A Research Framework for Compiling and Evaluating Green Infrastructure and Low Impact Development Incentive Programs

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Abstract

Green infrastructure (GI) and low impact developments (LID) benefits have been realized environmentally and economically. However, the application of the GI and (LID) is hampered by the lack of funding for stormwater utilities combined with the hesitancy of the private sector to take on the financing risk and transaction costs. Therefore, there are currently dozens of incentive programs and innovative financing models to attract private sector sources into GI and LID implementation beyond the minimum development ordinance requirements. While the multitude of incentive programs at the federal and state levels for GI and LID is encouraging, there is no assessment of those program's success, failures or the lessons learned from them. Although, there have been many case studies done by the EPA and others, there is no comprehensive research of the exact incentive programs and/or their effectiveness. The objective of this paper is to provide a research framework for creating an extensive, easy-to-navigate compendium of incentive programs that is categorized by several attributes for the end users as well as to establish a comprehensive set of measurable performance indicators for incentive programs that help the end-users to identify the most efficient incentives.

INTRODUCTION/BACKGROUND

Green Infrastructure

Green infrastructure can be defined as a network of interconnected green space that maintains the natural ecosystem and provides the human population its associated benefits. However, the definitions of green infrastructure are numerous and diverse (Benedict & McMahon, 2012). It generally embodies several components as a holistic approach including storm water management, climate adaptation, heat stress reduction, biodiversity, food production, air quality, sustainable energy production, clean water and healthy soils, as well as increasing quality of life through recreation and providing shade and shelter in and around towns and cities (Lehmann, 2010; Naumann et.al, 2011). U.S Environmental Protection Agency (EPA) defines the green infrastructure in two scales. The first scale is the macro scale level represented in a country or a mega city in which green infrastructure acts as patchwork of natural areas that provide habitat, flood protection, clean air and water. The second scale is the micro level represented in the neighborhood or site where the green infrastructure acts as the storm water management systems mimicking the nature by soaking up and storing water (EPA, 2015a). The exact term of green infrastructure application was originated in a Florida 1994 report to the governor, regarding land conservation

strategies, which emphasized the importance of natural systems as components of infrastructure in addition to the existing grey infrastructure systems (Firehock, 2013).

Low Impact Development (LID)

One of the main components of green infrastructure is the Low Impact Development (LID) designs that attempt to mimic and restore the pre-development hydrologic conditions resulting in less surface runoff (storm water), less pollution and improved water quality (EPA, 2015 b; Coffman, 2002; Davis, 2005). LID features many practices such as bioretention, Grass Swales, rain gardens and vegetative roof covers, permeable pavements and many more. Green Infrastructure, LID systems and their best practices implementation have proven to be of great benefit in mitigating flood risks, increasing water supply, reducing urban heat islands, improving air quality, increasing climate resiliency, providing habitat connectivity, improving recreation space, and increasing property values through many studies over the last decade (EPA, 2000; Wise, 2008; Dunn, 2010; Ahiablame, Engel, & Chaubey, 2012; Sexton, 2014; Kramer, 2014; Shafique & Kim, 2015).

GI AND LID INCENTIVE PROGRAMS

In the last decade, Green infrastructure and LID benefits have been realized environmentally and economically. A U.S. EPA study of six communities concluded that "on average, every $1 spent on source-water protection saved an average of $27 in water treatment costs" (Winiecki, 2012). Many other studies confirmed the economic and social benefits such as reducing grey infrastructure investments and the associated wastewater pumping and treatment costs, reducing energy consumption, improving air quality, increasing climate resiliency, providing habitat connectivity and recreation space, increasing property values among many others (Horinko Group, 2015; Gartner et.al., 2014; Myles, 2014; EPA, 2013; Gallet, 2011). However, the application of the green infrastructure and LID is hampered by the lack of funding for stormwater utilities combined with the hesitancy of the private sector to take on the financing risk and transaction costs (Cotting, 2013; Horinko Group, 2015). Therefore, there are currently dozens of incentive programs and innovative financing models to attract private sector sources into green infrastructure implementation beyond the minimum development ordinance requirements. These infrastructure & LID incentive programs include but are not limited to low/no interest loans, land banking until property value rise, urban easement and new market tax credits, tax increment financing, reinvestment zoning, and many other incentive programs used all over the U.S. (Horinko Group, 2015).

