ENoLL RECOMMENDATIONS ON LEVERAGING LIVING LABS FOR ZERO POLLUTION

European Network of Living Labs

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1 Foreword

The 2021 Zero Pollution Action Plan of the European Commission announced a flagship initiative on "Living Labs for green digital solutions and smart zero pollution". This initiative included the development of "recommendations on using for a climate and environment-friendly use of digital solutions to accelerate zero pollution efforts, with a particular focus on citizen engagement".

The European Network of Living Labs (ENOLL) took this task on in collaboration with the Commission services. This document represents the outcome of this work which was endorsed by the Zero Pollution Stakeholder Platform on 20 April 2023.

The document includes 11 recommendations which are underpinned by some examples of digital solutions from existing Living Labs. In the preparatory process, the Living Lab community embraced the zero pollution and zero emissions ambitions, which solicit action and entrepreneurship as well as institutional and citizen engagement. Digital solutions are a quick win to achieve early successes.

The Stakeholder Platform agreed that digital solutions have a significant potential to improve the following:

- Stakeholders' engagement and interaction
- Citizens' engagement
- Knowledge sharing and transfer
- Digital capabilities to reduce negative effects from pollution
- Testing (in open/real environments) before investing
- Policy making and regulatory learning.

To benefit from such improvements, digital solutions have to be at the service of society and of citizens' health and the environment.

To achieve this, the following 11 recommendations have been identified in these documents as a useful input for practitioners, namely:

1. Make every solution socially inclusive
2. Develop and apply integrated, multi-sectoral solutions
3. Break silos and communicate across a broad range of people and stakeholders
4. Ensure policy coherence and coordination
5. Make good use of the zero target for simple and robust heuristics for action
6. 6. Use digital solutions to evaluate and monitor pollutant levels and associated socioeconomic costs
7. Invest in the co-design of experimental loops for engaging in experiments, cutting-edge technology trials and investigation
8. Look for adaptive technologies
9. Go beyond the 'Death Valley' of innovation
10. Increase impacts through citizen empowerment and transition capacity building
11. Ensure engagement for cooperation among stakeholders and along the value chain and smart cities and territories.

In particular, the Zero Pollution Stakeholder Platform highlights the potential of digital solutions to develop and apply integrated, multi-sectoral solutions and thereby help to break silos and communicate across a broad range of people and stakeholders. Moreover, such solutions can significantly improve the collection and sharing of pollution-related data.

The Zero Pollution Stakeholder Platform is grateful to the European Network of Living Labs (ENOLL) for preparing these recommendations and thank in particular Georgia Ayfantopoulou, Martina Desole, Valentino Piana and Josep Maria Salanova for their commitment and dedication throughout the process.

2 Introduction

ENoLL Recommendations on leveraging Living Labs for Zero Pollution through digital solutions and citizens' engagement

The European Union's Zero Pollution Action Plan aims to address the societal request for Zero Pollution by creating an environment in which citizens can live healthy lives, ecosystems are not compromised, and people can choose to buy goods and services that align with their values. The plan has a comprehensive vision for an environment where everyone can live safely. It contains several Zero Pollution targets for 2030 to protect health and biodiversity and to move towards a clean and circular economy.

To achieve these targets, the involvement of citizens and businesses is crucial. The Action Plan is well connected with the Green Deal, REPowerEU, Fit for 55, New European Bauhaus, NextGenerationEU and other policies, in particular the Digital Strategy and Digital Decade. Digital technologies, including the integration of digital infrastructure, data spaces, digital designs, and apps, play a vital role in the fast transition to a green economy as long as they are in the service of people and the environment. A key contribution to the realisation of the Zero Pollution Action Plan can be provided by digital monitoring and tracking of pollution-relevant product and process features, of emissions, of ecosystem status, and of material flows, as well as by tools that simulate, forecast, manage, virtualise, and collect and analyse data. **Citizens are empowered by digital tools, which support them to become more sustainable.**

