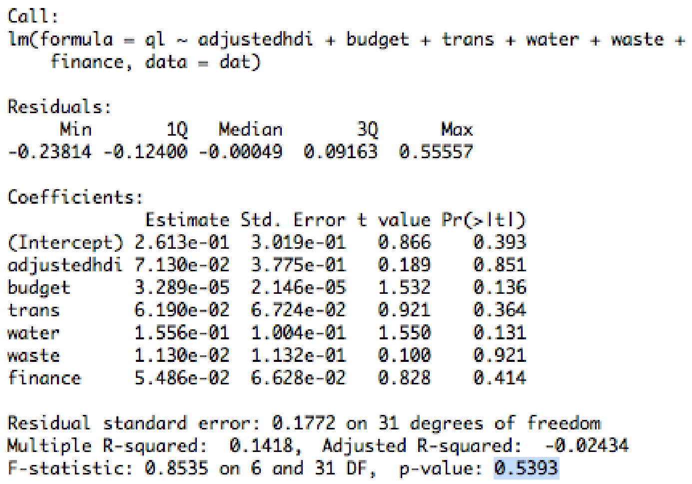
```
> summary (dat)
X9.4.20169.4.20169.4.20169.4.20169.4.20169.4.20169.4.20169.4.2016            type
Min.   : 1.00                                                     Windfarm     : 7
1st Qu.:10.25                                                     Hydroelectric: 6
Median :19.50                                                     Port         : 4
Mean   :19.50                                                     PV           : 4
3rd Qu.:28.75                                                     Airport      : 3
Max.   :38.00                                                     Road         : 3
                                                                  (Other)      :11
          category      country    adjustedhdi         budget          finance
Energy        :20   Brazil  :7   Min.   :0.6060   Min.   :  31.0   Min.   :0.0000
Transportation:11   Peru    :7   1st Qu.:0.7340   1st Qu.:  64.0   1st Qu.:0.0000
Waste         : 3   Mexico  :6   Median :0.7550   Median : 194.0   Median :0.0000
Water         : 4   Chile   :5   Mean   :0.7785   Mean   : 516.0   Mean   :0.3158
                    Colombia:3   3rd Qu.:0.8320   3rd Qu.: 525.5   3rd Qu.:1.0000
                    Ecuador :2   Max.   :0.9150   Max.   :8590.0   Max.   :1.0000
                    (Other) :8
      ql               ld               ra               nw               cr
Min.   :0.0900   Min.   :0.0700   Min.   :0.0900   Min.   :0.1000   Min.   :0.0100
1st Qu.:0.2725   1st Qu.:0.2725   1st Qu.:0.2100   1st Qu.:0.2175   1st Qu.:0.1300
Median :0.3850   Median :0.3600   Median :0.2350   Median :0.3150   Median :0.2300
Mean   :0.3863   Mean   :0.3974   Mean   :0.2605   Mean   :0.3184   Mean   :0.2363
3rd Qu.:0.4900   3rd Qu.:0.5075   3rd Qu.:0.3350   3rd Qu.:0.3800   3rd Qu.:0.3300
Max.   :0.9400   Max.   :0.7900   Max.   :0.5100   Max.   :0.7300   Max.   :0.5000

    total            trans            energy           water            waste
Min.   :0.1380   Min.   :0.0000   Min.   :0.0000   Min.   :0.0000   Min.   :0.00000
1st Qu.:0.2600   1st Qu.:0.0000   1st Qu.:0.0000   1st Qu.:0.0000   1st Qu.:0.00000
Median :0.3170   Median :0.0000   Median :1.0000   Median :0.0000   Median :0.00000
Mean   :0.3204   Mean   :0.2895   Mean   :0.5263   Mean   :0.1053   Mean   :0.07895
3rd Qu.:0.3802   3rd Qu.:1.0000   3rd Qu.:1.0000   3rd Qu.:0.0000   3rd Qu.:0.00000
Max.   :0.4930   Max.   :1.0000   Max.   :1.0000   Max.   :1.0000   Max.   :1.00000
```

Model 1: Analyzing quality of life:

*** Multiple analysis with all the variables to determine the significance of the relationship

```
>mod1 = lm( ql~ adjustedhdi + budget + trans + water + waste + finance , data= dat)
> summary(mod1)
```

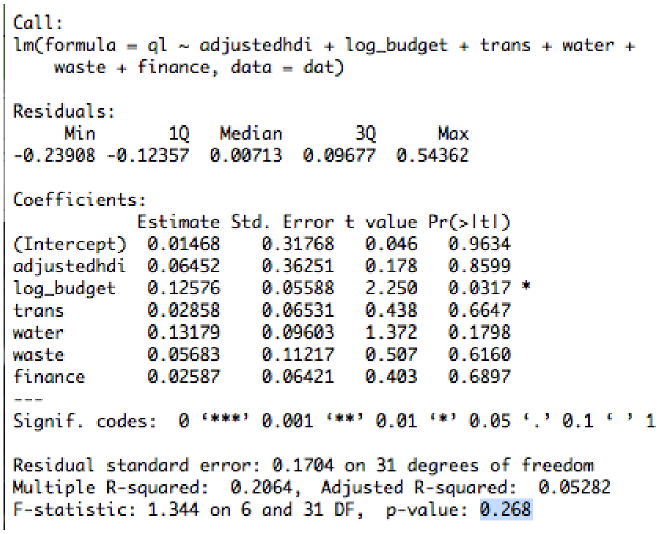
- R-squared: -0.02434
- p-value: 0.5393 (fail to reject the null hypothesis, > 0,05)



```
Call:
lm(formula = ql ~ adjustedhdi + budget + trans + water + waste +
    finance, data = dat)

Residuals:
     Min       1Q   Median       3Q      Max
-0.23814 -0.12400 -0.00049  0.09163  0.55557

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 2.613e-01  3.019e-01   0.866    0.393
adjustedhdi 7.130e-02  3.775e-01   0.189    0.851
budget      3.289e-05  2.146e-05   1.532    0.136
trans       6.190e-02  6.724e-02   0.921    0.364
water       1.556e-01  1.004e-01   1.550    0.131
waste       1.130e-02  1.132e-01   0.100    0.921
finance     5.486e-02  6.628e-02   0.828    0.414

Residual standard error: 0.1772 on 31 degrees of freedom
Multiple R-squared:  0.1418,  Adjusted R-squared:  -0.02434
F-statistic: 0.8535 on 6 and 31 DF,  p-value: 0.5393
```

```
> log_budget=log10(dat$budget)
>mod1 = lm( ql~ adjustedhdi + log_budget + trans + water + waste + finance , data= dat)
> summary(mod1)
```

- R-squared: 0.05282
- p-value: 0.268 (fail to reject the null hypothesis, > 0,05)



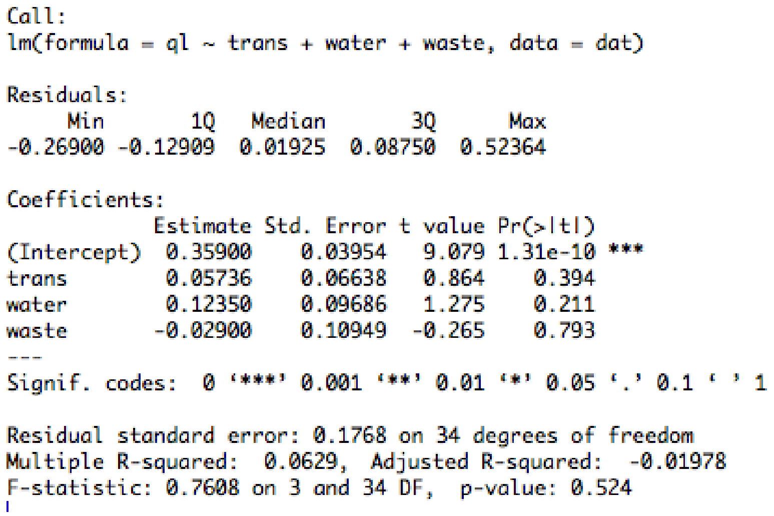
```
Call:
lm(formula = ql ~ adjustedhdi + log_budget + trans + water +
    waste + finance, data = dat)

Residuals:
     Min       1Q   Median       3Q      Max
-0.23908 -0.12357  0.00713  0.09677  0.54362

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.01468    0.31768   0.046   0.9634
adjustedhdi  0.06452    0.36251   0.178   0.8599
log_budget   0.12576    0.05588   2.250   0.0317 *
trans        0.02858    0.06531   0.438   0.6647
water        0.13179    0.09603   1.372   0.1798
waste        0.05683    0.11217   0.507   0.6160
finance      0.02587    0.06421   0.403   0.6897
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.1704 on 31 degrees of freedom
Multiple R-squared:  0.2064,  Adjusted R-squared:  0.05282
F-statistic: 1.344 on 6 and 31 DF,  p-value: 0.268
```

***Compare energy against the other typologies.

>mod1 = lm(ql~ trans + water + waste, data= dat)

> summary(mod1)

- R-squared: -0.01978
- p-value: 0.524 (fail to reject the null hypothesis, > 0,05)



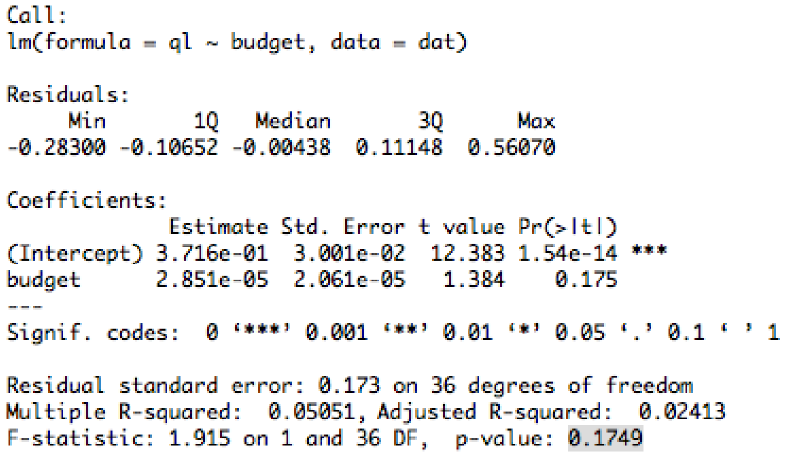
```
Call:
lm(formula = ql ~ trans + water + waste, data = dat)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.26900 -0.12909  0.01925  0.08750  0.52364 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  0.35900    0.03954   9.079 1.31e-10 ***
trans        0.05736    0.06638   0.864    0.394    
water        0.12350    0.09686   1.275    0.211    
waste       -0.02900    0.10949  -0.265    0.793    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.1768 on 34 degrees of freedom
Multiple R-squared:  0.0629,	Adjusted R-squared:  -0.01978 
F-statistic: 0.7608 on 3 and 34 DF,  p-value: 0.524
```

***Simple regression ~ budget

>mod1 = lm(ql~ budget, data= dat)

> summary(mod1)

- R-squared: 0.02413
- p-value: 0.1749 (fail to reject the null hypothesis, > 0,05)

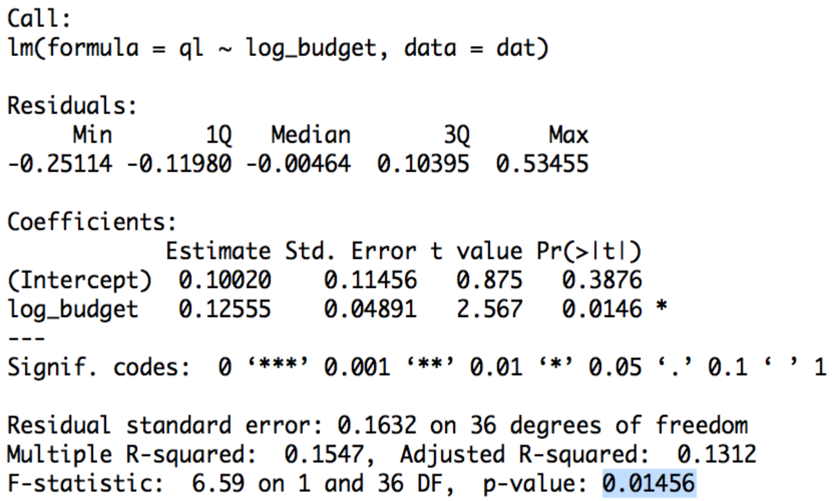


```
Call:
lm(formula = ql ~ budget, data = dat)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.28300 -0.10652 -0.00438  0.11148  0.56070 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 3.716e-01  3.001e-02  12.383 1.54e-14 ***
budget      2.851e-05  2.061e-05   1.384    0.175    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.173 on 36 degrees of freedom
Multiple R-squared:  0.05051,	Adjusted R-squared:  0.02413 
F-statistic: 1.915 on 1 and 36 DF,  p-value: 0.1749
```

>mod1 = lm(ql~ log_budget, data= dat)

> summary(mod1)

- R-squared: 0.1312
- p-value: 0.01456 (fail to reject the null hypothesis, > 0,05)



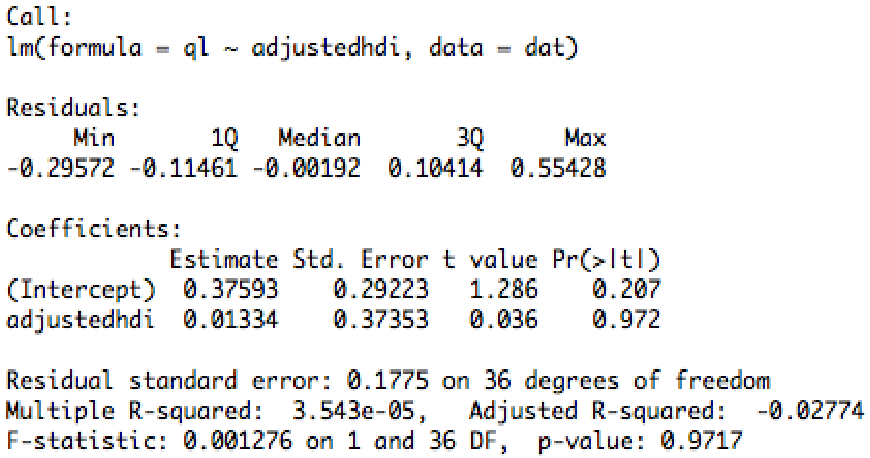
```
Call:
lm(formula = ql ~ log_budget, data = dat)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.25114 -0.11980 -0.00464  0.10395  0.53455 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)  
(Intercept)  0.10020    0.11456   0.875   0.3876  
log_budget   0.12555    0.04891   2.567   0.0146 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.1632 on 36 degrees of freedom
Multiple R-squared:  0.1547,	Adjusted R-squared:  0.1312 
F-statistic:  6.59 on 1 and 36 DF,  p-value: 0.01456
```

***Simple regression ~ adjustedhdi

>mod1 = lm(ql~ adjustedhdi , data= dat)

> summary(mod1)

- R-squared: -0.02774
- p-value: 0.9717(fail to reject the null hypothesis, > 0,05)

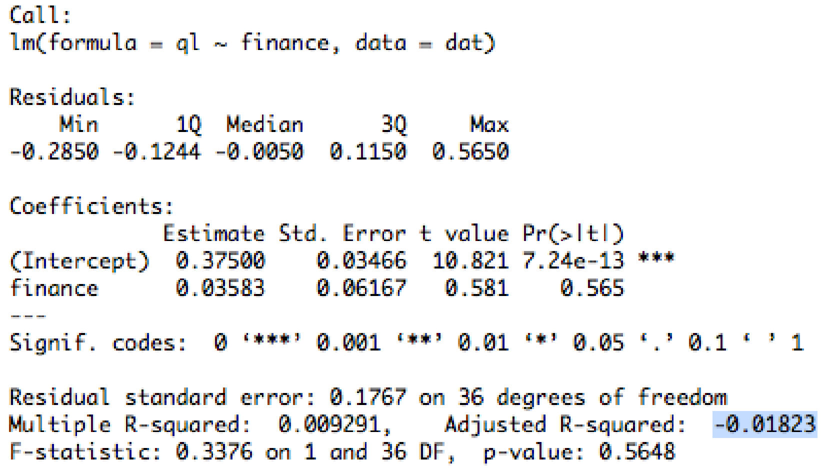


```
Call:
lm(formula = ql ~ adjustedhdi, data = dat)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.29572 -0.11461 -0.00192  0.10414  0.55428 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.37593    0.29223   1.286    0.207
adjustedhdi  0.01334    0.37353   0.036    0.972

Residual standard error: 0.1775 on 36 degrees of freedom
Multiple R-squared:  3.543e-05,	Adjusted R-squared:  -0.02774 
F-statistic: 0.001276 on 1 and 36 DF,  p-value: 0.9717
```

>mod1 = lm(ql~ finance , data= dat)

> summary(mod1)

- R-squared: -0.01823
- p-value:0.5648 (fail to reject the null hypothesis, > 0,05)

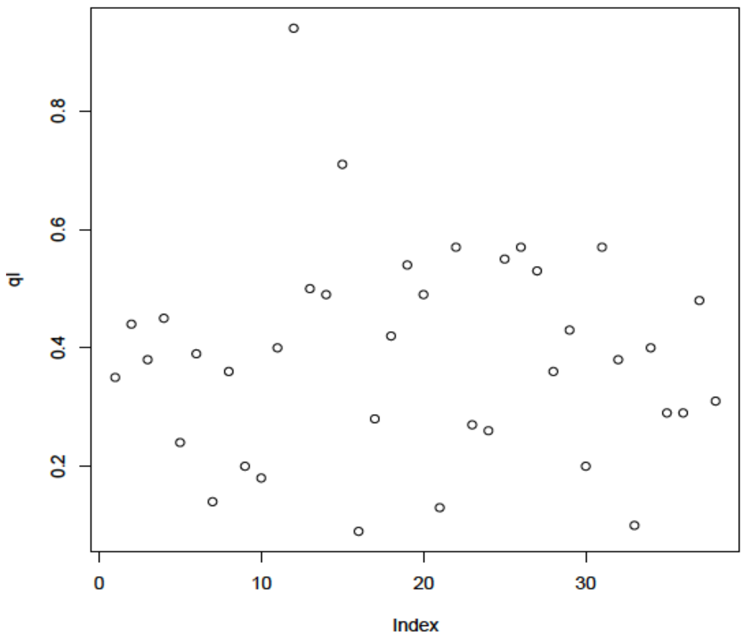


```
Call:
lm(formula = ql ~ finance, data = dat)

Residuals:
    Min      1Q  Median      3Q     Max 
-0.2850 -0.1244 -0.0050  0.1150  0.5650 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  0.37500    0.03466  10.821 7.24e-13 ***
finance      0.03583    0.06167   0.581    0.565    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.1767 on 36 degrees of freedom
Multiple R-squared:  0.009291,	Adjusted R-squared:  -0.01823 
F-statistic: 0.3376 on 1 and 36 DF,  p-value: 0.5648
```

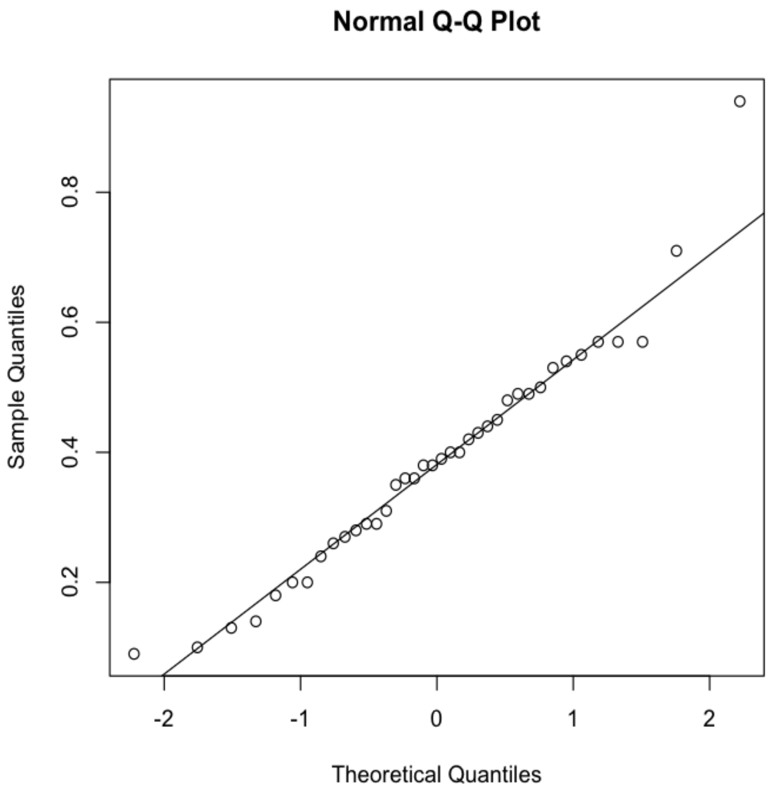
Summary of the results Model 1_ql	Adj r^2	p-value (<0.05)
mod1 = lm(ql~ adjustedhdi + budget + trans + water + waste + finance , data= dat)	-0.02434	0.5393
mod1 = lm(ql~ adjustedhdi + log_budget + trans + water waste + finance , data= dat)	0.05282	0.268
mod1 = lm(ql~ trans + water + waste, data= dat)	-0.01978	0.524
mod1 = lm(ql~ budget, data= dat)	0.02413	0.1749
mod1 = lm(ql~ log_budget, data= dat)	0.1312	0.01456
mod1 = lm(ql~ adjustedhdi , data= dat)	-0.02774	0.9717
mod1 = lm(ql~ finance , data= dat)	-0.01823	0.5648

*** Model 1: Graphs

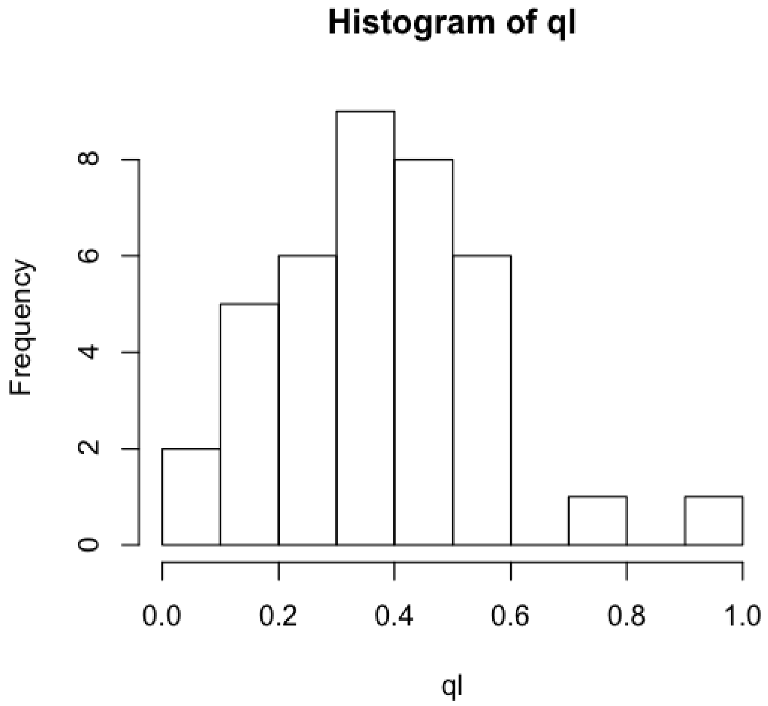
```
>  plot(ql)
```



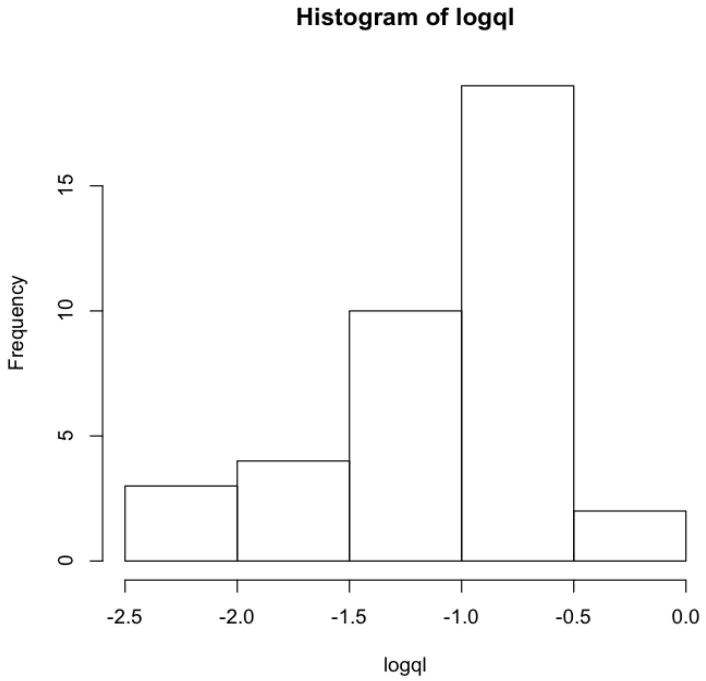
```
>qqline(ql)
```



```
> hist(ql)
```



```
> hist(logql)
```



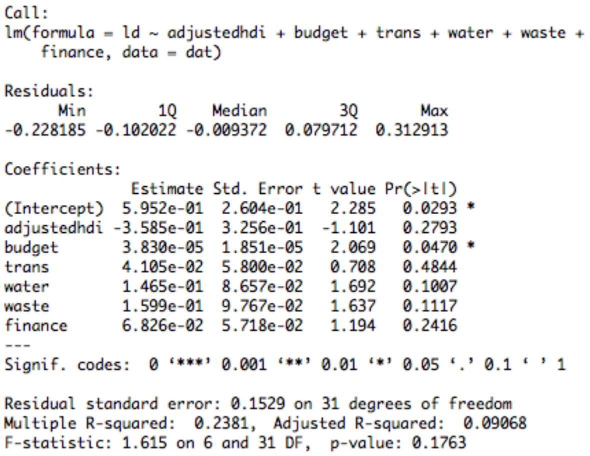
Model 2: Analyzing Leadership:

*** Multiple analysis with all the variables to determine the significance of the relationship

>mod2 = lm(ld~ adjustedhdi + budget + trans + water + waste + finance , data= dat)

> summary(mod2)

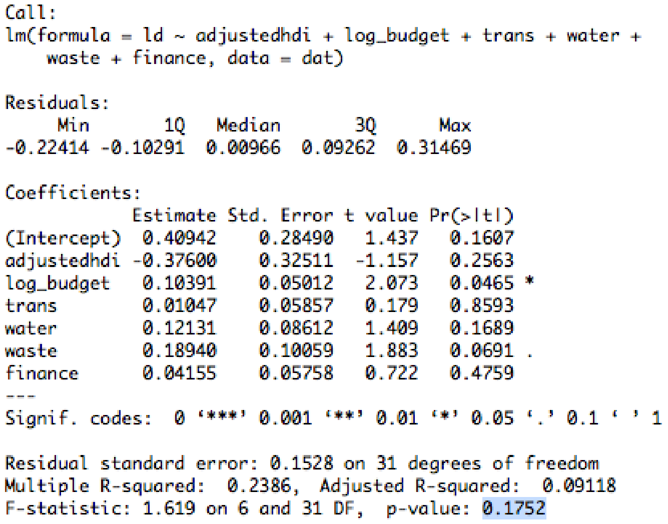
- R-squared: 0.09068
- p-value: 0.1763 (fail to reject the null hypothesis, > 0,05)



```
Call:
lm(formula = ld ~ adjustedhdi + budget + trans + water + waste + 
    finance, data = dat)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.228185 -0.102022 -0.009372  0.079712  0.312913 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)  
(Intercept)  5.952e-01  2.604e-01   2.285   0.0293 *
adjustedhdi -3.585e-01  3.256e-01  -1.101   0.2793  
budget       3.830e-05  1.851e-05   2.069   0.0470 *
trans        4.105e-02  5.800e-02   0.708   0.4844  
water        1.465e-01  8.657e-02   1.692   0.1007  
waste        1.599e-01  9.767e-02   1.637   0.1117  
finance      6.826e-02  5.718e-02   1.194   0.2416  
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.1529 on 31 degrees of freedom
Multiple R-squared:  0.2381,	Adjusted R-squared:  0.09068 
F-statistic: 1.615 on 6 and 31 DF,  p-value: 0.1763
```

>mod2 = lm(ld~ adjustedhdi + log_budget + trans + water + waste + finance , data= dat)
> summary(mod2)

- R-squared: 0.09118
- p-value: 0.1752 (fail to reject the null hypothesis, > 0,05)



