24 Ecosystem Services Guiding Built Environment Design—Understanding the Impacts of Building Practice on Ecosystems and Their Fundamental Contribution to Human Wellbeing

Marcus Ming Fricke, Katharina Hecht, Michael Vollmer, and Werner Lang

Abstract

This research presents two novel ecosystem services assessment (ESA) approaches to quantitatively (I) and qualitatively (II) assess the built environment (BE) on ecosystem services (ES) provision. Therefore, this paper offers a unique view at value creation and greater responsibility of BE developments. Societal livelihoods and global economies depend on ES which arise from healthy functioning ecosystems. Yet, the BE lacks the understanding and fails to address this ecological foundation. ESA bridges this deficit and communicates both the losses and contributions to human wellbeing in BE practice. The application to different case studies demonstrates how ESA systematically identifies shortcomings, potentials, trade-offs, and synergies while allowing for the redefinition of urban regulations and optimization of design. (I) The quantitative approach utilizes easily accessible ES data with global coverage for benchmark setting. The results emphasize significant decline in the conversion of natural to urban environments with an economically measurable societal deficit of the ES lost. (II) The qualitative approach enables a detailed understanding of construction impacts on the environment. It exposes ES losses throughout a building's entire lifecycle, leading to general but also lifecycle-specific requirements for the provision of supporting ES. A subsequent review of common green roofs and facades as nature-based solutions reveals their unfulfilled potential. This highlights the current immaturity of the BE to rebuild a resilient biosphere and inability to safeguard prosperous living conditions for mankind. Therefore, ESA offers the blueprint to transform the BE into the key driver to achieve sustainable development goals within planetary boundaries.

Keywords

Ecosystem services · Regenerative design · Sustainable development · Sustainable urban planning · Nature-based solutions

M. M. Fricke (✉) · M. Vollmer
Institute of Energy Efficient and Sustainable Design and Building, Technical University of Munich, Munich, Germany
e-mail: ming.fricke@gmail.com

K. Hecht
Biology, Utrecht University, Utrecht, Netherlands

W. Lang
Institute of Energy Efficient and Sustainable Design and Building, Technical University of Munich, Munich, Germany

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24.1 Introduction

Ecosystem services (ES) are the fundamental benefits which people obtain from nature's ecosystems (MEA 2005). ES appear in many forms and are categorized into four highly interlinked and hierarchical categories (MEA 2005):

(1) Supporting services, such as habitat provision, water cycling and nutrient cycling,
(2) Regulating services, such as pollination, air quality, and climate regulation,
(3) Provisioning services, such as food, water, medicine, and raw materials,
(4) Cultural services, such as recreation, cultural diversity, and inspiration.

ES are essential to human existence, development, and wellbeing (IPBES 2019). They are the result of an ecosystem's biophysical structure and functioning which is grounded in its biodiversity and abiotic interactions (Orians et al. 1996). The derived ecosystem processes provide the conditions for an ES to occur. Thus, ES are the bridge between the environment and the social and economic system which derives human benefits and attributes value to the service provision. Hence, ES remarkably represent the direct linkage between the vitality of nature as ecological system and human wellbeing. Therefore, it is said to be "one of the most powerful concepts to have emerged over the last two decades. [Because] It is shaping our understanding of the role that biodiverse ecosystems play in the environment and their benefits for humankind" (Potschin et al. 2016). Haines-Young and Potschin (2010) schematize and term this chain of derivates "the cascade model" (Fig. 24.1).

More than half of the gross domestic product (GDP) worldwide is moderately or highly dependent on ES (WEF 2020). The value of global ES was estimated to be 347 trillion \$/year (2000) which was 4.5 times larger than the global GDP (Costanza et al. 2014). Yet, accounting for nature's value in decision-making remains

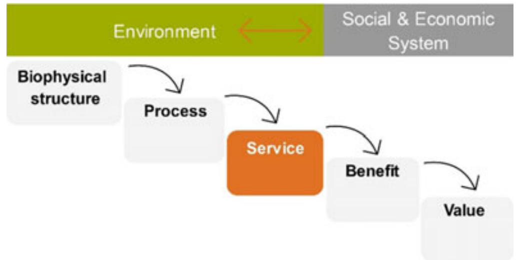

Fig. 24.1 Ecosystem service cascade model adapted from Haines-Young and Potschin (2010)

exceptionally excluded from policy uptake and practice, despite many valuation methods and approaches (IPBES 2022). This ignorance often in favor of short-term profits (IPBES 2022), has —to a great extent—led to the present-day global environmental and social challenges (Sangha et al. 2022) which originate from the economical exploitation of fossil resources and the degradation of natural environments (Steffen et al. 2015). Breaking this tie and taking planetary stewardship by decoupling development from excessive resource use and impact on the environment has yet to be achieved (Steffen et al. 2015; UNEP 2011).

It is known better than ever that almost all yet quantified planetary boundaries are exceeded with an increased risk of irreversible changes to the stability and resilience of the earth system (Potsdam Institute for Climate Impact Research 2022). The biosphere, as humanity's life support system where ES arise, is the second core boundary besides climate change (CC) upon which all other planetary boundaries depend most (Häyhä et al. 2018). Furthermore, it is confirmed that biodiversity protection is also CC mitigation (Dinerstein et al. 2020) which underlines the potential of nature conservation and restoration to provide synergies and effectively tackle multiple challenges simultaneously (IPBES 2019; IPCC 2022). Yet, as with all planetary boundaries, anthropogenic activity drives the detrimental changes (Potsdam Institute for Climate Impact Research 2022). The BE plays a crucial role in this vicious cycle which externalizes burden. It is key driver for land conversion, CC, and biodiversity loss (Bushnell 2021; Ellen MacArthur Foundation 2021; Pedersen Zari 2014). Its construction consumes half of the world's natural resources and emits 40% of global greenhouse gases (WorldGBC 2021; European Commission 2022b). In addition, urban areas are home to the increasing majority of the global population (68% by 2050, United Nations 2018) whose activity and consumption significantly disrupt and degrade distant ecosystems (Elliot et al. 2022, Häyhä et al. 2018, Irwin et al. 2022). Thus, "Most cities are [already] in a state of ecosystem services deficit, whereby demand exceeds local supply" (Elliot et al. 2022), while the BE continues to further deteriorate the biosphere as the above-mentioned driver. This substantially decreases ES supply and accelerates decline in many direct and indirect ways which is disregarded in development paradigms. Facing the increasing demands of the predicted growing global population and shortages due to progressing CC, this is, as a matter of fact, a striking security issue of global scale.

