Recreation services from engagement with urban nature
- illustrating some methodological challenges for ecosystem accounting

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Abstract

For the purpose of ecosystem accounting, monetary valuation of local nature recreation faces challenges of double counting with local environmental amenities to urban residences. The challenges to valuation are a combination of issues related to confounding extent and condition of nature in urban ecosystems, overlapping definitions of recreation service supply and use, and limited choice of SNA accounting compatible monetary valuation methods.

Foreword

The presentation is loosely related to the two submitted abstracts to the LG meeting which were requested to be combined into a single presentation for the meeting:

- Valuation of cultural ecosystem services in ecosystem accounting – a comparison of methods for local nature recreation in the Oslo Region, Norway (David N. Barton (NINA), Kristine Grimsrud (SSB))
- Valuation of ecosystem services for ecosystem accounting – challenges with hedonic valuation on an urban rural gradient in the Oslo Region, Norway (Kristine Grimsrud, (SSB), David N. Barton (NINA))

The content is preliminary and biased by the selection of examples taken from urban accounting work conducted mainly in the Oslo metro area in South-eastern Norway. The illustrations will feed into a discussion paper "Recreation services from engagement with urban nature" as part of a series on Individual Ecosystem Services for the SEEA Experimental Ecosystem Accounting Revision 2020 by the UNSD.

Acknowledgements

We acknowledge the Norwegian Ministry of Climate and Environment for supporting participation in revision of the System of Environmental-Economic Accounting 2012—Experimental Ecosystem Accounting (SEEA EEA). We acknowledge the contribution of empirical examples by the research project Urban Experimental Ecosystem Accounting in Greater Oslo (URBAN EEA), in collaboration between the Norwegian Institute for Nature Research (NINA), Statistics Norway (SSB) and the Oslo School of Architecture and Design(AHO), funded by the Research Council of Norway. Zofie Cimburova, Megan Nowell, Frank Hanssen (NINA) and Marta Suarez (Transitando) have produced the mapping examples.

1. Introduction

Ecosystem accounting aims both to mapping ecosystem services using all available spatial information (a focus on resolution), and identify significant changes for aggregate spatial accounting units (a focus on scale). Urban ecosystems used for recreation have been hypothesised to have a higher 'density' of human perspectives and value heterogeneity than any other ecosystem (Gómez-Baggethun and Barton, 2013). Urban recreation preferences are determined by qualities at the spatial scale of human sensory perception (0-100m) (Gehl, 2010). The use of open spaces and amenities near a person's home is repeated and extended over longer periods, meaning the environment is familiar to a high level of spatial and seasonal detail.

A number of issues identified below focus on the challenges of lacking resolution in available spatial data relative to the resolution that matters to people using their local urban 'habitat'. Ecosystem accounting at European or national scale cannot obtain data at 'a resolution that matters' everywhere. However, in this presentation we illustrate the spatial resolution we think is required to identify ecosystem condition that in turn determines urban outdoor recreation. This should make us better able to assess what policy purposes ecosystem accounting can attend to for urban recreation.

2. Describing the ecosystem and service

2.1 Common nature of the ecosystem service

Proposition #1: recreation services from engagement with nature near the home – urban outdoor recreation - is not defined as a mutually exclusive ecosystem service in CICES (Table 1). The most relevant classes are "Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through passive or observational interactions" and " Characteristics of living systems that enable aesthetic experiences".

Filter	Section	Division	Group	Class	Code	Use clause	Example Service	Example Benefit(s)
CICES	Cultural (Biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Physical and experiential interactions with natural environment	Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through passive or observational interactions	3.1.1.2	*.... that are viewed/observed by people or enjoyed in other passive ways by virtue of sounds and smells etc.*	*Mix of species in a woodland of interest to birdwatchers Or Whales, birds, seals and reptiles can be enjoyed by wildlife*	*Recreation, fitness; de-stressing or mental health; eco-tourism*
CICES	Cultural (Biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Intellectual and representative interactions with natural environment	Characteristics of living systems that enable scientific investigation or the creation of traditional ecological knowledge	3.1.2.1	*...that are the subject matter for insitu research*	*Site of special scientific interest, Natura 2000 site*	*Knowledge about the environment and nature*
CICES	Cultural (Biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Intellectual and representative interactions with natural environment	Characteristics of living systems that enable education and training	3.1.2.2	*...that are the subject matter for insitu teaching or skill development*	*Site used for voluntary conservation activities*	*Skills or knowledge about environmental management*
CICES	Cultural (Biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Intellectual and representative interactions with natural environment	Characteristics of living systems that are resonant in terms of culture or heritage	3.1.2.3	*...that contribute to cultural heritage or historical knowledge*	*Sherwood Forest*	*Tourism, local identify*
CICES	Cultural (Biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Intellectual and representative interactions with natural environment	Characteristics of living systems that enable aesthetic experiences	3.1.2.4	*... that are appreciated for their inherent beauty*	*Area of Outstanding Natural Beauty; panorama site*	*Artistic inspiration*

Table 1. CICES cultural ecosystem service classification for direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting. Source: (Haines-Young and Potschin, 2017)

Proposition #2: CICES ecosystem services classes do not identify beneficiaries to a level that is operational for urban ecosystem accounting. Identification of specific users is necessary in order to identify relevant ecosystem types and condition indicators appropriate for those uses.

Proposition #3: Beneficiaries in national accounts are identified at household level (an institutional beneficiary). Local recreational uses are individual-specific and particular to household composition (households with infants, children, elderly, the physically impaired). Households contain plural and diverse values related to different types of local outdoor recreation (Barton, 2016). Beneficiaries use open spaces for multiple use purposes. This plurality in types of beneficiaries of local outdoor recreation may means that ecosystem use accounts that only identify a single "households" sector, will not have an awareness raising effect through speak to specific constituencies, nor provide indicators for policy support.