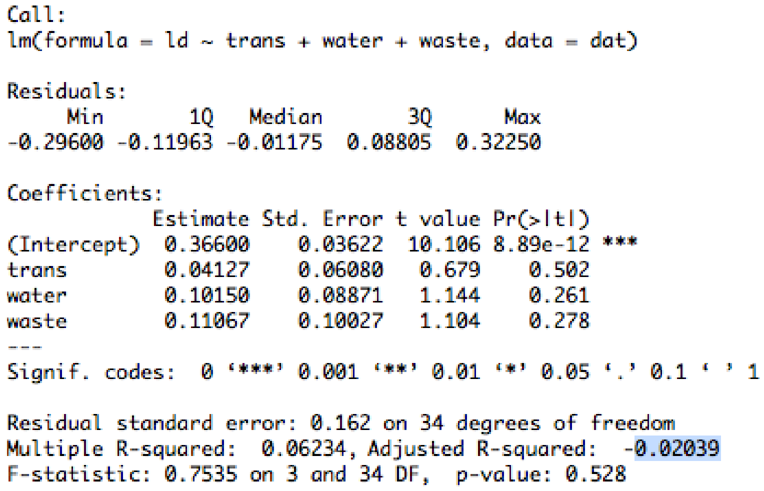
```
Call:
lm(formula = ld ~ adjustedhdi + log_budget + trans + water + 
    waste + finance, data = dat)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.22414 -0.10291  0.00966  0.09262  0.31469 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)  
(Intercept)  0.40942    0.28490   1.437   0.1607  
adjustedhdi -0.37600    0.32511  -1.157   0.2563  
log_budget   0.10391    0.05012   2.073   0.0465 *
trans        0.01047    0.05857   0.179   0.8593  
water        0.12131    0.08612   1.409   0.1689  
waste        0.18940    0.10059   1.883   0.0691 .
finance      0.04155    0.05758   0.722   0.4759  
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.1528 on 31 degrees of freedom
Multiple R-squared:  0.2386,	Adjusted R-squared:  0.09118 
F-statistic: 1.619 on 6 and 31 DF,  p-value: 0.1752
```

***Compare energy against the other typologies.

>mod2 = lm(ld~ trans + water + waste, data= dat)

> summary(mod2)

- R-squared: -0.02039
- p-value: 0.528 (fail to reject the null hypothesis, > 0,05)



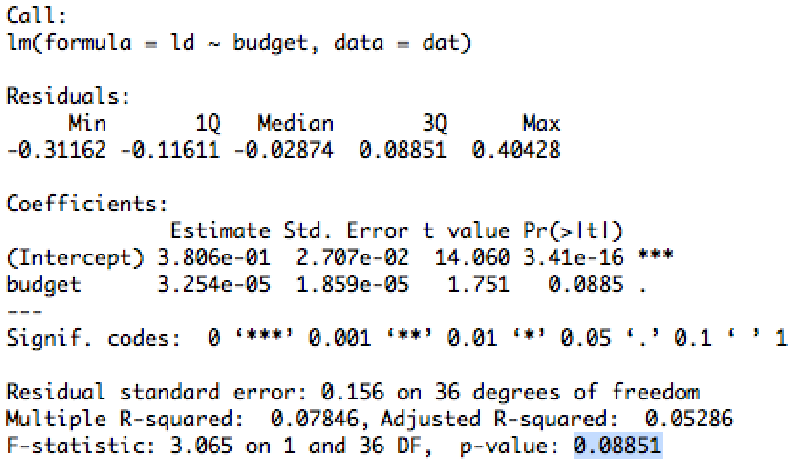
```
Call:
lm(formula = ld ~ trans + water + waste, data = dat)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.29600 -0.11963 -0.01175  0.08805  0.32250 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  0.36600    0.03622  10.106 8.89e-12 ***
trans        0.04127    0.06080   0.679    0.502    
water        0.10150    0.08871   1.144    0.261    
waste        0.11067    0.10027   1.104    0.278    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.162 on 34 degrees of freedom
Multiple R-squared:  0.06234,	Adjusted R-squared:  -0.02039 
F-statistic: 0.7535 on 3 and 34 DF,  p-value: 0.528
```

***Simple regression ~ budget

>mod2 = lm(ld~ budget, data= dat)

> summary(mod2)

- R-squared: 0.05286
- p-value: 0.08851 (fail to reject the null hypothesis, > 0,05)

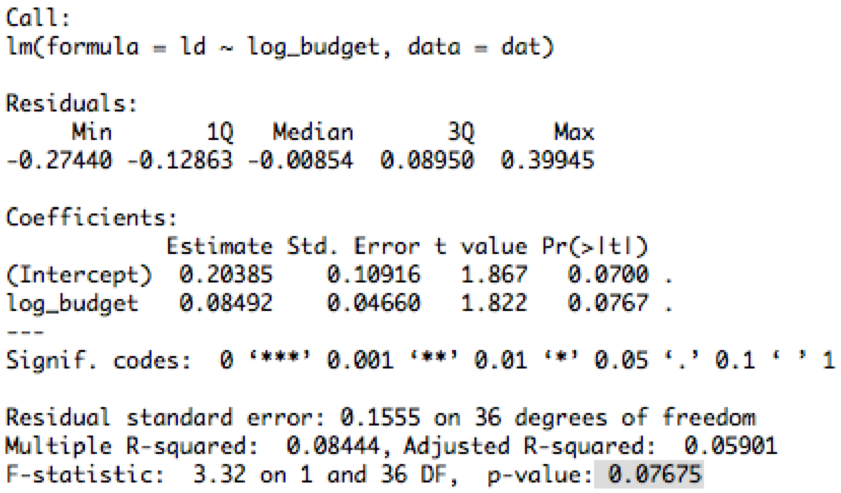


```
Call:
lm(formula = ld ~ budget, data = dat)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.31162 -0.11611 -0.02874  0.08851  0.40428 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 3.806e-01  2.707e-02  14.060 3.41e-16 ***
budget      3.254e-05  1.859e-05   1.751   0.0885 .  
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.156 on 36 degrees of freedom
Multiple R-squared:  0.07846,	Adjusted R-squared:  0.05286 
F-statistic: 3.065 on 1 and 36 DF,  p-value: 0.08851
```

>mod2 = lm(ld~ log_budget, data= dat)

> summary(mod2)

- R-squared: 0.05901
- p-value: 0.07675(fail to reject the null hypothesis, > 0,05)



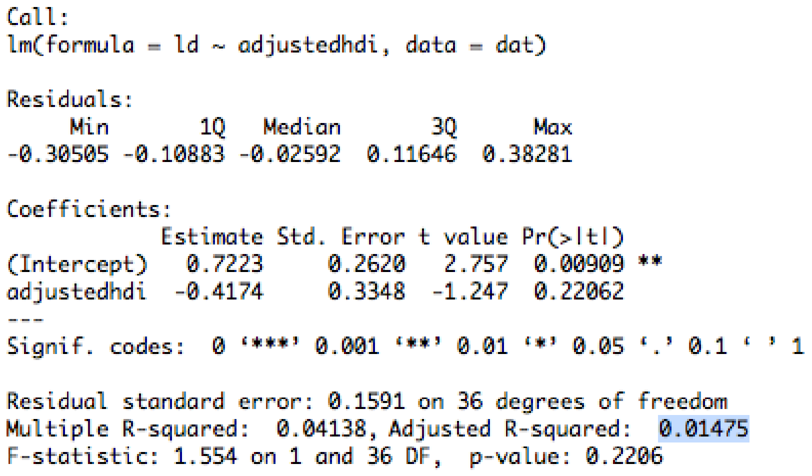
```
Call:
lm(formula = ld ~ log_budget, data = dat)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.27440 -0.12863 -0.00854  0.08950  0.39945 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)  
(Intercept)  0.20385    0.10916   1.867   0.0700 .
log_budget   0.08492    0.04660   1.822   0.0767 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.1555 on 36 degrees of freedom
Multiple R-squared:  0.08444, Adjusted R-squared:  0.05901 
F-statistic:  3.32 on 1 and 36 DF,  p-value: 0.07675
```

***Simple regression ~ adjustedhdi

>mod2 = lm(ld~ adjustedhdi , data= dat)

> summary(mod2)

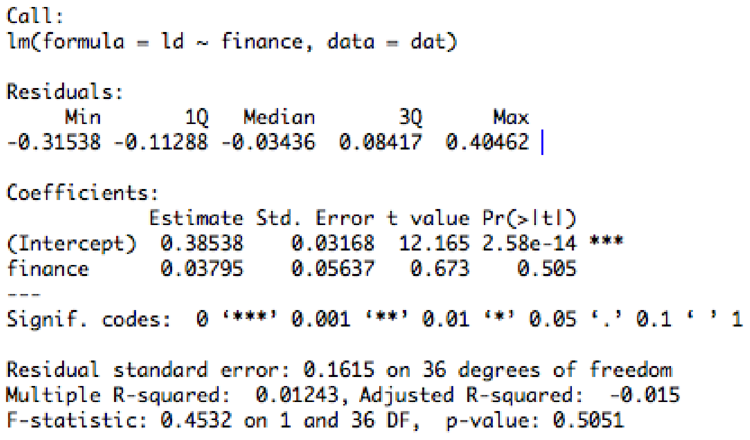
- R-squared: 0.01475
- p-value: 0.2206 (fail to reject the null hypothesis, > 0,05)



```
Call:
lm(formula = ld ~ adjustedhdi, data = dat)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.30505 -0.10883 -0.02592  0.11646  0.38281 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)   
(Intercept)   0.7223     0.2620   2.757  0.00909 **
adjustedhdi  -0.4174     0.3348  -1.247  0.22062   
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.1591 on 36 degrees of freedom
Multiple R-squared:  0.04138, Adjusted R-squared:  0.01475 
F-statistic: 1.554 on 1 and 36 DF,  p-value: 0.2206
```

```
>mod2 = lm( ld~ finance , data= dat)
> summary(mod2)
```

- R-squared: -0.015
- p-value: 0.5051 (fail to reject the null hypothesis, > 0,05)



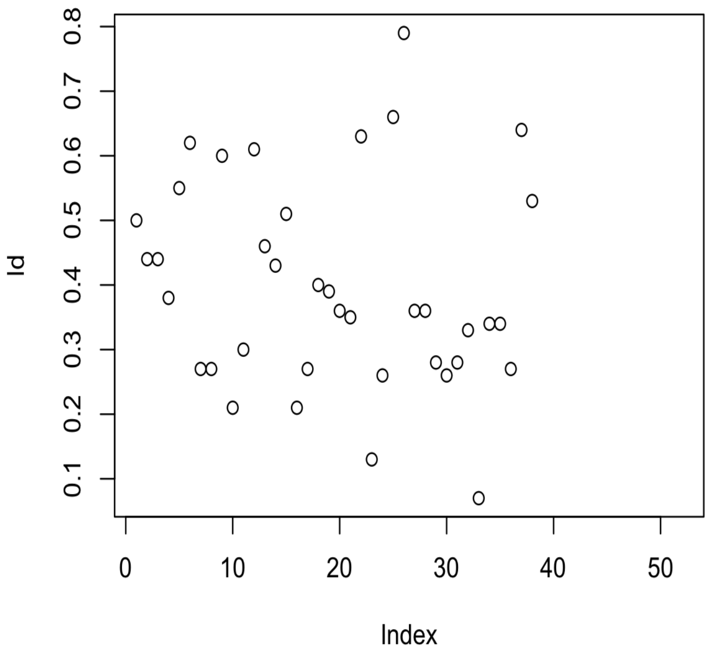
```
Call:
lm(formula = ld ~ finance, data = dat)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.31538 -0.11288 -0.03436  0.08417  0.40462 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  0.38538    0.03168  12.165 2.58e-14 ***
finance      0.03795    0.05637   0.673    0.505    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.1615 on 36 degrees of freedom
Multiple R-squared:  0.01243,	Adjusted R-squared:  -0.015 
F-statistic: 0.4532 on 1 and 36 DF,  p-value: 0.5051
```

Summary of the results Model 2_ld	Adj r^2	p-value (<0.05)
mod2 = lm(ld~ adjustedhdi + budget + trans + water + waste + finance , data= dat)	0.09068	0.1763
mod2 = lm(ld~ adjustedhdi + log_budget + trans + water + waste + finance , data= dat)	0.09118	0.1752
mod2 = lm(ld~ trans + water + waste, data= dat)	-0.02039	0.528
mod2 = lm(ld~ budget, data= dat)	0.05286	0.08851
mod2 = lm(ld~ log_budget, data= dat)	0.05901	0.07675
mod2 = lm(ld~ adjustedhdi , data= dat)	0.01475	0.2206
mod2 = lm(ld~ finance , data= dat)	-0.015	0.5051

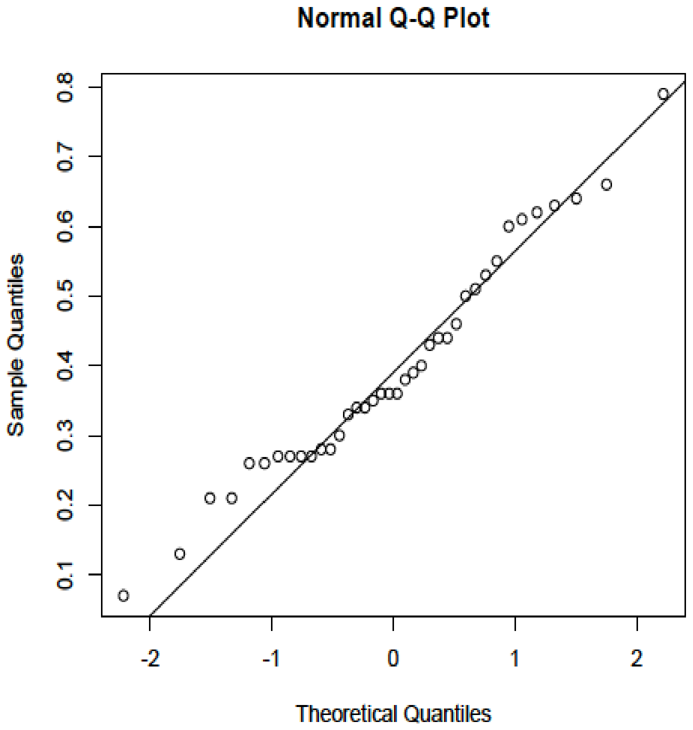
:

*** Model 2: Graphs

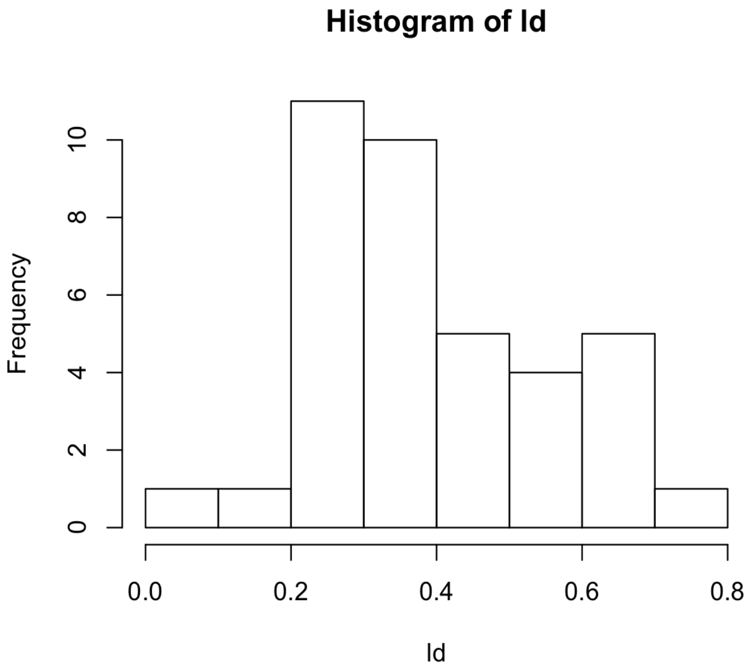
```
> plot(ld)
```



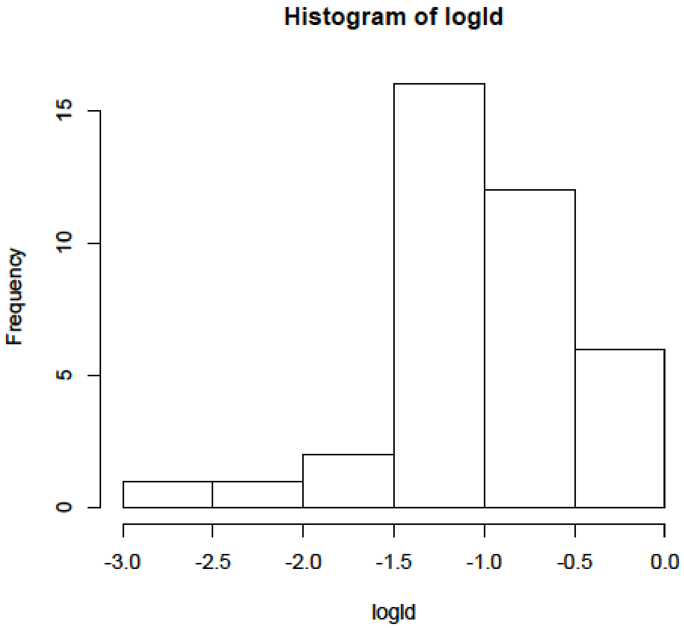
```
>qqline(ld)
```



```
>  hist(ld)
```



```
> hist(logld)
```



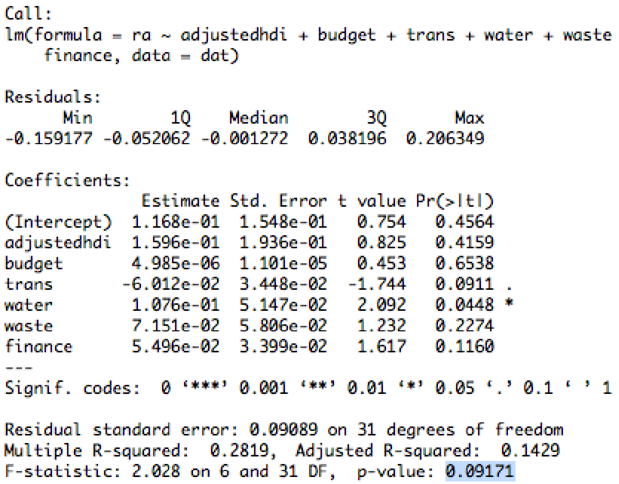
Model 3: Analyzing Resource Allocation:

*** Multiple analysis with all the variables to determine the significance of the relationship

>mod3 = lm(ra~ adjustedhdi + budget + trans + water + waste + finance , data= dat)

> summary(mod3)

- R-squared: 0.1429
- p-value:0.09171 (fail to reject the null hypothesis, > 0,05)

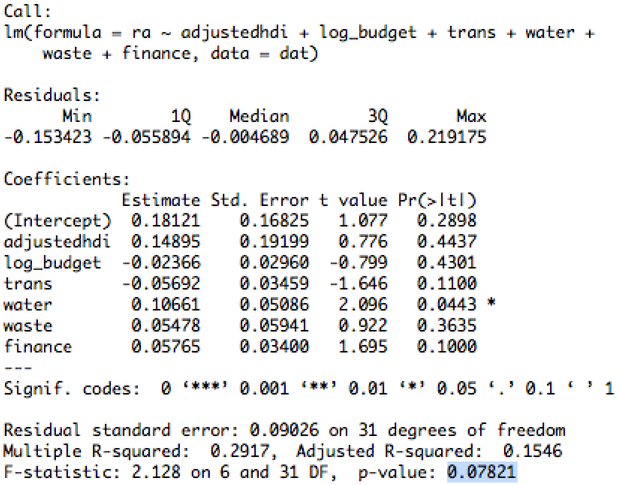


```
Call:
lm(formula = ra ~ adjustedhdi + budget + trans + water + waste +
    finance, data = dat)

Residuals:
      Min        1Q    Median        3Q       Max
-0.159177 -0.052062 -0.001272  0.038196  0.206349

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  1.168e-01  1.548e-01   0.754   0.4564
adjustedhdi  1.596e-01  1.936e-01   0.825   0.4159
budget       4.985e-06  1.101e-05   0.453   0.6538
trans       -6.012e-02  3.448e-02  -1.744   0.0911 .
water        1.076e-01  5.147e-02   2.092   0.0448 *
waste        7.151e-02  5.806e-02   1.232   0.2274
finance      5.496e-02  3.399e-02   1.617   0.1160
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.09089 on 31 degrees of freedom
Multiple R-squared:  0.2819,	Adjusted R-squared:  0.1429
F-statistic: 2.028 on 6 and 31 DF,  p-value: 0.09171
```

> log_ra=log10(dat$ra)

>mod3 = lm(ra~ adjustedhdi + log_budget + trans + water + waste + finance , data= dat)
> summary(mod3)

- R-squared: 0.1546
- p-value: 0.07821 (fail to reject the null hypothesis, > 0,05)



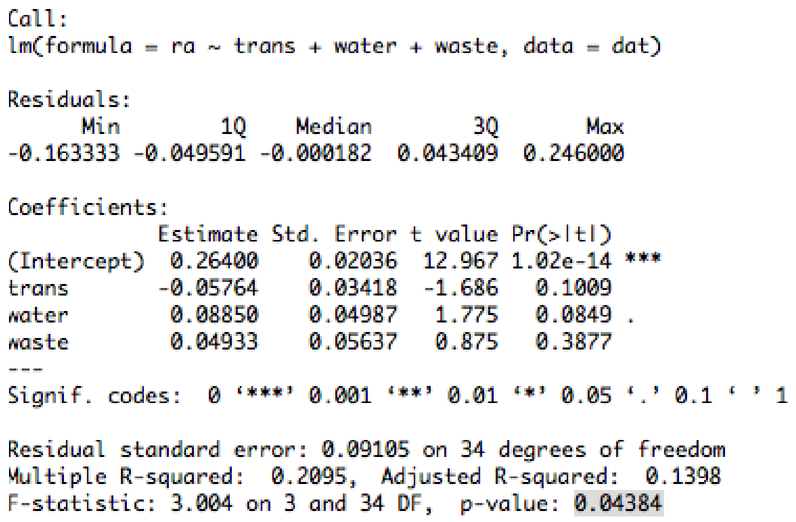
```
Call:
lm(formula = ra ~ adjustedhdi + log_budget + trans + water +
    waste + finance, data = dat)

Residuals:
      Min        1Q    Median        3Q       Max
-0.153423 -0.055894 -0.004689  0.047526  0.219175

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.18121    0.16825   1.077   0.2898
adjustedhdi  0.14895    0.19199   0.776   0.4437
log_budget  -0.02366    0.02960  -0.799   0.4301
trans       -0.05692    0.03459  -1.646   0.1100
water        0.10661    0.05086   2.096   0.0443 *
waste        0.05478    0.05941   0.922   0.3635
finance      0.05765    0.03400   1.695   0.1000
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.09026 on 31 degrees of freedom
Multiple R-squared:  0.2917,	Adjusted R-squared:  0.1546
F-statistic: 2.128 on 6 and 31 DF,  p-value: 0.07821
```

***Compare energy against the other typologies.

>mod3 = lm(ra~ trans + water + waste, data= dat)

> summary(mod3)

- R-squared: 0.1398
- p-value: 0.04384 (reject the null hypothesis, > 0,05)



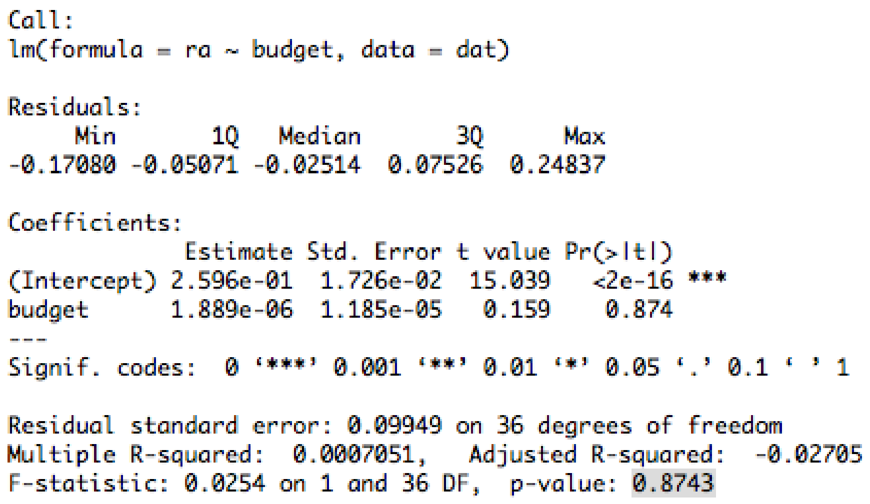
```
Call:
lm(formula = ra ~ trans + water + waste, data = dat)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.163333 -0.049591 -0.000182  0.043409  0.246000 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  0.26400    0.02036  12.967 1.02e-14 ***
trans       -0.05764    0.03418  -1.686   0.1009    
water        0.08850    0.04987   1.775   0.0849 .  
waste        0.04933    0.05637   0.875   0.3877    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.09105 on 34 degrees of freedom
Multiple R-squared:  0.2095,	Adjusted R-squared:  0.1398 
F-statistic: 3.004 on 3 and 34 DF,  p-value: 0.04384
```

***Simple regression ~ budget

>mod3 = lm(ra~ budget, data= dat)

> summary(mod3)

- R-squared: -0.02705
- p-value:0.8743 (fail to reject the null hypothesis, > 0,05)

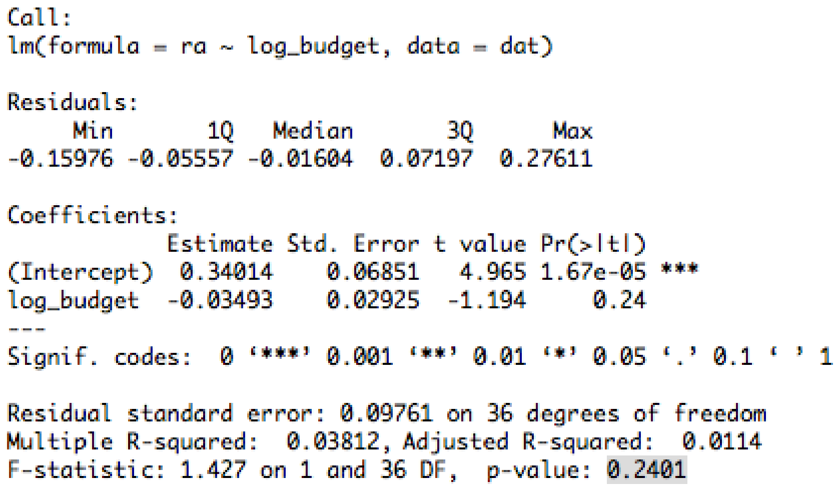


```
Call:
lm(formula = ra ~ budget, data = dat)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.17080 -0.05071 -0.02514  0.07526  0.24837 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 2.596e-01  1.726e-02  15.039   <2e-16 ***
budget      1.889e-06  1.185e-05   0.159    0.874    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.09949 on 36 degrees of freedom
Multiple R-squared:  0.0007051,	Adjusted R-squared:  -0.02705 
F-statistic: 0.0254 on 1 and 36 DF,  p-value: 0.8743
```

>mod3 = lm(ra~ log_budget, data= dat)

> summary(mod3)

- R-squared: 0.0114
- p-value: 0.2401(fail to reject the null hypothesis, > 0,05)



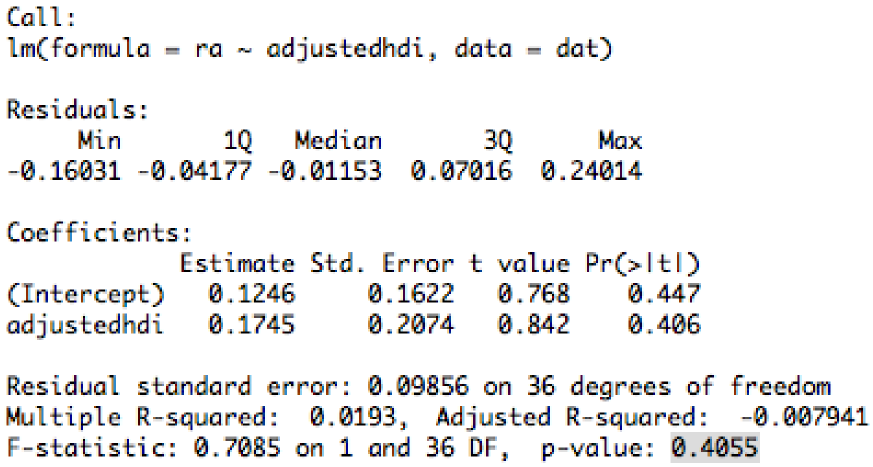
```
Call:
lm(formula = ra ~ log_budget, data = dat)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.15976 -0.05557 -0.01604  0.07197  0.27611 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  0.34014    0.06851   4.965 1.67e-05 ***
log_budget  -0.03493    0.02925  -1.194     0.24    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.09761 on 36 degrees of freedom
Multiple R-squared:  0.03812,	Adjusted R-squared:  0.0114 
F-statistic: 1.427 on 1 and 36 DF,  p-value: 0.2401
```

***Simple regression ~ adjustedhdi

>mod3 = lm(ra~ adjustedhdi , data= dat)

> summary(mod3)

- R-squared: -0.007941
- p-value: 0.4055 (fail to reject the null hypothesis, > 0,05)