Currently, ES-related concerns are, if at all, only individually addressed in urban planning and building design, such as simulations for urban-heat-island mitigation, sponge cities for flood management, or decarbonization pathways via lifecycle assessments (LCA) against CC overall. Landscape architecture has a better awareness and starts to address more of the ES potentials (Kishnani 2022; Ndubisi 2014). In contrast, on European governance level, efforts are already made to map ES on a national scale (Maes and Burkhard 2017) but the fundamental understanding, comprehensive accounting, and translation into the development of the BE have yet to emerge (Thompson et al. 2020; Pedersen Zari 2018). Even current green building standards fail to properly address and enable net-positive buildings in this regard (Catalano et al. 2021).

However, this is the decisive task for humanity which requires a holistic transformation to increase natural capital and revert previous environmental damages to fundamentally safeguard societal livelihoods (Folke et al. 2021). Holistically dealing with the ES concept, to inform and alter design and development decisions in relation to building practice, is a novel approach. So far, only few scientific and mostly theoretical explorations are currently available, which are mostly related to Pedersen Zari's (2012; 2018) pioneering framework on "ecosystem services analysis."

This paper presents two novel approaches of ecosystem services assessment (ESA) which are exemplary illustrated through different case studies to provide insights to three research questions (RQ):

(RQ1) How does ES provision differ between urban and natural environment
(RQ2) How does the BE impact ES provision?
(RQ3) How can the BE provide ES by its building actions?

Extended background research and elaborations are provided in the thesis by Fricke (2022).

24.2 Materials and Methods

(I) The first ecosystem services assessment (ESA) approach quantifies the provision of ecosystem services (ES) and illustrates trade-offs. It is based on freely accessible data and easy usage for non-specialists once ES are adequately matched with available data. This is to enable quick and uncomplicated uptake by and orientation for spatial analysis and planning prior to design. It offers a high-level insight into RQ1, "How does ES provision differ between urban and natural environment?" It is separated into three steps: matching the available data with the ES which are to be investigated, identifying trends by a selected case study comparison and lastly coupling these with monetary data available (Fig. 24.2). This paper illustrates the approach via two case studies: a) the Campus Garching as historical appropriation of originally dominant temperate forest in Germany and b) the planned relocation of the Indonesian capital Jakarta to a globally important biodiversity hotspot, the island and tropical forest of Borneo, as recurring conflict between natural capital and human development.

