IDENTIFICATION OF KEY-TRENDS AND EVALUATION OF CONTEMPORARY RESEARCH REGARDING URBAN ECOSYSTEM SERVICES: A PATH TOWARDS SOCIO-ECOLOGICAL SUSTAINABILITY OF URBAN AREAS

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Abstract. The challenges accompanying socio-ecological and demographic transformations in the urban areas necessitate for coordinated efforts to ensure urban ecological resilience. Trans-disciplinary analytical construct of urban ecosystem services (UES) empowers the policy makers and urban planners to synchronize the orientations of human impacts and resilience of ecological resources in urban areas. The current study provides a systematic overview about the research orientations, approaches and techniques used in the recent studies regarding UES. The study examined: what types of evaluation methods were adopted in the recent UES research? What is their spatial and temporal pattern? What types of UES were focused and environmental components relied upon for the assessment? To address these questions, 116 relevant publications were scrutinized by using a set of assessment criteria. The findings indicated a lesser focus in research towards UES in developing countries as compared to the volume and increasing share of their urban population. The study also establishes that an overwhelming proportion of the UES research was carried out in the industrialized countries of the northern hemisphere but rather skewed towards studying regulatory ecosystem services. The recommendations for improving the relevancy of contemporary research for stakeholders were made.
Keywords: *urban ecosystem services, ecosystem disservices, urbanization, socio-ecological systems, urban environment, resilience, urban ecology*

Introduction

The contributions of natural resources to social and economic systems are referred to as ecosystem services (ES) defined as the benefits humans draw from the functioning and processes of ecological systems (Costanza et al., 1997; Daily et al., 1997; De Groot et al., 2002). It is acknowledged that the life on the planet Earth is a product of and

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dependent upon the constant support and productivity of ecosystems and services arising thereby (De Groot et al., 2002). These benefits from the ecological resources are classified into four major groups or categories i.e. regulatory, cultural, provisioning and supporting services (De Groot et al., 2002; Millennium Ecosystem Assessment, 2005a).

The birth of new urban settlements and/or the increase in the size of existing urban centers at the cost of non-urban land usages pose(s) new social and environmental challenges (Haase et al., 2014b). The increase in the proportion of global urban population (Heilig, 2012; Haase et al., 2014b), transformations in the urban based economic activities and concomitant life style changes in the urban centers have their visible impacts on the natural environment. The conjectured estimations suggest that the process of urbanization will accelerate in the future (Cohen, 2004; United-Nations, 2014; Graça et al., 2017). The promising technological advancements are sometimes misconstrued as a replacement for the natural ecosystems of urban areas. These advancements can supplement the contributions of natural ecological systems in an urban area but are incapable of substituting their role (Honey-Rosés et al., 2014).

The term "ecosystem services", initially appeared in Ehrlich and Ehrlich's work in 1981 (Liu et al., 2010; Chaudhary et al., 2015) while highlighting the contribution of ecological systems for human life. Now the term ES is frequently used for assessing the material contribution of natural resources in human wellbeing. The concept provides a common vocabulary for evaluating tripartite linkages between ecological, social and economic systems to ensure their integrated management. The concept of ES has proven useful, firstly, to synthesize the efforts for linking human and ecological systems for coherence and sustainability (Costanza and Daly, 1987; Daily et al., 2009). Secondly, scientists and policy makers rely on the concept while evaluating economic and political tradeoffs between landscape development and conservation alternatives (De Groot et al., 2010; Mcshane et al., 2011; Bürgi et al., 2015).

The analytical construct of Urban Ecosystem Services (UES) is relied upon for the assessment, management and conservation of the urban ecological resources and their correlation with human life. The paradigm of UES seems to be a more pragmatic strategy to ensure that the impacts of urbanization, climate change and socio-ecological transformations on the urban environment are addressed.

The first studies on UES date back to the mid-1990s (Cairns Jr and Palmer, 1995) but the interest in this sphere had spread worldwide by the end of the last century (Bolund and Hunhammar, 1999). The researchers such as Alavipanah et al. (2017), supported the previous findings of (Gómez-Baggethun et al., 2010; Kronenberg and Hubacek, 2013; Haase et al., 2014b) that less than 10% of ES research in scientific publications was investigated in urban areas and also depicted a decline in the publication concerning UES after 2015.

It transpires from scholarly efforts that the demands for UES are mounting but paradoxically the efforts are less focused to address the challenges associated with the urban environment (Millennium Ecosystem Assessment, 2005b; Haase et al., 2014b). The situation demands a systematic review of UES studies based upon an innovative framework for postulating pragmatic measures to improve the orientations, trends and techniques in research regarding UES.

Keeping in view these expectations, the current study was designed to decipher various dimensions of UES research in recent years. In this connection, the present review was carried out on the basis of selected research publications to analyze: 1) The current spatial-temporal trends in UES research 2) To weigh research orientations,

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approaches, and techniques adopted in the recent studies 3) to evaluate the components of urban environment used for assessments in the reviewed publications. The outcomes of the current study will provide insights and innovative options for integrating efforts to ensure the sustainable provision of UES.

Material and method

The current review is a meta-analysis and is based upon the bibliographic information obtained from ISI web of Knowledge (www.webofknowledge.com). The study considered the articles published in English during the period (May 2007 - May 2017) against the search term "urban ecosystem services'. The search returned a total of 127 records. Out of these, only those records were considered for further scrutiny, where, the search term UES was included in either the Title, Abstract or Keywords of a publication. On these criteria, 116 records were identified for further processing and content analysis (*Appendix-1*).

The content analysis of selected papers, based upon a list of assessment criteria with the predetermined choices (*Table 1*), was carried out to determine the current orientations of or in the UES studies, techniques and measures (monetary/non-monetary) relied upon in the research for assessments and inferences. The information pertaining to environmental components used for evaluating UES was also extracted from the reviewed publications. A component was only included in this study, provided, it was used as a parameter for assessment to publish the article. The components with different appellations, used to assess analogous goals (such as Hedonic Pricing or Property Value; carbon absorption or storage etc.) amalgamated into a single category for brevity and analysis. In this way 10 classes were formulated to interpret trends to select component(s) for assessing UES. The quantitative findings of this analysis were cartographically displayed in *Figures 1-7* for estimations and inferences.

Table 1. *Selection and assessment criteria adopted for the review of selected research publicatons*

Criterion (question)	Possible entries
Which type(s) of ES were analysed?	i. Regulating Services ii. Provisioning Services iii. Cultural Services iv. Supporting Services v. Cumulative Assessment of ES vi. Ecosystem Disservices
From which country (city) empirical data/ contextual information were obtained? If required for assessments.	The name of country/city in which the site/situation of study is located.
What is the location of Principal/corresponding author of the study?	The location of author

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What kinds of evaluation methods/indicators were relied upon for assessments in these studies?	i. Monetary ii. Non-Monetary iii. Both (Monetary and Non-Monetary) iv. Not Applicable
What was the principal objective of the study?	The objectives of these publications were grouped into eight categories on the basis of homogeneity in focus: i. Planning and Management ii. Assessment study iii. Governance and Policy iv. Assessment of Method v. Climate Adaption vi. Landuse Planning vii. Urban Ecology viii. Environmental Justice
Which specific component(S) of urban environment was/ were assessed?	The name of component(s) assessed in a publication: i. Aesthetics ii. Biodiversity iii. Carbon Sequestration/Storage iv. Climate Regulation v. Energy vi. Food Fuel vii. Hedonic Pricing viii. Others ix. Socioecological x. Water Management
What type of enquiry technique was used in the study?	i. Assessment (technique)study ii. Experimental (technique)study iii. Exploratory (technique) method iv. Conceptual Framework
What was the principal consideration of the study?	The content analysis revealed that reviewed studies were inherently designed to address the impacts of the following challenge (s): i. urbanization, ii. climate change iii. Loss of urban biodiversity

Results

Spatio-temporal trends

The temporal analysis of these publications in *Figure 1* reflected an upward trend to use the term UES in title, abstract or keywords in the initial years of the selected timeframe. However, a decline in tendency to use the term UES in publications was noticed in the last two years of the selected period.

The *Figure 2* illustrates that a leading share of UES research was carried out in European (62.71%) and North American (23.73%) contextual surroundings. The contributions in UES research from other continents were found disproportionately less as compared to the proportion of people residing in the urban areas of these continents (*Figure 2*).

The spatial analysis of these selected publications revealed (*Figure 3*) that a predominant proportion of UES research (99%) was carried out in the contextual settings of the northern hemisphere while the share from the southern hemisphere was found to be the less than (1%).The significant intra-continental inequalities in the publications regarding UES were also observed (*Figure 3*). In this connection, the

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contributions from Germany (20) are significantly higher than those from other European countries; China (4) is at the forefront from Asia while the USA (24) is the leading country in North America. The city of Berlin (Germany) was most frequently assessed in (9) studies from different perspectives of UES and followed by New York (USA) in (7) and Stockholm (Sweden) in (6) studies (*Appendix-2*).