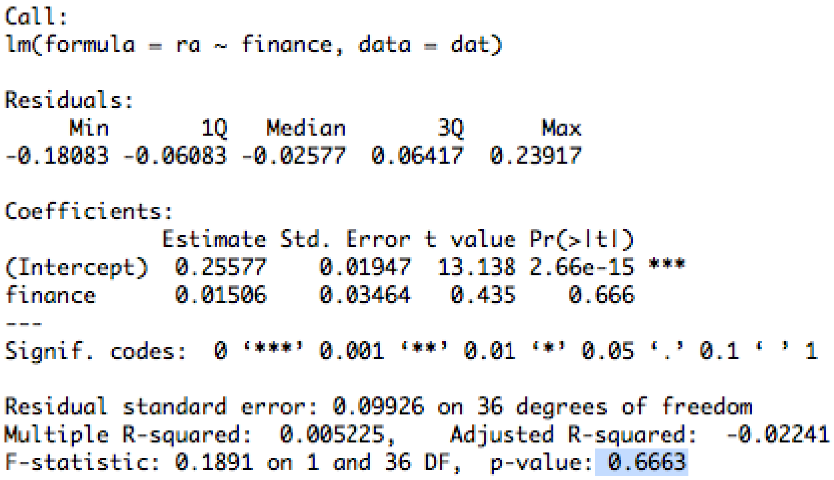


```
Call:
lm(formula = ra ~ adjustedhdi, data = dat)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.16031 -0.04177 -0.01153  0.07016  0.24014 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)   0.1246     0.1622   0.768    0.447
adjustedhdi   0.1745     0.2074   0.842    0.406

Residual standard error: 0.09856 on 36 degrees of freedom
Multiple R-squared:  0.0193,	Adjusted R-squared:  -0.007941 
F-statistic: 0.7085 on 1 and 36 DF,  p-value: 0.4055
```

>mod3 = lm(ra~ finance , data= dat)

> summary(mod3)

- R-squared: -0.02241
- p-value: 0.6663 (fail to reject the null hypothesis, > 0,05)

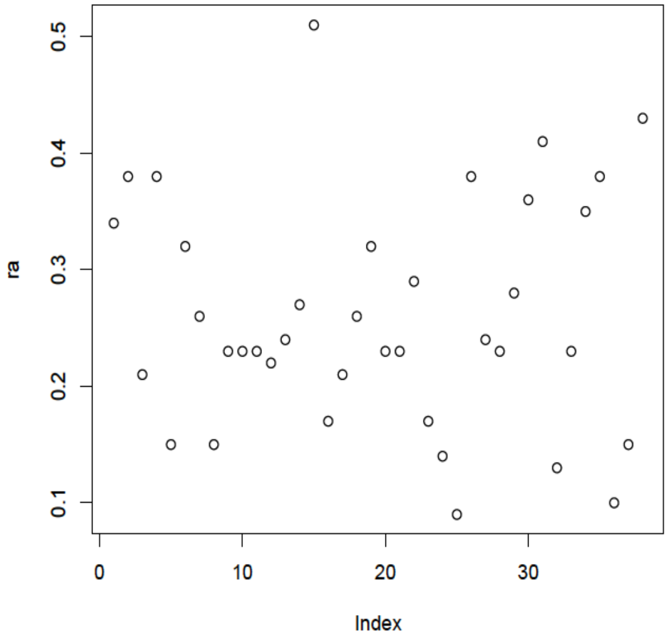


```
Call:
lm(formula = ra ~ finance, data = dat)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.18083 -0.06083 -0.02577  0.06417  0.23917 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  0.25577    0.01947  13.138 2.66e-15 ***
finance      0.01506    0.03464   0.435    0.666    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.09926 on 36 degrees of freedom
Multiple R-squared:  0.005225,	Adjusted R-squared:  -0.02241 
F-statistic: 0.1891 on 1 and 36 DF,  p-value: 0.6663
```

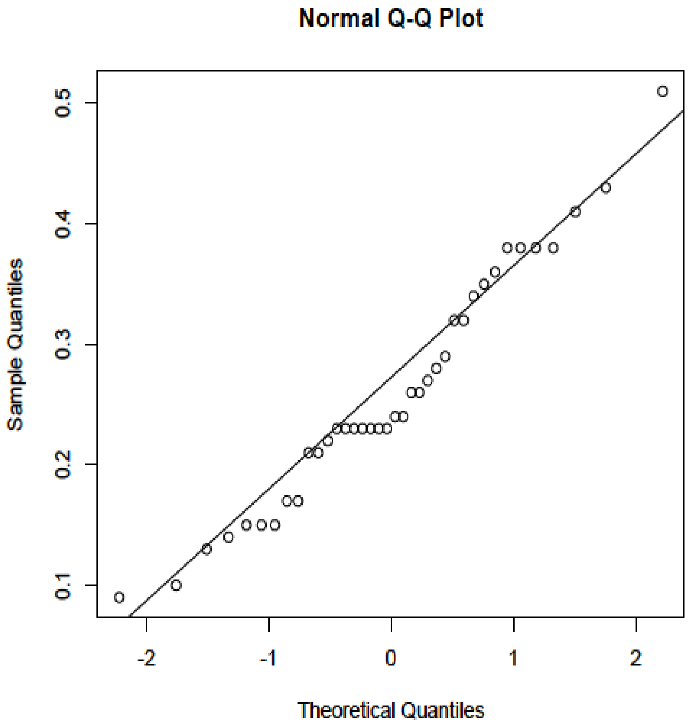
Summary of the results Model 3_ra	Adj r^2	p-value (<0.05)
mod3 = lm(ra~ adjustedhdi + budget + trans + water + waste + finance , data= dat)	0.1429	0.09171
mod3 = lm(ra~ adjustedhdi + log_budget + trans + water + waste + finance , data= dat)	0.1546	0.07821
mod3 = lm(ra~ trans + water + waste, data= dat)	0.1398	0.04384
mod3 = lm(ra~ budget, data= dat)	-0.02705	0.8743
mod3 = lm(ra~ log_budget, data= dat)	0.0114	0.2401
mod3 = lm(ra~ adjustedhdi , data= dat)	-0.007941	0.4055
mod3 = lm(ra~ finance , data= dat)	-0.02241	0.6663

*** Model 3: Graphs

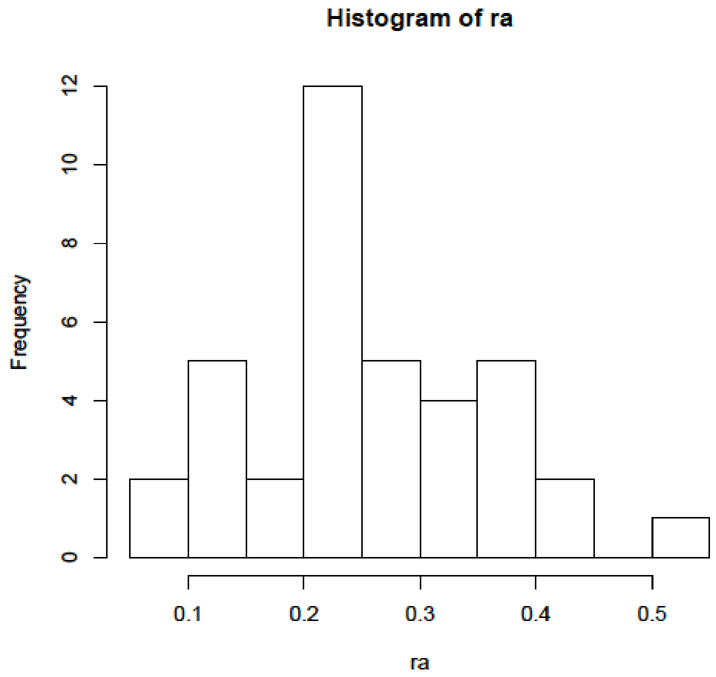
```
>plot(ra)
```



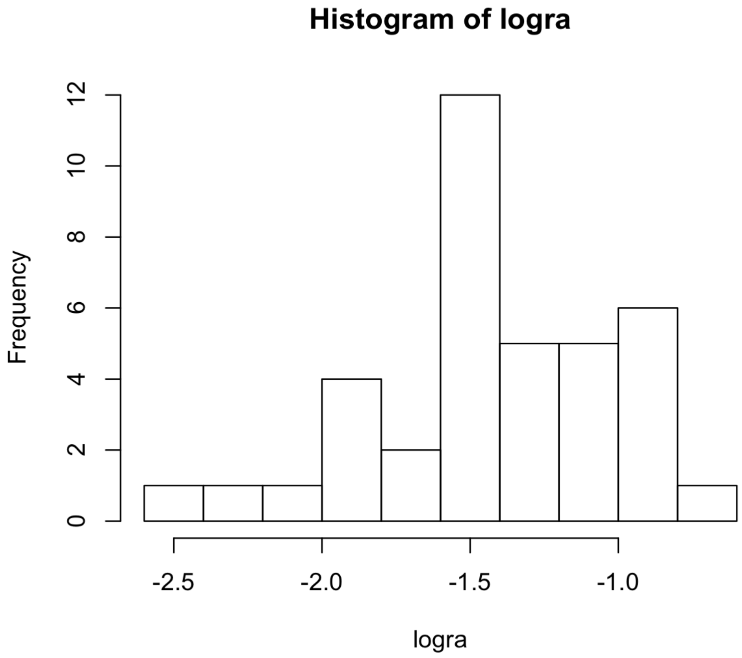
```
>qqline(ra)
```



```
>hist(ra)
```



```
> hist(logra)
```



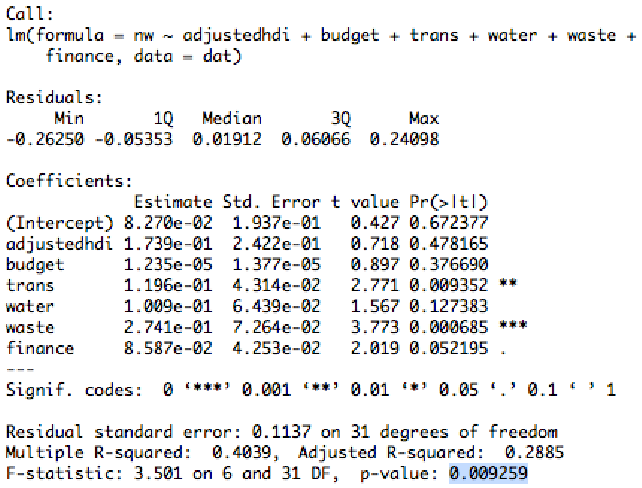
Model 4: Analyzing Natural World:

*** Multiple analysis with all the variables to determine the significance of the relationship

>mod4 = lm(nw~ adjustedhdi + budget + trans + water + waste + finance , data= dat)

> summary(mod4)

- R-squared: 0.2885
- p-value:0.009259 (reject the null hypothesis, > 0,05)



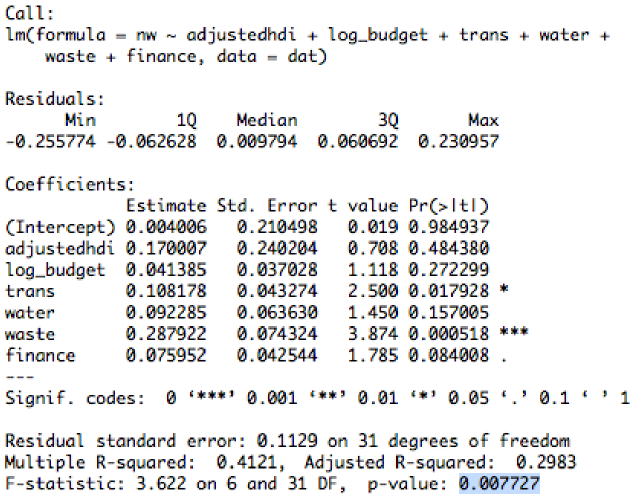
```
Call:
lm(formula = nw ~ adjustedhdi + budget + trans + water + waste +
    finance, data = dat)

Residuals:
     Min       1Q   Median       3Q      Max
-0.26250 -0.05353  0.01912  0.06066  0.24098

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 8.270e-02  1.937e-01   0.427 0.672377
adjustedhdi 1.739e-01  2.422e-01   0.718 0.478165
budget      1.235e-05  1.377e-05   0.897 0.376690
trans       1.196e-01  4.314e-02   2.771 0.009352 **
water       1.009e-01  6.439e-02   1.567 0.127383
waste       2.741e-01  7.264e-02   3.773 0.000685 ***
finance     8.587e-02  4.253e-02   2.019 0.052195 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.1137 on 31 degrees of freedom
Multiple R-squared:  0.4039,	Adjusted R-squared:  0.2885
F-statistic: 3.501 on 6 and 31 DF,  p-value: 0.009259
```

> log_nw=log10(dat$nw)

>mod4 = lm(nw~ adjustedhdi + log_budget + trans + water + waste + finance , data= dat)

> summary(mod4)

- R-squared: 0.2983
- p-value: 0.007727 (reject the null hypothesis, > 0,05)



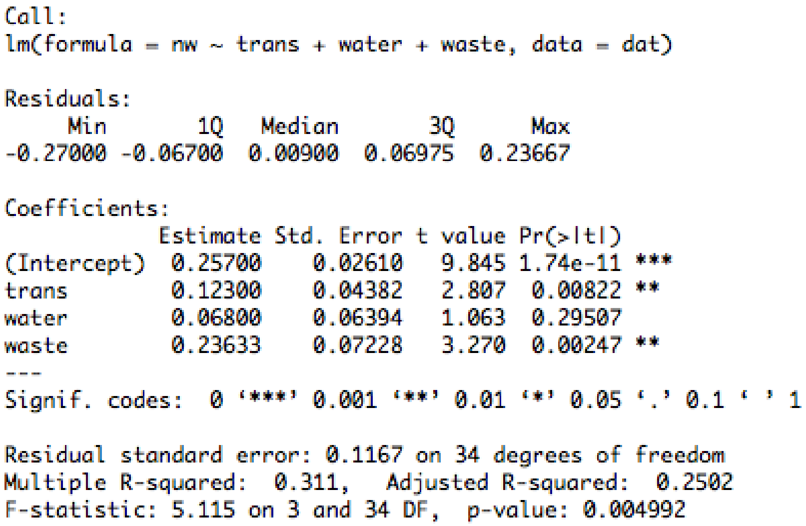
```
Call:
lm(formula = nw ~ adjustedhdi + log_budget + trans + water +
    waste + finance, data = dat)

Residuals:
      Min        1Q    Median        3Q       Max
-0.255774 -0.062628  0.009794  0.060692  0.230957

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 0.004006   0.210498   0.019 0.984937
adjustedhdi 0.170007   0.240204   0.708 0.484380
log_budget  0.041385   0.037028   1.118 0.272299
trans       0.108178   0.043274   2.500 0.017928 *
water       0.092285   0.063630   1.450 0.157005
waste       0.287922   0.074324   3.874 0.000518 ***
finance     0.075952   0.042544   1.785 0.084008 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.1129 on 31 degrees of freedom
Multiple R-squared:  0.4121,	Adjusted R-squared:  0.2983
F-statistic: 3.622 on 6 and 31 DF,  p-value: 0.007727
```

***Compare energy against the other typologies.

>mod4 = lm(nw~ trans + water + waste, data= dat)

> summary(mod4)

- R-squared: 0.2502
- p-value: 0.004992 (reject the null hypothesis, > 0,05)



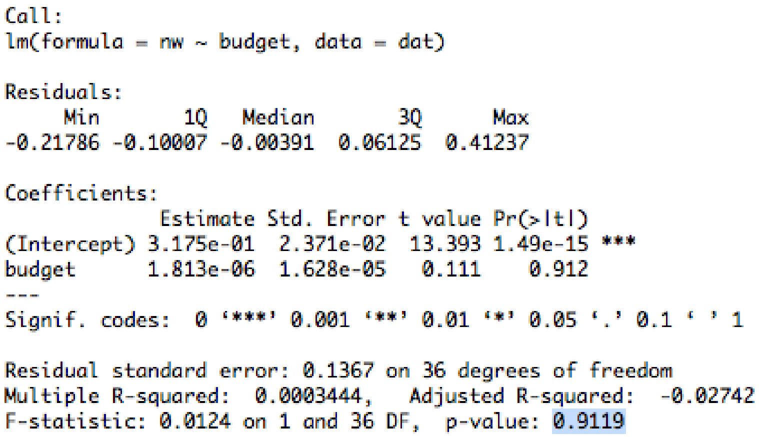
```
Call:
lm(formula = nw ~ trans + water + waste, data = dat)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.27000 -0.06700  0.00900  0.06975  0.23667 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  0.25700    0.02610   9.845 1.74e-11 ***
trans        0.12300    0.04382   2.807  0.00822 ** 
water        0.06800    0.06394   1.063  0.29507    
waste        0.23633    0.07228   3.270  0.00247 ** 
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.1167 on 34 degrees of freedom
Multiple R-squared:  0.311,	Adjusted R-squared:  0.2502 
F-statistic: 5.115 on 3 and 34 DF,  p-value: 0.004992
```

***Simple regression ~ budget

>mod4 = lm(nw~ budget, data= dat)

> summary(mod4)

- R-squared: -0.02742
- p-value:0.9119 (fail to reject the null hypothesis, > 0,05)

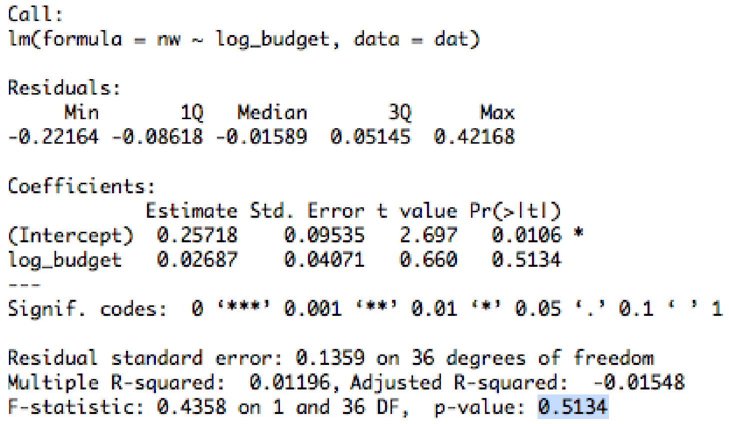


```
Call:
lm(formula = nw ~ budget, data = dat)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.21786 -0.10007 -0.00391  0.06125  0.41237 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 3.175e-01  2.371e-02  13.393 1.49e-15 ***
budget      1.813e-06  1.628e-05   0.111    0.912    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.1367 on 36 degrees of freedom
Multiple R-squared:  0.0003444,	Adjusted R-squared:  -0.02742 
F-statistic: 0.0124 on 1 and 36 DF,  p-value: 0.9119
```

>mod4 = lm(nw~ log_budget, data= dat)

> summary(mod4)

- R-squared: -0.01548
- p-value: 0.5134 (fail to reject the null hypothesis, > 0,05)



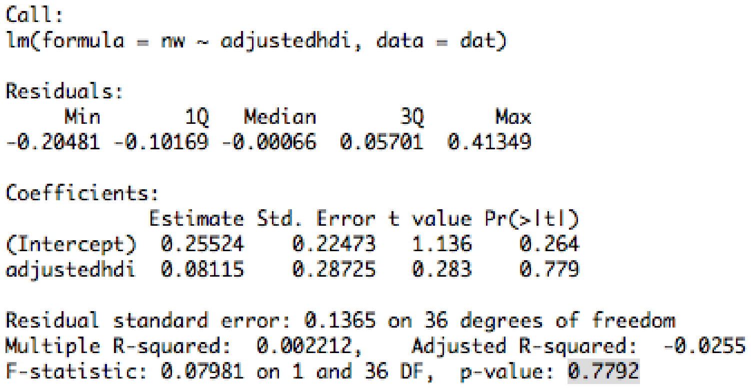
```
Call:
lm(formula = nw ~ log_budget, data = dat)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.22164 -0.08618 -0.01589  0.05145  0.42168 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)  
(Intercept)  0.25718    0.09535   2.697   0.0106 *
log_budget   0.02687    0.04071   0.660   0.5134  
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.1359 on 36 degrees of freedom
Multiple R-squared:  0.01196, Adjusted R-squared:  -0.01548 
F-statistic: 0.4358 on 1 and 36 DF,  p-value: 0.5134
```

***Simple regression ~ adjustedhdi

>mod4 = lm(nw~ adjustedhdi , data= dat)

> summary(mod3)

- R-squared: -0.0255
- p-value: 0.7792 (fail to reject the null hypothesis, > 0,05)

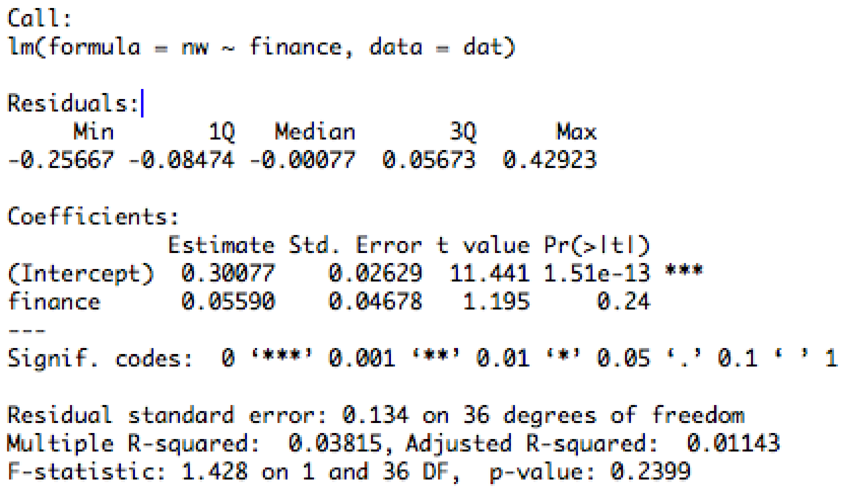


```
Call:
lm(formula = nw ~ adjustedhdi, data = dat)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.20481 -0.10169 -0.00066  0.05701  0.41349 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.25524    0.22473   1.136    0.264
adjustedhdi  0.08115    0.28725   0.283    0.779

Residual standard error: 0.1365 on 36 degrees of freedom
Multiple R-squared:  0.002212,    Adjusted R-squared:  -0.0255 
F-statistic: 0.07981 on 1 and 36 DF,  p-value: 0.7792
```

>mod4 = lm(nw~ finance , data= dat)

> summary(mod4)

- R-squared: 0.01143
- p-value:0.2399 (fail to reject the null hypothesis, > 0,05)

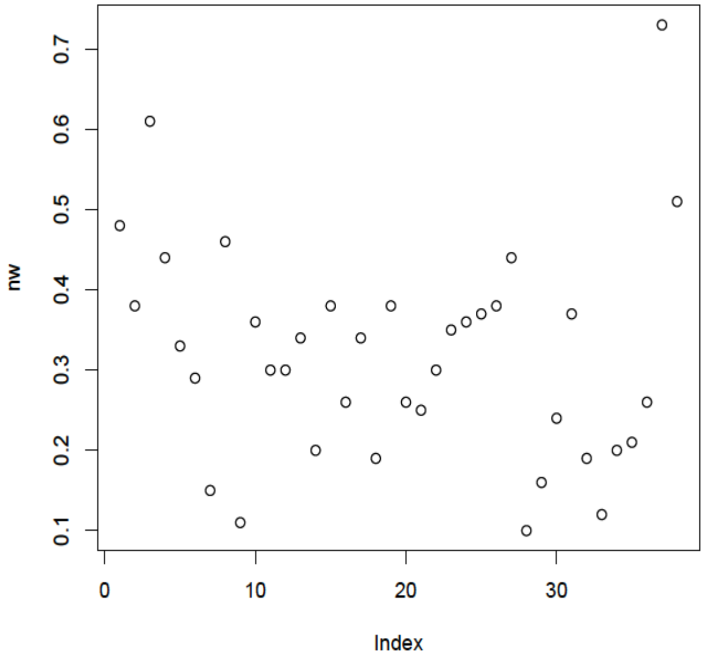


```
Call:
lm(formula = nw ~ finance, data = dat)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.25667 -0.08474 -0.00077  0.05673  0.42923 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  0.30077    0.02629  11.441 1.51e-13 ***
finance      0.05590    0.04678   1.195     0.24    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.134 on 36 degrees of freedom
Multiple R-squared:  0.03815,	Adjusted R-squared:  0.01143 
F-statistic: 1.428 on 1 and 36 DF,  p-value: 0.2399
```

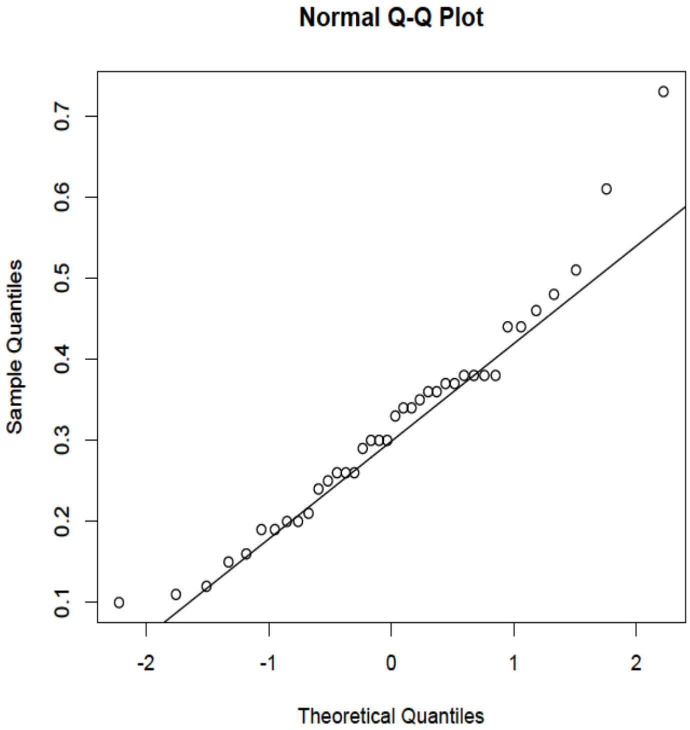
Summary of the results Model 4_nw	Adj r^2	p-value (<0.05)
mod4 = lm(nw~ adjustedhdi + budget + trans + water + waste + finance , data= dat)	0.2885	0.009259
mod4 = lm(nw~ adjustedhdi + log_budget + trans + water + waste + finance , data= dat)	0.2983	0.007727
mod4 = lm(nw~ trans + water + waste, data= dat)	0.2502	0.004992
mod4 = lm(nw~ budget, data= dat)	-0.02742	0.9119
mod4 = lm(nw~ log_budget, data= dat)	-0.01548	0.5134
mod4 = lm(nw~ adjustedhdi , data= dat)	-0.0255	0.7792
mod4 = lm(nw~ finance , data= dat)	0.01143	0.2399

*** Model 4: Graphs

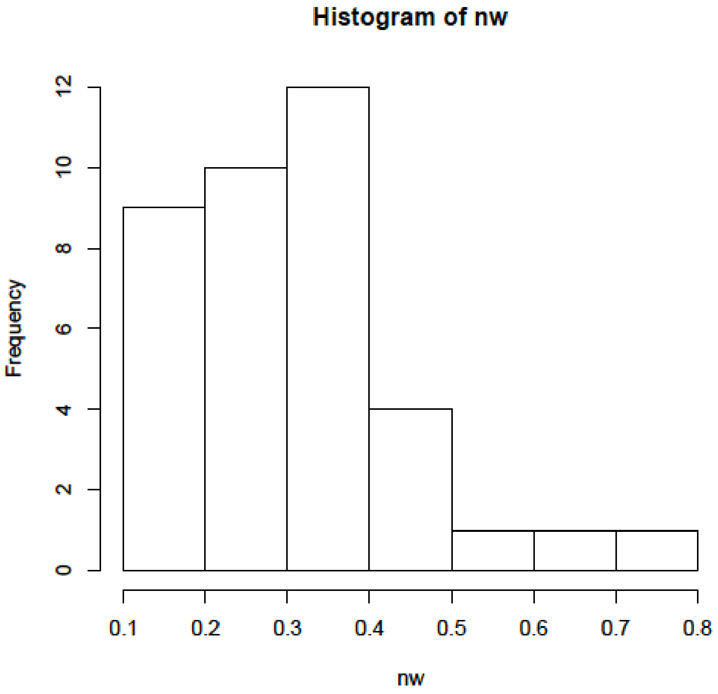
```
>plot(nw)
```



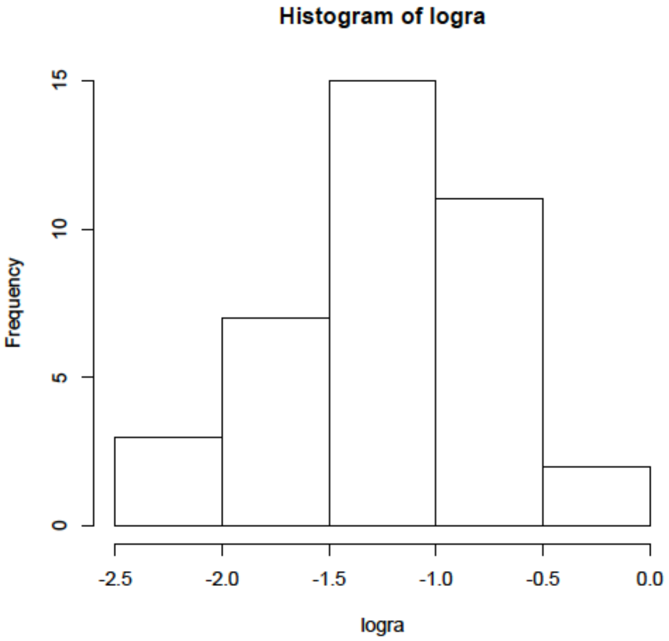
```
>qqline(nw)
```



```
>hist(nw)
```



```
>hist(lognw)
```