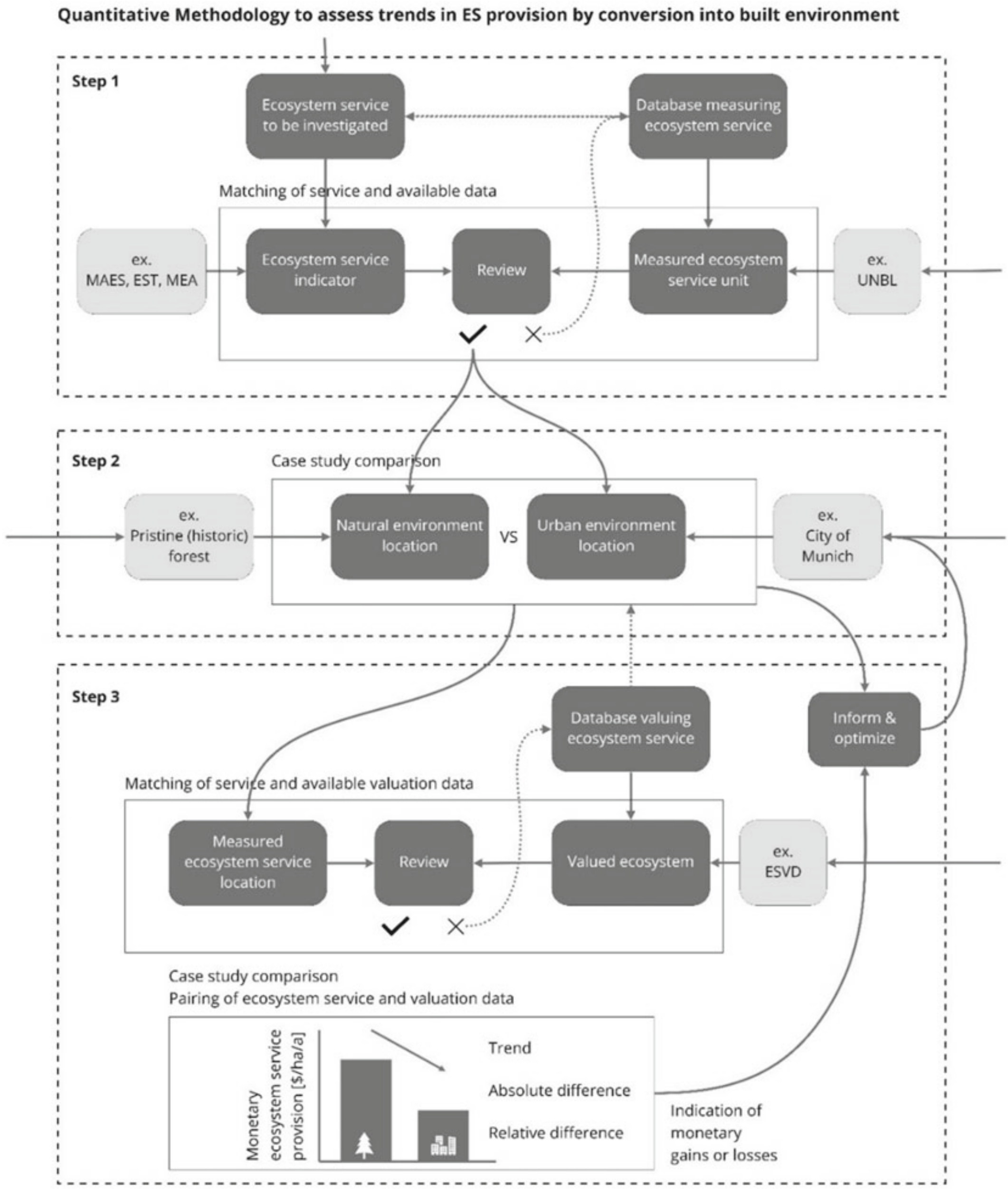

Fig. 24.2 Process diagram for a high-level quantitative ecosystem services assessment (I)

(I) Step 1 A selection of ES is made, i.e., based on their identified relevance to the built environment (BE) (Pedersen Zari 2014) or their supporting character to other ES (MEA 2005) and based on the matching of their indicators to the available datasets (Fig. 24.3, Step 1). Data is taken from the free and open-source UNBL (UN Biodiversity Lab 2022) platform which centrally collects over 400 global spatial datasets on several different environmental and human development topics. The Geographic Information System (GIS) data is readily converted and thus visually accessible without requiring any GIS knowledge. This enables the attribution of data

Fig. 24.3 Example of ESA (I): Data coupling for Indonesian case study with monetary valuation

	(I) Quantitative ESA - Indonesia Case Study	Supporting		Regulating
Step 1	Ecosystem Service (ES)	Habitat Provision	Primary Production	Climate Regulation
	UNBL Data Type	*Land cover type*	*Annual NPP*	*Above+Below biomass + soil carbon (d=1m)*
	UNBL Data Unit	*Qualitative land cover classification*	*gC/m2*	*tC/km2*
	UNBL Dataset (UN Biodiversity Lab 2022)	*ESA CGLS Land Cover 2019*	*2020 MODI Net Primary Production*	*WCMC Terrestrial Carbon 2010 Soil & Biomass Carbon*
Step 2	ES Data Borneo	Closed Forest Evergreen Broad Leaf	15000	8.5
	ES Data Jakarta	Urban/ Built Up	0	3
	Difference Urban to Pristine	Loss of forest	15000	5.5
	Difference ESΔ in %	1.00	1.00	0.65
Step 3	*Monetary valuation scales (Source)*	*Global biome (de Groot et al. 2021)*		*Indonesian biome (de Groot et al. 2021)*
	Tropical forest mean standardised values *in Int$/hectare/year; 2020 price levels*	6	235	635
	Monetary losses per hectare conversion per year*; Based on ESΔ*mean standardised value*	6.00	235.00	410.88
	Societal deficit incurred by conversion of tropical forest to urban environment in regard to three valued ecosystem services in Int$/hectare/year	***651.88***		

For more information see Fricke (2022) – Ecosystem Services guiding Built Environment Design

on quantifiable ES to a geographical point of interest worldwide, increasing usability and applicability for a global audience.

(I) Step 2 Two sites, a natural and urban location, are chosen to compare and identify trends in ES provision by conversion into urban BE. The natural, unmodified site serves as reference point for the pre-development potential in ES service provision. The corresponding data on the provision of the different ES on both sites is then documented and compared. Column charts with a trend line between the natural and urban location indicate the losses or gains by conversion for each service. Moreover, the relative change and difference between the two sites are deducted for conclusions to serve decision-making based on this stage or further processing (Fig. 24.3, Step 2).

(I) Step 3 Due to the bridging definition of the ES concept (ES cascade, see Introduction), the inhibited ES provision can be shown as loss to human wellbeing. Monetary valuation based on a service's importance for the economic system or demand by markets is one tangible way to indicate ES societal relevance and offers a first indication and possibility to integrate information into the economically driven reality of the BE. Therefore, the relative losses caused by conversion from natural to urban environments are multiplied with these currently known standardized monetary values for a specific ES. These are provided by the Ecosystem Services Valuation Database (ESVD) (Brander et al. 2021) in international $ of the year 2020 per hectare and per year. It is developed by de Groot et al. (2012) who continuously provide different monetary valuations (currently > 6700) across biomes worldwide based on scientific studies (currently > 950). This pairing of information enables an indication of the magnitude and also financial strain posed on society by establishing the BE according to current practice. Due to the limited monetary valuation data related to investigated contexts, the scope of assessable ES is possibly narrowed further.

The case studies are exemplary assessed on three monetary-quantifiable ES: habitat provision, primary production, and climate regulation (Fig. 24.3, Step 3). The valuation of ES benefits or lack thereof is a continuously progressing discipline on its own. Yet, it needs to be emphasized that used and resulting monetary values should not be seen as absolutes and should rather serve indicative purposes only, as also advocated by the ES valuation experts themselves (Brander et al. 2021; Costanza et al. 2014; Hernández-Blanco et al; 2022; IPBES 2022; O'Higgins et al. 2020; Považan et al. 2021).

(II) The second ESA approach qualitatively investigates the impact of a development proposal on the natural environment and the causes for expected or already inflicted changes in ES provision. It offers a design-level insight throughout the entire building lifecycle and analyzes RQ2, "How does the BE impact ES provision?" It is separated into four steps: assessing a design in its ecosystem context, identify construction impacts throughout the lifecycle, capitalize on shortcomings, and define ES provision requirements which can then be used for an optimization of the design by iterating the assessment approach (Fig. 24.4). This approach is illustrated with a case study application (c) assessing the provision of three supporting ES (habitat provision, nutrient cycling and water cycling) of a design proposal for a research settlement on an Indonesian island within the tropical rainforest, making mainly use of the locally available resources (Bacheva and Pepin 2022) and (d) review of common green roof and façade setups as nature-based solutions (NbS) to optimize outcomes. However, the results and insights of the ESA are representative for many designs, European forests, and building practice.