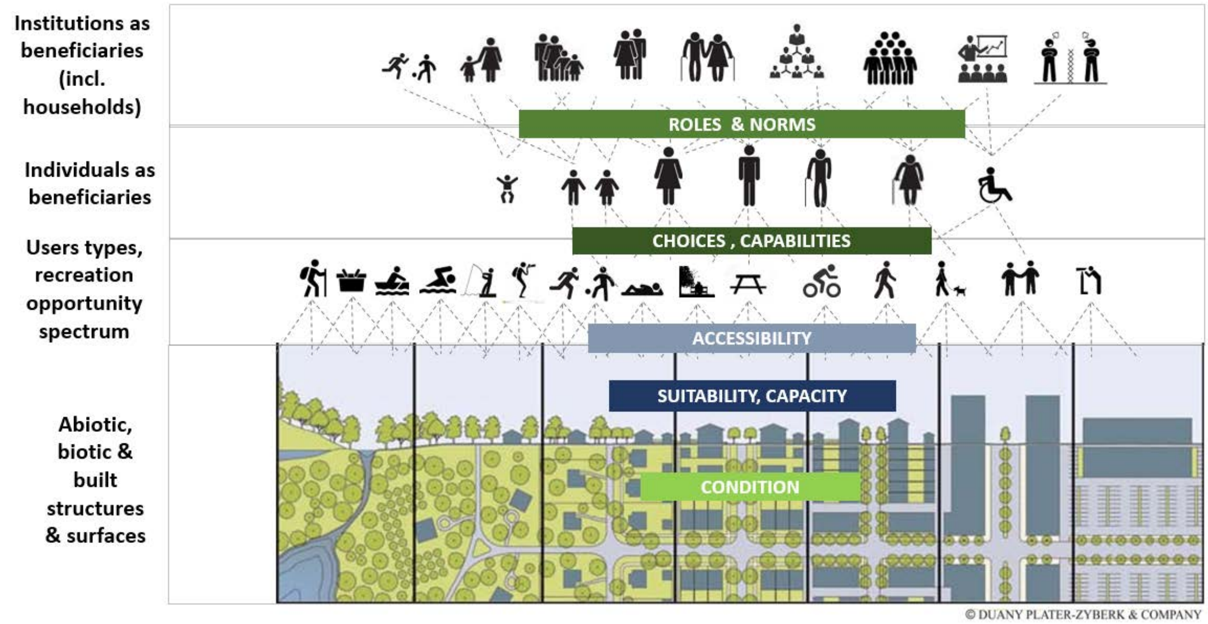

Figure 1. A conceptual framework for further classification of local recreation services Source: adapted from Barton(2016). Urban transect by Duany Plater-Zyberk & Company

2.2 Spatial extent of urban ecosystems

Proposition #4: Urban ecosystem extent can be defined based on landcover, ecosystem condition, or recreational landuse which leads to very different accounting areas.

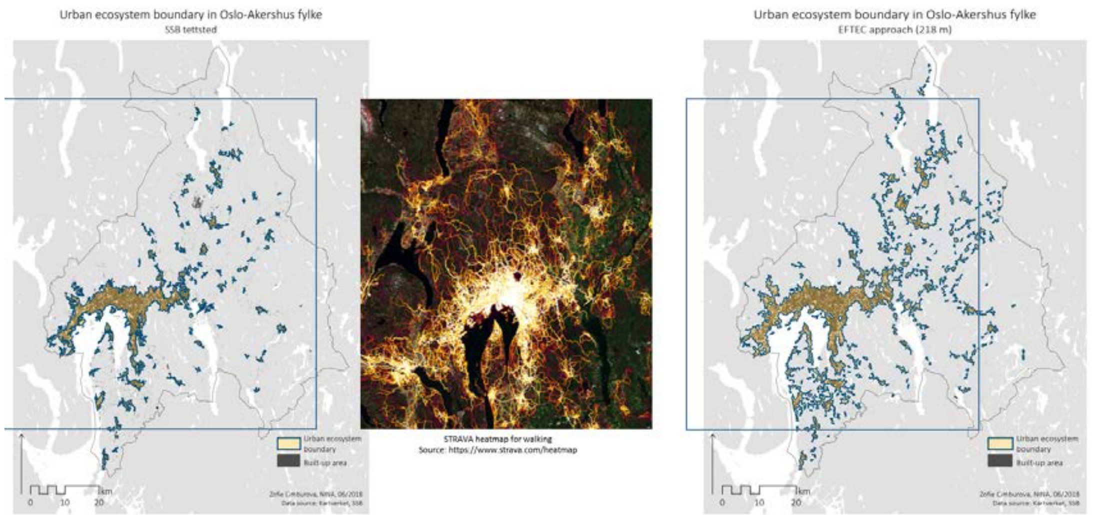

Figure 2 Defining the boundary of urban ecosystem extent using settlements definition (left hand side), a definition using a buffer around built urban area following the UK Eftec approach (right hand side) and identification of urban influence zone based on recreational movement (centre). Source: maps by Zofie Cimburova, NINA. Heatmap by STRAVA.

3. Measuring condition

3.1 Urban ecosystem characteristics and context

Proposition #5: In densely built urban areas the spatial configuration of vegetation and water in the urban ecosystem is fragmented, confounding accounting definitions of “extent” and “condition”. In the denser part of the urban transect mapping “surfaces” and “structures”, indicators that capture gradients of urban design and private-public access rights, are necessary to describe “conditions” that determine outdoor recreation use.

