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REPORT ON ASSESSMENT OF NBS PROCESSES, TRIPARTITE PROTOCOL AND OUTCOMES FROM LIFE LABS (LEARNING CYCLE 3)

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1. Executive Summary

The following report is the third report of three, analyzing how NbS are implemented and assessed through indicators in a variety of European and Latin American Cities, which are partners in the CONEXUS project. Analysis was done based on the results of learning cycle 3 but also reflecting of the overall learning of the project and the learning log methodology. The learning cycle reflections derives from the process of self-reported progress and needs from the implementation of NbS pilots from the Life Labs (LL). Reflections resulted from results obtained in Milestone 14, 18 and deliverable 4.2a. Following the main findings from the learning cycles are summarized according to three topics: NbS implementation, NbS indicator implementation and the learning cycle approach.

Multiple benefits of NbS are a long-term commitment. The planning, implementation and monitoring of NbS should consider that benefits might be realized at different times, so evaluating impacts and effectiveness needs to be thought in a longer term. Institutional support demonstrated through personnel and financial commitment and political will are critical for NbS success. Funding should also be adequately spread across the stages of NbS: planning, design, implementation and monitoring. Capacity building for NbS should be practical, showing all the key stages in NbS rollout, the expertise needed and stakeholders who can better provide them. Student learning is an untapped avenue for NbS advocacy and improving the capacity of youth and early career professionals. Engaging stakeholders with a clear purpose facilitate NbS implementation and improves trust and equity. Is necessary to recognize the participatory processes are resource and time-consuming. Hence, they should be planned strategically in the sense of when they are most necessary or more meaningful. The results from the learning logs and related cycles reinforce the importance of having a continuous involvement of stakeholders to gain institutional commitment and community motivation and awareness.

NbS assessment plans should be comprehensive but also flexible to support long-term monitoring. Indicators implementation for NbS ought to be goal-oriented and context-specific, considering the challenges being addressed and institutional rubrics. The selection of indicators showed to be influence by those implementing the indicators, a revision of those decision should be advanced collaboratively. Comprehensive monitoring of the indicators is preferred but may not always be feasible. In that case, aspects can be prioritized based on local needs and resources. However, early linkages between indicators and challenges allows not losing the validation from multiple stakeholders. Finally, the timing of the implementation of the indicators should consider the timelines of the pilot implementation. This concludes in **long term monitoring should be institutionalized**, where meaningful indicators are included within the regular work of departments.

Learning cycles enable continuous stocktaking, reflection on progress made, cataloging of good practices, and improvement in the face of changing conditions. They are unique avenues for delving deeply into barriers and finding solutions in a collaborative way. They offer opportunities for identifying potential conflicts that may not be mentioned during co-learning forums and Life Lab Exchange meetings since they focus more on implementation rather than outcomes. Learning logs promote transparency by sharing and documenting decisions and why they were taken, they are a useful tool for systematically documenting processes and not just outcomes. Having multiple stakeholders update the learning logs can produce more comprehensive learnings and overcome limitations with human resources.

1. Introduction

Regular systematic assessment of the implementation and monitoring in the Life-Labs allows for a learning process to identify the successes, barriers, and difficulties the Life Lab partners experienced during the process. Insights on the use of participatory approaches to implementation and monitoring can also be obtained from a systematic assessment of data related to processes behind NbS, beyond outcomes. Furthermore, the repeated assessment of data from Life-Lab's NbS processes allows to build a baseline data of institutional barriers, stakeholders, logistics, NbS indicators and needs for expertise that can support long-term monitoring of the NbS pilots. To support the learning process, within WP4, we established learning cycles of six months, where for each cycle we collected a learning log from each Life Lab, evaluate the learnings and changes and develop workshops relative to indicators of NbS. Based on these self-reported progress reports from the Life Labs, Task 4.2 findings were derived.

The following report is the third and final report of the series regarding the analysis of NbS implementation and their assessment through indicators in the three European and four Latin American Life Labs, partner cities in the CONEXUS project (M18, D4.2a, M30 and the present D4.2b). This report is based on the results of Learning Cycle 3, but also contains an analysis of the overall learning cycles (1,2 and 3) including NbS pilot implementation, NbS indicators and use participatory approaches to implementation and monitoring of NbS. The report then includes a fist section summarizing the methods of learning cycles and logs; then goes into reporting the results from learning cycle 3 including pilot implementation, indicators and workshops; to then developed a section of analysis of learnings from the three implemented learning cycles based on the topics recognized in D4.1 and in van de Jagt et al (2023) by reflecting on the meeting of governance dimensions of NbS in the Conexus project. We finalized the report with some recommendations that emerged from the 7 Life Labs participating in Conexus relative to the information obtained from the three learning cycles. This analysis allowed us to recognize ways to further support NbS implementation and reflect on the adequacy of indicators for monitoring NbS impacts.

2. Summary of Learning Cycles and Learning Log Methods

We established Learning Cycles as a way for systematically registering processes and data of institutional barriers, logistics, stakeholders, NbS indicators and need for expertise from Life Labs, that enables them to evaluate NbS in the longer-term and allows to recognize barriers and aspects to consider during NbS implementation further to what has been disclosed in the literature. Therefore, within WP4, we established a learning cycle with learning cycle workshops and learning logs. The purpose of the learning logs is to facilitate regular follow up on the progress of the indicator and pilot implementation and to guide the learning cycles.

The learning logs allowed us to distinguish good practices and difficulties in the process behind pilot and indicator implementation, and to follow up the progress of the participatory approach for NbS implementation and monitoring. The learning logs help to identify changes that need to be made in the indicator implementation process: e.g., the type of indicator, the method used, or the participatory process involved adapting the process accordingly in a collaborative manner. The learning log content was reviewed and validated by all Life Labs, and it contains the following sections:

- Progress on pilot implementation
- Progress on indicator implementation
- Progress on participatory indicator assessment
- Adequacy of the selected indicators

The learning log should be completed for each pilot and be based on the information available at that time. The data from the learning logs is stored in the CONEXUS Google Drive and contains no references to who answered the learning log. The Life Lab coordinators are the contact persons for requesting the completion of the learning log. The learning logs were provided in the language of the Life Lab and the results were translated after the log was completed. Both original and translated data were stored in the same drive.

3. Results from Learning Log 3

The following section reports on the progress on pilot implementation (Section 2.1), the indicators of implementation (Section 2.2) and the participatory approach to pilot and indicator implementation (Section 2.1 and 2.2). Life Lab coordinators were asked to complete the learning log within a month with the deadline on the 30th of August 2023.

3.1. Learning Log 3: Progress on pilot implementation

The Barcelona Life Lab advanced in all their pilots. The N*aturalizing Places and* M*onitoring Naturalization* pilot was able to compare changes in greening between the years 2019 and 2022, which allowed them to draw conclusions on their implemented policies. They also shared their knowledge on indicator implementation and prepared a presentation on their experience on measuring accessibility to green spaces. The Barcelona partners also collaborated with the Universidade de São Paulo for monitoring pollutants through the analysis of tree cores from *Tipuana tipu* (Rosewood)*,* as part of a larger research project for Mediterranean cities. The latter finance with sources outside Conexus (FAPESP-Brazil). The U*rban Allotments* pilot made good progress through teamwork and new collaborations. The Museum (Museo de Ciencias Naturales de Barcelona) has been engaged in monitoring the impact of urban allotments on insects and pollinators. Collaboration within CONEXUS with the University of Sheffield on biodiversity sampling will further support accounting for biodiversity impacts of urban allotments, while collaboration with the Universidad de Buenos Aires and Universidad de Burgos from Work Package (WP) 5 will allow conducting a cost-benefit analysis on the urban allotment NbS pilots. The third pilot on monitoring pollutants advanced on the sampling of soils but is still waiting for results. The latter is the only one advancing less than expected, because focus has been on the naturalizing places.

In both pilots in the Bogota Life Lab, progress was reported on the development of live classrooms for environmental education in nearby schools. Informed by a previous environmental diagnosis by the Humboldt Institute, in both pilots, potential restoration activities were explored. For the *Borde Sur* pilot, the school, El Uval, was engaged in supporting restoration activities and monitoring of native species. Collaboration with an expert was established to assess the water quality in the wetland, who already made two visits to the site. Finally, the project will produce some signage for the community financed by Pontificia Universidad Javeriana. In the *Borde Norte* pilot, collaborations with students from PUJ allowed for comparisons of the use of native and exotic grasses for ecological restoration of the wetland. In the upcoming months, another student will evaluate diversity of insects on pollinator gardens in schools.