The concept and practice of permanent Living Labs have emerged as an important infrastructure supporting the green and digital transitions, promoting innovation through user and co-creator involvement in the processes of development, diffusion, and social appropriation. Living Labs bring together citizens, institutions, industry, and research, engaging citizens in social practices and connecting the big picture to local action. Living lab methods and tools, especially if applied in meaningful projects and by permanent structures, are powerful ways to attract, engage and deliver solutions with both experts and citizens. Living lab permanent structures are business-friendly, environmentally committed, institutionally relevant, and citizen-engaging active players. Living Labs also have a special focus on digitalisation, by being heavy users, by co-developing solutions through citizens engagement, and by contributing to closing the digital divide. Again and again, they can facilitate the development and distribution of mobile and cross-platform apps for environmental protection, as well as of digital supports to the production of physical objects, embedding FabLabs[1] in broader processes. Furthermore, Living Labs can facilitate visibility and access to open knowledge, supporting open data and open-source initiatives and the European Data Spaces. Living Labs pursue an open and multi-stakeholder participatory approach, facilitating common understanding and decision-making; they can be considered important contributors in speeding up the transition process to Zero Pollution and climate neutrality. Overall, Living Labs have emerged as a crucial platform to promote innovation, sustainability, and digitalisation, bridging the gap between citizens, industry, public administration, and research.

1. Digital fabrication laboratories

The current set of recommendations are expected to help stakeholders, including local and regional authorities, to accelerate Zero Pollution efforts, through a range of means that include digital solutions. The recommendations will also serve to raise cities' awareness of the benefits of using Living Labs to become green and digital, with a particular focus on citizen engagement, and how Living Labs can be best used, and their impact maximised.

Living Labs and converging community-based action-oriented participatory trans-disciplinary research structures are key components of open science for sustainable development. They have a special relevance to digitalisation as they are likely to use digital technologies to facilitate innovation and address sustainability challenges. Their socio-technical infrastructure can be used to demonstrate novel Zero Pollution technologies at the pre-industrial and market-ready levels under real configurations. Moreover, Living Labs can be used to test and demonstrate digital solutions for reducing pollution and achieving environmental sustainability. They can support stakeholder analysis creatively in order to understand the needs and perspectives of different groups and develop targeted solutions. Their location and operation in cities and territories provides access to the tacit knowledge and local trust needed to address multiple challenges. Living Labs can also facilitate cooperation between all actors in the value chain and the establishment of circular economies in conjunction with new remuneration systems or payment mechanisms for performance and ecological services.

European Network of Living Labs

Digital solutions and capabilities

Digital solutions are a key component of the transition towards Zero Pollution, e.g. by reducing energy consumption and improving air, soil, and water treatment processes to prevent or reduce pollution. Overall, digital technologies can play an important role in supporting Living Labs' sustainability solutions: from facilitating stakeholder engagement and cooperation to developing and testing innovative solutions for reducing pollution and achieving environmental sustainability. Living labs mobilise demand for green digital solutions, such as those developed by the European Green Digital Coalition[2]. They map untapped potential for further solutions and establish Europe-wide networks to spread them. To sceptics of the transition in climate and environment, we can see how fast mobile phones have been adopted and used.

Cooperation among stakeholders should focus on two families of digital game-changers for sustainability, Zero Pollution and emissions: mobile and cross-platform "Apps" (including, for instance, energy monitoring and management, noise measurement, nutritional and chemical declaration of toxicity for products) and "digitalised product designs". The role of Living labs in supporting digital solutions can be visualised as the "double daisy", as shown in the following image and explained below.