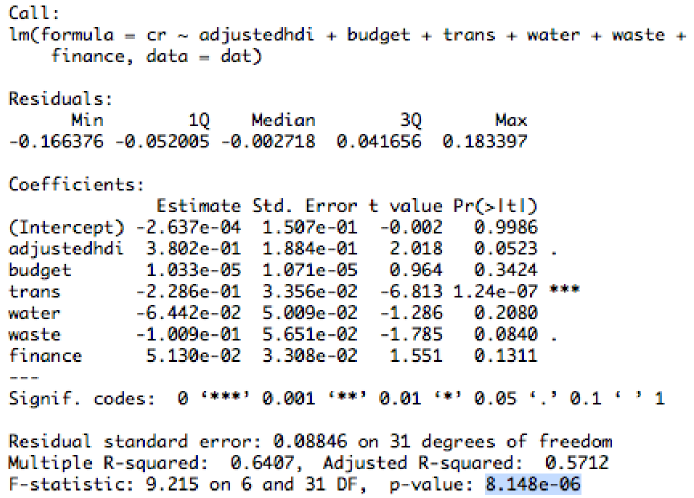
Model 5: Analyzing Climate and Risk

*** Multiple analysis with all the variables to determine the significance of the relationship

>mod5 = lm(cr~ adjustedhdi + budget + trans+ water + waste + finance , data= dat)

> summary(mod5)

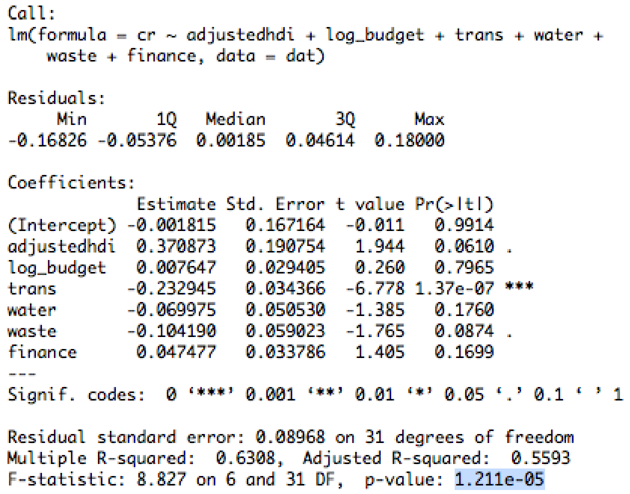
- R-squared: 0.5712
- p-value:8.148e-06 (reject the null hypothesis, > 0,05)



```
Call:
lm(formula = cr ~ adjustedhdi + budget + trans + water + waste +
    finance, data = dat)

Residuals:
      Min        1Q    Median        3Q       Max
-0.166376 -0.052005 -0.002718  0.041656  0.183397

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) -2.637e-04  1.507e-01  -0.002   0.9986
adjustedhdi  3.802e-01  1.884e-01   2.018   0.0523 .
budget       1.033e-05  1.071e-05   0.964   0.3424
trans       -2.286e-01  3.356e-02  -6.813 1.24e-07 ***
water       -6.442e-02  5.009e-02  -1.286   0.2080
waste       -1.009e-01  5.651e-02  -1.785   0.0840 .
finance      5.130e-02  3.308e-02   1.551   0.1311
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.08846 on 31 degrees of freedom
Multiple R-squared:  0.6407,  Adjusted R-squared:  0.5712
F-statistic: 9.215 on 6 and 31 DF,  p-value: 8.148e-06
```

>mod5 = lm(cr~ adjustedhdi + log_budget + trans + water + waste + finance , data= dat)
> summary(mod5)

- R-squared: 0.5593
- p-value: 1.211e-05 (reject the null hypothesis, > 0,05)



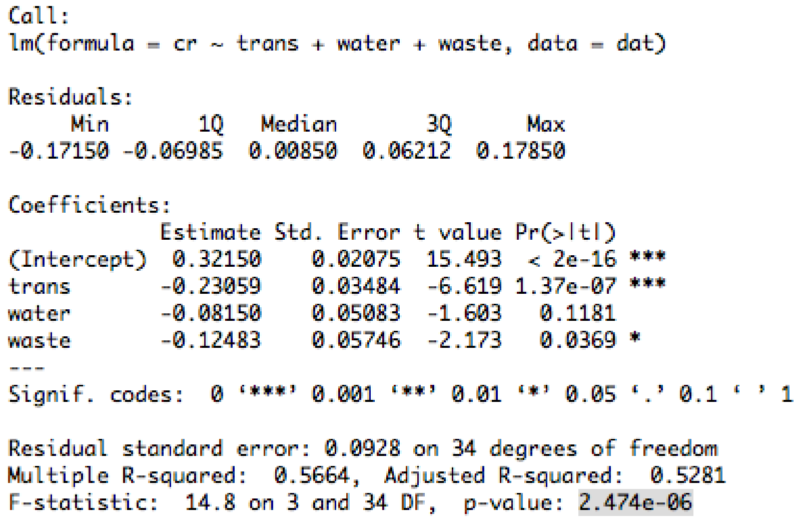
```
Call:
lm(formula = cr ~ adjustedhdi + log_budget + trans + water +
    waste + finance, data = dat)

Residuals:
     Min       1Q   Median       3Q      Max
-0.16826 -0.05376  0.00185  0.04614  0.18000

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.001815   0.167164  -0.011   0.9914
adjustedhdi  0.370873   0.190754   1.944   0.0610 .
log_budget   0.007647   0.029405   0.260   0.7965
trans       -0.232945   0.034366  -6.778 1.37e-07 ***
water       -0.069975   0.050530  -1.385   0.1760
waste       -0.104190   0.059023  -1.765   0.0874 .
finance      0.047477   0.033786   1.405   0.1699
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.08968 on 31 degrees of freedom
Multiple R-squared:  0.6308,  Adjusted R-squared:  0.5593
F-statistic: 8.827 on 6 and 31 DF,  p-value: 1.211e-05
```

***Compare energy against the other typologies.

>mod5 = lm(cr~ trans + water + waste, data= dat)

> summary(mod5)

- R-squared: 0.5281
- p-value: 2.474e-06 (reject the null hypothesis, > 0,05)



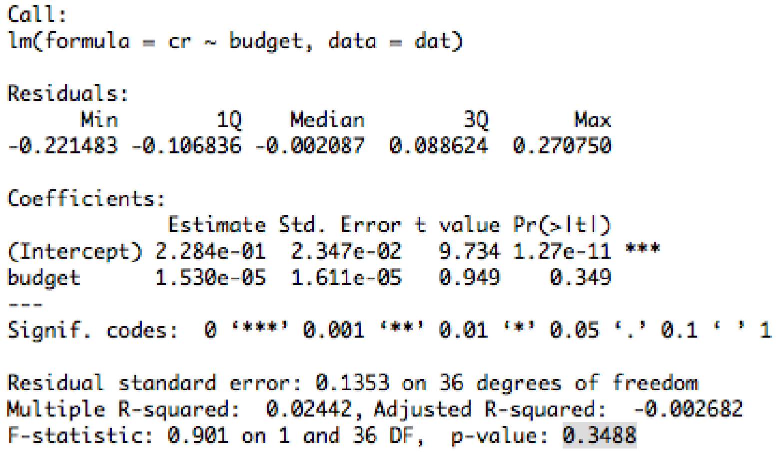
```
Call:
lm(formula = cr ~ trans + water + waste, data = dat)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.17150 -0.06985  0.00850  0.06212  0.17850 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  0.32150    0.02075  15.493  < 2e-16 ***
trans       -0.23059    0.03484  -6.619 1.37e-07 ***
water       -0.08150    0.05083  -1.603   0.1181    
waste       -0.12483    0.05746  -2.173   0.0369 *  
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.0928 on 34 degrees of freedom
Multiple R-squared:  0.5664,	Adjusted R-squared:  0.5281 
F-statistic:  14.8 on 3 and 34 DF,  p-value: 2.474e-06
```

***Simple regression ~ budget

>mod5 = lm(cr~ budget, data= dat)

> summary(mod5)

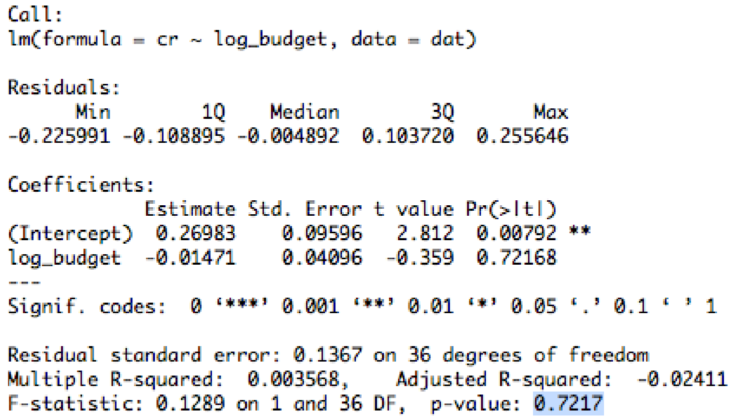
- R-squared: -0.002682
- p-value:0.3488 (fail to reject the null hypothesis, > 0,05)



```
Call:
lm(formula = cr ~ budget, data = dat)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.221483 -0.106836 -0.002087  0.088624  0.270750 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 2.284e-01  2.347e-02   9.734 1.27e-11 ***
budget      1.530e-05  1.611e-05   0.949    0.349    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.1353 on 36 degrees of freedom
Multiple R-squared:  0.02442,	Adjusted R-squared:  -0.002682 
F-statistic: 0.901 on 1 and 36 DF,  p-value: 0.3488
```

```
>mod5 = lm( nw~ log_budget, data= dat)
> summary(mod5)
```

- R-squared: -0.02411
- p-value: 0.7217 (fail to reject the null hypothesis, > 0,05)

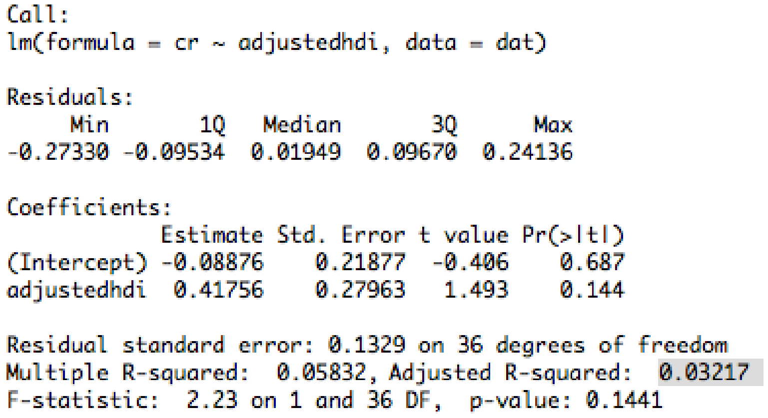


```
Call:
lm(formula = cr ~ log_budget, data = dat)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.225991 -0.108895 -0.004892  0.103720  0.255646 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)   
(Intercept)  0.26983    0.09596   2.812  0.00792 **
log_budget  -0.01471    0.04096  -0.359  0.72168   
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.1367 on 36 degrees of freedom
Multiple R-squared:  0.003568,	Adjusted R-squared:  -0.02411 
F-statistic: 0.1289 on 1 and 36 DF,  p-value: 0.7217
```

***Simple regression ~ adjustedhdi

```
>mod5 = lm( cr~ adjustedhdi  , data= dat)
> summary(mod 5)
```

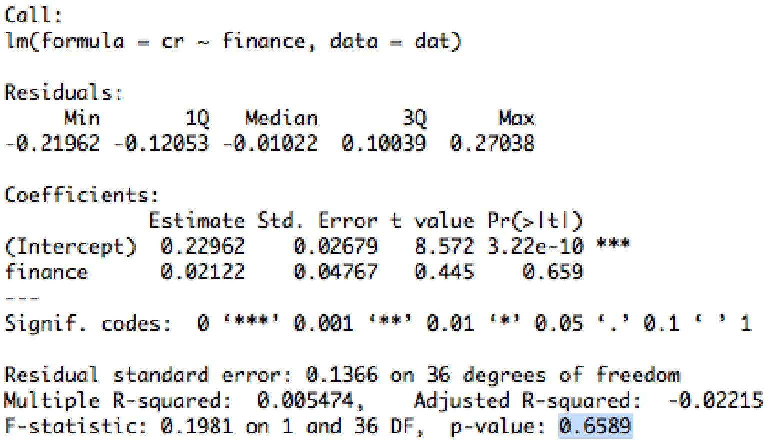
- R-squared: 0.03217
- p-value: 0.1441 (fail to reject the null hypothesis, > 0,05)



```
Call:
lm(formula = cr ~ adjustedhdi, data = dat)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.27330 -0.09534  0.01949  0.09670  0.24136 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.08876    0.21877  -0.406    0.687
adjustedhdi  0.41756    0.27963   1.493    0.144

Residual standard error: 0.1329 on 36 degrees of freedom
Multiple R-squared:  0.05832, Adjusted R-squared:  0.03217 
F-statistic:  2.23 on 1 and 36 DF,  p-value: 0.1441
```

```
>mod5 = lm( cr~ finance , data= dat)
> summary(mod5)
```

- R-squared: -0.02215
- p-value: 0.6589 (fail to reject the null hypothesis, > 0,05)

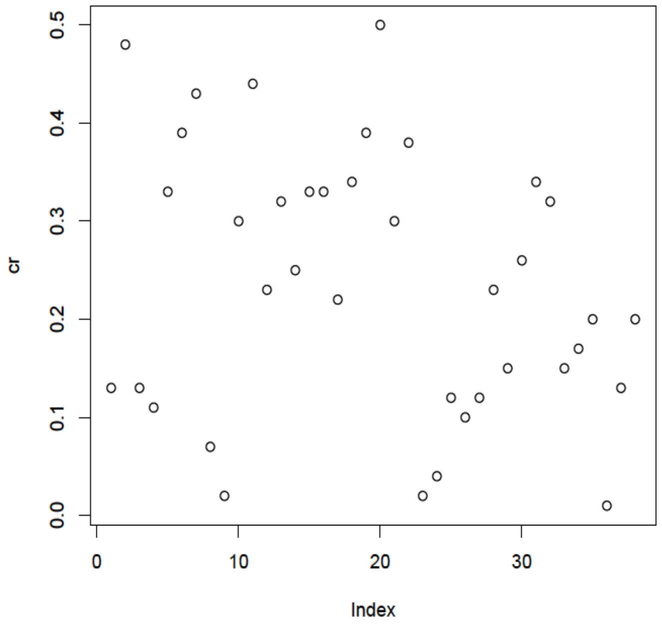


```
Call:
lm(formula = cr ~ finance, data = dat)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.21962 -0.12053 -0.01022  0.10039  0.27038 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  0.22962    0.02679   8.572 3.22e-10 ***
finance      0.02122    0.04767   0.445    0.659    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.1366 on 36 degrees of freedom
Multiple R-squared:  0.005474,	Adjusted R-squared:  -0.02215 
F-statistic: 0.1981 on 1 and 36 DF,  p-value: 0.6589
```

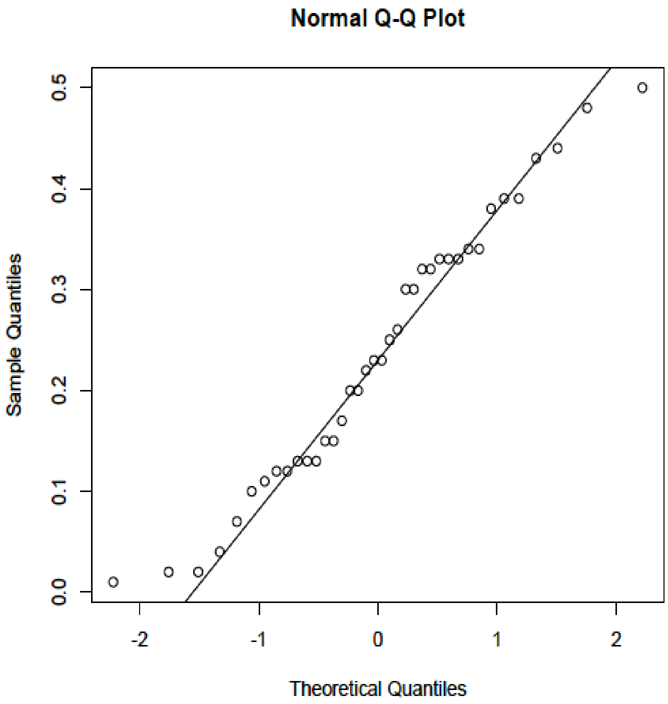
Summary of the results Model 5_cr	Adj r^2	p-value (<0.05)
mod5 = lm(cr~ adjustedhdi + budget + trans+ water + waste + finance , data= dat)	0.5712	8.148e-06
mod5 = lm(cr~ adjustedhdi + log_budget + trans + water + waste + finance , data= dat)	0.5593	1.211e-05
mod5 = lm(cr~ trans + water + waste, data= dat)	0.5281	2.474e-06
mod5 = lm(cr~ budget, data= dat)	-0.002682	0.3488
mod5 = lm(cr~ log_budget, data= dat)	-0.02411	0.7217
mod5 = lm(cr~ adjustedhdi , data= dat)	0.03217	0.1441
mod5 = lm(cr~ finance , data= dat)	-0.02215	0.6589

*** Model 5: Graphs

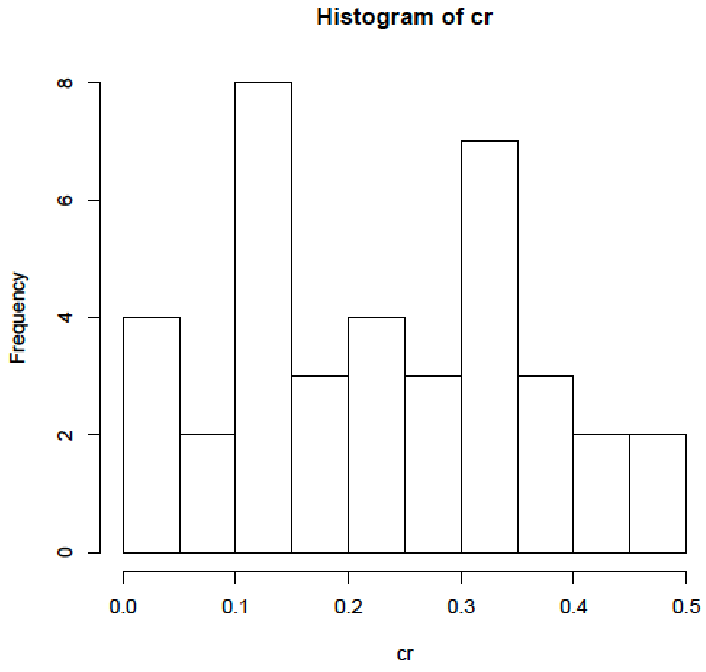
```
>plot(cr)
```



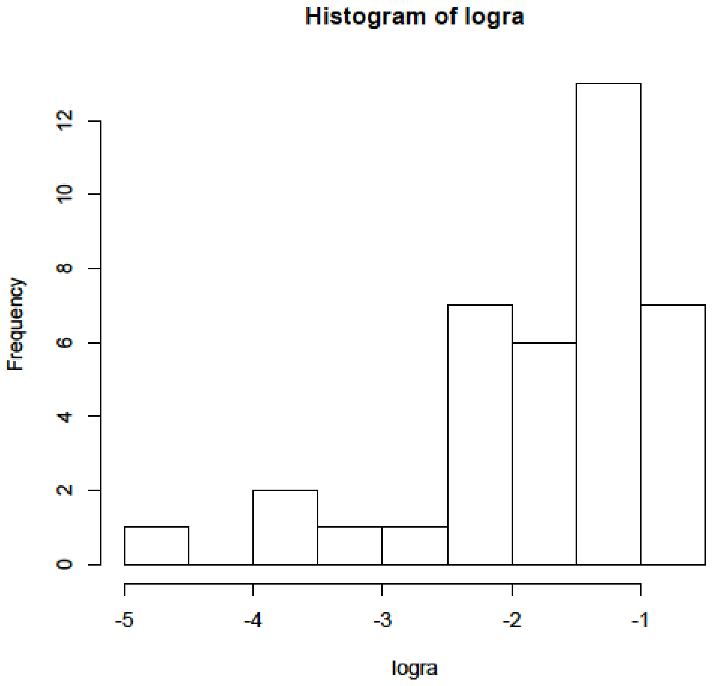
```
>qqline(cr)
```



```
>hist(cr)
```



```
>hist(logcr)
```

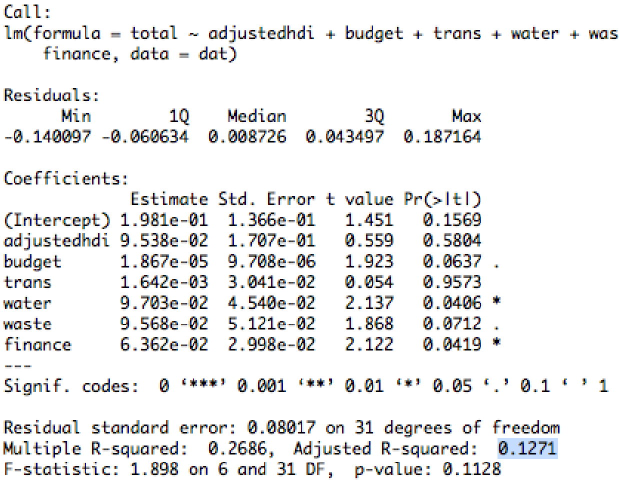


Model 6: Analyzing Total score

*** Multiple analysis with all the variables to determine the significance of the relationship

>mod6 = lm(total~ adjustedhdi + budget + trans+ water + waste + finance , data= dat)
> summary(mod6)

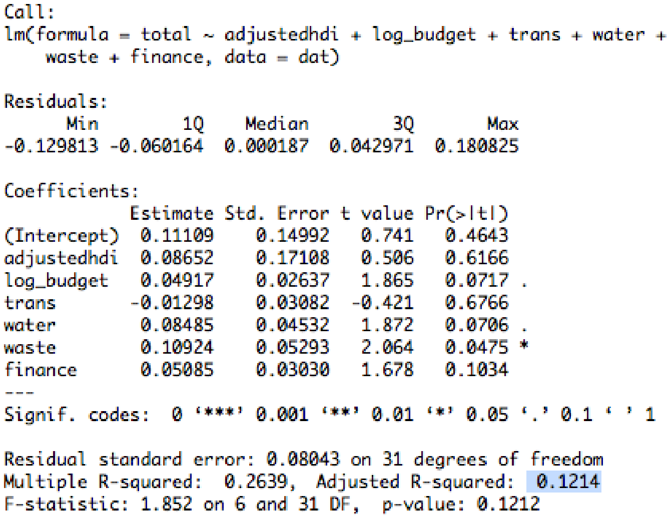
- R-squared: 0.1271
- p-value:0.1128 (reject the null hypothesis, > 0,05)



```
Call:
lm(formula = total ~ adjustedhdi + budget + trans + water + waste +
    finance, data = dat)

Residuals:
      Min        1Q    Median        3Q       Max
-0.140097 -0.060634  0.008726  0.043497  0.187164

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 1.981e-01  1.366e-01   1.451   0.1569
adjustedhdi 9.538e-02  1.707e-01   0.559   0.5804
budget      1.867e-05  9.708e-06   1.923   0.0637 .
trans       1.642e-03  3.041e-02   0.054   0.9573
water       9.703e-02  4.540e-02   2.137   0.0406 *
waste       9.568e-02  5.121e-02   1.868   0.0712 .
finance     6.362e-02  2.998e-02   2.122   0.0419 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.08017 on 31 degrees of freedom
Multiple R-squared:  0.2686,  Adjusted R-squared:  0.1271
F-statistic: 1.898 on 6 and 31 DF,  p-value: 0.1128
```

>mod6 = lm(total ~ adjustedhdi + log_budget + trans + water + waste + finance , data= dat)
> summary(mod6)

- R-squared: 0.1214
- p-value: 0.1212 (reject the null hypothesis, > 0,05)



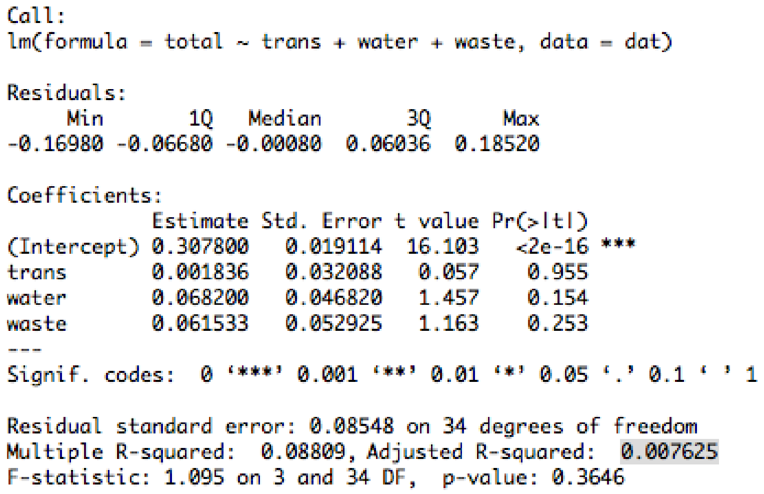
```
Call:
lm(formula = total ~ adjustedhdi + log_budget + trans + water +
    waste + finance, data = dat)

Residuals:
      Min        1Q    Median        3Q       Max
-0.129813 -0.060164  0.000187  0.042971  0.180825

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.11109    0.14992   0.741   0.4643
adjustedhdi  0.08652    0.17108   0.506   0.6166
log_budget   0.04917    0.02637   1.865   0.0717 .
trans       -0.01298    0.03082  -0.421   0.6766
water        0.08485    0.04532   1.872   0.0706 .
waste        0.10924    0.05293   2.064   0.0475 *
finance      0.05085    0.03030   1.678   0.1034
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.08043 on 31 degrees of freedom
Multiple R-squared:  0.2639,  Adjusted R-squared:  0.1214
F-statistic: 1.852 on 6 and 31 DF,  p-value: 0.1212
```

***Compare energy against the other typologies.

>mod6 = lm(total ~ trans + water + waste, data= dat)

> summary(mod6)

- R-squared: 0.007625
- p-value: 0.3646 (reject the null hypothesis, > 0,05)



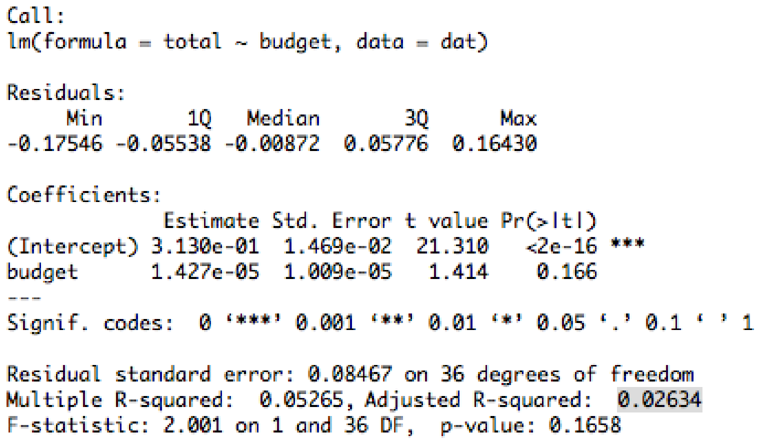
```
Call:
lm(formula = total ~ trans + water + waste, data = dat)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.16980 -0.06680 -0.00080  0.06036  0.18520 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept) 0.307800   0.019114  16.103   <2e-16 ***
trans       0.001836   0.032088   0.057    0.955    
water       0.068200   0.046820   1.457    0.154    
waste       0.061533   0.052925   1.163    0.253    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.08548 on 34 degrees of freedom
Multiple R-squared:  0.08809, Adjusted R-squared:  0.007625 
F-statistic: 1.095 on 3 and 34 DF,  p-value: 0.3646
```

***Simple regression ~ budget

>mod6 = lm(total~ budget, data= dat)

> summary(mod6)

- R-squared: 0.02634
- p-value:0.1658 (fail to reject the null hypothesis, > 0,05)