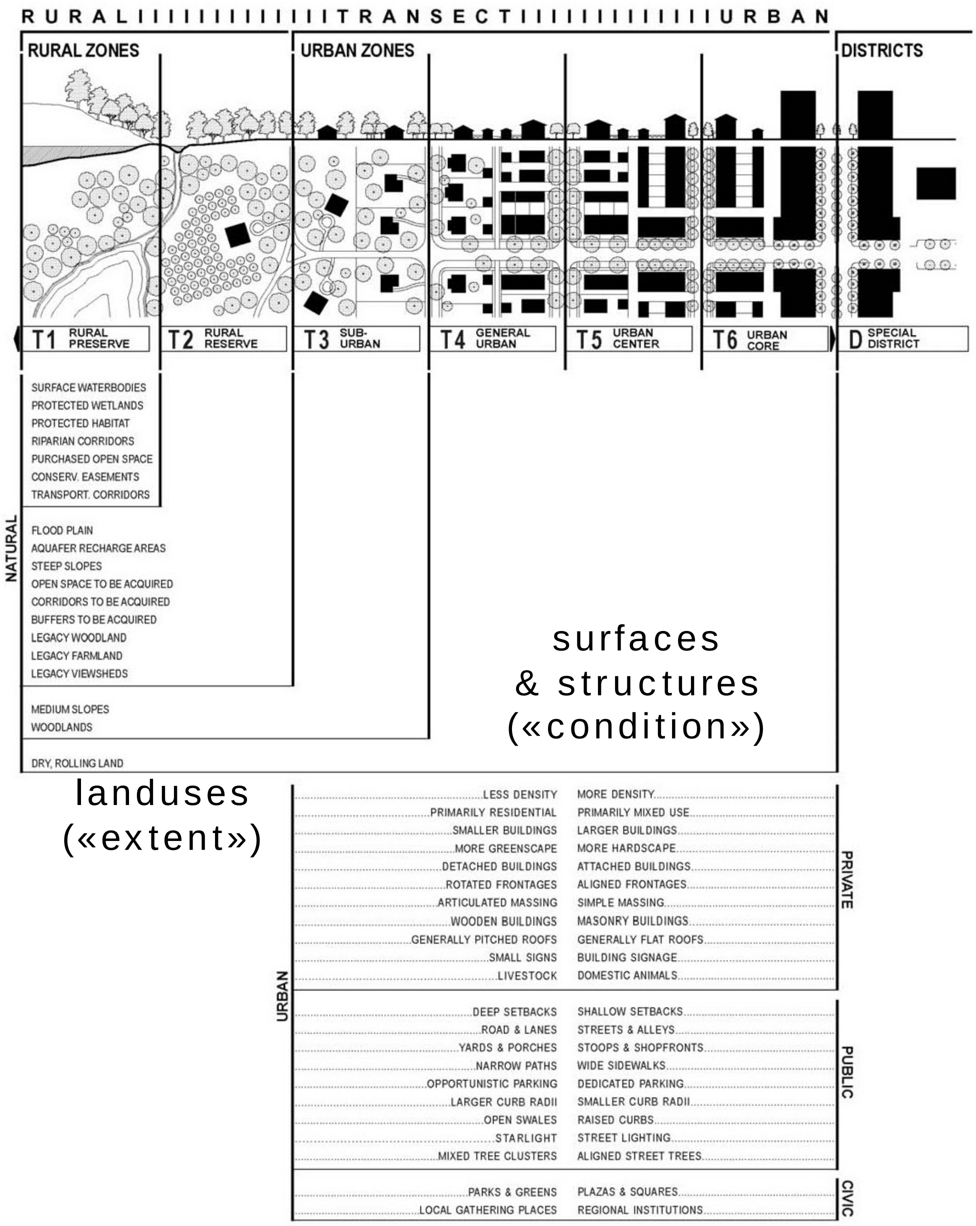

Figure 3 Identifying urban ecosystem extent and condition using concepts from rural-urban transect theory. Source: adapted from Duany Plater-Zyberk & Company, Centre for Applied Transect Studies, https://transect.org

3.2 Metrics for measure urban ecosystem condition for recreation

Proposition #6: Urban ecosystem condition as perceived by inhabitants is hierarchical and nested. Variables of ecosystem condition at different resolutions are spatially autocorrelated which may have implications for their use in predicting demand for neighbourhood amenities (e.g. in hedonic pricing). Condition indicators at different, but nested spatial resolutions, may be used as explanatory variables in valuation estimates that are later aggregated in accounting.   Spatial autocorrelation of condition variables makes the valuation of outdoor recreation use and amenities susceptible to double counting when aggregated across the urban landscape.

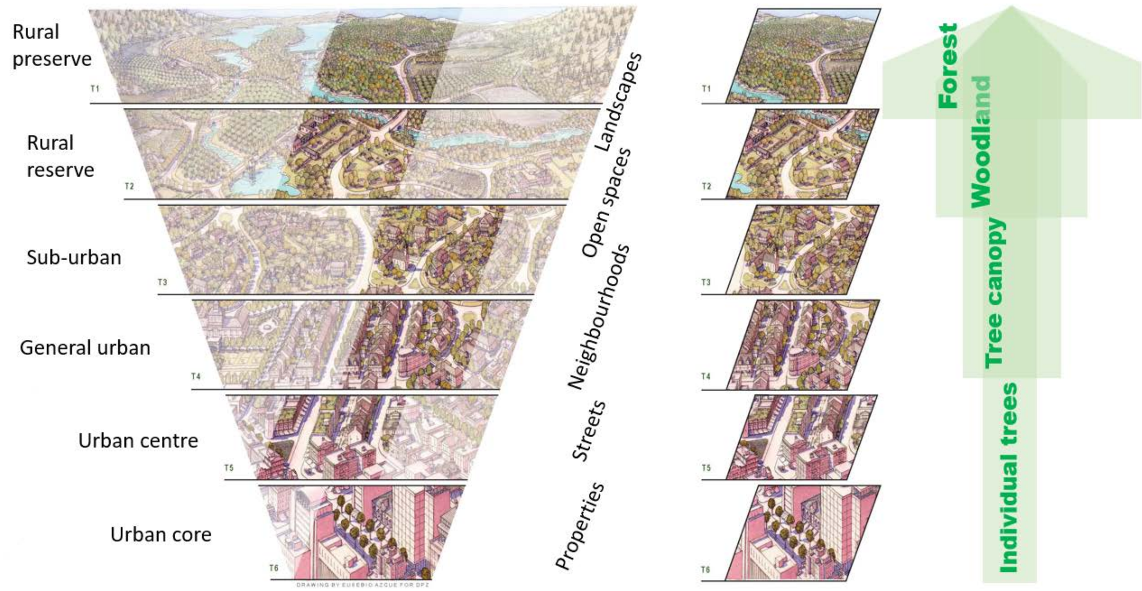

Figure 4.1 Hierarchical classification of urban ecosystem condition is necessary as mapping moves across the rural-urban transect. Different recreational uses of urban open space play out at different levels of landscape hierarchy. Source: adapted from Duany Plater-Zyberk & Company, Centre for Applied Transect Studies, https://transect.org

Figure 4.2 Differences in mapping landuse according to municipal zoning and actual vegetation structure shown on the right hand side by tree canopy cover based on Lidar remote sensing. Is tree canopy cover – nested in green spaces - an extent or a condition of the urban ecosystem? Data source: FKB GeoNorge and Lidar from PBE, Oslo Municipality. Tree canpy modelling by Frank Hanssen, NINA.

Table 2.1 illustrates biotic, abiotic and man-made elements (structures and surfaces) in green spaces in Oslo which were tested for their significance for recreation preference. Table 2.2 shows Structural Diversity Index (SDI) scores for the different types of elements for different sizes of green space.

Biotic elements	Abiotic elements	Man-made elements	
Forest dominance	Fountain	Public transport access	Swimming area
Grass dominance	River/water course/stream	Sitting facility	Silence/tranquility area
Balanced forest/grass	Lake/pond	Grill/Picnic	Cultural/art element
Old/big tree	Varied terrain	Fishing area by the fjord	Urban agriculture area
Tree species diversity		Dog facility	High presence of people
Shrub		Playground	Low presence of people
Fruit tree		Walking/Cycle path	High intensity lighting
Flowerbed		Sport equipment	Low intensity lighting
Wild plants and animals		Bars/restaurant	

Table 2.1 Biotic, abiotic and mand-made elements used to construct a structural diversity index for green spaces in Oslo. Source: Soy Massoni et al. (2018)

GREEN SPACE SIZE	BIOTIC ELEMENTS Mean SDI	95%CI	ABIOTIC ELEMENTS Mean SDI	95%CI	MAN-MADE ELEMENTS Mean SDI	95%CI
Pocket (<0.1ha)	0.170	0.145 - 0.196	0.106	0.040 - 0.173	0.071	0.047 - 0.096
Pocket (<0.3ha)	0.205	0.184 - 0.226	0.129	0.083 - 0.175	0.083	0.069 - 0.097
Small (0.1-0.5ha)	0.208	0.185 - 0.232	0.163	0.110 - 0.216	0.105	0.086 - 0.124
Medium (0.5-10ha)	0.226	0.215 - 0.236	0.274	0.249 - 0.300	0.146	0.135 - 0.156
Big (>10ha)	0.326	0.285 - 0.368	0.531	0.456 - 0.605	0.255	0.211 - 0.299

Note: partially overlapping definitions of pocket green spaces are used for comparability with definitions in Oslo Municipality (2009) and Nordh and Østby (2013). Green spaces include parks, cementaries and unmanaged public open spaces.