The Buenos Aires Life Lab progressed in all their pilots. The Medrano pilot is almost finished and is progressing according to schedule. The pilot, *Breathe,* is considered as a good practice example to be replicated by other schools not collaborating in Conexus. The first finished school and its outcomes have very positive impact as a demonstration project leading to two other schools showing interest in replicating the same type of NbS, which are currently in the design stage by the Buenos Aires Life Lab team. At the Medona School, they have included accessibility for disabled in their design in collaboration with students at the University of Buenos Aires. For the monitoring of the pilot, a variable has been added through the installation of passive tubes to measure NO2. This pilot keeps serving as a student learning project independent of its stage of advancement. The pilot, *Breathe,* is currently exploring ways to scale up the project by looking for new funding schemes, disseminating outcomes and outputs, and delivering the participation of students as part of their university course with the existing schools. Finally, the *Humedal Lugano* pilot is in its last stage of the construction process. There were some unexpected expenses, as politicians requested the installation of a water bomb to irrigate the wetland during the dry season. This could affect the natural ecological functioning of the wetland, and therefore the diversity of fauna that uses the wetland as their habitat, hindering one of the NbS purposes.

The Lisbon Life Lab made progress on both pilots, although both are delayed. Delays have been a combination of institutional bureaucracy and complexity, relative to too many stakeholders to involve, as mentioned in the Learning Log. Therefore, the Ruas Verdes is still in the early stages of implementation. For the Ruas Verdes pilot, the activities focused on engaging residents in the project by providing them flower boxes and gardening techniques and starting the sub-contract for the planting and alignment of trees. For the *Renatura* pilot, the non-profit (NGO), URBEM is still leading all community participation concerning the maintenance of the small forest, such as weed removal and mulch application. Its scheme of community participation facilitated by URBEM is particularly impactful, as it is aimed to be replicated in other small forests from the NGO Quercus and the Portuguese Environmental Agency.

In the Santiago Life Lab, both pilots advanced, however, not according to expectations. The document for the *Plan Santiago+ Infrastructura Verde* has been finalized and presented to city, regional and national authorities, and academic and civil society stakeholders. This required meeting with several authorities in advance and organizing the launch event. Also, the experiences in the process of the plan formulation served as input for three undergraduate projects and two professional internships for students. The pilot *Quiero Mi Barrio experienced* some delay due to bureaucracy regarding funding availability, but the educational activities and the implementation of the urban allotments occurred as planned. The project has also been testing the use of recycled water from a washing machine of one of the residences for irrigating the new community greening. The Quiero Mi Barrio pilot has provided research experience and

data for three undergraduate student projects, one master student thesis, and one professional internship from Geography and Engineering in Natural Resources.

The Sao Paulo Life Lab has been progressing according to the plan in its three pilots. In park *Conciencia Negra,* the pilot showed slower progress, but municipal endorsement of the establishment of green corridors will allow for stronger support to monitoring the NbS indicators. The pilot *Ibirapuera* is going according to plan, with continuous monitoring of the selected indicators. This pilot drew attention within the University of Sao Paulo, leading to the potential implementation of the same monitoring process for the forest patch owned by the university. *Parque Estadual Fontes do Ipiranga* is going according to plan. Indicators of growth, non-structural carbohydrate, and phenology are being monitored constantly. Also, the Edy covariance tower has been working properly, continuously collecting data on carbon dioxide, water, and energy fluxes.

The Turin Life Lab almost finished the construction stage, and the monitoring stage will follow. The monitoring has been outsourced to a private firm. The community and student engagements concluded with a public event that showed comparisons and results from the engagement process. The engagement process with students started for the third year. The pilot proved to be successful in its implementation, and will the pilot be replicated in two other lots of the public municipal land.

3.2 Progress on indicator implementation

Most Life Labs continue the assessments on some of their selected indicators. Some Life Labs have outsourced the measurements, while others, who are now in the process of implementation, became aware of some difficulties with the indicators. Similarly, to the last report (M30), most indicators being measured are not using methods for indicator assessment described in the European Union (EU) Handbook by Dumitru and Wendling (2021). The details of the indicator can be found in Appendix.

The Barcelona Life Lab is measuring five indicators with methods different from the EU Handbook (Dumitru and Wendling, 2021). Only one indicator is measured using a participatory monitoring. The main difficulty encountered on indicator implementation was on the time needed to measure them. The Life Lab did not identify any needs for training in this Learning Log 3 (Appendix). The Life Lab suggested that the accessibility indicator could be complemented doing the assessment by category of income group, so its accessibility by income group. The indicator of agriculture production was identified as complex to implemented given that is time intensive to measure and was considered to function better as a long-term effort. Active users on urban allotments were estimated rather than measured because it happens at different

moments of the days, while indicator on heavy metal concentration was identified as costly, therefore the sample size had to be reduced.

The Bogotá Life Lab started measuring several of their selected indicators in particular those related to cultural ecosystem services. No methods from the EU Handbook of NbS indicators are being used (Appendix). Bogota is using the questionnaire prepared for Santiago Life Lab for five of their indicators, recognizing that the questions needed to be revised according to the local context. The indicator of native species was the only using a participatory approach to measure with children from schools using INaturalist. Some of the indicator's measurements were delayed because pilots are still in construction. The indicators for carbon storage and sequestration, water quality, and pollutants in suspension were omitted. Presently, the activities defined for the pilots make these indicators irrelevant, since they are unlikely to show any significant change within the given timespan.

The Buenos Aires Life Lab continued their data collection focusing on three indicators for all the pilots. However, they indicated difficulties with their implementation, including the timing in relation to the progress of the construction, inadequate methods on the openness to participatory process method. The questionnaire on openness to participatory processes needed to be adjusted to the local context and because of the number of stakeholders, the indicator got more complex and required more time for implementation. Most measurements planned for the six-month period of this reporting period, will resume later in October. As with other Life Labs, the methods from the EU handbook are not being used. The need for more personnel time to implement the indicators is once again mentioned as a difficulty (Appendix).

The Lisbon Life Lab focused its progress on the *Renatura* pilot, as there were personnel changes for the *Ruas Verdes* pilot. The remaining five indicators are currently being measured and are not using methods suggested by Dumitru and Wendling (2021). Only one indicator is measured using a participatory approach, which has been outsourced to an NGO (URBEM). Only two of the indicators are measured by the local government in charge of the pilot. The other indicators are outsourced, making it more challenging to do a follow up. The indicator related to number of green spaces and NBS was found to be inadequate for the scale needed which is micro-scale. Reported difficulties include delays in the pilot implementation and communication among partners (Appendix).

In the case of the Santiago Life Lab, indicators were applied in two of the pilots and most indicator assessment processes have started. For none of the selected indicators, assessment methods indicated in Dumitru and Wendling (2021) are being used. Difficulties were encountered in the assessment of indicator. These were related to lack of time, funding, and how lengthy the instrument, which requires more time to be completed. The use of data,

collected prior to the CONEXUS project, supports the assessment of some indicators, especially the ones accounting for impact at larger scales (e.g., accessibility to green spaces) (Appendix). They mentioned how the training also allowed them to understand how to better implement the indicator on public-private partnerships.

For both pilots, the Life-Lab of Sao Paulo started measuring most of the indicators on regulating ecosystem services. The assessments of the indicators related to cultural ecosystem services are lacking, mainly because the personnel were not familiar with the assessment methods (Table 6). Other indicators are even more difficult to measure, such as biodiversity enhancement, because they demand a lot of time. Like other Life Labs, no indicators after Dumitru and Wendling (2021) were used. Participatory processes were not used also because the lack of knowledge in how to set up a monitoring process with the community.

Turin has started the assessment of most of their selected indicators, but with methods different from the ones suggested in Dumitru and Wendling (2021) (Appendix). All soil indicators were eliminated given that the soil used in planting was a combination of mulch and volcanic, therefore cannot be measured immediately. Several of the indicators are being measured by a subcontractor of the municipality. The indicator of permeability had the method changed based on leaf area as decided by the subcontractor, while the heat mitigation index also had an adjustment in method that excluded data on soil temperature. Similarly, the green usability index had adjustment to the method to use a participatory approach to monitoring.