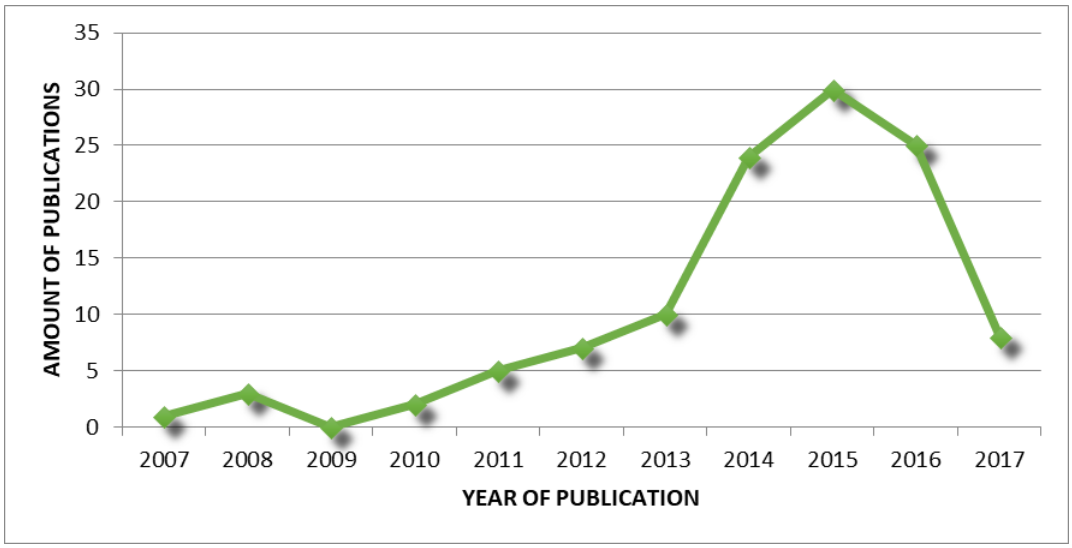

Figure 1. *The year wise distribution of publications which used the term UES during the period (2007-2017)*

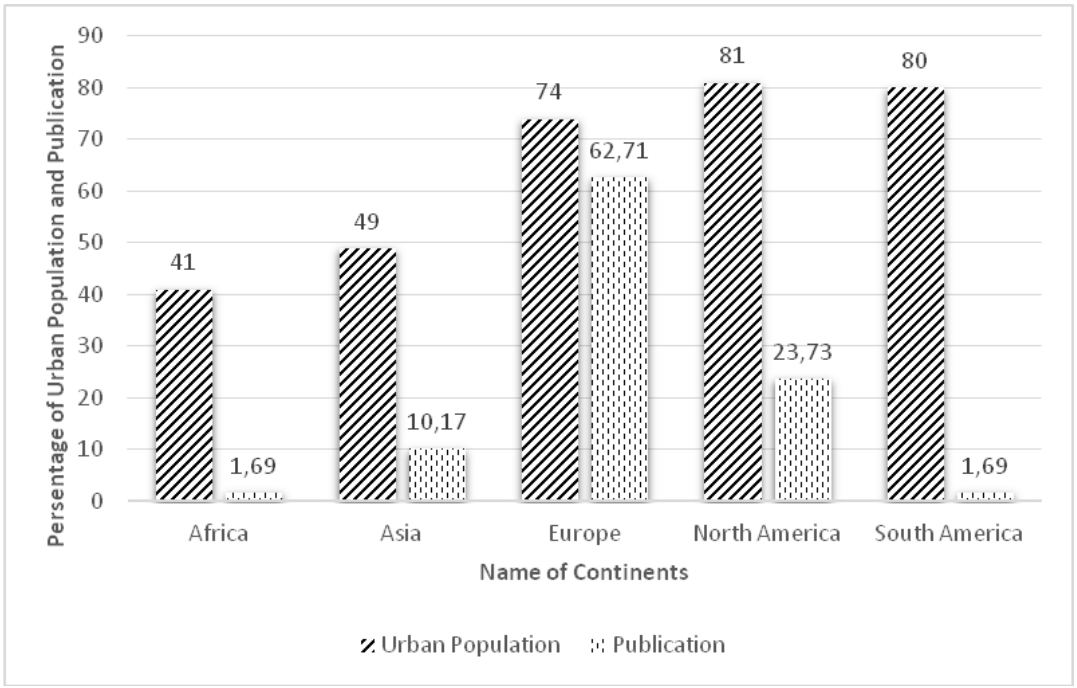

Figure 2. *Graph comparing the contribution in urban ecosystem research and the proportion of urban population of a continent (Urban population data Source: https://www.statista.com)*

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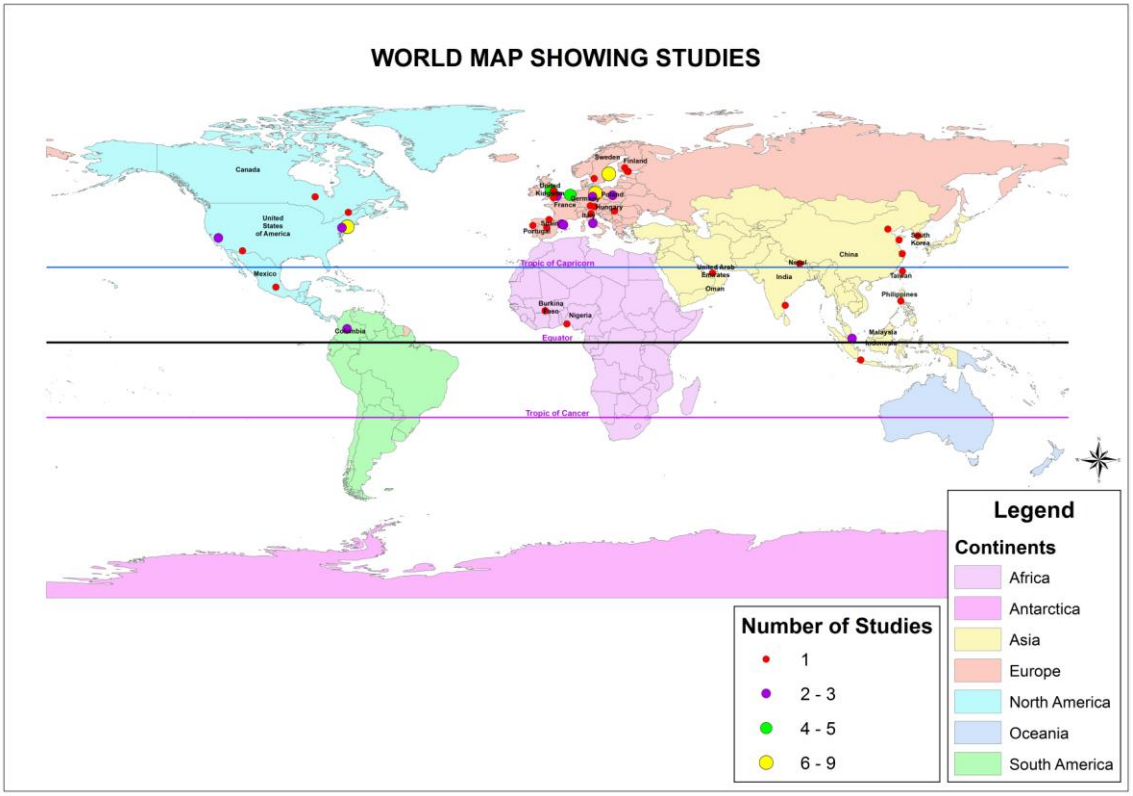

Figure 3. *World map showing locations and the numbers of UES studies*

The use of term UES in the title, abstract or keyword of a publication provides a measure to assess how much importance is given in research on highlighting the contributions of green infrastructure in urban social life. The *Figure 4* explicitly describes the frequency with which the term UES was used in the title, abstract and keywords of reviewed publications. The term urban ecosystem services was most frequently used in the abstracts (70), followed by keywords (56) and titles of (41) the reviewed publications.

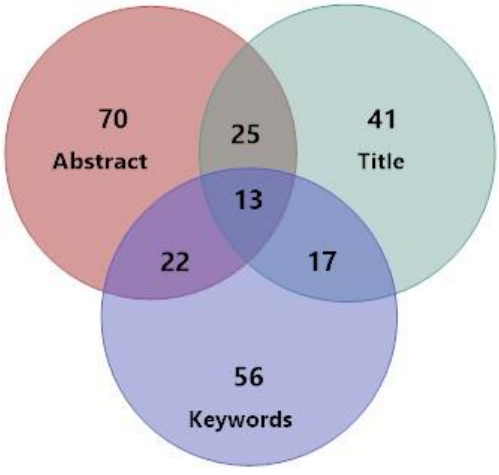

Figure 4. *Showing the use of the term UES in abstract, title and keywords*

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Types of UES and research trends

The intertwined and overlapping nature of contributions from UES makes it more intricate to catalogue a study into a specific category of services. As a pragmatic measure to overcome the problem, a specific study was simultaneously catalogued into different categories of ecosystem services provided these services were tested/evaluated in the publication. In the majority of publications, the focus of research was observed on the cumulative assessment of UES. It was followed by the deliberations on Regulatory services, cultural services and provisioning services. While the supporting services were assessed the least. However, urban ecosystem disservices (UESD) were also focused in (13) publications (*Figure 5*).

