Utrecht University

Regenerative implementation of the SDGs

Analysis through the Ecosystem Services framework and the Living Lab approach

Abstract

The world is experiencing global changes that could lead to societal collapse. To counter these unwanted changes the UN introduced the Sustainable Development Goals (SDGs). Despite unifying goals globally, the SDGs have not been effective in driving change. To address this, a workflow is proposed for the efficient implementation of SDGs, incorporating the concepts of Ecosystem Services and the Living Lab approach. This systemic and nature-inclusive workflow ensures concreteness and accountability in the plans developed. Additionally, a regenerative measurement tool is provided to record the impact of the project. This workflow was ideated from the experience of UULabs and applied in a case study. As a result, the principles of regeneration and deep ecology are aligned in this initiative, promoting a more sustainable future.

Key words: *Regenerativity, Sustainable Development Goals (SDGs), Ecosystem Services, Living Labs, Deep Ecology*.

Name: Abraham Ortega Reboso

Student number: 4877764

Date: 00/02/23

Master's programme: Bio Inspired Innovation - Major Research Project report

Supervisor: Katharina Hecht, Department of Science, K.Hecht@uu.nl

Examiner: Jaco Appelman, Department of Science, j.h.appelman@uu.nl

Second reviewer: Pauline Krijgsheld, Department of Science, P.Krijgsheld@uu.nl

Index

1. Introduction

1.1 Climate change, the regenerative approach and deep ecology.

Current human activity is leading to an overshoot of, at least, four times our planetary boundaries, yet still millions of people earn less than the internationally agreed minimum standards. Famine, poverty, lack of energy and water access, biodiversity loss, nitrogen and phosphorus loading, climate change and land conversion are a few examples of the many problems that humanity is facing in the XXI century. As it is explained in the Doughnut model created by Kate Raworth, social and ecological boundaries encompass human wellbeing (Figure 1) (Raworth, 2017).

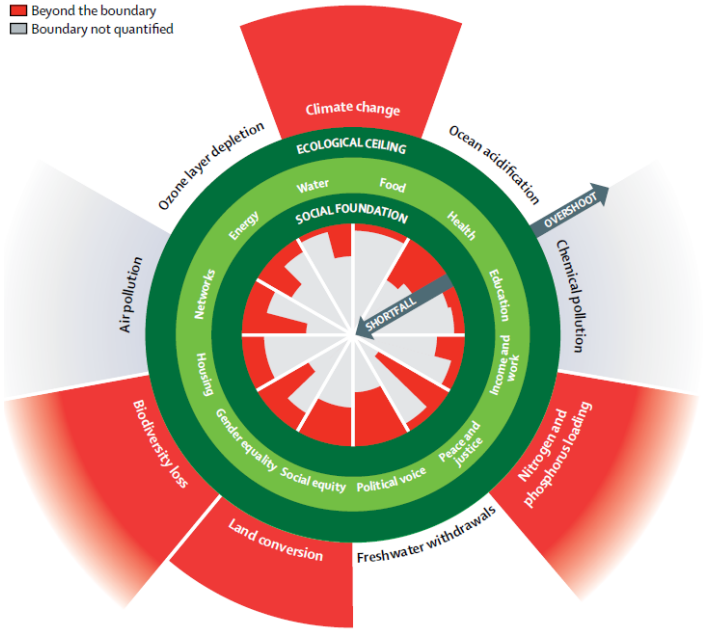


Figure 1. In the outer circle (ecological ceiling), it is represented the overshot of pressure on the life-supporting systems of the Earth. In the inner circle (social foundation), it lays the shortfalls in wellbeing. Between them, the 12 internationally agreed minimum standards established by the Sustainable Development Goals are named. Red wedges show which of the boundaries have been crossed (Raworth, 2017).

Awareness about this situation increasingly spreads through society, making academia and companies look for new ways and solutions to become more sustainable. Generally, the aim has been to become neutral in terms of carbon footprint. Nevertheless, a negative balance is needed to efficiently mitigate the effects of climate change and ecosystem degradation, as we are depleting crucial resources such as fertile land and potable water and these need to be restored to earlier levels to provide enough for all people on Earth. This is the reason why the mainstream term of 'sustainability' had to evolve into a new approach called 'regeneration' (also referred to as regeneration impact or regenerativity during this document) (Figure 2) (Reed, 2007).

Regeneration is a concept that not only covers the industrial perspective, but also gives room to a paradigm shift in the way nature is conceived. This paradigm shift turns the generalized mindset of "shallow ecology", which considers humans outside and above of nature; into "deep ecology", which perceives the world as a network of interconnected and interdependent phenomena, acknowledging the intrinsic value of all living beings in the web of life (Capra & Luisi, 2017; Reed, 2007) .

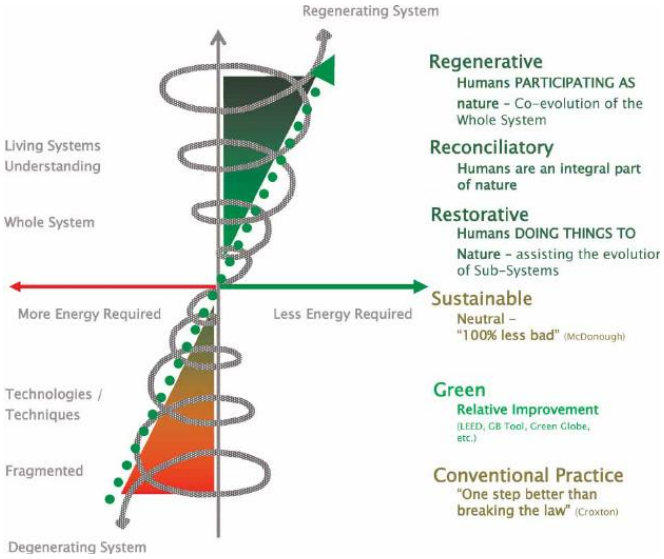


Figure 2. Trajectory of environmentally responsible design. This graph represents the steps humanity must go through when aiming towards environmentally responsible design. Starting from the conventional practice, passing through a sustainability centred mindset, and finalizing in the regenerative approach. In this trajectory, less energy will be required in the process, a living system understanding is needed, and a systemic perspective will be the default (Reed, 2007).

So far, some ideas have been proposed to channel human progress and decrease the problems previously listed in our society. These ideas align at different levels with the concepts of deep ecology and regeneration. As expected, they also vary in terms of values and priorities, hampering the collaborative work between stakeholders to perform efficient change (Johnson et al., 2019) (Kopnina, 2020). In this research, we will focus on the promising frameworks of the Sustainable Development Goals (from now on called SDGs), the Ecosystem Services framework (from now on, ES), and the Living Labs approach (from now on, LL).

1.2 From the creation of the MDGs, to the outcomes of SDGs

At the beginning of the XXI century, a global campaign named 'the Millennium Development Goals' (also known as MDGs) was launched to address public concern about poverty, disease, hunger, lack of schooling, gender inequality and environmental degradation. This was proposed by the United Nations General Assembly and lasted until 2015 (Sachs, 2012). Something noticeable from this campaign was its focus on developing countries, in contrast to the growing urgency to promote sustainable development in the entire world (Sachs, 2012; Woodbridge, 2015).

Even though there are estimations that 50% of poverty was reduced globally since the application of the MDGs, critics argued that they were both thematically and regionally unbalanced. This is due the 'piecemeal approach' that some countries adopted, in which they engaged with some but not all the MDGs. A further critique was that the MDGs were only applied to countries of the global South, despite these countries playing a minimal role in their design, which leaded to the MDGs being considered as another imposed measurement by the more "developed" countries (Woodbridge, 2015).

As a result of these critiques, the Millennium Development Goals grew into a new set of targets with a bigger profile, so they could unify and guide public policies, inspire societal actors and promote sustainable development worldwide (Woodbridge, 2015). In 2015, The 2030 Agenda for Sustainable Development was adopted by all United Nations Member States, and the SDG were presented (*THE 17 GOALS | Sustainable Development*, 2015). In this case, the SDGs divided its actions into 17 goals, in contrast of the 8 goals proposed by the MDGs (Figure 3).

Figure 3. On the left, the 8 MDG proposed by the United Nations General Assembly in 2000. On the right, the evolution of the MDGs into the SDG. The SDGs were adopted in 2015 by the United Nations Member States and will last until 2030 (Images took from the United Nations webpage).

Seven years later, the arrangement and impact of the SDGs has been compared to the MDGs. On the one hand, the SDGs were made with the promise of focusing on a global development with-and-for sustainability, removing the "developing" versus the "developed" dichotomy. Whereas the MDGs maintained a narrow focus on poverty reduction, the SDGs included new themes about the environment, economy and society as an embedded system rather than separated pillars (Figure 4) (Woodbridge, 2015). On the other hand, some studies question the validity of this previous statement. Many of the critiques are based on the assumption that 'sustainable development' is a desirable target, when unlimited growth in a limited-resource planet is not possible: addressing the first two targets of the SDGs 'eliminating poverty and hunger' may not respect target 15, 'life on land'. Thus, contradictions are present within the framework of the SDGs (Kopnina, 2020). Besides, other assessments of over 3,000 scientific articles have concluded that the impact of the SDGs has been mainly discursive, rather than transformative (Biermann et al., 2022).

Figure 4. Hierarchical representation of the SDGs, stating the priorities in which the targets should be addressed. Biosphere is shown as the base of our society, followed by the human wellbeing, and finishing at the top with the economic success. Image adopted from the Stockholm University webpage "The SDGs wedding cake".

Despite the shortcomings of the SDG framework, several reasons make them still relevant. Many entities are integrating SDGs into their business models, and they report according to them. However, there is still a big margin between their good intentions and their ability to incorporate SDGs into their business strategies (Ionașcu et al., 2020). Addressing again the outcomes of

Biermann et al., 2022, most of the impact of the SDGs have been largely discursive, but it still unifies common goals to achieve globally. At the same time, they fostered mutual learning among institutions in their sustainable development policies and strategies, while offering a new instrument for organization, support from governments and mobilization of funding. SDGs serve to hold the interest of powerful actors accountable (Biermann et al., 2022).

In the work of Servaes, 2017, some points were identified as key factors for the successful implementation of the SDGs: (1) bring together the right stakeholders at the right time in the right place; (2) find a way to make difficult trade-offs; (3) build in accountability and transparency for action; (4) and organize this in a participatory and democratic way. These points will be used in this research as a guideline for the final conclusion.