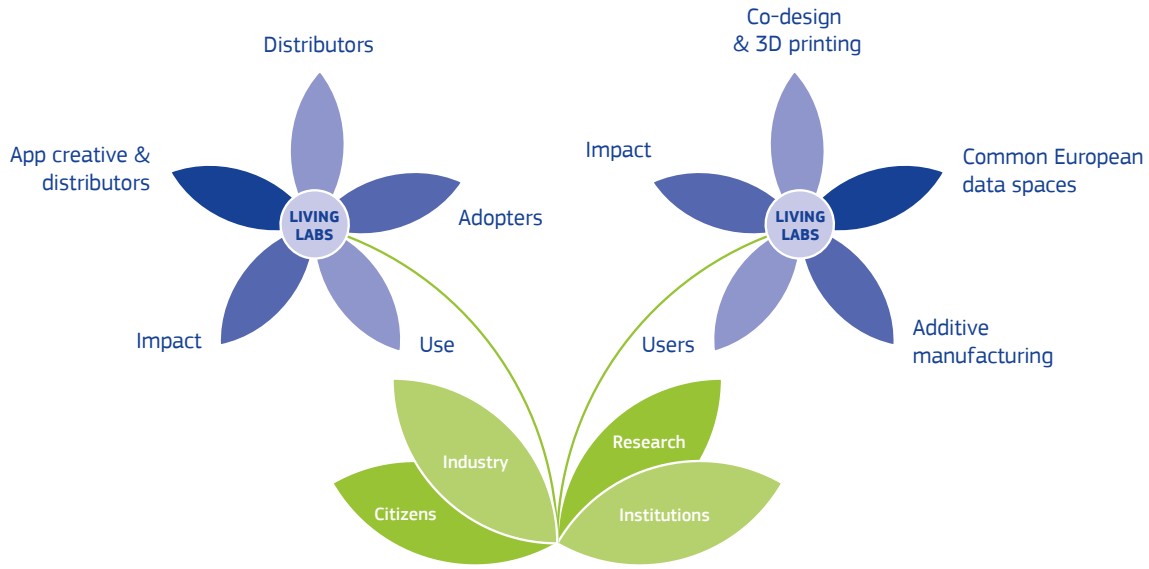

Figure 1: The double daisy of Living Labs roles in orchestrating apps and digitalised product designs

2. https://digital-strategy.ec.europa.eu/en/policies/european-green-digital-coalition

From the initial need for the app, to its broadest impact through adopters' download and use, overall orchestration should be assured. Digital support to the production of physical objects can similarly be orchestrated by Living Labs, which typically offer spaces for collaborative design, through a range of techniques for involvement, and by offering rapid prototyping, thus embedding FabLabs in the broader process. But what is devised locally, including through virtualisation[3], should not remain there: the Living Labs should upload the 3D digital design of the new product into global and European Data Spaces[4] – such as the Green Deal data space, the Mobility data space, the Energy data space, the Agricultural data space, or the Skill data space – which can then function as a 3D repository and community where you can download 3D models and print them, as well as transmitting to digitally controlled machines in factories.

A number of digital solutions for Zero Pollution exist, which have been successfully tested by Living Labs, such as:

- **The ICT solutions** for the agro-ecological transition developed by Occitanum and its several open labs in France;
- **The HSB Washing Machine Control Unit**, co-studied by the HSB Living Lab in Gothenburg (Sweden);
- **SofiaCoin**, an app that enlists locally appropriate sustainable practices, keeps track of them and rewards them with free access to innovative eco-friendly services and products, developed by SofiaLab (Bulgaria);
- **CODALoop**, Community Data-Loops for energy-efficient urban lifestyles involving the StadtLabor in Graz (Austria).

These and other examples have been compiled in Annex 1.

It is important to enhance the digital capabilities of people of every social background in order to make use of the resulting green digital solutions. To this end, training programmes should be initiated and promoted to help management and technical staff in utilities and urban administrations develop their abilities in managing data and using digital technologies. Educating citizens about the effects of their lifestyle, such as on air quality, can also motivate them to adopt more sustainable behaviours. Moreover, standardising key performance indicators is necessary for assessing the effectiveness of innovative solutions for reducing pollution. Building on the existing Zero Pollution monitoring and outlook mechanisms and institutions, all actors should also feed into the digital observatories regarding air, soil, and water pollution to enhance the quality of modelling and monitoring of current conditions, facilitating the sharing of environmental quality-related information through intuitive and transparent visualisation dashboards. This is part of populating the European Dataspaces, in particular the Green Deal Dataspace.

These data can also be used to test the feasibility of solution implementation in social, technical, and operational terms, e.g. by using city models and digital twins. For this, best practices and knowledge sharing should always be the output of any research and innovation project, with an emphasis on three main aspects: transferability (establishing the non-idiosyncratic reasons behind the success), replicability (for areas identified as potential replicators after the transferability analysis), and scalability (which is not about numbers, but about processes). In this, compliance has a particular role: digital solutions can be used to track pollution and proxies, to provide basic evidence for non-compliance, which can be evaluated (and if necessary, sanctioned) by official bodies.

Underpinning such developments, attention should be paid to safe and ethically sound Artificial Intelligence (AI), with practical approaches for the development, testing, and evaluation of the EU Ethics Guidelines for Trustworthy AI[5]. Furthermore, the shift toward digital solutions that are computationally expensive but also energy intensive presents new challenges that need to be addressed through energy efficiency and exclusive sourcing from zero-emission and Zero Pollution energy sources.

3. e.g. activities in the digital domain of the Santa Chiara Lab (https://santachiaralab.unisi.it/digitale) of the University of Siena (Italy).
4. https://digital-strategy.ec.europa.eu/en/policies/strategy-data and http://dataspaces.info/common-european-data-spaces/
5. Ethics guidelines for trustworthy AI | Shaping Europe's digital future (europa.eu)

4 Recommendations

EnoLL engaged the broader community of Living labs and pollution experts in five participatory workshop sessions between April and September 2022, to stimulate discussion and exchange of knowledge about the impact on the environment that can be achieved by cross-domain actions by and in Living Labs, thus contributing to the development of the current set of recommendations.