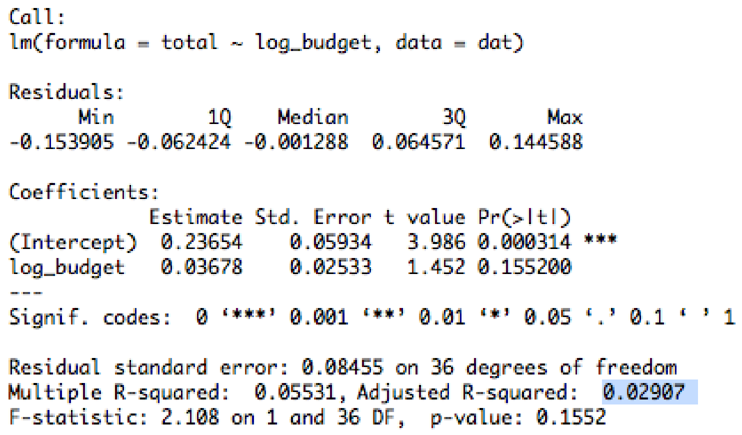


```
Call:
lm(formula = total ~ budget, data = dat)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.17546 -0.05538 -0.00872  0.05776  0.16430 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 3.130e-01  1.469e-02  21.310   <2e-16 ***
budget      1.427e-05  1.009e-05   1.414    0.166    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.08467 on 36 degrees of freedom
Multiple R-squared:  0.05265, Adjusted R-squared:  0.02634 
F-statistic: 2.001 on 1 and 36 DF,  p-value: 0.1658
```

>mod6 = lm(total ~ log_budget, data= dat)

> summary(mod4)

- R-squared: 0.02907
- p-value: 0.1552 (fail to reject the null hypothesis, > 0,05)



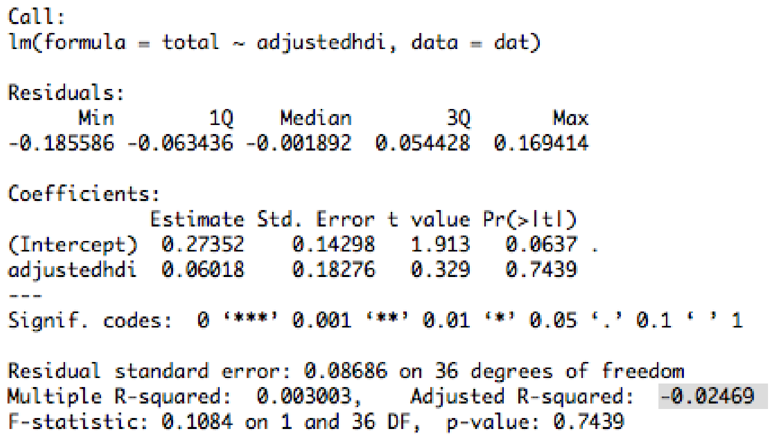
```
Call:
lm(formula = total ~ log_budget, data = dat)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.153905 -0.062424 -0.001288  0.064571  0.144588 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  0.23654    0.05934   3.986 0.000314 ***
log_budget   0.03678    0.02533   1.452 0.155200    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.08455 on 36 degrees of freedom
Multiple R-squared:  0.05531, Adjusted R-squared:  0.02907 
F-statistic: 2.108 on 1 and 36 DF,  p-value: 0.1552
```

***Simple regression ~ adjustedhdi

>mod6 = lm(total ~ adjustedhdi , data= dat)

> summary(mod6)

- R-squared: -0.02469
- p-value:0.7439 (fail to reject the null hypothesis, > 0,05)

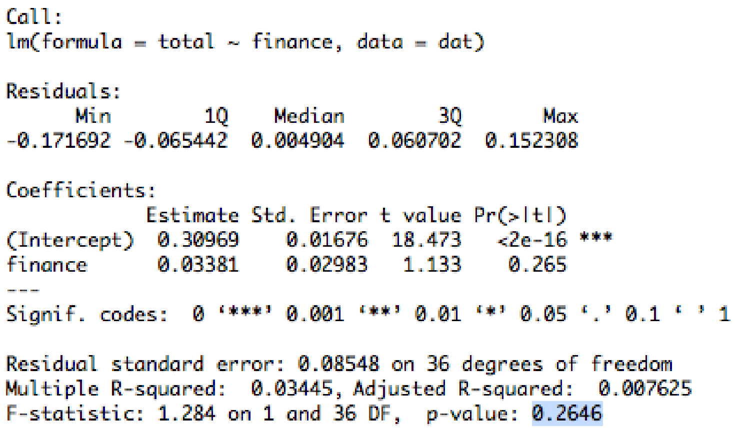


```
Call:
lm(formula = total ~ adjustedhdi, data = dat)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.185586 -0.063436 -0.001892  0.054428  0.169414 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)  
(Intercept)  0.27352    0.14298   1.913   0.0637 .
adjustedhdi  0.06018    0.18276   0.329   0.7439  
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.08686 on 36 degrees of freedom
Multiple R-squared:  0.003003,	Adjusted R-squared:  -0.02469 
F-statistic: 0.1084 on 1 and 36 DF,  p-value: 0.7439
```

>mod6 = lm(total~ finance , data= dat)

> summary(mod6)

- R-squared: 0.007625
- p-value: 0.2646 (fail to reject the null hypothesis, > 0,05)

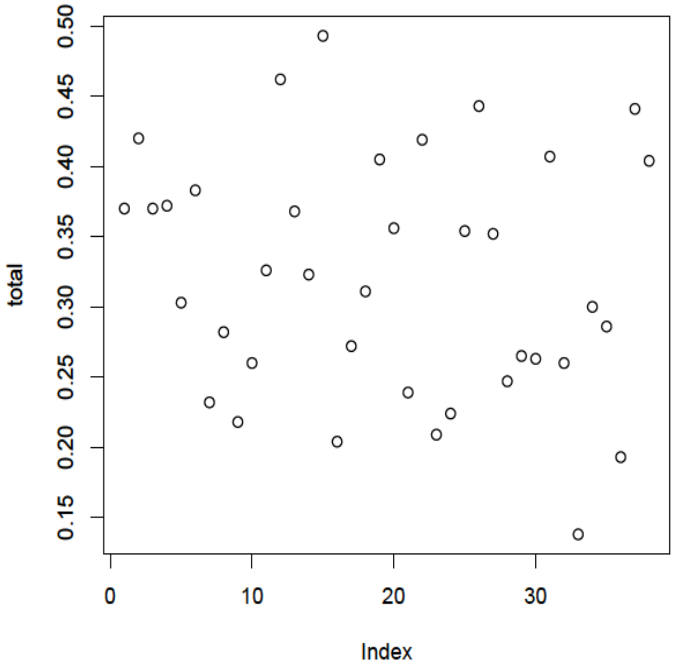


```
Call:
lm(formula = total ~ finance, data = dat)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.171692 -0.065442  0.004904  0.060702  0.152308 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  0.30969    0.01676  18.473   <2e-16 ***
finance      0.03381    0.02983   1.133    0.265    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.08548 on 36 degrees of freedom
Multiple R-squared:  0.03445,	Adjusted R-squared:  0.007625 
F-statistic: 1.284 on 1 and 36 DF,  p-value: 0.2646
```

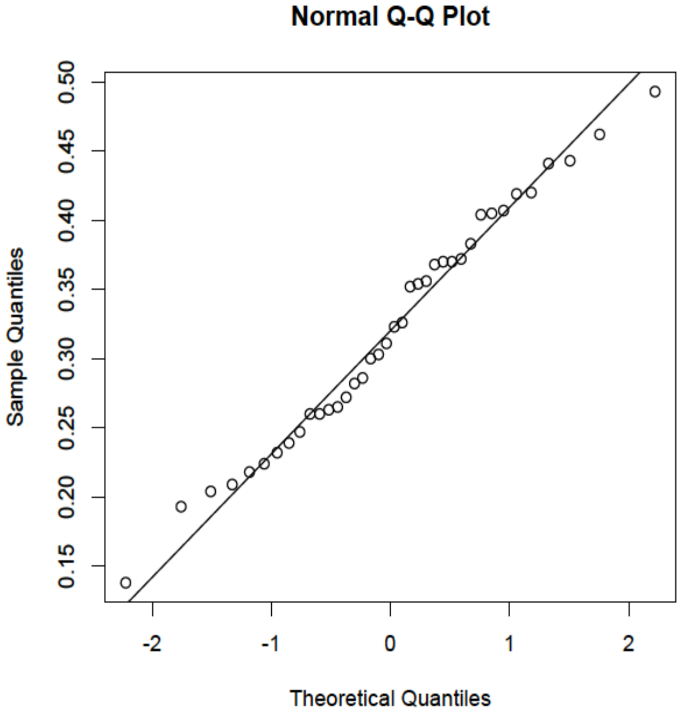
Summary of the results Model 6_total	Adj r^2	p-value (<0.05)
mod6 = lm(total~ adjustedhdi + budget + trans+ water + waste + finance , data= dat)	0.1271	0.1128
mod6 = lm(total ~ adjustedhdi + log_budget + trans + water + waste + finance , data= dat)	0.1214	0.1212
mod6 = lm(total ~ trans + water + waste, data= dat)	0.007625	0.3646
mod6 = lm(total~ budget, data= dat)	0.02634	0.1658
mod6 = lm(total ~ log_budget, data= dat)	0.02907	0.1552
mod6 = lm(total ~ adjustedhdi , data= dat)	-0.02469	0.7439
mod6 = lm(total~ finance , data= dat)	0.007625	0.2646

*** Model 6: Graphs

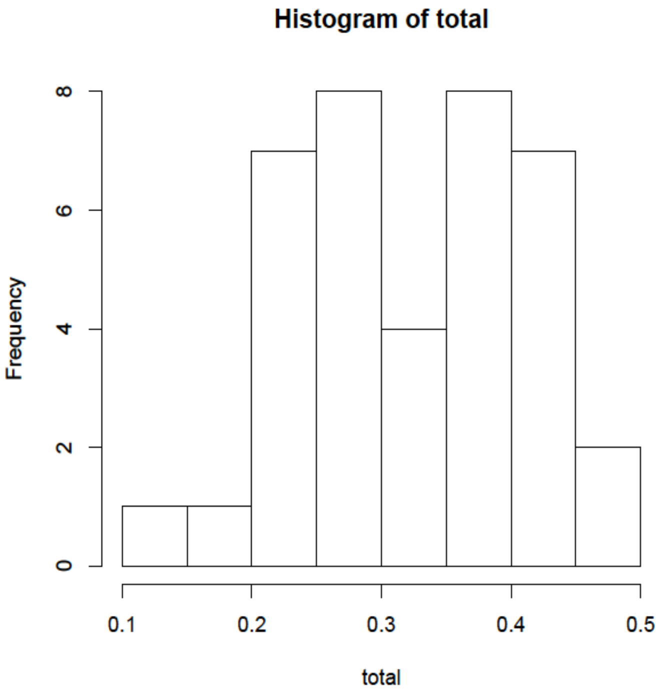
```
>plot(total)
```



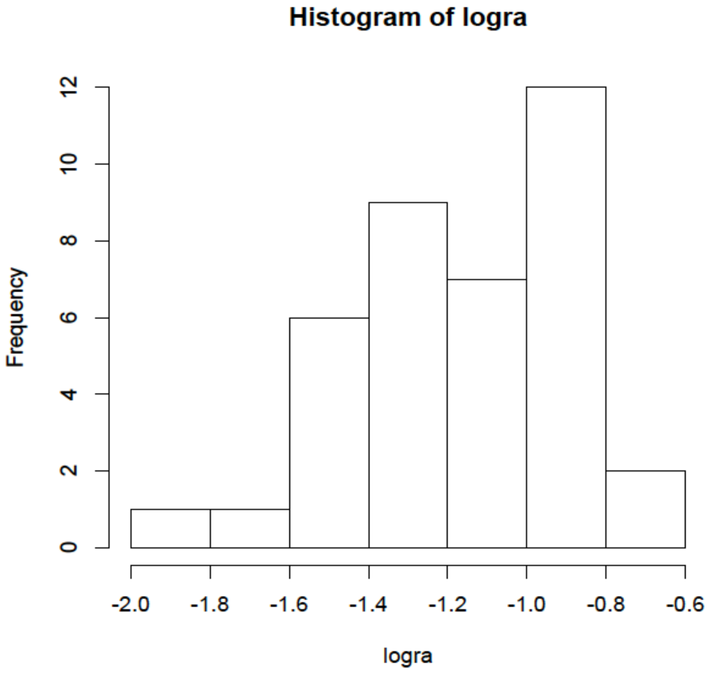
```
>qqline(total)
```



```
>hist(total)
```



```
>hist(total)
```



Annex 2

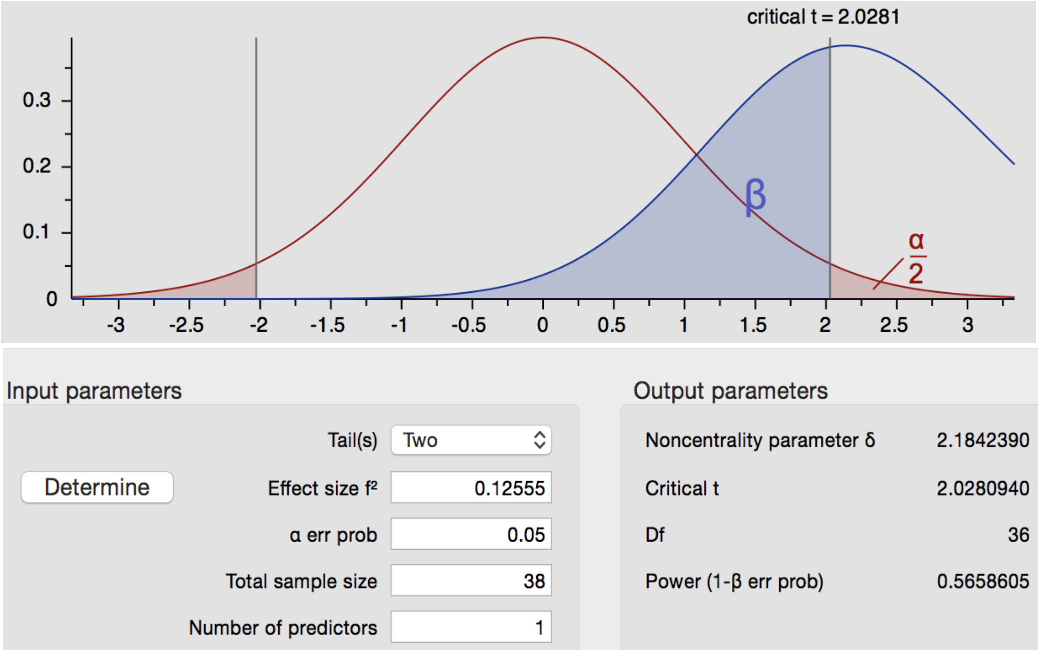
Estimation of the sample size. G*Power for Statistical Power Analyses.

All the models will be build following the criteria below:

- Test family: t-test.
- Statistical test: Linear multiple regression: Fixed model, single regression coefficient.
- Type of power analysis: Post hoc_ Compute achieved power- given α, sample size , and effect size.
-