RESEARCH NEED

While the multitude of incentive programs at the federal and state levels for green infrastructure and LIDs is encouraging, there is no assessment of those program's success, failures or the lessons learned from them. Although, there have been many case studies done by the EPA and others (Hall, 2010; Kazmierczak and Carter, 2010; EPA, 2013; Jaffe, 2011; Allen, 2012; Mayer et.al, 2012), there is no comprehensive

research on the different variations of the incentive programs and/or their effectiveness. Some of these programs might be very successful while others might struggle with issues where the economics for the incentives are not favorable due to low fees and the credits/rebates associated with these fees (Thurston et.al, 2008). Also, incentive programs are not a one size fits all. Hence, the end-users represented by utility and stormwater program managers, city planners, and water demand managers cannot depend on one anecdotal case study or an incentive program best-practices that have been developed for a different size utility or one that is operating in a very different location with different environmental and economic conditions.

Therefore, the end-users are in need to access a compendium of incentive programs that is organized and sorted by attributable characteristics (size, location, financial structure, etc.…) along with a benchmark that determines the effectiveness of different programs based on quantitative measures. With an attribute-based compendium of incentive programs and established benchmarks, utilities will be able to learn from these programs and establish and promote better cost-effective incentives that are customized to their needs, size, location and operational structure. Given this, the main objectives of this paper is to provide a detailed research framework for the creation of an extensive, easy-to-navigate compendium of incentive programs that is categorized by several attributes (e.g. types, geographic location and size of utilities) for the end users. It will also establish the base to devise a comprehensive set of measurable performance indicators for GI and LID incentive programs that helps the end-users to identify the most efficient incentives through a simple decision framework.

RESEARCH APPROACH/METHODOLOGY FRAMEWORK

The proposed research framework will adopt a thorough comprehensive methodology to identify, examine and analyze key/major GI and LID incentive programs. In addition, the research will develop measurable quantitative metrics to assess and benchmark the efficiency of the different incentive programs and base the recommendations on solid qualitative and quantitative platforms. The methodology is built on a conglomerate of well-established conventional research methods including literature review, interviews, workshops and primary data collection and analysis. The full research framework including all the phases and the tasks employing these methods is diagrammed in Figure 1. The main methods to be used in this framework is as in the following:

Literature Review: review and organize published information on the different incentive programs for GI and LID and their application in different settings (size, location, regulatory restrictions) to summarize and synthesize relevant findings and information. A literature review establishes a sound foundation for research by surveying the past and current studies in the field to identify the current state of knowledge and documents the need for the proposed study (Creswell, 2009).

Interviews: conduct semi-structured interviews with the identified range of stakeholders and subject matter experts by asking fixed-structured questions with an option of follow-up with open-ended questions to obtain the needed information and capitalize on their experience in the subject matter (Kvale and Brinkmann, 2009).

Empirical Evaluation and Data Collection: Build on the previous two methods (Literature Reviews & Interviews) to develop comprehensive quantitative metrics/performance indicators to evaluate the incentive programs' performance. This also include developing a data collection tool to collect these metrics from a representative sample of different incentive programs. The data collection tool is a flexible tool to collect data from different utilities that implement incentive programs with different settings as they pertain to their geographical location, size, regulatory restrictions, etc.

Workshops: Engage experts from water utilities and use the industry stakeholders' expertise in interactive sessions to brainstorm, identify, confer, and add metrics/performance indicators and quantitative measure for the incentive programs.

Data Analysis: Analyze the collected data through a non-parametric analysis to benchmark different incentive programs. This will establish references for the best practices to select or create successful incentives based on specific attributes.

The aforementioned research methods will be employed according to the phases and tasks in the research approach as shown in Figure 1. Phases 1 and 2 are aiming to achieve the objective of producing a compendium of research that will identify successes and lessons learned on how GI and LID can be incentivized on private property. Phases 3 and 4 will be tasked to achieve the objective of developing and collecting measurable quantitative metrics for the incentive programs in order to benchmark the different incentives and select the most effective recommendations for practice.

