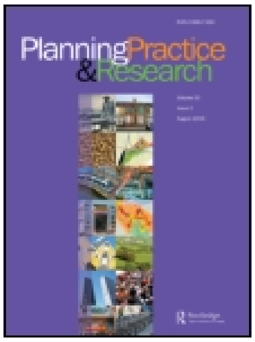

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ARTICLE

Conceptualization and System Design in the Monitoring of Urban Form

ISABEL CERON CASTANO & DAVID WADLEY

Abstract

Historically, humanity has congregated in certain places to benefit from a division of labour and scale economies. Yet, in this process, issues inevitably emerge surrounding urban form, understood as the physical configuration of the built environment. As settlements expand and technologies change, so do these inherent problems. Official responses are put in place to address them, thereby creating direct and indirect social costs and distorting pure market forces. Efficacious and transparent governance presumes accountability and some means of appraising these interventions. Thus, systems have been established worldwide to monitor physical changes in urban form against predetermined goals and objectives. Yet, many of these efforts have fallen short in terms of effectiveness, efficiency and equity and, whether acknowledged or not, they continue to do so. The research and policy focus should be upon the fundamentals – the conceptualization stage and design of such systems. In this article, diagnosis of common problems leads to six ameliorative strategies applicable in these early phases which could improve overall outcomes. Monitoring the physical features of the built environment is significant not only in terms of the logic and integrity of city planning but also for the welfare of urban populations. While equally important and challenging problems of implementation exist on the path to urban sustainability, they are left for another day.

Introduction

Urban form, the physical expression and extent of a town or city, has most likely preoccupied humanity with problems of quantity and quality since the times of antiquity. The size and composition of such form first determine urban distances from the city centre to a boundary, from boundary to boundary and from any point of local interest to another. Next, as distances expand with the growth of a settlement, relative location and intra-urban accessibility change commensurately. Access and servicing can thereby be facilitated or become more difficult. In any given state of technology, changes in physical scale have impacted the provision of infrastructure. Technological developments, as for example in fixed transport systems, have had dramatic effects on form. Thus, the phenomenon of suburbanization followed the onset of rail travel in the 1800s, only to accelerate again in the 20th century with the upsurge of automobile ownership. Now, energy

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efficiency and emissions concerns are among the urban *Leitmotive*, with reactionary movements underway to achieve ‘consolidation’, ‘smart growth’ and ‘compact cities’. It would be naive to think that such initiatives will not involve a new raft of known or unanticipated problems.

In this milieu, Millichap (1998, p. 340) describes ‘monitoring’ as the basic mechanism within policy making to address the ‘systemic fallibility of decision making’. Usually effected by means of statistical or other indicators, those simple, uni-dimensional parameters which provide an interface to complex dynamic systems, it should play a central role in the operation of urban growth management policies. By keeping track of changes which occur in the built environment, indicators provide the best way to determine the success or otherwise of actions undertaken towards the general aims of containing growth and fostering more sustainable development patterns. Their primary role is to assess the progress, impact and achievements of a given policy in relation to its stated objectives. Information conveyed through indicators also creates utility in improving governability by helping steer public action (Hezri & Dovers, 2006); signalling social costs of production when the market fails to do so (Hueting & Reijnders, 2004); warning about turning points in ongoing trends; fine-tuning policy goals and instruments; and helping validate/invalidate social theories underlying policy (Button, 2002). Indicators further influence the style of the planning operation, as between ‘fast and light’ or ‘deep and delayed’ and, hence, introduce concepts of risk and effectiveness (Perdicoúlis & Glasson, 2011).

Yet, if indicators are poorly designed or put into place, a monitoring system can offer a distorted picture of progress, potentially hiding the need for urgent improvements in policies and programs and allowing social problems to build up without warning. Here is a brief example from Australia. In 2008, the first monitoring report of the South East Queensland Regional Plan announced significant improvements in the pattern of built form across its area of jurisdiction (Queensland Government, 2006, 2008). The indicators used were at odds with current theoretical progress on measurement issues achieved by urban morphologists such as Moudon (2002) and Talen (2003). Specifically, and among other issues, the chosen measures lacked appropriate data aggregation, spatial referencing and relationship with the material characteristics of the urban form. While reports suggested that new developments were creating more compact and sustainable settlement, the data used in the analysis were actually insufficient to determine whether new development was denser and located adjacent to existing urban services, or simply reproduced the existing low-density, car-dependent suburban mode within a previously defined boundary designed to contain urban *vis à vis* agricultural land uses. Further shortcomings have been observed to affect the design of indicators in different localities (Talen, 2003; Song & Knaap, 2004). The outcome, in all cases, is unfounded statements about the efficacy of the policies and the sustainability of urban environments.

