Agroecosystem Living Laboratories

Executive Report

April 2019

Table of Contents

Agroecosystem Living Laboratories

Introduction

Current environmental, economic and sociological challenges to our agroecosystems[1] are diverse and numerous, and can collectively degrade an agroecosystem's health and reduce its ability to support desired plants and animals. These challenges involve:

- The direct degradation of soils, water, and other resources present or used in our agroecosystems;
- Whole climate dynamics, such as increasingly frequent extreme weather events and increased atmospheric carbon dioxide (CO_2) which can impact agricultural yield and quality;
- Social issues and economic factors arising from trade or other market forces, as well as barriers to the adoption of practices and technologies by producers; and,
- A global need to provide growing populations with sufficient food, feed, fiber, and fuel.

Traditional approaches to research need to be rethought. The magnitude of these challenges requires comprehensive approaches involving producers and other partners in the development of effective and economically viable practices and technologies. National agricultural research institutes are considering applying the Living Laboratories approach to agriculture as a way to improve and protect agroecosystems. They envision that this approach can accelerate the adoption of new practices and technologies through the direct and explicit participation of all producers, scientists and other interested partners in the performance of scientific activities in real life experimental setups.

Living Laboratories

An early implementation of a Living Laboratory is credited to William J. Mitchell, at the Massachusetts Institute of Technology (MIT). Finalized in 2004, Mitchell developed the "PlaceLab", a highly instrumented apartment equipped to record the interactions of human beings with new technologies within their living environment. Research participants lived in the space, were comprehensively observed by instrumentation, and were included in discussions of results and improvements to the technologies being tested.

Living Laboratory formulations have gained traction since 2004. The European Network of Living Labs (ENoLL), a network of open and citizen-centric innovation ecosystems (stemming from European Union investments into Living Laboratories under the 6th Framework Programme for Research and Innovation), currently counts approximately 150 active members across six continents. Living Laboratories are now being used to improve practices and technologies in sectors including health care, urban planning, application design, service delivery and information management and technology.

The Living Laboratories approach, which builds on the three core principles of user centered innovation, real life experimental setups and private-public-people partnerships, has not been widely applied to

[1] An agroecosystem can be defined, as by the OECD (https://stats.oecd.org/glossary/detail.asp?ID=82), as an ecosystem under agricultural management, connected to other ecosystems. An ecosystem can be defined as a system in which the interaction between different organisms and their environment generates a cyclic interchange of materials and energy.

agricultural research and innovation, though these core concepts offer the potential to better address current agroecosystem challenges.

Agroecosystem Living Laboratories

The international Agroecosystems Living Laboratories (ALL) working group was formed following a presentation by Canada at the 2018 G20 Meeting of Agricultural Chief Scientists (MACS) in Argentina. Co-chaired by Canada (Agriculture and Agri-Food Canada, AAFC) and the United States (U.S. Department of Agriculture, USDA), this working group includes representatives of national agricultural research institutes from 10 countries[2] and the European Commission, participating on a voluntary basis.

Acknowledged in the 2018 G20 Agriculture Ministers' Declaration, the working group seeks to develop a framework to promote and catalyze collaboration around ALL, and to foster dialogue, standardization, and the sharing of knowledge and data related to ALL and their use. This report, a key deliverable for the working group, summarizes the current state of ALL use in participating countries, and presents mutually identified findings and opportunities related to its implementation.

For the purpose of the ALL working group and report, ALL are defined as: *Transdisciplinary approaches which involve farmers, scientists and other interested partners in the co-design, monitoring and evaluation of new and existing agricultural practices and technologies on working landscapes to improve their effectiveness and early adoption.*

This definition of ALL used by the working group builds on the core principles of a Living Laboratory, and applies them to the specific context of agricultural research. The three components of the working group's ALL definition form the basis of the analytical framework of this report (see **Figure 1**). To better understand the variety of current uses, ALL examples are analyzed against these three components:

- **Transdisciplinary Approach**;
- **Co-Design and Co-Development with Participants** (where "participants" refer to all individuals and groups involved in an ALL, including producers, scientists, citizens and other interested partners); and,
- **Monitoring, Evaluation, and/or Research on Working Landscapes**.

An ideal ALL implements all three components concurrently to accelerate the adoption of agricultural practices and techniques. This integration is what distinguishes ALL from more traditional research formulations.

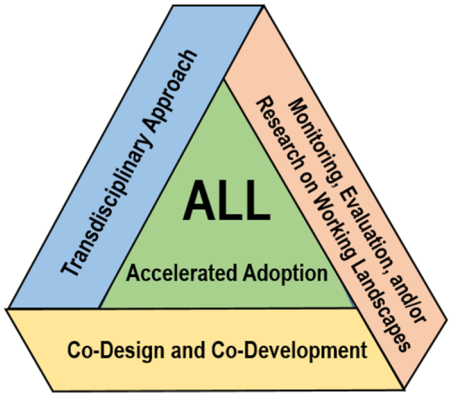

Figure 1: The three main ALL components

[2] Members include, alphabetically: Argentina, Canada, European Commission, France, Germany, Japan, Mexico, New Zealand, Turkey, United Kingdom, and United States of America. See **Annex A** for participants list.

Agroecosystem Living Laboratories Use

Analyzing Current ALL Use

ALL working group members shared their understanding of ALL and current use in their countries through two in-person meetings: a three-day workshop in Sherbrooke, Quebec, Canada (October 30 to November 1, 2018), and another in Oklahoma City, Oklahoma, United States (March 5 to 7, 2019).

Examples of initiatives presented by working group members provided the working group with reference material to analyze current ALL use, and helped the group to identify challenges and opportunities more broadly (see **Annex B** for country "Case Studies"). The names of these initiatives are captured in **Table 1**.