One sector that has a strong need to adhere to the SDGs is the real estate sector. The facts are that "the real estate sector consumes over 40% of the global energy annually, 30% of the raw materials and 12% of the drinking water, generating 25%–40% of the solid waste and 20% of the total gas emissions' (Ionașcu et al., 2020). The SDGs help the real estate industry to identify goals and targets, allowing external parties to evaluate their sustainable development and hold them accountable for their actions. This is especially relevant for UULabs (for definition, see section 2.4), which works closely to V&C, the real estate department of UU.

1.3 Ecosystem services, a nature inclusive approach.

In 2005, the Millennium Ecosystem Assessment (from now on, MEA) proposed a more nature inclusive and ecologically functional framework, expressing the importance of investing in ecosystem management to address the challenges described by the MDGs. This framework is based on ES, which are "the benefits that humans derive, either directly or indirectly, from the functioning of ecosystems". The MEA believed in the premise that the central components of human well-being (health, basic goods for a fair life, choice and freedom, health, security and social relations) can be linked to status of the environment (*Ecosystems and Human Well-Being: A Framework for Assessment*, 2005).

The ES of the MEA were originally divided in four different groups: supporting services, provisioning services, regulating services and cultural services. Supporting services are 'the ES that are necessary for the production of all other ES'; provisioning services are 'the products obtained from ecosystem processes'; regulating services are 'the benefits obtained from the regulation of ecosystem processes'; and cultural services are 'the non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation and aesthetic experience' (Cramer et al., 2005). The Common International Classification of Ecosystem Services (CICES) made a latter revision of this framework in which the category of supporting services was eliminated, rearranging these ES into the other groups. The purpose was to create a framework that focused more on the boundary between ecosystems and society, avoiding intermediate processes and describing only 'final outputs' of ecosystem processes (Haines-Young & Potschin, 2012). This research is based on the work of Hecht, who unified different existing frameworks and adapted them to the building context (Hecht et al., 2022). In total, 59 elements were identified and distributed in the three ES categories (Table 1), but the framework is still in constant evolution.

Table 1. Ecosystem Services. Revised ecosystems (ES) framework by Hecht, 2022 (work in progress) based on the MEA, Pedersen Zari and CICES. The three ES categories are found at the top of the table, while the subcategories are listed below each of them.

Provisioning Services	Regulating Services	Cultural Services
Food/nutrition for humans	Regulation of temperature	Spiritual and artistic inspiration
Food/nutrition for non-humans	Regulation of humidity, ventilation and transpiration	Recreation
Biochemicals for medicine and pesticides	Regulation of noise	Aesthetic values
Biological fertilizers	Pest and disease regulation	Social relations
Fresh water (<3,000 Mg/L TDS)	Control of invasive species and other natural hazards	Educational values and knowledge
Brackish water (3,000-10,000 Mg/L TDS)	Regulation of wind	Sense of place
Saline water (>10,000 Mg/L TDS)	Regulation of flood events	Cultural heritage and historical values
Brine water (groundwater > 35,000 Mg/L TDS)	Regulation of drought	Cultural diversity
Reclaimed and recycled water	Regulation and attenuation of seismic activity	Relaxation and psychological wellbeing
Fresh air	Attenuation of erosion and mass movement	
Raw materials (timber, fiber, stone, minerals, ores)	Fire protection and moderation	
Recycled materials	Regulation of weathering processes	
Reused materials	Regulation of water quality	
Biomass energy	Recycling of materials	
Active solar energy	Regulation of air quality	
Wind energy	Regulation of soil quality	
Fresh water as energy source	Regulation of smell	
Marine water as energy source	Pollination and seed dispersal	
Mineral substances as energy source	Soil formation	
Geothermal energy	Regulation of biogeochemical cycles (nutrient cycling and storage)	
Passive solar energy	Primary production	
Hydrogen energy		
Seeds, spores and other organism (plant, animal and fungi, protists and bacteria) material to maintain species and genetic diversity		
Organisms (plants, animals, fungi, protists, bacteria) and genes to produce genetic library for food, fibers, pharmaceuticals, and materials		
Ornamental resources		
Habitat		
Soil		

Human demand for ecosystem services has grown vastly in the latest years. Nevertheless, those needs cannot be met because human activity is hampering the very capabilities of ecosystems to provide these services. This is a concerning conundrum, as all economies depend on the proper functioning of them: “The full wealth of a nation can be evaluated only with due consideration to all forms of capital: manufactured, human, social, and natural” (*Ecosystems and Human Well-Being: A Framework for Assessment*, 2005). One of the fundamental drawbacks of SDGs is that they do not explain the challenge of sustaining eight billion consumers – under a green mindset – without endangering the other forms of life or the own species survival in a planet of limited resources (Kopnina, 2020). In contrast, the ES framework states explicitly that ecosystem management decisions usually involve trade-offs among ES, and it is essentially a

quantitative and scientific assessment for sound decision-making (Cramer et al., 2005). Thus, using ES as a tool for social decisions might be the most optimal way to address the targets of the SDGs while aligning to the principles of Deep Ecology. This framework offers a well-designed categorization that assesses and provides logical structure for evaluating systems, giving appropriate weight to the different components and the relationships among them (*Ecosystems and Human Well-Being: A Framework for Assessment*, 2005).

The relationships between humans and nature described by the MEA may serve as metaphors or heuristics for explaining and/or structuring a problem, but other times they can be used as a tool for measuring and evaluating (Jax, 2018). Nevertheless, they can be (mis)interpreted in a capitalistic perspective – when it is said that ecosystems provide services, these services are not only for humans, they are for all living and non-living things (*Ecosystems and Human Well-Being: A Framework for Assessment*, 2005). This is a result delivered by the focus on benefits and services, which implies that ecosystem services are open to economic valuation (Summers et al., 2012). The notion of value should not be restricted to merely monetary value - it is important to include other values as well, such as health value, sociocultural value, or conservation value (Maes et al., 2016). As stated before, benefits derived from ES cover various dimensions of general well-being: basic human needs, economic needs, environmental needs and subjective happiness (Summers et al., 2012). The non-monetary values of nature will reflect not only the instrumental value of natural capital, but also inherent, fundamental and eudaimonistic values, which are the right actions that lead to the well-being of the individual (Figure 5) (Maes et al., 2016).

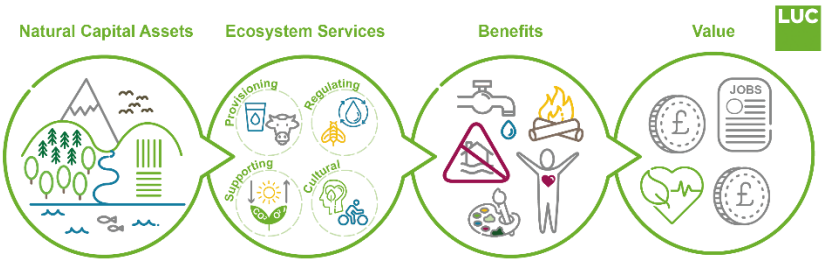


Figure 5. In this image the relation between nature and value is explained in a chain of effects: natural capital assets produce ecosystem services, these ecosystem services serve as benefits for the well-being, creating health value, sociocultural value, conservation value and economic value. Image taken from the LUC webpage "What are natural capital and ecosystems services?"

1.4 Living labs: the voice of the community

So far, the SDGs have been described, which gathers important targets to accomplish in our society; and the ES, a framework that helps to address these targets in a regenerative way if the framework is correctly understood and applied. Nevertheless, one of the principles of deep ecology is still missing: the involvement of the community. The Living Lab methodology is the final element required to bind everything together.

The concept of Campus as a Living Laboratory (CLL) was introduced first during the early 1990s in the University of Columbia. There, it was stated that universities are not only drivers of knowledge and innovation, but also educators that should respond to the complex challenges faced in the 21st century. So, they used the university campus as a giant test bed to explore and solve problems (Pilon et al., 2020). This perspective evolved into the Living Lab methodology, refining its description as it follows: "application of research conducted in the university to address sustainability issues across different levels of impact" (Schuurman et al., 2020).

At Utrecht University, the organisation in charge of this task is UULabs. The aim of UULabs is bringing education, research and operations together to co-create solutions for complex

sustainability challenges in real-world experiments. For that, a set of landmarks (Figure 6) have been developed by Stuckrath & Rosales (2021) (unpublished work), defining the backbone of a LL:

(1) User-centred, open, and experiment in a life setting.

The focus lays within the user, embodying the three E's action code: exploring, experimenting and experiencing. LL serve as learning experience for real-life contexts, which are uncontrolled environments. In this way, results obtained are already contextualized in society. At the same time, key actors are identified (who is the problem owner and who is the user), and responsibilities are shared.

(2) Address sustainability ambitions from different perspectives.

It is a transdisciplinary research process of mutual learning between sciences from different fields and society. Academics and non-academics parties join forces to deliver systemic and innovative solutions.

(3) Contribute to the global impact.

The topics covered by the living lab are usually aligned with the targets of the SDG.

(4) Bring theory and practice together.

LL are co-creative spaces that increase and strengthen collaborations between academics, students and operational staff: academics can increase the social impact of their research; students can participate in practical and innovative projects; and operational staff is supported in their effort to achieve operational sustainability targets. External parties – such as innovative companies and governments – are also involved in the process.

(5) Influence daily routines to integrate sustainable behaviour in users.

Sustainable transition requires behavioral changes, and LL create an impact on the people implied and their routines.

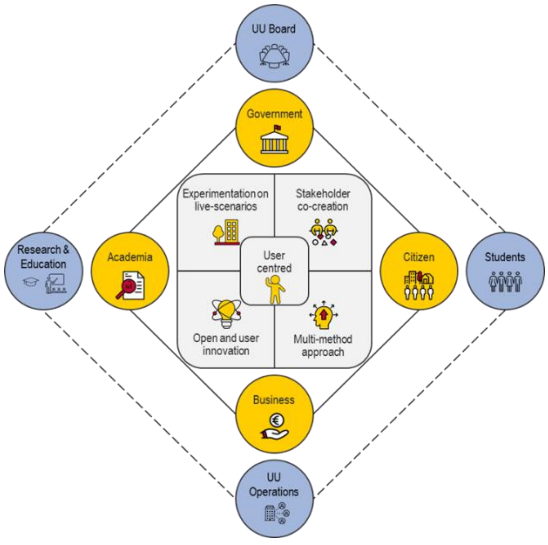


Figure 6. This diagram represents the core values of UULabs. The user is placed in the centre, surrounded by the main characteristics of LL: experimentation in a real life-scenario, co-creation with the stakeholders, open, innovative and multidisciplinary. In the next layer (yellow), the different parties involved in LL are named, accompanied (in blue) with the representation of that power within the University of Utrecht (Stuckrath & Rosales, 2021).

This research is embodied in the context of LL, using the Utrecht University campus as a testing ground to address the targets of the SDGs through the ES.