Phase 1: Extensive Literature Review and Jurisdiction Targeting

The main goal of the literature review is to explore the current state of knowledge and research regarding the implementation and the success and failures of the different incentive programs across different utilities and jurisdictions. This task will also accumulate all the pertinent information from different published literature and the existing case studies on the GI and LID incentives programs that encourage private investment or public-private partnerships (PPP). The main outcome of this phase is to identify and create a diverse list of potential key/major incentive programs (stakeholders) to be targeted for data collection and interviews in the next phase of research. The diversity of the list is paramount to insure that the research covers a variety of incentive programs with different attributes such as goals, type, size, etc...

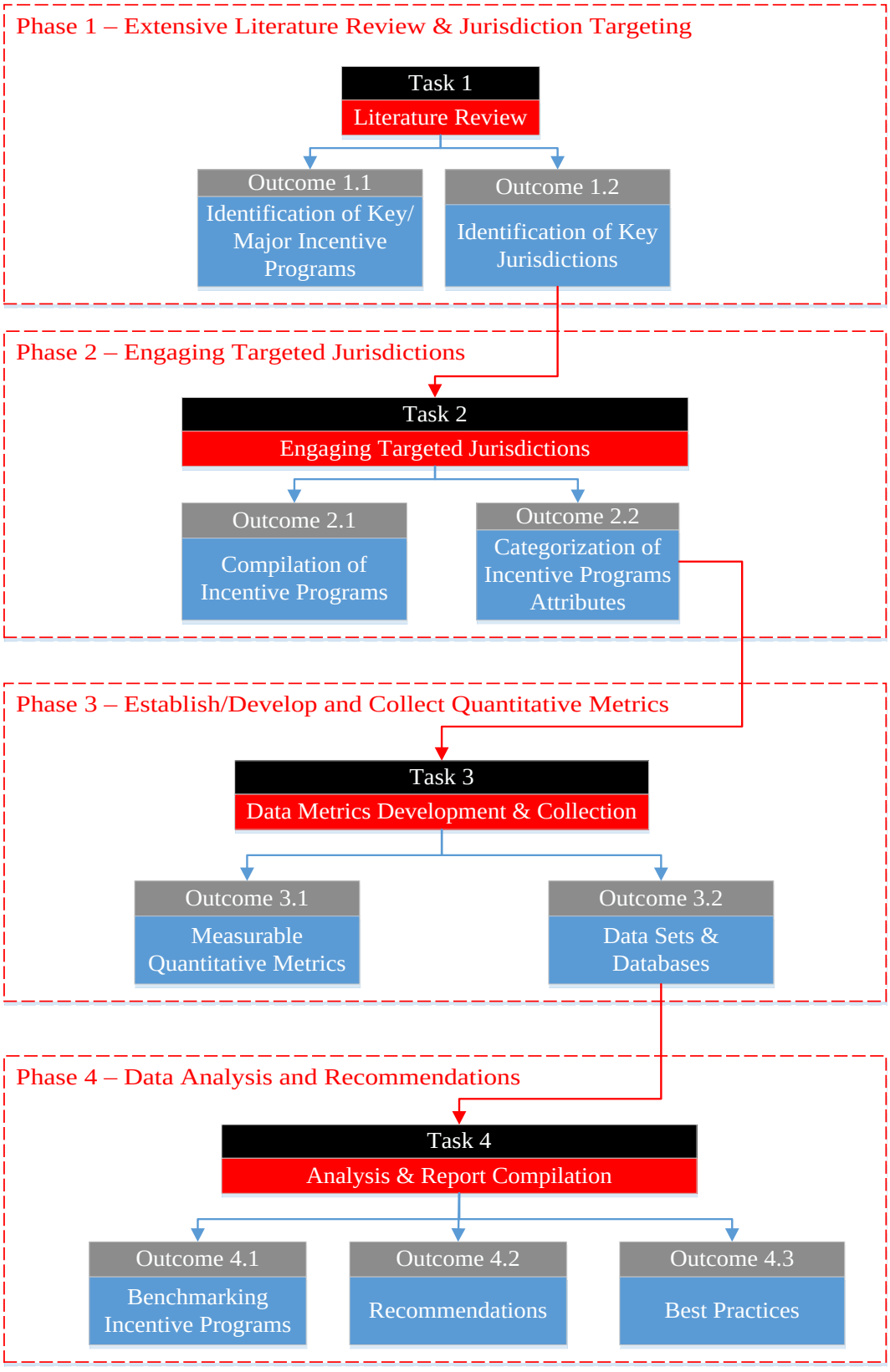

Figure 1. Research Framework

This phase will also help to design structured potential interview questions for the identified set of diverse stakeholders to warrant quantitative and qualitative responses that will confer previously established measurable performance indicators for the incentive programs as well as to identify new ones.

Phase 2: Engaging Targeted Jurisdiction

This phase will be tasked with the collection of the incentive programs that will be based on geo-specific targeting to accumulate a representative sample of the incentive programs all across the U.S. The collection of the incentive programs will be through meetings, interviews and follow up calls with the utilities/jurisdictions identified. In this phase, the compiled programs will be organized based on a developed set of attributes based on the types of incentives (Water Environment Federation "WEF" recognized types), the geographic location and the