As with other policy arenas, such as unemployment or social deprivation, in which the level of complexity requires a research-intensive approach (Wong, 2006), the South East Queensland growth case reflects a recurrent problem in the design of monitoring systems. Difficult social phenomena are often analysed using just empirical indicators, instead of ones which might be additionally informed by a sound theoretical framework (Hueting & Reijnders, 2004; Hezri & Dovers, 2006). Hence, despite research progress towards the creation of sustainability indicators and enlarged scientific comprehension of built form and urban morphology, there seems to be insufficient integration of theoretical insights into the evaluation of government policy. Intuition and pragmatism commonly infuse design. Poor conceptualization produces monitoring systems that are ineffective (measuring the wrong thing), inefficient (measuring it the wrong way) and inequitable (reporting figures which conceal the true social and environmental costs of the decisions made).

Given these shortcomings, the following research question emerges: ‘can improved understanding of urban form contribute to the design of better monitoring systems in the context of government-driven (i.e. publicly planned) growth management processes?’ This line of enquiry specifies the study of indicators published recently in this journal by Perdicoúlis and Glasson (2011). The aim of the current project is to identify ways in which theoretical developments could improve practice in the monitoring of relevant policy. It is accomplished through a review of the literature, centred on works that capture the interplay between conceptual developments and measurement techniques. The outcome is presented in two segments, the former relatively short and the latter more extended, which together afford a complete answer to the research question. Accordingly, they comprise:

- An account of the conceptualization stage in the construction of urban form indicators (a general approach, to outline the extent and limitations of conceptualization); and
- An inventory of monitoring practices which can be improved through better conceptualization of urban form (a specific approach, to identify concrete ways in which current theory can yield more effective, efficient and equitable monitoring outcomes).

The discussion is rounded off with a set of conclusions which summarize and point to significant and prospective aspects of the current enquiry.

The Conceptualization Stage

As foreshadowed, the concern of this article is with the integrity of evaluations in urban policy and with the ability of current monitoring to assess where we stand in terms of oft-proclaimed goals to contain growth and foster more sustainable urban form. Although different policies and appraisal purposes demand tailored design of indicators (Brugmann, 1997), a general approach should move logically through four stages set out by Coombes and Wong (1994):

- Conceptual consolidation – the evaluator starts by clarifying which concept(s) will be represented in the analysis;
- Analytical structuring – following conceptualization, a detailed framework is developed to collate and interpret the data;

- Identification of indicators – key factors identified in previous steps are translated into specific measurable indicators; and
- Creation of an index – the identified indicators are synthesized into composite indices or an analytical summary.

Conceiving and Constructing Indicators

'Conceptualization' or 'conceptual consolidation' is regarded as the most important stage in the design of a monitoring system and will thus be emphasized in the present account (Coombes & Wong, 1994). It is challenging because, as Perdicoúlis and Glasson (2011, p. 350) observe, 'due to the subjectivity of th[e] filtering or scoping operation, many alternative indicator sets may exist for the same system.' They can be 'reductionistic', designed to suit all situations, or 'participatory', created expressly for individual needs. They can also have different functions or uses within a monitoring system – to alert observers to trends, to quantify processes or to provide deeper understanding of process or phenomena. To deal with this arena of problems, before any selection of individual or composite indicators or data sources, the designer takes adequate time to envision the direction of the project and focus on the basic concepts which need to be measured. The essence, according to Wong (2006), is to achieve clarification of:

- The purpose of the monitoring. What are the objectives of the policy? Which issues can be linked to the achievement of its objectives? and
- The concepts and theories underpinning the monitoring. Which theories and concepts should guide the selection of indicators? Which can dictate appropriate methods for data collection and analysis? Which ones can inform the interpretation of the results?

First, the purpose at hand relates to the effectiveness of the monitoring framework: to get these basics right is to guarantee that indicators will be measuring the right thing. In the present application, this criterion means assessing changes in urban form and determining whether they meet instrumental goals but, more particularly, contribute to a sustainable outcome. Second, the definition of underpinning concepts and theories plays a role in guaranteeing efficiency ('doing the thing right'). It ensures that measurement methods are appropriate and that data are adequately collected and analysed, and convey valid results. It also addresses equity (in that potential biases in the outcomes of the monitoring are identified and addressed, and what is interpreted by the indicators as 'sustainable' actually corresponds to the best available knowledge on sustainability and good urban form). Only after a solid conceptual basis has been established can the evaluator create a framework, make an informed selection of indicators and design a robust procedure to collate and analyse the data.