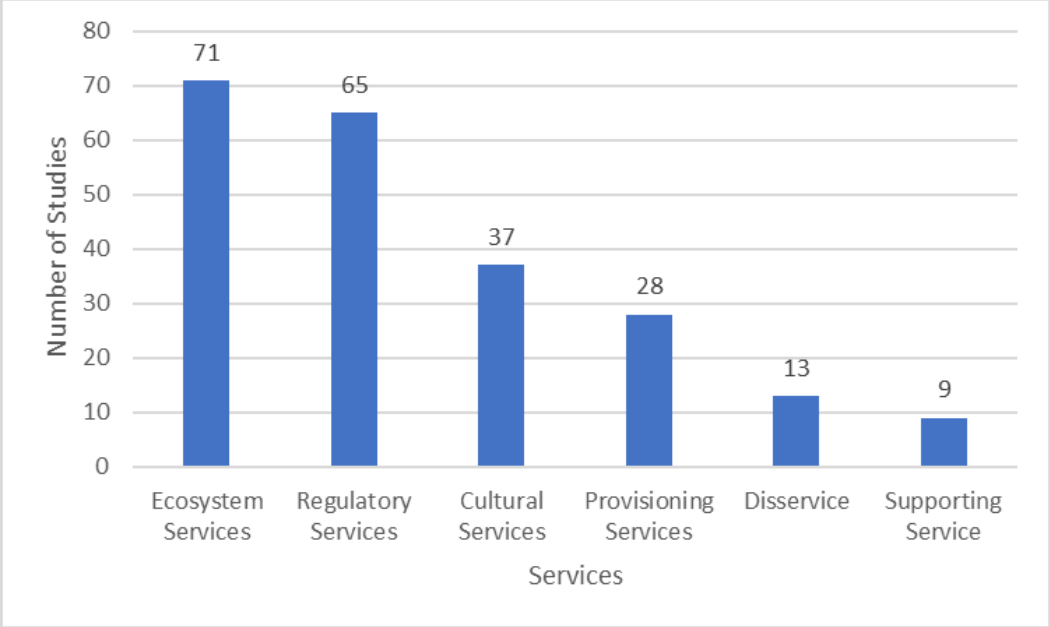

Figure 5. *Graph showing number of studies designed to focus the types of ecosystem services and disservices*

Study paradigms and UES

The impacts of urbanization, ecological degradations in urban areas and threats from global climatic changes are the potential stressors for UES. The content analysis of selected publications was carried out for assessing how much emphasis is being given to these stressors in UES studies. The findings in *Figure 6* revealed an intersecting nature of research inclinations. It also enumerates the number of studies designed to scrutinize the role of these stressors on the resilience of UES.

The trends in UES assessments

The findings of content analysis have been condensed in *Figure 7* to illustrate the numbers and proportion of studies focusing on a particular type of ES: nature of methods/indicators opted for evaluation, types of techniques relied upon for investigations, research or study objective(s) in contemporary research and selection of environmental component(S) for measurements (*Appendix-3*). These findings are indispensable for interpreting contemporary trends in UES studies.

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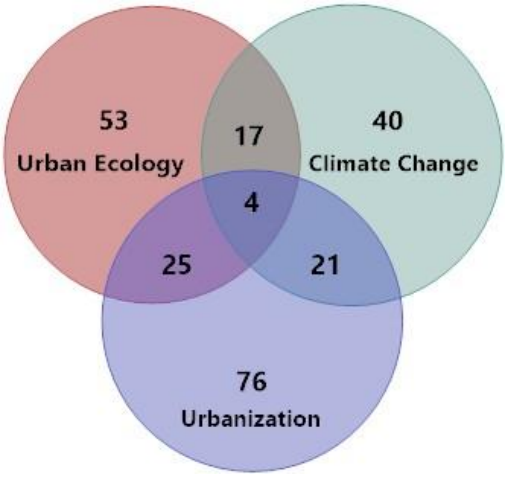

Figure 6. *Showing the focus of recent UES research*

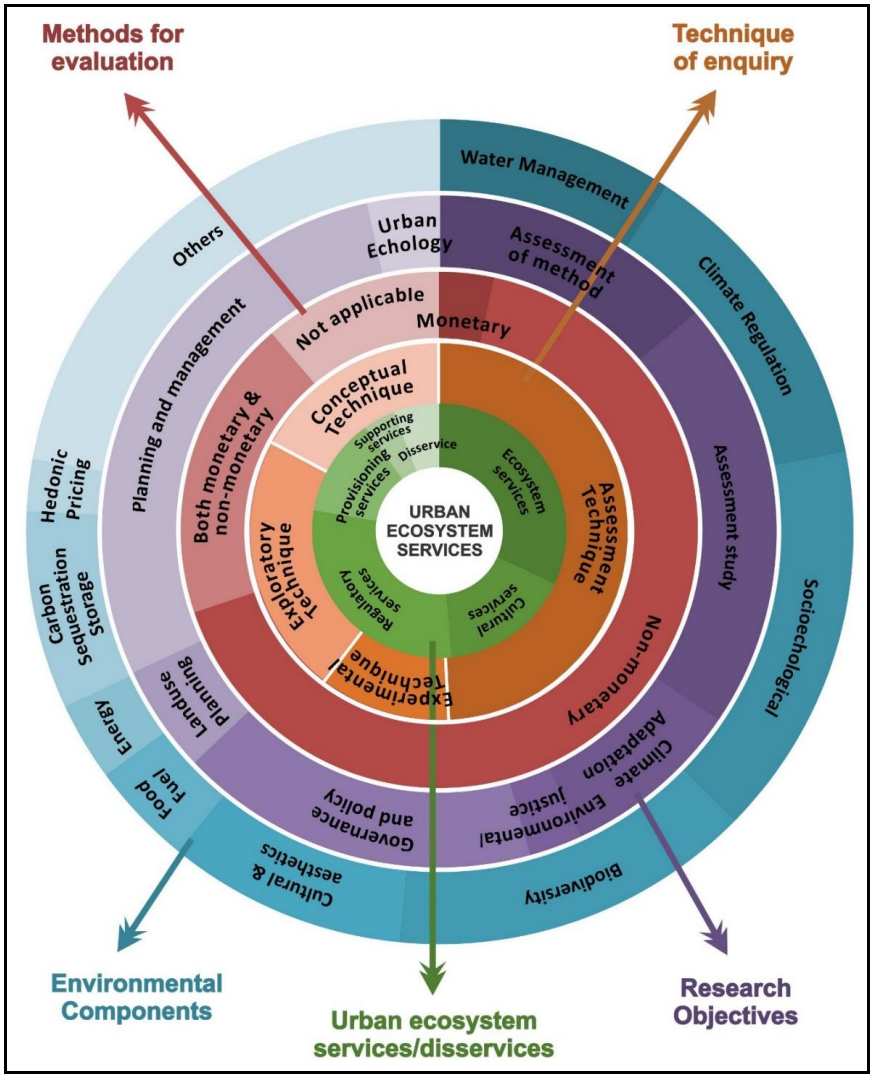

Figure 7. *The Multi-pie diagram showing types and proportion of environmental components, research objectives, evaluating methods, techniques for enquiry and types of UES relied upon in recent research*

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Discussion

Trends and techniques used in UES evaluation

The contingent valuation techniques proposed by Ciriacy-Wantrup in 1947, laid the foundations of Ecosystem Valuation (ESV) in modern times (Ciriacy-Wantrup, 1947; Spash, 2011; Mitchell and Carson, 2013) and a subsequent fervor for environmentalism in the 1960s, providing the much needed impetus to ESV (Liu et al., 2010; Salzman, 2011).

The findings in *Figure 5* indicated that Regulatory services (RS) are more in focus of the contemporary UES research compared to the other three types of ES or ESDS. It is followed by the focus of researchers on studying cultural services (CS) and Provisioning services (PS). In this connection, supporting services (SS) were observed as a lesser priority area of investigation. These dissimilarities in focus towards different types of UES are due to the nature of urban economic activities and socio-cultural life style of urban areas. Besides this, a recent surge in reported incidents of "urban heat island effect" and exacerbating climatic and environmental settings of urban areas are other plausible explanations for this skewedness in favor of RS and CS. Whereas, it is pertinent to mention that the societal acknowledgement of ecological resources meaningfully enhanced by the tangible contribution of PS. Besides this, the resilience of an ecological system is significantly determined by the performance of SS. Therefore more focus in UES research is required on assessing the contribution/role of SS and PS for ensuring sustainable provisions of UES in the face of mounting challenges to urban environment.

A marked emphasis in the majority of the reviewed publications (*Figure 6*) was observed on either 1) to measure the socio-ecological impacts of urbanization and concomitant behavioral changes on provision of UES for informed decision making 2) to assess the potentials of urban ecology for ensuring human wellbeing and urban environmental resilience or 3) to decipher the consequences of global warming and climate change on the supply of UES and socio-ecological sustainability of the urban areas. These propensities in research reflect the growing consciousness for ensuring urban ecological resilience in the face of imminent social, psychological, climatic and environmental vulnerabilities of urban areas.

The assessment or evaluations of an urban phenomenon, situation, policy or problem appeared a preferred technique of enquiry (49.14%) in the recent research (*Figure 7*). This analytical approach was adopted from different perspectives such as assessing the validity of a technological innovation/method (Lakes and Kim, 2012; La Rosa and Wiesmann, 2013; Schreyer and Lakes, 2016; Tigges et al., 2017), the effectiveness of a policy or planning instrument (Kaczorowska et al., 2016; Larondelle et al., 2016), or to estimate the impacts of socio-cultural factors on urban environment in studies (Kremer et al., 2013; Buchel and Frantzeskaki, 2015; Escobedo et al., 2015; Sutton and Anderson, 2016). As compared to this, the Experimental mode of enquiry was observed in a few studies (11.21%) for estimating the potentials of green infrastructure in the given urban context (Taylor et al., 2014; Cameron et al., 2015; Coma et al., 2017) and for assessing sthe role of building material (Capener and Sikander, 2015) in regulating the climate of urban areas. Experimentations with the help of Remote Sensing (RS) and Geographic Information System (GIS) were also made in studies (Tigges et al., 2013; Schreyer and Lakes, 2014) to evaluate their effectiveness for integrated planning of urban ecological resources. The experimentations with new options and opportunities

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are incumbent but resource dependent (financial and technological resources) however, the use of GIS and RS is gaining acceptance among the research communities (Kolanuvada et al., 2016) in the developing countries and in the less developed regions (Thapa, 2012) as well. These findings corroborate the notions that application and acknowledgement of RS and GIS as a research tool for integrated urban environmental managements will increase in the future.

