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Framework to assess city-scale sustainability

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Abstract

This paper establishes the need to act at a city scale to reduce energy use and improve sustainability in general. The paper evaluates the plans that the City of Fargo (Climate zone 6), North Dakota has established to grow in a sustainable manner. As part of this effort, the City of Fargo is participating in the Georgetown University Energy Prize Competition to reduce the energy use of residential and municipal buildings. As such, the City is engaged in assessing, defining, designing and implementing the Go 2030 plan (2012) as the basis for a sustainable future. This paper reviews and evaluates several methods of city-scale assessments and identifies distinguishing characteristics of these tools and assessments and creates a categorization to make the methods ordered and understandable. The two broad categories developed are (1) category- and (2) indicator-based models of urban sustainability. Further, this paper reviews the tools through a literature search and compares the City of Fargo's Go 2030 plan against these categorizations. Based on this evaluation this paper proposes a framework that has the potential to fill the gaps in the current Go2030 plan.

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1. Introduction

Per the World Urbanization Prospects by United Nations Department of Economic and Social Affairs' (UN DESA) population division, 54% (3.9 billion) of the world's population lives in urban areas and is expected to increase to 66% by 2050. [1] Almost half of the 3.8 billion urban population resides in smaller towns with fewer than 500,000. The Intergovernmental Panel on Climate Change projects that urban areas are responsible for 76% of global energy use and 75% of carbon emissions.[2] These conditions clearly present an opportunity for impacting global energy use and carbon emissions by acting on sustainability criteria at the city scale.[3] Urban interventions have the potential to reduce global energy use by 26%, and urban form modifications would constitute a low cost or negative cost urbanization model for climate change mitigation.[4] Although greenhouse gas emissions are seen as a global problem,

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it is municipalities that control major factors that impact greenhouse gas emissions such as land use policy, urban morphology, building regulations, transit and waste.[5]Like several other North Dakota cities, Fargo is growing at a very fast pace. Per the 2010 census, the population grew by 16.5% since the last census and is projected to exceed a quarter of a million people by 2040 as compared to 105,550 people in 2010.[6] In 2009, the City of Fargo received almost a million dollars in an Energy Efficiency and Conservation Block Grant from the United States Department of Energy (US DOE).[1] The City invested nearly $250,000 of its grant funding to formulate a comprehensive plan called the Go2030 plan with extensive community participation.[8] The City of Fargo, formalized the Go2030 plan as policy on May 24, 2012.[9] Currently, as a participant in the national Georgetown University Energy Prize competition that aims to reduce the energy use of municipalities over a two-year competition period, the City of Fargo has proposed several programs to reduce its energy use, comprehensively called *efargo* which are aligned with the Go2030 goals.

Given the pace of growth in Fargo, and the opportunities with city-scale interventions, this paper evaluates the Go2030 plan against the findings through the literature search and other urban scale sustainability assessment models based on indicators.

2. Methodology

There is a large diversity in the ways to assess and measure urban sustainability. Assessment methods may be structural frameworks for issues inherent in city-scale sustainability or assessments tools that provide qualitative and quantitative check lists to measure urban sustainability. The structural frameworks may be used to test the thoroughness of tools, identify gaps and provide the structure to create new assessment tools. This paper focusses on an analysis and categorization of the structural frameworks, with specific focus on the indicator-based frameworks. First, a literature search was conducted to identify the state-of-the-art in models and tools to assess urban sustainability. Following this, findings were categorized into the following: (a) Structural frameworks*;* (b) Assessment tools. Structural framework models were further sub-categorized into into category- and indicator-based models. A comparative tabular analysis of the City of Fargo Go 2030 plan, the Neves et al and Shen et al indicator-based models was conducted to identify gaps in the plan. Finally, an overarching structural framework was proposed as a means to test both *models* and *tools*.

3. Background and Analysis

Two major types of urban sustainability frameworks are as follows: (a) broad category-based system; (b) detailed indicator-based system of comprehending urban sustainability. This paper focusses on the analysis of the indicator-based system. For an analysis of the category-based frameworks please refer to the extensive version of this paper for the special edition.

