Financial Benefits of Green Infrastructure

Model Usage Guide

Applied Business Research Project

Pedram Salehi, Kodie Lee & Orville Smith

LAZARIDIS
School of Business & Economics

Model Inventory

- Stormwater Management
- Energy Savings
- Air Quality
- Mental Health
- Longevity
- Commercial Property Tax
- Residential Property Tax
- Commercial Property Income Tax
- Health Care

Stormwater Management – Flood Damage Prevention

- Required User Inputs
  - User selects region of interest from dropdown list.
  - Alternatively, user manually enters the expected annual rainfall (MANUAL_ENTRY).
  - User selects the green space type to be deployed in that region.
  - User enters the penetration of incremental green space that would be deployed in that region.
- How Does the Model Work?
  - Model retrieves estimated annual precipitation level for selected region.
  - Alternatively, model uses the precipitation level manually entered.
  - Model retrieves the retention capability of the selected green space type based on research performed by student team (see Reference Data tab for sources).
  - Model assumes that the estimated annual insured damage due to flooding in Canada ($1.9 billion) is prorated across the flood-prone regions (based on annual precipitation) listed in the Reference Data tab.
  - Model assumes that for each $1 of insured damage, the Canadian governments pay $3 to recover public infrastructure damage.
- Model Outputs
  - Potential avoidance of flood damage costs from deploying the selected green infrastructure in the selected region for the penetration level entered by the user.

Flood Damage Prevention Cost Savings Model		
Assumptions		
Expected Precipitation in Calgary (mm per year)		437
Retention Capability of Tree Canopy		62%
Estimated Annual Damage to Flood-Prone Canadian Homes	$	1,900,000,000
Inputs		
Select Region of Interest from Dropdown		Calgary
OR		
Manual Entry of Annual Precipitation (mm per year)		400
Select Green Space Type		Tree Canopy
Penetration of Incremental Tree Canopy Deployed in Calgary:		3%
Outputs		
Estimated Damage Due to Flooding in Calgary:	$	55,972,765
Potential Savings of Deploying Tree Canopy in Calgary (Personal):	$	1,041,093
Potential Savings of Deploying Tree Canopy in Calgary (Government):	$	3,123,280
Total Value in Reducing Flood Damage Costs		4,164,374

Sources:

Major Canadian Cities Average Precipitation

Multi-purpose rainwater harvesting for water resource recovery and the cooling effect

Severe Weather Damage – 2018 (Insurance Bureau of Canada)

Energy Savings – Air Conditioning Cost Reduction

- Required User Inputs
  - User selects green space type to be deployed from the dropdown list.
  - User enters the current cost of electricity.
  - User enters the expected usage of air conditioning in the household (day/year and hours/day).
- How Does the Model Work?
  - Model calculates the annual electricity consumption based on the user's entered usage pattern.
  - Model calculates the estimated annual energy cost of the calculated consumption.
  - Model retrieves the estimated cooling effects of the selected green space type based on research performed by student team (see Reference Data tab for sources).
  - Model applies the cooling effect to the annual energy consumption to calculate potential savings (assumes for every degree Celsius that ambient temperature is lowered for 8 hours, a household can save 2% in energy costs).
- Model Outputs
  - Potential reduction in annual energy costs to cool a house (in dollars and % savings).

Air Conditioning Energy Cost Savings Model		
Assumptions		
Power Use for Household A/C Unit (Watts)		3,500
Cooling Effect of Deploying Green Roof (Degrees Celcius)		3.00
Inputs		
Select Green Space Type		Green Roof
Cost of Electricity (cents / kWh)		14.4
Hours Per Day A/C is Used		8.0
# Days per year A/C is used		180
Outputs		
Annual Household Electricity Consumption - Air Conditioning (kWh)		5,040
Annual Household Electricity Cost - Air Conditioning	$	725.76
Annual Household Savings Electricity Cost - Air Conditioning	$	43.55
Annual Savings (%)		6.00%

Sources:

Urban green space cooling effect in cities
Cooling Effect of Permeable Asphalt Pavement Under Dry and Wet Conditions
Energy Saving Potentials and Air Quality Benefits of Urban Heat Island Mitigation
Money Saving Effects of Thermostat Adjustments

Air Quality – Carbon Sequestration Value

- Required User Inputs
  - User selects the type of green space to be deployed from the dropdown list.
  - User enters the area of the green space to be deployed (in km^2).
- How Does the Model Work?
  - Model retrieves the estimated sequestration capabilities of the selected green space type based on research performed by student team (see Reference Data tab for sources).
  - Model calculates the estimated carbon that can be sequestered by deploying selected green space in the area entered by the user.
  - Model applies the estimated annual carbon sequestered to the current cost of carbon based on the Greenhouse Gas Pollution Pricing Act (note this price can be updated by the user).
- Model Outputs
  - Estimated amount of carbon sequestered per year and annual value based on carbon pricing in Ontario.