The results of the thematic workshops on air, water and soil generated the following general recommendations which are applicable more widely:

1. Make every solution socially inclusive

Living Labs can raise awareness for pollution and origins, influencing behaviour towards the environment locally. They aim to reverse the burden on minorities, women, and lowest-income citizens who are often the most affected. Some groups may also be less informed and capable of decrypting scientific messages while needing immediate solutions. Living Labs can use a language, frame and action based on intuitive information-sharing (dashboarding) on water, soil, and air quality – with the integration of other themes – which makes it easier to implement citizen science and involvement.

2. Develop and apply integrated, multi-sectoral solutions

This recommendation emphasises the importance of involving stakeholders from different sectors, such as transport, energy, agriculture, and urban planning, in the development and implementation of solutions. With their characteristic co-design hinging on the hybridisation of different technologies and social norms, they support a nexus approach in the real environment among sectors, for example, water-energy, water-industry, water-agriculture, water-industry-agriculture-cities, water- energy-food, water-chemicals, extended and adapted to include soil and air.

3. Break silos and communicate across a broad range of people and stakeholders

It is necessary to translate the Zero Pollution ambition into the specific local context and identify who can contribute to inter/intragovernmental intersection alignment methodology and to what extent. The key alignment across legislation, permits, and compliance systems is made easier by sharing information and results on institutional websites and by transparently and comparatively assessing replicability, transferability and adaptability of pilots and case studies from a technical, socio-economic, and environmental point of view.

4. Ensure policy coherence and coordination

Innovative and practical responses to policies should be co-developed under the leadership of cities and regions, also drawing on their Smart Specialisation, while increasing their readiness to adopt innovative Zero Pollution solutions developed elsewhere. Living Labs can be used to test and evaluate the effectiveness of policy solutions in real-life settings. Achieving the next level involves supporting Living Labs coordinators and actors in translating results into regulatory and legislative proposals and to act to overcome legal barriers. This recommendation also emphasises the need for greater engagement and participation from stakeholders in the policy-making process, to ensure that policies are informed by the needs and perspectives of those affected by pollution.

5. Make good use of the zero target for simple and robust heuristics for action

Setting a zero target for pollution makes behavioural and technological choices easier. Simple and robust heuristics for action can guide decision-making toward Zero Pollution. This can be achieved using Living Labs, where stakeholders can co-create and test innovative solutions in real-life settings,

and through the development of clear indicators and targets that can drive progress (such as the diffusion of Zero Pollution lifestyles, behaviours and technology). One should promote awareness through educational activities, learning materials, and the dissemination of Living Labs activities. This can lead to changes in social norms.

6. Use digital solutions to evaluate and monitor pollutant levels and associated socioeconomic costs

Use digital solutions to evaluate and monitor pollutant levels and associated socioeconomic costs, establishing a common understanding for Zero Pollution among all stakeholders, and establishing circular economy in conjunction with a payment mechanism for ecological services and resource efficiency. Simulating and forecasting can aid in improving efficiency, such as with Digital Twins that simulate a product's lifecycle or the processes of an ecosystem. Economic activities can be moved online, and their environmental impact reduced with virtualisation.

7. Invest in the co-design of experimental loops

Invest in the co-design of experimental loops for engaging in experiments, cutting-edge technology trials and investigation, ongoing value-chain monitoring, and the installation of spatiotemporal high-resolution sensor infrastructure, e.g. for agricultural systems' nutrition and needs for pest control.

8. Look for adaptive technologies

Living Labs can carry out demonstration activities for new technologies at a pre-industrial scale in a real environment. It may also include activities for the optimisation/adaptation of technology. Demonstration may include issues related to regulation, costs, environmental technology verification (ETV), and end-user/client involvement. Living Labs can find partners and funding for scaling-up of a specific technology. They can also link with green procurement.

9. Go beyond the Death Valley of innovation

Emerging technologies are slow to take off and risk failure to achieve mass production even if they solve the pollution problem. So it is important that Living Labs promote niches for early adopters, and test their scalability, replication and transfer. For water, this involves for instance:

- supporting water operators in the transitional shift to the Internet-of-Things era, including the application of various data sources and smart data fusion;
- spreading 'matchmaking' of water reuse/recycling techniques to various users (public, industry, governments);
- evaluating how the risk-based approach has been applied, validated, and (informatively) communicated concerning circular value chains;
- establishing communities of practices and communicating their results.