(II) Step 1 Firstly, based on the European standard DIN EN 15,978 and the selected design proposal, construction activity profiles can be ascribed to each lifecycle stage from A1 (Raw material supply) to D (benefits and loads beyond the system boundary), such as, e.g., transport by road or foot (A2) or site preparations and setting of the structure (A5). These will unavoidably have consequences on the investigated ecosystem, e.g., damage to the vegetation cover and integrity of top soil. To summarize and visually simplify this information, it is suggested to create a schematic graphic per lifecycle stage of construction within the designs' biome context (Fig. 24.5). Choosing the European lifecycle assessment (LCA) standard as framework to describe construction activities makes designs comparable and qualitative assessments representative for common practice, even though development projects might differ in the intensity and degree of execution.

Secondly, extensive ecological knowledge is required to define the cascade model for each ES to be assessed (ES cascade, see Introduction). For every ES, there is a different set of key processes which are to be identified together with their approximate location (Fig. 24.6). Priority lies on understanding and simplifying the functioning of an ecosystem for an appropriate and sufficient knowledge transfer to inform BE practice based on the biome-specific ecological knowledge available. In this case study, the Indonesian tropical rainforest serves as an example. However, insights apply to other biomes, as long as the identified ecosystem processes match because, despite containing different sets of animal and plant species, biophysical structures and functions can be alike (Tryse 2017). Therefore, (European) temperate forests compare to tropical forests in qualitative ES provision requirements because they have a similar, though simpler and less biodiverse, structure (EEA 2016).

(II) Step 2 Thereafter, the defined design proposal impacts per lifecycle stage on the BS can be directly tied to influences on specific ecosystem processes of an ES by pairing the construction activity and ES profile. Due to this

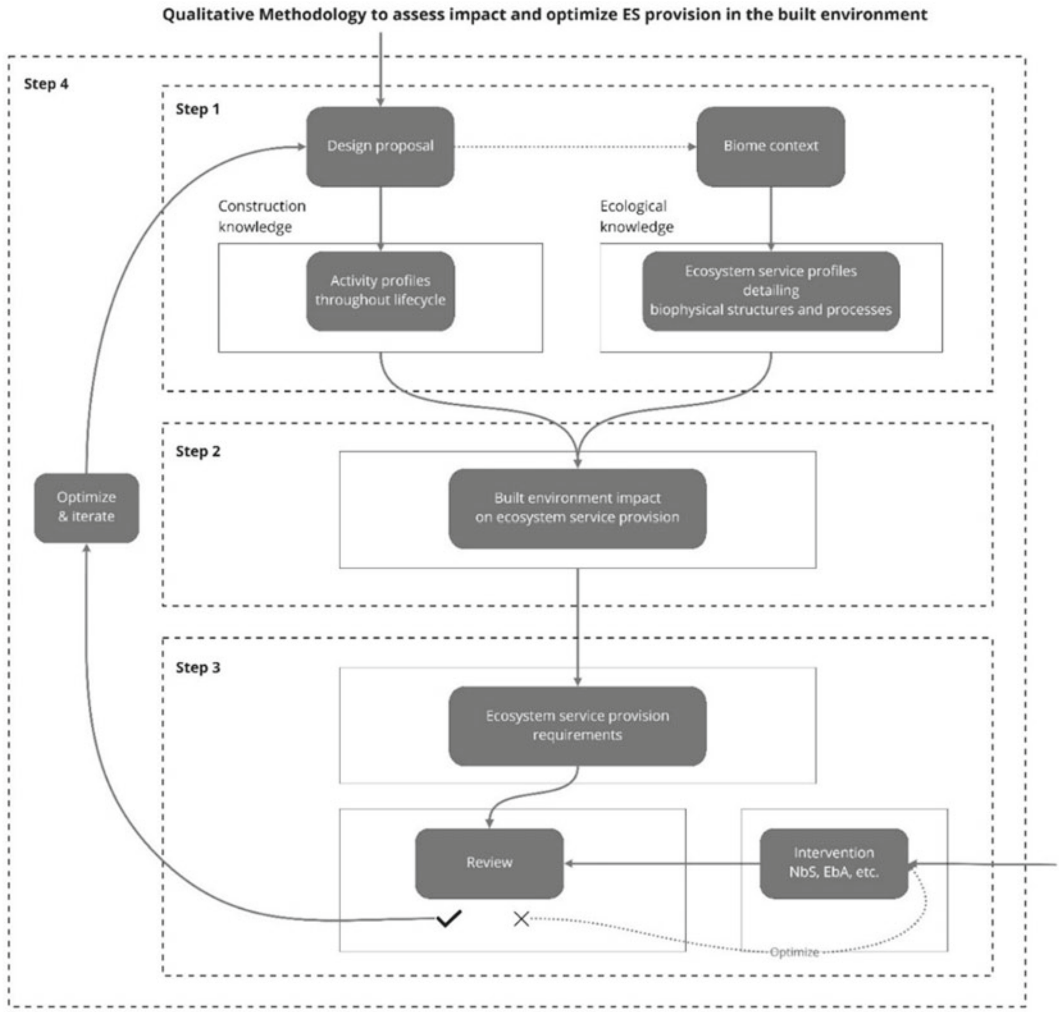

Fig. 24.4 Process diagram for design-level qualitative ecosystem services assessment (II)

methodology, it is possible to identify shortcomings in ES provision and their causes across all lifecycle stages (A1-D) of the design proposal. Specific attention lies on the ability or inability for the specifically required ecosystem processes for an ES to occur. The construction activity directly or indirectly influences the biophysical structure and its processes. Therefore, ESA (II) links BE activity impacts to consequences in the social and economic system dimension by identifying qualitative changes in ES provision (Fig. 24.7).