Table 2.2 Green spaces have different “condition” corresponding more or less to recreational preferences, depending on size and structural diversity. Source: Soy Massoni et al. (2018)

Proposition #7: Ecosystem condition of importance for local recreation depends on abiotic and man-made elements. Biotic structural elements are also man-made, making it more challenging to identify a (natural) baseline condition with which to construct condition indices for accounting (Soy Massoni *et al.*, 2018)

Figure 5 shows a correlation between airborne laser (ALS) measurement of the proportion of tree canopy cover per street segment on the vertical axis, and average Greenview Index per street segment on the horizontal axis. It shows that street segments are greener observed at street level in 3D, than observed remotely from above in 2D.

Proposition #8: Ecosystem condition indicators for recreation used in valuation methods should strive to approximate human perspectives.

Figure 5. Street segments are greener observed at street level in 3D, than observed in 2D by remote sensing. Ecosystem condition indicators for recreation should strive to approximate human perspectives. Source: Green View Index, Senseable Cities, MIT.

4. Measuring ecosystem service flow

Figure 6 shows the structural features of green spaces ranked by respondents in terms of their contribution to recreation attractiveness. (Soy Massoni *et al.*, 2018)

Proposition #9: Ecosystem condition indicators predicting recreation service flow need to use indicators of the biotic, abiotic and built environment that matter for outdoor recreation.

Structural feature	Mean ranking	Std. deviation	% Presence	Structural feature	Mean ranking	Std. deviation	% Presence
Public transport access *(Transport)*	7.44	2.50	72.1	Silence/tranquility areas *(Silence)*	5.40	2.99	20.8
Grass dominance *(Grass)*	7.22	2.02	78.6	Tree species diversity	5.27	2.84	ND
Balanced forest/grass *(Balanced)*	6.89	2.28	19.9	Cultural/art element *(ArtCult)*	5.07	2.62	7.3
Lake/pond *(LakePond)*	6.63	2.52	5.8	Fountain *(Fountain)*	4.88	2.77	1.8
Sitting facility *(Sitting)*	6.62	2.69	39.3	Sport equipment (Sport)	4.85	3.10	11.5
River/stream *(Stream)*	6.52	2.48	44.4	Swimming area *(Swim)*	4.81	2.90	4.2
Forest dominance *(Forest)*	6.22	2.48	1.6	Urban agriculture area *(Agro)*	4.47	2.70	9.9
Walking/Cycle path *(WalkCycl)*	6.18	2.55	14.8	Fruit tree *(Fruit)*	4.34	2.59	3.1
Low presence of people *(LowCong)*	6.18	2.32	79.9	Bars/restaurant *(Bars)*	3.97	2.79	1.3
Old/big tree *(Old_big)*	6.14	2.75	6.4	Shrubs *(Shrub)*	3.95	2.13	44.4
High intensity lighting *(HighLigh)*	6.14	2.47	21.9	Low intensity lighting *(LowLight)*	3.81	2.18	78.1
Grill/Picnic *(Picnic)*	5.96	2.67	2.4	Playground *(Play)*	3.66	2.96	5.5
Flowerbed *(Flower)*	5.90	2.77	7.7	High presence of people *(HighCong)*	3.55	2.10	19.6
Wild plants and animals *(Wildlife)*	5.75	2.87	21.4	Fishing area by the fjord *(Fishing)*	2.74	2.48	2.0
Varied terrain *(Slope)*	5.56	2.28	23.7	Dog facility *(Dog)*	2.67	2.67	1.6

Figure 6. Preferences vary for different conditions – indicated by the presence of structures, surfaces and other users - in urban open spaces. Source: Soy Massoni et al. (2018)

Figure 7.1 shows the model structure of ESTIMAP applied to urban recreation (Zulian et al , 2018). Recreational potential (RP) is computed based on physical characteristics of urban green infrastructure and expert assessed suitability of land to support recreation. Facilities to reach recreation sites (roads, paths) and facilities to enjoy map opportunities, which combine to map recreation opportunity spectrum (ROS). Urban population's access to recreation opportunities combined with ROS are used for demand analysis.

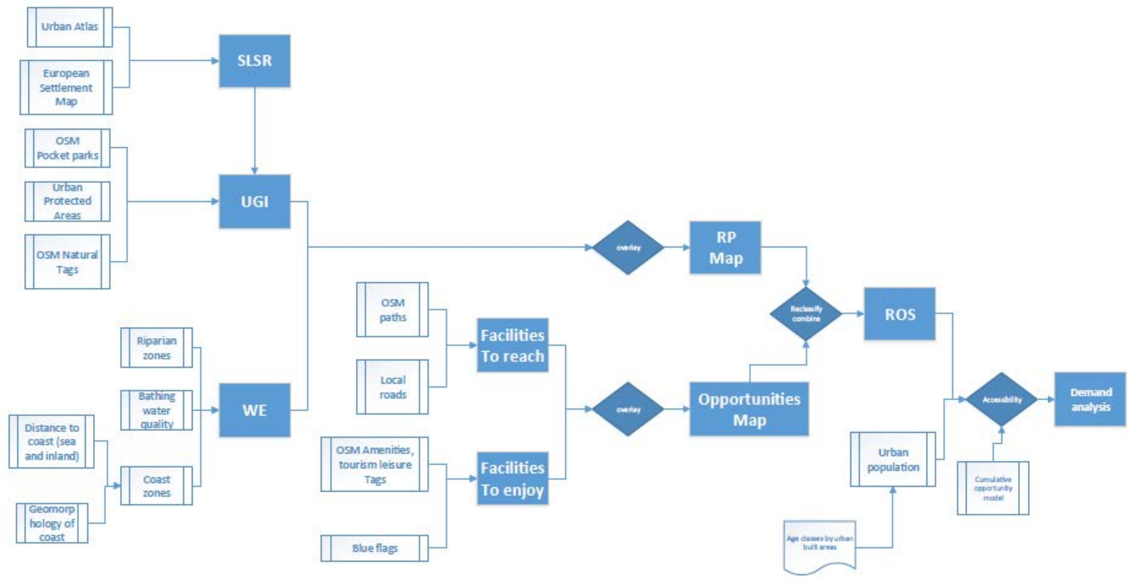

Figure 7.1 ESTIMAP Urban Recreation model structure.

SLSR= Suitability of land to support recreation. RP=recreation potential. ROS=recreation opportunity spectrum. UGI=urban green infrastructure WE=water elements. Source: Zulian, G. S. Vallecillo, A. La Notte (2018) Ecosystem services accounting: outdoor recreation and ecosystem condition. EC-JRC Presentation URBAN EEA Symposium, 18-9-18 Statistics Norway.