Overall, this closes a crucial gap for the uptake of the technology.

10. Increase impacts through citizen empowerment and capacity building

Empower citizens to be active participants and adopters in the development and implementation of innovative solutions to mitigate and prevent air pollution. This can be achieved through tailored capacity-building programmes, such as training and mentoring, supplemented by complementary learning materials and tools. Conversely, citizens' first-hand knowledge should be channelled into action by others. Citizen science and Living Labs can be used to gather air quality data, present evidence for changing citizen behaviour towards sustainability, and test and evaluate innovative solutions. This recommendation also emphasises the need to invest in building up the digital skills of citizens and public authorities.

11. Ensure engagement for cooperation among stakeholders, along the value chain, and in smart cities and territories

Living Labs can have a role in the identification and production of 'activators', the key bottleneck for the Smart City, because the abundance of sensors and the growing intelligence in analysing their real-time data contrast with the paucity of actions that can be taken. Living Labs are a great place to pose questions like this, to re-imagine social, political, behavioural, and technological 'activators', and to make the Smart City a better place. For soil, this points to improved reduction of soil contaminants, with early adopters and stakeholders receptive to new ideas included in the soil health conversation. For water, Living Labs can generate within a precise territory a co-dependency (and co-autonomy) along the whole chain of actors, boosting not only a circular economy but a circular society from the core, e.g. reintegrating clean water at the source within its natural cycle.

5 Conclusions

Living Labs stand up for Zero Pollution and zero emissions. These ambitious targets can solicit action, entrepreneurship, and institutional and citizen engagement. Digital solutions are a quick win to achieve early successes. They can build a comprehensive science-informed, citizen-centric, business-friendly development. Interoperability of processes and the adoption of best practices will enable in the short- to mid-term far-reaching innovations in social norms, lifestyles, and consumption and production patterns, as well as in skills, and territorial systems. This can be facilitated by the network of open research, industry, institutions, and citizens that Living Labs nurture.

Annex 1
Action areas for green digital solutions applied by Living labs

Origin of pollutants (non- exhaustive list)	Pollution domain[6]	Technological trajectories providing solutions (non- exhaustive list)	Role of Living Labs (examples)
Municipal waste	Soil	• Elimination of packaging • Nature-based and biodegradable packaging • Reuse of products and of packaging • Waste prevention • Recycling in general • Recycling building • materials after demolition	• Citizens behavioural training • Quadruple helix co-creation process for new methods and substances in cleaning[7] • Support to coordination action with points of sales and the respective supply chains • Support to the introduction of innovative packaging and other waste-eliminating solutions • Co-design of zero packaging solutions • Support to recycling • Digital solutions for products to be classified and allocated to recycling bins
Abandoned macroplastics	Water	• Social norms • Availability of disposal accessible facilities • Operational routines by the waste management utility	• Co-design of social norms (e.g. no-plastics outdoor activities) • Co-design of facilitated adoption (e.g. no-plastics dishes) • Efforts to reduce proprietary plastic packaging towards generics, which can lead to higher recycling • Digital solutions for beach and wood littering • Clean-up days
Pervasive microplastics	Water	• Social norms • Reducing plastic use and waste • Plastic recycling • Proper plastic waste management	• Co-design of social norms on plastics and its substitutes • Co-design of facilitated adoption of substitutes (natural[8] or bio-based and bio-degradable plastics) • Support to zero-plastics cities and commercial premises • Support to the bioeconomy[9]

6. Air, water, soil and, mutatis mutandis, sediments
7. See the project on surface hygiene and project on microbiological efficiency of public facilities cleaning (https://projects.tuni.fi/pihy/in- english/) by the Living labs at TAMK (Finland), related to pre- moistened cleaning.
8. See for instance the oat hulls paper, which has been developed in the HeräätPahvi! project (https://www.heraapahvi.com/in-english-1) by a cooperation involving TAMK in Tampere and its Living labs (https://www.tuni.fi/en/research/research-and-development- tamk/tamks-living-labs). For more in general, see https://www.packall.eu/.
9. See for instance the activities of the BioökonomieREVIER Rheinland in Germany (https://www.humtec.rwth- aachen.de/cms/HUMTEC/Forschung/Living-Labs-Incubator/LLI-Netzwerk/Liste-der-Living-Labs/~rtaix/BiooekonomieREVIER/), supported by the Living Labs Incubator (LLI)of the RWTH Aachen University (https://www.humtec.rwth-aachen.de/cms/HUMTEC/Forschung/~mgveq/Living-Labs-Incubator/?lidx=1).

