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Abstract

This article reports and analyzes survey and focus group data regarding baseline goals for public works administration, against which new metrics can be constructed that meaningfully reflect the ideals implied by the notion of sustainability, focusing in particular on four policy areas in the Philadelphia metropolitan region. We administered a survey to key informants, all of whom had also agreed to participate in focus groups. The major conclusion from the survey and focus group data is that land-use policies could most likely serve as a common matrix for sustainability baselines and measurements in water, energy, and transportation.

Keywords

metrics, Philadelphia, public works, sustainability

Sustainability is a term with paradigm-shifting potential because it envisions a dramatic shift away from the hegemony of profit maximization and economic efficiency to a worldview that seeks a balance between economic development, social equity, and environmental stewardship. Yet it has come to mean so many things that it runs the risk of ultimately meaning very little (see, for instance, Marshall & Toffel, 2005; Norton, 2005, p. 48). An important challenge is thus to come to some rough consensus over what sustainability means at a given place and time, with a definition precise enough that it can be used to set policy goals related to the responsible use of natural resources.

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This article reports on the results of an initial attempt to establish baseline goals for public works administration, against which new metrics can be constructed that meaningfully reflect the ideals and imperatives implied by the notion of sustainability, focusing in particular on four policy areas (transportation, land-use planning, energy, and water and sewerage) in the Philadelphia metropolitan region. Toward that end, we administered a survey to both decision makers and technically proficient personnel from government, industry, the nonprofit sector, and academia in the Philadelphia region, all preselected through a snowball sampling method. Survey respondents were also invited to a workshop in June 2008, where they were divided into four separate focus groups, each covering a different policy area that reflected participants' areas of expertise. The purpose of the survey and focus groups was to establish a basic and initial understanding of how the regional environmental policy community understood and defined the notion of sustainability and what they would like to see in terms of new measurements that reflected their understandings.

Sustainability was an especially salient issue in the city at the time of our study because the term figured prominently in the 2007 mayoral election. The Democratic primary—which for all basic purposes determined the winner of the general election—was notable among other reasons for being the first in the history of the city in which each candidate released a “green paper” describing their environmental platform. The winning candidate, Michael Nutter, created the Mayor’s Office of Sustainability (MOS) and appointed the city’s first-ever sustainability director, Mark Alan Hughes, in May 2008.¹

Early in 2009, the MOS started to release details of the city’s sustainability plan, titled *Greenworks*, which was officially released in April of that year. Among large American cities, Philadelphia came a bit late to sustainability planning, having been preceded by plans in San Francisco, Chicago, Seattle, New York, and elsewhere (Portney, 2005). Much like other cities, Philadelphia’s plan consists of a series of laudable goals and initiatives, though with no overarching definition of sustainability, and thus no explanation of how meeting the stated goals would make the city more “sustainable” in any other than a very shallow sense (compare cf. Berke & Conroy, 2000). By focusing on common baselines for sustainability metrics, this present study represents an initial attempt to build on the agendas set by cities by providing more concrete criteria against which initiatives and goals can be judged. Philadelphia is a good case in this regard because it is representative of a group of other large and midsized U.S. cities that have experienced dramatic changes over the last 60 years that have had a significant impact on infrastructure systems, such as the dispersion of population and businesses from the central city to the surrounding suburbs and the shift from a manufacturing to a service economy, with resultant changes in land use, commuting patterns, and spatial socioeconomic and racial segregation (Adams, Bartelt, Elesh, & Goldstein, 2008).

As described in the following sections of this article, in designing our study, we assumed that (a) baselines should be derived from fundamental definitions of sustainability, though with the recognition that different, and conceivably conflicting, definitions might require multiple baselines and measurements and (b) from those baselines

we assumed that appropriate spatial scales were required to adequately define the events or objects to be measured. Our survey focused on definitions of sustainability, appropriate scales of measurement, and the objects and events that should be measured. We used the focus groups primarily to specify baselines in more detail. The major conclusion from the survey and focus group data is that land-use policies could most likely serve as a common matrix for sustainability baselines and measurements in water, energy, and transportation.

The centrality of land-use planning to urban sustainability is a well-trodden topic in the literature, though the specific relationship between planning and sustainability is often simply assumed, usually in the form of an axiom that the “compact city” is by definition also a sustainable city, despite ample contradictory evidence (Holden & Norland, 2005; Neuman, 2005). Possibly, the best that can be said is that the appropriate urban planning policy from the standpoint of sustainability is one specifically tailored to a given place (Guy & Marvin, 2000, p. 11; Haughton, 1997). Thus, this current study contributes a preliminary foray into the relationship between land-use planning and sustainability in public works within a single region, Philadelphia, with the promise that the findings here might serve as the basis for future research. In particular, we suggest that our proposal to measure sustainability in public works through land-use planning would fruitfully expand the usefulness of Yosef Jabareen’s (2006) matrix of sustainable form.