Model 1: Analyzing Quality of Life

>log_Budget



Input parameters

Tail(s) Two

Effect size f² 0.12555

α err prob 0.05

Total sample size 38

Number of predictors 1

Output parameters

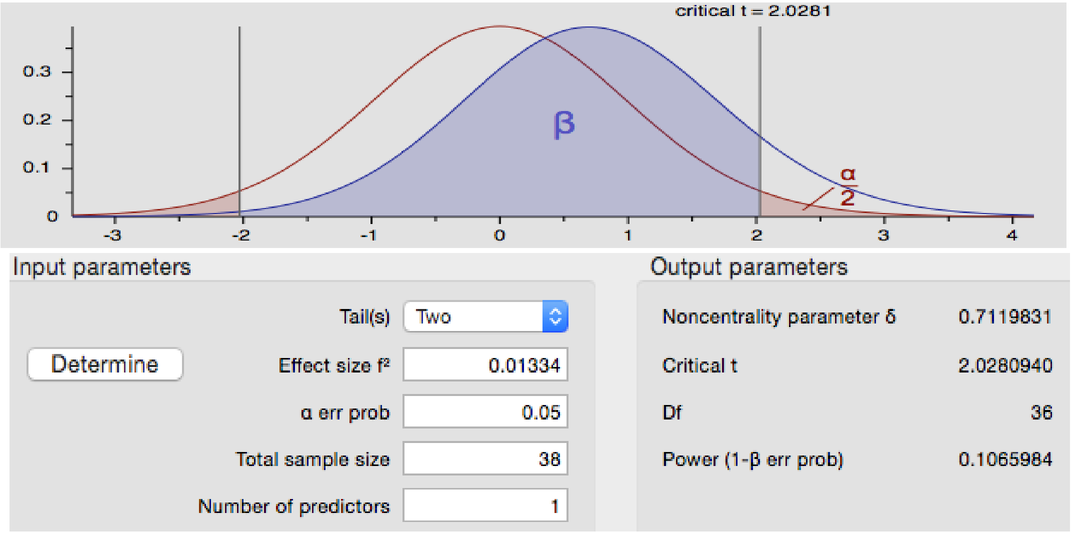
Noncentrality parameter δ 2.1842390

Critical t 2.0280940

Df 36

Power (1-β err prob) 0.5658605

>Adjustedhdi



Input parameters

Tail(s) Two

Effect size f² 0.01334

α err prob 0.05

Total sample size 38

Number of predictors 1

Output parameters

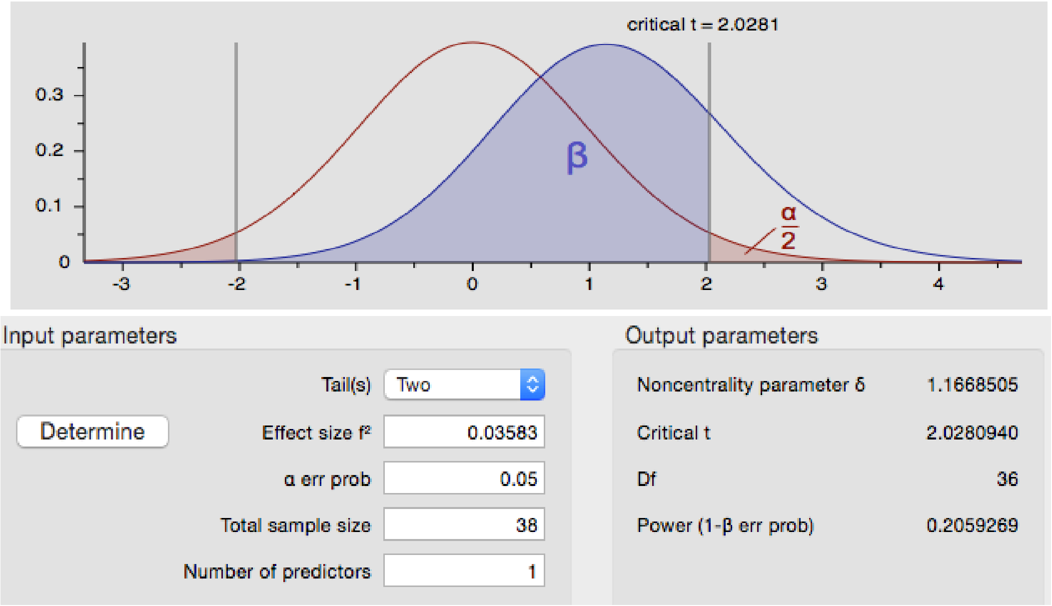
Noncentrality parameter δ 0.7119831

Critical t 2.0280940

Df 36

Power (1-β err prob) 0.1065984

>Finance



Input parameters

Tail(s) Two

Effect size f² 0.03583

α err prob 0.05

Total sample size 38

Number of predictors 1

Output parameters

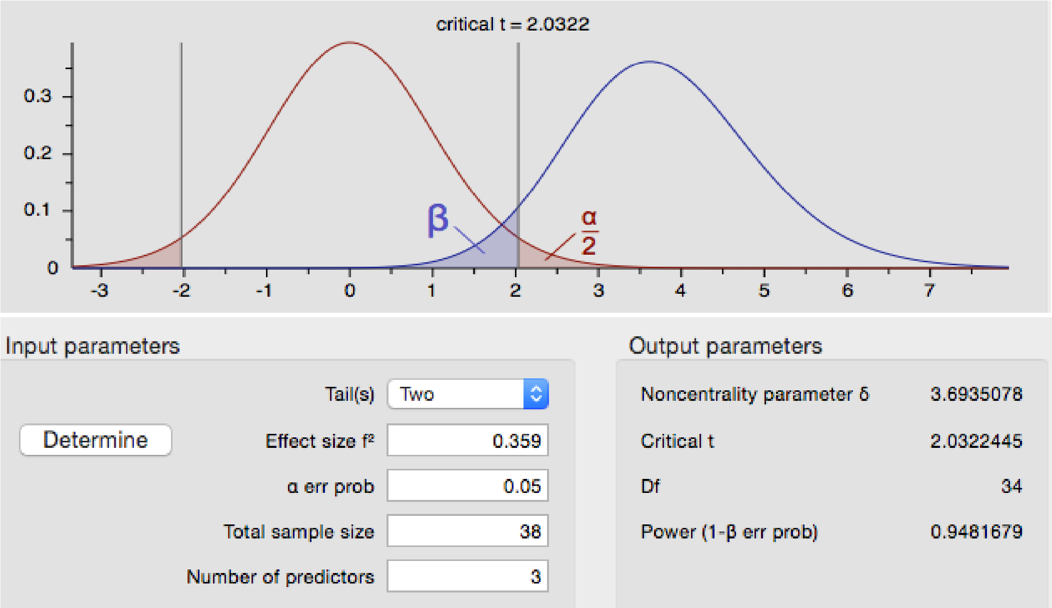
Noncentrality parameter δ 1.1668505

Critical t 2.0280940

Df 36

Power (1-β err prob) 0.2059269

>Energy



Input parameters

Tail(s) Two

Effect size f² 0.359

α err prob 0.05

Total sample size 38

Number of predictors 3

Output parameters

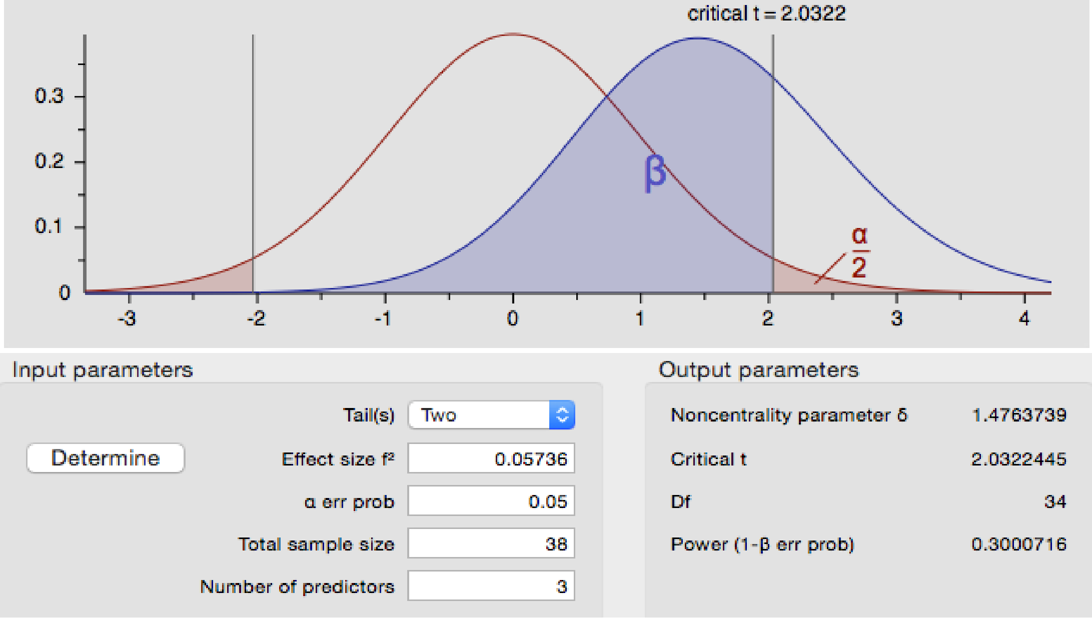
Noncentrality parameter δ 3.6935078

Critical t 2.0322445

Df 34

Power (1-β err prob) 0.9481679

>Transportation



Input parameters

Tail(s) Two

Effect size f² 0.05736

α err prob 0.05

Total sample size 38

Number of predictors 3

Output parameters

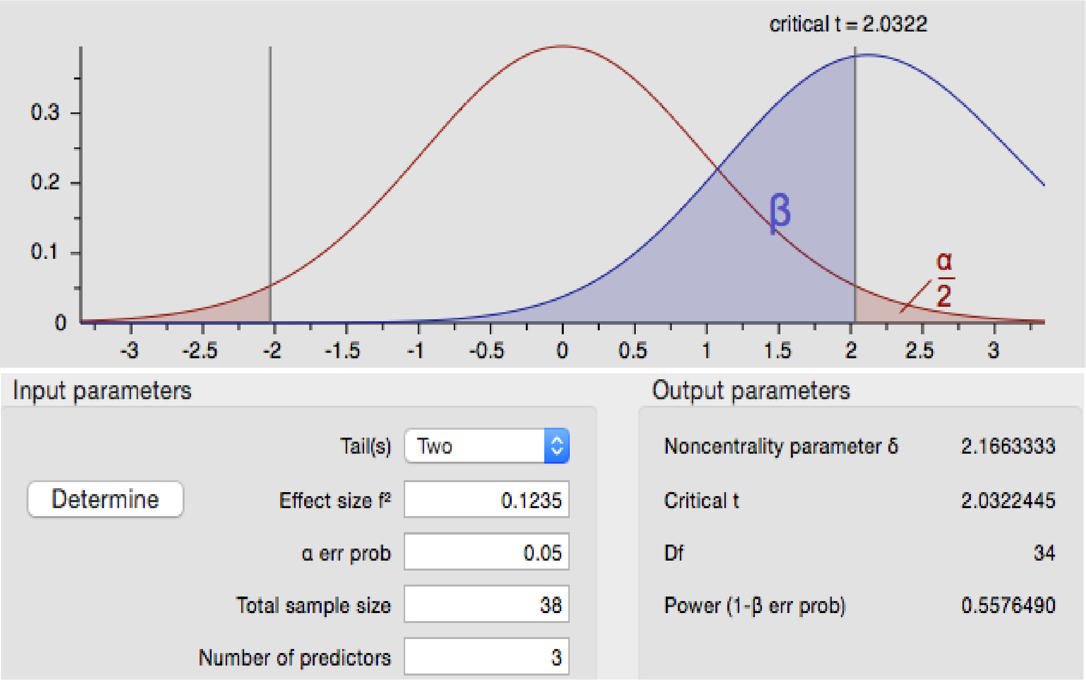
Noncentrality parameter δ 1.4763739

Critical t 2.0322445

Df 34

Power (1-β err prob) 0.3000716

>Water



Input parameters

Tail(s) Two

Effect size f² 0.1235

α err prob 0.05

Total sample size 38

Number of predictors 3

Output parameters

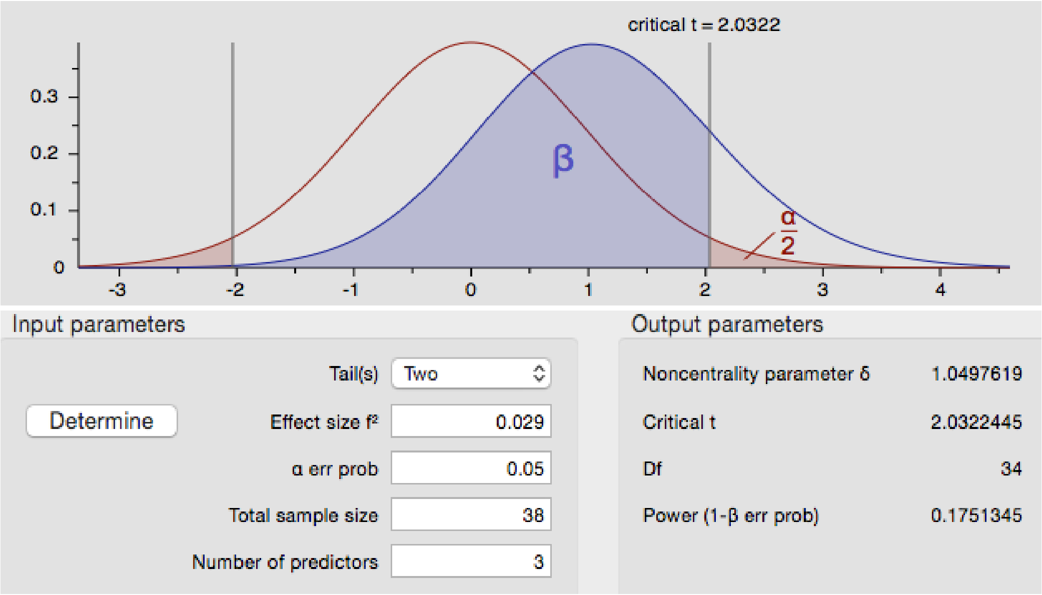
Noncentrality parameter δ 2.1663333

Critical t 2.0322445

Df 34

Power (1-β err prob) 0.5576490

>Waste



Input parameters

Tail(s) Two

Effect size f² 0.029

α err prob 0.05

Total sample size 38

Number of predictors 3

Output parameters

Noncentrality parameter δ 1.0497619

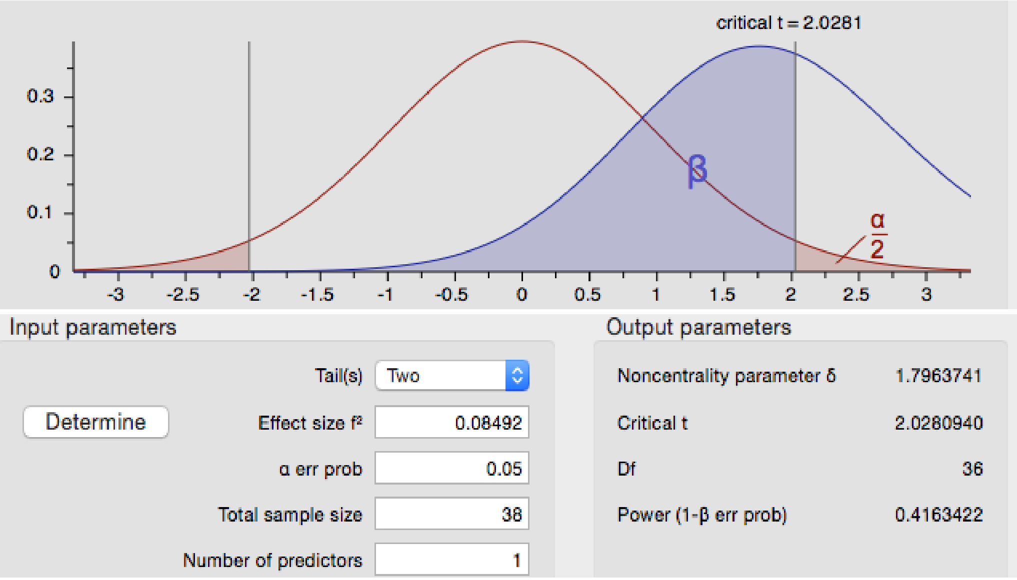
Critical t 2.0322445

Df 34

Power (1-β err prob) 0.1751345

Model 2: Analyzing Leadership

>log_Budget



Input parameters

Tail(s) Two

Effect size f² 0.08492

α err prob 0.05

Total sample size 38

Number of predictors 1

Output parameters

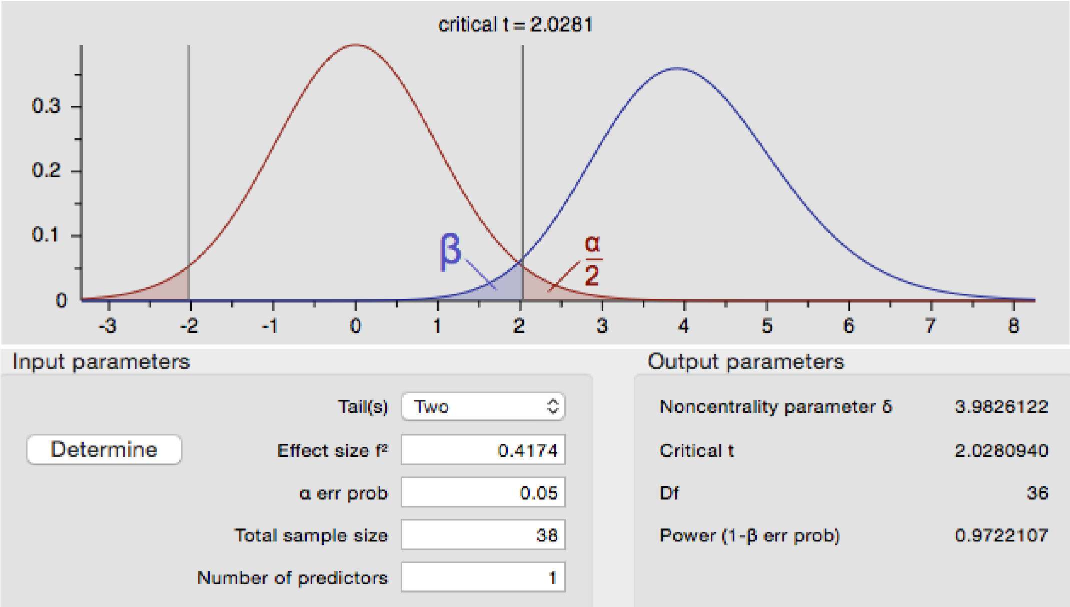
Noncentrality parameter δ 1.7963741

Critical t 2.0280940

Df 36

Power (1-β err prob) 0.4163422

>Adjustedhdi



Input parameters

Tail(s) Two

Effect size f² 0.4174

α err prob 0.05

Total sample size 38

Number of predictors 1

Output parameters

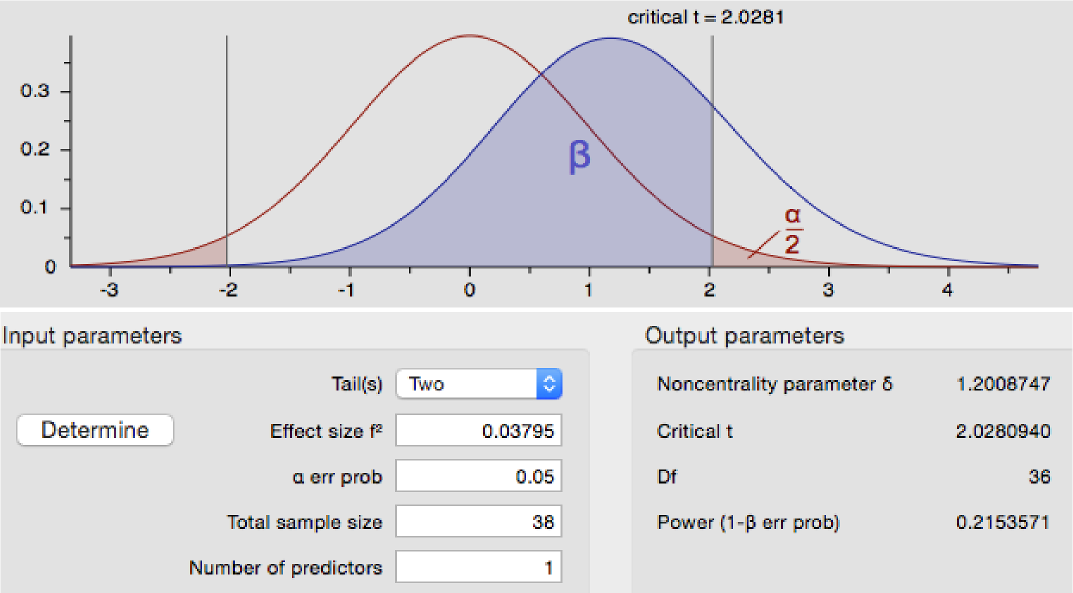
Noncentrality parameter δ 3.9826122

Critical t 2.0280940

Df 36

Power (1-β err prob) 0.9722107

>Finance



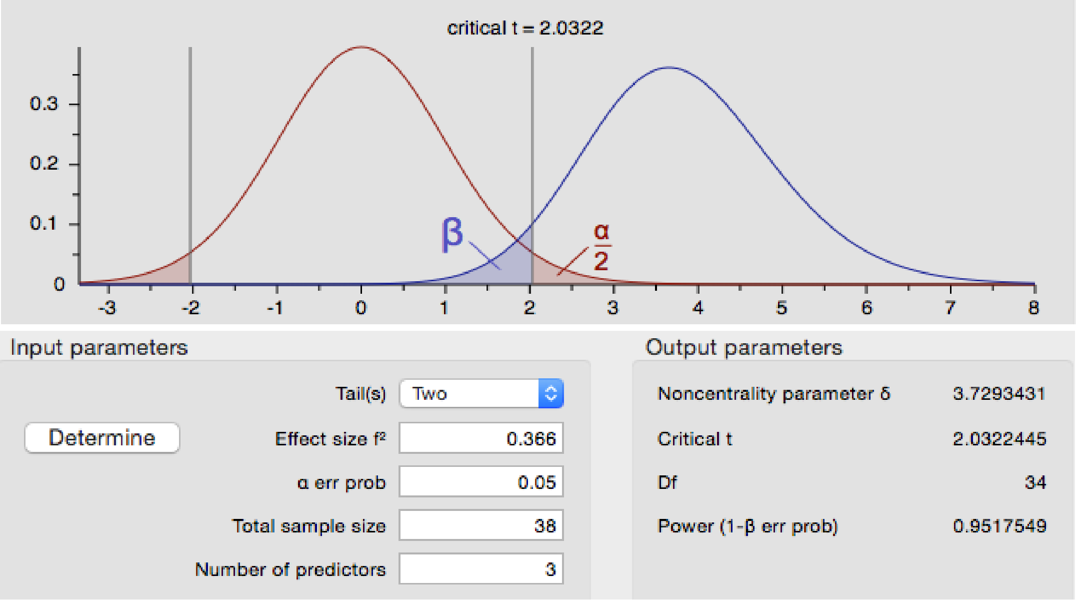
Input parameters

Tail(s) Two
Effect size f² 0.03795
α err prob 0.05
Total sample size 38
Number of predictors 1

Output parameters

Noncentrality parameter δ 1.2008747
Critical t 2.0280940
Df 36
Power (1-β err prob) 0.2153571

>Energy



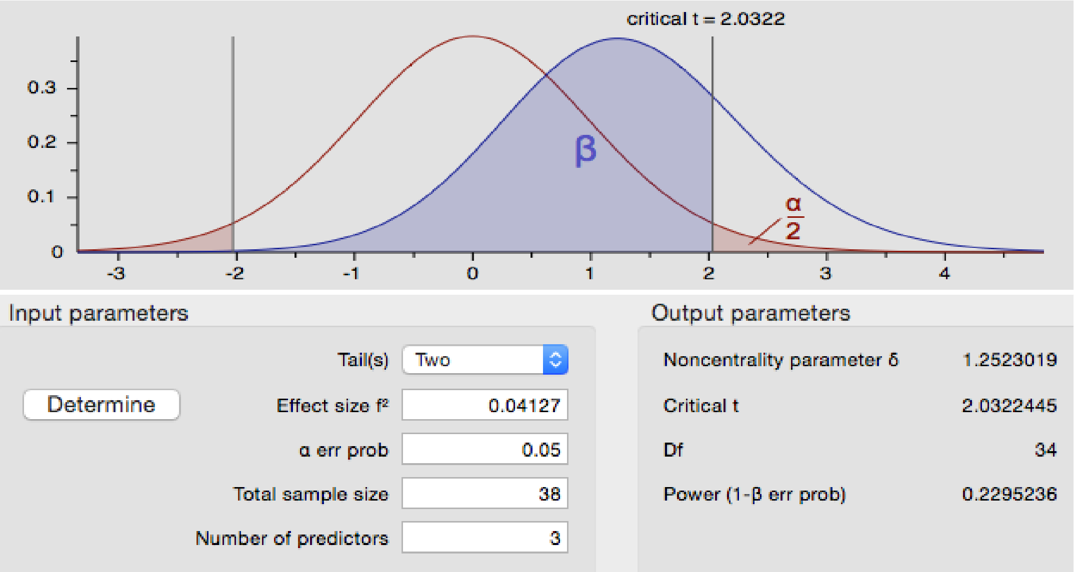
Input parameters

Tail(s) Two
Effect size f² 0.366
α err prob 0.05
Total sample size 38
Number of predictors 3

Output parameters

Noncentrality parameter δ 3.7293431
Critical t 2.0322445
Df 34
Power (1-β err prob) 0.9517549

>Transportation



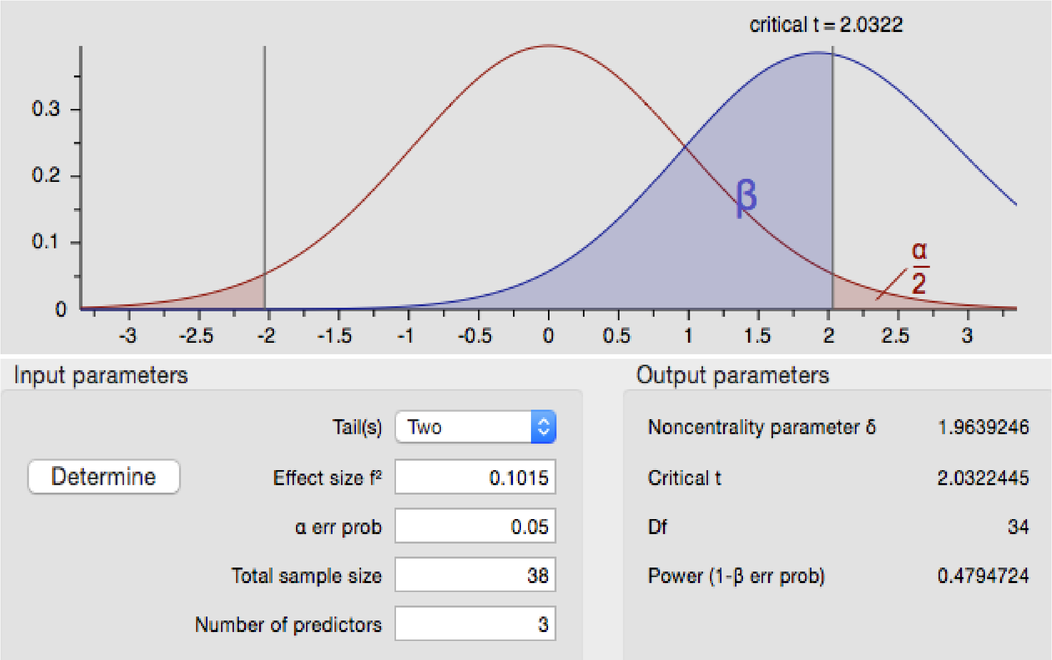
Input parameters

Tail(s)	Two
Effect size f²	0.04127
α err prob	0.05
Total sample size	38
Number of predictors	3

Output parameters

Noncentrality parameter δ	1.2523019
Critical t	2.0322445
Df	34
Power (1-β err prob)	0.2295236

>Water



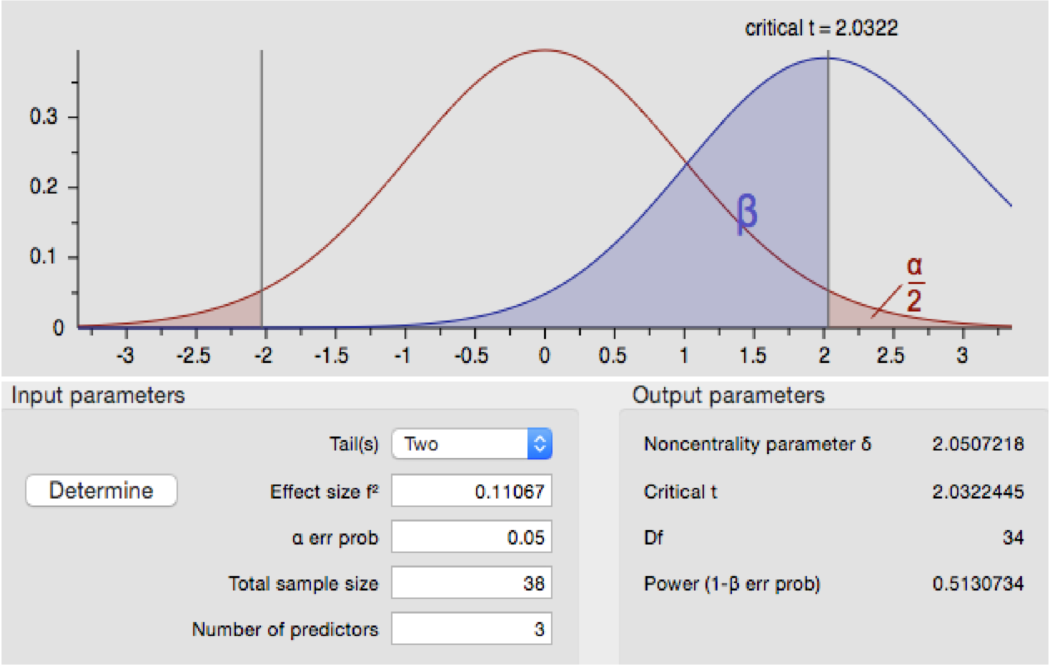
Input parameters

Tail(s)	Two
Effect size f²	0.1015
α err prob	0.05
Total sample size	38
Number of predictors	3

Output parameters

Noncentrality parameter δ	1.9639246
Critical t	2.0322445
Df	34
Power (1-β err prob)	0.4794724