Origin of pollutants (non- exhaustive list)	Pollution domain[6]	Technological trajectories providing solutions (non- exhaustive list)	Role of Living Labs (examples)
Household cleaning, laundry, etc.	Water	• Social norms • Local knowledge of water hardness • Different chemistry and biodegradable solutions	• Co-design of social norms • Facilitating smart solutions design and adoption[10] • Incentivisation systems for sustainable lifestyles[11] • Locally relevant information on water hardness and heuristics for effective results but with minimal/non-polluting inputs
Fossil-fuel mobility (by exhaust fumes)	Air	• Non-motorised transport • Electrification of private and public transport vehicles	• Contribution to setting up fleets of shared vehicles and promoting demand responsive transport services, increasing the occupancy while reducing operation distances[12] • Co-design of future zero-emissions vehicles and business models • Support in the establishment of Zero Pollution zones and "silent zones" in the city • Improve traffic and fleet management in cities • Overall support to cities in this transition[13]
All type of mobility (tyres)	Air / Water / Soil	• Different chemistry for tyres	• Mapping advances in supply • Promote eco-driving training and awareness programmes • Catalyser for new business models (e.g., pay-for-performance in tyres)
Fossil-fuel heating	Air	• Insulation of buildings, especially with nature-based, recyclable, non- toxic materials • Heat pumps	• Mapping of user needs • Entry point to local markets for new eco-friendly solutions • Platform of knowledge and tools for cooperation between citizens and providers of finance, i.e. technical solutions • Support to mobilisation of low-pollution districts
Industrial processes	Water	• Industrial wastewater treatment • Short closed loops	• Mapping current practices in local companies • Comparing with good practices in the European Union[14] • Detecting gaps in adoption • Organising matchmaking events between solution suppliers, regulators, and industry • Connecting health and pollution in health-enhancing activities[15] • Bathing quality detection and information[16]

10. See for instance the HSB Washing Machine Control Unit, co-studied by the HSB Living Lab (https://www.hsb.se/) in Gothenburg (Sweden), which allows for setting the latest hour for a laundry load to be done by, but lets the machine choose the actual times in function of the presence of renewables in the electricity supply (https://www.hsb.se/hsblivinglab/projekt-i-huset1/tvatta-och-torka-med-full- kontroll-pa-elforbrukningen/).
11. See for instance SofiaCoin, an app that enlists locally-appropriate sustainable practices, keeps track of them and rewards them with free access to innovative eco-friendly services and products (https://www.sofia-da.eu/en/current/innoair-project/activities/2307- sofiacoin-when-efforts-are-rewarded.html). Developed by SofiaLab, the Urban city lab of the Bulgarian capital (https://www.sofia- da.eu/), the app is downloadable from e.g. https://play.google.com/store/apps/details?id=bg.sofia.coin.
12. For several green digital solutions for mobility, see https://mobilitylab.hel.fi/ and https://wcontent/uploads/2021/09/EITUrbanMobility_Living_labs_report_update_July2021-1.pdf
13. Out of the many possible examples, see CODALoop – Community Data-Loops for energy efficient urban lifestyles (https://stadtlaborgraz.at/de/2019/05/codaloop/) involving the StadtLabor (https://stadtlaborgraz.at/) in Graz (Austria); the Thessaloniki Smart Mobility Living Labs (https://www.smartmlab.imet.gr/).
14. For a rich catalogue of good practice in water-oriented Living Labs, see https://watereurope.eu/wp-content/uploads/2019/07/Atlas- of-the-EU-Water-Oriented-Living-Labs.pdf, https://watereurope.eu/wp-content/uploads/WoLLs-Notebook-Series-1.pdf, https://watereurope.eu/wp-content/uploads/WoLL-Notebook-Series2_2pages.pdf
15. See for instance the Healthcare Living Lab Catalonia (https://healthcarelivinglab.cat/) in Spain and the Lecco Living Lab (https://www.leccolivinglab.com/en/) in Italy.
16. See for instance the many digital solutions (https://www.digital-water.city/digital-solutions/) of the Digital Water City project (https://www.digital-water.city/), animated by the Living Lab of PIREN-Seine (https://piren-seine.fr/en).