Table 1 - ALL examples presented by working group members

Country	Initiative Name
Argentina	Proyecto Regional con Enfoque Territorial (PRET)
Canada[3]	Living Laboratories Initiative
European Union	Projects and approach implemented in Horizon 2020 and in the European Innovation Partnership "Agricultural productivity and sustainability"
France[4]	Territoires d'Innovation (TI) projects + projects developed and funded in other frameworks and in other calls for projects at national and regional scales.
Germany	Facilitating insects in agricultural landscapes through integration of renewable resources into cultivation systems (FInAL)
Japan[5]	Projects funded by the Government of Japan and implemented by the National Agriculture and Food Research Organization (NARO)
New Zealand	Sustainable Food and Fibre Futures programme, Projects in the Primary Innovation research programme
Turkey	Projects within the General Directorate of Agricultural Research and Policy (TAGEM)
United States	Long-Term Agroecosystem Research (LTAR) network, including the Collaborative Adaptive Rangeland Management (CARM) project.

The working group assessed the activities of each initiative against the three components of the ALL definition. Each of the three following report sections expands on the meaning of these components and their application. This includes defining use in participating countries, and framing challenges and successes in implementation as they had been discussed by the working group.

[3] Canada will have two living laboratories established by April 1, 2019. They are currently in the implementation phase. There are three more sites in the planning phase.

[4] France's Territoires d'Innovation (Innovation Areas) projects are not yet implemented. A call for proposals is to be completed in April of 2019.

[5] Apart from the examples presented to the working group, Japan's Ministry of Agriculture, Forestry and Fisheries (MAFF) has 74 ongoing research projects that involve a team or consortium of participants including producers, scientists and other interested partners to establish clear research objectives, based on their on-site needs.

Transdisciplinary Approaches

By using transdisciplinary approaches to integrate participants with expertise in natural and social science disciplines, national agricultural research institutes can:

- Gather data on multiple dynamics at play in the performance of scientific activities and in the dissemination of results;
- Address challenges and develop solutions for complex problems facing agroecosystems using multi-pronged approaches; and,
- Maximize the contribution of all participants by empowering them to work together in an equal, meaningful and productive way.

The first component analyzed for a better understanding of current ALL use within case studies is the way different scientific disciplines are integrated within an initiative. We used the following categories to sort examples:

- ***Interdisciplinary****:* Expertise from several scientific disciplines is mobilised. Each discipline works on and reaches a separate conclusion. These separate conclusions are then considered and integrated to a varying degree.
- ***Transdisciplinary****:* Expertise from several scientific disciplines is mobilised. All disciplines work together and seek to collaboratively reach one set of conclusions. Partners and producers engage directly in the formulation and performance of science and innovation activities.

By integrating multiple and diverse disciplines into the analysis of an issue, including not only natural sciences but also social sciences, research teams can identify and address barriers to adoption of practices and technologies more effectively. Another benefit in the use of a transdisciplinary approach is the increased variety of data collected, and the ability to comprehensively analyze this various data alongside other participants in the ALL.

In case studies presented by member countries (**Table 2**), most examples use Interdisciplinary approaches and combined disciplines from the natural sciences (e.g., genomics, taxonomy, soil science). In several examples, including Argentina, Japan, Germany, New Zealand, the U.S., and Turkey, economics are also integrated to identify an issue worthy of focus, or to analyze the economic impact of adopting a new agricultural practice or technique. New Zealand has incorporated geographers and sociologists into research teams to improve understandings of community values and

Beginning to Foster a Transdisciplinary Approach

In Canada, while sites and research have not yet been implemented, a transdisciplinary approach is the goal. Initial implementation of ALL sites has included focus-grouping and sociological analysis of participant engagement in the priority-building and issue-identification phase. The various groups involved in these initial phases, and their interactions, have also been analyzed and retained for future use and ALL implementation. This preliminary work at two sites, which will begin operations in 2019, will inform and help to improve the implementation of three more sites, to occur over the next five years.

attitudes, and behavioural scientists and psychologists to support improved adoption and behaviour change. Argentina utilizes social scientists to analyze a variety of innovation processes to improve institutional strategies for intervention. The mobilization of other social science disciplines (e.g., anthropology, communications, community development, diversity studies, education, facilitation or mediation, marketing, and political science) was identified as a challenge by working group members, as most national agricultural research institutes do not have broad capacities in these other disciplines.

Building transdisciplinary teams that can effectively bring diverse perspectives together in a constructive way was also identified as a challenge. Currently, only the U.S. example uses this approach, but this is a feature that Canada (see text box on page 6) and France aim to do in the ALL initiatives they are currently implementing.

Co-Design and Co-Development with Participants

By co-designing and co-developing activities with participants, national agricultural research institutes can:

- Build a community of trust between participants from various backgrounds, including producers, scientists and other interested partners;
- Increase participant engagement in ALL activities and outcomes; and,
- Improve the utility, effectiveness and adoption of agricultural practices and technologies through a user-centric innovation process.

How participants are engaged in scientific activities is the second component analyzed to better understand the level of use of ALL. The following categories are used to analyze engagement level:

- ***Input gathering****:* Engagement occurs at the beginning and end of scientific activities. Participants validate priorities or share experiences. Once research is completed, researchers may go back to participants to share results.
- ***Ongoing consultations****:* Engagement happens throughout the research project and results may be shared as they are produced. Participants have limited capacity to influence the research agenda.
- ***Co-design and Co-development****:* Participants are engaged in all phases of the project, including the identification and selection of issues, innovation activities, and the monitoring, evaluation or scientific activities performed.

Co-design specifically refers to a collaborative approach to identifying issues and planning scientific activities. Co-development refers to the active participation of producers, scientists, and other interested partners in the monitoring, evaluation, and/or research of new agricultural practices and technologies. In a well functioning ALL, with both elements present, the project can evolve on an ongoing basis, which strengthens the applicability of results, and fosters increased adoption of new practices and technologies.

Co-design and Co-development are already used by Argentina, New Zealand and the U.S. (see text boxes on pages 8 and 9), and will be applied in initiatives currently being launched by Canada, France and Germany.