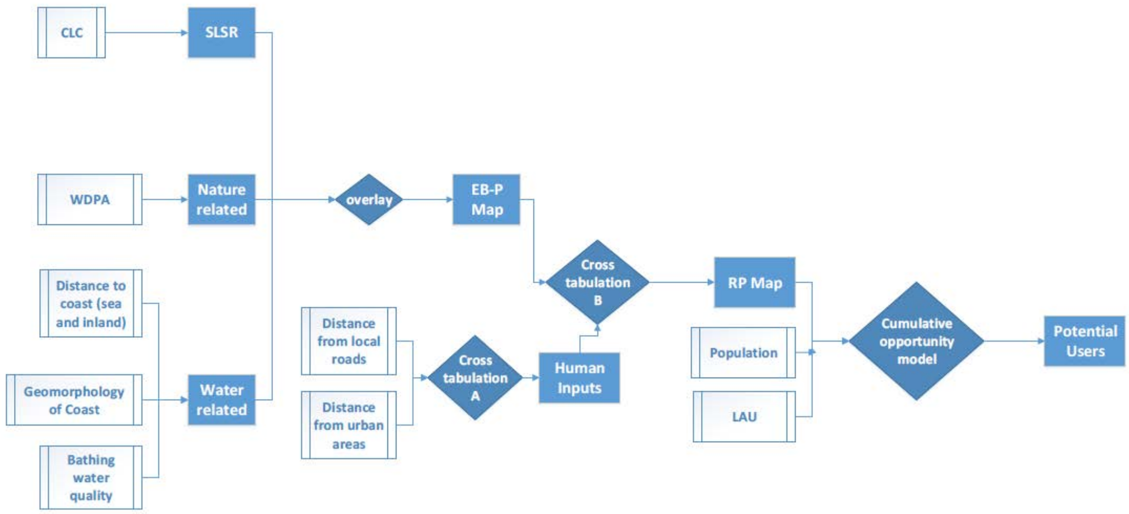

Figure 7.2 ESTIMAP Recreation model structure adapted for accounting.
EB-P= Ecosystem-Based potential Map. RP=recreation potential. SLSR= Suitability of land to support recreation. Local administrative unit. Source: Vallecillo et al. 2018.

Figure 7.2 shows the ESTIMAP recreation model at European level applied to ecosystem accounting (Vallecillo *et al.*, 2018). The EU level model does not use detailed data on facilities to reach and to enjoy on-site. Other data is similar with the urban application. The model predicts potential use.

Proposition #10. The mapping terminology applied to urban recreation modelling requires translation to ecosystem accounting terminology. Further matching of terminologies is required for condition, capacity, recreational opportunity spectrum, potential supply and actual use (demand analysis) (Figures 3.1,3.2).

Figure 8 shows the criteria set used by municipalities in Norway for mapping and qualitative valuation of outdoor recreation (Miljødirektoratet, 2014). The criteria are meant to be applied by local recreational users in a participatory GIS process. The criteria defining outdoor recreation value are quite different from GIS-driven models such as ESTIMAP.

Proposition #11: outdoor recreation mapping and valuation methods show a large variation in variable specification between countries, because they are adapted to available data, local recreation preferences and institutions in place. Generic ecosystem accounting terminology for recreation that 'communicates with' classification systems at municipal level is a challenge for the relevance of ecosystem accounting for local governments.

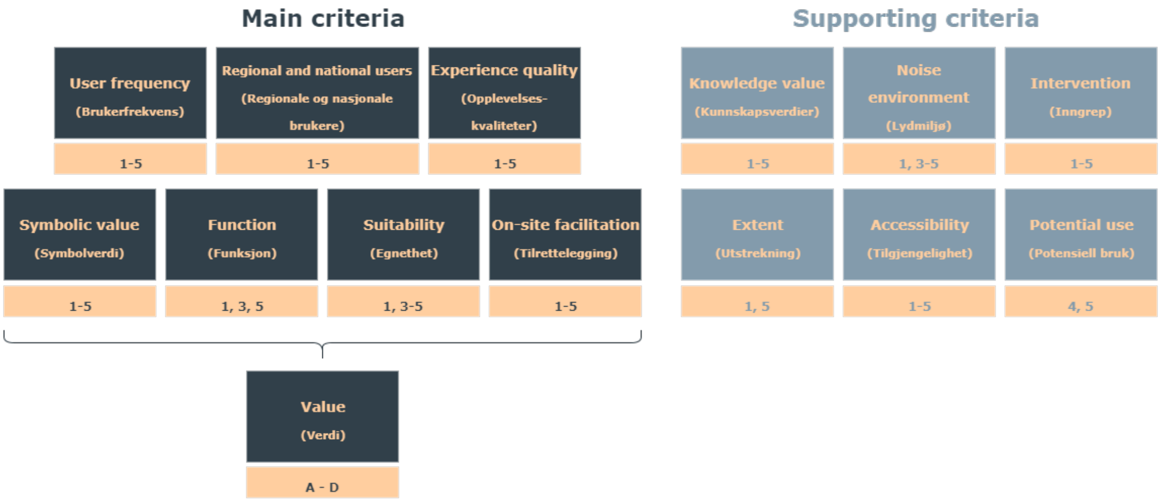

Figure 8. Criteria set for mapping and qualitative valuation of outdoor recreation at municipal level in Norway (Norwegian Environment Agency, Miljødirektoratet 2014).

5. Valuation of the local recreation services

5.1 Monetary valuation methods for local recreation

Monetary valuation methods that are compatible with the SNA only articulate exchange values. Monetary valuation methods for outdoor recreation and urban amenities are subject to further assumptions about institutional context that articulate values, including conditions of access, use rights and management regimes. Local recreation and neighbourhood amenities close to the home are often open access, free of entry charge, and being local are conducted on foot, bicycle or with public transport with no/minimal outlays for travel.

Proposition #12: While ubiquitous, local recreation choices leave few direct 'exchange value' contributions to economy.