More specifically, we suggest that land-use planning variables, such as the type and mix of land uses, and population and housing density, be used to construct scales of sustainability on which baselines can be established. The impact of planning variables on sustainability can be determined through regression analyses that estimate the impact of land use on water quality, vehicle miles traveled, energy use, and other more direct measures of sustainability. In making this suggestion, we are choosing one among an array of possible ways in which sustainability might be integrated into planning models, similar to what Condon et al. (2009) identified, in their survey of primarily geographic information system (GIS)-based urban planning tools used to measure the impact of land-use decisions on greenhouse gas (GHG) emissions, as observation-based simulation that establishes the basic relationships between land use and GHG emissions through “statistical techniques [that] can establish general relationships between two parameters . . . such as the impact of density on the proportion of nonvehicular trips” (p. 12).

Defining and Measuring Sustainability

Measurement is “the assignment of numerals to objects or events according to rules” (Stevens, 1946, p. 677). To construct at least an ordinal scale of measurement (i.e., a scale that provides a rank ordering, though not the magnitude of difference between ranks) some baseline must be established, against which objects or events can be ranked. This relatively obvious point has been widely neglected in sustainability studies. As Bell and Morse (2008, pp. 39-40) have summarized the problem in their review of the literature, “A value of X units is meaningless unless we have an idea of

what range equates to sustainability or, in other words, what represents the target or reference condition." A *sustainability baseline*, then, is the point in a scale below which the thing being measured is unsustainable, and above which it is sustainable.

City sustainability plans have to some degree skirted the definition of baselines by adopting "goals" and "targets" that represent improvements over current conditions, thus making current conditions the implicit baseline, above which anything becomes, ipso facto, "sustainable." A good example is GHG emission reduction targets for which, unlike many sustainability goals, there is a relatively clear baseline. For instance, Chicago establishes an interim goal of reducing GHG emissions to 25% below 1990 levels by 2020 and a final goal of 80% below 1990 levels by 2050 (Chicago Department of Environment, n.d., pp. 10-11). The 2050 target was established with reference to the findings of the Intergovernmental Panel on Climate Change (IPCC, established by the United Nations Environment Program) that "a 50-85 percent reduction below 2000 global GHG emissions by 2050 is required to achieve an atmospheric concentration of GHGs at 445-490 ppm and stabilize the climate at 2.0-2.4 degrees Celsius above pre-industrial temperatures" (Bernstein et al., 2008, p. 10). The city of Seattle has adopted an identical 2050 GHG reduction goal as Chicago (City of Seattle, 1995-2010), though with no explanation for why the target achieves sustainability.

In contrast to Chicago (and possibly Seattle), the GHG reduction targets established by San Francisco and Philadelphia provide no clear indications of how they would achieve something that can meaningfully be called "sustainability." Indeed, San Francisco defines its "baseline" as its 1990 GHG emissions level, against which reductions are measured. The city's goal of reducing emissions 20% below 1990 levels by 2012 is certainly laudable, though explained only by reference to the fact that it is more ambitious than the 2012 targets established by the Kyoto Protocol (which themselves are not justified by any specific baseline definition of sustainability), though less than those established by the IPCC (San Francisco Department of the Environment & San Francisco Public Utilities Commission, 2004, ES-4-5, 2-1-2). In the case of Philadelphia, *Greenworks* establishes a GHG reduction target of 20% below 1990 levels, with no mention of any kind of baseline (City of Philadelphia, Mayor's Office of Sustainability, n.d., pp. 28-30).

The Philadelphia GHG reduction target also raises a second measurement issue, of spatial scale. The *Greenworks* target is in part based on an earlier target, established in the 2007 *Local Action Plan for Climate Change*, to reduce emissions by 2010 to 10% below 1990 levels (City of Philadelphia, Mayor's Office of Sustainability, n.d., p. 3). By the time of the 2007 report, the target had in fact almost been met, in part simply because the city had lost population and industry (City of Philadelphia, Sustainability Working Group, 2007, pp. 3-4). Surrounding counties had gained population and industry during this period (Adams et al., 2008, pp. 17, 42-51), leading ostensibly to an increase in GHG emissions in the larger metropolitan region that offset if it did not entirely negate the reduction in the city. The change in GHG emissions in Philadelphia over time, in other words, could only be translated as an improvement in sustainability at the city level but not as a regional or national improvement (a fact the report

acknowledges). Were GHG emissions in the city measured per capita or as a ratio to some unit of economic output, they could conceivably be commensurable with measurements of GHG emissions at higher geographic scales, though would have likely shown little reduction in emissions at the city level.