size of utilities. These efforts will help leverage the experts' input regarding the attributes of the incentive programs, and assist in the identification of the qualitative and quantitative evaluation measures and performance indicators. The main outcomes of this phase is to compile a comprehensive exhaustive list of green infrastructure, LID and incentive programs that identify successes, failures/challenges and lessons learned for each program. In addition, this compendium will be categorized by several attributes (e.g. types, geographic location and size of utilities) to provide an easy to navigate accessible database/results for the end users.

Phase 3: Data Metrics Development and Collection

This phase will be tasked with final development and collection of measurable metrics/performance indicators for the incentive programs which will be referenced to the sustainability triple bottom line (TBL): 1) Economic bottom line, 2) Environmental bottom line, and 3) Social bottom line. The choice of the performance metrics will be determined and based upon interview questions (identified in task 1) along with a series of workshops to confer and validate the incentive programs metrics. These workshops will be a central part of this phase with the goal to engage experts from water utilities and the industry to confer old and establish new performance metrics for the incentive programs. A demonstration example of these metrics are as shown in figure 2. The data collection tool will be a flexible survey tool to collect the performance data from different utilities that implement incentive programs with different attributes (e.g. location, size, etc.). The main outcomes of this phase is to Identify and establish a comprehensive set of measurable performance indicators for GI and LID incentive programs which will be the base for the datasets to be analyzed in phase 4.