Most working group members consider it challenging to implement co-design and co-development activities, but consider the implementation of this component as having the potential to increase adoption of new agricultural practices and technologies. More precisely, several working group members find it challenging to build structures to incentivize and maintain sustained engagement from producers without providing direct financial support. Another challenge identified by the working group was that the process for building trust among ALL participants and the associated skill set required to do so is not necessarily present within most national agricultural research institutes.

Co-Development and Decision Making with Participants at LTAR-CARM in the U.S.

In the U.S., the Long-Term Agroecosystem Research (LTAR) network is a coordinated, systems-level research initiative across 18 USDA Agricultural Research Service locations. At one LTAR location, the Collaborative Adaptive Rangeland Management (CARM) project is transdisciplinary and achieves continuous partner engagement through quarterly decision-making meetings, and weekly status updates in easy to understand pictorial and informatic formats. Partners are also involved in data collection and analysis. These practices give partners the chance to provide their input in an adaptive decision-making model, which has built greater interest and engagement within the broader community.

While the "Common Experiment" applied to all LTAR network sites decides the research topic (evaluating "status quo" and "aspirational" management), and partners do not necessarily identify it, all other aspects of design and implementation are done collaboratively with partners, including multiple user groups and integrating diverse research disciplines.

Monitoring, Evaluation, and/or Research on Working Landscapes

By monitoring, evaluating, and/or researching agricultural practices and technologies on working landscapes, national agricultural research institutes can:

- Capture data on multiple dynamics at play in real agricultural contexts, allowing for the development of more practical and comprehensive practices and technologies;
- Validate practices and technologies in real life experimental setups, during the performance of research and development; and,
- Accelerate adoption, as initial adoption by producers occurs during development, within the community of the Agroecosystem Living Laboratory, on working landscapes, in a way that can be scaled-up.

The third component of the ALL definition defines the contexts within which scientific activities are performed. This report categorizes the landscapes on which monitoring, evaluation, and/or research are performed as:

- ***Public land/demonstration site****:* scientific activities are either performed or demonstrated on publicly owned lands.
- ***Private land/demonstration site/subsidized****:* scientific activities are performed on privately owned lands, but with either subsidies or some other mechanism that decreases the risk for producers.
- ***Private land/not subsidized****:* Activities are performed on a producer's lands, and participation is not subsidized. Participation occurs not through direct financial incentive, but through a participant's interest, engagement and access to the ALL community.

Of case studies with activities that are currently being implemented, two are on private, non-subsidized lands: the Argentinian PRET Network (see text box), and the New Zealand Sustainable Food and Fibre futures programme, which undertakes projects, co-designed by researchers and community groups on both private and public land.

PRET Network – Innovative Demonstration and Engagement

Within a national network, spread across the entire country, Argentina has found success in allowing producers to set their regional priorities, and communicate their needs, making use of the advantage of having research and extension in a single public institution. By following up with customized and innovative engagement and demonstration practices to address these needs, this network is applying innovations on private landscapes, without subsidy.

While this network is largely built around the concept of better communicating and transferring proven innovations and technologies to end-users, their lessons learned in engagement and real life setups could be useful for the implementation of ALL elsewhere.

Other examples use the traditional model applied by national agricultural research institutes, which historically involves the use of demonstration sites or direct incentives to reduce the risks of scientific activities for producers. Increasing the producer's tolerance to risk and failure, and getting them to see the benefit of participation in ALL is a challenge. This highlights a question repeated by the broader group as to how participation can be or is incentivized. The sustainability of using financial incentives for participation, the financial sustainability of localized ALL communities, and the wider adoption of new practices and technologies are also of concern.

Application of the ALL Components, in Summary

As has been found through analysis and in drafting this report, the transformative power promised by the ALL approach can best be captured when an initiative implements the three components analyzed here simultaneously and comprehensively. The activities within examples of use in this report can be placed on three continuums:

- Under the transdisciplinary approaches component, the continuum ranges from the performance of research through the lens of a single discipline of research, to the integration of producers, scientists and partners in a transdisciplinary approach to research and innovation;
- Under the co-design and co-development component, the continuum ranges from scientific and innovation activities occurring without the participation or input of producers and partners, to the involvement of all relevant participants in the co-design and co-development of scientific and innovation activities, practices and technologies; and,
- Under the monitoring, evaluation, and/or research on working landscapes component, the continuum ranges from scientific and innovation activities occurring in the controlled environment of a lab, to monitoring, evaluation, and/or research on the producers' working landscapes without financial subsidy.

The ALL approach and its intended benefits are most likely to manifest when an initiative progresses along all three of these continuums simultaneously. While a shift to applying these three components results in increased complexity and the possibility of increased risk, it has the potential to: increase the relevance and impact of scientific activities; accelerate innovation and adoption; and, empower participants to tackle more complex challenges facing agroecosystems.

Table 2 - Country examples with components categorized

Country	Disciplinarity	Level of Co-design/Co-development	Types of Landscapes
Argentina[6]	Inter and some trans	Co-design/Co-development	Private/not subsidized
Canada*	Trans	Co-design/Co-development	Private/subsidized/not subsidized[7]
European Union	Inter and some trans	Ongoing Consultation[8], Co-design/Co-development	Public/demonstration, private/subsidized
France*	Trans	Co-design/Co-development	Public/private/ demonstration/subsidized
Germany	Inter	Co-design/Co-development	Private/demonstration/ subsidized
Japan	Inter	Ongoing Consultation	Private/demonstration/ subsidized
New Zealand	Inter and trans	Co-design/Co-development	Public/private/ demonstration/not subsidized
Turkey	Inter	Input Gathering	Public/demonstration
United States	Trans	Co-design/Co-development	Public/demonstration

* Initiative currently being implemented. Scientific activities are not yet being performed.

[6] The Argentinian example captures a well performing PRET case and is not necessarily representative of the entire PRET network.

[7] The Canadian initiative aims for a non-subsidized approach, while the program currently allows for subsidy in certain cases.