1.5 Research gaps

Although SDGs and ES were created in the same context, their methods and popularity differ among sectors, being susceptible to biases, misinterpretations and conflict of interests. This hampers the possibility of orchestrating a paradigm shift focused on regeneration, as projects with different frameworks step on each other their work cannot be integrated. With this research, we propose to unify both frameworks by linking SDG's to ES, facilitating the communication between departments, between institutions and, in a bigger scope, between governments.

On the other hand, the paradigm shift suggested by deep ecology questions every foundation of our society, and it needs to be addressed directly from a network and not a hierarchical perspective. In a social network, people become empowered by simply being connected to the network itself (Capra & Luisi, 2017). Previous approaches have forgotten about the importance of involving the community to create efficient social change. This is why the LL methodology must be integrated in the process: decide with the user in order to satisfy the user; decide with the user to understand its needs and deliver social impact, self-reflection and behavioural change.

Once the three approaches are aligned and ready to be applied in future projects, we lack a way to measure the impact they will exert in the direct environment. Projects adopting the LL methodology can exist in many forms, some can be structures like buildings, others are concepts – they can be born from research on the ecological footprint analysis for urban planning; the design of high-performance buildings in architecture; or the study of the social and economic impact of urban policies (Pilon et al., 2020). If a tool of measurement has to be proposed, it should be flexible enough to cover abstract perspectives to concrete spaces. So far, different authors have been working on the matter of measuring with indicators, yet they are scattered in different disciplines and may not work as a standardized tool (Johnson et al., 2019). Some of them lack social representation, they have a narrow scope or are outdated. An integrative model is needed.

1.6 Bridging the knowledge. Context of the research and purpose

This research threads the projects of Hecht and Stuckrath & Rosales, 2021 into a common mission, overcome the drawbacks of the SDGs previously mentioned. For that, it suggests a workflow strategy specialised in the pursuit of regenerative societies. This project could be of use for universities and organizations, in the development of their projects and policies.

The novelty of the proposed model relies in the linkage between SDGs and ES, which is one of the main focuses of this research. In the first step of the workflow, ES are selected from the SDG targets. These ES will be used in the tool created by Hecht to combine some regenerative design strategies. The trade-off of the ES will be assessed by existing data platforms. Once the ecosystem design is done, the LL methodology described in the research of Stuckrath & Rosales, 2021 is introduced, suggesting a practical application of the design. Finally, indicators from several datasets were merged serving as a tool to measure regenerativity. This last step allows to track the progress, visualize the impact for communication purposes, and fine tune parameters that could be improved.

The proposed workflow was ideated from the experience of LLs existing in the University of Utrecht, thanks to the collaboration with the organization of UULabs. At the same time, one of the LLs is shown as an example of the application of the suggested model.

2. Hypothesis and research questions

If we link the different frameworks, we can unify and facilitate the integration of new developments towards climate mitigation, adaptation and design for regenerative cities. In order to reach this goal, this work aims to answer the following research questions:

1. What are the links between SDGs and ES in the context of LL?

2. How can we measure regenerativity?

3. Is it possible to integrate the different frameworks?

3. Methodology

3.1 Research process

The first part of the project is centred in the research question 1, trying to link the targets of the SDGs with the ES categories and the LL methodology. Not the whole list of targets was used. Instead, a selection was made according to the scope of this study: the university strategic plan for 2025, the LL themes, and the UULabs portfolio. Every linkage was found first by logical argumentation, then supported by literature. To enhance visualization of the findings, the linkages were represented by a Sankey diagram.

The second stage addresses question 2, developing a table of indicators to measure regeneration. For this, indicators to quantify ES from different frameworks were gathered. Besides, indicators were divided in sections according to the measuring perspective they proposed (if they had an ecosystem perspective or if they had a capitalistic focus). Similar indicators were merged into one.

The last part of the project unified the previous frameworks into a workflow plan, answering to research question 3. This workflow was applied in a case study.

3.2 Stage one

Selection of SDGs in the LL context

The 17 SDGs were narrowed down to a list of goals, targets and indicators (or subcategories) most relevant in the context of this research. To establish such relevance, a set of criteria was proposed within the team of UULabs, highlighting the interests of the Utrecht University, the current LL portfolio of the team, and the general topics and constrains presented by LL. However, the total set of SDGs should be considered in future approaches to offer a better overview of the matter.

The criteria used for the selection of relevant SDGs, targets and indicators is listed in Table 2. Three subgroups can be spotted, representing (1) the interest of the UULabs core themes in red; (2) the 2025 UU Strategic Plan in yellow; and (3) the contribution of LL to sustainable development in purple, gathered from the work of Pastorelli, 2022. SDGs were selected only when they fitted the criteria presented in the three subgroups. In such manner, it is ensured that the selected ones addressed the most urgent and general topics, specific enough to fit the current mission of the university, but broad enough to be used in other projects from different environments.

Table 2. Selecting criteria. Three different categories are represented in the table: the UULabs perspective in orange, the 2025 UU Strategic Plan in yellow, and the areas of the LL in purple.

Category	Criteria		Justification
Aligning with UULabs core themes, portfolio analysis and living lab model	1.1	**Relevant for UULabs core themes, portfolio, and LL model (internal documentation and planning)**	SDGs, targets, and indicators selection made by UULabs team: the selection was initially obtained based on the 4 core themes of UULabs (biodiversity, climate action, circularity, and creative space) and the archive of UULabs Living Labs. The selection was then revisited and integrated through a deeper analysis of UULabs four core themes and UULabs portfolio.
Aligning with the 2025 UU Strategic Plan, specifically with UU operational management line of actions	2.1	**SDGs relevant due to the direct effect that the environment has in the development of health issues**	One of the missions from UU is related to the multidisciplinary topic of healthy living in society for all people (physical health, mental health, and social health).
	2.2	**SDGs relevant in the context of a healthy lifestyle, non-toxic recreational behaviour, and a safe living space all people of all genders, races, and orientations**	
	2.3	**SDGs relevant due to the correlation to mental health**	
	2.4	**SDGs address the transition for sustainable societies in terms of energy production and usage which are applicable to the effort for such topics**	In the 2025 UU Strategic Plan some focus is set on sustainable development. Research on sustainability at UU is strong and covers many diverse fields, bringing UU at forefront in innovation within this topic: "*In the recent period, we have made major strides in our efforts to realise sustainable operations, geared toward curtailing CO2 emissions, reducing energy consumption, deploying sustainable alternatives and raising awareness among students and staff*"
	2.5	**SDGs address the transition for sustainable societies in terms of ecosystem preservation and climate change mitigation and adaptation which are applicable to the effort for such topics**	
	2.6	**SDGs address the transition for sustainable societies in terms of circular economy and changes in social behaviour which are applicable to the effort for such topics on UU campus**	
	2.7	**SDGs address social action within UU campus, in which values like diversity, equality, inclusiveness, openness, accessibility and mutual respect are covered**	As it is stated in the 2025 UU Strategic Plan, the pillars of the strategic plan and its activities reside in the following values: equality, diversity, inclusiveness, openness, accessibility, and mutual respect. Involved students, employees and alumni are the means and ends for the practice of these value.
Relevant within one of the main areas of LLs contribution to sustainable development	3.1	**Contribute within the sustainable food sector**	Literature analysis of LLs areas of action and impact for sustainable development
	3.2	**Contribute to the social dimension of sustainability transitions**	
	3.3	**Contribute within the sectors of land, water and waste use and management**	
	3.4	**Act as change catalysts for the co-adoption of (new) attuned behaviour, lifestyles, and beliefs**	
	3.5	**Contribute within the sectors of emissions, energy, infrastructure, and transportation**	
	3.6	**Foster circular practices**	
	3.7	**Promote innovations and knowledge co-creation**	
	3.8	**Contribute to climate change mitigation and adaptation, and preservation and planning for (future) ecosystems**	
	3.9	**Foster transdisciplinary education, partnerships, conversations, and policymaking**	

On the other hand, a set of non-selecting criteria was made (Table 3). This helped to explain why some specific targets or whole groups of SDGs categories were left out from the final table. With the positive and negative selection, the scope of this research is better understood, but future approaches may deviate from this first selecting criteria.

Table 3. Non-selecting criteria. Four different non-selecting reasons for the targets of the SDGs are explained in this table, highlighting the limits of the framework.

Category	Criteria		Justification
Non-selecting criteria	NS1	**Not relevant for the scope of living labs. Long term changes that can't be measured during the life span of a living lab within UULabs context**	The strategic plan of the university aims to achieve the proposed changes for the year 2025. The results of them will be evaluated on this time. On the other side, SDGs goals are proposed to be reached by 2030, thus Living Labs should be measured for period shorter than 3 years.
	NS2	**Not relevant for the scope of living labs. One of the conditions for UULabs LLs is the local action they can have within the UU campus**	UULabs LLs model aims to use collaborative research conducted within the university to advance sustainability principles across different levels of impact. The community in which this project is framed initially needs to belong to the campus of the Utrecht University and be related to the local impact that LLs can have on it.
	NS3	**Not relevant for the scope of living labs. No access to that information**	Some of the indicators proposed by the SDGs call for data that is unavailable for the working organisation.
	NS4	**Not relevant as the necessary "selecting criteria" are not met**	Not selected because the conditions set for the selecting criteria are not met.

Linkage between SDGs and ES

The research method to find correlations between the SDGs and the ES framework was logic argumentation, according to the topics the target's indicator addressed. Each target of the SDGs was linked to the categories of ES by answering to one of the following questions:

a) Which ES can be generated by achieving the SDG?
b) Through the generation of which ES could we tackle the proposed target?

In this way, each association was explicit between the selected SDGs targets and the list of ES following the scheme of Figure 7. It is marked which question was addressed in each case. To support the proposed linkage between these two elements, scientific literature was provided to show existing research on the matter, usually sustained by practical examples.

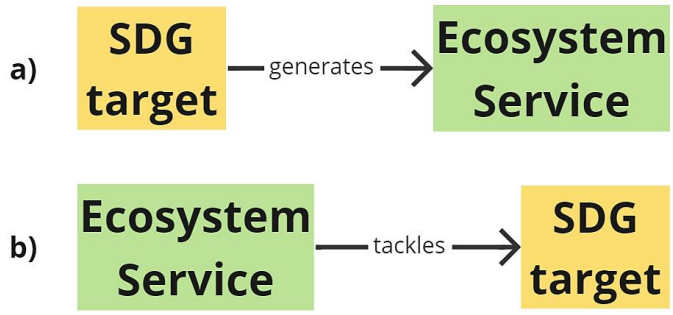


Figure 7. Link reasoning procedure. In the first case, the link was found by thinking which ES may be generated once the SDG target is accomplished. In the second case, the link was found by thinking which ES may help to achieve the SDG target.