(II) Step 3 Requirements for an improved ability to provide the conditions for ES supply can be summarized into a review list for construction interventions throughout a buildings entire lifecycle based on this understanding of shortcomings on ES provision of the design proposal. This enables clear guidance on what has to be achieved by a change in construction approach, its management, or design to reduce impacts and improve conditions for an ES to occur and be provided to the human benefit. This responds to RQ3, "How can the BE provide ES by its building actions?".

(II) Step 4 The last step entails implementing the newly gained information and definition of optimized solutions for the previously analyzed

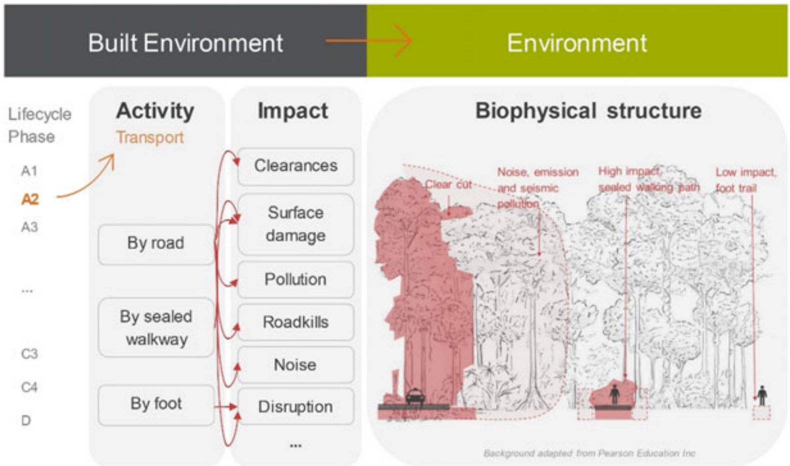

Fig. 24.5 Exemplary activity profile for lifecycle phase A2: Transport and consequences for the ecosystem's biophysical structure with different degrees of impact

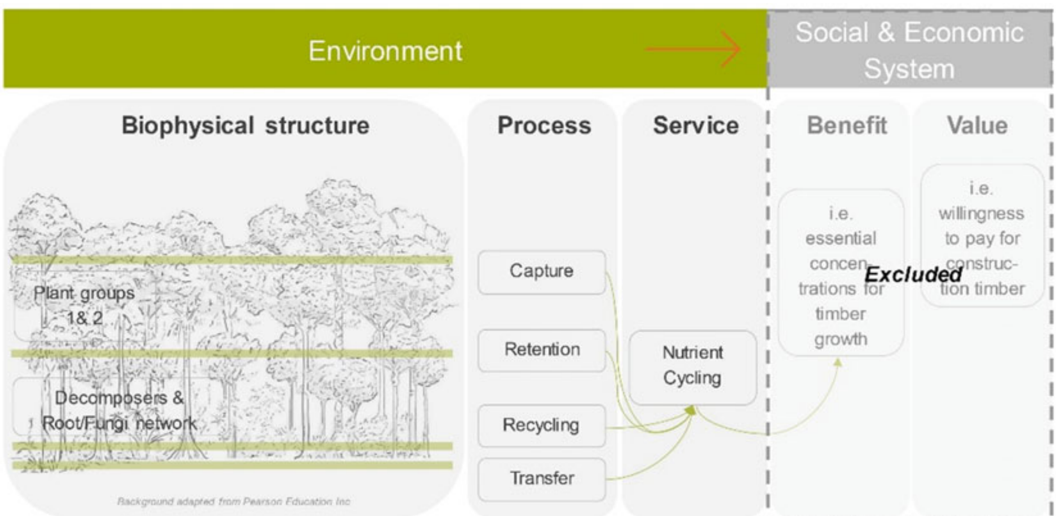

Fig. 24.6 Exemplary ecosystem services profile illustrating the prerequisites for nutrient cycling with the main underlying ecosystem processes emerging from the tropical rainforest's biophysical structure

design. By iterating these process steps, a design gradually improves in its ES provision performance and impact on pre-existing ecosystems. This creates building integrated nature (Weisser et al. 2022) but with a clear and measurable contribution to human wellbeing rooted in learning from the natural system itself.

24.3 Results

(I) Both case studies, (a) the German historical deforestation and conversion process leading to the current Campus Garching and (b) building the planned new Indonesian capital on Borneo in

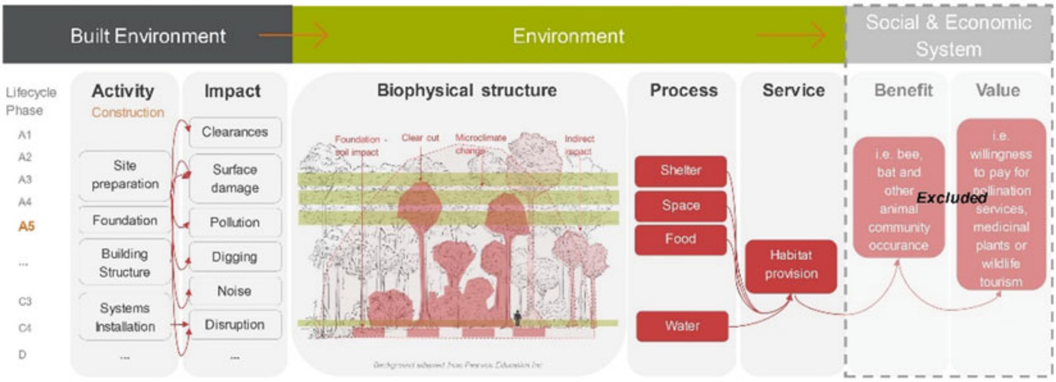

Fig. 24.7 Exemplary illustration of lifecycle phase A5. Construction impacts on habitat provision based on ESA(II)

the same way as Jakarta identify that ecosystem services (ES) are to a significantly lower degree provided by the urban environments compared to the natural forest environments analyzed (Fig. 24.8). The results prove that developing the built environment (BE) not only changes the provision of ES but that, in contrast to a "positive building" paradigm and intention to "build for people," it incurs losses and societal deficit which is also monetary measurable.