Typically, elaboration of the conceptual apparatus will involve a critical review of existing literature and, if possible, consultation with experts in the field of interest (Wong, 2006). Deliverables should include:

- A list of dimensions or concepts which need to be measured in order to provide a sufficient picture of policy progress;
- Operational (measurable) definitions of those concepts, which are consistent with current theory; and
- Explicit acknowledgement of any shortcomings in meeting these conditions (i.e. inability to measure progress in one or more of the policy objectives, reliance on unstable or provisional definitions, or utilization of untested or substandard measurement methods).

The ramifications of these points are now examined in more detail.

Effectiveness, Efficiency and Equity in Practice

Hezri and Dovers (2006) maintain that a conceptual indicator set should improve decision-making via better understanding of the social phenomenon studied. In an era of climate change and economic volatility which demands public policy accountability, we argue that the purpose of evaluating physical urban form should be to measure success in encouraging positive change under an explicit definition of sustainability. Monitoring should notify policy-makers and end-users what is happening spatially within a jurisdiction, so that this shared knowledge can constitute a better basis for public discussion and decision-making.[1] At the most basic level, the need is to determine procedurally whether policy (as opposed to straightforward market forces) has produced changes in urban form, and substantively whether any demonstrable changes can be called progress in the sense of being ‘more sustainable’.[2]

Conceptual consolidation should thus aim to cover the dimensions of urban form by providing responses to the following queries:

- What is actually meant by ‘urban form’?
- Furthermore, what is meant by ‘*sustainable* urban form’?
- Which operational and theoretically sound definitions can guide the measurement of these qualities?

In an ideal world, evaluators could build a good conceptual framework by browsing a library and collecting off-the-shelf concepts and measurement methods. In respect of the listing above, such readiness is some way off. The current literature is equipped to answer the first question, namely, ‘what is meant by urban form?’ It is ‘the morphological attributes of an urban area at all scales’ (Dempsey *et al.*, 2010). However, despite considerable research in the broad environmental domain, there are no explicit, quantifiable definitions of a ‘sustainable urban form’ which allow an unequivocal diagnosis of the health of an urban environment in terms of its physical parameters such as city size, building densities and so forth (Talen, 2003; Perdicoúlis & Glasson, 2011). Galster *et al.* (2001, p. 685) spotlight the gaps which exist in our understanding:

> ‘These descriptions . . . leave one grasping for something more solid. How far does the development frog have to leap and how light and

> broad must its footprint be for sprawl to be present? When do land uses thin sufficiently from being compact, centered, or concentrated before they degrade into sprawl? An empirical definition is needed if the discussion is to move from polemics to a common understanding and useful analysis of urban form.'

The absence of concrete, measurable parameters relies partly on the fact that 'sustainability' itself can be read right across the triple bottom line (economically, socially and environmentally) and is open to multiple interpretations (Lombardi, 1998; Hezri & Dovers, 2006; Dresner, 2008). Moreover, this area of research, though vibrant, is relatively young (Bramley & Power, 2009). Although efforts are currently directed to introduce the necessary rigour into urban discussion (Longley & Mesev, 2000; Galster *et al.*, 2001; Alexander & Tomalty, 2002; Jun, 2004; Song & Knaap, 2004, Cutsinger *et al.*, 2005; Wolman *et al.*, 2005), translation of growth management policy objectives into indicators is hindered by the lack of operational definitions of most of the sought-after urban qualities. There is much talk about which characteristics are desirable in a city, but little of it has actually advanced into workable definitions:

> 'Too much discussion about cities is devoid of measurement that is capable of communicating the normative language of smart growth ... Examples are words such as suburb, public realm, mixed use, diversity and access. These concepts are vital to the discussion, but have been difficult to 'pin down'. In effect, the measurement, evaluation and representation of the urban realm have not kept pace with the sophistication of new ideas about how to change it' (Talen, 2003, p. 203).