3.3 Workshops for supporting indicator implementation

We deliver two sessions of training according to the needs for training derived from Learning Log 2 and the Buenos Aires General Assembly. Both sessions occurred during the Life Lab Exchanges (WP3) and were led by T4.2 and organized by Universidad de Chile. The first training session was on how to measure the indicator on accessibility to green spaces. Barcelona and Santiago showed how they were calculating the indicator, which was differently to what the EU Handbook of indicators proposes. The second training session was on how to calculate carbon sequestration and storage, T4.2 included different methods that have been use for measuring this indicator such as remote sensing and allometric equations, while Sao Paulo Life Lab showed how they are measuring those indicators in their pilots.

4. Learning cycles as sources for self-reflection and shared learning

The following section derived from reflecting on the learning cycles and its components, i.e. logs and training, as a tool that can inform better future implementation and monitoring of NbS, derived from lessons reported in M18, M30, and D4.2a. The learning cycles are a useful avenue for cataloging good practices and difficulties in NbS implementation. They also help in recognizing the changes that are needed after an evaluation has been carried out. In an adaptive management process, they enable reflection on challenges, planning, implementation, monitoring, evaluation, knowledge-sharing, and adaptation. In addition, they provide the opportunity to assess the participatory processes in NbS implementation and monitoring by monitoring actors that are involved in each one of the pilots, involvement of the community in assessing NbS indicators and on how the community is engaged in pilot implementation. Learning cycles admits responses to changing conditions given by its multiple cycles and is also a recognition that NbS planning is mediated by place-based administration, resources, personnel, infrastructure conditions. The process of the learning cycles was especially useful to identify barriers to NbS implementation and how the lessons they helped catalog were useful in overcoming the same by the pilot implementation leads. Information derived from this will be further discussed in section 4.

4.1 Learning cycles as a pathway to improving NbS implementation and monitoring

The collected changes, challenges and observations helped to inform future NbS implementation and to anticipate potential issues that should be incorporated into the planning and design stage of NbS. Following, the report summarizes the contribution of the learning cycles according to four different topics: the Life-Labs socio-environmental challenges, the process of NbS implementation, the process of indicator implementation, and the approach to community participation in NbS.

The learning cycles created the avenue to revisit the challenges defined by multiple stakeholders in relation to the pilot that was proposed. For some cases, such as the Santiago Life Lab, challenges were defined by a larger group of stakeholders beyond the pilot, while in other cases, they were defined by a small group of stakeholders as was the case in the Bogota Life-Lab. The review of the challenges every six months through the learning logs allowed the incorporation of views of other stakeholders that might not have been involved in the process from the beginning.

The learning cycles helped to show that NbS planning requires the involvement of all relevant stakeholders from the early stages. Co-learning should not only include knowledge on how nature works and on mitigating socio-environmental challenges through ecosystem services

delivery, but also the technical aspects of pilot implementation should be considered. In particular, the ecological and social context, the institutional bureaucracy and important collaborations can be accounted for in planning and implementation of NbS from the beginning of the process. Sao Paulo and Buenos Aires experienced some delays from acquiring permits for intervention. Turin also experienced some delays, because of a lengthy set up of the participatory processes. For Buenos Aires, the delays were due to the team having to wait for the right season before the proposed concrete removal could be done. Such delays could have been avoided by having that know-how already in the planning stage.

The learning cycle also enables revisiting the indicators that were selected or exempted through the participatory processes, or when they became obsolete due to changes in the NbS implementation. In the case of the Bogota Life lab, once the community was more integrated into the project, they realized that some indicators selected at the beginning were no longer relevant for the community. Other Life Labs dismissed some of the indicators once they realized that the methods were too complex or too expensive to be implemented.

The learning cycle also serves for understanding how the participation of the community is embedded in the co-creation of NbS and on the monitoring of NbS, while also detecting if new actors were added to the pilot through the period of implementation of the cycles. Santiago Life Lab added new stakeholders to the Life Lab that allowed them to implement an NbS pilot that was not planned at the beginning of CONEXUS, while Buenos Aires recognized the need of new stakeholders, in their case a hydrologist, to better implement the pilot. We were also able to recognize the importance of community participation in NbS implementation, such as the case of Turin and Lisbon, however these participatory processes required additional funding, personnel, and available time to properly doing them. The learning cycles showed that participatory processes for indicator implementation can be overwhelming for the leading institutions given that they required strong efforts for organization and because of the complexity of the methods involved in measuring the indicators, which was the case for most Life Labs.

The process of learning cycle provides additional evidence to support the importance of the local context for implementing NbS. Moreover, they can shed light on potential pathways to replicate NbS, especially in relation to financial, personnel, and logistics constraints that need to be considered when planning NbS.

Learning cycles also helped to identify potential conflicts or constraints that were not mentioned during co-learning forums and Life Lab Exchange meetings. Because the learning cycles were more focused on the process of implementation, rather than outcomes at this time, they gave further details on aspects related to progress. Causes behind progress or no progress

were disclosed through the content of the learning logs. Results of the learning cycles were reported in milestones and deliverables and presented to the CONEXUS partners. However, learning could have been more emphasized through longer workshops. Learning logs should have been filled by different actors involved in the implementation of NbS pilots for collecting different perspectives on progress.

The learning cycles also allowed us to observe the lifespan of this funding, whether it was long enough to adequately reflect on the impacts of interventions from a social, economic and ecological timescale. Ultimately, the length of the project did not permit unpacking the changes from these NbS interventions in detail.

Like an adaptive management framework, NbS showed similar perceived scientific, practical and philosophical barriers to implementation as the ones described by Gilson et al., (2018). Learning cycles were appreciated as a pathway to continuous self-reflection on the NbS implementation process, especially to record changes to local situations that have an impact on NbS implementation or monitoring.

4.2 Learning logs as a method for systematic monitoring

The learning logs promoted transparency, by collecting reasons, changes in decision-making, or delays in implementation. Learning logs for addressing the process of NbS implementation can provide a pathway towards transformative learning by allowing reflection on the experimentation and governance behind NbS (Neij and Heiskaken, 2021). Learning logs also allowed us to have better insights on how experimentation behind NbS can lead to changes in formal planning through clashes with formal planning (Peris and Bosch, 2020).With the learning logs, we were able to distinguish that Buenos Aires had to accommodate the dynamics of the wetland to the political desire of having a water body all year long, or we were able to recognize the effects of political changes into the mainstreaming of NbS, disclosing the fragility behind transformative planning in the case of Lisbon. Therefore, the information derived from the learning logs present as an opportunity for providing guidance and advice for replication within the same Life Lab or for other cities, a matter much needed in NbS research (Sowińska-Świerkosz and García, 2021).

The learning logs became a useful tool for systematically documenting processes more than outcomes of NbS pilots that produce insights beyond what has been reported in the literature as descriptions of case studies. It allows the collection of information on changes that needed to be made at the Life Lab once planning and implementation of pilots had started. The learning logs are also flexible by allowing the incorporation of new aspects that might emerge as important in the Life Lab process. The learning logs are capable of recording reasons behind

some decision that might not emerge in Life Lab exchanges, where only reporting on activities was done.

Learning logs resemble a laboratory log or a computer program log to record decisions that were made, activities that were done and things that did not work. In this sense, learning logs allowed understanding what worked, what didn't work to draw lessons for future implementation. The learning log was a simple entry of data that was repeated every six months and that collects the same information, not lasting more than 30 minutes to be filled. The frequency of implementation for the learning log was adequate, allowing a balance between not losing information relevant to progress and allowing Life Labs to make progress on implementation before having to report on it. Another advantage of a learning log is that once it was filled for the first time, the following cycles have a quick turnover and the process of filling it was embedded in the actions that the Life Labs needed to do every six months.

The learning log information allowed WP4 to obtain information on NbS pilots and indicators, and it permitted Life Labs to do a self-reflection on progress. Consequently, a final evaluation of the learning logs usefulness should be explored with the Life Labs.

One of the downsides of the learning log is that we only collected insights on progress of NbS pilots from one perspective, given that they were filled by the Life Lab coordinators. Improvements to this process could be made through periodic collection of learning logs from different stakeholders so different perspectives on the pilot progress are recorded. Having multiple perspectives could help to incorporate others' opinions of progress implementation. For example, in the case of the Lisbon Life Lab, there was a change in the Life Lab leadership between the learning cycles. The newly arisen perspectives on the pilot implementation could render it necessary to determine more comprehensive accounts on pilot implementations. A limitation of the learning log is that even if it can help identifying reasons behind barriers to progress or things that help progress, it does not give deeper insights into them. Therefore, it might be good to complement the learning log information with some follow up interviews to clarify or further explore some of the information obtained. This follow up interviews should be embedded in the learning cycles after the learning log analysis.