In the illustrated cases, this amounts to (a) 14,133 and (b) 652 international$/hectare/year (Fig. 24.3) for the three monetary-valued ES. Besides absolute deviations in incurred losses, the overall deficit variation between (a) and (b) originates from the different socio-economic contexts and their attributed value to the same service, such as climate regulation. The loss represents a "partial minimum site value to human wellbeing." This means that ESA identifies a basic capital which is to be outperformed to create greater societal benefit than a) in retrospective once has been traded off or b) is currently existent and society would be deprived by through destructive development. Interestingly, the monetary significance of the climate regulation service stands out in the assessment of both of these contexts [(a) 231–4463; (b) 229–411 Int $/ha/a]. Yet, such ES provision potentials in or losses caused by the construction of man-made environments are not addressed in BE practice. It even contradicts pledges to decarbonize the industry and actively address climate change. Reducing and offsetting operational and embodied carbon, as increasingly practiced, are absurd if carbon sinks are lost at the outset. From a mere natural capital and ES perspective, this assessment of both contexts does theoretically not offer any argumentation why the conversion of natural to an urban environment is to be preferred (see also Bradbury et al. 2021). Especially, comparing the case study results on Indonesia (b) to the valuation of tropical forests in South East Asia at 41,785 to 73,233 Int$/ha/a for a much wider set of ES. This is approximately two orders of magnitude larger which emphasizes the need for holistic assessments of the many ES to realize the extent of societal values at risk (IPBES 2022). Thus, in terms of development contributions to overall society, the case is rather made for nature conservation than for any false "sustainable development" label. This also suggests that in ES-poor, man-made, urban environments any green infrastructure addition in comparison with the previously "gray city" will yield a great contribution, while the actual trade-offs, potential, and overall importance of the intervention remain blurred. Therefore, setting the right agendas for the fundamental transformation of the BE is not possible with the existing urban system perspective and can only be realized by framing the bigger picture and deriving benchmarks thereof. If it is therefore the aspiration to decouple human development from nature degradation, then it is necessary to set pristine environments as reference to assess impacts. This

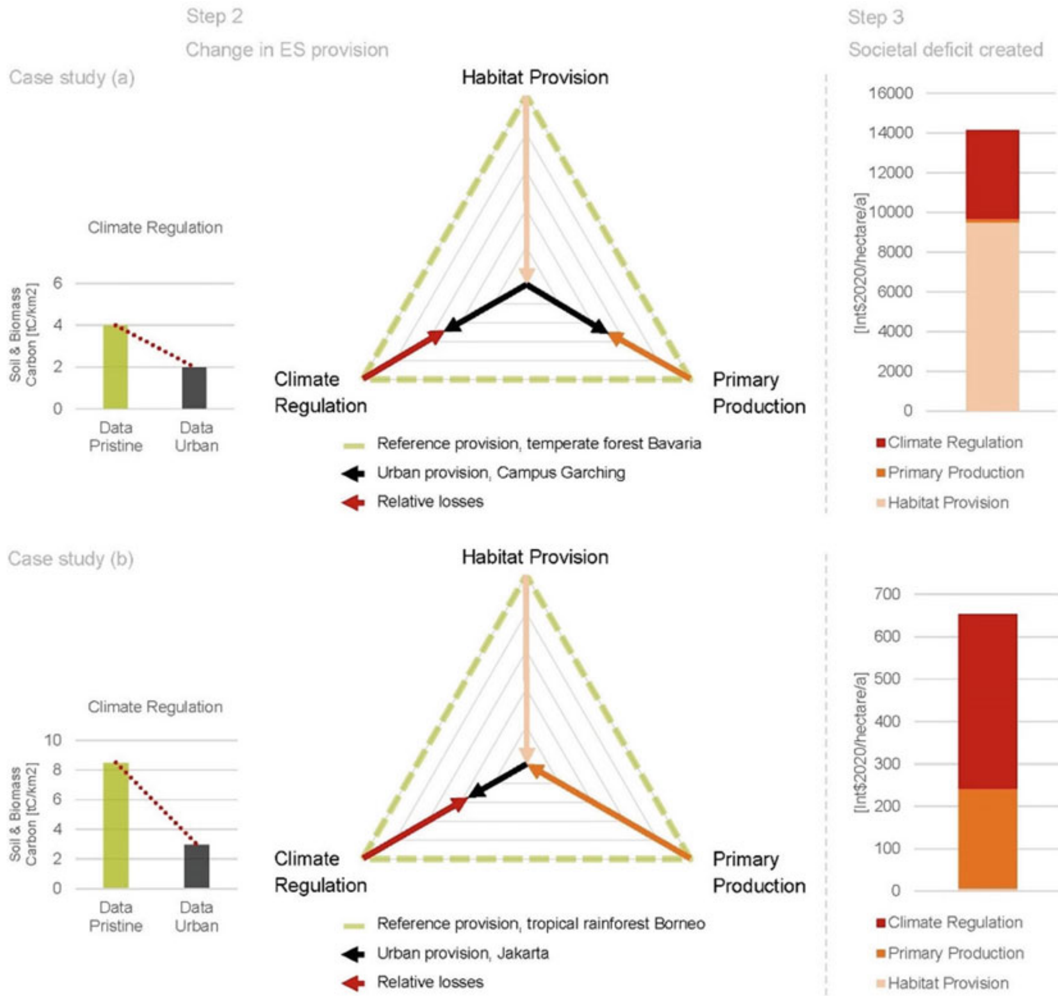

Fig. 24.8 Data summary on ES provision between **a** Bavarian forest and Garching campus (top), and between **b** Bornean tropical rainforest and Jakarta (bottom)

challenges projects and current BE practice by establishing a new baseline while avoiding pseudo practice and its disguise. Thus, ESA creates a fundamentally different view on what is to be generated through construction and suggests a novel notion for the BE's transformation.