At the end, three things were counted in this stage: (1) the number of links created from an SDG to ESs and the proportion of each ES category per SDG; (2) the times each question was used to

create a link between a target and an ES and its proportion per ES category; (3) the total number of times each ES was linked.

For the last element, different thresholds were proposed to generate a new list of ES, only gathering the ES with the higher amount of links and suggesting, in this way, which ES require a special focus to address the wider range of SDG targets.

Sankey diagram

Using the digital tool SankeyMATIC.com, the linkages between the SDGs and the ES categories were represented to facilitate the visualization. In this way, it was possible to count the number of associations in total, the number of associations per SDG, and the ES categories with the largest number of linkages.

Data analysis

After the selection of the SDGs targets and suggesting their links to the ES, data was collected and analysed using the software Microsoft Excel version 2211. First of all, the number of selected SDGs targets was compared to the unselected ones. Secondly, the number of links found was counted and divided into the three different categories of the ES. The proportion of each ES category on the global count of links was obtained after normalization: the total number of links per ES category was divided by the number of ES present in the official list of that category. Finally, the number of times question 'a)' or 'b)' was used to create a link between the SDG target and a ES was shown per ES category.

Linkage with LL

The LL methodology was studied from within during the course of this research. Using the work of Stuckrath & Rosales, 2021 and their generalised definition of the LL methodology, the elements of this framework were suggested to overcome the current missing action plan of the SDGs.

3.3 Stage two

Indicators collection

This part of the project was done in collaboration with Katharina Hecht. The indicators were unified from different databases: the Canadian toolkit of 2017 (Preston, 2017), ValuES from 2014 (Berghöfer & Schneider, 2014) and the indicators previously collected by Hecht. In future research, the verification and completing of the table with experts of the field will be an important step. The source is given next to each indicator.

3.4 Stage three

Workflow development

With the purpose of connecting the different frameworks, make the most of their strengths and overcome their weakness, a workflow was proposed. This workflow integrated the ES perspective through LL to effectively address the SDGs, fitting the systemic approach discussed in (Capra & Luisi, 2017).

Case study "P-Olympos".

The research project of Armin Geluk was used as case study to apply the workflow (Geluk, 2023). The mission of his research is to enhance biodiversity and plant abundance in cities using bio inspired design techniques. In this case, he is working on how to make bio receptive building bricks and how to integrate them in an irrigation system, using the new parking garage at the

Olympos Sport Park of the UU as a desired location. In this way, he shows a way of favouring plant growth on buildings through regenerative design.

4. Results

4.1 Selection of SDGs

Once the criteria of Table 2 and Table 3 was applied to the list of SDGs, the selection of SDG targets was made. SDGs 1, 4, 5, 8, 10, 16 and 17 were not included in this research due to their humanistic perspective, which can be unfeasible to link, at least at this point, through the ES framework. In total, 35 subcategories were selected out of 131 (from the SDGs covered in this study), as it can be seen in Figure 8. These targets are embodied into the most urgent aims of Utrecht University (mostly shared by other institutions); they fit into the LL methodology; they can be tackled locally; and their progress can be followed in the short run. The complete list of the selection of SDGs can be seen in Hyperlink 1.

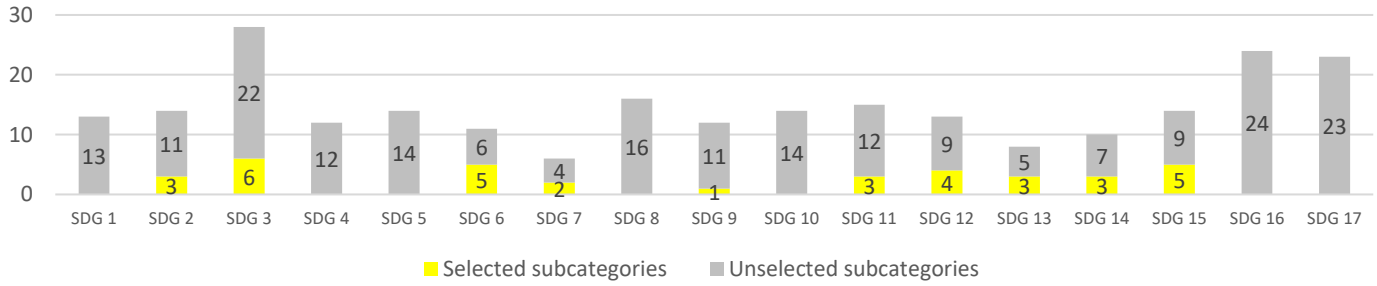
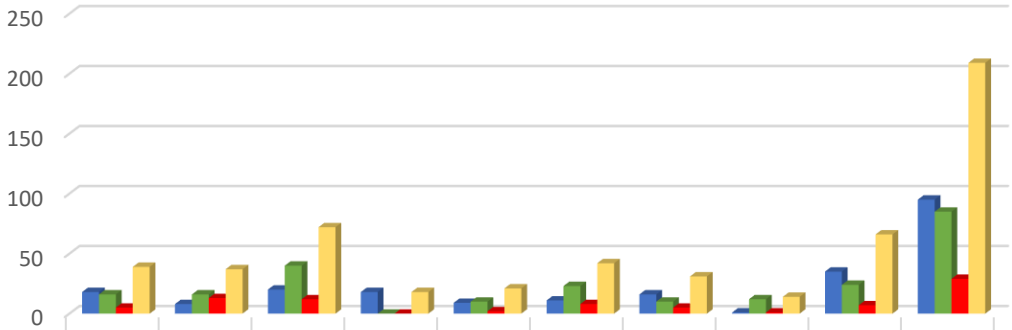


Figure 8. Selection of SDG targets according to the criteria. In yellow, the number of targets that were selected according to the criteria described in Table 2. In grey, the number of targets unselected according to Table 3.

4.2 Links between SDG targets and ES.

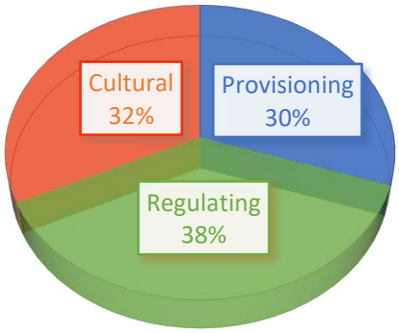
Each selected target was connected to the ES framework (Hyperlink 1) through the methodology explained in Section 3.1.2. In Figure 9, it is shown the number of links divided per category of ES. In total, 549 links were found, where 231 accounted for provisioning services; 236 for regulating services; and 82 for cultural services.



	SDG 2	SDG 3	SDG 6	SDG 7	SDG 9	SDG 11	SDG 12	SDG 13	SDG 14	SDG 15
Provisioning Services	18	8	20	18	9	11	16	1	35	95
Regulating Services	16	16	40	0	10	23	10	12	24	85
Cultural Services	5	13	12	0	2	8	5	1	7	29
Total nº of links	39	37	72	18	21	42	31	14	66	209

Figure 9. Number of links found per SDG. On the left graph, the number of links found between the SDGs and the ES framework is divided among the ES categories. On the right, the total number of links is shown.

The total count of links was normalized by the amount of ES present in the offical list of each category. As it can be seen in Figure 10, the ES category with the higher proportion was the

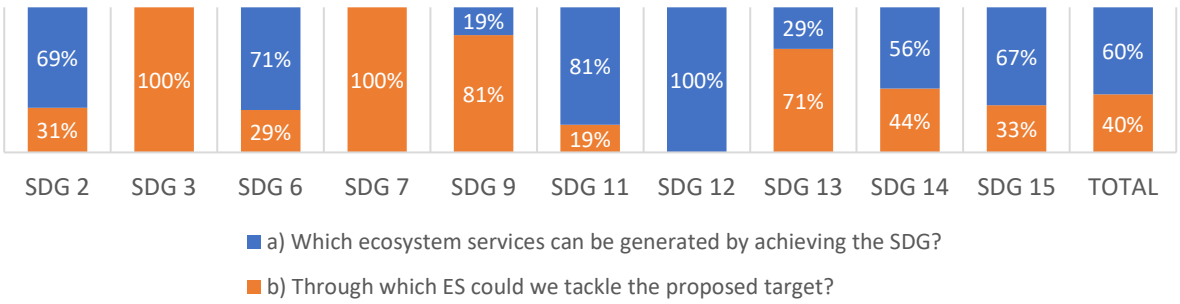


regulating services (38%); followed by the cultural services (32%); and finalizing with the provisioning services (30%).

Figure 10. Proportion of ES categories on the global count of links. After normalizing the total number of links between the SDGs and the ES per ES category, the proportion of each category on the global count was expressed.

In regard to the questions applied to create the link between an SDG target and an ES, 'a) Which ecosystem services can be generated by achieving the SDG?' was used 329 times; while 'b) Through which ES could we tackle the proposed target?' was used 220 times. The proportion of each question per SDG is shown in Figure 11. In the total count, question 'a)' was used 60% of the time, with the remaining 40% addressing question 'b)'. As it can be seen in Figure 12, question 'a)' was mostly used for provisioning services (167 times out of 239); in contrast to question 'b)', which was mostly used for regulating services (132 times out of 228). Almost the total amount of links in cultural services were created through question 'a)' (66 times out of 82). Consequently, SDGs that were mostly linked through question 'a)', 'provisioning services' predominated; while SDGs mostly linked through question 'b)' had a higher proportion of 'regulating services'. Precise values can be seen in Hyperlink 1.

Figure 11. Question used to support the link between each SDG and the ES. Each link was created after



answering to question a) or b). In this graph, the proportion of each question is shown per SDG. At the end, it is shown the proportion of each question on the total count.

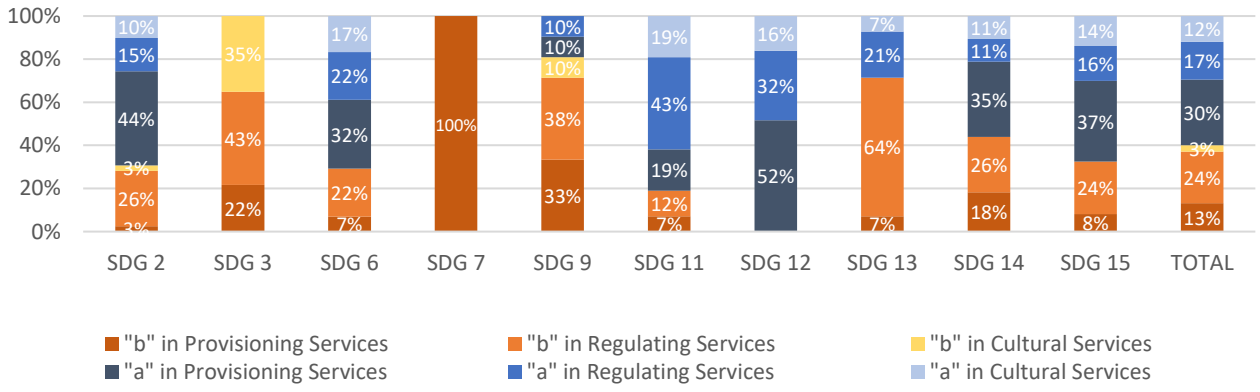


Figure 12. Proportion of each question on the different ES categories. In this graph, the proportion of the use of question a) or b) to create the link between an SDG and ES is divided per ES category.