[8] The European Union projects mentioned here are funded under the "multi-actor approach" created in Horizon 2020, in 2014 (with over 100 individual projects active in the spring of 2019). The legal requirement for these projects is for co-design and co-development. While a good proportion of the projects reach this level of engagement, some do not attain this level and remain at "ongoing consultation". Most innovation projects (800 currently active) within the Common Agricultural Policy (CAP) involve co-design / co-development.

Findings and Opportunities

The ALL working group fulfills its mandate through the completion and distribution of this report. The findings and opportunities identified below may be useful to inform future national activities, or voluntary international cooperation or consultation going forward. These findings and opportunities were identified and validated during workshops in Sherbrooke, Canada (October 31 to November 2, 2018) and Oklahoma City, United States (March 5 to 7, 2019).

Finding 1

ALL is a comprehensive approach to deal with complex issues

- Complex challenges in the agricultural sector require comprehensive approaches to address them. Given that Living Laboratory approaches have been successfully applied in other fields to address complex issues, we expect that using ALL can lead to similar success in agriculture.
- Integrating all relevant partners using a transdisciplinary approach may increase operational transaction costs. However, by increasing the complexity of analysis through ALL, the expectation is that these costs will be greatly offset by the significant increase in benefits of using this approach, including accelerating the adoption of new agricultural practices and innovations.

Finding 2

Applying and integrating all three components of ALL offers the greatest benefits

- What really distinguishes the ALL approach from more traditional research formulations is the integration of its three components (i.e., transdisciplinary approaches; co-design and co-development with participants; and monitoring, evaluation, and/or research on working landscapes).
- The transformative power of ALL resides in the successful integration and application of these three components in a comprehensive way, taking into account specific national and sub-national contexts.

Finding 3

Participating countries are applying components of ALL already

- Each country example demonstrated the use of some aspect of the ALL components. This can be attributed to the fact that national agricultural research institutes are working to improve existing mechanisms to formulate research, development and innovation for the public good.
- All participating countries have existing programs with inspiring features. Some countries are already using and implementing transdisciplinary approaches; others are co-designing and co-developing activities with participants; and others are performing monitoring, evaluation, and/or research on working landscapes without providing financial subsidies to producers.

Finding 4

Implementation and interest in ALL is increasing

- All participating countries indicated growing interest in the ALL approach and its components as a framework for implementing scientific and innovation activities. Several working group members are shifting existing projects and initiatives to better align with this approach.
- Canada and France are rolling out comprehensive initiatives that aim to apply the ALL approach as a whole, giving significant consideration to the three components of the ALL definition.
- Outside of the working group, several multilateral organizations, including the Food and Agriculture Organization of the United Nations and the Global Research Alliance, have expressed interest in the ALL approach, and look to this new formulation of research as a promising avenue to accelerate the adoption of innovative practices and technologies.

Opportunity 1

Implementing the ALL approach could help us respond more effectively to agroecosystem issues, and increase the speed and spread of adoption of new practices and technologies

- Working group members have expressed a realization that the paradigm shift presented by ALL could allow for an acceleration of adoption, on a scale and timeframe necessary to address local and global challenges facing agroecosystems.
- Working group members agreed that the ALL approach outlines a promising framework and approach to tackling agroecosystem challenges.

Opportunity 2

ALL creates opportunities for innovation, and scientific research

- There are additional ways of thinking of using the ALL approach in environmental and sustainability research. Some examples include:
    - One approach in the U.S. is to comprehensively monitor the DNA in a working dairy production system, including the soil, forage, cows, ruminal microbiome and manure. Human management of the system, as well as diverse biological components, are analyzed to understand how all of the living aspects of the system effect outcomes in the broader agroecosystem.
    - Using the ALL approach to engage producers and other partners could accelerate the adoption of climate-smart technologies. This is suggested in the concept paper by Japan for discussion at MACS 2019, titled "International Collaborative Partnership to Scale out Climate-smart Technologies through Social Experiment-like Approaches."
- There are also opportunities to explore use of the ALL approach beyond environmental and sustainability research areas, such as focussing on other aspects of food production and consumer sciences, or applying ALL in additional research settings, such as the urban agricultural environment.

Opportunity 3
There is interest in working together on ALL
➢ Following the actions of the working group, the possibility of building a broader international community of practice is being considered, around issues of common interest. ➢ There are aspects of ALL where several participating countries have expressed interest in working together. Preliminary topics discussed for further exploration include: • Governance of ALL (participation incentives, management practices, decision making process); • Practices to manage information and data; • Integration of more social science disciplines; and, • Development of quantitative and qualitative ALL impact indicators.