(II) (c) Fifteen activity profiles of the complete building lifecycle and three ES profiles within the tropical rainforest as biome context are coupled together. This results in 45 distinct design impacts which describe changes in ES provision due to typical building-related activities and their specific influence on the environment. Remarkably, destruction and disruption are identified across all lifecycle phases for each of the analyzed ES. Therefore, this meticulous ESA provides evidence on the root causes for ES losses in the development of the BE. However, by identifying the failures, practice can be systematically rethought and supported in defining better solutions. Severe alterations, such as through the clearance for the building site and setting of the foundation in lifecycle phase A5 (Construction), likely result in services losses due to the disappearance or heavily reduced ecosystem process functionalities. This is shown schematically in Fig. 24.7 for the habitat provision service because natural shelter, space, food, and water sources are lost. The insights establish specific provision requirements to, e.g., reduce construction impacts by limiting the damage, intensity, and scale of interventions and that known sources of ecosystem processes need to be preserved and incorporated in planning and design. Subsequently, a partial preservation of canopy habitats does not eradicate impacts, but it curbs adverse effects on services provision. This yields a much higher likeliness of ecosystem processes and thus ES to occur, limiting losses in the first place. This represents an easy start for practice to make use of the generated understanding and enable an inclination for further uptake of improvements as outlined by the remaining more challenging requirements (for a full overview of results see Fricke 2022). The review format, as further simplification of the 45 results, ensures quick inspections and initiates more in-depth discussions through simple yes or no questions. No lifecycle distinctions are made, yet it is usable for any lifecycle-phase assessment. While some questions are straightforward for practitioners in the BE, others might require some ecological knowledge beyond the common background. It highlights what is essential and that if damage cannot be avoided, the lost functionality needs to be provided either in the analyzed lifecycle phase or a following, e.g., if conditions critical to the habitat provision service cannot be preserved or mimicked during construction (A5), an operated building design (B1) could ideally reinstate shortcomings. Thus, it suggests that development does not inherently have to entail degradation and perfectioning practice could truly add to the baseline.

(d) Nature-based solutions review The review list is scale unspecific, meaning that a whole building, complete site, or an element such as an envelope intervention can be assessed. Despite high expectations on NbS contributions to biodiversity and ES supply (European Commission 2022a), there are multiple shortcomings to the commonly implemented extent and quality of green roofs and facades in terms of ES provision. In their general form, they do not provide the complete range of prerequisites for the support and actual occurrence of the assessed habitat provision, water cycling, or nutrient cycling ES. The results further highlight that these interventions merely target the provision of ES during the operation phase of a buildings lifecycle but do not influence any of the adverse effects during previous or later lifecycle stages (Fig. 24.9). Possibly the only benefit to other lifecycle phases could be seen in the reuse of them (lifecycle phase D) if appropriately deconstructed and kept intact. Another alternative specifically for the nutrient cycling service lies in their decomposition during lifecycle phase C4 (Disposal). However, by identifying that these NbS improve a fraction of lifecycle phases, the review affirms that BE practice can contribute to ES provision. Based on the theoretical cascade model and the natural development of the constructed, mimicked ecosystem over time, these could also generate monetary-measurable and continuous benefits for society in the long term. Consciously choosing, designing, and appropriately implementing solutions based on ES requirements, identified by the use of ESA, ultimately represent a key to regenerate and strengthen human well-being while co-evolving with nature.

24.4 Discussion

The results underline that the impairment of the environment leads to significant losses and costs for society which highlights that growth and development at the cost of natural capital is not sustainable (Hansjürgens et al. 2018). The alleviation of poverty (Dasgupta 2021) and progress on achieving the United Nations (UN) Sustainable Development Goals (SDGs) are directly tied to the continued and increased provision of ecosystem services (ES) (Retsa et al. 2020). Therefore, recent international agreements rightfully require businesses to assess and disclose their risks, impacts, and dependencies on nature (CBD 2022). This makes ESA well suited for the BE to proactively take responsibility and effectively address these international agendas as outcomes of the UN Climate Change Conference (COP27) and UN Biodiversity Conference (COP15) in 2022. The new paradigm is