3.1. Detailed Indicator-based urban sustainability models (Table 1):

The goal of indicator-based assessment structures of urban sustainability is to provide an easy-to- communicate and measurable checklist of all relevant sectors as cities formulate an urban sustainability plan. Based on a comparison of the indicator-based models in [15, 16] to the City of Fargo's Go 2030 plan [7], an analysis of overlaps, gaps and specialized local conditions or concerns is outlined. (Table 1)

a. Neves *et al*. [15] argue that the three dimensions of sustainable development (economic, environmental and social) must be fulfilled simultaneously at the local level. The selection criteria utilized for whether indicators were included in the model were based on three criteria: (1) relevance of the indicator for local energy sustainability; (2) potential measurability; and (3) the power of the local authority to impact the outcomes measured by the indicator. Sustainability Indicators based on economic, environmental and social sectors divided into S (state) and P (policy)

[1] Most of the information on the Go2030 plan process comes from the Georgetown University Energy Prize proposal called efargo put together by this author and other members of the core efargo team.

indicators by Never et al are shown in Table 1.

b. Shen *et al*. [16] argue that indicators fulfill the role of measuring performance. In their study of ten international cities, [16] conclude that while a list of urban sustainability indicators may be possible for all cities, the selection of the indicators to act upon can only be a choice made in the context of a city's particular circumstances. As such, [16] provide a comprehensive and lengthy list of indicators in the following categories: (1) Environmental (10 indicators and several sub-indicators); (2) Economic (5 indicators and several sub-indicators); (3) Social (18 indicators and several sub-indicators) and (4) Governance (4 indicators and several sub-indicators). See Table 2 for a list of indicators. While the indicators included in [16] address the larger ideas of a sustainable society, the indicators list in [15] is an evaluation of energy use by the varied systems of a city and its occupants.

	Neves *et al.* [15]	Go 2030 [7]	Shen *et al.* [16]
	ENVIRONMENT		
1			Geographically balanced settlement (planned growth) (En1)
2			Freshwater (total water resources, water use intensity, quality of water) (En2)
3		Green stormwater strategies that can be public parks (W5)	Wastewater (% of pop served by system, % of wastewater receiving treatment) (En3)
4	GHG emissions from energy use/capita.unit of GDP per sector (S1) Air emissions from transport (S11)	Improve air quality by reducing emissions from transport, energy production, industry etc (En5)	Quality of ambient air and atmosphere (number of times air pollutants are exceeded, GHG emissions, Ozone depletion) (En4)
5			Noise pollution (any noise plan, noise levels, exposure to high noise levels) (En5)
6		Promote Infill and create density in existing established areas instead of urban sprawl on farm areas (NIND1)	Sustainable land use (contaminated land, restoration of land use, protected areas, desertification, farming, forests) (En6)
7		Reduce waste, composting policy, increase recycling (En4)	Waste generation and management (% of pop with solid waste collection, disposal to landfill, solid waste generation per capita, treatment and disposal, radioactive waste) (En7)
8		Bicycle and transportation connectivity (T1)	Effective and environmentally sound transportation systems (times, nodes, intensity) (En8)
9			Mechanisms to prepare and implement environmental plans (master plan, environmental plan) (En 9)
10			Biodiversity habitats, fragmentation, native species, foreign species) (En10)
	ECONOMIC		
11	Primary Energy use (S2) Final Energy use (S3) Ratio of renewables (S4/S12) Industrial, agricultural, service/commercial, household, transport energy intensity (S5-S9)	Incentivize energy use reduction and energy production by working with City, State and Federal governments (E2)	Consumption and production patterns (material consumption, energy consumption, renewable energy consumption, intensity of energy use) (Ec1)