4.3 Training in learning cycles

The implementation of learning logs allowed us to recognize the need for knowledge behind indicator implementation. This was confirmed by the attendance to the training sessions prepared at the end of the learning cycles. This can also be seen as a confirmatory interest in monitoring the impact of NbS using indicators. However, it also highlights the interdisciplinary nature of NbS, as there is coalescence of different disciplines for NbS implementation and

monitoring to produce more evidence on the impact of NbS. For example, in the Sao Paulo Life Lab, forestry related indicators were measured with no major difficulties; however, biodiversity and social indicators have not been measured given the lack of the expertise of the team and the lack of sufficient funding and time to incorporate this expertise into the Life Lab. We also learnt from training aspects that one session of training is not sufficient for building capacity within the Life Lab and that those should have been complemented by one-on-one sessions with experts that supported indicator measurement according to available data and local expertise.

Highlights

- Learning cycles enable continuous stocktaking, reflection on progress made, cataloging of good practices, and improvement in the face of changing conditions.
- They are unique avenues for delving deeply into barriers and finding solutions in a collaborative way.
- They offer opportunities for identifying potential conflicts that may not be mentioned during co-learning forums and Life Lab Exchange meetings since they focus more on implementation rather than outcomes.
- Learning logs promote transparency by sharing and documenting decisions and why they were taken.
- The learning logs are a useful tool for systematically documenting processes and not just outcomes.
- Having multiple stakeholders update the learning logs can produce more comprehensive learnings and overcome limitations with human resources.

5. Reflections on NbS implementation

This section compiles the reflections derived from the implementation of the three learning cycles of the CONEXUS project. All pilots from the CONEXUS Life Labs were designed to be place-specific, addressing the local challenges that were identified through an open participatory process with multiple stakeholders. Results from this process were derived from WP3. Place-based, as conceived in the Life Labs, should not only respond to local challenges, but also respond to the local conditions to implement an NbS, including administrative, logistic, and technical conditions.

There is large consensus that NbS ought to be evidence-based, that they can deliver multiple benefits and can help addressing multiple socio-environmental challenges (Seddon et al. 2020), however this consensus is restricted to the characteristics of the NbS and not the process behind its implementation. Evidence should also be provided on the process of implementation of an NbS and on setting out a monitoring system to obtain data on their impacts. Also, having this information early on could enhance the implementation of NbS and its benefits.

All Life Labs were able to integrate the multiple dimensions of NbS into practice through a combination of ecosystem services, blue-green infrastructure, ecosystem-based management approaches, and combining ecological and social benefits from NbS (Raymond et al., 2017). However, the tradeoffs among multiple ecosystem services derived from NbS were not reflected on, and the time scale in which different benefits would reach their potential was not accounted for either (Raymond et al., 2017). Future projects should establish the time it takes for the benefits of NbS to accrue, to help align impacts with expectations. This is particularly important, when contrasting NbS with purely technical solutions, which hitherto have been more preferred.

All NbS in the project incorporated a transdisciplinary and inclusive approach where experts from a variety of disciplines and non-academic participants discussed the range of issues, spanning the definition of NbS (Learning log 1) to the monitoring of NbS (Learning log 1 to 3). This was not unique to T4.2 but throughout all work packages.

An equity perspective was included for all the Life Labs and there was a recognition of the value and the interests' different stakeholders associate to the Life Labs. Efforts were made to include stakeholders in the decision-making of all steps of the implementation process, and to reconcile technical and resource capacities with stakeholders' perspectives. The results from the learning logs and related cycles reinforced the importance of having a continuous involvement of stakeholders to gain institutional commitment and community motivation and awareness. As such the continuous participation of institutional authorities in the Buenos Aires Life Lab

allowed new funding from the regional government to be allocated for NbS implementation, while for other Life Labs, such as Santiago, the participation of wider stakeholders (further from just the pilots), derived in other actors to get further interest in NbS. The learning logs also showed that participatory processes should be planned strategically in the sense of understanding where participation becomes more relevant, i.e. planning, implementation, and monitoring, similarly to findings of Albert et al. (2020). As such, all Life Labs were successful at incorporation of participation for identifying the socio-environmental challenges important to be addressed through NbS. In the co-design, Bogota, Santiago and Turin were very successful at following a participatory process, using different strategies. Bogota started their co-design process by firstly establishing the relationship with the community, Santiago engaged with a community that already had an existing participatory process with a national public institution, while Turin focused their participatory approach in a particular social group i.e. university students. Monitoring was the stage that Barcelona chose for implementing participatory processes in the urban allotment pilot where older citizen was engaged for measuring indicators of impact.

In the following, we discuss our findings from the learning cycles within the nine dimensions of governance identified by van der Jagt et al. (2023), as a way of testing its validity within the Latin American and European contexts.

5.1 Agency

The successful implementation of NbS largely depends on the leadership and long-term commitment of governmental institutions enabling their survival beyond political cycles (Mell, 2020). This commitment can be through developing or changing laws and regulations to promote NbS, providing resources to implement NbS, funding internal professional development, or adapting the structure and roles of those involved in planning (Wamsler, 2015; van der Jagt et al., 2023).

The opportunities that the European Commission gives to NbS through their H2020 funding scheme had great impacts worldwide. However, those grants cannot be the only source of funding for NbS projects. These need to be complemented with local funding that can be complementary to promote the long-term sustainability of NbS interventions. Long term funding is one of the critical necessities for enabling transformation through NbS, given that many of the co-benefits are realized in the long term (Sarabi et al., 2019).

The Life Labs of Santiago and Buenos Aires mentioned in their learning cycles how the lack of funding was a barrier to implementation and replicating the pilot activities in other locations. Turin got funding to subcontract the implementation of some of the pilot activities. Similarly,

Lisbon also outsourced the implementation of the participatory processes. Investing in NbS from local institutions is a demonstration on how committed they are to NbS. The evidence that WP5 is constructing and analyzing will also support investment towards NbS. From learning cycles, it can be concluded that for some of the Life Labs after getting political endorsement for the project, they received extra funding their local public institution (municipal or regional) that sped up the implementation process.

Funding was not mentioned as a barrier from the European Life Labs; however, the Lisbon Life Lab mentioned that the maintenance cost was not included in the original budget and that is something that creates uncertainty for the long-term success of the NbS. Incorporating maintenance costs into NbS implementation can be an indicator on institutional commitments that are independent of the political or policy landscape and are the reflection of a desired and agreed vision for the future of the city.

Through the three learning cycles, all the Life Labs mentioned the lack of time to dedicate to the CONEXUS project, which could be interpreted as indication of a weak institutional commitment to NbS. Even a municipality with a strong green commitment, such as Barcelona, struggled with the time, they could dedicate to the project. Institutional commitment should, therefore, include making time commitments to NbS project implementation and monitoring. Funding agencies for NbS should accept budget allocation for full time personnel to the project in each one of the Life Labs, when personnel or partners are from public institutions like local government and academia to facilitate the progress of the NbS implementation.

The role of NGOs and the community is highly relevant for disseminating the importance of NbS and the overall success of NbS implementation (van der Jagt et al., 2023). In the case of Lisbon, the participatory approach being used by the NGO URBEM for the planting and maintenance of the tiny forest pilot has caught the attention of another NGO and a federal institution. Processes behind NbS implementation are also a pathway towards NbS advocacy. In that sense, reinforcing capacity building within institutions, communities and NGOs serves not only increasing knowledge of NbS, but also advocating the mainstreaming of participatory NbS implementation in other cities, neighborhoods, or other scales of implementation.

Another opportunity for gaining NbS advocacy is through student learning. Several Life Labs have served as hubs of student learning, which also creates advocacy in early career professionals. Buenos Aires had Landscape Architecture and Environmental Psychology students from the Universidad de Buenos Aires involved in designing NbS and integrating inclusivity approaches into design. Santiago has students from Natural Resources, Environment, and Geography supporting research on pilots beyond the pilot objectives, while the pilot itself provided opportunities for professional internships to students. Sao Paulo incorporated data

samples from Barcelona's trees to be part of a larger research project on Mediterranean cities and pollutants to be processed by students from Universidade do Sao Paulo. Bogota also has students from Pontificia Universidad Javeriana researching the pilot actions, that would feed into understanding the ecological impacts of NbS.