In this article, we only begin the process of formulating baselines for sustainability metrics in public works, through an effort to define what those baselines should be. Most fundamentally, baseline definitions must embody the general moral imperative of intergenerational justice that lies at the core of the sustainability concept (see, for instance, Dobson, 1999, chap. 3-5; Howarth, 2007; Padilla, 2002; Toman, 1994). As the World Commission on Environment and Development (WCED, 1987, p. 43) put it in what is probably the most widely cited definition in the literature, “sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” In this context, *needs* are generally categorized as environmental, economic, and social—a “triple bottom line” (see Elkington, 1994, 1998; Henriques & Richardson, 2004).

For the sake of this study, we focused on two major issues suggested by the literature as crucial in the construction of sustainability metrics. First, baselines that establish goals in preserving or improving resources for future generations may conflict. The classic conflict is of course that between economic development and environmental protection (see, for instance, Feiock & Stream, 2001), though any variety of conflicts between sustainability goals are possible, depending on how they are defined and emphasized in relation to one another. Indeed, conflicts between economic development, social equity, and environmental protection goals might even suggest that a universal definition and measurement of sustainability is unrealizable, and attempts at such a metric have generally been unsuccessful (Böhringer & Jochem, 2007; Hanley, Moffatt, Faichey, & Wilson, 1999).

Second, sustainability baselines and goals must be set at specific scales. Sustainability has been widely discussed at global (WCED, 1987), national (Esty et al., 2008), and local (Portney, 2005) levels, though there has been little attempt to establish whether baselines at different geographic scales are commensurable with one another (see, however, Costanza et al., 2004). For instance, does the now-common idea of a “sustainable city” imply that cities are important nodal points for establishing a sustainable world, in which case the city is a unit of measurement against a broader benchmark, or merely that cities themselves should be made sustainable, in which case city-level benchmarks would be adequate (Satterthwaite, 1997, p. 1682)? As the example of Philadelphia’s GHG reduction targets indicates, city-level sustainability metrics can be highly misleading when set against a metropolitan context. Yet, at the same time, a city that “exports” its environmental problems (as Philadelphia conceivably has done with its emissions) may still be “sustainable” in some sense. As heterotrophic systems and centers of wealth, cities are often assumed to be inherently unsustainable in the sense that their “ecological footprint” will always extend beyond their borders (Rees & Wackernagel, 1996; see also Haughton, 1999, p. 234; Kennedy, Cuddihy, & Engel-Yan, 2007), yet if those cities import resources from places that have resource

surpluses and a sustainable extraction rate, then the larger system of trade may be sustainable (see van den Bergh & Verbruggen, 1999).

The Survey

Our survey and focus group participants were not randomly selected, and while thus not representative in a statistical sense, they did represent what Hugh Hecló (1978) has called an “issue network,” or what John Kingdon (1995) has called a “policy community” (pp. 117-121), which could not have been captured through a random selection process.² As this was not a representative sample, we report our survey results without confidence intervals or evidence of statistical significance. They should be interpreted as suggestive evidence of the opinions of our participants, all of whom can be considered “key informants” (Payne & Payne, 2004, pp. 134-138).

There is some evidence from random sample polls that the Philadelphia population supports local environmental policies. In a series of polls conducted in 2006, commissioned by Citizens for Pennsylvania’s Future as part of its Next Great City initiative, majorities of both Philadelphia residents and business owners “approve[d] of increasing city funding so the city can address many features of the neighborhood environment, including improving air quality, updating the water and sewer systems, modernizing zoning regulations, expanding the city’s recycling program, improving parks, and helping reduce energy use Almost nine in ten residents and business owners stated that Philadelphia must clean up its environment to become a competitive city” (Black, n.d., p. 3).

Our participants were selected through a modified snowballing technique, starting with recommendations from a subcommittee of the steering committee for the Urban Sustainability Forum (USF) of the Academy of Natural Sciences of Philadelphia. The USF is a public lecture series that, since its inception in 2005, has become the premier regional venue for discussing environmental issues, including a series of mayoral debates on sustainability in which the candidates discussed their green initiatives. People invited based on the recommendation of the USF subcommittee were asked to recommend additional people who were regional leaders in environmental policy. Invitations were sent out with the guidelines that all participants should be in a decision-making position or be technically proficient. In addition, to get roughly equal representation of people from government, academia, industry, and the nonprofit sector, we also invited select members from the boards of directors of organizations from which people had already been invited.