The exploratory style of investigation was observed in (22.41%) studies. The method was specifically adopted in studies to understand patterns of urban land use changes (Haase et al., 2014a; Kain et al., 2016) or to explore nature based solution for the resilience of urban environment (Pataki et al., 2011; Kuittinen et al., 2016; Santiago Fink, 2016). This technique of investigation was also observed in the reviwed publications such as (Ernstson et al., 2008; Connolly et al., 2014; Kronenberg, 2015; Dennis and James, 2016b). These studies were designed to improve the environmental governance and management of urban areas.

The (17.24%) studies based their conclusions on conceptual discourses for postulating measures to ensure the resilience of urban ecosystems. This sort of orientation in UES research was specifically observed in the studies which were conceived to address the challenges of land use changes (Stott et al., 2015; Kain et al., 2016) and socio-cultural transformations in urban areas (Ernstson et al., 2010; Andersson et al., 2014). The researchers also contributed their scholarships through conceptual framework in the studies (Rozos et al., 2013; Wu, 2014; Mcphearson et al., 2015; Haas and Ban, 2017) to improve the precision and practicability of research regarding UES.

Monetary vs. non-monetary parameters for evaluating UES

The publications were assessed to study prevailing inclinations in UES research regarding the use of monetary and/or non-monetary parameters.

The monetary assessments of cost and benefits linked with UES are vital for informed decision making (Aevermann and Schmude, 2015). After the publication of The Economics of Ecosystems and Biodiversity (TEEB) in 2011 the use of monetary parameters in ES research are gaining more recognition. The use of monetary parameters for corroborating findings was found limited (3.45%) and restricted to the assessment mode of investigation. These findings are in line with the assertions of Sutton and Anderson (2016) that the monetary valuations of UES are more intricate and complex as compared to non-monetary valuations of ES. The overlapping nature of the benefits from UES: contestations over classification between benefits and/or services, controversies over methodology used for data acquisition and differences over spatial-temporal scale used for study are the conceivable explanations for less reliance on monetary parameters in the research concerning UES. However, the findings in monetary terms are readily and unambiguously understood in the present age of market economy and, thus, offer an effective technique for disseminating awareness about the contributions of ecological resources. Therefore, further investigations are needed to address the methodological/operational ambiguities responsible for discouraging the use of monetary parameters in UES research.

However, the majority of studies (66.38%), irrespective of their study design or orientation, preferred non-monetary parameters for evaluations of benefits arising from the ecological infrastructure of urban areas (Alam et al., 2016; Dennis and James, 2016b; Grafius et al., 2016; Kain et al., 2016; Kolanuvada et al., 2016; Kuittinen et al.,

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2016). As compared to this a substantial proportion of (18.97%) publications based their conclusions on the cumulative outcomes of monetary and non-monetary parameters (Elmqvist et al., 2015; Kiss et al., 2015; Langemeyer et al., 2015; Czembrowski et al., 2016). The added focus towards the cumulative assessments of UES is needed for holistic appraisal regarding the contributions of natural capital. The outcomes of such a research will ensure more support from social institutions and scientific communities for integrated ecological management of urban areas. Whereas, a number of publications (11.21%) extended their assertions through scholastic discourses or conceptual understandings rather than relying on either monetary or non-monetary measurements such as (Wu, 2014; Frantzeskaki and Kabisch, 2016; Corburn, 2017). These orientations, in the contemporary research, are indispensable for postulating out of the box strategies for uninterrupted supply of UES in the face of accelerating urbanization, ecological degradation and looming threats from climate change.

Study components and UES evaluation

The environmental component(s), relied upon for assessments in UES studies also reflect the inclinations of contemporary research. The findings in *Figure 7* indicate the proportion of studies which focused on a particular component of urban environment for assessment.

The anthropocentric orientations in UES research are stressed (Alberti et al., 2003; Graça et al., 2017) for integrated urban environmental management. In line with these demands a substantial number of studies (n=69) relied on the cumulative outcomes of socio-ecological parameters for drawing inferences and estimations regarding UES from diversified contextual settings such as (Ernstson et al., 2008; Buchel and Frantzeskaki, 2015; Escobedo et al., 2015; Vollmer et al., 2015; Graça et al., 2017).

It was followed by the selection of components related to urban biodiversity (n=64). The assessments about different forms of urban green infrastructures such as street trees (Kiss et al., 2015; Mcpherson et al., 2016), urban forests (Baró et al., 2014; Fusaro et al., 2015), parks (Sutton and Anderson, 2016) and impacts of urban vegetative diversity (Wang et al., 2015; Calderón-Contreras and Quiroz-Rosas, 2017) were made for different purposes ranging from the assessments of services and disservices of urban ecological infrastructure to urban planning.

A significant number of studies (n=57) in the 3rd category based their findings on atmospheric components of the urban environment. The measurements and quantifications of atmospheric temperature (Taylor et al., 2014; Di Leo et al., 2016) humidity (Capener and Sikander, 2015) and gaseous components (Manes et al., 2012) were made in these studies from various aspects while evaluating their impacts on the urban environment. The acquisition of accurate, cost effective and time efficient data related to atmospheric components at different spatial scale have become possible and easier due to advancements in the atmospheric and remote sciences (Larondelle and Lauf, 2016). In this connection a growing reliance on remotely sensed data for evaluating different components of urban climate was also observed.

The component of water was analyzed in the 4th category (n=42) from diversified perspectives for efficient use and management of urban blue infrastructure. The dominant orientations in the urban water studies were found towards accurate measurement of urban water resources (Larondelle and Lauf, 2016), to illustrate the importance of the rivers for urban residents (Vollmer et al., 2015; Weber and Ringold, 2015) and to postulate measures to ensure the efficient use of available water (Mccarthy

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et al., 2011). A growing interest to evaluate the impacts and complementing ability of technological innovations on urban water supply was also observed in studies (Rozos et al., 2013; Honey-Rosés et al., 2014). The components relied upon for assessment of cultural/aesthetic services such as the availability, role and importance of parks and urban green spaces were adjudged in the 5th category (n=42).

Urban climatic anomalies such as the urban heat island effect, smog, haze and resultant global warming are attributed to imbalance in the atmospheric carbon emanating from industrial, vehicular and domestic sources which are mostly located in the urban areas (Rosenfeld et al., 1998; Di Leo et al., 2016). These unwarranted climatic incidents induce researchers to strive for 'green oriented' solutions to control carbon emissions and concentration in the urban areas. In response to these challenges the focus of (n=35) studies in the 6th category was observed for finding plausible solutions to control and mitigate the adverse impacts of carbon concentrations in urban areas (Kuittinen et al., 2016; Tigges et al., 2017).

The assessments were made in (n=18) studies to evaluate the contribution of the urban ecological resources in providing food and fuel to urban residents and to weigh their contributions in managing the energy requirements of the urban areas in (n=14) studies. The market price of dwellings was also used as a proxy variable in (n=9) studies to assess the interrelationship between urban environments and worth of the property.

Besides these, a large number of other components (n=100) of urban environments from diversified settings were also used as parameters to evaluate the role and significance of UES for the urban areas.

Focus of research in UES

The studies in this review were designed to achieve multiple and diverse objectives, ranging from resolution of local environmental concerns to philosophical discourses for improved performance and resilience of urban ecological capital. The objectives found in the selected publications reflect the focus of these studies.The objectives set to achieve identical targets by using different linguistic expressions were condensed into eight groups for brevity and analysis (*Table 1*).The findings in *Figure 7* reflect the proportion of studies designed to achieve a specific target.

The sustainable planning and management of UES was observed as the most common objective of (28.45%) publications such as (Kronenberg, 2015; Stott et al., 2015; Vollmer et al., 2015; Alam et al., 2016; Dennis and James, 2016b). A closer scrutiny of the data indicates that such orientations in the research are closely associated with the industrialized nations. The appraisal of governance and policy associations with UES in (17.24%) studies appeared as the next important stream of investigation. The studies such as (Ernstson et al., 2010; Connolly et al., 2013; Connolly et al., 2014; Kronenberg, 2015; Frantzeskaki and Kabisch, 2016) were carried out to decipher the effects of environmental governance and policy framework on their contextual urban environment.

The assessments of context specific phenomena and practices are also stressed in the recent literature (Schreyer and Lakes, 2016) to get insights for optimal utilization and resilience of urban ecological resources. The focus of (20.69%) publications such as (Honey-Rosés et al., 2014; Youngsteadt et al., 2015; Dennis and James, 2016a; Kain et al., 2016) were found to estimate the impacts of contextual occurrences on the provisions of UES.