The way forward lies in intensive collaboration between government and researchers of urban form to forge the underpinning definitions. A rigorous conceptualization is in order given that the efficacy of desired or acclaimed qualities of urban form has not actually been tested against the precepts of ecologically sustainable development.[3] As per the scalar in the Dempsey definition of urban form and the views of Perdicoúlis and Glasson (2011), solutions will need to find sufficiency not just at the local level but as a component of a far broader response to current and oncoming environmental problems created by relentless demographic growth.

The current limitations are a reminder that the conceptual consolidation process is never complete but needs to be revised and updated periodically. In the absence of the sort of work undertaken to create the universal definitions now underlying contemporary international statistical collections, progress in improving the monitoring of urban form is likely to be constrained. Prospective suggestions are tendered below.

Improving Monitoring and Evaluation Practices

We now present a review of the urban form literature focused on uncovering deficiencies and failures in monitoring systems believed to originate in poor conceptualization processes. Six areas are identified as problematic in the coming subsections: materializing the form; seeing it; answering the monitoring question; acknowledging differences in urban form; dealing with net versus absolute change; and using scientific measures of sustainability. The approach is to describe the theoretical backdrop to each one, and the potential implications of poor practice in its sphere of influence. What follows does not constitute a complete inventory of problems in monitoring, but only those originating from the earliest stage in system development.

Materializing the Form

Any attempt to appraise urban form and patterns must measure the physical/material reality of cities. Following Dempsey *et al.* (2010), form consists of the morphological attributes of an urban area at all scales. According to Talen (2003), they are strictly physical and material in nature. They could include, for example, building densities or block length. In monitoring, though, the physical dimension has been lacking. Commonly, evaluators measure non-physical, surrogate dimensions of urban change, such as population densities (Nelson, 1999; Hasse & Lathrop, 2003) or vehicle miles travelled (Nelson, 1999; Kline, 2000). Nelson (1999), for instance, appraised the capacity of the urban growth boundary of Portland (Oregon) to contain sprawl by estimating, among other parameters, the change in vehicle miles travelled over the period of implementation of the policy, 30 years. In this case, a positive change in the physical form of the city was inferred from a perceived change in car usage (a behaviour). Even if a reduction in vehicle usage is desirable and an objective of the policy, this indicator cannot confirm that a change in form has actually taken place.

By choosing indirect, non-physical, surrogate measures to report changes in urban form, we accept two risks:

- Interpreting change in the surrogate measure as a sign that the form has changed when actually it has not (i.e. a change of behaviour might occur for other reasons). Or *vice versa*: taking apparent stability in the surrogate measure as a sign that the form has not changed, when it has (due, for example, to inertia in a behavioural response).
- Correctly inferring from the surrogate measure that there has been a change in the form (in the case of a proven, statistically significant correlation), but being unable to tell exactly what changed, and how; in which case, we would not know which instruments of the policy are working and which ones need improvement.

As generically illustrated by the exemplars in Table 1, lack of reference to the physical drastically handicaps the utility of monitoring at the local government level, where information of that sort is needed to improve strategic planning and development assessment decisions. Frey and Bagaeen (2010) maintain that the work of urban planners is to make decisions about the physical reality of cities. To explain, strategic plans and development codes dictate building densities, heights, street layouts and design standards; similarly, developments are approved or

TABLE 1. Efficient and inefficient measurement of urban form: selected exemplars

Parameter of interest	Efficient (physical) measurement	Inefficient (non-physical) measurement
Access to public transport		
Proposed measurement	Transit stops per square mile (Indicator used in INDEX Plan Builder, a planning support system created by Criterion Planners (2011), in Oregon).	Modal split – proportion of work trips undertaken by private car, train or tram, bus or minibus, motorcycle, cycling or other (Alberti, 1996) (UNCHS indicators, Urban Indicator Program).
Comment	This type of measurement allows planners to identify areas with low access to public transport caused by deficiencies in the physical built form (i.e. areas insufficiently covered by bus routes). It is easy for planners to pinpoint the problem on a map and take action to improve it.	These indicators can give an idea of the extent of use of public transport in a locality, but do not help to identify any causes within the built form. High or low figures cannot be associated with features in the built form.
Jobs/Housing balance		
Proposed measurement	Actual land use mix – acres of commercial, industrial and public land uses in the neighbourhood divided by the number of housing units (Song & Knaap, 2004) (Used by the authors to assess progress in fighting sprawl in Portland, Oregon).	Number of commuters into and out of conurbation (Alberti, 1996). (Used by the European Environment Agency in 1995 to monitor 'urban patterns').
Comment	This measurement allows planners to identify areas with low levels of land use mix, which increase the need of residents to commute. Such specific information can facilitate a response by planners by way of, for example, amendments to land use regulations in specific areas.	This measurement can only indirectly inform planners about the extend of the land use mix. The registered behaviour (miles travelled) cannot be related directly to a feature of the physical form in each locality, producing uncertainty as to the type of response needed from the urban planning department.
Compactness		
Proposed measurement	Building density – dwelling units per gross acre (Criterion Planners, 2011). (Also used within INDEX PlanBuilder planning support system).	Population density (population growth per land unit) (used by Hasse & Lathrop (2003), to assess the extent of sprawl in New Jersey).
Comment	Gives a straightforward indication of the effectiveness of a compact-form policy in specific areas.	However valuable in itself, this information is hard to relate to planning decision-making as it