The organizations that responded to our survey and participated in the focus groups are listed in Appendix A and the survey questions are listed in Appendix B. Of the survey respondents, 15 (27%) identified their area of expertise as water, 12 (22%) as energy, 12 (22%) as land use, and 16 (29%) as transportation. In terms of employment, 16 (27%) respondents were faculty members at a college or university, 6 (11%) worked for a for-profit company, 10 (18%) for a nonprofit, 8 (15%) for a local government agency, 4 (7%) for a state government agency, 3 (5.5%) for a federal agency, and 6 (11%) for a multijurisdictional commission³ (Table 1).

Table 1. Cross-Tabulation of Respondents by Area of Expertise and Place of Work (Errors Due to Rounding)

Place of work (column)	Area of interest and expertise					No response	Total (%)
	Water	Energy	Land use	Transportation			
University or college	6	2	5	3	0	16 (27.2)	
For-profit company	1	3	1	1	0	6 (10.9)	
Nonprofit company	3	1	3	3	0	10 (18.2)	
Local government agency	3	1	1	3	0	8 (14.5)	
State government agency	0	1	0	3	0	4 (7.3)	
Federal government agency	0	3	0	0	0	3 (5.5)	
Multijurisdictional government commission	1	1	1	3	0	6 (10.9)	
No response	1	0	1	0	0	2 (3.6)	
Total (%)	15 (27.2)	12 (21.8)	12 (21.8)	16 (29.1)	0 (0)	55 (100)	

The survey was distributed via email to 55 people, all of whom answered at least some of the questions, though only 43 (72%) completed the survey entirely. Questions 1 and 2 asked about employment and expertise, to confirm adequate representation among all sectors under examination. Questions 3 through 5 probed for different emphases that different respondents placed on the notion of sustainability and were designed in part to confirm our assumption that sustainability was conceived of in terms of intergenerational justice. Question 3 asked respondents to choose between three justifications for preserving the world's resources, in terms of (a) economic development, (b) intergenerational justice, or (c) the intrinsic value of nature. Question 4 then asked respondents to choose between inter- or intragenerational justice. Finally, Question 5 asked respondents to define sustainability in their own words, so as to capture any diversity in answers that was not already captured in Questions 3 or 4. We assumed that, the greater the diversity of answers to Questions 3 through 5, the greater the potential conflicts among respondents in arriving at collective and comprehensive baselines for sustainability metrics. Most respondents likely considered all three justifications for environmental protection offered in Question 3 to be legitimate and most likely also would prefer both inter- and intragenerational justice. Our goal, however,

was to uncover potential conflicts in cases where respondents would have to make choices between the values subsumed in the notion of sustainability.

Questions 6 through 9 asked about the scale at which sustainability should be measured and the specific objects or events to be measured. Question 6 offered respondents six possible levels at which sustainability could be measured (local, metropolitan, state, regional, national, global) and allowed them to choose as many levels as they liked; Question 7 asked respondents to name actual objects or events that could be measured; and Question 8 asked respondents to indicate the scales at which it would be most appropriate to measure the items they listed in Question 7. We assumed that any great discrepancies between the scales chosen in Questions 6 and 8 would reflect some dissonance between respondents' definitions of sustainability in theory and practice or between their ideal definitions and the data available for measurement. Question 9 asked respondents if the measures of sustainability they provided could be combined in a single measure, as an initial test of the potential demand and feasibility of creating a unified index.

Survey Results

Responses to both Questions 3 and 4 provide strong support for our initial assumption that intergenerational justice lies at the conceptual core of sustainability. When asked to justify environmental protection either on the grounds of intergenerational justice, economic development, or the intrinsic value of nature, the majority of respondents chose intergenerational justice (60%), followed by the intrinsic value of nature (22%), and then economic development (13% (Table 2)). When asked in Question 4 to choose between inter- or intragenerational justice, 49 respondents (89%) chose intergenerational justice whereas 2 (4%) chose intragenerational justice (the remaining respondents offered no response). The survey also suggested that water professionals' notions of sustainability may differ significantly from those in other policy areas. Of the 15 respondents who identified their area of expertise as water, 6 (40%) justified environmental protection on the basis of the intrinsic value of nature, compared with 6 out of the 40 other respondents (15%). Excluding the responses of the water professionals, support for intergenerational justice as a justification for environmental protection increased from 60% to 83%.