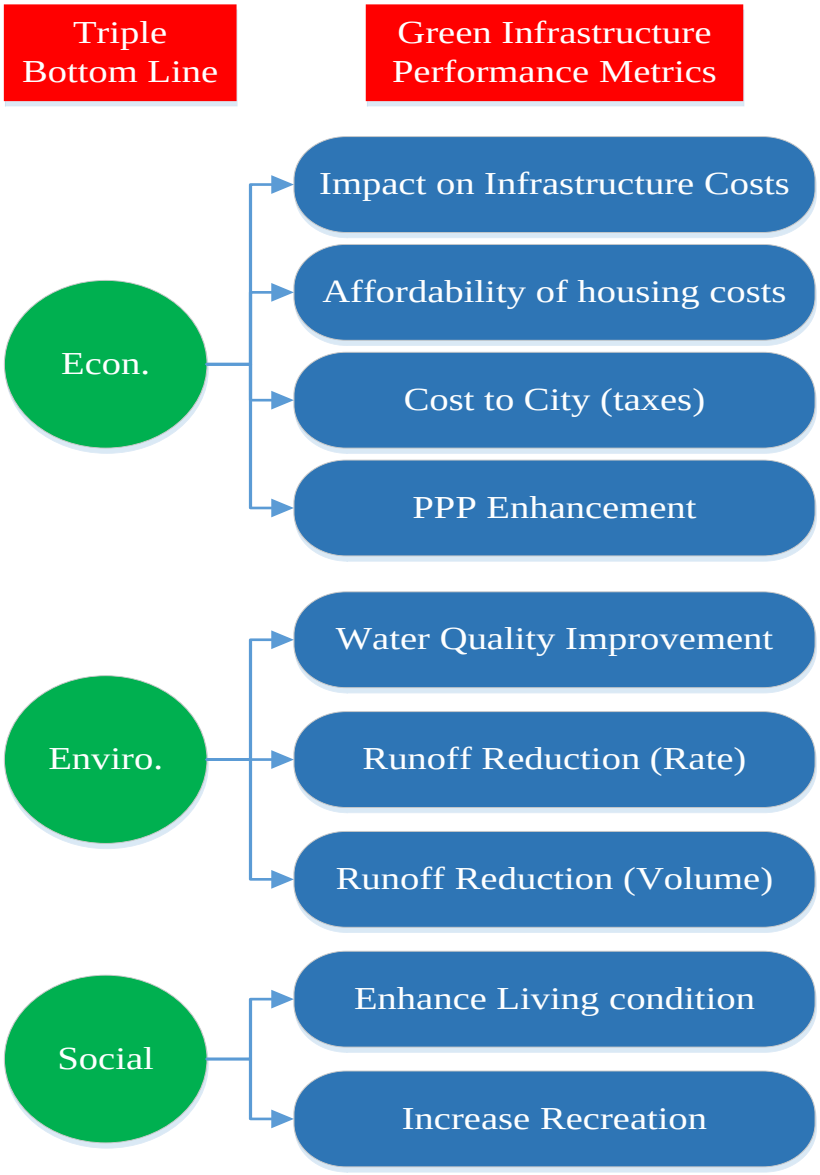

Figure 2. Demonstration of Performance Indicators referenced by the Sustainability Triple Bottom Line (TBL)

Phase 4: Analysis & Recommendation

The final phase is tasked with the analysis of the datasets collected, organized, and categorized by the predefined attributes. The data will be analyzed to benchmark different incentive programs and identify the most efficient incentives for the different datasets. The results of this analysis will then provide the basis for recommendations and best practices for identifying the most efficient incentives by a utility/jurisdiction. Several statistical tools can be used separately or combined for the analysis including but not limited to Causey-Trager Benchmarking, non-parametric Data Envelopment Analysis (DEA) and Natural Cubic Splines Benchmarking Method. Causey-Trager Benchmarking is an iterative nonlinear method that uses numerical algorithm subjected to asset of constraints. DEA is a nonparametric that is

based on production theory and the principles of linear programming to imperially measure decision making efficiency while Natural Cubic splines is an interpolating method that uses new points to form a converging function toward the optimal results.

The benchmarking and evaluation of the different incentive programs will identify the most efficient incentives based on different attributes. It will also provide well-informed recommendations for future efficient incentives and incentive programs based on past data. It will also act as a simple decision framework and/or best practice that helps to select the suitable incentive or establish an efficient incentive program based on specific attributes.

EXPECTED RESULTS AND BENEFITS

The key expected results and outputs of the research approach following the aforementioned main framework are as in the following:

- To identify and develop a list/inventory of incentive programs across the country that represent different attributes and conditions for utilities and municipalities. This list/inventory will be based on the in-depth literature and case study review and the interviews of a diverse range of stakeholders that mostly include but not limited to the water utilities and municipalities who are implementing incentive programs.
- To identify, document and compile the different incentive programs and categorize the programs by specific attributes such as goals, type, size, etc.
- To produce a well-organized and categorized compendium of GI and LID incentive programs.
- To develop triple bottom line (economic, environmental and social) performance metrics for the different incentive programs.
- To create a flexible data collection tool that allows for collecting incentive programs' performance data for a broad range of utilities/municipalities that varies in their attributes.
- To collect organized datasets and analyze the collected data through a non-parametric analysis in order to identify and recommend the most successful and efficient incentives and the best practices for establishing an efficient incentive program based on specific attributes.
- To provide a simple decision framework for the end-user as a best practice for establishing or selecting an efficient incentive program based on specific attributes.

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