On the other side, the total number of times an ES was linked was also counted. The list can be seen in Hyperlink 1. A reduced list was generated by gathering all the ES with more than 8 links (for description of the results, continue to section 4.1.3).

4.3 Representation on a Sankey Diagram

The Sankey Diagram tool helped to enhance the visualization of the connections between the SDGs and ES. The reduced list of ES was used in Figure 13 to provide a clearer picture. As it can be seen in Appendix 1, SDG 15 "life on land" with 209 links; SDG 6 "clean water and sanitation" with 73 links; and SDG 14 "life below water" with 66 links are, in order, the SDGs best connected to the ES. On the other hand, "regulation of temperature" with 20 links; "relaxation and psychological wellbeing" with 18 links; and "educational values and knowledge", "habitat", "fresh water", "regulation of drought" and "regulation of water quality" with 16 links are the ES more present in these connections.

4.4 Table of indicators

Indicators from different sources were collected and unified, previously explained in 3.3. The resulting table can be seen in Hyperlink 2.

4.5 Workflow proposal and application in the case study

The proposed workflow is divided in 6 stages, being able to jump from stage to stage when it is required. Stage 1 and 2 belong to the ideation phase. Stage 3 and 4 cover the designing phase. Stage 5 is the application phase, and stage 6 is the quantification phase, measuring the regenerative impact it has been exerted. After the description of each stage, there is an example below of how it was applied in the case study.

Stage 1: Defining the purpose and selection of SDGs. If the group in charge has an idea or intention in mind, related SDGs can be selected. It is recommended to work with 1-3 SDGs to not deviate from the original scope. If no specific purpose is yet defined, SDGs can be chosen according to urgency of topics, local interests, expertise of the group and / or availability of resources. From the SDGs selected, it is advised to look at their targets and check if any of them resonates best with the defined objective. The list of SDGs and their targets can be found in sdgs.un.org/goals or in Hyperlink 1.

Objective: 'One of the biggest challenges of today is a decrease of biodiversity and plant abundance in cities. Therefore, we have to investigate other possibilities that integrate nature with our way of living. One solution for this problem could be to ensure plant growth on buildings.

SDGs addressed: 11, 13 and 15.

Stage 2: Selection of ES. Using Appendix 1, it can be searched which ES are common to the SDGs selected. What's more, in Hyperlink 1 it is described the individual relationships between SDG targets and the ES framework, with an explanation supported by literature. This explanation may help to understand the link and inspire new solutions, but it should be kept in mind that it is just an example, not the exclusive reason why these two elements can be connected. If the team does not count with expertise in the field of ES, it is encouraged to inquire about the selected ones and their relationship with the ecosystem before moving to the next step.

It is shown in In Table 4 which ES were selected, all of them linked to the SDGs of focus.

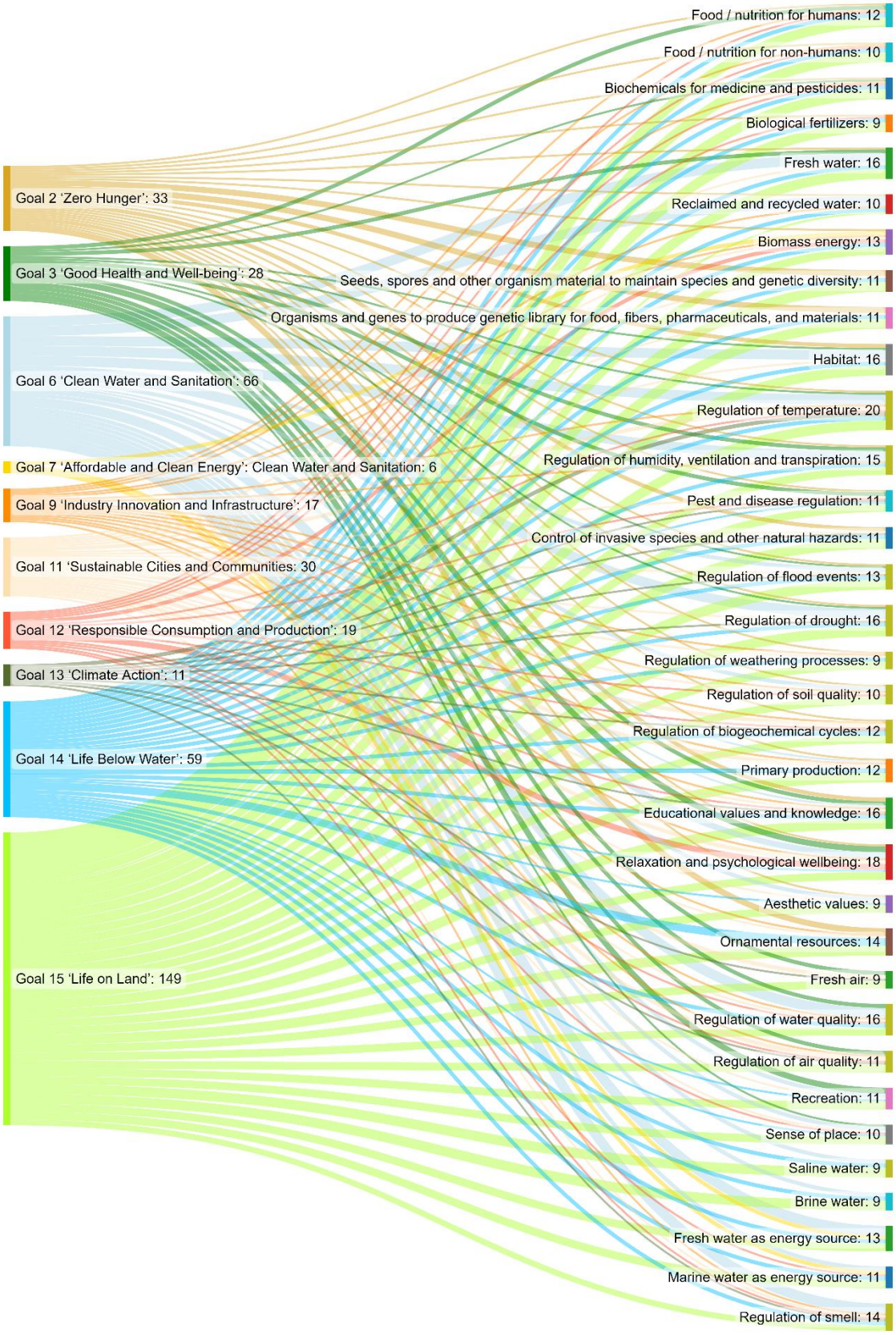


Figure 13. Reduced Sankey Diagram. The links between the SDGs and the most connected ES of this study are displayed on this diagram. On the right, the SDGs are presented next to the number of total links found (on the reduced list). On the left, each ES is accompanied by the number of times it was linked to a SDG target. The thickness of the line is given by the number of links. Figure made with SankeyMATIC.

Table 4. ES selection. *Case study selection of ES according to the topic of the project.*

Provisioning Services	***Regulating Services***	***Cultural Services***
Fresh air	*Regulation of temperature*	*Aesthetic values*
Seeds, spores and other organism (plant, animal and fungi, protists and bacteria) material to maintain species and genetic diversity	*Regulation of humidity, ventilation and transpiration*	
Organisms (plants, animals, fungi, protists, bacteria) and genes to produce genetic library for food, fibers, pharmaceuticals, and materials	*Regulation of biogeochemical cycles (nutrient cycling and storage)*	
Habitat	*Primary production*	

Stage 3: Systemic design. Using the tool in development by the team of Hecht, design strategies and case studies are provided according to the ES they relate (Pedersen Zari & Hecht, 2020). Multiple design/strategies can be combined to create a system generator of the selected ES. However, the trade-off between the ES must be evaluated. Mapping ES is possible thanks to platforms like MESH or the ESII tool, among others (Douglass, 2020; *ESII Tool*, 2016). They measure the local ES present at a project location and allow a comparison to the ES expected to be provided once the design is successfully implemented. If the desired trade-off is not achieved, there should be a change in the ES design/strategy.

Design strategy 1: bio receptive building bricks walls in the new parking garage at the Olympos Sport park, UU campus.

Design strategy 2: irrigation system following the bioinspired design cycle. One component of the irrigation system will be the passive capture of atmospheric water, possibly rainwater or condensation. The other is the passive distribution of the captured water to the gabions.

It will be performed a baseline ecological scan to investigate what kinds of plants grow in the plant/soil layer that is directly adjacent to the garage, to look for possible synergies between the plant layer and wall gabion. Trade-offs among ES will be assessed with the ESII tool in the future.

Stage 4: Systemic planning. Once the purpose of the project is defined and a design/strategy is proposed, the set-up plan must be negotiated and described. For that, the LL methodology (or the tools involved for it) should be applied, according to the work done by Stuckrath & Rosales, 2021. This step allows the possibility to turn giant SDGs chunks into more digestible and precise plans.

The project is a LL from the UU, aligning with the UU strategic plan for 2025. The strategy is stated internally by the Faculty of Science and the organization of UULabs. Other parameters can be seen in Table 5.

Table 5. Parameters selection. *Enumeration of the different elements that define the project. This table is originally proposed in the work of Stuckrath & Rosales, 2021.*

Territory	*Local*
Location	*Building/unit*
Duration	*Short-term*
Network	*Single LL network having multiple stakeholders*
Coordination	*Bottom-up*
Participation	*Exhalation-dominated*
Innovation Mechanism	*Enabler-driven*
Innovation Outcomes	*Modular*

Stage 5: Application of the project. As stated in the LL methodology, life-setting scenarios are always prone to face unexpected and uncontrolled circumstances. Adaptation and improvement of the original project plan is usually required, thus it is encouraged to return to previous stages to redefine the elements involved.

Currently ongoing.