>Waste



Input parameters

Tail(s) Two

Effect size f² 0.11067

α err prob 0.05

Total sample size 38

Number of predictors 3

Output parameters

Noncentrality parameter δ 2.0507218

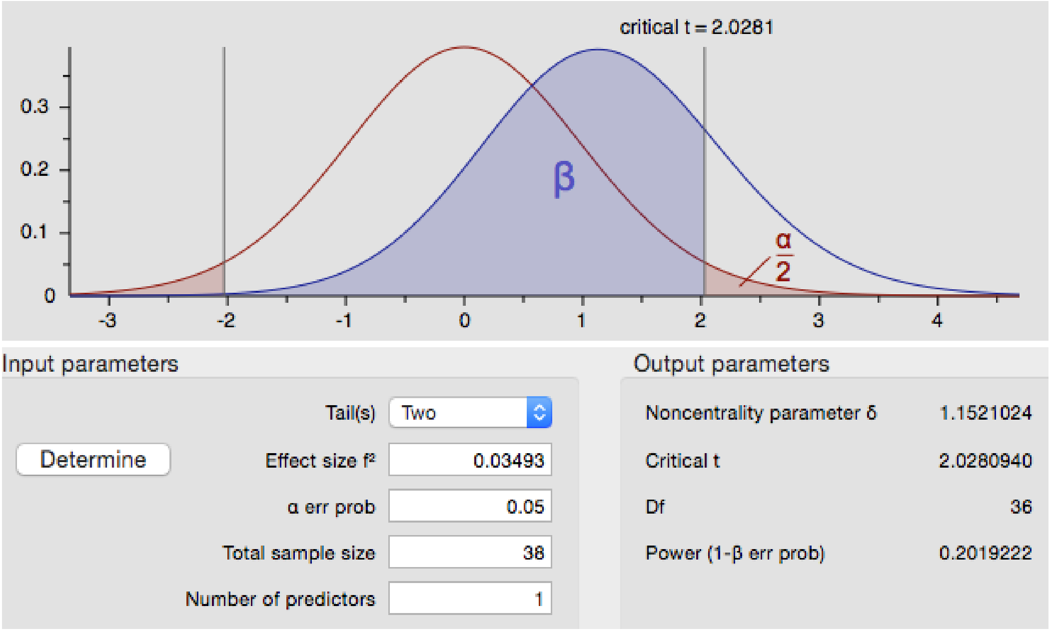
Critical t 2.0322445

Df 34

Power (1-β err prob) 0.5130734

Model 3: Analyzing Resource Allocation

>log_budget



Input parameters

Tail(s) Two

Effect size f² 0.03493

α err prob 0.05

Total sample size 38

Number of predictors 1

Output parameters

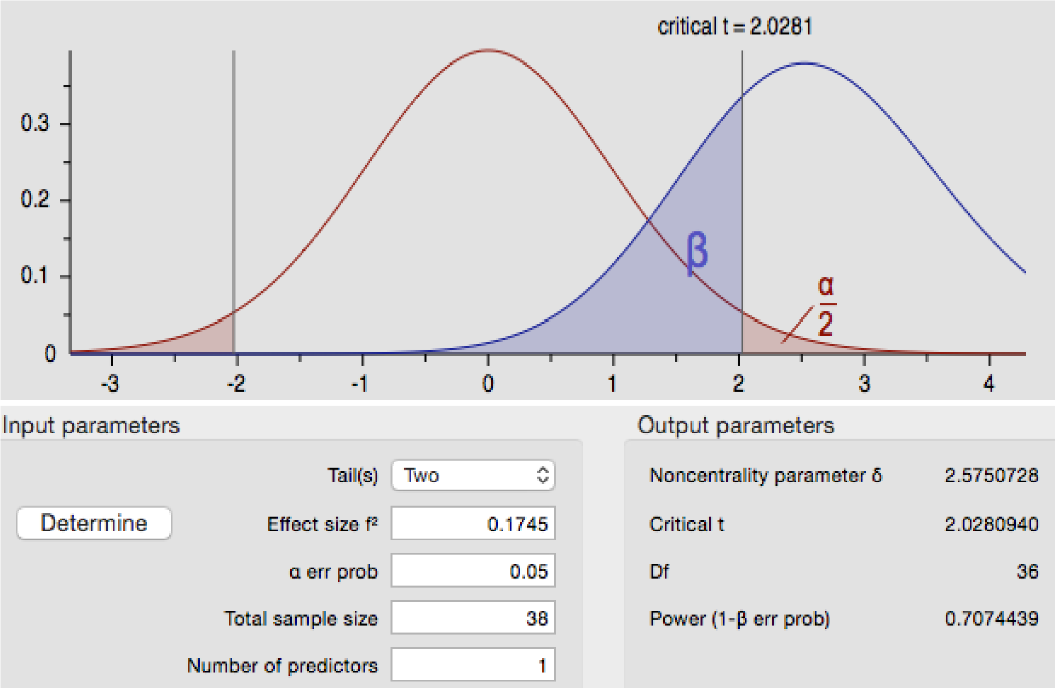
Noncentrality parameter δ 1.1521024

Critical t 2.0280940

Df 36

Power (1-β err prob) 0.2019222

>Adjustedhdi



Input parameters

Tail(s) Two

Effect size f² 0.1745

α err prob 0.05

Total sample size 38

Number of predictors 1

Output parameters

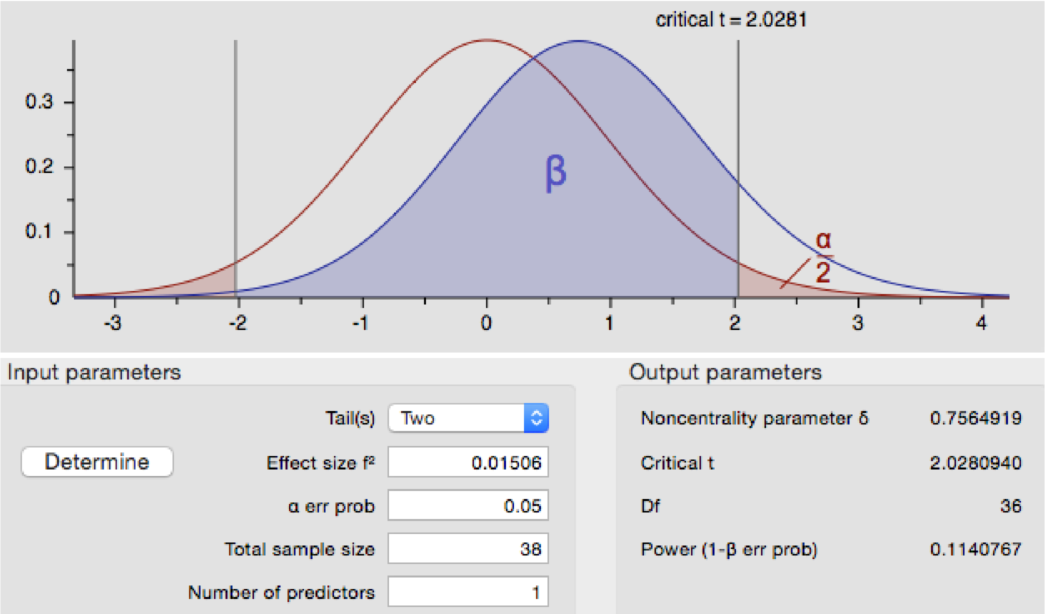
Noncentrality parameter δ 2.5750728

Critical t 2.0280940

Df 36

Power (1-β err prob) 0.7074439

>Finance



Input parameters

Tail(s) Two

Effect size f² 0.01506

α err prob 0.05

Total sample size 38

Number of predictors 1

Output parameters

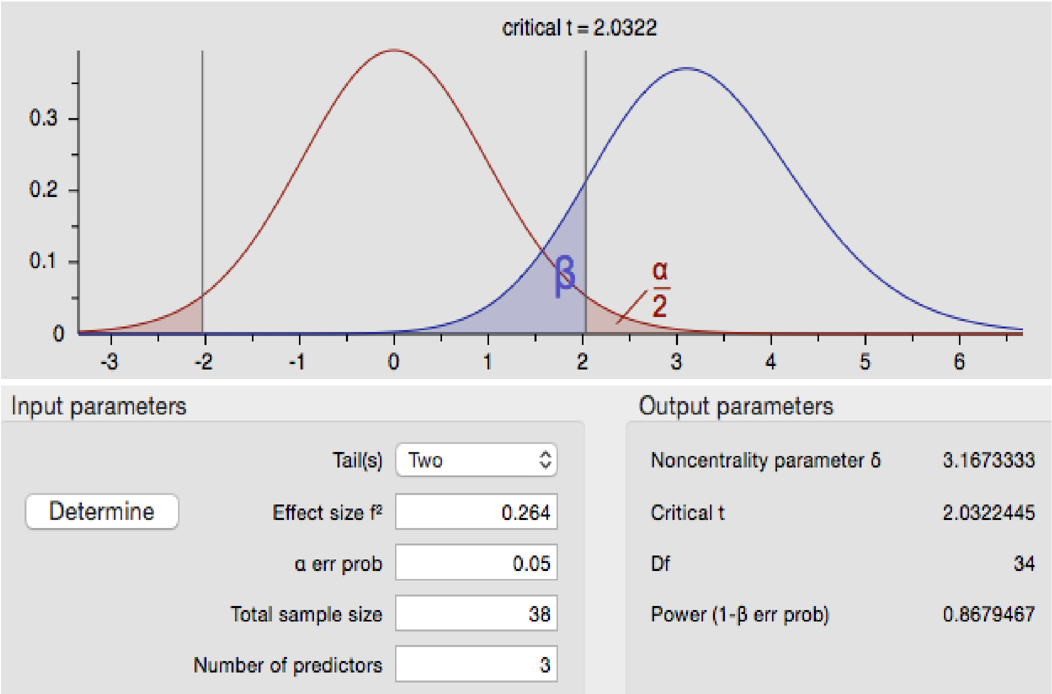
Noncentrality parameter δ 0.7564919

Critical t 2.0280940

Df 36

Power (1-β err prob) 0.1140767

>Energy



Input parameters

Tail(s) Two

Effect size f² 0.264

α err prob 0.05

Total sample size 38

Number of predictors 3

Output parameters

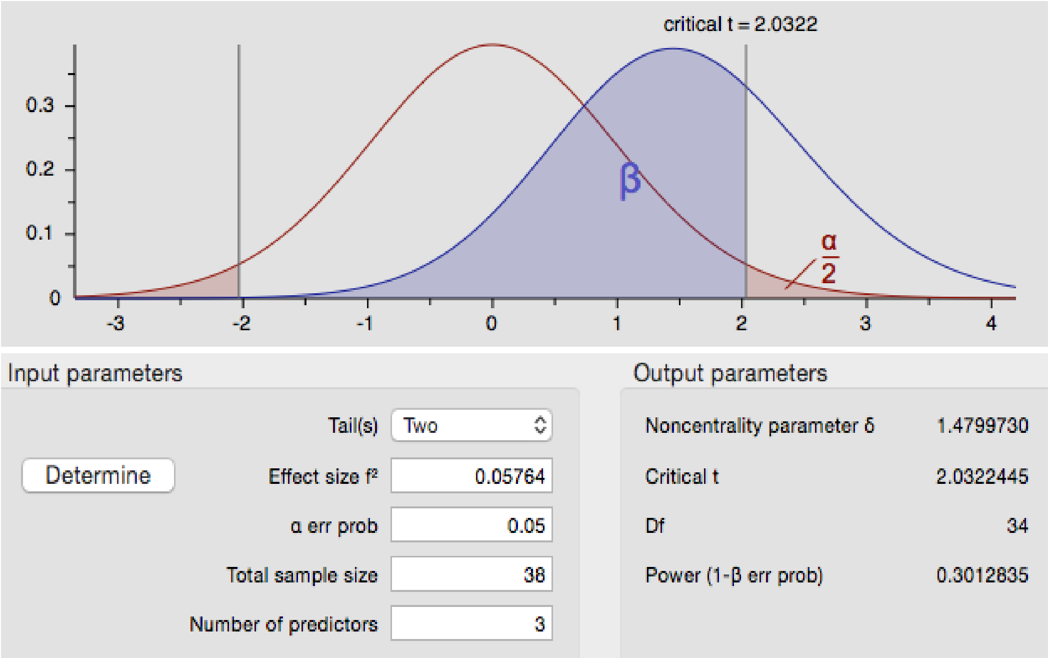
Noncentrality parameter δ 3.1673333

Critical t 2.0322445

Df 34

Power (1-β err prob) 0.8679467

>Transportation



Input parameters

Tail(s) Two

Effect size f² 0.05764

α err prob 0.05

Total sample size 38

Number of predictors 3

Output parameters

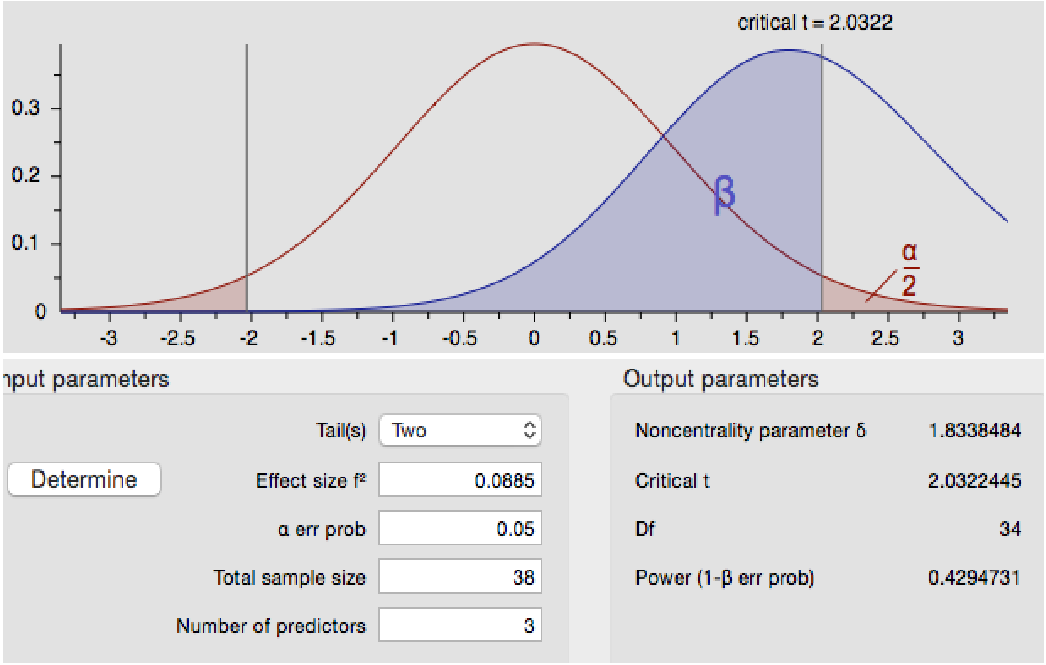
Noncentrality parameter δ 1.4799730

Critical t 2.0322445

Df 34

Power (1-β err prob) 0.3012835

>Water



nput parameters

Tail(s) Two

Determine

Effect size f² 0.0885

α err prob 0.05

Total sample size 38

Number of predictors 3

Output parameters

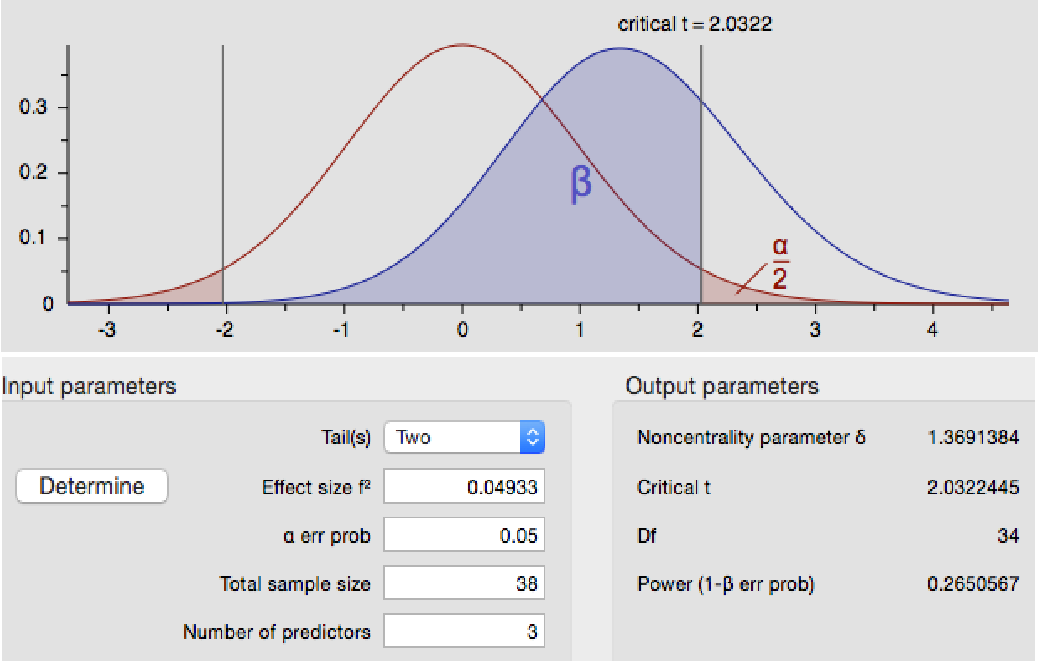
Noncentrality parameter δ 1.8338484

Critical t 2.0322445

Df 34

Power (1-β err prob) 0.4294731

>Waste



Input parameters

Tail(s) Two

Determine

Effect size f² 0.04933

α err prob 0.05

Total sample size 38

Number of predictors 3

Output parameters

Noncentrality parameter δ 1.3691384

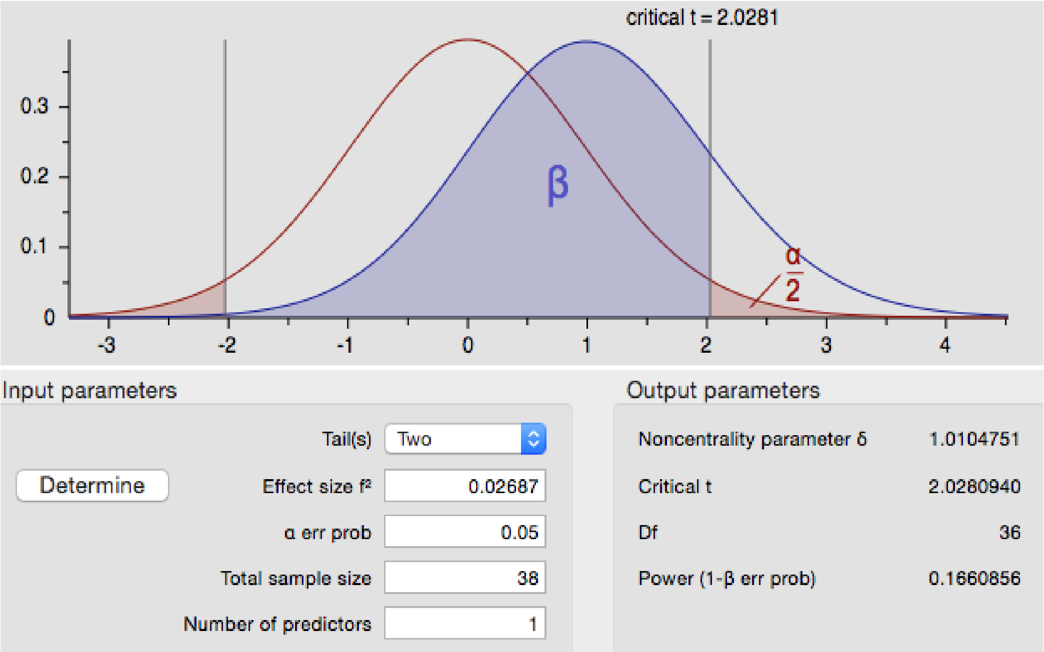
Critical t 2.0322445

Df 34

Power (1-β err prob) 0.2650567

Model 4: Analyzing Natural World

>Log_budget



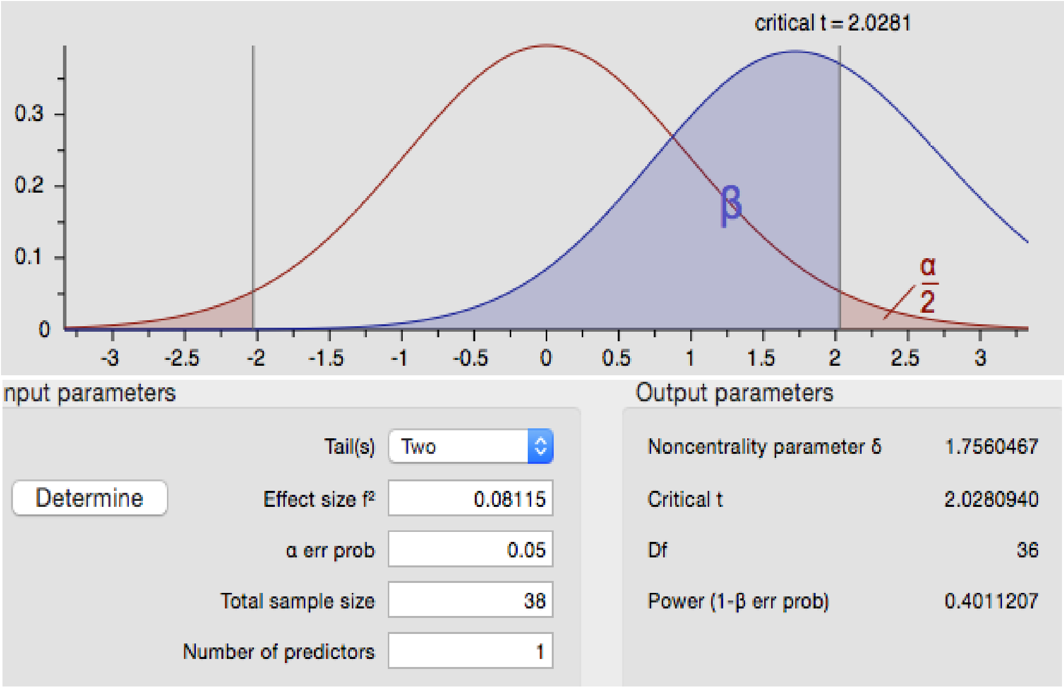
Input parameters

Tail(s) Two
Effect size f² 0.02687
α err prob 0.05
Total sample size 38
Number of predictors 1

Output parameters

Noncentrality parameter δ 1.0104751
Critical t 2.0280940
Df 36
Power (1-β err prob) 0.1660856

>Adjustedhdi



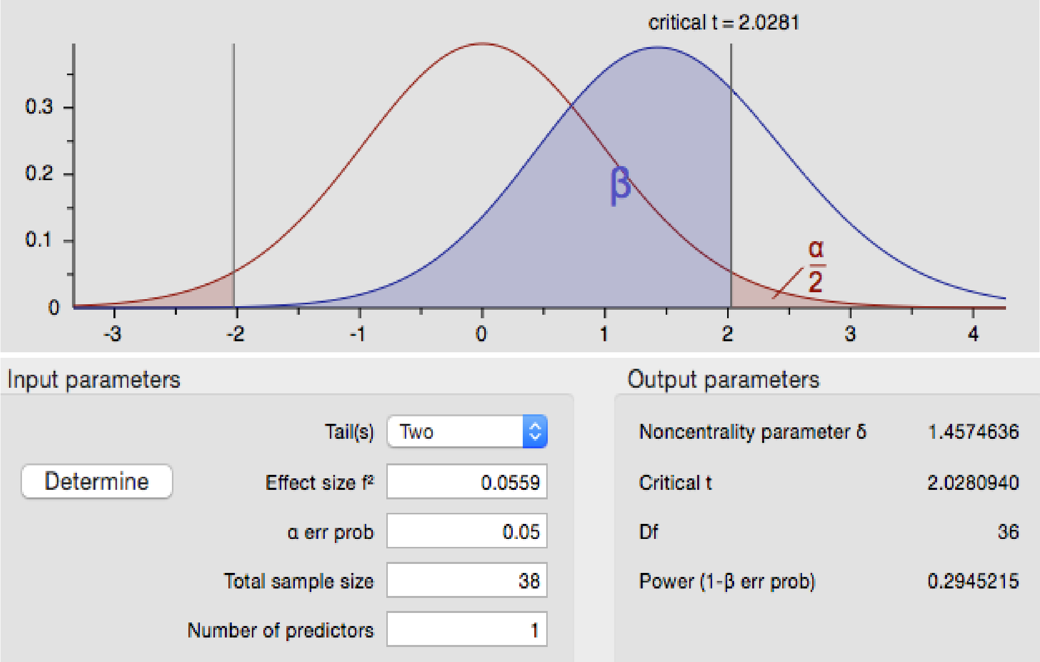
nput parameters

Tail(s) Two
Effect size f² 0.08115
α err prob 0.05
Total sample size 38
Number of predictors 1

Output parameters

Noncentrality parameter δ 1.7560467
Critical t 2.0280940
Df 36
Power (1-β err prob) 0.4011207

>Finance



Input parameters

Tail(s) Two

Determine

Effect size f² 0.0559

α err prob 0.05

Total sample size 38

Number of predictors 1

Output parameters

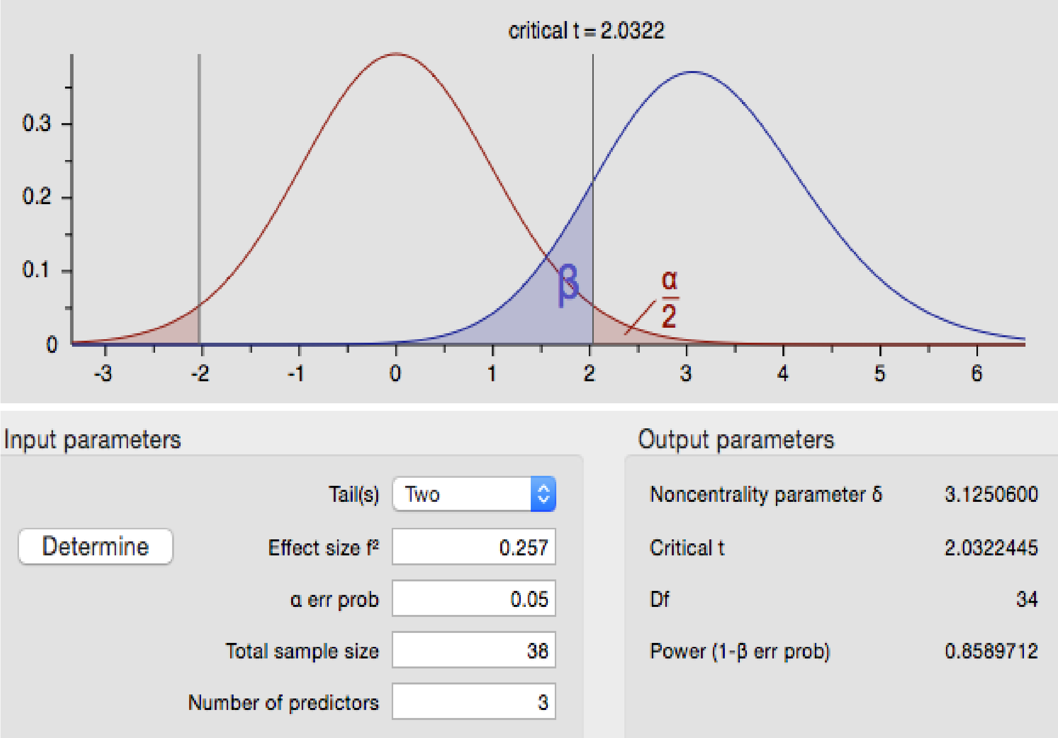
Noncentrality parameter δ 1.4574636

Critical t 2.0280940

Df 36

Power (1-β err prob) 0.2945215

>Energy



Input parameters

Tail(s) Two

Determine

Effect size f² 0.257

α err prob 0.05

Total sample size 38

Number of predictors 3

Output parameters

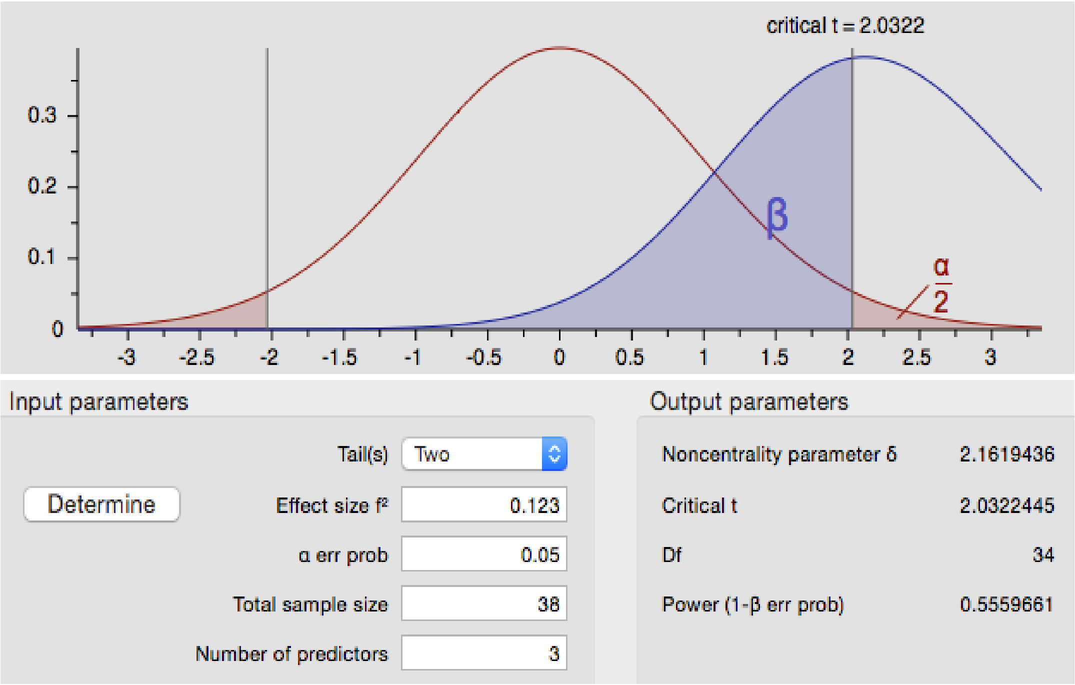
Noncentrality parameter δ 3.1250600

Critical t 2.0322445

Df 34

Power (1-β err prob) 0.8589712

>Transportation



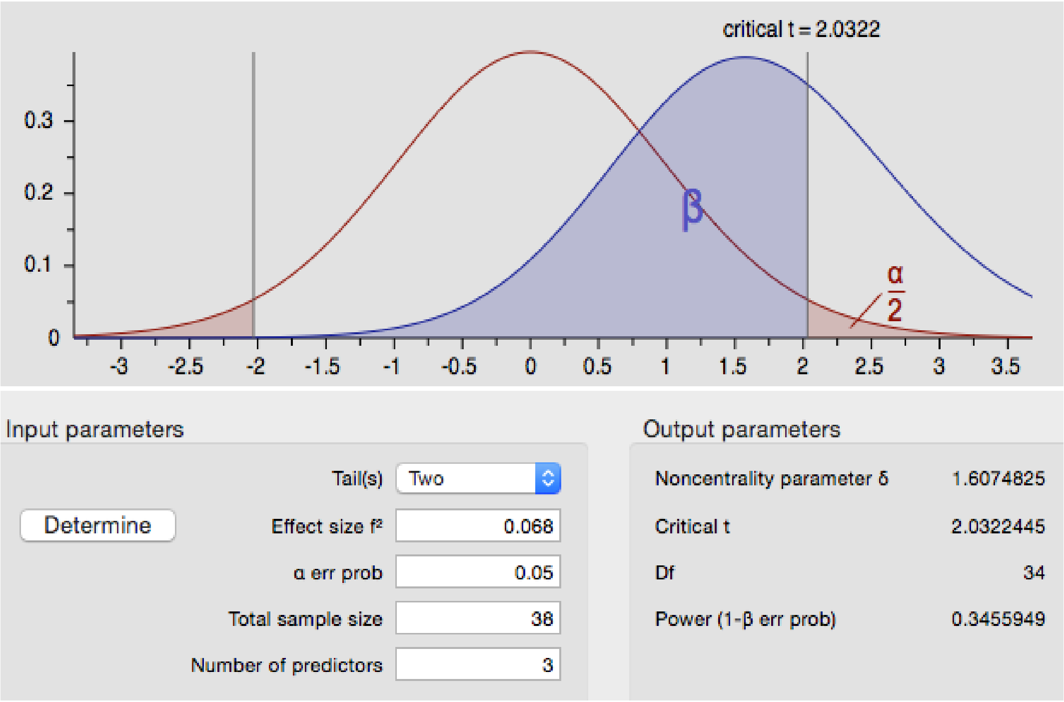
Input parameters

Tail(s)	Two
Effect size f²	0.123
α err prob	0.05
Total sample size	38
Number of predictors	3

Output parameters

Noncentrality parameter δ	2.1619436
Critical t	2.0322445
Df	34
Power (1-β err prob)	0.5559661

>Water



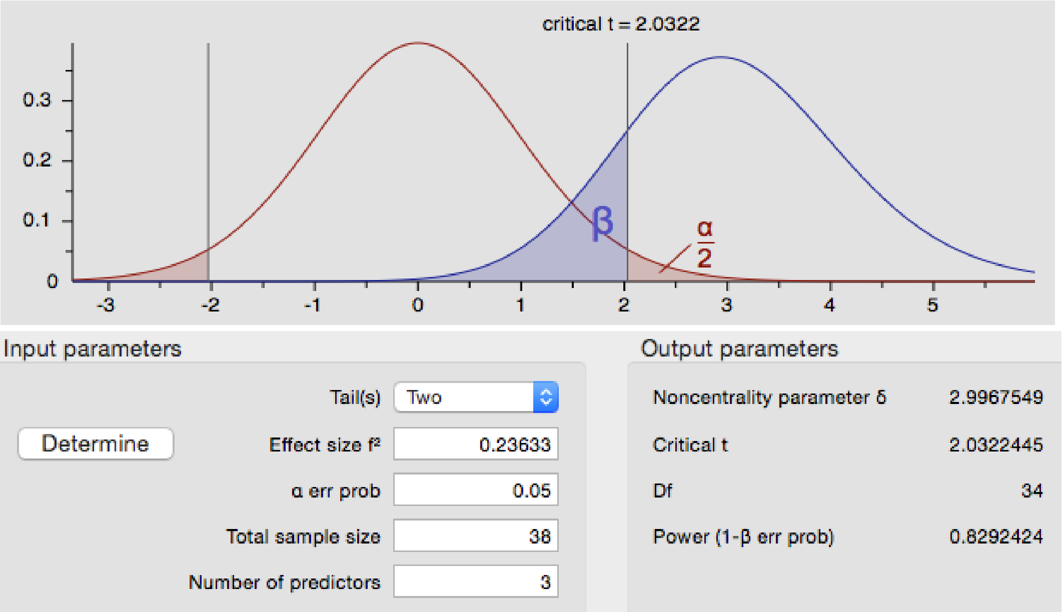
Input parameters

Tail(s)	Two
Effect size f²	0.068
α err prob	0.05
Total sample size	38
Number of predictors	3

Output parameters

Noncentrality parameter δ	1.6074825
Critical t	2.0322445
Df	34
Power (1-β err prob)	0.3455949