Carbon Sequestration Air Quality Model		
Assumptions		
Sequestration Capability of Tree Canopy (kgC per square meter per year)		0.30
Federal Price of Carbon (per tonne)	$	30
Inputs		
Select Green Space Type		Tree Canopy
Area of Tree Canopy Deployed (in square kilometres)		2.00
Outputs		
Estimated amount of carbon sequestered (tonnes)		600
Annual value of carbon sequestered	$	18,000

Sources:

Carbon sequestration potential for mitigating the carbon footprint of green stormwater infrastructure

Carbon storage and sequestration by urban trees in the USA

Federal Carbon Pricing

Mental Health Cost Savings

- Required User Inputs
  - User enters most recent mental health cost data and year of research
  - User will also need to enter population in year of research, forecast year, and subject area population
  - Decrease in mental health burden will need to be updated as new research on green space and mental health comes out
  - Escalation will need to be updated based on user preference
- How Does the Model Work?
  - Model assumes improved happiness, self-worth, and life satisfaction result in improved mental health
  - Model uses mental health cost data and population in same year to calculate mental health cost per capita
  - Year of mental health cost research and forecast year along with escalation % are used to inflate the mental health cost to the forecast year
  - Subject area population and % decrease in mental health burden are then applied to inflated mental health cost per capita to produce output
- Model Outputs
  - Mental health cost savings in subject area due to addition of green space

Mental Health Cost Savings Model		
Assumptions		
Decrease in Mental Health Burden[1,2,3]	6.7%	a
Escalation %	2%	b
Inputs		
Mental Health Burden		
Year of Most Recent Mental Health Costs in Canada[4]	2003	c
Population in 2003	31,641,630	
Most Recent Mental Health Costs in Canada	$51,000,000,000	
Most Recent Mental Health Costs in Canada per Capita	$1,612	d
Forecast Year	2020	e
Subject Area Population	1,000	f
Outputs		
Total Mental Health Cost Savings	$150,461	d*((1+b)^(e-c))*f*a

Sources:

Green Space and Good Mental Health

A new population-based measure of the economic burden of mental illness in Canada

Canadian Population in 2003

Income Tax Revenue due to Increased Longevity

- Required User Inputs
  - User enters most recent tax revenue per capita and year of research (Federal and Provincial; province will need to be chosen) along with increase in survival scenario (Low, Mid, High)
  - User will also need to enter population in year of research, forecast year, and subject area population
  - Increase in survival will need to be updated as new research regarding green space and mortality risk mitigation comes out
  - Escalation will need to be updated based on user preference
- How Does the Model Work?
  - Model assumes decrease in mortality risk translates to increase in survival
  - Year of tax revenue research and forecast year along with escalation % are used to inflate the federal and provincial tax revenue to the forecast year
  - Subject area population and % increase in survival are then applied to inflated federal and provincial tax revenue per capita to produce output
- Model Outputs
  - Incremental federal and provincial income tax revenues in subject area due to addition of green space

Incremental Individual Income Tax Revenues Due to Longevity Model

Assumptions

		Low	Mid	High	
Increase in Survival[1,2]	10%	8%	10%	12%	a
Escalation %	2%				b

Inputs

Federal Tax:		
Most Recent Individual Federal Tax Revenue per Capita[3]	$6,729	c
Year of Most Recent Individual Federal Tax Revenue[3]	2016	d
Provincial Tax:		
Subject Province	ON	
Most Recent Individual Provincial Tax Revenue per Capita[3]	$2,450	e
Year of Most Recent Individual Provincial Tax Revenue[3]	2016	f
Scenario	Mid	
Forecast Year	2020	g
Subject Area Population	1,000	h

Outputs

Incremental Individual Federal Income Tax Revenues	$728,369	c*((1+b)^(g-d))*h*a
Incremental Individual Provincial Income Tax Revenues	$265,196	e*((1+b)^(g-f))*h*a
Total Incremental Income Tax Revenues	$993,564	

Sources:

Urban Greenness and mortality in Canada's Largest Cities

Revenue per Capita in Canada

Commercial Property Tax

- Required User Inputs
  - User enters current total value of commercial real estate in subject area
  - Increase in rental revenue will need to be updated as new research regarding green space and commercial rent comes out
  - Average commercial property tax rate will need to be updated based on new research
- How Does the Model Work?
  - Model assumes constant Net Operating Income margin % and Direct Capitalization Method of Real Estate Valuation which allows for the assumption that increase in rental revenue translates to property price premium from professional landscaping
  - Property price premium and average commercial property tax rate are then applied to current total value of commercial real estate in subject area to produce output
- Model Outputs
  - Incremental commercial property tax revenues due to green space and professional landscaping