The open-ended answers to Question 5 suggest stronger support for intragenerational justice than suggested from Question 4. Of the 45 respondents who offered a set of definitions, 43 made some explicit reference to satisfying present needs. Responses to both Questions 5 and 7 suggested strong support as well for a social equity definition of sustainability. Seven of the responses to Question 5 made explicit reference to social equity. In addition, of the 205 measures offered in response to Question 7, 18 were explicitly related to social equity, including "disadvantaged peoples recreating in our parks and rivers," "human hunger," employment and poverty rates, access to health care, "investments in green-collar jobs," and availability of quality education.

Table 2. Cross-Tabulation Between Area of Expertise/Interest and Response to the Question, Which of the Following Do You Think Is the Best Reason to Preserve the World's Natural Resources?

Which of the following do you think is the best reason to preserve the world's natural resources? (column)	Area of interest/expertise (row)				Total (%)
	Transportation	Water	Energy	Land use	
To ensure future economic growth and prosperity	1	0	3	3	7 (12.7)
To protect the environment and its resources for future generations	12	8	9	4	33 (60)
Because nature has intrinsic value independent of human needs and we thus have a moral obligation to preserve the environment	3	6	0	3	12 (21.8)
No response	0	1	0	2	3 (5.5)
Total (%)	16 (29.1)	15 (27.3)	12 (21.8)	12 (21.8)	55 (100)

In answer to Question 6, all respondents except land-use planning professionals preferred to define sustainability in terms of higher geographic scales. Forty-three respondents chose 119 scales to which their definitions of sustainability (from Question 5) applied, the most popular being global (chosen 28 times, or 21% of the time), followed by national (21 times, or 16%), regional and metropolitan (each chosen 20 times, or 15% each), local (16 times, or 12%), and, finally, state (14 times, or 11%). Among the 41 scale choices made by land-use planning professionals, however, the local scale was chosen 7 times (17%), metropolitan scale 8 times (20%), state scale 5 times (12%), regional scale 7 times (17%), and national and global scales 6 times (15%) each. Among all respondents, the scale ordering nearly reversed itself when respondents were asked, in Question 8, the appropriate scales to measure the more specific items they had identified for measurement in Question 7. Of the 111 scales chosen by 44 respondents, the most popular was metropolitan (chosen 25 times, or 23% of the time), followed by local (23 times, or 21%), regional (19, or 17%), global (18 times, or 16%), national (14 times, or 13%), and state (12 times, or 11%).

Cross-tabulating the answers to Questions 6 and 8 indicates even more clearly that respondents tended to define sustainability at scales higher than they suggested it should be measured. For instance, Of the 28 respondents who defined sustainability

Table 3. Cross-Tabulation of the Scales Which Respondents Thought Best Applied to Their Definitions of Sustainability and the Scales at Which Their Definitions of Sustainability Could Best Be Measured

To which scale does your definition of sustainability best apply? (column)	At which scale do your measures of sustainability work best? (row)						
	Local	Metro	State	Regional	National	Global	Total
Local	14	1	0	0	0	1	16
Metro	4	15	1	2	3	2	27
State	1	3	7	1	1	1	14
Regional	3	6	1	12	0	2	24
National	1	5	0	3	10	3	22
Global	5	7	3	8	4	14	41
Total	28	37	12	26	18	23	144

Note: Cells to the left of the diagonal indicate an instance when respondents chose scales in their definitions of sustainability that were higher than the scales at which they believe sustainability could actually be measured—for instance, if a respondent chose only the global scale in Question 6 and only the local scale in Question 8. Cells to the right of the diagonal indicate an instance when respondents chose scales in their definition of sustainability that were lower than the scales at which they believe sustainability could actually be measured—for instance, if a respondent defined sustainability only in terms of the local level, yet said sustainability could only be measured at a national level. In instances when respondents chose less scale options in one question than in another, we matched their lesser choices successive times. For instance, if a respondent chose only “global” in Question 6 but chose both “local” and “metropolitan” in Question 8, we matched “global” to both “local” and “metropolitan,” and the respondent was counted in two cells to the left of the diagonal.

globally in Question 6, only 14 also said it should be measured globally in Question 8. By contrast, of the 16 people who defined sustainability locally, 14 also said it should be measured locally (Table 3). The tendency to define sustainability at higher scales than it could be measured may reflect the common environmental mantra, “think globally, act locally.” It might also reflect a sense that local measurements should serve as proxy measures or indicators of broader phenomenon, in which case those local measurements should be commensurable with higher-scale measurements.

At the same time, however, respondents were clearly wary of combining measurements into a single index, as reflected in their responses to Question 9, which asked if the individual measurements they supplied could be combined into a single measure, to which 27 (63%) responded in the negative whereas 16 (37%) responded positively.