5.2 Integrated working

High level actors can promote multidisciplinary work by sharing and renegotiating roles and responsibilities that would facilitate the implementation of NbS (van der Jagt et al., 2023). Most Life Labs did not report on boundary spanning actors, however, there is a recognition of the need to assign personnel that cross boundaries across departments to reduce the uncertainty behind the bureaucracy of NbS implementation on public lands. In the case of Buenos Aires, early collaboration with the engineering department would have improved the planning of the concrete removal from the pilot, as it was seasonally dependent. This example reinforces the need of transdisciplinary work for NbS implementation, where knowledge of each of the steps might require an understanding of all the aspects, including ecological, engineering and social. For most Life Labs, the design stage of the NbS lasted about one year; therefore, having collaborations among departments within institutions might help speed up the process. For all Life Labs, actions, activities, implementation, and coordination took more time than estimated, when preparing these projects for most Life Labs. Barcelona and Santiago had previous progress in their pilots before Conexus but they still lack the time to speed up progressing on implementation. Lisbon and Turin had contracted a third party to support progress, however they still have delays on implementation. The Conexus partners did not have exclusive dedication to this project, and they were not released from previous institutional duties. Investment in project coordinators exclusively dedicated to the project would probably facilitate NbS implementation and intersectoral liaison.

Another aspect relevant to integrated work was the need to define roles and responsibilities from early in the project planning. This was mentioned several times, especially in the Buenos Aires, Bogota and Santiago Life Labs. This can also be linked to the weak institutional commitment from the planning stage of the NbS.

Other aspects related to integrated working, such as shared meetings, joint field trips, and intersectoral collaborations, occurred in the monthly Life Lab exchanges, the annual CONEXUS forums, and the pilot meetings between Life Lab partners and the institutions involved.

5.3 Legislation, regulation and policies

The discussion on the role of legislation, regulation, and policies on NbS commonly links to how NbS can be mainstreamed into land use and planning policies, ordinances and laws. Less is

discussed on how these can prevent NbS implementation. Revisiting regulations related to implementation can facilitate the uptake of NbS, including innovations towards climate adaptation, participatory processes, and collaborative governance (Zingraff-Hamed et al., 2020). The Life Labs reported that institutional bureaucracies delayed implementation. The reorientation of the state towards co-goverance, might support the mainstreaming of NbS into policies, laws, and regulations.

5.4 Collaborative arrangements

Multisectorial and multidisciplinary collaborations are determinants of the successful implementation, uptake, and long-term impacts of NbS (Wickenberg et al., 2021). All Life Labs established projects that required multiple sectors, and the involvement of local communities, NGOs, and academics. Because of how technical NbS is, potential collaborations should be established from the beginning of the project so that the necessary knowledge is considered early in the stages of the project (Wickenberg et al., 2021). This could reduce the risk of delays because of uncertainties related to implementation.

In the case of CONEXUS, collaborations were mainly with academic and research institutions for both Latin American and European Life Labs. The Barcelona Life Lab had established a collaboration with the Museum (Museo de Ciencias Naturales de Barcelona), while the Buenos Aires Life Lab collaborated with an ecologist from Universidad de Buenos Aires to monitor biodiversity impacts to NbS implementation. Barcelona and Sao Paulo had the support from biodiversity experts from the University of Sheffield to assess biodiversity in their pilot locations. These collaborations not only helped to monitor the NbS, but also helped the researchers to obtain data, that could help to understand the impact of NbS on urban biodiversity. Barcelona is also receiving support for the cost-benefit analysis for their pilots from WP5. Bogota and Buenos Aires are supported by academics for monitoring or informing design with expertise that is non-existent in the Life Lab team.

Collaborations should be established carefully. An excessive number of collaborators in a pilot might complicate the organization of the project, increasing the coordination time. Lisbon and Sao Paulo mentioned that one of their respective pilots had perhaps too many stakeholders involved in the project that made it difficult to make significant progress. Also choosing partners that are open to innovation, which is the base of NbS, is decisive for a successful collaboration. Buenos Aires mentioned that some alliances opposing innovation delayed the process of NbS implementation.

All Life Labs established alliances with the communities involved with their pilots, which enabled incorporating local socio-ecological knowledge into NbS design and implementation, in addition to the information derived from experts.

Collaborations with public institutions should be carefully planned and strategically advanced also since changes in political leadership can affect such collaborations.

5.5 Active community engagement

Community engagement has taken different approaches for the CONEXUS Life Labs. Barcelona had most of their actions institutionally defined, where the engagement of the community is focused on urban allotments planting and monitoring. Lisbon has both projects largely driven by the community, where their involvement occurs from the early stages of the project and throughout the project and likewise for Bogota and Turin and one pilot from Santiago. Sao Paulo and Buenos Aires engaged mainly stakeholders related to decision-making and land ownership.

All the Life Labs implemented an approach of continuous engagement, which allowed them to advance implementation with the respective communities. Communities were engaged not solely for participation, but also for public dissemination, for recording progress, and continuous listening that allowed reflecting on the NbS pilots and indicators. However, the contribution of the stakeholders towards the advancement of the pilot implementation was seen as moderate.

Establishing relationships with a community takes time. Previous relationships with communities help to progress faster in NbS implementation, which is why the Life Labs were established in communities where project participating stakeholders already had relationships. If new to the community, timing for establishing a relationship should be considered in the planning process, usually about a year. Particularly in Santiago and Barcelona, the pilot implementation processes were greatly expedited, because the stakeholders had had previous engagement with the communities. Such prior relationships did not exist in Bogota, and hence a good amount of time had to be committed to establish connections, before the NbS actions relevant to the community could be defined.

Effective community participation, especially with marginalized communities, can facilitate equal opportunities to participate in environmental decision-making and can also support the long-term sustainability of NbS initiatives (Kabisch et al., 2016). To be noted is that some Life Labs were able to include marginalized communities in decision-making, such as the case of Barcelona, where elderly were the targeted group of the urban allotment pilot. The Turin Life Lab had youth as their target group for engagement. In Santiago, it was low-income females in

the *Quiero Mi Barrio* pilot. Buenos Aires and Bogota also engaged in activities with school children. These are all target groups commonly overlooked when implementing urban NbS.

Community engagement and participation were recognized in most Life Labs as the hardest part of the project. Finding ways of initiating engagement required an investment in time and innovation. For Turin, engaging with university students and preparing activities tailored for their interest helped in getting institutional support for replicating pilots in two other lots. The Lisbon Life Lab used the innovative approach to community participation, led by URBEM, in all the stages of growing a forest, from soil assessment to maintenance and monitoring. Santiago also included some innovative strategies for engaging women through knitting and weaving.

The Life Labs recognized that improvements could be made, first, to the participatory processes, especially in relation to personnel that would be exclusively in charge of the associated activities. Second, simpler indicators assessment methods were recommended to ease community engagement in monitoring and simplify the measurements. Third, the establishment of the role that the participatory processes will have from the beginning of the NbS project can help in organizing implementation, together with allocating funding support exclusively for this activity.

5.6 Monitoring and assessment

Assessment of the impact of NbS and its long-term monitoring can provide evidence of benefits on local challenges, trade-offs, and multiple ecosystem services that may be delivered after NbS implementation (Pauleit et al., 2019). Therefore, the monitoring and assessment are dependent on the time the pilot takes to implement. In CONEXUS, monitoring started in the second year for Barcelona and Buenos Aires, while for the other Life Labs, it was after two and a half years. With that in mind, it is recommended that funding for NbS projects is divided by stages: i.e. planning, design, implementation and monitoring. Funding can also be for longer periods, which is more difficult, but several NbS projects that are showing changes in ecological processes, for example, are derived from long term implementation (Frantzeskaki et al. 2017, Sarabi et al. 2019). Long term monitoring is an aspect that also should have institutional support, where meaningful indicators could be included within the regular work of the department. More on this will be discussed in the indicator section 6.

5.7 Knowledge development and sharing

From the previous section, the importance of considering the designing, planning, implementation and monitoring of NbS from different disciplines and sectors was established (van der Jagt et al., 2023). In Latin America, it emerged more strongly that institutions work in silos, therefore, unknown aspects related to the pilot implementation delayed the processes.