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To test the viability/application of new methods, techniques and approaches in the research are needed and validated in (13.79%) research initiatives regarding UES such as (Lundy and Wade, 2011; Lakes and Kim, 2012; Pincetl, 2012; Tigges et al., 2013). The use of GIS and RS for measuring, evaluating and planning of urban ecological resources is gaining acceptance. The researchers preferred to rely on the data retrieved through RS and GIS for detecting Urban Land use changes (Thapa, 2012; La Rosa and Wiesmann, 2013), estimating carbon storage/ sequestration (Baró et al., 2014; Tigges et al., 2017), assessing water availability (Yao et al., 2015) and for the measurements of urban vegetative cover (Banzhaf and Kollai, 2015; Schreyer and Lakes, 2015; Kolanuvada et al., 2016; Schreyer, 2016; Schreyer and Lakes, 2016). Besides this, a growing trend of computer-aided modelling for better utility and conservation of urban ecological resources was observed in this review (Grêt-Regamey et al., 2013). The scholastic efforts of (Huang et al., 2011; Inostroza, 2014; Martinico et al., 2014) for improvements in methodologies, techniques and approaches for better assessments of potentials and pressures on UES were also observed in this review.

The focus in studies were also observed on postulating measures to mitigate the consequences of creeping global warming for urban areas. The orientations of (8.62%) publications such as (Geneletti and Zardo, 2016) were found towards conjecturing on adaptive measures for the sustainability of urban environmental health, to address the challenges associated with global warming and consequential climate change. The researchers like (Mcwilliam et al., 2014; Estoque and Murayama, 2015; Grafius et al., 2016; Kaczorowska et al., 2016) tried to decipher the imprints of Urban Land use changes (5.17%) on sustainable provision of UES and highlighted the importance of land use planning for urban environmental resilience in their studies. The content analysis also indicated a growing emphasis in UES research on the accurate assessments of urban ecological resources in (3.45%) studies such as (Wu, 2014; Wang et al., 2015).

Besides, these dominant orientations in UES research a growing propensity in recent studies (2.59%) was also noticed in studies such as (Corburn, 2017) to ensure equitable distribution of UES among urban inhabitants under the influence of Environmental Justice debate.

Conclusions

This study is based on a systematic review protocol applied on a set of 116 scientific publications. It provides an overview of the evolving trends and gaps in UES research. The most obvious finding of this overview is that the concept of urban ecosystem services is gaining recognition as a component of informed decision making in urban planning and as a tool to monitor socio-ecological resilience of the urban areas. This review also establishes the fact that the research regarding UES is more focused in the technologically advanced and economically developed countries which have a really significant exposure to urban based industrial activities. The appearance of environmental externalities due to earlier industrialization, pressures from the society for healthy urban environment and availability of resources to fulfill these demands are the plausible explanations for more determined efforts to ensure resilience of UES in these countries. However, the insights of these studies are also immensely important for the regions where the research regarding UES is still in its embryonic stages.

The majority of publications based their appraisals on non-monetary parameters instead of monetary measurements. However, the evaluation of ecological contributions

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in monetary terms increases the acceptability of scientific findings and encourages policy makers/planners to adopt and utilize these findings.

A greater proportion of studies in this review either relied on assessment or an exploratory mode of investigations. These research techniques are frequently used in the social sciences and are comparatively easier, however an inherent element of subjectivity associated with them may compromise the objectivities in findings. As compared to it, a reliance on experimental mode of enquiry in UES will augment the credibility of findings. However, the conceptual style of investigation is imperative for postulating novice approaches for integrated management of UES in the face of emerging challenges for the urban areas.

The outcomes of this study stress on further investigations for devising standard protocols for the monetary measurements of UES. These initiatives should, hopefully, help to overcome the operational and methodological ambiguities for assessments of UES. The future research collaborations between and among nations based upon interdisciplinary research paradigm seems a viable option to achieve this objective. The trans-national research collaborations between the developed world and the less developed regions are also incumbent for postulating comprehensive strategies. These collaborations will also provide the opportunities to retrieve data from the contextual settings of these less investigated regions for conceptual discourses at the global level. Furthermore, these initiatives will directly and indirectly extend the much needed exposure and technical support to researchers investigating UES in these regions.

It is the considered opinion of the authors of this research contribution that the Sustained focus in research on UES is more needed in the less developed regions of the world. In these geographical regions the poor are the worst victims of urban ecological degradation. Thus, sustainable and equitable provisions of UES in these regions is a question of equity and justice debate and a real challenge for the researchers and urban planners to address.

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APPENDIX

Appendix 1. *116 selected and reviewed articles*

Author Name(s)	Title	Source Title	Year	Vol.	Issue	P. Start	P. End	Doi
Juntti Meri, Lundy Lian	A mixed methods approach to urban ecosystem services: Experienced environmental quality and its role in ecosystem assessment within an inner-city estate	Landscape and Urban Planning	2017	161		10	21	10.1016/j.landurbplan.2017.01.002
Dan Friess	Singapore as a long-term case study for tropical urban ecosystem services	Urban Ecosystems	2017	20		277	291	10.1007/s11252-016-0592-7
Chunglim Mak, Miklas Scholz, Philip James	Sustainable drainage system site assessment method using urban ecosystem services	Urban Ecosystems	2017	20		293	307	10.1007/s11252-016-0593-6
Jason Corburn	Urban Place and Health Equity: Critical Issues and Practices	International Journal of Environmental Research and Public Health	2017	14				10.3390/ijerph14020117
Jan Haas, Yifang Ban	Mapping and Monitoring Urban Ecosystem Services Using Multitemporal High-Resolution Satellite Data	IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing	2016	10		669	680	10.1109/JSTARS.2016.2586582
Jan Tigges, Galina Churkina, Tobia Lakes	Modeling above-ground carbon storage: a remote sensing approach to derive individual tree	Urban Ecosystems	2017	20		97	111	10.1007/s11252-016-0585-6

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	species information in urban settings							
Marisa S. Graca, Joao F. Goncalves, Paulo J.M. Alves, David J. Nowak, Robert Hoehn, Alexis Ellis, Paulo Farinha-Marques, Mario Cunha	Assessing mismatches in ecosystem services proficiency across the urban fabric of Porto (Portugal): The influence of structural and socioeconomic variables	Ecosystem Services	2017	23		82	93	10.1016/j.ecoser.2016.11.015
Rafael Calderon-Contrerasa, Laura Elisa Quiroz-Rosasb	Analysing scale, quality and diversity of green infrastructure and the provision of Urban Ecosystem Services: A case from Mexico City	Ecosystem Services	2017	23		127	137	10.1016/j.ecoser.2016.12.004
Sadroddin Alavipanaha, Dagmar Haasea, Tobia Lakes,Salman Qureshi	Integrating the third dimension into the concept of urban ecosystem services: A Review	Ecological Indicators	2017	72		374	398	10.1016/j.ecolind.2016.08.010
Julia Coma,Gabriel Perez,Alvaro de Gracia,Silvia Bures,Miguel Urrestarazu,Luisa F. Cabeza	Vertical greenery systems for energy savings in buildings: A comparative study between green walls and green facades	Building and Environment	2017	111		228	237	10.1016/j.buildenv.2016.11.014
Neele Larondelle, Steffen Lauf	Balancing demand and supply of multiple urban ecosystem services on different spatial scales	Ecosystem Services	2016	22		18	31	10.1016/j.ecoser.2016.09.008
Kaczorowska Annaa,Kain Jaan-Henrik,Kronenberg Jakub,Haase Dagmar	Ecosystem services in urban land use planning: Integration challenges in complex urban settings-Case of Stockholm	Ecosystem Services	2016	22		204	212	10.1016/j.ecoser.2015.04.006
Johannes Schreyer,Tobia Lakes	Deriving and Evaluating City-Wide Vegetation Heights from a TanDEM-X DEM	Remote Sensing	2016	11	8	777	780	10.3390/rs8110940

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Jaan-Henrik Kaina,Neele Larondelleb,Dagmar Haaseb, Anna Kaczorowskaa	Exploring local consequences of two land-use alternatives for the supply of urban ecosystem services in Stockholm year 2050	Ecological Indicators	2016	70		615	629	10.1016/j.ecolind.2016.02.062
Neele Larondelle,Niki Frantzeskaki,Dagmar Haasea	Mapping transition potential with stakeholder- and policy-driven scenarios in Rotterdam City	Ecological Indicators	2016	70		630	643	10.1016/j.ecolind.2016.02.028
Piotr Czembrowski,Jakub Kronenberg,Michał Czepkiewicz	Integrating non-monetary and monetary valuation methods - SoftGIS and hedonic pricing	Ecological Economics	2016	130		166	175	10.1016/j.ecolecon.2016.07.004
Theodore S. Eisenman	GREENING CITIES IN AN URBANIZING AGE The Human Health Bases in the Nineteenth and Early Twenty-first Centuries	Change Over Time	2016	6	1	216	246	10.1353/cot.2016.0014
Vaino Nurmi,Athanasios Votsis,Adriaan Perrels,Susanna Lehvävirta	Green Roof Cost-Benefit Analysis: Special Emphasis on Scenic Benefits	Journal of Benefit-Cost Analysis	2016	7	3	488	522	10.1017/bca.2016.18
Tom L. Green,Jakub Kronenberg,Erik Andersson,Thomas Elmqvist,Erik Go´mez-Baggethun	Insurance Value of Green Infrastructure in and Around Cities	Ecosystems	2016	19	6	1051	1063	10.1007/s10021-016-9986-x
Darren R. Grafius,Ron Corstanje,Philip H. Warren,Karl L. Evans,Steven Hancock,Jim A. Harris	The impact of land use/land cover scale on modelling urban ecosystem services	Landscape Ecology	2016	31	7	1509	1522	10.1007/s10980-015-0337-7
Matti Kuittinen,Caroline Moinel,Kristjana Adalgeirsdottir	Carbon sequestration through urban ecosystem services A case study from Finland	Science of the Total Environment	2016	563-564		623	632	10.1016/j.scitotenv.2016.03.168
Peleg Kremera,Zoé A. Hamsteadb,Timon McPhearsona	The value of urban ecosystem services in New York City: A	Environmental Science & Policy	2016	62		57	68	10.1016/j.envsci.2016.04.012