ANNEX A - Working Group Members

Country (Alphabetical Order)	**Name**	**Title**
Argentina	Eduardo Cittadini	Ph.D. National Coordinator of the Programa "Regional and Territorial Development", Instituto Nacional de Tecnología Agropecuaria (INTA)
	Pablo Mercuri	Ph.D. Director of the Research Centre on Natural Resources, INTA
	Martín Irurueta	Ph.D. National Coordinator of Research and Development, INTA
Canada	Javier Gracia-Garza (co-chair)	Director General, Ontario-Quebec Region, Science and Technology Branch (STB), Agriculture and Agri-Food Canada (AAFC)
	François Chrétien	Associate Director of RDT, Living Laboratories Initiative, STB, AAFC
	Samantha David	Policy Analyst, International Engagement Division (IED), STB, AAFC
	Yannik Melançon	Acting Deputy Director, IED, STB, AAFC
	Mathieu Rioux	Rapporteur, STB support, AAFC
European Commission	Marc Duponcel	Ph.D. Head of Sector Research, Directorate-General for Agriculture and Rural Development
France	Hervé Guyomard	Director of Research, Institut national de la recherche agronomique (INRA)
	Christian Huyghe	Director of Research, Scientific Director for Agriculture, INRA
Germany	Jens Dauber	Prof. Dr., Head of Institute, Thünen Institute of Biodiversity
Japan	Naoaki Kamoshida	Director, International Research, Agriculture, Forestry and Fisheries Research Council Secretariat (AFFRCS), Ministry of Agriculture, Forestry and Fisheries
	Hiroyuki Tanaka	Team Leader for preparation for G20 MACS, International Research, AFFRCS
	Kazuyuki Ono	Deputy Director, International Research AFFRCS
	Makoto Sato	International Research Expert, AFFRCS
	Sohei Kobayashi	Head of International Relations Office, National Agriculture and Food Research Organization (NARO)
	Makoto Kaneko	Senior Researcher, NARO
Mexico	Ramon Ignacio Arteaga Garibay	Director, Centro Nacional de Recursos Genéticos, Instituto Nacional de Investigaciones Forestales Agricolas y Pecuarias
New Zealand	Steve Kelly	First Secretary – Agriculture and Trade, New Zealand Embassy to the United States.
Turkey	Dilek Kahraman	Director, Turkey International Agricultural Research and Training Centre (IARTC)
United Kingdom	Brian Harris	Head of Strategy – Agriculture, Food and Environment, Biotechnology and Biological Sciences Research Council (BBSRC)
United States	Marlen Eve (co-chair)	Deputy Administrator, Natural Resources and Sustainable Agricultural Systems, Agricultural Research Service (ARS), U.S. Department of Agriculture (USDA)
	Genevieve Croft	Advisor for International Affairs, Office of the Chief Scientist, USDA
	Justin Derner	Supervisory Research Rangeland Management Specialist, ARS, USDA
	Dannele Peck	Director, Northern Plains Climate Hub, ARS, USDA
	Jeff Vallet	National Program Leader for Food Animal Production and Co-leader for the National Program for Grass, Forage and Rangelands Agroecosystems, ARS, USDA

ANNEX B - Country Case Studies

Argentina

Territories are dynamic spaces, complex, under construction, with biophysical and social components in conflict. Its complexity requires a participatory, inter-institutional and interdisciplinary approach. In this framework, innovation in the territories (technological, organizational and institutional) is seen as a socio-technical process of continuous change in the forms of production, marketing or organization which implies both technological and empirical scientific knowledge, and which involves the traditions, the culture, the history and the social and institutional plots in a certain territory, in which they transform and generate products, processes and methods, which in turn feed back the process.

In recent years, INTA has adapted its programmatic instruments in pursuit of an institutional strategy that allows a better approach to territorial complexity. In 2014, 120 Regional Projects with Territorial Focus (PRET) distributed in all the provinces of the country, formally initiated their activities.

To make the implementation of the PRET operative, territories were delimited as geographical areas, knowing that these spaces did not fully coincide with the different territories, but in a compromise between the conceptualization and the practical possibilities of implementation. The general objective of the PRET network was "to promote innovation processes in the territory to contribute to the development of the actors and productive systems present in the region".

The implicit working hypothesis is that the promotion of innovation processes that contribute to sustainable local development requires a management strategy that addresses the problem integrating the strategic components of INTA: Research and Technological Development; Transfer and Extension; Institutional Relations; Technological Linkage; and, Information and Communication. For this, it is necessary to take advantage of all the resources of the region, cultural, social and economic, as well as agro-ecological, and all productive economic opportunities, institutional and environmental partners that the territory provides.

Therefore, the different social actors are active parts of the PRET and for this their capacities and competencies are strengthened; and organizational agreements, supervisions, evaluations and responsibilities are established. Thus, the project advances towards a greater understanding of the innovation systems, which encompass policies, institutional capacities, organizational processes and social relations.

In addition, for research to contribute definitively to territorial development, research activities arose from the demand of the territory and therefore are executed and validated in it. The methodology of the projects is based on the creation of an integrated system of research and extension in the territory and the development of joint actions formed by institutional projects and other institutions.

With the joint action of research and extension aimed at solving the problems of the territory, the training of human resources, the improvement of business management, the management of market information, and the organization for marketing, projects tend to the transformation of complex and problematized regions.

The process began with the participatory identification of needs and demands of the productive sectors and the community of each territory. In in this context, those needs and demands are addressed by the

extension and the research service working articulately. Research is performed in both real (Participatory Action Research) and controlled conditions (in research stations and institutes). Research agenda is managed and coordinated by 17 National Programs. ProFeder9 and other institutional and extra-institutional projects support the general strategy.

Due to its complexity, the PRET management model is based on a planning, monitoring and evaluation process that is systematic and ongoing on the part of all project participants through the local management teams. After four years of implementation, the results of the PRET network varied across the country, strongly depending on the project management and technical team and its strategy for implementing the intervention. In those cases in which partners really participated in the definition of the problems, the identification of key issues and the development of technological and organizational solutions, the engagement was a success and the results promising. However, long term analyses are needed to evaluate the impacts. Presently, the PRET initiative evolved from projects to territorial innovation platforms, starting the implementation of the new instrument in 2019.

Canada

The Canadian Agroecosystems Living Laboratories (ALL) initiative is built on three key pillars: A user-centered innovation approach, in which producers, scientists and other interested partners work together throughout the performance of scientific activities; a Private-Public-People Partnership, involving participants from various disciplines and backgrounds to tackle a common issue; and, real life experimental setups, such as working farms as the incubators for new agricultural practices and technologies.

Recently launched, the Living Laboratories initiative led by Agriculture and Agri-Food Canada (AAFC) will involve the establishment of five ALL across Canada over the next five years. While none of these labs are yet performing scientific activities, co-identification of priorities and other community building work with a wide variety of participants has occurred. Using focus groups and interaction theories, the first two sites under development aim to co-design and co-develop project activities while ensuring complementarity between all participants to ensure equal engagement on identified priority issues specific for each ALL site.