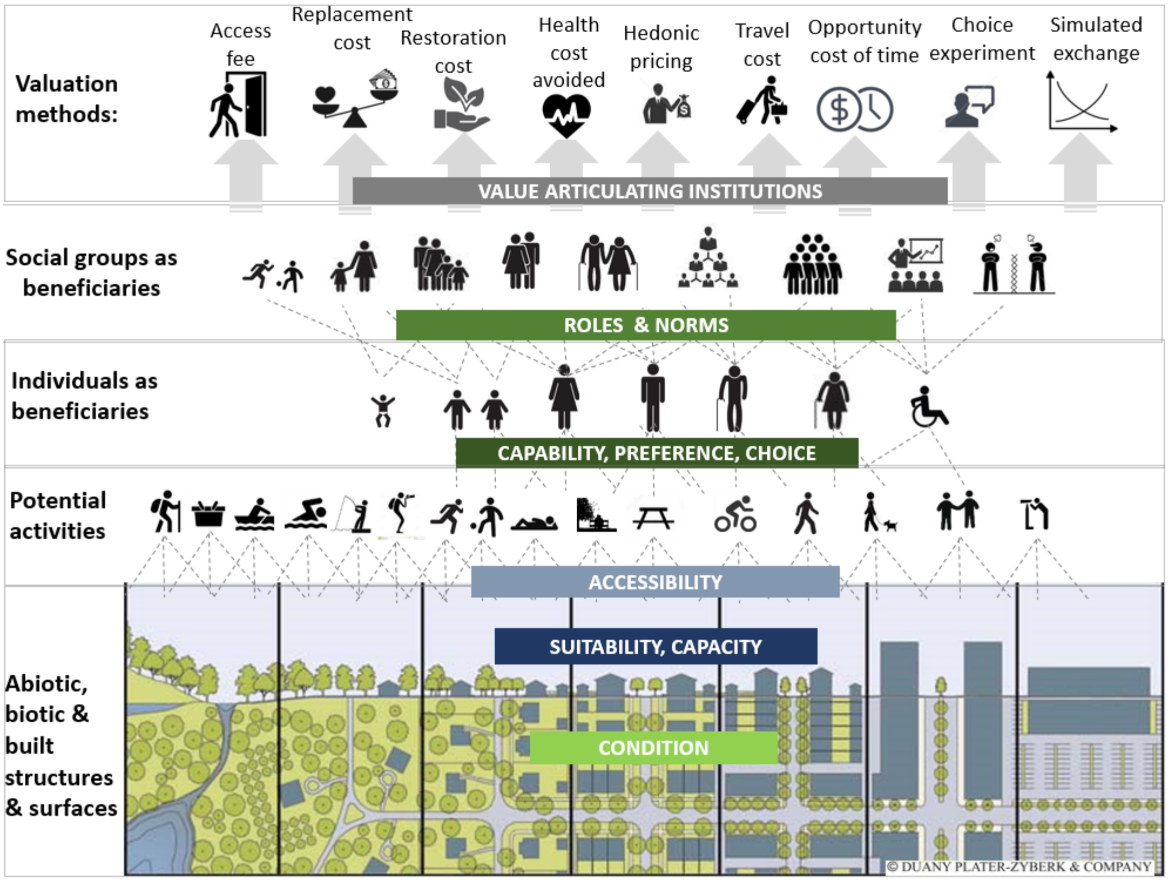

Figure 9. A number of monetary valuation methods address direct and indirect benefits of local recreation and amenities - few methods are sensitive to ecosystem condition at the high resolution determining recreational benefits in urban environments, while estimating across the whole urban landscape

Proposition #13: A number of monetary valuation methods address direct and indirect benefits of local recreation and amenities. However, few methods are sensitive to ecosystem condition at the high resolution determining recreational choice in urban environments, while being able to generalize and aggregate across the whole urban landscape or across rural- urban transects.

5.2 Time-spent in local recreational environments

Urban populations as individuals and in social groups (households, neighbourhood associations, clubs, volunteer organisations) allocate many time increments to maintain urban vegetation and spend time in local green spaces. When aggregated across an urban population time spent working with and being in urban nature is large(Figure 6) (Barton *et al.*, 2015; Cole *et al.*, 2018).

Proposition #14: Time spent on-site is an intuitive metric for a physical use account. Depending on the individual's employment situation recreation time can have opportunity costs in terms of foregone labour income.

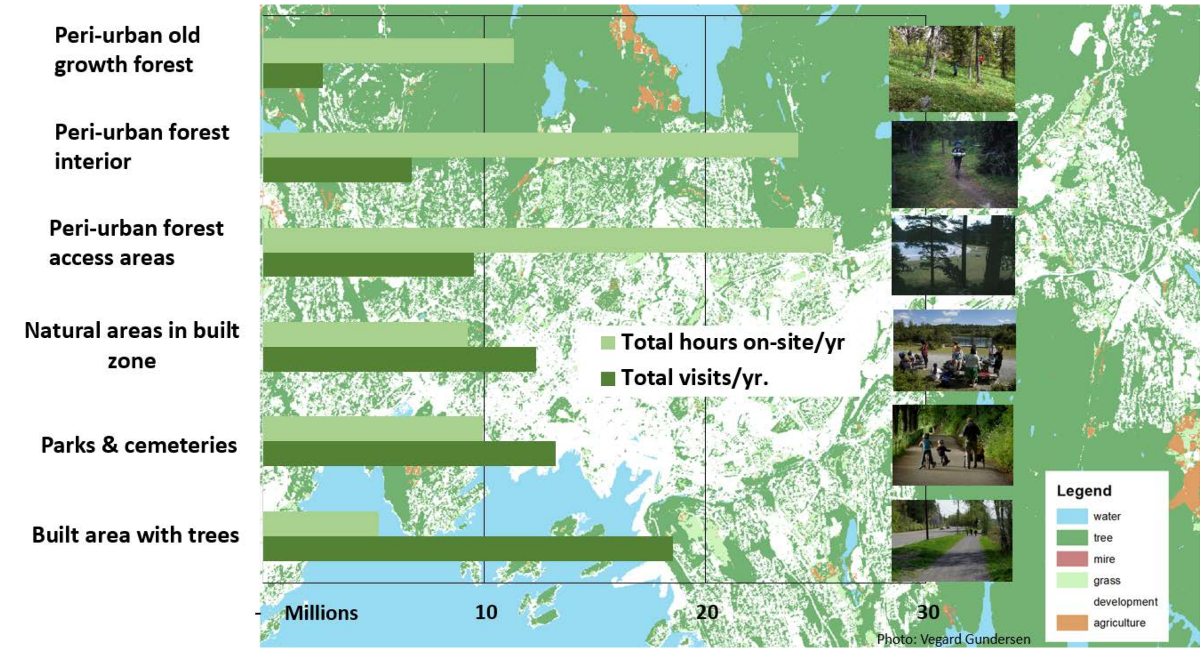

Figure 10. Large amounts of time is spent on an annual basis by individuals in local green spaces and open spaces with natural features such as tree-lined streets, and yet this time leaves little trace in terms of exchange values in the economy. Example of annual visitation frequency and estimated time on site in Oslo. Source: adapted from Barton et al. (2015)

Official recreation statistics in Norway are not disaggregated in terms of types of green space destinations. This seems to be the case in many European countries.   However, in the UK the Monitor of Engagement with the Natural Environment (MENE) Survey in (Natural_England, 2015) recorded visits and time to broad range of environments. MENE has been used to value vehicle-based outdoor recreation (Day and Smith, 2018).   Recreation in private gardens or the recreational effect of vegetation in local streets was not recorded in MENE.

Proposition #15. The challenge to urban ecosystem accounting is identifying time spent in recreational activities in private gardens, in local environment in round-trips with no destination (e.g. strolling, walking the dog or a pram), and in non-recreational destinations where recreation is enjoyed as part of the trip (e.g. biking to work).

5.3 Hedonic property pricing

Rather than develop increasingly sophisticated spatial models to allocate recreation use statistics across increasingly more detailed maps of recreation potential, an alternative approach is to value neighbourhood amenities through property prices as a capitalized ‘lump-sum’ for representing all neighbourhood amenities. Hedonic property pricing is a statistical method regressing property structural characteristics, plot and neighbourhood characteristics on property price. The marginal effect of proximity to greenspaces of different sizes and type is estimated holding all other property and neighbourhood characteristics constant. The hedonic pricing method was used in UK urban ecosystem accounts (ONS, 2018) to estimate the incremental value of homes within 200 meters of small, medium and large parks. The difference in average predicted property price with and without the proximity of green spaces was multiplied by the total number of residential properties to obtain the total asset value of blue and green spaces in the UK. A drawback of this averaging and aggregation across a large area is that local changes in green space availability will not be observed. The aggregation method is not sensitive to changes in local ecosystem condition.