>Waste



Input parameters

Tail(s) Two

Effect size f² 0.23633

α err prob 0.05

Total sample size 38

Number of predictors 3

Output parameters

Noncentrality parameter δ 2.9967549

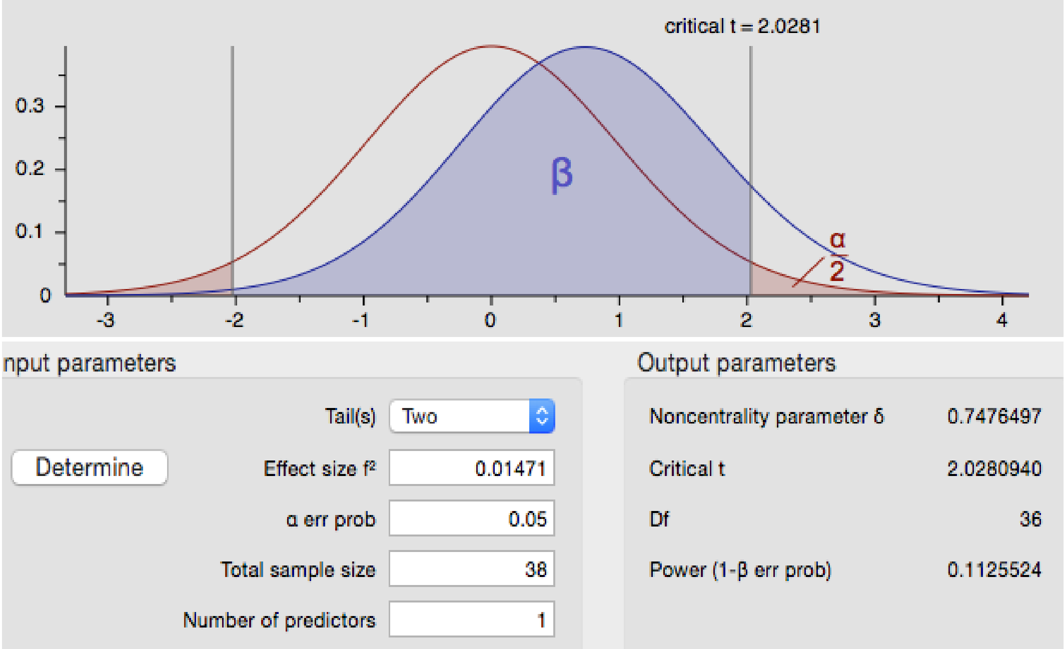
Critical t 2.0322445

Df 34

Power (1-β err prob) 0.8292424

Model 5: Analyzing Climate and Risks

>Log_budget



nput parameters

Tail(s) Two

Effect size f² 0.01471

α err prob 0.05

Total sample size 38

Number of predictors 1

Output parameters

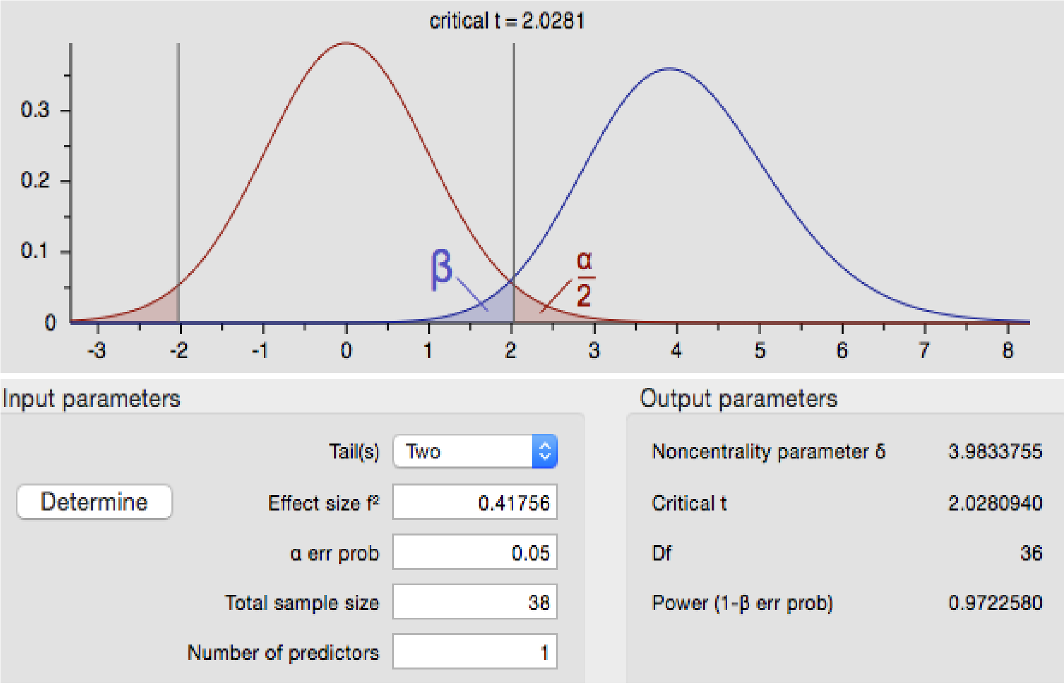
Noncentrality parameter δ 0.7476497

Critical t 2.0280940

Df 36

Power (1-β err prob) 0.1125524

>Adjustedhdi



Input parameters

Tail(s) Two

Effect size f² 0.41756

α err prob 0.05

Total sample size 38

Number of predictors 1

Output parameters

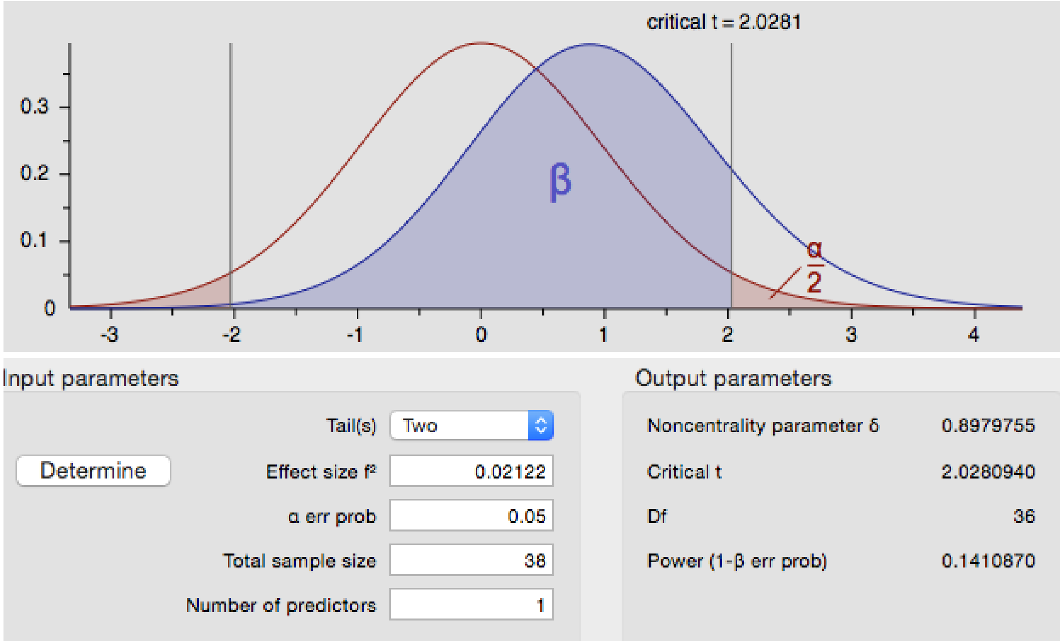
Noncentrality parameter δ 3.9833755

Critical t 2.0280940

Df 36

Power (1-β err prob) 0.9722580

>Finance



Input parameters

Tail(s) Two

Effect size f² 0.02122

α err prob 0.05

Total sample size 38

Number of predictors 1

Output parameters

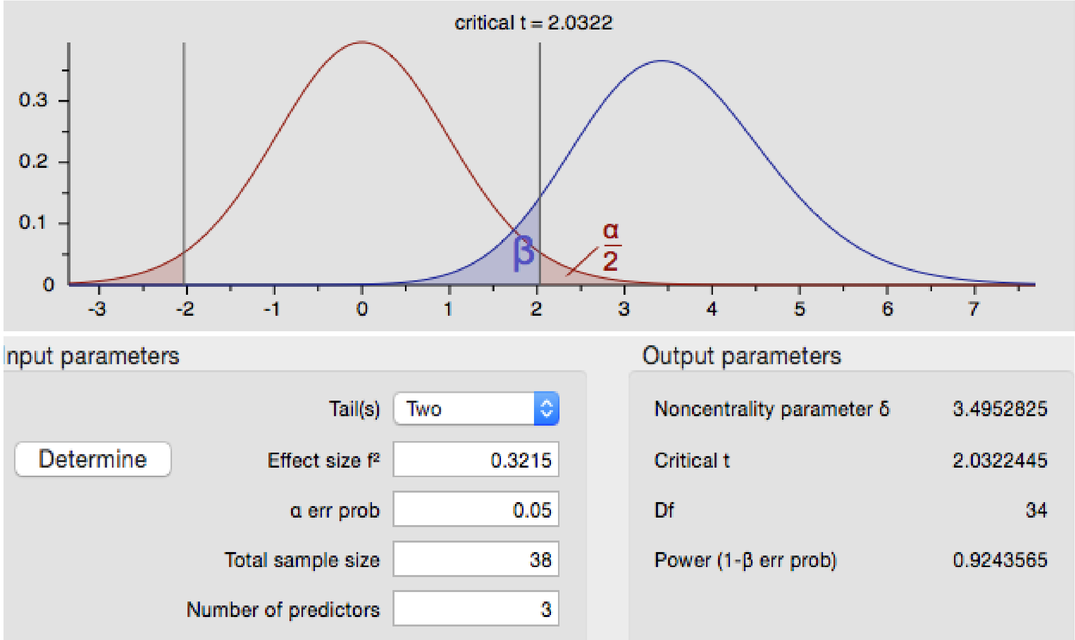
Noncentrality parameter δ 0.8979755

Critical t 2.0280940

Df 36

Power (1-β err prob) 0.1410870

>Energy



Input parameters

Tail(s) Two

Effect size f² 0.3215

α err prob 0.05

Total sample size 38

Number of predictors 3

Output parameters

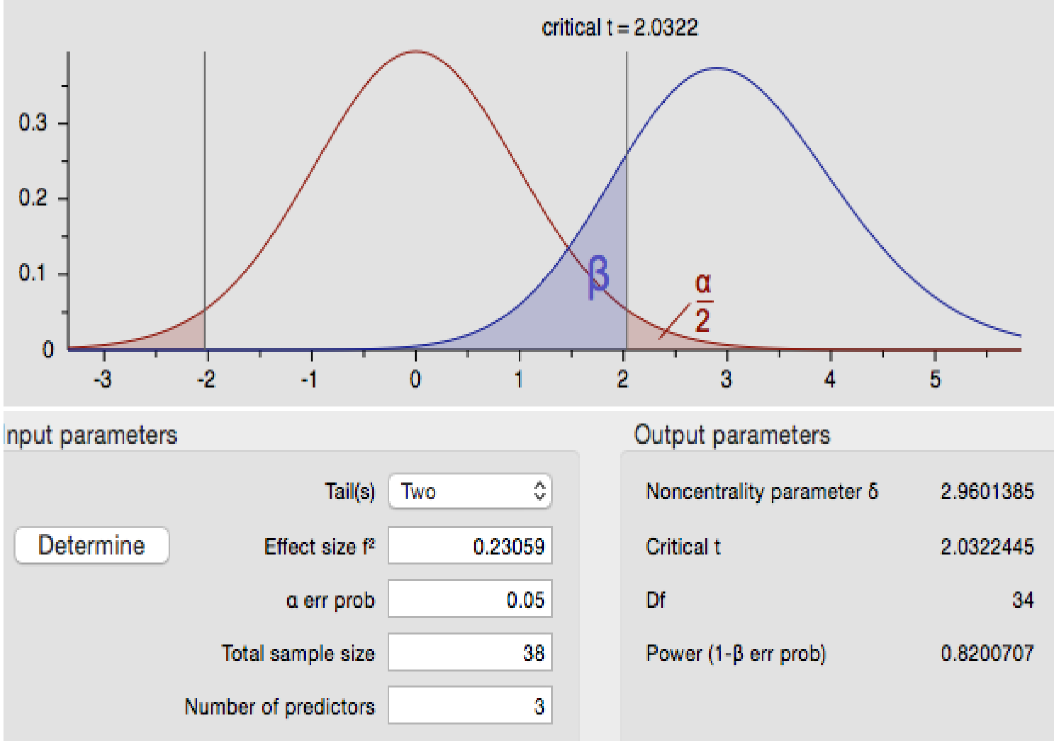
Noncentrality parameter δ 3.4952825

Critical t 2.0322445

Df 34

Power (1-β err prob) 0.9243565

>Transportation



Input parameters

Tail(s) Two

Effect size f² 0.23059

α err prob 0.05

Total sample size 38

Number of predictors 3

Output parameters

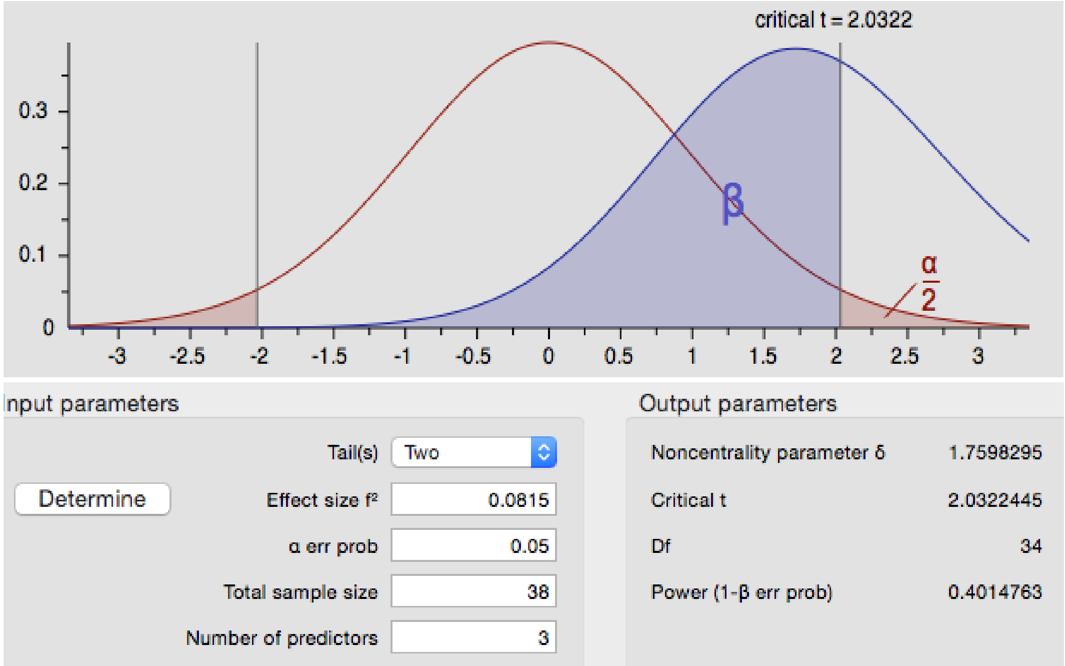
Noncentrality parameter δ 2.9601385

Critical t 2.0322445

Df 34

Power (1-β err prob) 0.8200707

>Water



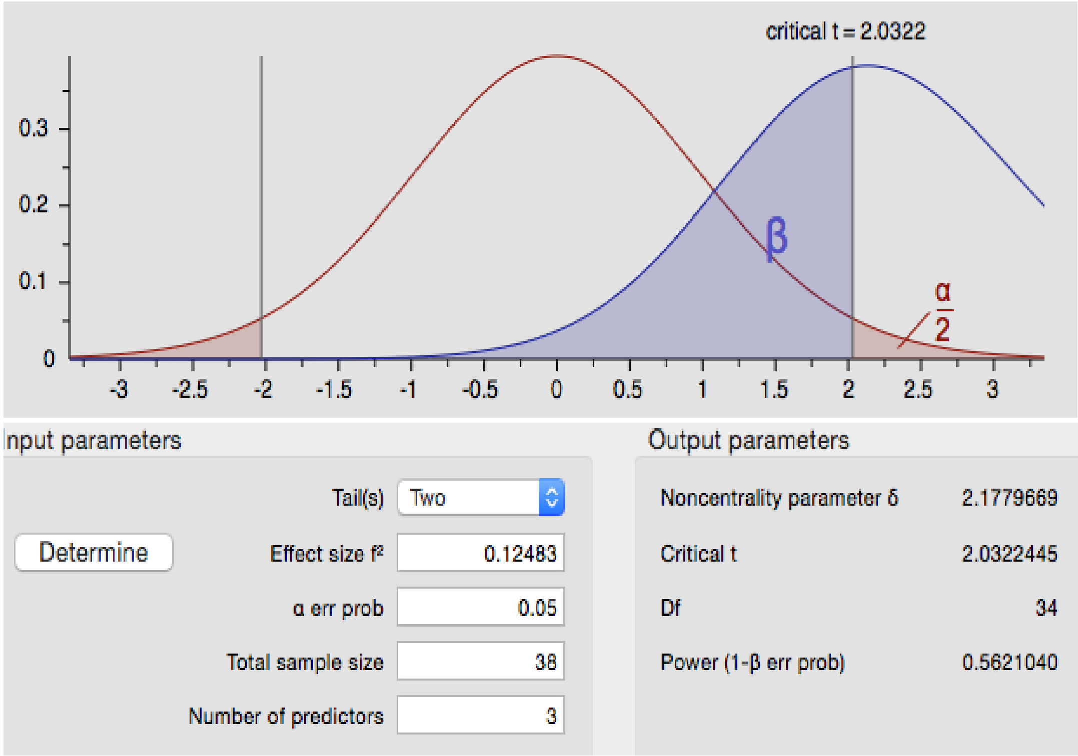
Input parameters

Tail(s): Two
Effect size f²: 0.0815
α err prob: 0.05
Total sample size: 38
Number of predictors: 3

Output parameters

Noncentrality parameter δ: 1.7598295
Critical t: 2.0322445
Df: 34
Power (1-β err prob): 0.4014763

>Waste



Input parameters

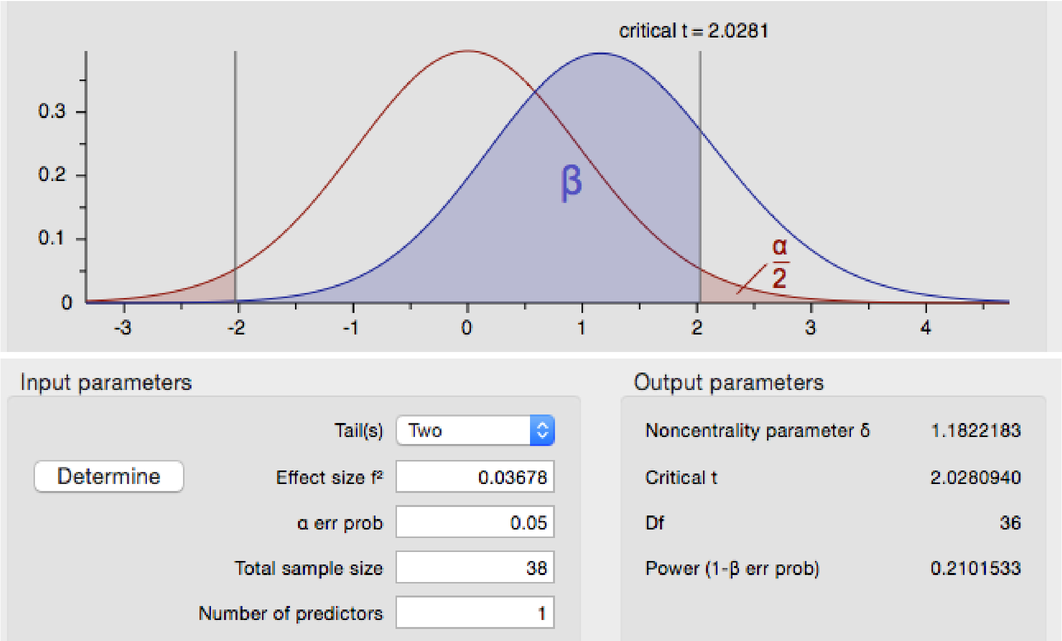
Tail(s): Two
Effect size f²: 0.12483
α err prob: 0.05
Total sample size: 38
Number of predictors: 3

Output parameters

Noncentrality parameter δ: 2.1779669
Critical t: 2.0322445
Df: 34
Power (1-β err prob): 0.5621040

Model 6: Analyzing Total score

>Log_budget



Input parameters

Tail(s): Two

Effect size f²: 0.03678

α err prob: 0.05

Total sample size: 38

Number of predictors: 1

Output parameters

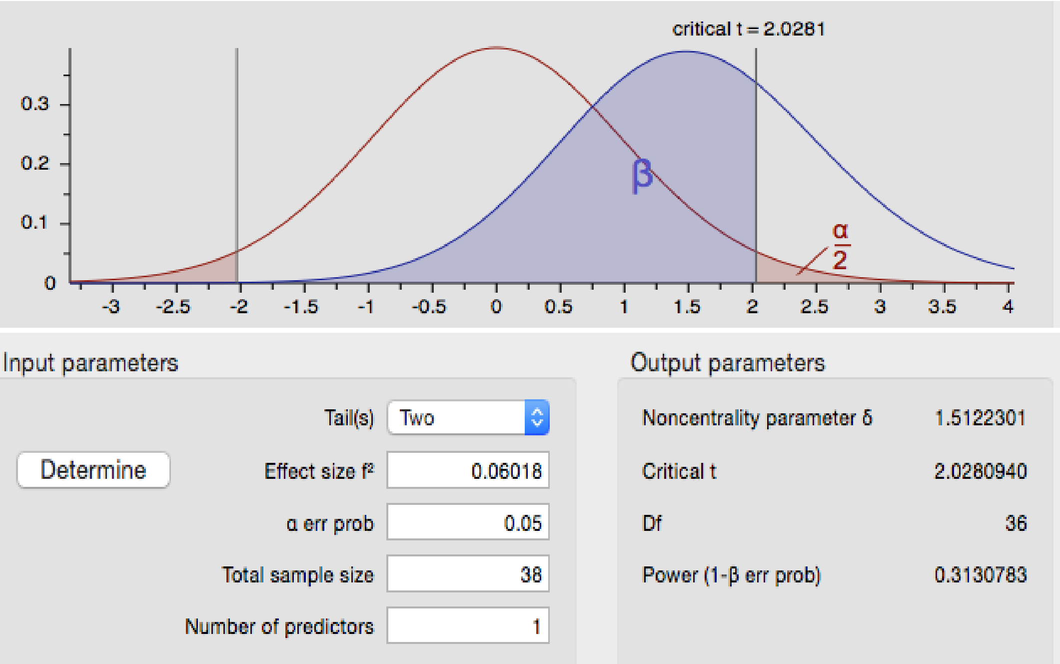
Noncentrality parameter δ: 1.1822183

Critical t: 2.0280940

Df: 36

Power (1-β err prob): 0.2101533

>Adjustedhdi



Input parameters

Tail(s): Two

Effect size f²: 0.06018

α err prob: 0.05

Total sample size: 38

Number of predictors: 1

Output parameters

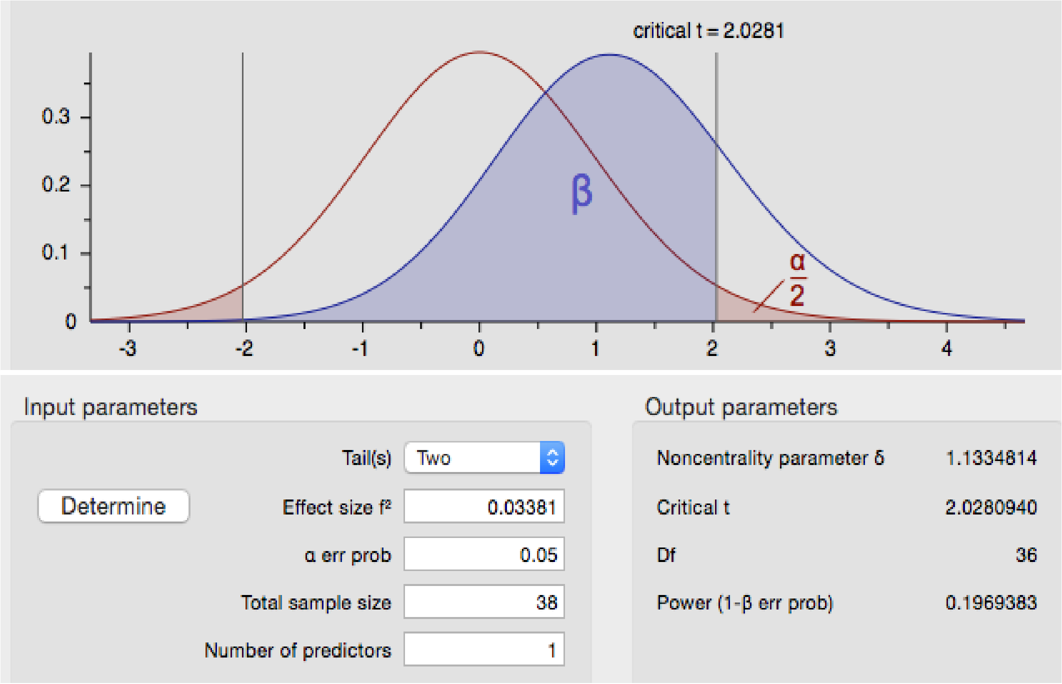
Noncentrality parameter δ: 1.5122301

Critical t: 2.0280940

Df: 36

Power (1-β err prob): 0.3130783

>Finance



Input parameters

Tail(s) Two

Effect size f² 0.03381

α err prob 0.05

Total sample size 38

Number of predictors 1

Output parameters

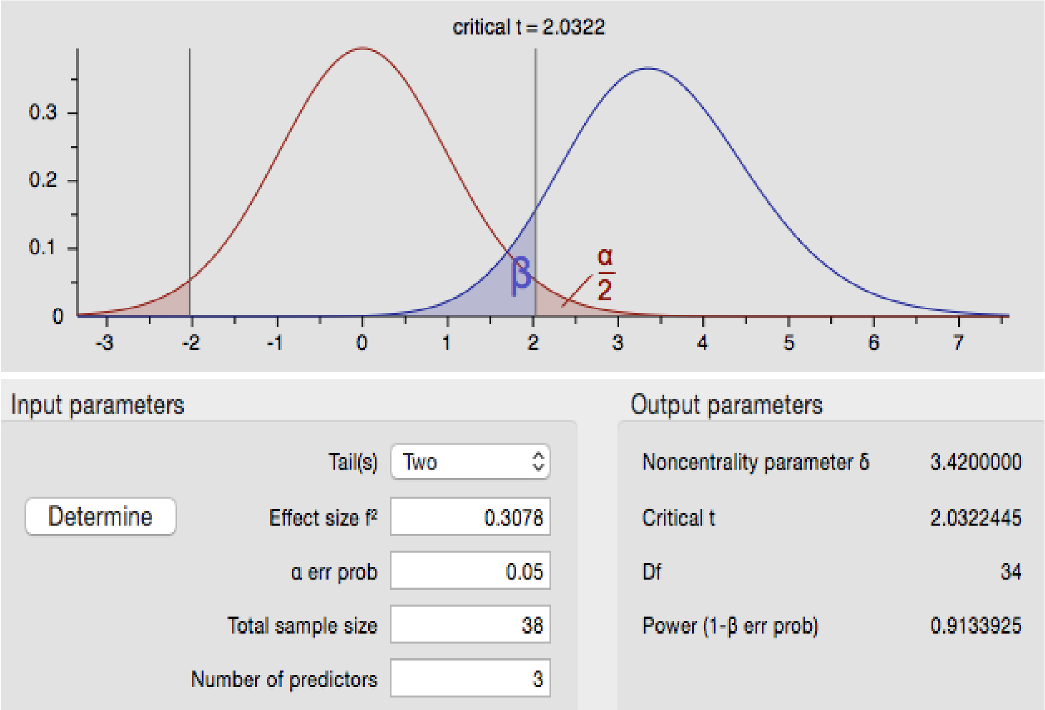
Noncentrality parameter δ 1.1334814

Critical t 2.0280940

Df 36

Power (1-β err prob) 0.1969383

>Energy



Input parameters

Tail(s) Two

Effect size f² 0.3078

α err prob 0.05

Total sample size 38

Number of predictors 3

Output parameters

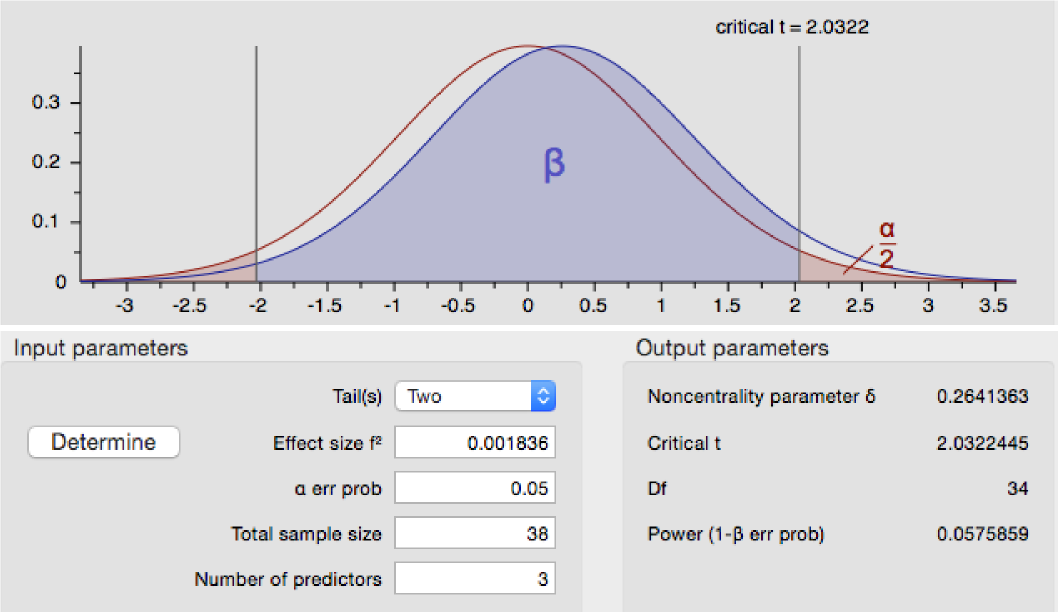
Noncentrality parameter δ 3.4200000

Critical t 2.0322445

Df 34

Power (1-β err prob) 0.9133925

>Transportation



Input parameters

Tail(s) Two

Effect size f² 0.001836

α err prob 0.05

Total sample size 38

Number of predictors 3

Output parameters

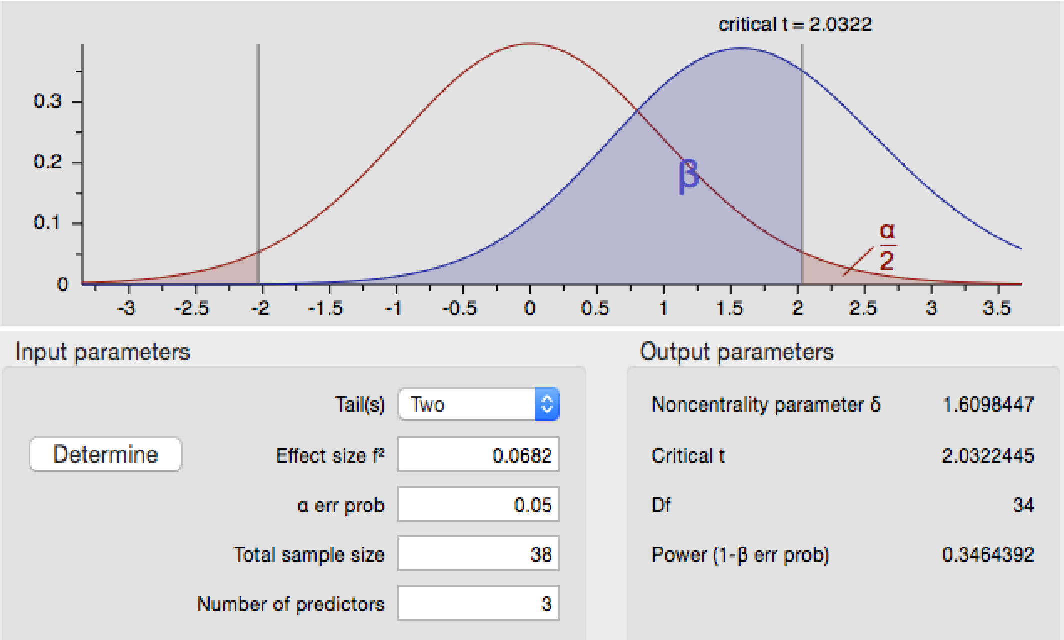
Noncentrality parameter δ 0.2641363

Critical t 2.0322445

Df 34

Power (1-β err prob) 0.0575859

>Water



Input parameters

Tail(s) Two

Effect size f² 0.0682

α err prob 0.05

Total sample size 38

Number of predictors 3

Output parameters

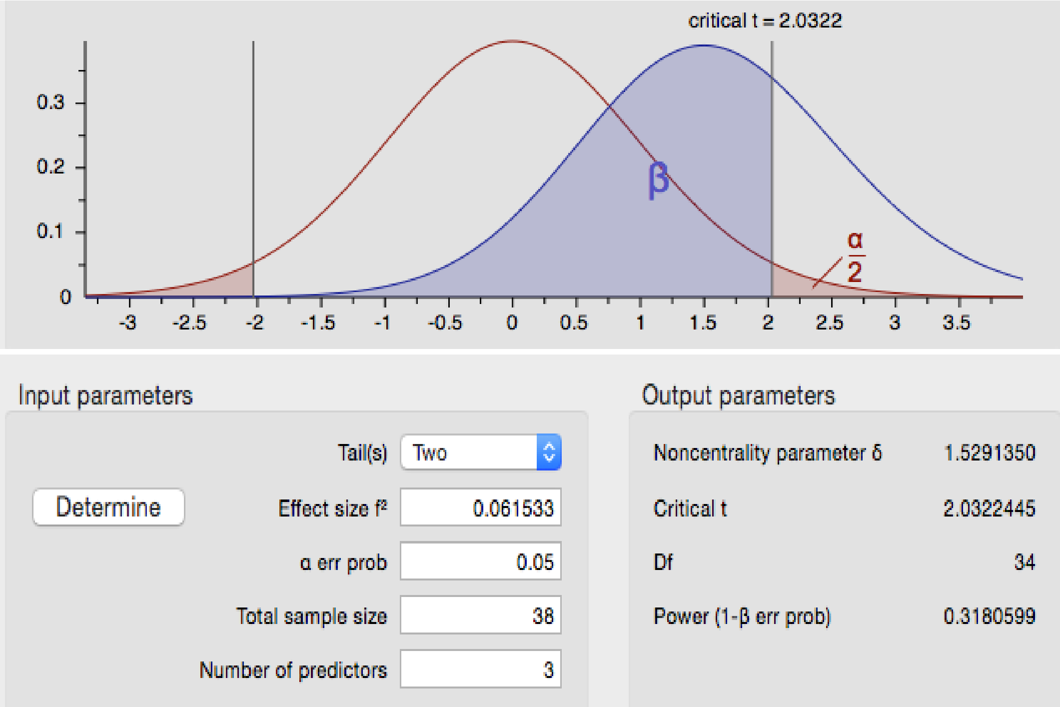
Noncentrality parameter δ 1.6098447

Critical t 2.0322445

Df 34

Power (1-β err prob) 0.3464392

>Waste



Input parameters

Tail(s) Two

Effect size f² 0.061533

α err prob 0.05

Total sample size 38

Number of predictors 3

Output parameters

Noncentrality parameter δ 1.5291350

Critical t 2.0322445

Df 34

Power (1-β err prob) 0.3180599