The Living Laboratories methodology that will be applied in each site will focus on working with producers and other interested partners throughout the innovation process. This could involve testing Best Management Practices (BMPs) against participant needs and interests, co-designing the refinement of technologies with producers, scientists and other interested partners or going into an exploration and experimentation phase to acquire new data, conducting research activities and developing new knowledge in real life experimental setups. To be true to the Living Laboratories co-development concept and innovative approach, AAFC organized five engagement sessions across Canada in 2018. The objectives of these engagement sessions were to introduce the draft initiative and receive feedback from diverse groups of partners on: regional environmental health priorities; involvement, roles, responsibilities, and contributions of potential partners and end-users; and, key criteria to be used in site selection processes.

Results from these sessions were fundamental in defining an ALL roll-out plan and to target environmental issues that will be investigated through the initiative. The Canadian network of sites will

[9] Programa Federal de Apoyo al Desarrollo Rural Sustentable

be established via a phased implementation: two ALL sites will commence operations by April 1, 2019, in central and eastern Canada; two additional sites in central-eastern Canada will be established by April 2020; and, one more site will be established in western Canada by April 2021. Establishing the network in phases will ensure an adaptive management capacity, which will ensure that these projects achieve objectives and desired outcomes of the Canadian Agroecosystems Living Laboratories Initiative.

The AAFC approach involves the establishment of these central sites through which the activities of ALL can be performed. To enable collaboration in ALL, AAFC has identified funding to enable both federal departments and external partner participation in activities. Working with transdisciplinary science teams, AAFC aims to ensure that project proposals for science activities at ALL sites are aligned with the broader ALL concept, and address mutually identified agri-environmental priorities for the area. Within this co-development of ALL proposals, internal and external applicants for each site define specific roles and responsibilities, project objectives and desired outcomes.

Once specific ALL scientific activities begin to take place, the goal of the broader ALL community in each location will be to evaluate results and adjust activities based on participant engagement and feedback. The goal is an iterative process, where the planning phase begins once more when a conclusion is reached, seeking to further improve and build on results, creating a feedback loop for continuous cycles of co-development, and co-design of scientific activities with all participants. This iterative loop continues until technologies are viable both from a scientific perspective and from the participant's point-of-view.

European Union

Agricultural research amounts roughly to €1.8 billion in Horizon 2020 in the European Union (EU) Framework Programme for Research and Innovation. EU investment levels in agriculture (and in most other areas) amount to about 10-15% of public R&I investments made by EU Member States. Hence, part of the value added of EU agricultural R&I consists in fostering integration and synergies of R&I between Member States so as to maximise impact.

As part of the Innovation Union of Europe 2020, **European Innovation Partnerships** (EIPs) were established to boost innovation in relation to major societal concerns[10]. EIPs act across the whole research and innovation chain, bringing together all relevant actors at EU, national and regional levels. They streamline, simplify and better coordinate existing instruments and initiatives.

Among those, the EIP "Agricultural Productivity and Sustainability" (EIP-AGRI) benefits from a unique setting as it is implemented through both Horizon 2020, the Framework Programme for R&I, and the rural development component of the Common Agricultural Policy (CAP).

The EIP-AGRI aims to foster innovation through the involvement of all relevant actors (farmers, foresters, advisors, cooperatives and industry, etc.) in a **process of knowledge co-creation** from the very beginning of the research and innovation process. This is what is referred to as the **interactive innovation model**. With the EIP-AGRI, the interactive innovation model is set in motion by a variety of measures or instruments under the CAP (bottom-up innovation projects at local and regional level) and

[10] EIPs have been established in five areas: active and healthy ageing; agriculture; water; raw materials; smart cities and communities.

Horizon 2020 (at transnational level), **combining bottom up and top down approaches to maximise impact**.

With Horizon 2020, the focus is set on the implementation of the specifically developed concept of **multi-actor approach** (MAA) in collaborative projects, aiming to involve all the actors in a process of genuine co-creation of knowledge (e.g. farmers, foresters, industry, product users or consumers) across all the phases of project formulation and activities. These projects are transnational, involving international consortia with about 10-20 partners from at least three Member States (in general at least ten Member States) and with a total budget amounting in the range of €4-6 million.

Out of a total of €1.8 billion invested in activities regarding sustainable food security and rural territories, about 60%, one billion, concern multi-actor projects. First statistics show that the multi-actor topics have attracted **48% participation of newcomers** to Horizon 2020, against 30% for non-multi-actor topics. These newcomers are mostly agricultural professional organisations, technical institutes, specialised education bodies and demonstration farms. These newcomers bring new knowledge and working approaches to the programme.

Moreover, knowledge exchange is facilitated by boosting requirements for focused outreach activities and providing support to transnational networks such as **thematic networks** that target particular sectors or issues and networks of experimental and demonstration farms. These networks strengthen the connections between the relevant actors and facilitate the inventory and use of knowledge as well as the collection of tacit knowledge.

Living Labs have come up spontaneously in a few projects in the period 2014-2020 in the area of agricultural and rural development R&I, mostly as a way to anchor the multi-actor approach in given places. In the future, with Horizon Europe, which will be implemented in the period 2021-2027, it is envisaged to reinforce the place-based part of multi-actor projects and to work more at the level of landscapes, which are considered a critical geographical scale for R&I work regarding sustainable farming practices. Preparatory work is on-going to design potential support for Agroecology Living Labs.

France

Recognizing a need to increase the rate of adoption of innovations in agriculture and agri-food, and to address competitiveness, environmental and societal concerns facing agriculture and food chains, INRA seeks to develop several Living Labs (LL), notably but non exclusively under the French TI programme (Innovation Areas). Looking to perform research along the lines of economic and social effects for producers, consumers and territories, participatory theories to increase engagement, and natural sciences research to address issues affecting agricultural production, the LL projects look to have innovations developed and adopted on a shorter timeframe. As the TI projects are to be approved in 2019, results and concrete examples of co-design and real landscape work are not available yet. This is, however, another promising approach. One of the more interesting aspects of the LL design in France is the weight of decision-making power carried by each participant group. Producers, consumers, local and regional authorities and scientists will have equal say on the priorities and outcomes of the research and innovation – to allow for a truly egalitarian model of participation. Projects will include researchers in social sciences as well as researchers in natural sciences (ecology, agronomy, nutrition, etc.). They will also include research at the landscape level. TI Projects, which are currently co-