Finally, when survey respondents were asked to list at least 3 things that could measure sustainability in Question 7, the vast majority of the 205 measurements offered could be divided into 11 categories: energy (suggested 32 times), water (31 times), solid waste and recycling (15 times), land use (15 times), transportation (13 times), air quality (10 times), GHG emissions (8 times), food (8 times), buildings and building materials (8 times), biodiversity (5 times), and temperature (4 times). Among those

few who provided specific examples of broad well-being measurements, examples included GNP or “economy by triple bottom line or value that GDP” and such suggestions as “comfort,” “peacefulness,” “happiness,” “extent of personal enjoyment in sustainable lifestyles,” “general ‘life satisfaction’ or ‘personal happiness’ surveys” and “balance of human needs and ecological needs.”

The Focus Groups

Focus group participants were presented the survey results on the day they convened to make sure everyone was similarly primed. Cross-referencing the list of survey respondents with a sign-in sheet on the day of the focus groups indicated only minimal likely discrepancies (estimated at 1-3 people, or 2%-6%) between who filled out the surveys and who attended the focus groups.

All of the focus groups except the energy group came to at least some rough definition of a baseline goal against which sustainability could be measured. Water group participants agreed on the hydrologic cycle prior to human intervention as a baseline for measuring water sustainability, an apparently appropriate goal for a group that had disproportionately defined sustainability in the survey (Question 3) in terms of the intrinsic value of nature. In the focus group, however, participants were emphatic that their baseline definition did not preclude human consumption of water and was thus not reflective of a “deep green” ideology.

The transportation group defined a baseline by distinguishing between “essential” and “constructed” needs for transportation. Transportation demand is constructed, for example, in the case of a new road built into undeveloped land that then stimulates development and thus new road traffic. Essential demand, which was suggested as the sustainability baseline, is that which exists prior to new means of transit, as in the case of inner-city residents who work in the suburbs whose commute times are lengthened by their dependence on weak transit systems.

The planning group agreed for the most part on the percentage of city land zoned for mixed use as a sustainability measure, with the baseline being an ideal city where all land is mixed use, though this did not receive unanimous consent. One participant noted, for instance, that if the city maintained land zoned exclusively for industrial uses, it would be well positioned to benefit from rising energy costs that might facilitate a resurgence in local manufacturing. A change in zoning from industrial to mixed use would be largely irreversible, since a change back to industrial use would involve displacement and NIMBY issues, thus constraining future possibilities for manufacturers to locate in the city.

Scale received the most attention in the water group, starting with one participant’s comment that the City of Philadelphia was sustainable in the sense that it returns more clean water to the Delaware River than it takes out. Other participants rejected this definition for two reasons. First, measuring intake and outtake at the city level ignores how the larger functions of the hydrologic cycle have been altered by urbanization (for instance, the elimination of smaller tributaries and pervious surface that has reduced

evapotranspiration), which has made the city itself less sustainable from a larger ecological perspective. Second, upstream development that creates greater runoff degrades the quality of the water the city draws, thus increasingly compromising its ability to return clean water to the Delaware River. In addition, water group participants noted that sustainability measurements at the city-level may run in an opposite direction to sustainability measures at the metropolitan or regional level, as the greater the extent to which metropolitan population growth is concentrated in the central city, the less stress regional growth will put on the watershed, even as it makes the job of the city harder in maintaining sustainable water practices.

In contrast to water professionals, land-use focus group participants quickly agreed that the city was the most appropriate scale at which to discuss sustainability metrics, an appropriate conclusion for a group that also disproportionately defined sustainability in the survey (Question 6) at the local and metropolitan levels. The energy group decided on a different set of scales than that offered in the survey, agreeing that energy sustainability should be measured at the levels of buildings, infrastructure, and transport.

In addition to specifying different scales, the discussion among energy group participants was distinctive for at least three other reasons. First, participants clarified three dimensions along which sustainability should be measured, with measures for each dimension: (a) an economic dimension of energy sustainability measured by load-growth and base load and peak; (b) an ecological dimension measured by the fraction of renewable energy in the energy mix and the carbon intensity of different energy sources; and (c) a social dimension measured by energy cost, affordability, and access to energy-efficiency programs. Second, the energy group clarified a time scale for measuring sustainability, suggesting short-term measurements of sustainability in specific energy systems and long-term measurements of different policies' abilities to foster the adoption and use of more sustainable energy systems (whose sustainability would be measured in the short term). Third, participants emphasized measurement in terms of categories of use (that is, for buildings, infrastructure, or transportation) rather than supply (e.g., coal, natural gas, etc.), so that metrics could be used to inform consumer choices. The emphasis in the energy group on consumers, and thus on purchasing power, was connected as well to participants' greater focus on social and economic equity, as reflected in the multiple dimensions they specified for measurement.