Apartment prices in Oslo depend non-linearly on walking distances to large and small parks (upper panels) and different parts of the peri-urban Marka forest (lower panels).(Heyman *et al.*, 2018) (Figure 11).

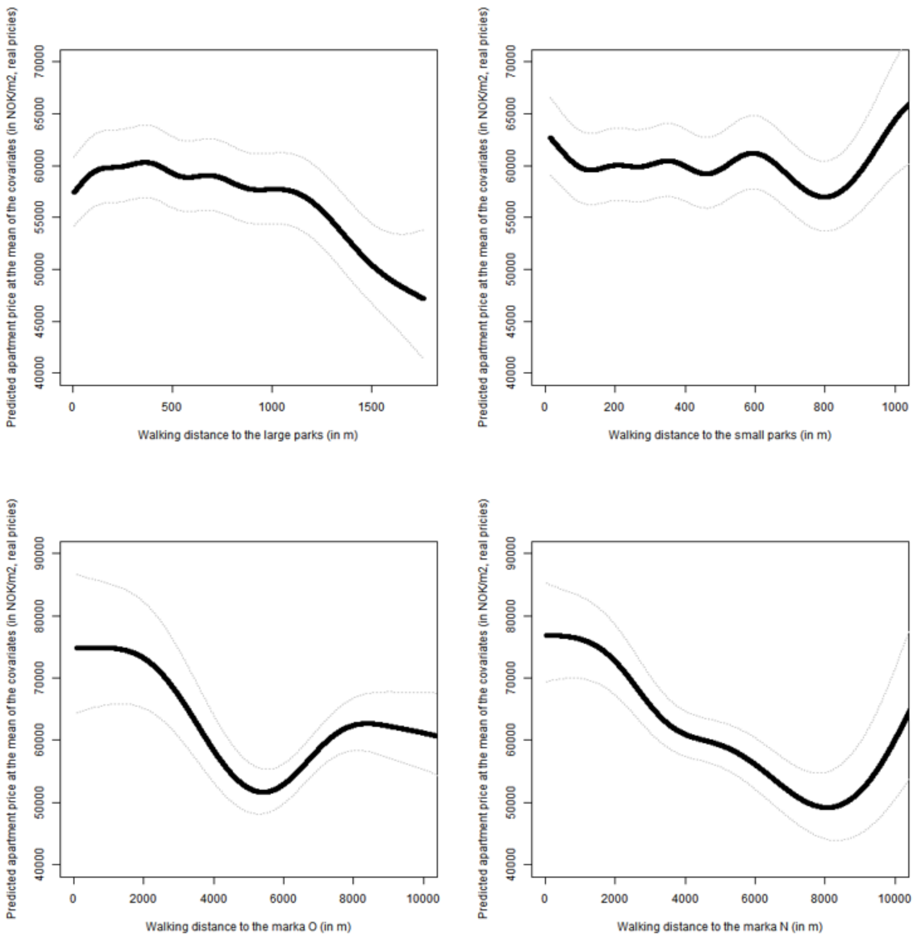

Figure 11. Apartment prices in Oslo depend non-linearly on walking distances to large and small parks (upper panels) and different parts of the peri-urban Marka forest (lower panels). Non-linear distance decay in the contribution of green space to property prices locally indicate that standardised approaches to valuing proximity may be highly uncertain.
Source: Heyman et al. (2018) A revealed preference study of Oslo apartment transactions

Proposition #16. Hedonic property pricing is likely to double count benefits already accounted for by valuation using other methods of (i) physical health benefits (ii) neighbourhood air quality and (iii) noise regulation (ONS, 2018).

Proposition #17. Hedonic pricing can potentially capture additional value of local recreational trips not incurring expenses. There would potentially be double counting with the valuation of time spent in the local neighbourhood. Spatial buffers used to define green space proximity in the hedonic price model and typical walking distances would need to be consistent (ONS, 2018).

Proposition #18. Non-linear distance decay in the contribution of green space to property prices locally indicate that standardised approaches to valuing proximity may be highly uncertain

5.4 Further assessment of monetary valuation methods for urban recreation services

For a more systematic assessment of appropriate valuation methods for urban recreation services, a series of screening criteria could be applied (Barton, 2018):

1. **Conceptual consistency with** SEEA EEA TR.
    a. **Exchange values?** Does the method use exchange values?
    b. **Individual services? Double counting?** Is the method able to identify the ecosystem service individually? Does this identification reduce the likelihood of double counting.
    c. **Sensitivity to scarcity**? Is the method sensitive to changes in ES supply and use? Are they average unit or marginal values?
    d. **Institutional compatibility?** Are the institutional assumptions of the valuation method compatible with current institutions governing ecosystem use?
2. **Practical considerations for application (to policy analysis)**
    a. **Significance?** Is the method vulnerable to zero or low monetary values? (relative to level of biophysical flows)
    b. **Robustness?** Is the valuation method complex, subject to a large number of data transformations and modelling assumptions? (methods with few data transformation steps and assumptions are more robust)
    c. **Accuracy?** Can valuation method variance/uncertainty be quantified? (is the method sensitive to spatial and temporal variation in the accounting area and period?)
3. **Institutional capacity to conduct valuation**
    a. **Technical complexity?** Does the method require a specialist in a particular software?
    b. **Information cost?** Is the method costly to implement (time to completion)
4. **Other policy applications?** Are the results of the method applicable to many other policy analysis purposes, than those of accounting?

In the following tables taken from we demonstrate how methods could be screened more systematically for the urban outdoor recreation service (Barton, 2018). The screening examples demonstrate that most methods have significant deficiencies when seen across all criteria. Take-away messages include:

Propostion #19 Remote sensing data provides biophysical resolution on ecosystem condition that far exceeds the spatial resolution of recreation use statistics, and spatial resolution of most monetary valuation methods for outdoor recreation.

Propostion #20. Models that simply allocate available aggregate visitation statistics over highly spatial resolved biophysical maps may easily give a false cartographic impression of spatial accuracy of monetary valuation.