(*continued*)

TABLE 1. (*Continued*)

Parameter of interest	Efficient (physical) measurement	Inefficient (non-physical) measurement
	Planners can compare prescribed and actual densities across the city and propose appropriate courses of action.	fails to provide details on the number and size of dwellings in each area (planners can only have an influence in the latter). Besides, high or low figures can respond to reasons other than the local building density (e.g. increasing numbers of lone-person households).

rejected based on their proposed physical features. A monitoring system which uses a language different from the working metric of the city is unlikely ever to influence development decisions on the ground.

In summary, an effective approach is one that focuses measurements and analyses on the physical and material attributes of the built form.

Actually Seeing the Form: Technical Demands

Also aligned with the Dempsey team's (2010) definition, Moudon (2002) and Kolster (2002) argue that urban form can only be measured if data are spatially referenced (can be located in a map) and collected and analysed at the lot level of aggregation. To these authors, form is a strictly spatial phenomenon. Differences in block layouts, for example, can only be appreciated by drawing the different parcel arrangements on a bi-dimensional plane. Similarly, because the lot is the basic unit of formation and change of the urban form, 'analyses that exclude plot-level data will fail to address how urban space is generated and transformed' (Moudon, 2002, p. 38).

It would, for example, be theoretically and practically useless to compare the efficiency of form in two neighbourhoods using the neighbourhood level itself as the smallest level of data aggregation. While it represents only a slightly coarser grain than the parcel, distinctive urban form is already invisible. Even so, it could be argued that, although unsuitable for neighbourhood comparisons, neighbourhood-level data might be a useful scale for studies at the regional level: if the scope is wide enough, relatively rough data will eventually show a pattern. Morphologists would probably reply that data aggregated at levels higher than the lot can eventually show some sort of pattern, but it will certainly not be one of urban form. To be able to *see* the form, one would have to see lot sizes, block lengths, building heights, among other characteristics, all of which are created, changed and become visible at the lot level of aggregation.

Whereas the use of these types of data has characterized research into urban form for some time, it is still the exception in assessment of policy, with coarser levels of aggregation co-existing in most *ex poste* evaluations (Talen, 2003; Song

& Knaap, 2004). Primitive monitoring methods employ figures at the regional or city level with no spatial referencing (as in Nelson, 1999; Kline, 2000; Hasse & Lathrop, 2003; and Queensland Government, 2008). Somewhat finer approaches use data aggregated at the census district level or similar. Though they improve resolution and give an impression of location, such methods are still fundamentally insufficient.

Morphologists are emphatic that the progression is not of a gradual improvement in the conciliatory sense of 'the more detailed the data, the better the result.' Rather, the monitoring of urban form is an all-or-nothing situation: for many parameters save areal demographic density, the lot level is the coarsest allowable scale. Above it, information simply becomes invalid. In such instances, meaningful evaluation faces a significant obstacle. It seems preferable to reduce the spatial scope of the monitoring effort to a limited number of critical areas for which it is economically or practically possible to source data at the required level of aggregation than to stick with the broader scale and obtain trite information. Again, the idea is not to collect data haphazardly but to make sure the monitoring system is measuring the right thing, that is, the actual urban form. Limitation of the analysis to specific study areas has, in fact, been a common response of urban form researchers to the high costs of accessing information at the required scale (Moudon, 2002).

Fortunately, as geographically referenced information is becoming progressively widespread and more technically accessible (Batty, 1998; Yao, 2010), the problem of coarseness is likely to recede as a practical issue.

Sufficiently Answering the Monitoring Question

Determining the amount of information needed to provide complete monitoring is a key problem to solve during the conceptualization stage. The number and type of parameters measured will necessarily be influenced by the operational objectives of each policy, among other factors. However, from a theoretical point of view, a relevant question is whether there is a specific or minimum set of parameters which *must* be measured in order to provide a satisfactory description of urban form.