The Latin American cases related to water in Bogota and Buenos Aires were lacking expertise in hydrology, which had to be sought later. In Brazil, there was expertise in forestry but expertise on biodiversity and social aspects were lacking. The Life Lab teams should be multidisciplinary and have multi-sectoral collaborations that will complement at the different stages of the NbS implementation. Similarly in the European cases, the Life Lab teams' expertise was not diverse. Even though the Conexus consortium has multiple expertise and training sessions, and knowledge exchange programs were developed, continuously supporting Life Labs in the field was not feasible but it was largely desired. This can be something relevant to consider in future multinational NbS projects. Better engagement with university students from different disciplines can also help in providing some of the expertise that was missing in the Life Labs.

Experiences on NbS implementation derived from websites like OPPLA, Nature4Climate, NetworkNature were appreciated by Life Labs as they give good insights of NbS in different contexts, but they do not detail the process behind implementation (or things to consider for the implementation process) for a successful NbS project. From the Latin American Life Lab another recurrent topic was the need for case studies from the Global South that might give information on implementation given that the institutional agency, institutional overregulation, funding and the existence of informal settlements might need different approaches to implementation in comparison to cities in the Global North.

All Life Labs incorporated ways of delivering environmental education to the communities and ensuring the participation of the communities in different activities of monitoring through citizen science. This was implemented in Bogota with schools, in Santiago with educational sessions with the community, with monitoring in Buenos Aires and as part of the co-design and management in Turin and Lisboa.

The learning cycles were an avenue for recognizing the social learning occurring within the project and the learning not happening. The learning cycles serve well as an iterative process of informed dialogue and reflection, such as the need recognized by Randrup et al. (2020).

5.8 Financing mechanisms

No new funding schemes were derived from the learning cycles, but there was an agreement among Life Labs that funding for NbS must be increased and the cost-benefit analysis done in WP5 would support further financing.

5.9 Valuing diversity, equity and inclusion

The pilots being implemented in the different Life Labs recognized the needs, challenges, and values of the respective communities in terms of selecting the type of NbS, how to approach

implementation and what to monitor to ensure environmental justice (Randrup et al., 2020). Participatory approaches were included in one or all the stages of NbS development, either with local communities or local decision-makers. Further funding or available personnel could have reinforced the participatory approach beyond the design, planning and implementation to also include the monitoring.

Several of the pilots in Latin America were implemented in low-income communities, which led to unexpected challenges, such as security issues and how they can impact NbS implementation and monitoring. For example, in the Sao Paulo Life Lab the installation of the monitoring equipment had to be delayed given that the park where the pilot was going to be installed became unsafe for the equipment and the team involved in the monitoring. While for Santiago indicators of safety on green spaces was important, this aspect was not considered within the indicators provided in the EU Handbook (Dumitru and Wendling, 2021). Safety was not a challenge in European Life Labs.

Highlights

- The results from the learning logs and related cycles reinforce the importance of having a continuous involvement of stakeholders to gain institutional commitment and community motivation and awareness.
- Participatory processes are resource and time-consuming. Hence, they should be planned strategically in the sense of when they are most necessary and most meaningful.
- Student learning is an untapped avenue for NbS advocacy and improving the capacity of youth and early career professionals.
- Funding should be adequately spread across the stages of NbS: planning, design, implementation and monitoring.
- Long term monitoring should be institutionalized, where meaningful indicators are included within the regular work of departments.

6. Reflections on NbS indicator implementation

One of the agreed needs for the uptake of NbS is to provide evidence that shows them as better than grey solutions in addressing climate change impacts but also in providing further benefits besides climate with the same intervention (Chausson et al. 2020). Further from scientific evidence, there is a need to implement indicators of NbS that can provide information for many cities and many types of NbS interventions in relation to their benefits. Therefore, the evaluation of NbS through indicators that are appropriate and meaningful become largely important for supporting a NbS replication and its institutional uptake (Sowińska-Świerkosz and García, 2021).

In Conexus we used the indicators included in the EU Handbook of Indicators of the European Commission developed by Dumitru and Wendling (2021) as a tool for evaluating NbS impacts. Differently to previous projects, Conexus used a participatory approach to indicator selection, detailed in Deliverable 4.1 and in van der Jagt et al. (2022). This allowed to select indicators that are place based and can address the challenges occurring in each Life Lab and are validated by stakeholders from the respective Life Labs. This section will focus its analysis on the process of implementing the selected indicators, discussing aspects to consider for future NbS. We also included a summary of the analysis behind the selected indicators.

6.1 Indicators selection

The Life Labs did a selection of indicators related to their socio-environmental challenges and according to the relevance of the NbS type. Most of the Life Labs focused their selection on cultural services, except for Sao Paulo where the selection leaned to regulating services related to urban forests. A third aspect that was considered relevant for all Life Labs was to assess biodiversity in relation to NbS types. The final selection of the indicators maintains the relevance towards the challenges that the city was facing, but also considering institutional agendas for driving policy implementation and researchers' discipline of research.

Several frameworks have been elaborated to address evaluation of NbS (e.g. Kabisch et al. 2016; Raymond et al. 2017; Dumitru and Wendling 2021; Sowińska-Świerkosz and García, 2021). Those agree on the importance of indicators as providing evidence for NbS to address challenges, evaluate solutions, identify change of state at different spatio-temporal scales and to integrate multiple stakeholders' preferences into evaluation. There is also large agreement on the importance of integrating multiple stakeholders into indicator selection and how that could support the assessment of NbS with a place-based perspective (van der Jagt et al. 2022).

Life Labs in the Conexus project was able to complete thoroughly the first two stages defined in the participatory monitoring and assessment framework by Van de Jagt et al. (2022) relative to define shared monitoring goals and objectives and the participatory selection of indicators. Stakeholders considered aspects of credibility, legitimacy, salience and feasibility of the indicators for its selection, as discussed in D4.1, M18 and D4.2a. With the final selection of indicators once implemented we can recognize that feasibility, defined by the availability of data, time, finance and expertise, was still a central criterion to decide on indicators. Similar findings were described by Carmen et al. (2020). This emerges from the difficulties that Life Labs encountered when trying to implement their indicators to start the monitoring. The reality of implementation by the team or institution in charge ended up with a second analysis of feasibility that narrowed down the indicator selection to their capacities. Institutional structures such as knowledge, working routine, actor network dynamics (Rydin et al. 2003) still influence the capabilities of implementing the selected indicators. The following sub-sections analyze those aspects to then finalize the section by making recommendations towards facilitating monitoring. Such aspects include who is measuring the indicators, for how long, do we have the expertise, who will use the indicators and for what decision, among others.

6.2 Purpose of the indicators

A distinction should be made between the need to generate evidence from NbS that is going to serve research purposes, showcase effectiveness of NbS or monitoring policy implementation. Monitoring NbS for research or showcasing should try to evaluate multiple benefits and reinforcing the need of transdisciplinary approach to NbS. Assessing multiple benefits would allow to understand tradeoffs and synergies occurring from NbS implementation (Giordano et al. 2020), which are decisive for addressing Life Lab challenges.

Indicator implementation ended up favoring few aspects of the multidimensional nature of NbS, probably due to the interests and expertise of who are implementing the indicator and because of the limitations from resources of personnel and budget. As such Sao Paulo focused on regulating ecosystem services, while Santiago and Bogota measured mostly cultural ecosystem services. Barcelona and Buenos Aires had a better balance among the types of ecosystem services, having included cultural, regulating and indicators related to biodiversity. Turin ended up measuring mostly regulating services. To be noted, there was a large variety of numbers of indicators that are currently been measured, ranging from 3 in Buenos Aires to 10 in Santiago.

Sao Paulo, Santiago and Bogota were led by researchers, therefore most of the implemented indicators followed the discipline of those researchers, with their resources and expertise.

Turin, Barcelona, Buenos Aires and Lisbon were led by government institutions; therefore, indicators followed a combination of project needs and political agendas.

Establishing the purpose of the indicators from the beginning can better inform indicator selection. The participatory process for indicator selection should also establish with stakeholders the purpose of the indicators, disclosing limitations to the potential selection. Having a better linkage between the challenges and the indicators might give a better flexibility to indicator selection without losing the validation obtain through the participatory process.

6.3 Spatio-temporal scale of indicators

Defining the scale of the monitoring will also impact indicator selection, whether it is for a one-time measurement in one project; to replicate the indicator for other NbS; to apply it at single or multiple scales. Decisions on those aspects will also have an impact in the final selection of indicators. The selection of the final indicators been measured showed that the impact of the pilots was at micro-scale. Selection of indicators was adequate for this scale of application. Only Barcelona and Santiago included meso-scale indicators corresponding to the scale of the pilot (Naturalizing places and Santiago+, respectively). The selection of indicators, when having a wider stakeholder involvement, were not solely inclusive to the pilots but also to the Life Labs. This might have impacted some of the differences between indicator selection at the beginning with actual measurements within each pilot, in terms of spatial scale.