Table 3. Ecosystem service: accessible local outdoor green space Benefit: local outdoor recreation	**Method selection criteria:**									
Monetary valuation methods	Double counting	Exchange values	Sensitivity	Institutional compatibility	Significant	Robustness	Accuracy	Technical complexity	Information cost	Other policy applications
1. Unit resource rent/net factors of production										
2. Production function, cost function and profit function										
3. Payments for ecosystem services										
4. Hedonic pricing	0	1	1	1	1	0	1	0	0	1
5. Replacement cost	1	1	1	0.5	1	1	0.5	1	1	0
6. Damage cost avoided (health)										
7. Averting behaviour										
8. Restoration cost										
9. Travel cost, random utility models										
10. Stated preference (contingent valuation, choice experiments)										
11. Simulated exchange values[1]										
13. Value of quality adjusted statistical life										
14. Value of household time	1	1	0	0.5	0	1	1	1	1	1

[1] "Marginal values from demand functions" in the SEEA EEA TR

Table 3.1. **Context:** **Criteria:**	**Ecosystem service: local outdoor recreation** **Valuation method: Hedonic property pricing**
1.Conceptual consistency	
Production boundary? Does the method address ecosystem services that fall inside SNA production boundary?	**No**. But imputed values of ecosystem services are already included in the rental value of housing in SNA. If included in ecosystem account, housing rental value net of ecosystem services must be computed.
Individual services? Is the method able to identify the ecosystem service individually? **Double counting?** Does the identification of services in the method reduce the likelihood of double counting.	**No**. Hedonic pricing regression identifies the marginal value of proximity to ecosystem assets, rarely unique services **No**. Neighbourhood landscape attributes posess a bundle of cultural and regulating services. Double counting can be 'avoided using reclassification of "amenity services"
Exchange values? Does the method use exchange values?	**Yes**. Real estate market
Sensitivity to scarcity? Is the method sensitive to changes in ES supply and demand? Are they average unit or marginal values?	**Yes**. But real estate markets are also highly sensitive to (virtual) financial markets and speculation Marginal values derived from spatial regression methods.
Compatibility of value articulating institution? Are the institutional assumptions of the valuation method compatible with current institutions governing ecosystem use?	**Yes**. The market is based on voluntary transaction between willing seller and buyer. Degree of compatibility will depend on degree of market regulation. In the extreme case, state ownership, with fixed rental will not be compatible.
2.Practical considerations for application (to policy analysis)	
Significance? Is the method vulnerable to zero or low monetary values? (relative to level of biophysical flows)	**Yes**. In some urban contexts accessibility to vegetation may have unobservable effects on overall property prices. In complex urban environments many degrees of freedom are used in specifying real estate preferences. Site specific differences may be small, requiring very large datasets.
Robustness? Is the valuation method complex, subject to a large number of data transformations and modelling assumptions? (methods with few data transformation steps and assumptions are more robust)	**Yes.** Econometric regressions are complex and marginal values are highly sensitive to model specification due to spatial autocorrelation
Accuracy? Can valuation method variance/uncertainty be quantified? (the variance is determined by the size and heterogeneity of the accounting area, but is the method sensitive to this variation?)	**Yes.** Spatial variation in controlled for statistically for each asset. (individual ecosystem services cannot be identified, though).
3.Institutional capacity to conduct valuation	
Technical complexity? Does the method require a specialist in a particular software?	**Yes.** Requires specialised GIS and econometrics software. Assigning marginal amenity values across a population of households to multiple specific green spaces is an unresolved GIS modelling task.
Information cost? Is the method costly to implement (time to completion)	**Yes.** Most applications are experimental. Production times could be reduced if standard variables for amenities were applied.
4.Other policy applications? Are the results of the method applicable to many other policy analysis purposes, than those of accounting?	**Yes**. Can be used to adjust property taxes to account for value-added to private property by public management of public green spaces.

Table 3.2 **Criteria:**	**Ecosystem service: local outdoor recreation** **Valuation method: Replacement cost (indoor gym/physical exercise)**
1.Conceptual consistency	
Production boundary? Does the method address ecosystem services that fall inside SNA production boundary?	No
Individual services? Is the method able to identify the ecosystem service individually? **Double counting?** Does this identification reduce the likelihood of double counting.	Yes. But the substitute is only for one attribute - the physical space in which to carry out physical exercise, not for the vegetation and landscape qualities. Yes.
Exchange values? Does the method use exchange values?	Yes
Sensitivity to scarcity? Is the method sensitive to changes in ES supply and demand? Are they average unit or marginal values?	Yes. Marginal
Compatibility of value articulating institution? Are the institutional assumptions of the valuation method compatible with current institutions governing ecosystem use?	Partly. It is acceptable to compensate for loss of access to outdoor recreation areas with indoor recreation areas, if outdoor recreation areas for specific physical activities become scarce (e.g. because of weather, seasons, climate change).
2.Practical considerations for application (to policy analysis)	
Significance? Is the method vulnerable to zero or low monetary values? (relative to level of biophysical flows)	No.
Robustness? Is the valuation method complex, subject to a large number of data transformations and modelling assumptions? (methods with few data transformation steps and assumptions are more robust)	No
Accuracy? Can valuation method variance/uncertainty be quantified? (the variance is determined by the size and heterogeneity of the accounting area, but is the method sensitive to this variation?)	Partly. The valuation is of only on attribute of outdoor recreation, the estimate may have precision, but is not accurate in relation to the valuation target.
3.Institutional capacity to conduct valuation	
Technical complexity? Does the method require a specialist in a particular software?	No
Information cost? Is the method costly to implement (time to completion)	No
4.Other policy applications? Are the results of the method applicable to many other policy analysis purposes, than those of accounting?	No

Table 3.3 **Criteria:**	**Ecosystem service: local outdoor recreation** **Valuation method: Value of household time at recreation site** **(opportunity cost)**
1.Conceptual consistency	
Production boundary? Does the method address ecosystem services that fall inside SNA production boundary?	No. Household time spent on production of goods and services for own subsistence is not considered.
Individual services? Is the method able to identify the ecosystem service individually? **Double counting?** Does this identification reduce the likelihood of double counting.	Yes. Time spent at a recreation site is commonly used to express the importance of a recreational visit. Yes. If separately identified from time allocated to reaching the site. For local recreation there is little or no travel time (going for walks).
Exchange values? Does the method use exchange values?	Yes. Opportunity cost of time , as foregone wages after tax.
Sensitivity to scarcity? Is the method sensitive to changes in ES supply and demand? Are they average unit or marginal values?	No. This monetary measure is insufficient where household members are not employed and/or do not have remunerated flexible working time. As demand for recreation by a household increases, the opportunity cost per hour may also shift, if terms of salary must be renegotiated. Also, opportunity costs may be a step function, if overtime is paid differently. However, in labour markets with flexible working hours (accumulative, non-remunerated overtime), opportunity cost of wages after tax may be a good proxy for the foregone monetary value of recreation time.
Compatibility of value articulating institution? Are the institutional assumptions of the valuation method compatible with current institutions governing ecosystem use?	Depends on the labour market. Individual specific.
2.Practical considerations for application (to policy analysis)	
Significance? Is the method vulnerable to zero or low monetary values? (relative to level of biophysical flows)	Yes. Unemployed.
Robustness? Is the valuation method complex, subject to a large number of data transformations and modelling assumptions? (methods with few data transformation steps and assumptions are more robust)	No
Accuracy? Can valuation method variance/uncertainty be quantified? (the variance is determined by the size and heterogeneity of the accounting area, but is the method sensitive to this variation?)	Yes
3.Institutional capacity to conduct valuation	
Technical complexity? Does the method require a specialist in a particular software?	No
Information cost? Is the method costly to implement (time to completion)	No
4.Other policy applications? Are the results of the method applicable to many other policy analysis purposes, than those of accounting?	Yes. Accounting for and valuing recreation time addresses can help answer questions about recreation access of different sectors of society, impacts of unemployment. The choice of monetary valuation method versus the physical indicator highlights issues of income inequality.

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