Incremental Commercial Property Tax Revenue Model		
Assumptions		
Increase in Rental Revenue (%)[1]	12%	
NOI Increase (%)[2]	12%	
Property Price Premium from Professional Landscaping (%)[3]	12%	a
Average Commercial Property Tax Rate	2.421%	b
Inputs		
Current Total Value of Commercial Real Estate in Subject Area	$60,000,000	c
Outputs		
Incremental Commercial Property Tax Revenues	$174,312	c*a*b

Sources:
Landscaping Can Boost Property Values
Canadian Property Tax Rate Benchmark Report

Residential Property Tax

- Required User Inputs
  - User enters distance from green space and area of green space along with current total value of residential real estate in subject area
  - Average residential property tax rate will need to be updated based on new research
- How Does the Model Work?
  - Residential property price premium is retrieved from table of data produced by research from the UK based on distance from green space and area of green space
  - Property price premium is applied against current total value of residential real estate in subject area to produce output
- Model Outputs
  - Incremental residential property tax revenues due to green space

Incremental Residential Property Tax Revenue Model		
Assumptions		
Average Residential Property Tax Rate[1]	0.882%	a
Residential Property Price Premium for Green Space (%)[2]	1.01%	b
Inputs		
Distance from Green Space (metres)	50	
Area of Green Space (square metres)	25,000	
Current Total Value of Residential Real Estate in Subject Area	$60,000,000	c
Outputs		
Incremental Residential Property Tax Revenues	$5,326	c*b*a

Sources:
Canadian Property Tax Rate Benchmark Report
Urban Greenspaces Raise Nearby House Prices

Commercial Property Tax Revenue

- Required User Inputs
  - User enters current total value of commercial real estate in subject area
  - Respective cap rate will need to be updated based on subject province and new research
  - Increase in rental revenue will need to be updated as new research regarding green space and commercial rent comes out
  - Average effective income tax rate (Federal and Provincial) will need to be updated based on new research
- How Does the Model Work?
  - Model assumes constant Net Operating Income margin % and Direct Capitalization Method of Real Estate Valuation which allows for the assumption that increase in rental revenue translates to increase in Net Operating Income
  - Applying the cap rate to the current total value of commercial real estate in subject area produces total NOI of commercial real estate in subject area
  - Total NOI of subject area used with the NOI increase % and average effective income tax rates (Federal and Provincial) to produce output
- Model Outputs
  - Incremental federal and provincial income tax revenues in subject area due to green space and professional landscaping

Incremental Commercial Property Income Tax Revenue Model		
Assumptions		
Subject Province	ON	
Commercial Property Cap Rate in Subject Area[1]	5%	
Increase in Rental Revenue from Professional Landscaping (%)[2]	12%	
NOI Increase from Professional Landscaping (%)[3]	12%	a
Average Effective Income Tax Rate		
Average Effective Federal Income Tax Rate[4]	15%	b
Average Effective Provincial Income Tax Rate[4]	12%	c
Inputs		
Current Total Value of Commercial Real Estate in Subject Area	$60,000,000	
Total NOI of Commercial Real Estate in Subject Area[5]	$3,000,000	d
Outputs		
Incremental Federal Income Tax Revenue	$54,000	a*d*b
Incremental Provincial Income Tax Revenue	$41,400	a*c*b
Total Incremental Income Tax Revenue	$95,400	

Sources:
Canadian Cap Rates
Landscaping Can Boost Property Values
Canadian Corporation Tax Rates

Health Care Cost Savings

- Required User Inputs
  - User enters most recent Canadian population data
  - User enters population of subject area
  - Update assumption regarding % reduction of air pollution by adding green infrastructure as more research becomes available
  - Escalation will need to be updated based on user preference
- How Does the Model Work?
  - Model assumes that healthcare cost savings as green infrastructure is added to subject area
  - Model assumes that a 10% reduction in air pollution translates into $500,000,000 of health care savings
  - Year of air pollution reduction figure and forecast year along with escalation % are used to inflate the health care cost savings to the forecast year
  - Savings from air pollution applied against % reduction of air pollution by adding green infrastructure and Canadian population to find health care cost savings per capita
  - Savings per capita applied to population in subject area to produce output
- Model Outputs
  - Potential annual health saving for subject area due to green infrastructure

Health Care Cost Savings Model	
ASSUMPTIONS	
Savings from air pollution reduction by adding green infrastructure [1]	$500,000,000
% reduction of air pollution by adding green infrastructure [2]	0.36%
Escalation %	2.00%
INPUTS	
Year of most recent air pollution reduction figure[1]	2013
Canadian population[3]	37,750,000
Annual health care cost savings related to air pollution reduction per Capita	$0.47
Population in Subject Area	12,000
Forecast Year	2020
OUTPUT	
Annual Health savings for subject area due to green infrastructure	$6,536

Sources:

Savings on Healthcare Costs

Reduction in air pollution represents average annual reduction of (NO_2, O_3, $PM_{2.5}$, SO_2)/4

Annual population estimate