	Neves *et al.* [15]	Go 2030 [7]	Shen *et al.* [16]
12		Amenities and beautification as a tool to attract a creative workforce (Ec1)	Economic development (economic activity, GDP, savings, investments, inflation, incomes) (Ec2)
13			Finance (taxes, debt service, revenue, spending) (Ec3)
14			Water (Price, consumption) (Ec4)
15		Environment of entrepreneurship through business support (Ec2)	Strengthen small- and micro- enterprises (formal and informal employment) (Ec5)
	SOCIAL		
16	Share of household income spent on energy (S13)	Develop policies for the city to lead the way with energy standards, emissions reduction in municipal buildings (E3)	Energy Access (electrical use, access, interruptions) (So1)
17		Long term drought plan and safe water supply long-term (W3)	Water Access (# with potable water supply, interruptions) (So2)
18		Continue the tradition of small neighborhood schools (Ed2)	Education (quality, student-teacher ratio, graduation numbers and rates) (So3)
19		Green way of street trails (H1) Year-round healthy recreational opportunity in the city (H2) Access to healthy food, community gardens (H3 Access to quality healthcare (H4) Regional recreational amenity such as conservatory, athletic center or a larger zoo/nature (H5)	Health (mortality rates, health care delivery, nutritional status) (So4)
20		Promote public safety through excellent police services and partnerships between agencies (Sa1)	Safety (homicide, # of police officers, crime rates, response time) (So5)
21			Fire & Emergency Response (# of firefighters, fire related deaths, response time (So6)
22			Poverty (income poverty, inequality) (So7)
23	Public transport ridership (S10)	Expand and improve existing MAT transport (frequency, venues, rapid transit, rideshare) (T2)	Transportation (public transit, transit modes, daily trips, distances) (So8)
24		Develop affordable housing near universities, develop a design standard for growth areas and new construction (NIND2)	Adequate Housing (durability, efficiency, crowding, density, costs) (So10)
25		Increase access to housing for workforce and low income residents (NIND3)	Shelter (homeless, informal living conditions) (So11)
26			Security of Tenure (evictions, authorized housing) (So12)
27			Access to Credit (finance for housing) (So13)
28			Access to Land (cost of land compared to income) (So14)
29			Promotes social integration and supports disadvantaged groups (segregation by income) (So15)

	Neves *et al.* [15]	Go 2030 [7]	Shen *et al.* [16]
30		Public art in public spaces (AC1)	Culture (# of cultural establishments, arts funding) (So16)
31		Increase access to arts classes and cultural programs in the city. (AC2)	
32		Establish Arts Commission (AC3)	
33		Develop spaces and programming for events (AC4); Develop more public gathering spaces for festivals and cultural events (AC5)	
34		Access to well-maintained parks (En2)	Recreation (Area of public spaces, % spending on public spaces, access to parks & playgrounds) (So17)
	GOVERNANCE		
35	Public participation in energy policy (P4)		Participation and civic engagement (voter participation, civic engagement, civic associations) (Go1)
36			Transparent, accountable and efficient governance (Go2)
37			Government (corruption) (Go3)
38			Sustainable management of the authorities and businesses (Go4)
	POLICY		
39	Ratio of energy based jobs to population (P1)		
40	Locally available finance schemes for efficiency and renewables (P2)		
41	Awareness raising campaign (P3)		
42	Local authority advice on energy issues (P5)		
	WATER & ENVIRONMENT		
43		Permanent Flood risk reduction (W1)	
44		Watershed management (W2)	
45		Green the city – plant more trees (En1)	
46		Reduce light pollution (En3)	
47		Reuse of waste water at the municipal level	
	ENERGY		
48		Smart grid strategy (E1)	
	TRANSPORTATION		
49		Develop additional Red River crossings for safety and efficiency (T3)	
50		Convert one way to two way streets (T4)	
51		Wayfinding to a strong core business district (downtown) (T5)	
52		Intelligent Transport systems to improve safety (T6)	

	Neves *et al.* [15]	Go 2030 [7]	Shen *et al.* [16]
53		Parking – Share night and day time parking sage, reduce parking requirements, activate parking structures. (T7)	
	ECONOMIC		
54		Promote infill and connections between strip commercial developments (Ec3)	
55		Promote jobs training at the local universities and colleges (Ec4)	
56		Improve communications infrastructure for tech business development (Ec5)	
57		Promote new higher technology businesses such as bioscience industry (Ec6)	
	INFILL AND NEW NEIGHBORHOOD DEVELOPMENT (NIND)		
58		Strengthen historical preservation (NIND4)	
59		Construct high quality, energy-efficient buildings (NIND 5)	

Table 1. Indicator-based assessment model comparison

LEGEND FOR TABLE 1:

En: Environmental	Ec: Economic	So: Social	Go: Governance
S: State	P: Policy	W: Water	NIND: Neighborhoods, Infill & New Development
AC: Arts & Culture	T: Transportation	H: Health	Sa: Safety
Ed: Education			