Stage 6: Quantification of the regenerativity impact. With the tool provided in this research, regeneration can be measured. This is an important step to evaluate the development or the creation of a new ecosystem, which will play a direct role in the targets of the SDGs initially selected. In perspective, it will be possible to apply the indicators of the SDG targets if the collaborative outcomes of a network of LLs are gathered.

Periodicity of the measurement may depend on the indicators but generally each 3 months, to see the evolution along seasons. The indicators proposed are the shown in Table 6.

Table 6. Indicators selection. *Indicators gathered from the regenerative measurement tool to be applied in the case study.*

<table>
<tr><th>Ecosystem Service</th><th>Indicator proposed 1</th><th>Indicator proposed 2</th><th>Indicator proposed 3</th></tr>
<tr><td>Fresh air</td><td>Air purification rate (through nature-based and technological strategies)</td><td></td><td></td></tr>
<tr><td>Seeds, spores and other organism (plant, animal and fungi, protists and bacteria) material to maintain species and genetic diversity</td><td rowspan="2">Total number of species and sub-species (Nº of element / m2)</td><td></td><td></td></tr>
<tr><td>Organisms (plants, animals, fungi, protists, bacteria) and genes to produce genetic library for food, fibers, pharmaceuticals, and materials</td><td></td><td></td></tr>
<tr><td>Habitat</td><td>Number of transient species and individuals (Nº of elements)</td><td rowspan="2">Vegetation cover (area and height expressed in m squared or m of height)</td><td></td></tr>
<tr><td>Regulation of temperature</td><td>Solar radiation interception per available plant species</td><td>Leaf area index (canopy measurement)</td></tr>
<tr><td>Regulation of humidity, ventilation and transpiration</td><td>Solar radiation intensity (kWh / m2)</td><td></td><td></td></tr>
<tr><td>Regulation of biogeochemical cycles (nutrient cycling and storage)</td><td>Carbon capture (C kg / ha)</td><td></td><td></td></tr>
<tr><td>Primary production</td><td>Increase of biomass (tons/ year)</td><td></td><td></td></tr>
<tr><td>Aesthetic values</td><td>Expressed aesthetic value (Qualitative measurement)</td><td></td><td></td></tr>
</table>

5. Discussion

5.1 Analysis of the SDGs in a regenerative context

After selecting the SDG targets from the criteria described in 3.2, 35 targets out of 131 appeared to coincide with the current sustainability goals of UU, fit into the LL methodology, have a local action, and can be tackled in the short run (Figure 8). From these results, two observations can be drawn:

(1) SDG targets were devised with a notably broad scope, hindering the establishment of a common framework applicable to most, or all of them. Even though SDGs were made with the intention to empower, at the same time, stakeholders from all levels of administration and non-state actors, the division of expectations is not clear (Woodbridge, 2015). Some of the targets appeared to be directed to governments or big institutions (as their indicators required of large collection of inaccessible population data, they measured the number of subsidies given to different parties, or they talked about international collaboration); while others described challenges that could be tackled locally. Therefore, we suggest reframing the SDG targets by adding the 'problem owner'/ stakeholder who should take action. These problem owners exist across a range of power structures and scales. If the targets could be structured depending on the relative influence of the project owner – from small-scale NGO up to governmental bodies – the ability of project owners to effectively implement SDG targets would be increased.

(2) More research needs to be done in the field of linking social aspects to the field of ecology. Although these two sciences may seem distant, the holistic perspective of society argues the interconnection between them (Capra & Luisi, 2017). This is the base of deep ecology and the regenerative approach (Raworth, 2017; Reed, 2007). Thus, frameworks of the future will be better at linking these two sciences, and no goals will be excluded for the reason of being 'too humanistic'.

Besides, some other aspects of the SDGs put in doubt the consistency of their elaboration. They will be described in the following paragraphs.

Initially, the United Nations proposed the SDGs as an updated version of the MDGs, turning the focus on a global development with-and-for sustainability: 'the SDGs include new themes which reflect an approach that sees the environment, economy and society as embedded systems rather than separate competing "pillars"' (Woodbridge, 2015). However, many studies argue that the SDGs lack coherence to foster and push economic growth at the planetary scale. To be more precise, SDG 8 (decent work and economic growth) might not be compatible with some of the targets of SDGs 6 (clean water and sanitation), SDG 13 (climate action), SDG 14 (life below water) and SDG 15 (life on land) (Biermann et al., 2022). Then, the SDGs do not show how to sustain eight billion consumers (even under a 'green' lifestyle) on a planet of limited resources, but they call for a change towards an 'unspecified' economic model that would be more inclusive and sustainable (Kopnina, 2020; Woodbridge, 2015).

On the other hand, the success of the SDGs directly depends on its vertical integration in all levels of organization, relying on strategic long-term planning between countries and the regions they contain (Woodbridge, 2015). Unfortunately, observable institutional change has merely replicated existing priorities, trajectories and government agendas, in which organizations selectively implemented SDGs that supported the policies they have already prioritized. This situation is favoured by the fact that SDGs are non-legally binding, being loose enough for actors to interpret the goals according to their interests (Biermann et al., 2022). As a result, effective collaboration cannot proceed because actors do not hold accountable to their real impact, following a piecemeal approach.

Aligning to the previous paragraph, a study of 3000 scientific articles evaluated the efficiency of the institutional changes delivered by the SDGs (Biermann et al., 2022). It showed little evidence of their transformative impact on the mandates, resource allocation and practices in the global governance. What's more, it also showed little evidence of normative and institutional changes in the direction of ecological integrity. Nevertheless, it was evinced that the SDGs have had an impact on the discussions around the climate and biodiversity regimes by offering new instruments for local, political and societal actors to organize around, gain more support from governments, and mobilize international funding. At least, their discursive impact has been proven (Biermann et al., 2022).

From this overview, it can be argued that the main problem resides on how the SDGs have been interpretated and applied so far. Suggestions to eliminate this framework may waste all the progress it already achieved in unifying international goals, dividing the different social actors once again. In the following sections, it will elaborated why integrating the perspective of ES and LL into the SDG targets is a useful approach to target ecological regeneration.

5.2 Reframing the SDGs. Linkage to ES

Understanding the goals and targets of the SDGs through the ES perspective will provide a more tangible and realistic way to address the matter. This is because the ES framework takes into account the inevitable involvement of 'trade-offs' in every ecosystem management decision (Cramer et al., 2005). What's more, it helps to deviate from the anthropocentric dogma of the SDGs, following a more nature inclusive and ecologically focused perspective (*Ecosystems and Human Well-Being: A Framework for Assessment*, 2005). In other words, it can change the current piecemeal and reductionist mindset into the interconnected system of the holistic approach (Capra & Luisi, 2017). During the following paragraphs, it will be discussed the main outcomes achieved from linking the previously selected SDG targets to the ES framework.

First, it can be seen in Figure 13 that the SDGs with the larger number of connections are: SDG 15 (life on land); SDG 6 (clean water and sanitation); and SDG 14 (life below water). The results coincide with what was expected, as these SDGs are precisely focused on the protection of the ecosystems and the ES they provide. The other SDGs had an average of 29 links, which can be explained due to their specificity to concrete topics, presenting more direct and simple connections. Having a lower number of links should not be necessarily perceived as a bad benchmark, it is just a consequence of the scope of the topic: SDGs addressing whole ecosystems are much easier to connect with larger number of ES than SDGs that only focused on concrete aspects of them (e.g. SDG 15, which covers the conservation of whole terrestrial ecosystems vs SDG 2, which is centered in their food production capacity). Just the mere presence of links should be understood as a success, proving the existence of a bridge between the SDG targets and ES framework.

The number of links found per ES category is represented in Figure 10, showing an uneven distribution of the categories on each SDG. The total number of links was normalized to allow its comparison. 'Regulating services' are the most frequent because they serve as the base in which the other services are born, according to the new conception of the ES framework followed by Haines-Young & Potschin, 2012 and Hecht. Ecosystem functions are only possible if regulating services are integrated in the first place. From them, provisioning services are generated and, ultimately, cultural services appear. Nevertheless, in our societies we prioritize cultural services, we supply few regulating services, and we rely on nearby ecosystems to provide provisioning services to us, instead of integrating these natural spaces in our environment (Pedersen Zari, 2020). This mindset is reflected by the SDGs, where most of the targets only measure the quantity or availability of provisioning services. Thus, with the help of the ES framework we can redirect the priorities toward regulating services, setting the grounds for full developed functional ecosystems.

Hypothetically, if the ES framework was better prepared to identify links between ecosystems and humanistic topics, many cultural services could have been found in the unselected SDGs (1, 4, 5, 8, 10, 16 and 17). However, the proportion of 'cultural services' in Figure 10 would have shifted to hold the largest frequency, which currently takes the second place. This supports the statement that in our western society there is a special emphasis on cultural services, but there is little representation of regulating services (and ecosystems in general) in the SDG framework.

In the next part of the results, the nature of the links between ES and SDG targets was studied. As explained in Figure 7, connections were made after answering to two different questions: 'a) which ES can be generated by achieving the SDG?', and 'b) through the generation of which ES could we tackle the proposed target?'. Consequently, SDGs can be divided depending on which question was predominant in their links: a group of SDGs that, when achieved, generate ES; and a group of SDGs that mainly require ES in order to be achieved. Following the results of Figure 11, the SDGs that are mostly 'generators' of ES are: SDG 2 (zero hunger), SDG 6 (clean water and sanitation), SDG 11 (sustainable cities and communities), SDG 12 (responsible consumption and production) and, in a more balanced proportion, SDG 14 (life below water) and SDG 15 (life on land). On the other hand, SDGs that may require ES to be achieved are: SDG 3 (good health and well-being), SDG 7 (affordable and clean energy), SDG 9 (industry innovation and infrastructure) and SDG 13 (climate action). Besides, following the outcomes of Figure 12, SDGs considered to be 'generators of ES' mostly provide 'provisioning services'. On the contrary, SDGs that were categorized as 'requiring from ES' were mainly linked to 'regulating services'. This result aligns with the idea previously expressed: SDGs focus on 'provisioning services', while 'regulating services' are the ones needed to accomplish the proposed goals. For further details, each individual connection is explained according to literature in Hyperlink 1. Finally, the links can be visualized in Figure 13 (the non-reduced version with all the ES is shown in Appendix 1).

The value of linking SDGs and ES relies on its use as a project design strategy in systemic thinking. In the work of Hecht, it is described how to design accordingly to ecosystems, mimicking their functions to provide desired ES (Figure 5) (Pedersen Zari & Hecht, 2020). Besides, assessment of the trade-off between ES can be performed through existing tools, like MESH or the ESII tool (Douglass, 2020; *ESII Tool*, 2016). For the matter of ES quantification and evaluation, a regeneration measurement tool is proposed in section 5.2. The goal is to quantify the presence and evolution of the selected ES and its trade-offs, inquiring, in this way, a positive progress in achieving the SDG target.