Discussion

The survey and focus group data point to both the limits and possibilities for establishing sustainability baselines and metrics for public works administration in the Philadelphia region. First, the data themselves are of course limited by the fact that they reflect the opinions of a set of participants who, while arguably crucial to the implementation of any environmental policy, are also not representative of the larger regional population. A second possible limitation is the divergent definitions of sustainability, especially between different professional fields. Although most survey and focus group participants were in apparent agreement that sustainability referred to

intergenerational environmental justice (though the open-ended portions of the survey and the focus groups suggest that Questions 3 and 4 may have overstated this agreement), the notably divergent definitions of sustainability between the water professionals and other participants suggests the necessity of area-specific baselines and measurement.

Yet at the same time, the focus group discussions revealed commonalities between policy fields that suggest land-use planning as a common matrix for sustainability baselines and measurement in water, transportation, and energy. In the water group, for instance, the choice of the hydrologic cycle prior to human intervention as a baseline, the focus on the larger ecological benefits of water beyond drinking and sewerage, and support for regional population growth concentrated in the central city, all imply land-use policies that would decrease impervious surface, restore tributaries, and restrict sprawl-type development. Similarly, the transportation group's focus on "essential" transportation demand also suggests restrictions on sprawling development. In fact, insofar as it aims at sustainability by a decrease in energy consumption through a decrease in vehicle miles traveled, and a decrease in impervious surface by a restriction on new roadways, the transportation baseline can be collapsed into the energy group's sustainability matrix (which included transportation) and the water group's baseline. The energy group's emphasis on end users also suggests land-use policies, such as zoning that would encourage smaller houses, which was mentioned in the focus group.

Interestingly, the 15 suggested measurements of sustainability from Question 7 that related to land use all referred to some variety of open space (e.g., the percentage of "greened" vacant lots or the acreage dedicated to agriculture), although none mentioned the extent of land zoned for mixed use, as was suggested in the focus group. The likely difference is that the suggestions from Question 7 used land use as a measurement of sustainability in general, whereas the focus group was charged with defining sustainability specifically with regard to land use. The fact that there is a disjuncture between these two things suggests that sustainability baselines are not appropriate for land use but that land-use outcomes could and should be used as a measure of sustainability in other areas.

Our survey and focus groups thus suggest a comprehensive model (or set of models) of sustainability in which land-use policies (e.g., open space requirements, restrictions on impervious surfaces, or zoning bonus provisions for meeting energy efficiency goals) serve as independent variables and sustainability metrics (derived from the baselines that we have begun to establish, such as those associated with a return to the prehuman hydrologic cycle or a reduction in nonrenewable energy consumption) serve as dependent variables. The beta coefficients from the models would measure the impact of the land-use policies on the sustainability measures, thus providing an empirical basis for using those policies as broader measures of sustainability.

Using land-use policies as sustainability measures still leaves unanswered the question of establishing baselines that define sustainability within a given measure. For

instance, if sustainability in water is defined as a return to the prehuman hydrologic cycle, and a decrease in impervious surface moves a city closer to the prehuman hydrologic cycle, it still does not specify the decrease in impervious surface necessary to create a sustainable city water system. What it does do, however, is narrow the question of sustainability to a select number of measures, using policies over which city officials have substantial control.

There is already substantial evidence that some land-use practices are related to possible sustainability measures, as in the cases, for instance, of well-established relationships between impervious surface and water quality (Brabec, Schulte, & Richards, 2002) and between energy consumption and housing stock (Holden & Norland, 2005, pp. 2149-2150), although these relationships clearly vary by place and thus cannot simply be assumed in the establishment of local and regional metrics. Moreover, most of the existing evidence is of only discrete relationships between a single land-use practice and a single type of resource use. The model proposed here, by contrast, would treat land-use practices as proxy measures of sustainability in a broader sense, and it thus fits with Jabareen's (2006) recent attempt to unify urban forms and design concepts in a "sustainability urban form matrix." Jabareen's matrix provides a framework for comparing different urban forms (neotraditional development, compact city, urban containment, and eco-city) on the basis of the extent to which each type of form embodies different sustainable design concepts (density, diversity, mixed use, compactness, sustainable transportation, passive solar design, and ecological design). Jabareen's design concepts overlap to a great extent with possible land-use policies, and they can thus be used, as we have suggested here, as independent variables in models that predict their impact on public works sustainability measures. As variables connected empirically to sustainability measures, Jabareen's design concepts could then also be used to more rigorously assess his hypothesized relationships between sustainability and urban form.