The works of Galster *et al.* (2001) and Cutsinger *et al.* (2005) set a precedent in scientifically addressing a conceptually optimum set of indicators to describe a phenomenon of urban form, namely, sprawl. After tests in 13 urbanized areas in the United States, Galster *et al.* proposed that sprawl could be satisfactorily described via eight distinct physical parameters (density, continuity, concentration, clustering, centrality, nuclearity, mixed uses and proximity). Song and Knaap (2004) criticized the study for using dimensions that lack direct policy relevance. They asked, 'should public officials in Houston, for example, be concerned or pleased that it ranked high in clustering and low in nuclearity? If so, how should they respond?' Nonetheless, the core value of Galster's work is indicated in that it attracted a replication project. Cutsinger *et al.* reduced the number of sprawl parameters to seven, which were then tested in 50 large American metropolitan areas.

As opposed to such theoretically informed outcomes, an intuitive stance to the design of a monitoring system is likely to result in an inefficient indicator set, understood as the omission of parameters that are relevant to describe the object of study and/or inclusion of an insufficient or excessive number of indicators. Ideally, the choice of measures should respond to the characteristics of the object (the urban form), and their number be based on the minimum required to provide a complete description of it. So much represents elegant modelling, as per classical scientific methodology.

Acknowledging Differences in Urban Form

Another significant finding by Galster *et al.* (2001) which should be capitalized upon during the conceptualization process is that there is not one but several types of sprawl. By measuring physical parameters separately, the researchers discovered that the physical conditions typically associated with sprawl were rarely found together in a single area. Instead, the outcome was for zones to score low on some sprawl features and high on others – e.g. high density, but no mixed uses. As a result, many areas perceived as contributing to an overall urban 'sprawl' would, in practice, require different interventions. A crucial implication of the method was the ability to advise policy actions tailored to the specific form deficits observed in each area relative to urban development goals previously enunciated. Following this research-based lead, monitoring systems should ideally do likewise in order to provide the best guidance for decision-making. Failure in this regard results in missed opportunities to improve policy and planning – an inefficient monitoring system.

In their sequel investigation, Cutsinger *et al.* (2005, p. 252) urged some important cautions:

> 'What the foregoing strongly shows is that sprawl is a term that cannot be used carelessly. Is a given metropolitan region sprawled or not? In most cases the answer must be preceded by, ''it depends on which dimension one is considering . . .'' Indeed, besides the aforementioned cases, we find that Philadelphia, Cincinnati, Boston, Baltimore, Milwaukee, Fort Wayne, New Haven, Tulsa, and Worcester rank in the top five on one dimension of land use but in the bottom five in another dimension.'

Alexander and Tomalty (2002) arrived at a similar conclusion when they found (after a study of sprawl patterns in three different regions in British Columbia, Canada) that denser municipalities did not necessarily score well in the jobs-housing balance. In other words, a neighbourhood can be very dense and still have a large proportion of outbound residents commuting long distances to work.

Therefore, monitoring systems should ideally be separate and measure the varying sources of form inefficiency (e.g. mixed use, densities) in order to provide the best backdrop for decision-making. If this capacity is lacking, the outcome is usually an imperfect appraisal system.

Net versus Absolute Change

Monitoring presents a chance for government agencies to publicize their performance (Hezri & Dovers, 2006). This is a legitimate but ultimately seductive opportunity within a public management structure which has agencies competing for the allocation of funds, and under increased accountability provisions which demand public steering of government action and performance (Wong, 2006).

During the design phase, the quest for positive publicity can result in a biased selection of indicators, to privilege measures that highlight good agency performance over others which provide less dramatic figures, or simply portray a modest picture of the social impacts of policy. A typical expression of this selection bias occurs when evaluators opt for indicators that measure intermediate outputs and net, rather than trend or absolute, change. An example could be found in a monitoring system which records land converted to public space in the foregoing year (net change in an intermediate output, land converted), rather than overall increase in access to public space (absolute change in the phenomenon of interest, access). Whereas net change measures provide a convenient way to showcase agency performance (activity of government during the accounting period), a protocol which focuses exclusively on this variable format loses sight of the wider social impacts of the policy which ultimately reflect the ability of an administration to meet its stated goals.