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	spatially explicit multicriteria analysis of landscape scale valuation scenarios							
Niki Frantzeskakia,Nadja Kabischb	Designing a knowledge co-production operating space for urban environmental governance-Lessons from Rotterdam, Netherlands and Berlin, Germany	Environmental Science & Policy	2016	62		90	98	10.1016/j.envsci.2016.01.010
Gregory McPhersona,Natalie van Doornb, John de Goede	Structure, function and value of street trees in California, USA	Urban Forestry & Urban Greening	2016	17		104	115	10.1016/j.ufug.2016.03.013
Paul C.Sutton,SharolynJ.Anderson	Holistic valuation of urban ecosystem services in New York City's Central Park	Ecosystem Services	2016	19		87	91	10.1016/j.ecoser.2016.04.003
Nestor Di Leo,Francisco J. Escobedo,Marielle Dubbeling	The role of urban green infrastructure in mitigating land surface temperature in Bobo-Dioulasso, Burkina Faso	Environment Development and Sustainability	2015	392	2	373	392	10.1007/s10668-015-9653-y
Helen Santiago Fink	Human-Nature for Climate Action: Nature-Based Solutions for Urban Sustainability	Sustainability	2016	8	3	254	264	10.3390/su8030254
Tommaso Sitzia,Thomas Campagnaro,Robert George Weir	Novel woodland patches in a small historical Mediterranean city: Padova, Northern Italy	Urban Ecosystems	2015	19	1	475	487	10.1007/s11252-015-0475-3
M. Dennis, P.James	Site-specific factors in the production of local urban ecosystem services: A case study of community-managed green space	Ecosystem Services	2016	17		208	216	10.1016/j.ecoser.2016.01.003
Sanna-Riikka Saarela, Janne Rinne	Knowledge brokering and boundary work for	Ecological Indicators	2016	61	1	49	62	10.1016/j.ecolind.2015.07.016

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	ecosystem service indicators. An urban case study in Finland							
Srinivasa Raju Kolanuvada,Muneeswaran Mariappan,Vani Krishnan	Demand-Based Urban Forest Planning using High Resolution Remote Sensing and AHP	Lidar Remote Sensing for Environmental Monitoring XV	2016	9879				10.1117/12.2223832
J.E. Taylor, R.W.F. Cameron, M.R. Emmett	The role of shrubs and climbers on improving thermal performance of brick walls during winter	International Conference on Landscape and Urban Horticulture and International Symposium on Sustainable Management in the Urban Forest	2016	1108		353	359	10.17660/ActaHortic.2016.1108.47
M. Dennis,P. James	User participation in urban green commons: Exploring the links between access, voluntarism, biodiversity and well being	Urban Forestry & Urban Greening	2016	15		22	31	10.1016/j.ufug.2015.11.009
Peleg Kremer,Zoé Hamstead,Dagmar Haase,Timon McPhearson,Niki Frantzeskaki,Erik Andersson,Nadja Kabisch,Neele Larondelle,Emily L. Rall,Annette Voigt ,Francesc Baró,Christine Bertram,Erik Gómez-Baggethun ,Rieke Hansen,Anna Kaczorowska,Jaan-Henrik Kain,Jakub Kronenberg,Johannes Langemeyer,Stephan Pauleit,Katrin Rehdanz,Maria Schewenius,Chantal van Ham,Daniel Wurster,Thomas Elmqvist	Key insights for the future of urban ecosystem services research	Ecology and Society	2016	21				10.5751/ES-08445-210229
Davide Geneletti,Linda Zardoa	Ecosystem-based adaptation in cities: An analysis of European urban climate adaptation plans	Land Use Policy	2016	50		38	47	10.1016/j.landusepol.2015.09.003
Mahbubul Alama,Jérôme Duprasb,Christian Messierba	A framework towards a composite indicator for	Ecological Indicators	2016	60		38	44	10.1016/j.ecolind.2015.05.035

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	urban ecosystem services							
Alison R.Holt,Meghann Mears,Lorraine Maltby,Philip Warren	Understanding spatial patterns in the production of multiple urban ecosystem services	Ecosystem Services	2015	16		33	46	10.1016/j.ecoser.2015.08.007
Ronald C. Estoque,Yuji Murayama	Intensity and spatial pattern of urban land changes in the megacities of Southeast Asia	Land Use Policy	2015	48		213	222	10.1016/j.landusepol.2015.05.017
Hua-Feng Wang,Salman Qureshi,Sonja Knapp,Cynthia Ross Friedman,Klaus Hubacek	A basic assessment of residential plant diversity and its ecosystem services and disservices in Beijing, China	Applied Geography	2015	64		121	131	10.1016/j.apgeog.2015.08.006
Ross W.F. Cameron ,Jane Taylor,Martin Emmett	A Hedera green facade - Energy performance and saving under different maritime-temperate, winter weather conditions	Building and Environment	2015	92		111	121	10.1016/j.buildenv.2015.04.011
Fangfang Yao,Chao Wang,Di Dong,Jiancheng Luo,Zhanfeng Shen,Kehan Yang	High-Resolution Mapping of Urban Surface Water Using ZY-3 Multi-Spectral Imagery	Remote Sensing	2015	7	9	12336	12355	10.3390/rs70912336
Iain Stott,Masashi Soga,Richard Inger,Kevin J Gaston1	Land sparing is crucial for urban ecosystem services	Frontiers in Ecology and the Environment	2015	13	7	387	393	10.1890/140286
Christopher Luederitz,Ebba Brink,Fabienne Gralla ,Verena Hermelingmeier,Moritz Meyer,Lisa Niven,LarsPanzer,Stefan Partelowb,Anna-LenaRau,Ryuei Sasaki,DavidJ.Abson,DanielJ.Lang,Christine Wamsler,Henrik von Wehrden	A review of urban ecosystem services: six key challenges for future research	Ecosystem Services	2015	14		98	112	10.1016/j.ecoser.2015.05.001
Marthe L. Derkzen,Astrid J. A. van Teeffelen,Peter H. Verburg	REVIEW Quantifying urban ecosystem	Applied Ecology	2015	52	4	1020	1032	10.1111/1365-2664.12469

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	services based on high-resolution data of urban green space: an assessment for Rotterdam, the Netherlands							
T Elmqvist,H Setala,SN Handel,S van der Ploeg,J Aronson,JN Blignaut,E Gomez-Baggethun,DJ Nowak,J Kronenberg,R de Groot	Benefits of restoring ecosystem services in urban areas	Environmental Sustainabilty	2015	14		101	108	10.1016/j.cosust.2015.05.001
D. Rodriguez-Rodriguez,J.H. Kain,D. Haase,F. Baro, A. Kaczorowska	Urban self-sufficiency through optimised ecosystem service demand. Autopian perspective from European cities	Futures	2015	70		13	23	10.1016/j.futures.2015.03.007
Derek Vollmera,Michaela F.Prescotta,Rita Padawangib, Christophe Girota,Adrienne Grêt-Regameyd	Understanding the value of urban riparian corridors: Considerations in planning for cultural services along an Indonesian river	Landscape and Urban Planning	2015	138		144	154	10.1016/j.landurbplan.2015.02.011
Kathleen L. Wolf, Alicia S.T. Robbins	Metro Nature, Environmental Health, and Economic Value	Environmental Health Perspect	2015	123	5	390	398	10.1289/ehp.1408216
Peleg Kremer, Erik Andersson, Timon McPhearson, Thomas Elmqvist	Advancing the frontier of urban ecosystem services research	Ecosystem Services	2015	12		149	151	10.1016/j.ecoser.2015.01.008
Timon McPhearson,Erik Andersson,Thomas Elmqvist,Niki Frantzeskaki	Resilience of and through urban ecosystem services	Ecosystem Services	2014	12		152	156	10.1016/j.ecoser.2014.07.012
Sophie Buchel,Niki Frantzeskaki	Citizens' voice: A case study about perceived ecosystem services by urban park users in Rotterdam, the Netherlands	Ecosystem Services	2014	12		169	177	10.1016/j.ecoser.2014.11.014
Johannes Langemeyer,Francesc Baró,Peter Roebeling,Erik Gómez-Baggethun	Contrasting values of cultural ecosystem	Ecosystem Services	2014	12		178	186	10.1016/j.ecoser.2014.11.016