The length of the monitoring period will largely affect the indicator selection. More complex to measure indicators might be adequate for one time but not for recurring measurements, when budgets and expertise might change. The length of the monitoring influences which indicators will be capable of showing meaningful change on the multiple dimensions of NbS benefits. Most of the indicators that are being measured have meaningful impacts on the short term, and they focused on matters of participatory processes or people's perception (Santiago, Bogota, Lisbon, Buenos Aires and Barcelona). Indicators on regulating services and biodiversity, especially when involving trees, might take longer to be in its optimal provision by this stage or the end of the project funding. NbS require time to get to their peak effectiveness (Raymond et al. 2017), which can vary from a few years to decades with varying co-benefits during those times (Giordano et al. 2020). Establishing indicators according to their effectivity to capture change requires to establish indicators according to time, i.e. short term within 5 years of implementation, medium term between 5 and 10 years of implementation of the pilots and long-term over 10 years of pilot implementation (Sowińska-Świerkosz and García, 2021). Selection of indicators could be done according to the temporal scale of the indicator, allowing a better organization and meaning of the indicators been measured according to the realization of NbS benefits.

6.4 Knowledge and expertise related to methods.

A recurring theme that emerged from the learning logs was the complexity of the indicators, mainly related to the methods for implementation. At the end of the third learning cycle, none of the Life Labs was using the methods detailed in the European Commission Handbook on NbS indicators. This was mostly because they were difficult to implement with the capacities and resources available. This occurred for both Latin American and European Life Labs.

Having an understanding from the beginning who is going to measure the indicators, allowed to identify the resources available for monitoring in terms of personnel time, expertise and budget. This requires institutional commitment from before the participatory process for indicator selection. This allows transparency for informing indicator selection, leading to less major barriers during implementation and better accountability towards the community of stakeholders.

Another aspect that might be helpful not to guide indicator selection too much would be to have a variety of methods that could be used for indicator implementation and that combine complexity with the level of decision making intended for the indicator. Complex methods for indicators could be favored when the objective of monitoring and assessment is to generate scientific evidence of the impacts of NbS in multiple dimensions. More simpler method indicators could be use in public institutions to account for state on NbS in the city, that would need less level of expertise in implementation and resources and lead to longer term monitoring. Additionally, less complex methods can allow replication of the indicators for multiple locations or NbS types given the flexibility in the need of resources for assessment. Linked to the type of outcome of the indicator according to its methodology, understanding who will use the indicator could also give insight into how complex the method for measuring can be. Having outcomes that are going to be understandable by a broader audience, including stakeholders involved in selection, is determinant for the usefulness of the indicator.

Similarly to pilot implementation, detail on the process of implementation of an indicator can serve for better planning and successfully measured indicator. Information of the frequency of measurements, including after NbS was established and on measurement of indicators, can help to organize long term monitoring. Understanding the frequency can also help in setting a monitoring program that is going to be able to detect changes and not waste resources on measuring. Details on the season of monitoring, number of repeated measures or samples within one monitoring event, considerations of time in the day for sampling, resolution of the measurements or analysis can all facilitate the implementation of indicators. All these were aspects mentioned during the learning cycles that we were able to identify as necessary for indicator implementation. Complementing the EU handbook with this type of information could

better support long term monitoring of NbS, given that allows to prepare better for budgeting, personnel time allocation and identify needed expertise.

6.5 All indicators at once might not be possible.

The implementation of the indicator depends on the process of pilot implementation, therefore Life Labs had to organize their measurements according to that. For example, Barcelona started first with the urban allotment pilot on the first part of monitoring to then move to assessing the pilot on accessibility. Santiago focused their indicator measurement on the Quiero Mi Barrio pilot and little in the Santiago+ pilot. Buenos Aires has been monitoring in parallel on the two wetland restoration pilots, similarly to Bogota. Turin had focused on first finalizing one pilot and measuring its indicators to its fullest that will serve as evidence and experience to move into the second and third location of this type of pilot. This showcases the need of having funding exclusively for monitoring when some time since NbS implementation has happened.

External support also allowed for some Life Labs to implement indicators for which the expertise or personnel time was lacking. Turin and Lisbon invested in external consultants for support the monitoring, which meant the budget was available for it. Santiago and Bogota are collaborating with university students to do the monitoring within the thesis or professional internship work. Similarly to NbS implementation, collaborations are important to support NbS, and multiple institutions or people involved allowed a variety of expertise to become available.

The importance of institutional commitment towards monitoring is essential for monitoring NbS. Like pilot implementation, linking monitoring to policies beyond the political cycles could allow a better uptake of NbS. Establishing a monitoring program might enable destining the adequate resources for the longer term.

6.6 Participatory data collection and analysis of indicators

The use of co-produced monitoring is limited in urban NbS and most experiences required the investment for trained professionals, restricting participatory monitoring for bottom-up NbS initiatives (Van der Jagt et al. 2022). The importance of participatory monitoring relies on the contribution towards mainstreaming NbS by incorporating user knowledge in understanding the capacity of NbS towards mitigating socio-environmental challenges (Stevance et al. 2020).

NbS Pilot implementation uses participatory processes in its design and implementation with the caveats already described in the previous section. The same approach was chosen for indicator implementation, setting it up as a participatory process towards monitoring the local impacts of the Conexus pilots. This was expected to have impacts on creating more awareness on NbS benefits, improve maintenance and stewardship for NbS, leading to a better uptake of

nature-based solutions for cities (Giordano et al. 2020; Norström et al. 2020; Stevance et al. 2020).

For several Life Labs, a participatory approach to monitoring indicators was not feasible due to the limited time and resources available. Setting up a citizen science initiative takes time and organization to obtain usable data in the long term. Strategies for developing these activities should be planned from the beginning of the project and with a clear purpose on what data is needed and what level of complexity this has, to select which indicators are the most adequate to follow a participatory approach and which probably not.

Several Life Labs also highlighted the complexity of the methods needed to measure the indicators that made the participatory monitoring difficult to implement. More complex methods will require organizing training sessions before assessment, availability of equipment of laboratory analysis capacity if needed. Organizing a participatory monitoring should be decided then at the beginning of the project, to incorporate the adequate financial resources and personnel resources that will be required. In addition, it is important to establish the objective of the participatory monitoring process: to create better awareness in the community of the benefits; to mainstream a policy; to obtain robust data on the impacts of NbS; is it a one-time event or is it a longer-term effort or is it a combination of different purposes. Establishing an objective early on will also allow to better plan for a participatory monitoring process.

Highlights

- Chosen indicators for NbS indicator implementation ought to be goal-oriented and context-specific, considering the challenges being addressed and institutional rubrics.
- The selection of indicators may be influenced by the interests of those implementing the indicators, hence, should be advanced collaboratively.
- Having better linkage between the challenges and the indicators improves flexibility in indicator selection without losing the validation obtained through the participatory process.
- The timing of the implementation of the indicators should consider the timelines of the pilot implementation.
- Comprehensive monitoring of the indicators is preferred but may not always be feasible. In that case, aspects can be prioritized based on local needs and resources.

7. Conclusions and recommendations

The establishment of learning cycles for NbS is a useful pathway to understand better governance behind NbS by disclosing details on the process behind NbS implementation,

monitoring and to evaluate the uptake of participatory approaches to NbS. Learning cycles allow to approach NbS through an adaptive management framework where there is continuous reflection on opportunities for improvement, responses to changing conditions and institutional structures. The learning cycles can focus on the process more than in the outcomes, which has been recurrent for NbS assessments and reporting. We expect that the information behind the learning cycles for the seven Life Labs in Conexus can better support NbS implementation and can revealed on some of the considerations to have with NbS in Latin American cities. Following some of the lessons and recommendations were derived from our experience.

NbS required time for implementation and for benefits to realized. The planning stages need to incorporate an estimated time of each of the activities and decisions, an understanding of the time of the personnel that needs to be involved and of the stakeholders and experts that need to be engaged for each step behind NbS implementation. This would allow to reduce the uncertainty behind NbS implementation. The benefits from NbS are multiple and not all of them are realized once the NbS is implemented. Recognizing from the beginning the timing of benefits can allow to better monitor the impacts of NbS but also to understand trade-offs, while improving communication to the public, setting up adequate expectations for recognizing the impacts. Further impacts (or benefits) from NbS can be more meaningful if we are able to identify their peak in realization.