An equitable evaluation process is one that provides a transparent portrait of policy effectiveness by communicating both net and overall trend changes. Importantly, the monitoring system should avoid any leanings which can produce unrealistic assessments of progress or in any way hide the true social or environmental costs of development. It would thus avoid 'soft-target' or merely intermediate parameters in the area of intervention.

Using Science-based Benchmarks to Determine the Sustainability of the Urban Form

In 1998, Lombardi cited sustainability as the new criterion against which planning and development outcomes should be judged, a view scarcely ever disputed today. Hence, to achieve best practice in contemporary urban monitoring system development, an explicit definition of sustainability and its likely manifestations should be provided. Despite the fact that discussions on sustainability have, for the most part, remained broad and abstract (Hezri & Dovers, 2006), there are at least two findings which should be integrated into the measurement and evaluation of urban form (Hueting & Reijnders, 2004). First, the sustainability of an urban system should be judged on the basis of scientifically determined benchmarks. Second, these benchmarks should accord with ecologically sustainable levels of resource use and emissions.

The foundations of this approach were laid in the 'strong' sustainability arguments set out by ecological economist, Herman Daly, in the early 1990s (Alberti, 1996). He suggested that the sustainability of an urban system should be determined according to three criteria: rates of use of renewable resources should not exceed replacement rates; rates of use of non-renewable resources should not exceed rates of development of renewable substitutes; and rates of pollution emissions should not exceed the assimilative capacity (the 'sinks') of the environment. This emphasis has its roots in the observation that economic progress will, in most cases, inevitably involve ecological damage. Therefore, unless limits to resource use and pollution are established, unchecked economic and demographic growth can only lead to the depreciation or elimination of the existing natural resources. From experience with the Netherlands fishing industry, Hueting and Reijnders (2004) add a rider to the Daly criteria for application in urban settings. Despite the adoption of allegedly sustainable uptake rates, several species became extinct because of the lack of a physical limit per period to the number of adult fish which could be caught. Importantly, they argue, both the rates and physical limits of resource use must therefore be determined by scientific means.[4]

How do such considerations relate to the specific context of urban form? Benchmarks used to measure the sustainability of urban systems rarely comply with these ‘strong’ ecological requirements. Misapplication of the physical limit constraint can be observed in the creation of greenbelts or urban growth boundaries (UGBs) around metropolitan areas, allegedly to avoid depletion of land of high agricultural or ecological value. In practice, UGBs have commonly been drawn to reflect growth expected to occur at the currently observed rates of residential expansion during the life of the plan. By this means, they set an outer margin for development in what might be a 20 year forward planning period. Over repeated rounds, such an approach favours one form of land use at the expense of another, such that the sector to be ‘protected’ will eventually suffer death by a thousand cuts. Apart from this frequent failure to limit residential expansion, UGBs have seldom reflected scientifically determined ecological thresholds (Jun, 2004). Instead, these and other benchmarks used to determine the sustainability of urban systems have tended to consist of merely empirical responses to economic needs.

Use of substandard concepts and methods to assess the sustainability of an urban system can result in false statements of policy effectiveness and overall progress towards sustainability. This outcome constitutes an inequitable evaluation and conceals, rather than reveals, the true social and environmental costs of development. A best-practice approach to evaluation should be based on scientifically determined rates and physical limits to resource use and emissions. In terms of a fair process leading to a just outcome (Rawls, 1971), any lack of a scientific rationale should be explicitly acknowledged and the resulting shortcomings of the evaluation explained.

Conclusion

This article originated from the conviction that analysis of complex social phenomena, such as urban form, demands a research-intensive approach to indicator design and policy appraisal. Rather than reflecting any new-found novelty, the question posed for the study has a long background and an enduring significance. It simply asked whether improved conceptualization could contribute to the design of more effective, efficient and equitable monitoring systems for growth management. Early in the account it was determined that conceptualization plays a critical role, since it is in this foundational stage that the purpose of the monitoring, and the operational definitions required to advance it, are formulated. In order to be effective, a monitoring system should aim to measure changes in urban form and determine whether they correspond to more or less sustainable outcomes; to be efficient, it should be based on operational definitions of the urban features of interest, employ appropriate measurement methods and yield valid results; and to be equitable, inter-personally, intra-generationally and inter-generationally, the indicator system should interpret the outcomes based on the best available knowledge of sustainability.