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	services in urban areas: The case of park Montjuic in Barcelona							
Christine Bertram, Katrin Rehdanz	Preferences for cultural urban ecosystem services: Comparing attitudes, perception, and use	Ecosystem Services	2014	12		187	199	10.1016/j.ecoser.2014.12.011
Jakub Kronenberg	Why not to green a city? Institutional barriers to preserving urban ecosystem services	Ecosystem Services	2014	12		218	227	10.1016/j.ecoser.2014.07.002
Elsa Youngsteadt,Ryanna C. Henderson,Amy M. Savage,Andrew F. Ernst,Robertr.Dunn,Steven D. Frank	Habitat and species identity, not diversity, predict the extent of refuse consumption by urban arthropods	Global Change Biology	2015	21	3	1103	1115	10.1111/gcb.12791
Banzhaf E, Kollai, H.	MONITORING THE URBAN TREE COVER FOR URBAN ECOSYSTEM SERVICES - THE CASE OF LEIPZIG, GERMANY	The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences	2015	XL.7	7	301	305	
Johannes Schreyer, Prof. Dr. Tobia Lakes	TanDEM-X & UAV data for modeling 3D vegetation information in urban areas REPEAT AT 84	Urban Remote Sensing Event	2015					10.1109/JURSE.2015.7120526
Jeannette Sieber, Manon Pons	Assessment of Urban Ecosystem Services using Ecosystem Services Reviews and GIS-based Tools	Procedia Engineering	2015	115		53	60	10.1016/j.proeng.2015.07.354
Carl-Magnus Capener,Eva Sikander	Green building envelopes - Moisture safety in ventilated light-weight building envelopes	Procedia Engineering	2015	78		3458	3464	10.1016/j.egypro.2015.11.179
Francisco J. Escobedo,Nicola	Socio-ecological	Urban Forestry & Urban	2015	14	4	1040	1053	10.1016/j.ufug.2015.09.011

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Clerici,Christina L. Staudhammer,Germán Tovar Corzo	dynamics and inequality in Bogota, Colombia's public urban forests and their ecosystem services	Greening						
Lina Fusaro,Elisabetta Salvatori,Simone Mereu,Federica Marando,Elisabetta Scassellati,Giovanna Abbate,Fausto Manes	Urban and peri-urban forests in the metropolitan area of Rome: Ecophysiological response of Quercus ilex L. in two green infrastructures in an ecosystem services perspective	Urban Forestry & Urban Greening	2015	14	4	1147	1156	10.1016/j.ufug.2015.10.013
Tim Aevermann,Jürgen Schmude	Quantification and monetary valuation of urban ecosystem services in Munich, Germany	The German Journal of Economic Geography	2015	59	3			10.1515/zfw-2015-0304
O. Adegun, S. Odunuga, O. S. Ajayi	Climate, runoff and landuse trends in the Owo River Catchment in Nigeria HYDROLOGIC NON-STATIONARITY AND EXTRAPOLATING MODELS TO PREDICT THE FUTURE	Proceedings of the International Association of Hydrological Sciences; Gottingen	2015	371		137	142	10.5194/piahs-371-137-2015
Kathleen L. Wolf,Marcus K. Measells,Stephen C. Grado,Alicia S.T. Robbins	Economic values of metro nature health benefits: A life course approach	Urban Forestry & Urban Greening	2015	14	3	694	701	10.1016/j.ufug.2015.06.009
Morton KISS ,Agnes TAKACS,Réka POGACSAS,Agnes GULYAS	The role of ecosystem services in climate and air quality in urban areas: Evaluating carbon sequestration and air pollution removal by street and park trees in Szeged (Hungary)	MORAVIAN GEOGRAPHICAL REPORTS	2015	23	3			10.1515/mgr-2015-0016

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Nadja Kabisch	Ecosystem service implementation and governance challenges in urban green space planning-The case of Berlin, Germany	Land Use Policy	2015	42		557	567	10.1016/j.landusepol.2014.09.005
Matthew A. Weber,Paul L. Ringold	Priority river metrics for residents of an urbanized arid watershed	Landscape and Urban Planning	2015	133		37	52	10.1016/j.landurbplan.2014.09.006
Wei Li,Jean-Daniel M. Saphores,Thomas W. Gillespie	A comparison of the economic benefits of urban green spaces estimated with NDVI and with high-resolution land cover data	Landscape and Urban Planning	2015	133		105	117	10.1016/j.landurbplan.2014.09.013
James J.T. Connolly,Erika S. Svendsen,Dana R. Fisher,Lindsay K. Campbell	Networked governance and the management of ecosystem services: The case of urban environmental stewardship in New York City	Ecosystem Services	2015	10		187	194	10.1016/j.ecoser.2014.08.005
Dagmar Haase,Annegret Haase,Dieter Rink	Conceptualizing the nexus between urban shrinkage and ecosystem services	Landscape and Urban Planning	2015	132		159	169	10.1016/j.landurbplan.2014.09.003
Yafei Wang,Frank Bakker,Rudolf de Groot,Heinrich Wörtche	Effect of ecosystem services provided by urban green infrastructure on indoor environment: A literature review	Building and Environment	2014	77		88	100	10.1016/j.buildenv.2014.03.021
Luis Inostroza	Measuring urban ecosystem functions through Technomass'-A novel indicator to assess urban metabolism	Ecological Indicators	2014	42		10	19	10.1016/j.ecolind.2014.02.035
Iris Lehmann,Juliane Mathey,Stefanie Rößler,Anne Bräuer,Valeri Goldberg	Urban vegetation structure types as a	Ecological Indicators	2014	42		58	72	10.1016/j.ecolind.2014.02.036

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	methodological approach for identifying ecosystem services - Application to the analysis of micro-climatic effects							
Jordi Honey-Rose,Nicholas Brozovic,Daniel W. Schneider	Changing Ecosystem Service Values Following Technological Change	Environmental Management	2014	53	6	1146	1157	10.1007/s00267-014-0270-6
Francesco Martinico, Daniele La Rosa, Riccardo Privitera	Green oriented urban development for urban ecosystem services provision in a medium sized city in southern Italy	Biogeosciences and Forestry	2014	7		385	395	10.3832/ifor1171-007
Neele Larondelle,Dagmar Haase,Nadja Kabisch	Mapping the diversity of regulating ecosystem services in European cities	Global Enviornmental Change	2014	26		119	129	10.1016/j.gloenvcha.2014.04.008
Jianguo Wu	Urban ecology and sustainability: The state-of-the-science and future directions	Landscape and Urban Planning	2014	125		209	221	10.1016/j.landurbplan.2014.01.018
Jack Ahern,Sarel Cilliers,Jari Niemelä	The concept of ecosystem services in adaptive urban planning and design: A framework for supporting innovation	Landscape and Urban Planning	2014	125		254	259	10.1016/j.landurbplan.2014.01.020
Dagmar Haase, Niki Frantzeskaki, Thomas Elmqvist	Ecosystem Services in Urban Landscapes: Practical Applications and Governance Implications	AMBIO	2014	43	4	407	412	10.1007/s13280-014-0503-1
Dagmar Haase,Neele Larondelle,Erik Andersson,Martina Artmann,Sara Borgstrom,Jurgen Breuste,Erik Gomez-Baggethun,Asa Gren, Zoe Hamstead,Rieke Hansen,Nadja Kabisch,Peleg	A Quantitative Review of Urban Ecosystem Service Assessments: Concepts, Models, and Implementation	AMBIO	2014	43	4	413	433	10.1007/s13280-014-0504-0

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Kremer,Johannes Langemeyer,Emily Lorance Rall,Timon McPhearson,Stephan Pauleit,Salman Qureshi,Nina Schwarz,Annette Voigt,Daniel Wurster,Thomas Elmqvist								
Erik Andersson,Stephan Barthel,Sara Borgstrom,Johan Colding,Thomas Elmqvist,Carl Folke,Asa Gren	Reconnecting Cities to the Biosphere: Stewardship of Green Infrastructure and Urban Ecosystem Services	AMBIO	2014	43	4	445	453	10.1007/s13280-014-0506-y
Daniel Wurster, Martina Artmann	Development of a Concept for Non-monetary Assessment of Urban Ecosystem Services at the Site Level	AMBIO	2014	43	4	454	465	10.1007/s13280-014-0502-2
Francesc Baro,Lydia Chaparro,Erik Gomez-Baggethun, Johannes Langemeyer,David J. Nowak,Jaume Terradas	Contribution of Ecosystem Services to Air Quality and Climate Change Mitigation Policies: The Case of Urban Forests in Barcelona, Spain	AMBIO	2014	43	4	466	479	10.1007/s13280-014-0507-x
Marek Giergiczny, Jakub Kronenberg	From Valuation to Governance: Using Choice Experiment to Value Street Trees	AMBIO	2014	43	4	492	501	10.1007/s13280-014-0516-9
Timon McPhearson, Zoe A. Hamstead, Peleg Kremer	Urban Ecosystem Services for Resilience Planning and Management in New York City	AMBIO	2014	43	4	502	515	10.1007/s13280-014-0509-8
Martina Artmann	Assessment of Soil Sealing Management Responses, Strategies, and Targets Toward Ecologically Sustainable Urban Land Use Management	AMBIO	2014	43	4	530	541	10.1007/s13280-014-0511-1
Anna Kaczorowska	Ecosystem Services and	ISOCARP International	2014			1080	1090	