Conclusions and Future Directions

Our study represents an initial step toward building a set of metrics for the Philadelphia metropolitan region that can meaningfully assess the extent and means by which the region is extracting and using natural resources in public works, so that those resources might be preserved in perpetuity. Our results suggest that a potentially fruitful avenue for future research would be specifying the impact of land-use policies and practices on measurements related to water, energy, and transportation, so that used land could serve as a common matrix for sustainability metrics.

To be sure, our study raises more questions than it answers. In doing so it suggests at least four new avenues for research. The first avenue, of course, is in specifying and testing a model of the relationship between land use and sustainability in public works. This would require as well a better specification of the actual measurements to be used in water, energy, and transportation. The second avenue of research would be to

include in the model (once specified) metrics for a greater array of policy areas, to gain a greater understanding of the full extent to which land use can explain various facets of regional sustainability. Third, building on Jabareen (2006), the model proposed here could be included in a larger model that placed public works and land-use criteria in the larger context of more general urban forms. Fourth, a final area for expanded research would be to expand on the sustainability baselines and definitions through broader random sample surveys.

Appendix A

Organizations Represented in the Survey and Focus Groups

Academy of Natural Sciences

Ameresco, Inc.

Andropogon Associates

Cahill Associates

Center City District

Clean Air Council

Delaware River Basin Commission

Delaware Valley Regional Planning Commission

Drexel University

Econsult

Energy Coordinating Agency

PennFuture

Pennoni Associates, Inc.

Pennsylvania Department of Transportation

Pennsylvania Horticultural Society

Pennsylvania Public Utility Commission

Philadelphia Association of Community Development Corporations

Philadelphia City Planning Commission

Philadelphia Law Department

Philadelphia Office of the Controller

Philadelphia Office of the Mayor

Philadelphia Water Department

Southeastern Pennsylvania Transportation Authority

SunTechnics Energy Systems, Inc.

Sustainable Business Network

Temple University

United States Environmental Protection Agency, Region III

University of Pennsylvania

Urban Engineers

Villanova University

William Penn Foundation

Appendix B

Survey Questions

1. Which of the following policy areas is most relevant to your area of expertise and/or interest?
 - a. Water
 - b. Energy
 - c. Land-use planning
 - d. Transportation
2. Where do you work?
 - a. A college or university
 - b. A for-profit company
 - c. A nonprofit company
 - d. A state government agency
 - e. A local government agency
 - f. A federal government agency
 - g. A multijurisdictional government commission
3. Which of the following do you think is the best reason to preserve the world's natural resources?
 - a. To ensure future economic growth and prosperity.
 - b. To protect the environment and its resources for future generations.
 - c. Because nature has intrinsic value independent of human needs and we thus have a moral obligation to preserve the environment.
4. If you had to choose would you do any of the following:
 - a. Guarantee equal access to the world's natural resources to all living people, even if it meant that those resources might not be available for future generations.
 - b. Guarantee the world's natural resources for future generations, even if it meant that some people living today might be denied access to those resources.
5. In three sentences or less, provide your own definition of sustainability.
6. To which of the following scales does your definition of sustainability best apply? (You can choose more than one answer.)
 - a. Local level (i.e., a single jurisdiction such as a city or town)
 - b. Metropolitan level
 - c. State level
 - d. Regional level (e.g., Midatlantic, New England, etc.)
 - e. National level
 - f. Global level
7. Name at least three things that could be measured that would indicate the extent to which some area (e.g., a city, region, state, country, or the world) was sustainable, as you defined it. (You will have a chance at the end of this survey to elaborate on these answers if you'd like to.) [Respondents

were provided space for listing a maximum of ten things that could be measured.]

8. At which of the following scales would your measurements most accurately measure sustainability? (You can choose more than one answer.)
 - a. Local level
 - b. Metropolitan level
 - c. State level
 - d. Regional level
 - e. National level
 - f. Global level
 9. Could your measures of sustainability be combined to provide a single sustainability measure?
 - a. Yes
 - b. No
 10. Use the space below to provide any elaborations or qualifications to your answers regarding (a) your sustainability measurements; (b) the scales to which those measurements would best apply; and/or (c) the combination of your measures into a single measure.
-

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Notes

1. Hughes left the MOS and was replaced by Katherine Gajewski in 2009 (see Hughes, 2009).
2. At least anecdotal evidence that we captured a large proportion of the regional environmental policy community comes from Mark Hughes's email response to our invitation: "your participants are virtually all on my must-speak-with list! . . . It's hard to imagine anything critical happening that day [June 19, 2008] on sustainability with all your participants engaged at the Forum [our conference] . . ." (Hughes, personal communication, May 15, 2008).
3. Percentages are rounded to the nearest whole number and may thus not add up to 100%.

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