5.3 Reframing the SDGs. Including the LL approach

In the previous section, it was described how to properly interpret the SDGs targets through the ES as a design strategy. Nevertheless, other solutions need to be implemented to ensure the success ratio of the targets addressed. The incapability of properly apply the SDGs in organization policies and actions is a direct effect of the flexibility in which these targets were framed, as explained in 5.1. This makes them not legally binding and open to interpretation, fitting the interests of the user. Furthermore, stakeholders take a piecemeal approach, collaboration is not promoted, actors cannot be held accountable for their actions and, even considering their positive impact at unifying the discourse, the fine line between real measurements and greenwashed cover-ups is still too thin (Biermann et al., 2022). In the following paragraphs, it is suggested how to efficiently apply the SDGs targets using the LL methodology, inspiring the creation of new social systems of work.

LLs arose two decades ago as a way to solve complex societal challenges. In the research done by Stuckrath & Rosales, 2021, it is defined: the general concept of LLs (section 1.4), the core attributes that frame them (Figure 6), and the parameters to consider when designing a project of this category (some examples shown in Appendix 2, further explained). The LL methodology was studied from within during the course of this research, done in the organization of UULabs

at the University of Utrecht. In this time, it was possible to experience the challenges faced by the LL organizations, spot their source, and understand the value created from this methodology. For this reason, it is proposed that the tools developed by Stuckrath & Rosales, 2021 should be brought into a wider scope, calling for a standardized procedure to work on the SDG targets using the LL methodology.

First thoughts on the previous statement may address that, generally, the LL topics already align with the SDGs. Nevertheless, the suggestion is to turn the focus of this statement upside down: SDG targets are the ones that should be always implemented by governments and organizations using (or getting inspiration from) the LL methodology.

Some of the points in favor of this belief are: (1) ecological action requires from the regenerative approach, as explained in 1.1, calling for the involvement of the community (Capra & Luisi, 2017). LL are user-focused, bringing different stakeholders and involving academia with non-academia (Stuckrath & Rosales, 2021). (2) the LL methodology precisely identifies the parameters playing a role in a project: territory, location, duration, network, coordination, participation, innovation mechanism and innovation outcomes. In this way, targets are divided in approachable and more concrete tasks, the problem owner is defined, and actors can be hold accountable for their impact (Stuckrath & Rosales, 2021). (3) LLs are promoting spaces for transdisciplinary research in life-settings. This feature could diminish the current gap between humanistic topics and the ecosystem present in the ES framework.

Some examples of the tools used for the LL creation are represented in Appendix 2 (Stuckrath & Rosales, 2021). First, it is shown a table that helps to identify all the essential parameters for the ideation and design of a LL. On the other side, the LL canvas, which collects the key elements to set up the project. It is encouraged to read their report to properly apply the LL methodology, having a further description of their elements and a general explanation of obstacles to overcome when applying this methodology.

5.4 Tool development. Quantifying ES and measuring regenerativity

Measure ecosystems and quantify its ES are essential tasks to perform sound decision-making. Many tools are already available to evaluate the ecosystem condition and support policy decisions that involve trade-offs between ES, like the previously mentioned in 5.1.2 (Cramer et al., 2005; Douglass, 2020; *ESII Tool*, 2016). In parallel to the indicators proposed by the SDGs, which can be too broad and hard to apply, ES indicators from different sources have been gathered in a new tool to help quantifying the regenerative progress of systems designed though the ES framework (Hyperlink 2). This part of the project addresses the second research question.

In the proposed tool, indicators should be selected according to the matter of study and the resources available, assigning a specific periodicity to take measures. Values from these indicators are meaningless by themselves, they should be understood within a context, following the ES trade-off expectations made in the design process. To be more precise, what gives meaning to these values is the trend they follow, showing the development of the ecosystems and its ES and proving the regeneration capacity of the system created.

The tool is still in its beta phase, and it consists of an excel sheet where indicators are listed for different ES, accompanied by a suggestion of the units to use. Future updates of the tool will offer a detailed description of methods and devices that can be used to perform the measurements. As well, the interface requires improvement to facilitate its navigation, being more user-friendly and understandable for people with different backgrounds. A revision of existing indicators for ES quantification is suggested to ensure completeness.

5.5 Workflow implementation to effectively address the SDGs

The arguments previously described lead to the third research question. Thus, in this section it is suggested to merge the previous elements together to overcome their downsides, make the most of their advantages, and align them effectively with the regenerativity principles. For that, the frameworks were threaded together in a workflow strategy, described in Section 4.3. This workflow allows the SDGs to be understood through the ES perspective, elaborates an action plan using the LL methodology, and measures the regenerative impact with the tool proposed.

Next to each stage of the workflow, there is an example of how it was applied in the case study. Nevertheless, this just an indicative and non-extensive result, as further details belong to internal work done by the stakeholders involved. It should not be forgotten that the workflow has a supportive purpose, thus each project should mould the stages in a way that it fits best to the topic addressed.

5.6 Future considerations and next steps

The resulting workflow drafts a possible bridge between the frameworks explained in this document. In this way, it lays the first foundations of new systems of work, but it still needs a lot of polishing. Nevertheless, the reasons why these frameworks should be interconnected are clearly explained, so as their drawbacks when used individually. Next steps can be divided in three main branches, requiring from different disciplines:

(1) Revision and improvement the table of links between ES and SDGs. Developing an interactive interface that enhances the visualization of the links. Besides, it will be useful to perform the task of linking the frameworks again but considering all the SDGs and their targets.

(2) ES experts, LL experts and different stakeholders should be brought together to express their perspectives about the proposed workflow. In this way, each stage is better adapted to their specific challenges, and the system is improved to fit realistic scenarios.

(3) More indicators should be added in the regenerative measurement tool. As well, its interface needs to be improved, guiding the user on how to perform each measurement.

In the future, all these stages and their tools might be combined in an interface. There, you could select SDGs and ES, access to the database of ES designs, go through the LL tools, and access to the list of indicators to measure regenerativity. However, there is a lot of work to be done. This project is a LL itself, so applying this whole system in real case scenarios may help to improve the system, learning from experience and redefining its elements.

6. Conclusion

The SDGs are a valuable framework for addressing global issues, but they have several problems that need to be tackled. On the one hand, SDGs are contradictory at the matter of sustainability; lack accountability; and are elaborated with a general scope, making it difficult to analyse them through the same perspective and understand which stakeholder is responsible for each target. On the other hand, they have not been effective in bringing change, often being used as a method of greenwashing. This lack of effectiveness highlights the need of redefining a new way to use them, finding a more holistic and nature inclusive approach. For this reason, a workflow has been proposed, threading the main points of the ES framework and the work of Hecht; the main points of the LL methodology and the work of Stuckrath & Rosales; and a final tool to measure regeneration.

Exploring the SDGs through the lens of the ES perspective avoids the misuse of the SDGs. Besides, it also provides a more realistic and systemic perspective on how to address them, considering trade-offs between decisions. The number of links found to ES differed among the SDGs, but just the mere presence of connections between these two frameworks is to be considered a success. Furthermore, it was also found that most of the SDG targets were related to "provisioning services". Understanding the SDGs through the ES framework enhances regenerativity because it shifts the focus towards "regulating services", being the real generating scaffold of the other ES.

Proposing the LL approach as a mediator fixes the lack of accountability and direction of the SDGs. This methodology and its tools align with the principles of regenerativity and deep ecology, as they focus on systemic design, bring different stakeholders together, are user-centred, and perform transdisciplinary research. At the same time, they are clear about the parameters playing a role in a project, ensuring the elaboration of a concrete action plan.

Finally, elaborating a tool to measure regenerativity helps to track the impact of the action taken. This is an important task to check if the desired outcome is achieved or if the original plan needs to be redefined. As well, being able to give concrete values to abstract concepts such as ‘regeneration impact’ is important for communication purposes.

The presented workflow can be compared with the report of Servaes, 2017, in which it is described the key factors to successfully implement the SDGs. For ‘(1) bring together the right stakeholders at the right time in the right place’, ‘(3) Build in accountability and transparency for action’ and ‘(4) Organize this in a participatory and democratic way’, it is used the LL methodology. For ‘(2) find a way to make difficult trade-offs’, it has been proposed the understanding of the SDGs through the ES framework (ecosystem design) and the use of the regenerativity measurement tool. However, this workflow is a draft of what a future system of work could look like. More research needs to be invested in this direction: enhancing the applicability of the ES framework to address humanistic topics and analyze the whole set of SDGs; improving the regenerative measurement tool with more indicators and descriptions; and developing an interface to facilitate the use of this workflow.

7. Bibliography

Berghöfer, A., & Schneider, A. (2014). *Indicators for Managing Ecosystem Services – Options & Examples*.

Biermann, F., Hickmann, T., Sénit, C.-A., Beisheim, M., Bernstein, S., Chasek, P., Grob, L., Kim, R. E., Kotzé, L. J., Nilsson, M., Ordóñez Llanos, A., Okereke, C., Pradhan, P., Raven, R., Sun, Y., Vijge, M. J., van Vuuren, D., & Wicke, B. (2022). Scientific evidence on the political impact of the Sustainable Development Goals. *Nature Sustainability*, *5*(9), 795–800. https://doi.org/10.1038/s41893-022-00909-5

Capra, F., & Luisi, P. L. (2017). *The systems view of life: A unifying vision*. Cambridge university press.

Cramer, W., Falconı, F., Fritz, S., Green, R., Gutierrez-Espeleta, E., Hamilton, K., Kane, R., Latham, J., Matthews, E., Ricketts, T., & Yue, T. X. (2005). *Analytical Approaches for Assessing Ecosystem Condition and Human Well-being*. 36.

Douglass, J. (2020). *Mesh. Natural Capital Project*. https://naturalcapitalproject.stanford.edu/software/mesh

Ecosystems and Human Well-being: A Framework for Assessment. (2005). 23.

ESII tool. (2016). https://www.esiitool.com/

Haines-Young, R., & Potschin, M. (2012). *Paper prepared following consultation on CICES Version 4, September 2012*.

Ionașcu, E., Mironiuc, M., Anghel, I., & Huian, M. C. (2020). The Involvement of Real Estate Companies in Sustainable Development—An Analysis from the SDGs Reporting Perspective. *Sustainability*, *12*(3), 798. https://doi.org/10.3390/su12030798

Jax, K. (2018). Handling a messy world: Lessons learned when trying to make the ecosystem services concept operational. *Ecosystem Services*, 13.