NbS require institutional commitment for progress and uptake. The dedication of personnel, financing, facilitating multi-department engagement, and recognition of the transdisciplinary nature of NbS from high level decision makers and politicians can largely favor NbS uptake. Multi-department (or multi-sectoral) engagement can support recognizing permits, technical opinions or equipment needed before starting with NbS implementation. Incorporating the needed time and the personnel during the planning stage for each step of implementation can reduc uncertainties that might affect progress.

NbS provide opportunities for capacity building and new partnerships. NbS involved multiple disciplines and expectations on capacity building should not be looking at developing in one person expertise from multiple disciplines. Capacity building should focus on giving an understanding of all the important decisions related to NbS and which are the disciplines or sector in which we should try to find that knowledge. Therefore, in NbS implementation, collaborations or partnerships can largely facilitate the process of implementation. Collaborations with NGO can add expertise and personnel to support implementation, community can bring local knowledge and personnel to the project, universities can provide expertise and help from students. Recognizing that collaborations are important in NbS can allow adding it to the budget of the project, with a clear identification on their role and responsibility within NbS implementation.

NbS need continuous implementation of participatory processes. As mentioned in the report, the continuous engagement of stakeholders with a clear purpose and role can facilitate NbS implementation. Having a relationship built with the community, previous to the NbS project, can facilitate engagement and implementation of NbS given that community schemes and trust are already existing. Building trust with a community takes time and investment, and planning of NbS should incorporate those in their timing and budget.

NbS required monitoring and assessments and there should be clarity on the role of it. The purpose and methods of the assessment should be clearly established at the planning stage, to include the timing, budget, training required, expertise needed, equipment, among other aspects. Institutional purposes are different than academic and can also differ from community, while been capable of measuring the same impact on a challenge or need validated by multiple stakeholders. Providing a gradient of methods in terms of complexity and robustness can allow better uptake of monitoring NbS and of monitoring multiple dimensions, improving the assessment in the impacts of NbS. Flexibility in methods also increases the likelihood of supporting long term monitoring of NbS, that do not depend on solely on personal expertise. Establishing the length of the monitoring, aligned with the purpose, and deciding early on whether participatory assessments are desired will allow to incorporate the necessary resources at the planning stage.

NbS offer an opportunity for addressing equity in urban areas. Continuous participatory process can open opportunities for marginalized groups to participate in the future planning of their cities. As such the Conexus has incorporated seniors, females and children in the implementation and monitoring of NbS, commonly overlook voices in NbS.
The planning of NbS from implementation to monitoring is critical to implement NbS more smoothly and reducing its uncertainties for progressing and for creating the most needed awareness of NbS impacts required for a better uptake towards supporting equitable, sustainable and resilient cities.

Takeaways

- Since NbS take time for their benefits to be realized, their planning, implementation and assessment should be well streamlined to reduce uncertainties and ambiguities.
- Institutional support demonstrated through personnel and financial commitment and political will are critical for NbS success.
- Capacity building for NbS should be practical, showing all the key stages in NbS rollout, the expertise needed and stakeholders who can better provide them.
- Engaging stakeholders with a clear purpose facilitates NbS implementation and improves trust and equity.
- NbS assessment plans should be comprehensive but also flexible to support long-term monitoring.

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9. ANNEX

Table A.1 Progress on indicator implementation from Barcelona Life Lab

	Using handbook methods?	Started measuring	Participative monitoring	Difficulties	Need for training
Carbon sequestration and storage per unit of time	NA	No	No	NA	NA
Greenspace Accessibility	No	Yes	No	Not meaningful for equity	NA
M2 of urban allotments per capita/area	No	No	No	Work intensive	No
Agriculture production	No	Yes	Yes	Too complex	No
Number of cultivated species	No	Yes	No	Time consuming	No
Number of active users of urban allotment	No	Yes	No	Estimated not measured	No
Number of biodiversity structures	No	Yes	No	NA	NA
Air quality	No	No	No	NA	No
Heavy metal concentration on urban allotment production	No	Yes	No	Costly	No

Table A.2 Progress on indicator implementation from Bogotá Life Lab

Bogota	Using handbook methods?	Started measuring	Participative monitoring	Difficulties	Need for training
Citizen participation in environmental education initiatives	No	Yes	No	No	No
Sense of place	No	Yes	No	Questionnaire needs revision	No
Learning on ecosystem functioning and services	No	Yes	No	Questionnaire needs revision	No
Trust within the community	No	Yes	No	Questionnaire needs revision	No
Number of native species	No	No	Yes	Delay	No
Perceived quality from green and blue spaces	No	Yes	No	Questionnaire needs revision	No
Greenspace accessibility	No	No	No	Pilot in construction still	No

Table A.3 Progress on indicator implementation from Buenos Aires Life Lab

Buenos Aires	Using handbook methods?	Started measuring	Participative monitoring	Difficulties	Need for training
Water quality	No	Yes	No	In construction	No
Number of native and invasive species	No	Yes	No	Last quarter of 2023	No
Openness to participatory processes	No	Yes	No	Validation questionnaire	No
Air quality	No	No	No	Schedule for next month	No

Table A.4 Progress on indicator implementation from Lisbon Life Lab

	Using handbook methods?	Started measuring	Participative monitoring	Difficulties	Need for training
NbS Diversity	No	Yes	Yes	outsourced	No
Number of green spaces and Nbs and new NbS	No	Yes	Yes	Inadequate scale	No
Conversion and requalification of vacant land	No	Yes	No	Delay	No
Number of planted species	No	Yes	No	outsourced	No
Activities of citizen participation, public engagement and collaborative process	No	Yes	Yes	outsourced	No

Table A.5 Progress on pilot indicator implementation from Santiago Life Lab

Santiago	Using handbook methods?	Started measuring	Participative monitoring	Difficulties	Need for training
Maximum daily temperature	No	No	No	Lack of adequate equipment	No
Quantity of active public-private associations	No	Yes	No	Not informative	No
Accessibility and distribution of green and blue spaces	No	Yes	No	No	No
Participation in environmental education activities	No	Yes	No	No	No
Total green space for unit of area	No	Yes	No	Available data before CONEXUS	No
Accessibility to green spaces	No	Yes	No	Available data before CONEXUS	No
Sense of place	No	Yes	No	Questionnaire	No
Well-being and happiness	No	Yes	No	Questionnaire	No
Maintenance costs of NbS	No	Yes	No	Lack of adequate equipment	No
Diversity of birds	No	Yes	No	No	No
Diversity of vegetation	No	Yes	No	No	No
Pro-environmental identity	No	Yes	No	Questionnaire	No

Table A.6 Progress on pilot indicator implementation from Sao Paulo Life Lab

	Parque Fontes do Ipiranga					Functional Forests - Ibirapuera				
	Using handbook methods?	Started measuring	Participative monitoring	Difficulties	Need for training	Using handbook methods?	Started measuring	Participative monitoring	Difficulties	Need for training
Carbon sequestration and storage per unit of time	No	Yes	No	No	No	No	No	No	No	No
Carbon Flux	No	Yes	No	No	No	No	No	No	No	No
Evapotranspiration	No	Yes	No	No	No	No	No	No	No	No
Energetic equilibrium	No	Yes	No	No	No	Yes	Yes	No	No	No
Mean monthly daily maximum temperature	No	Yes	No	No	No	No	Yes	No	No	No
Tree growth rate	No	Yes	No	No	No	No	Yes	No	No	No
NSC Dynamics	No	Yes	No	No	No	No	Yes	No	No	No
Biodiversity enhancement	No	No	No	Lack personnel	No	No	No	No	Lack personnel	No
Perceived quality from blue and green spaces	No	No	No	Method	Yes	No	No	No	Method	Yes
Recreation value of public spaces	No	No	No	Method	Yes	No	No	No	Method	Yes
Openess to participatory processes	No	No	No	Method	Yes	No	No	No	Method	Yes

Table A.7 Progress on pilot indicator implementation from Turin Life Lab

	Using handbook methods?	Started measuring	Participative monitoring	Difficulties	Need for training
Permeability	No	Yes	No	Method changed	No
Avoided runoff	No	Yes	No	Method changed	No
Heat mitigation index	No	Yes	No	Method changed	No
Green usability	No	Yes	No	Method changed	No
Pollination	No	No	No	No	No
Pollutants removal	No	No	No	No	No