Pursing the research question by way of a literature review, the article presented six ways in which sound, theory-based conceptual consolidation can improve the effectiveness, efficiency and equity of monitoring systems. Key findings regarding urban form indicators are that:

- Any parameters used in the monitoring should refer to physical or material attributes of the built form;
- Data must be spatially referenced, and collected and analysed at the lot level of aggregation;
- The choice of indicators should respond to the characteristics of the object (the urban form); and their number be based on the minimum required to provide a complete description of it;
- Indicators should measure separately the different sources of form inefficiency in order to maximize their utility for decision-making;
- Both net and absolute changes in the features of interest should be measured and reported; and
- Assessments of the sustainability of the outcomes should be based on scientifically determined rates and physical limits to resource use and emissions.

Notably, the enquiry also demonstrates that, in the urban sphere, the use of purely intuitive or empirical approaches to indicator design can seriously compromise the integrity of monitoring and potentially conceal the environmental and social costs of development.

Calls for more research within the genre of academic conclusions can often sound hackneyed. Here, however, the alternative is the continuation of sub-optimal monitoring systems. They will act only to beguile their perpetrators and lessen trust among those for whom planning is undertaken. As desirable as further theorizing might be, another prospective route might lie in the assembly of case studies from the more advanced planning jurisdictions or those beset with issues of strong spatial or demographic growth. Comparison of the inputs, mechanisms and outputs of a monitoring system will be challenging and require capable workers. Their aims should be inductively to seek out best monitoring practices in the various domains of urban form and function, analyse them and their outcomes thoroughly, and then to publish their findings. Critical appraisal of monitoring protocols might seem arcane, given that the function is often underemphasized and/or costly to perform. However, cogent evaluation can become a badge of professionalism and transparency in administration, leading to improved long-term standards and outcomes. Despite ideographic elements among cities, discoveries of value can be replicated spatially, from one jurisdiction to another. By analogy, and to retire on a somewhat controversial note, incisive monitoring could be to planning what total quality management has become to manufacturing.[5]

The link between policy evaluation and theory is two-way. Well conducted monitoring would not only enlarge the boundary of best practice but could act as a testing ground and recursively benefit the development of theories about urban form (at a scale rarely seen in scholarly research). To make these future exchanges possible, solid initial conceptualization of the monitoring framework is essential.

Notes

1. Other approaches to indicator development include *tactical* (as a delaying strategy, substitute for action and deflector of criticism); *political* (when the results of evaluation are used as ammunition to support a certain political stand) or simply *instrumental* (when the content of indicators is used as evidence during judicial hearings or to guide action in the event of an environmental crisis).
2. This focus on effectiveness is ultimately more important than any key performance indicators which measure the efficiency of the monitoring agency, despite their prominence in many bureaucratic agendas (Wong, 2006).
3. For a demonstration of the potential difficulties, consider Bramley and Power's (2009) wrestle with non-linearity exhibited in just one variable, demographic density, as it influences (only) *social* sustainability within the urban form.
4. During the late 1990s and early 2000s, there was an attempt to introduce indicators based on community preferences rather than scientifically determined ecological levels. This system, commonly referred to as 'views' indicators, was introduced in the belief that community engagement was the shortest pathway to sustainable behaviour (Alberti, 1996; Innes & Booher, 2000). Basically, it entailed a redefinition of sustainability in terms of a desired set of 'quality of life' standards. Although the social capital benefits of such a system have been acknowledged (Sawicki, 2002; Wong, 2006), most authors agree that a community-generated approach cannot replace methodological and analytical rigour when it comes to determining the long-term ecological sustainability of an urban system (Brugmann 1997, Button 2002, Hueting & Reijnders, 2004; Hezri & Dovers, 2006; Wong, 2006). Whenever there is a risk of irreparable damage to ecological values, researchers opt for science-based physical limits (over views) as the most equitable approach to defining sustainability.
5. The 'total quality management' claim relates not to some retro application of the rational method and the physical excesses it produced in urban development in the 1960s and 1970s. Rather, it follows the thought that planning needs always to improve its technical performance, just as has industrial production and also more physically oriented professions such as dentistry and surveying. There can be no case for a failure to innovate just because the subject matter of planning is at once very large and widespread (as in the entire built environment), politically involved and conceptually complex. Critics would at very least argue that, despite these backdrops, a static stance fails to appreciate the potential of geographical information science and other recent facilitating technologies (e.g. Google Earth; decision support systems), which bear on the analysis of urban form. Just as progress has been made by scientists in measuring the natural environment, one would expect the advancement of capacities within city planning in the physical monitoring of the built environment.

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