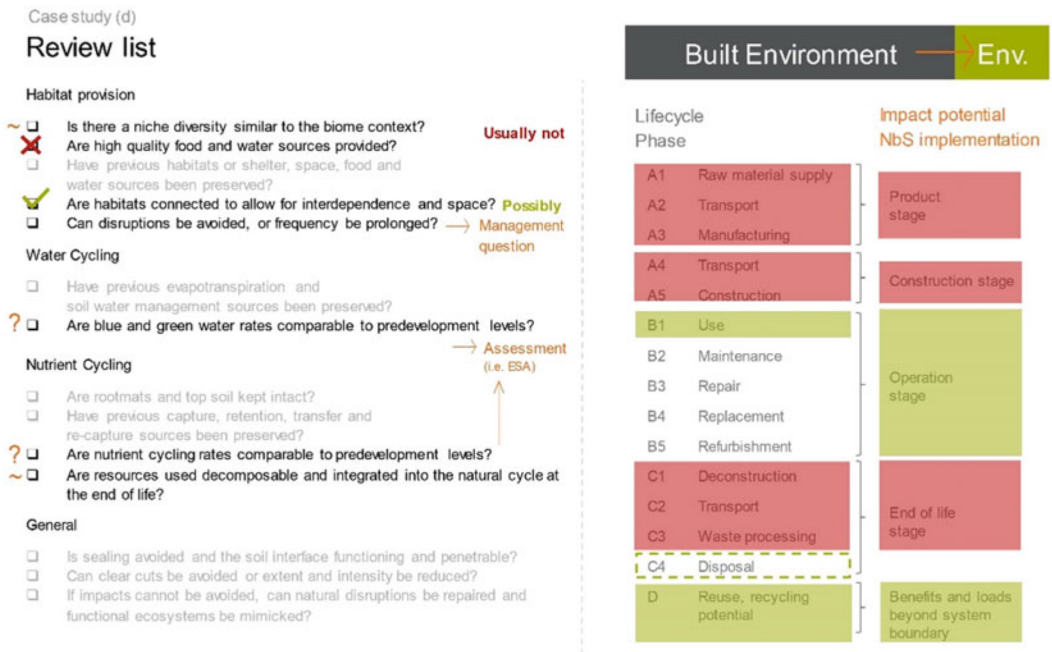

Fig. 24.9 Review of common green roof and facade setups for the provision of three supporting ecosystem services (left) on a selection of questions of the review list (bold), and their potentially beneficial but limited influence on only parts of the building lifecycle (right)

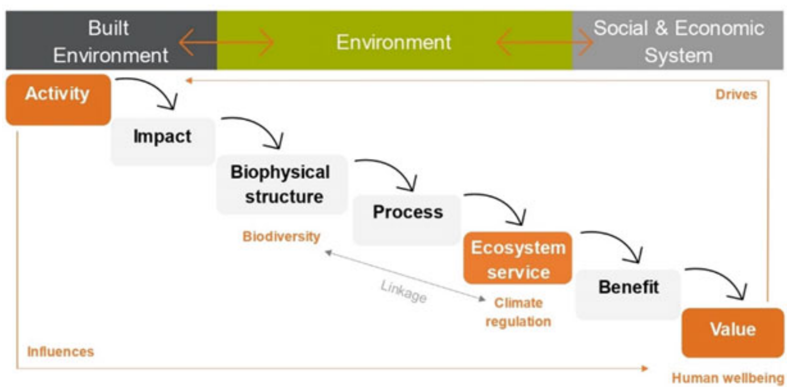

Fig. 24.10 Transformation process through ESA

designing the BE under a different and extended set of requirements while providing measurable benchmarks for ES provision which enforces and ultimately secures society's life support system (Fig. 24.10).

Furthermore, connecting such requirements to constituents in the law enables the opportunity for societal intervention by law enforcement based on national climate change mitigation goals, counteractions against biodiversity loss, or overall intergenerational protection of wellbeing. This could in the future be similar to the stop of new infrastructure developments due to the exceedance of sectoral carbon budgets as derived from national targets tied to climate protection laws. Thus, if a third party were to identify that a project development is evading responsibility to provide a bottom line of ES, subsequently jeopardizing the wellbeing of current and future generations, this could evoke public action and prosecution.

Further research reviewing city, regional or national goals could in turn practically help matching BE projects, which incorporate tangible ES provision, with different departments and separate focus areas, such as on climate change, biodiversity, innovation but also real estate value, by identifying convergences of interest. This could channel funding and create attractive incentives for businesses to be compensated or rewarded for societal contributions by ES design (see Evans et al. 2020; UK GBC 2022), effectively establishing positive feedback loops advancing the transformation of practice. Present tools such as lifecycle assessments (LCA), aspirations, and approaches to design for circularity and climate neutrality beneficially integrate in ESA's optimization process but are guided toward more holistic added value. In contrast to LCA, as main tool for analyzing environmental impacts in the BE, ESA conclusions are able to tangibly communicate the direct effects on environment and human wellbeing, while even post-processed LCA results remain intangible and different studies difficult to compare. However, it needs to be emphasized that assessing only one or a small number of ES is not sufficient because only a diverse set of values and ES assessed is likely to identify inherent trade-offs between ES categories (MEA 2005). Assessments will further recognize that only the complete scope of ES maintains nature's vitality to the overall, long-term optimum to the human benefit.

Conclusion Without ecosystem services (ES) from the natural environment, our constructed, current built environment (BE) would not be able to sustain its inhabitants. Thus, it is paradox that, despite knowing of a growing world population and demand, the consumption of mainly urban residents and the construction of cities themselves adversely affect this dependency and foundation. The future BE needs to efficiently and resourcefully create value in obtaining increased ES self-sufficiency for people as a matter of individual, national, and global security. The ES perspective clarifies biodiversity's and nature restoration's importance for this cause. Moreover, it highlights that multiple societal challenges and sustainable development goals can be simultaneously pursuit when increasing ecosystem vitality while greatly contributing to human wellbeing and resilience as a whole. The developed ecosystem services assessment (ESA) approaches introduce the understanding and novel working with this ecological knowledge. They identify shortcomings but also the abundance of opportunities to improve masterplans, construction activities, and building designs. This integration of a (living) systems perspective opposes the traditional disciplinary and sectoral exclusive thinking. Yet, ESA complements present design tools and leads practice toward better outcomes. It enables synergies between usually differentiated departments which offer the potential for novel types of funding schemes and business models in the BE. Furthermore, these can emerge from the long-term value creation by the constructed and developing ecologies which are rooted in the next generation of nature-based, regenerative design. As built ecosystems grow, so does the provision of ES. This represents a transformation to an ecological net-positive economy whereby increasingly demanded "nature's contributions to people," as synonym for ES, stem from the BE itself. Valuing nature is a controversial debated topic despite entirely lacking in the financial market system. Nevertheless, it is seen as a timely means to initiate the discourse in BE policy and practice with a growing body of scientific research advancing accuracy. Regardless of ever obtaining the true and infinite value of nature, ESA permits an increased uptake of nature-based-solutions and ES design in current frameworks today, toward an ideal of "sustainable development" projects where such becomes obsolete and the new norm.

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