constructed and co-designed, include: a project on animal welfare and antibiotics' use in livestock in the west part of France; a project on water quality in the Region Bretagne around the town of Rennes; a project on the reduction of pesticides in vineyards in the South-West of France; and, at least two projects on food chains in the perspective of an increased sustainability of food supplies of towns. Projects are not limited to agriculture and food as al least one project concerns the sustainability of forest and forestry in the East of France. Several projects are developed outside the call for TI projects; they concern either a specific production (for example, the LL on animal welfare in rabbit farming) or both a production and a territory (for example, the LL devoted to the competitiveness and sustainability of annual crops in the ''plaine de Limagne'' (Auvergne), with a special focus of soil and soil quality). The intention of French research and education institutions is to use the LL approach for two main purposes: first, to facilitate adoption and acceptation innovations through their co-design by all stakeholders, from agricultural producers to consumers and citizens; second, to increase to transformation speed of research results into concrete innovations. These latter are of all kinds: they can be biological and technological, but also organisational or systemic (holistic).

In France, the TI action launched by the state [11] will dedicate around €450 million to original projects innovating in given territorial ecosystems, with agriculture and food as one of the possible areas of focus.

Germany

Inter- and transdisciplinary collaboration in research is well established in Germany. A Living Labs approach, however, has so far not been established in the context of agriculture. Germany faces a unique opportunity for the application of the Living Laboratory concept. With a recently developed and launched participatory research project (FInAL, https://www.thuenen.de/en/institutsuebergreifende-projekte/facilitating-insects-in-agricultural-landscapes-through-renewable-resources/) looking at beneficial practices for enhanced insect diversity, biomass and performed ecosystem services (natural biocontrol, pollination) in agricultural landscapes, Germany has looked to perform research directly in real landscapes. A landscape approach based on regionalised guiding principles ("Leitbilder") that encompasses both agricultural land and non-cultivated areas will be adopted by involving the participation of regional partners. The Landscape Laboratories (e.g. the landscape sections where identified measures for facilitating insect activity enhancement will be established) will be investigated with respect to their initial state, land-use options, and effects of measures on different features, primarily in relation to incidence and functionality (e.g. in integrated plant protection) of various groups of insects. The choice and implementation of suitable measures will be based on a co-design process involving partners. Prior to establishment in the landscape labs, the measures will be pre-evaluated at test sites, if necessary. The results from the landscape labs will be summarised and assessed in an integrative way with respect to effectiveness of measures, acceptance by practitioners, transferability to other agricultural landscapes and options for schemes of agricultural policies. Given the intended spatial and temporal scale of transformation to the cropping systems, challenges comprise incentivizing farmer participation financially, willingness of land users and land owners to enter into an innovative transformation process, and implementation of innovative practices which are outside the existing regulatory framework. With regulations surrounding research capabilities complicating the matter,

[11] https://www.caissedesdepots.fr/territoires-dinnovation-grande-ambition

Living Laboratories may meet some problems performing research on real landscapes, depending on research topic and participants.

Japan

The examples presented for the Japanese case were reported to have been research performed on working landscapes on priority issues identified by consortia of interested participants. While interdisciplinary approaches were partially applied in the two examples provided, the engagement of participants on identified issues provided an effective model for collection or evaluation of progress. In one of the examples, natural scientists established a grazing-promotion council for the targeted region. This council provided partners with opportunities for sharing the latest information and for discussions. A sociologist was also involved and contributed to the council to figure out and prioritize issues to be addressed for the social implementation of technologies by partners. Another benefit of the council composed of many partners is that research is developed or evaluated by partners including members of the public. Since the first council was dissolved, a smaller local council has been launched in a specific area by the municipality. The small network size is considered better for sharing the latest information and shaping solutions for specific issues in the area.

New Zealand

The terminology of Agroecosystem Living Labs (ALL) has not gained purchase in the New Zealand context, but research which reflects ALL's central principles (inter/trans-disciplinarity, co-design and co-development and monitoring and evaluation on working landscapes) has a long history stretching back to at least the 1960s and remains widespread today, including through relevant National Science Challenges "Our Land and Water" and "Resilience to Nature's Challenges".

The reform of the New Zealand agricultural science system as part of wider economic reform in the 1980s and 1990s had significant implications for the way research was funded, governed, delivered and shared with end-users. Where functions were once centralised under either the, then, Department for Science and Industrial Research or the Ministry of Agriculture, the government's core role today is as the science policy maker and research funder. Using this central lever to guide research investment, New Zealand's modern science system emphasises research that integrates the needs of land-users, industry, regulators and other stakeholders into research design, delivery and extension. A key feature of this system is an ongoing commitment to acknowledge and integrate Māori (New Zealand's indigenous peoples) values and mātauranga (knowledge) into research. This acknowledges both the significant financial interests of Māori in agricultural industries and their core environmental stewardship (kaitiakitanga) role in many ecosystems. As a result co-design and co-innovation are increasingly put to work to support interdisciplinary and transdisciplinary research which delivers improvements to agricultural productivity and sustainability.

In agricultural research, this is true both for smaller projects that affect a specific community, and larger multi-year projects that might have relevance for an entire productive sector. The Sustainable Farming Fund, administered by the Ministry for Primary Industries, is an example of the former and has provided funding for over 1000 individual community-driven research programmes over the last 20 years. These projects must be co-designed by researchers and local land-users, before joint funding is sought. The research takes place on working landscapes, often with specific local farms used for monitoring, evaluation and demonstration for the local community. The Sustainable Farming Fund was recently

incorporated into Sustainable Food and Fibre Futures, a co-investment fund supporting both small and larger projects created by businesses, non-government organisations, researchers, training institutions, Māori landowners, community groups, and industry bodies (see: https://www.mpi.govt.nz/funding-and-programmes/sustainable-food-and-fibre-futures/about-sustainable-food-and-fibre-futures/)

At the larger end of the scale, the seven year, Ministry for Business, Innovation and Employment co-funded, Primary Innovation programme is an example of individual agricultural research projects sharing ideas to foster co-learning and co-innovation to bring greater economic benefit and a more sustainable future for New Zealand. Primary Innovation comprises a set of nine research projects, which form the basis for understanding co-innovation across a range of industries. Projects cover nutrient management, heifer rearing, intensive forest management and integrated fruit production. Across the projects, co-design and co-innovation are championed, with inter-disciplinary research teams contributing to research often on working land. The cross-cutting success in these examples has been to raise the capability of researchers and communities in addressing challenges for specific agricultural landscapes and ecosystems.