Johnson, J. A., Jones, S. K., Wood, S. L. R., Chaplin-Kramer, R., Hawthorne, P. L., Mulligan, M., Pennington, D., & DeClerck, F. A. (2019). Mapping Ecosystem Services to Human Well-being: A toolkit to support integrated landscape management for the SDGs. *Ecological Applications*, *29*(8), e01985. https://doi.org/10.1002/eap.1985

Kopnina, H. (2020). Education for the future? Critical evaluation of education for sustainable development goals. *The Journal of Environmental Education*, *51*(4), 280–291. https://doi.org/10.1080/00958964.2019.1710444

Maes, J., Liquete, C., Teller, A., Erhard, M., Paracchini, M. L., Barredo, J. I., Grizzetti, B., Cardoso, A., Somma, F., Petersen, J.-E., Meiner, A., Gelabert, E. R., Zal, N., Kristensen, P., Bastrup-Birk, A., Biala, K., Piroddi, C., Egoh, B., Degeorges, P., … Lavalle, C. (2016). An indicator framework for assessing ecosystem services in support of the EU Biodiversity Strategy to 2020. *Ecosystem Services*, *17*, 14–23. https://doi.org/10.1016/j.ecoser.2015.10.023

Pastorelli, N. (2022). *Analysing Living Labs as enablers of sustainability transitions: Could regenerative development nurture their impact?* 20.

Pedersen Zari, M. (2020). Biomimetic Urban and Architectural Design: Illustrating and Leveraging Relationships between Ecosystem Services. *Biomimetics*, *6*(1), 2. https://doi.org/10.3390/biomimetics6010002

Pedersen Zari, M., & Hecht, K. (2020). Biomimicry for Regenerative Built Environments: Mapping Design Strategies for Producing Ecosystem Services. *12 May 2020*. https://doi.org/doi:10.3390/biomimetics5020018

Pilon, A., Madden, J., Tansey, J., & Metras, J. (2020). Campus as a Living Lab: Creating a Culture of Research and Learning in Sustainable Development. In E. Sengupta, P. Blessinger, & T. S. Yamin (Eds.), *Innovations in Higher Education Teaching and Learning* (pp. 213–227). Emerald Publishing Limited. https://doi.org/10.1108/S2055-364120200000019017

Preston, S. M. (2017). *Completing and using ecosystem service assessment for decision-making: An interdisciplinary toolkit for managers and analysts*. Environment and Climate Change Canada.

Raworth, K. (2017). A Doughnut for the Anthropocene: Humanity's compass in the 21st century. *The Lancet Planetary Health*, *1*(2), e48–e49. https://doi.org/10.1016/S2542-5196(17)30028-1

Reed, B. (2007). Shifting from 'sustainability' to regeneration. *Building Research & Information*, *35*(6), 674–680. https://doi.org/10.1080/09613210701475753

Sachs, J. D. (2012). From millennium development goals to sustainable development goals. *The Lancet*, *379(9832), 2206–2211*.

Schuurman, D., Marez, L. D., & Ballon, P. (2020). *Living Labs: A systematic literature review*. 17.

Servaes, J. (Ed.). (2017). *Sustainable Development Goals in the Asian Context* (Vol. 2). Springer Singapore. https://doi.org/10.1007/978-981-10-2815-1

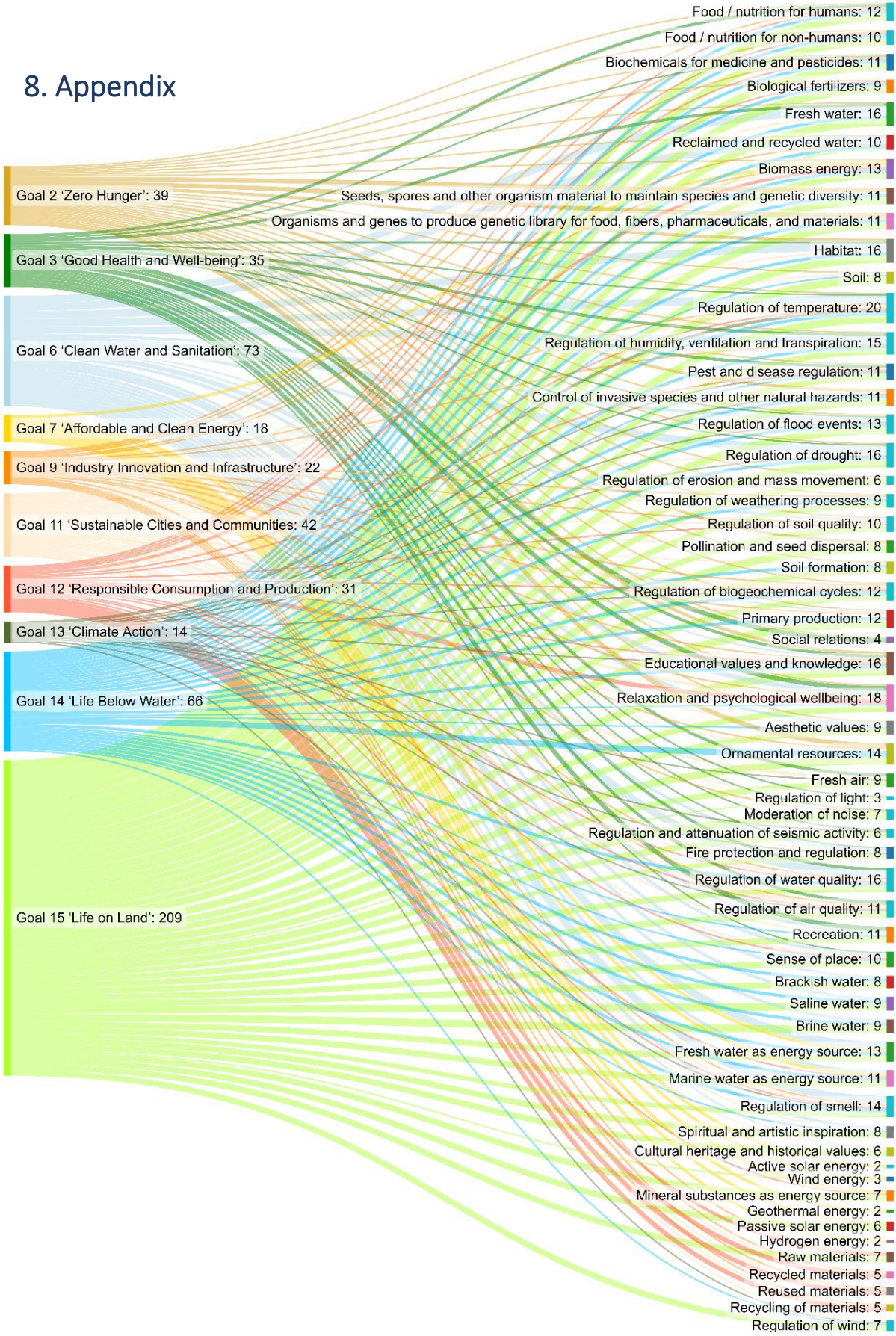
Stuckrath, C., & Rosales, J. (2021). *Understanding and Planning a Living Lab*.

Summers, J. K., Smith, L. M., Case, J. L., & Linthurst, R. A. (2012). A Review of the Elements of Human Well-Being with an Emphasis on the Contribution of Ecosystem Services. *AMBIO*, *41*(4), 327–340. https://doi.org/10.1007/s13280-012-0256-7

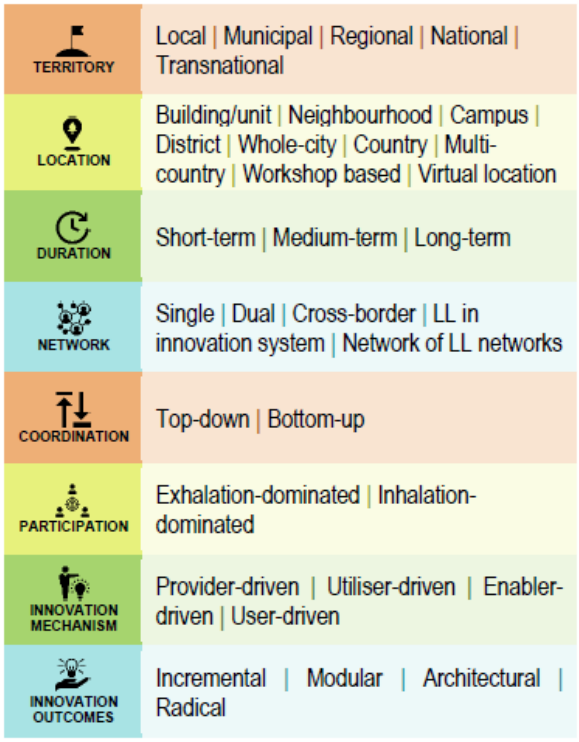
THE 17 GOALS | Sustainable Development. (2015). https://sdgs.un.org/goals

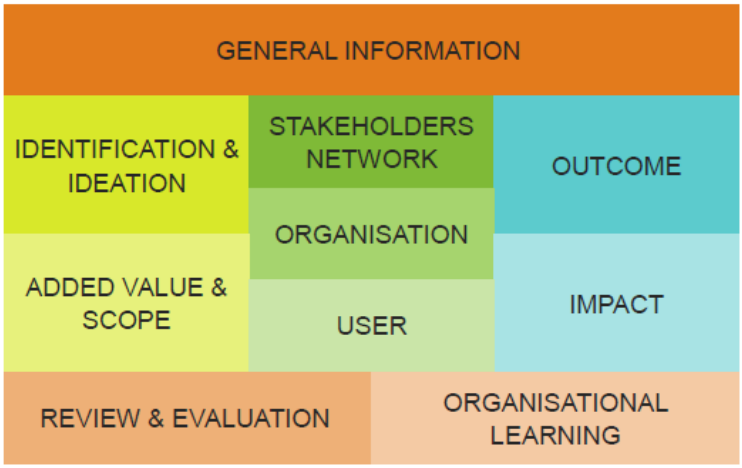
Woodbridge, M. (2015). From MDGs to SDGs: What are the sustainable development goals. *Bonn: ICLEI—Local Governments for Sustainability.*

8. Appendix



Appendix 1. Complete Sankey Diagram. The links between the SDGs and the ES are displayed on this diagram. On the right, the SDGs are presented next to the number of total links found. On the left, each ES is accompanied by the number of times it was linked to a SDG target. Figure made with SankeyMATIC.





Appendix 2. Example of tools for the creation of a LL. On the left, it is represented a table with the different parameters that will act in the ideation of a LL. On the right, the LL canvas shows the aspects to consider at the time of planning a living lab set up. Further description of the elements of these tools can be found in Stuckrath & Rosales, 2021, source of the images.