Origin of pollutants (non- exhaustive list)	Pollution domain[6]	Technological trajectories providing solutions (non- exhaustive list)	Role of Living Labs (examples)
Industrial emissions	Air / Soil	• Best Available Technology adoption • Advances at the frontier • Avoidance of products whose production process is irremediably polluting	• Popularising BAT guidelines for SMEs • Entry point and matchmaking of innovative solutions into the local entrepreneurial environment • Distilling simple information and action-oriented messages from studies and databases[17] • Mapping needs and co-design solutions to completely avoid products whose production process is irremediably polluting
Consumption of pharmaceu-tical produc-tions	Water / Soil	• Healthy practices and active lifestyles, reducing the needs for medicines • Non-polluting medicines • Better management of disposal • Reductions in the use of antibiotics	• Co-design of removal of obstacles to such lifestyles (e.g. walking/biking hindered by road design) • Mapping social and business practices in pharmaceutical products disposed without having been used[18] and possible roles for citizens' education and involvement • Identifying hotspots in pharmaceutical products consumption (e.g. hospitals), so good practices of localised upstream pre-treatments may be transferred.
Agriculture	Soil	• Rethinking of fertilisers and pesticides • Precision agriculture • Organic and regenerative agriculture and agro-ecology	• Support to local communities in addressing the locally appropriate strategy • Entry point and matchmaking for solutions.
Agriculture, animal husbandry, fishing	Water / Living resources	• Organic production • Low-input agriculture • Precision agriculture • Aquaponics	• Consumer side of organic food promotion • Local food systems with high level of ecological integrity[19] • ICT for the agro-ecological transition[20] • Aquaponics solutions[21] • Matchmaking of solution providers with the local texture of SMEs and commercial premises.

The use of water by citizens (involving both saving water[22] and fighting water pollution) can be addressed with data-based storytelling and other urban actions[23]. Actions may be focused on solutions with plenty of benefits[24]. Zero Pollution and emissions local plan should include co-design of citizens to be more implementable[25].

17. For instance, the https://energy-industry-geolab.jrc.ec.europa.eu/, which according to EC plans will also contain data on pollutants.
18. See https://medsdisposal.eu/ for a relevant campaign.
19. For a project embedding ammonia reduction in cattle husbandry, see the ProteCow project (https://www.interreg-protecow.eu/) , with the contribution of Living Labs Circular at Inaigro (https://inagro.be/living-lab-and-cocreation), based in Belgium.
20. For a comprehensive regional Living Labs to leverage digitalisation in this see Occitanum (https://occitanum.fr/) and its several Open labs, facilitated by the Earth Observation Living Labs (https://e2l-coop.eu/en/home-page/) .
21. See for instance the Mittegarden project (https://www.torinocitylab.it/en/mitte-garten), supported by the Living Lab Acquaponica proGIreg financial facility (https://www.torinocitylab.it/it/news/636-aquaponica) of the Torino City Lab (https://www.torinocitylab.it/en/).
22. See in particular the EU Water Scarcity and Drought Policy.
23. This is for instance what happens at the Energy & Water Greater Copenhagen Living Labs Energivand (https://energiogvand.dk/en/frontpage/). In the same city, a Living Lab for Urban Nature will measure pollution at street level and test out creative solutions to improve urban space like flower planting, placement of vertical rain gardens and the reuse of building elements to design wooden urban furniture (https://www.arup.com/projects/living-lab-for-urban-nature). For a list of Urban Nature Living Labs and a handbook on how to set up one, see https://climate-adapt.eea.europa.eu/en/metadata/projects/urban-nauture- labs, funded by Horizon 2020. Case studies can be found in the Regreen project (https://www.regreen-project.eu/urban-living-labs/).
24. For instance, trees are very important both for city environment and for healthy soil, the water cycle and clean air. A very comprehensive project (https://www.deshommesetdesarbres.org/) is supported by Lorraine Smart Cities Living Lab (https://erpi.univ- lorraine.fr/projects/lorraine-smart-cities-living-lab/).
25. See https://2isecap.eu/ for a systematic and participatory planning approach for viable plans and projects.

Annex 2
Specific recommendations

Specific recommendations for businesses

- **Industry Associations:**
  Trade associations should construct processes of original discussion on the theme of Zero Pollution and look to Living Labs as an opportunity to think outside the box. They should also focus on transitioning out of 'stranded assets' while simultaneously fostering innovation.

- **Large Innovative Companies:**
  These companies should be aware of the world of Living Labs and engage in a mutually fruitful dialogue. They should cooperate with Living Labs under clear non-disclosure agreements and recognise that open innovation, including Living Labs, may cut the time-to-market (in particular for utilities operating in fields such as digital infrastructure and services, water and waste management, electricity, and transport).