4. Analysis

A total of 59 indicators are compared in Table 1. Indicators have varying levels of overlap. 14.6% of the indicators showed 100% overlap in the three assessment plans. The following categories were common to and are included in these assessment models, namely (a) quality of air and emissions; (b) primary energy use patterns, ratios of renewables, incentives for reducing energy use and (c) public transport ridership, expand and improve existing frequency, venues, rapid transit, rideshare, transit modes, daily trips, distance. 24.5% of categories from [7] showed either overlap with [15] or [16] indicating areas of moderately common concerns but not common indicators for all three models. 32.9% indicators in [7] had 0% overlap with [15] or [16]. Some examples of these indicators were safety from floods, development of a strong center with special attention paid to the historic district, mitigating fast growth in favour of dense inner city development, and special attention to education from K-12 to higher education. The remaining (28%) category of indicators are present in [15] and [16] but not in [7], thus indicating gaps that need to be examined by the technical committee for the City of Fargo.

The following categories identified from the tabular analysis were found to be missing from the Go2030 plan which needs to be reviewed by City of Fargo planners:

i. Planned growth
    1. Geographically balanced settlement (planned growth and planned settlements
ii. Water availability
    1. Freshwater (total water resources, water use intensity, quality of water)
    2. Water (Price, consumption)
iii. Urban acoustics

1. Noise pollution (any noise plan, noise levels, exposure to high noise levels)

iv. Environmental planning
1. Mechanisms to prepare and implement environmental plans (master plan, environmental plan)
2. Biodiversity habitats, fragmentation, native species, foreign species)

v. Economic health / Access
1. Finance (taxes, debt service, revenue, spending)
2. Poverty (income poverty, inequality)
3. Security of Tenure (evictions, authorized housing)
4. Access to Credit (finance for housing)
5. Access to Land (cost of land compared to income)
6. Promotes social integration and supports disadvantaged groups (segregation by income)
7. Ratio of energy based jobs to population
8. Locally available finance schemes for efficiency and renewables

vi. Government
1. Transparent, accountable and efficient governance
2. Government (corruption)
3. Sustainable management of the authorities and businesses

vii. Education
1. Public participation in energy policy
2. Awareness raising campaign
3. Local authority advice on energy issues

Though the Go2030 process was an example of community participation reflected in the diversity of initiatives and guiding principles, the analysis shows that it lacked an effort to develop a comprehensive sustainability assessment plan with targeted goals for improvements and ongoing evaluations. It also lacked a quantitative evaluation of environmental status of the city or ongoing evaluations as actions are undertaken.

Based on the analysis in this paper, a broad framework of three-part assessment is proposed. Namely, mandatory category, optional category and local/unique category. (a) Mandatory: A substantial number of criterion will form the central core of issues that are mandatory for participating cities to assess qualitatively and quantitatively at a city-wide scale; (b) Optional: A fewer number of criterion would be arranged as a system of optional issues that may or may not be relevant categories of assessment for cities. Each city must be required to evaluate a minimum number of these "optional" issues both quantitatively and qualitatively to achieve a baseline of compliance with optional indicators; (c) Local: Lastly, fewer but a substantial number of criterion that consider local and unique conditions of the community should be proposed by the cities themselves. This is the assessment of unique local conditions that are not in the common core criteria or the optional criteria of assessment. Within each category the indicators could be defined by the following criteria: (a) Policy criteria (policy makers); (b) Urban morphology (planners); (c) Building and systems efficiency criteria (architects & engineers); (d) Economic criteria (government-business) and (e) Cross-boundary and in-boundary usage of urban materials (users of food, water, energy, materials) and lastly, occupant behaviors (occupants and markets):

5. Conclusions:

The framework proposed in this paper provides the grounds to create a comprehensive assessment tool that accounts for the central core of issues that are common to all cities where sustainability is concerned such as energy use, urban morphology, systems and building efficiency. In addition this framework accounts for multiple optional criteria that are relevant to urban sustainability in every city but might take various forms due to location, regional resources and demographics. These include the use of urban materials and associated behavioural and economic issues. Lastly, it allows cities to identify relevant issues in their own context and measure unique local conditions that will have a great impact on long-term sustainability. For example, for the City of Fargo, such unique circumstances include the ongoing flooding issues due to geography and topography, and the unprecedented fast

pace of growth due to the boom cycle of a fossil fuels economy. This paper is thus a first step towards a comprehensive framework and ongoing assessment tools for urban-scale sustainability.

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