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	Urban Resilience - Case of Stockholm	Planning Congress: URBAN TRANSFORMATIONS: CITIES AND WATER						
Johannes Schreyer, Tobia Lakes	Remote sensing-based approaches for modeling 3D vegetation information in urban areas	International Conference on Computational Science and Its Applications	2014	14				10.1109/ICCSA.2014.30
Wendy McWilliam,Robert Brown,Paul Eagles,Mark Seasons	Barriers to the effective planning and management of residential encroachment within urban forest edges: A Southern Ontario, Canada case study	Urban Forestry & Urban Greening	2014	13	1	48	62	10.1016/j.ufug.2013.08.002
Jürgen Breuste,Salman Qureshi,Junxiang Li	Applied urban ecology for sustainable urban environment	Urban Ecosystem	2013	16		675	680	10.1007/s11252-013-0337-9
Robert F. Young	Mainstreaming urban ecosystem services: A national survey of municipal foresters	Urban Ecosystem	2013	16	4	703	722	10.1007/s11252-013-0287-2
Peleg Kremer,Zoé A.Hamstead,Timon McPhearson	A social-ecological assessment of vacant lots in New York City	Landscape and Urban Planning	2013	120		218	233	10.1016/j.landurbplan.2013.05.003
Izaskun Casado-Arzuaga,Iosu Madariaga,Miren Onaindia	Perception, demand and user contribution to ecosystem services in the Bilbao Metropolitan Greenbelt	Journal of Environmental Management	2013	129		33	43	10.1016/j.jenvman.2013.05.059
Sarah Taylor Lovell,John R. Taylor	Supplying urban ecosystem services through multifunctional green infrastructure in the United States	Landscape Ecology	2013	28	8	1447	1463	10.1007/s10980-013-9912-y
Jan Tigges,Tobia Lakes,Patrick Hostert	Urban vegetation classification: Benefits of multitemporal Rapid	Remote Sensing of Environment	2013	136		66	75	10.1016/j.rse.2013.05.001

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	Eye satellite data							
Neele Larondelle,Dagmar Haase	Urban ecosystem services assessment along a rural-urban gradient: A cross-analysis of European cities	Ecological Indicators	2012	29		179	190	10.1016/j.ecolind.2012.12.022
Daniele La Rosa,Daniel Wiesmann	Land cover and impervious surface extraction using parametric and non-parametric algorithms from the open-source software R: an application to sustainable urban planning in Sicily	GIS Science and Remote Sensing	2013	50	2	231	250	10.1080/15481603.2013.795307
Erik Gómez-Baggethun,David N. Barton	Classifying and valuing ecosystem services for urban planning	Ecological Economics	2012	86		235	345	10.1016/j.ecolecon.2012.08.019
E. Rozos,C. Makropoulos, C Maksimovic	Rethinking urban areas: an example of an integrated blue-green	Water Science and Technology	2013	13	6	1534	1542	10.2166/ws.2013.140
Simon Farrugia,Malcolm D. Hudson,Lindsay McCulloch	An evaluation of flood control and urban cooling ecosystem services delivered by urban green infrastructure	International Journal of Biodiversity Science, Ecosystem Services & Management	2013	9		136	145	10.1080/21513732.2013.782342
Robert F. Young,E. Gregory McPherson	Governing metropolitan green infrastructure in the United States	Landscape and Urban Planning	2012	109	1	67	75	10.1016/j.landurbplan.2012.09.004
James J. Connolly,Erika S. Svendsen,Dana R. Fisher,Lindsay K. Campbell	Organizing urban ecosystem services through environmental stewardship governance in New York City	Landscape and Urban Planning	2012	109	1	76	84	10.1016/j.landurbplan.2012.07.001
Adrienne Grêt-Regamey,Enrico Celio,Thomas M. Klein,Ulrike Wissen Hayek	Understanding ecosystem services trade-offs with	Landscape and Urban Planning	2013	109	1	107	116	10.1016/j.landurbplan.2012.10.011

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	interactive procedural modeling for sustainable urban planning							
Kathleen Gail Radford,Philip James	Changes in the value of ecosystem services along a rural-urban gradient:A case study of Greater Manchester, UK	Landscape and Urban Planning	2012	109	1	117	127	10.1016/j.landurbplan.2012.10.007
Stephanie Pincetl	Nature, urban development and sustainability - What new elements are needed for a more comprehensive understanding?	Cities	2012	29	2	S32	S37	10.1016/j.cities.2012.06.009
Tobia Lakes,Hyun-Ok Kim	The urban environmental indicator "Biotope Area Ratio"-An enhanced approach to assess and manage the urban ecosystem services using high resolution remote-sensing	Ecological Indicators	2011	13	1	93	103	10.1016/j.ecolind.2011.05.016
Rajesh Bahadur Thapa	Monitoring landscape change in Kathmandu metropolitan region using multi-temporal satellite imagery	Earth Observing Missions and Sensors: Development, Implementation, and Characterization II	2012	8528				10.1117/12.978927
Fausto Manes,Guido Incerti,Elisabetta Salvatori,Marcello Vitale,Carlo Ricotta,Robert Costanza	Urban ecosystem services: tree diversity and stability of tropospheric ozone removal	Ecological Applications	2011	22	1	349	360	10.1890/11-0561.1
Heather R. Mccarthy,Diane E. Pataki,G. Darrel Jenerette	Plant water-use efficiency as a metric of urban ecosystem services	Ecological Applications	2011	21	8	3115	3127	10.1890/11-0048.1
L. Lundy, R. Wade	Integrating sciences to sustain urban ecosystem	Progress in Physical Geography	2011	35	5	653	669	10.1177/0309133311422464

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	services							
Shu-Li Huang ,Yu-Hwa Chen,Fei-Yu Kuo,Szu-Hua Wang	Emergy-based evaluation of pen-urban ecosystem services	Ecological Complexity	2010	8	1	38	50	10.1016/j.ecocom.2010.12.002
Diane E Pataki,Margaret M Carreiro,Jennifer Cherrier,Nancy E Grulke,Viniece Jennings,Stephanie Pincetl,Richard V Pouyat,Thomas H Whitlow,Wayne C Zipperer	Coupling biogeochemical cycles in urban environments: ecosystem services, green solutions, and misconceptions	Frontiers in Ecology and the Environment	2011	9	1	27	36	10.1890/090220
Henrik Ernstson,Stephan Barthel,Erik Andersson,Sara T. Borgström	Scale-Crossing Brokers and Network Governance of Urban Ecosystem Services: The Case of Stockholm	Ecology and Society	2010	15	4			
Klaus Lorenz,Rattan Lal	Biogeochemical C and N cycles in urban soils	Environment International	2008	35	1	1	8	10.1016/j.envint.2008.05.006
Henrik Ernstson,Sverker Sörlin,Thomas Elmqvist	Social Movements and Ecosystem Services-the Role of Social Network Structure in Protecting and Managing Urban Green Areas in Stockholm	Ecology and Society	2008	13	2			
Susannah E. Gill,John F. Handleya,A. Roland Ennosb, Stephan Pauleit,Nicolas Theuraya,Sarah J. Lindleya	Characterising the urban environment of UK cities and towns: A template for landscape planning	Landscape and Urban Planning	2008	87	3	210	222	10.1016/j.landurbplan.2008.06.008

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Appendix 2. *The table showing the name of urban centres and number of UES studies conducted*

City	Country	Number of Studies
Berlin	Germany	9
New York	USA	7
Stockholm	Sweden	6
Manchester	UK	5
Rotterdam	Netherland	4
Catalonia	Spain	3
Barcelona	Spain	3
Leipzig	Germany	3
London	UK	2
Singapore	Singapore	2
Lodz	Poland	2
Reading	UK	2
Bogota	Colombia	2
Rome	Italy	2
California	USA	2
Shanghai	China	1
Porto	Portugal	1
Mexico City	Mexico	1
Helsinki	Finland	1
Milton Keynes, Bedford, Luton	UK	1
Espoo	Finland	1
California	USA	1
Bobo-Dioulasso	Burkina Faso	1
Padova	Italy	1
Tampere	Finland	1
Chennai	India	1
Mascouche (MONTREAL)	Canada	1
Sheffield	UK	1
Manila, Bangkok	Philippines, Thailand	1
Beijing	China	1
Qingdao	China	1
Jakarta	Indonesia	1
Boras	Sweden	1
Munich	Germany	1
Lagos	Nigeria	1
Szeged	Hungary	1
Tucson (Arizona)	USA	1
Dresden	Germany	1
Salzburg	Austria	1
Ontario	Canada	1
Bilbao	Spain	1
Southampton	UK	1
Masdar City	Abu Dhabi	1
Seoul, Berlin	South Korea, Germany	1
Kathmandu	Nepal	1
Taipei	China	1

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Appendix 3. *The content analysis showing the number and proportion of reviewed publications focused a specific type of UES and also indicating the contemporary trends in research regarding techniques for enquiry, methods for evaluation, research/study objectives and environmental components relied upon for assessments*

The assessment criteria and research orientations of selected Publications	**No. of studies**	**(%)**
Type of Ecosystem services/ Disservices		
Ecosystem Services	71	31.84
Cultural Services	37	16.59
Regulatory Services	65	29.15
Provisioning Services	28	12.56
Supporting Service	9	4.04
Disservice	13	5.83
Technique of enquiry		
Assessment	57	49.14
Exploratory	26	22.41
Experimental	13	11.21
Conceptual framework	20	17.24
Method of Evaluation		
Monetary	4	3.45
Non-Monetary	77	66.38
Both (M - NM)	22	18.97
Not Applicable	13	11.21
Research/study Objective		
Landuse Planning	6	5.17
Planning and Management	33	28.45
Assessment of Method	16	13.79
Urban Ecology	4	3.45
Environmental Justice	3	2.59
Assessment study	24	20.69
Governance and Policy	20	17.24
Climate Adaption	10	8.62
Environmental Component(s) evaluated		
Water Management	42	9.33
Climate Regulation	57	12.67
Socioecological	69	15.33
Biodiversity	64	14.22
Aesthetics	42	9.33
Food Fuel	18	4.00
Energy	14	3.11
Human Health	24	5.33
Carbon Seqestration Storage	35	7.78
Hedonic Pricing	9	2.00
Others	76	16.89

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