- **Local and export-oriented SMEs:**
  SMEs should set up a dialogue with Living Labs, which can provide a map of green digital solutions as well as other relevant components for the Zero Pollution horizon. Living Labs can locally mobilise demand for products characterised by Zero Pollution, helping to cut the payback period of investments. Innovative SMEs can quickly expand their market, including abroad, thanks to the network of Living Labs, operating as a selective boost for products embedding the Zero Pollution trajectory.

- **Farmers:**
  Farmers can draw on rural and non-rural Living Labs to pose challenges, offer their solutions, and take specific steps toward sustainable agriculture.

- **Product 'Makers':**
  Do-it-yourself people and 'Makers', including those using 3D printers and additive manufacturing, should devote more attention to the specific sustainability of their solutions, designs, and energy sources. They are encouraged to establish structural links with Living Labs, even in some cases to be embedded in them and in their co-design activities, so as to enjoy much better conditions in coping with the Zero Pollution challenge.

- **Start-ups and Net-ups:**
  Future entrepreneurs and members of these communities should consider the 'incubator' side of Living Labs and actively participate in societal discussions around Zero Pollution to come up with innovations, and use Living Labs to understand the market and de-risk innovation.

- **Banks, investors, and venture capitalists:**
  The articulated financial world is invited to map innovations and early successes, taking clues from different sources, including Living Labs.

Specific recommendations for civil society

- **Environmental NGOs:**
  Environmental NGOs can extend their scientific underpinning of ecological activism to include methods of involvement and consensus-building in the fight for Zero Pollution.

- **Citizens:**
  Citizens should take an active part in the activities and governance of Living Labs. They can see them as an empowering platform, bringing their ideas to realisation. Living labs help foster intergenerational justice by bringing together different generations concerned about different mid- and long-term environmental and climate issues. Citizens should participate in public discussions around Zero Pollution and continue to demand that their governments take action. They should reduce their carbon and material footprint by changing their consumption habits, including through digital solutions. People with financial investments should consider their alignments with a future of zero emissions and Zero Pollution.

- **Patients with health problems:**
  Participation in the processes and the goals of healthcare delivery can take shape in Living Labs activities[26]; patient mobilisation and organisation can help bring the message of Zero Pollution to the authorities.

Specific recommendations for administrations at national, regional, and local level

- **City and Regional Authorities:**
  City and regional authorities should make Zero Pollution a priority and work towards creating Zero Pollution cities and regions, aligning with efforts on zero emissions, including in their use of EU funds. Cities and Regional Authorities should develop the appropriate innovative policy response, including via regulatory learning[27], to speed up the transition to Zero Pollution through digitisation. They can also collaborate with and support Living Labs to speed up the green and digital transitions. Cities of every dimension should be part of the conversation.

- **National Governments:**
  National governments can set ambitious pathways for Zero Pollution and create the regulatory and financial frameworks necessary to achieve them. They should include support to Living Labs and provide funding for Zero Pollution projects, so as to favour learning and future-proof competitiveness.

- **Cross-national regions and macro-regional strategies:**
  Open borders and common natural assets, such as seas, rivers, and mountains, have led – within the facilitative conditions of the European Union – to experiments in co-imagination, co-design, and co-management. They are invited to cope with Zero Pollution in a multi-sectoral and multi-lateral way and favour the rise of regional and transnational Living Labs.

26. See for instance the activities of the Neurolab at the Adacen Living Lab (https://www.adacen.org/index.php?m=que- hacemos&subm=investigacion&submm=living-lab) in Spain.
27. See on regulatory learning the JRC publication at https://publications.jrc.ec.europa.eu/repository/handle/JRC130458

Specific recommendations for academia and the living lab constituencies

- **The Living Labs World**
  Living Labs should take a leading role in creating and operating Open Innovation Community schemes for Zero Pollution in their territories. At least some Living Labs should make Zero Pollution their core activity and provide advanced solutions and methods as a reference point for European stakeholders. Other Living Labs should develop specific projects related to Zero Pollution and provide ongoing updates. Urban and rural Living Labs should actively monitor the Living Labs network and act as local entry points and matchmakers for solutions developed by other Living Labs. Living Labs should advance in institutionalising their role in the systems, and create agreements with the actors of the local territory.

- **Academia and Research Institutions**
  Universities, research centres, technical training units, schools and vocational training systems should embrace the trans-disciplinary nature of Living Labs, by recognising them as a key component of Open science, so as to drastically improve the impact of their research and education for Zero Pollution and sustainability.

#ZeroPollution