Both the Sustainable Farming Fund and Primary Innovation examples highlight the focus on co-design (and co-funding) in the New Zealand system. While the scale of the project often has an impact on the level of inter-disciplinary input, smaller projects are often built on established relationships between researchers, research teams and local communities that rely on a deep knowledge of the social, economic and environmental challenges of land-users. With the project (or programme) of work the normal organising structure for research, a key challenge remains maintaining the relationship between researchers and land-users within individual projects, as well as making the most of the consolidated lessons which might flow from these.

Turkey

With research centres located in close proximity to agricultural producers, and as a source for scientific analysis and verification of samples from surrounding farms, Turkey's agricultural service provides support and advice to farmers in relation to, and in support of, their production. Turkey also has a contingent of economists to help provide cost-benefit analysis on research innovations and to allow for the communication of benefits of adoption of certain technologies and techniques. Some research has employed an income protection model to allow for research participation in real landscapes. The examples provided also communicated some of the cultural and economic issues that could affect adoption and implementation for producers. While most adoption is enabled through extension services, some of the demonstration activities approach a Living Laboratory – real landscape model.

United States of America

The United States (U.S.) has a network of 18 research centres, the LTAR (Long-Term Agroecosystem Research) network, that have established a "common experiment" across the various agro-ecozones of the country. This experiment, a validation and comparison of "business as usual" versus "aspirational" agricultural techniques, works with producers on their landscapes to identify potentially beneficial practices, prove their use, implement, and begin identifying potential practices once more as part of a cyclical approach. Some of the LTAR locations incorporate co-development, co-design, and engagement into the research performed. All LTAR sites, and in fact all USDA Agricultural Research Service (ARS) research, involve partner engagement in the development of research objectives and in

regular discussions of research results. Each site performs comprehensive analyses (local and regional) of the agroecosystem, with an emphasis on increasing our understanding of the interactions of genetics by environment by management (G x E x M). While challenges have been encountered in implementing the "common experiment" approach across all locations, notable successes have been documented. Another challenge stems from the volume of data collected, and the interoperability of the data across multiple sites to make truly nationwide comparisons – one of the goals of the LTAR network.

The most well-developed example of ALL across the LTAR network is the Collaborative Adaptive Rangeland Management project (CARM, https://www.ars.usda.gov/plains-area/fort-collins-co/center-for-agricultural-resources-research/rangeland-resources-systems-research/docs/range/adaptive-grazing-management/research/). This project takes place at the USDA ARS's Central Plains Experimental Range, a semiarid, shortgrass steppe rangeland socio-ecological system in the western Great Plains. CARM is a novel, participatory, co-production study with partners having full decision-making power for the entire project. Eleven partners represent ranchers, state and federal land managers, and non-governmental conservation organizations. The overarching goal is to conduct science at ranch-level scales with human dimensions for decision-making, to evaluate the effectiveness of adaptive management for triple win (win-win-win) scenarios for production, environmental, and economic aspects of this ecosystem. Partners are actively involved in all aspects of this project with full decision-making authority based on quantitative, repeatable measurements and monitoring information collected at multiple spatial and temporal scales. Weekly updates (https://www.ars.usda.gov/plains-area/fort-collins-co/center-for-agricultural-resources-research/rangeland-resources-systems-research/docs/range/adaptive-grazing-management/research/) provide pictorial and informatic figures for interpretation and conveyance of data/monitoring information/decision-making. Partners are leading technology transfer of information, including a project video (https://www.ars.usda.gov/ARSUserFiles/30123025/CARM%20video_final_2.mp4).

Another example is a comprehensive analysis of a large agroecosystem. This example contains less emphasis on co-design. Nevertheless, like all ARS research, partners are consulted and updated regarding progress of the research at regular focus group meetings. Researchers at the U.S. Meat Animal Research Center (USMARC) in Nebraska refer to this effort as a living lab approach to the problem of antimicrobial resistance in the landscape. All living components of an entire watershed are being comprehensively monitored for antimicrobial resistance. Measurements include the soil, water, livestock, extant wildlife (small mammals, etc.), and both migratory and resident waterfowl that contribute resistant microbes to the agroecosystem. By monitoring the living components of this system, the contribution of each to antimicrobial resistance in the entire landscape can be ascertained, to provide the true contribution of livestock and other living components to antimicrobial resistance.

The final U.S. example comes from the USDA Climate Hub network, which consists of 10 regional Hubs located throughout the country (https://www.climatehubs.oce.usda.gov/). The Climate Hubs' mission is to develop and deliver science-based, region-specific information and technologies, in collaboration with USDA agencies and other partners, to enable climate-informed decision-making in agriculture and natural resources management. An example technology is Grass-Cast (Grassland Productivity Forecast, https://www.ars.usda.gov/news-events/news/research-news/2018/grass-cast-a-new-experimental-grassland-productivity-forecast-for-the-northern-great-plains/), which uses the ALL framework, resulting in enhanced relevance and usability of the tool. Grass-Cast translates seasonal climate outlooks into grassland production estimates, which ranchers and other rangeland managers can then

use in their grazing management decisions. The Grass-Cast product benefited from: a transdisciplinary research team inclusive of both biological and social science disciplines; co-development with Federal, state, and local partners; and, informal evaluation and feedback from managers on both private and public working-lands.