Interdisciplinary Objects 2021

Application Form

Part 1: Project profile

Project title (in French):
Centre d'Etudes Interdisciplinaires sur la **B**iodiversité, l'**A**groécologie, la **S**ociété et le **C**limat

Project title (in English):
Center for Interdisciplinary Studies on **B**iodiversity, **A**groecology, **S**ociety and **C**limate

Acronym (in French and English): **C-BASC**

Description of the team making the project proposal:

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Note: References in the proposal text are footnoted and can be found in Appendix 5. These include journal articles and links to web pages providing short written and video overviews of work carried out by scientists in the C-BASC consortium

Résumé

C-BASC rassemble des scientifiques de 17 laboratoires de l'Université Paris-Saclay pour contribuer à l'étude, la conception et la mise en œuvre des transitions écologique et agroécologique par de la recherche, formation et innovation interdisciplinaires. La transition écologique, devenue le leitmotiv de la politique environnementale française, est une évolution vers de nouveaux modes de production et de consommation pour faire face aux défis conjugués du changement climatique, de la perte de la biodiversité, de la raréfaction des ressources et des risques environnementaux. La transition agroécologique porte plus spécifiquement sur le passage à des systèmes agricoles et alimentaires durables qui englobent les dimensions environnementale, économique et sociale. C-BASC aborde en particulier les défis scientifiques et sociétaux liés aux interactions entre la protection et la restauration de la biodiversité, l'adaptation et l'atténuation du changement climatique, et les transitions dans les systèmes agricoles et alimentaires qui augmentent les bénéfices sociétaux et réduisent les impacts environnementaux négatifs. Ce faisant, elle met l'Université Paris-Saclay en position d'être un acteur majeur de la transition vers la durabilité aux niveaux local, national et international.

La recherche et l'innovation dans C-BASC s'appuient sur une combinaison d'observations, d'expérimentations et de modélisation couvrant trois axes qui se distinguent par les niveaux d'organisation qui sont au centre de l'étude :

- **Comprendre et accompagner la transition vers des systèmes socio-écologiques durables**, en mettant l'accent sur l'étude des conditions d'émergence des comportements individuels, organisations sociales, politiques publiques et stratégies d'entreprise en faveur de biens publics (tels que biodiversité et services écosystémiques), ainsi que sur la conception innovante d'options de réponse qui contribuent à la durabilité.
- **La gestion des écosystèmes et la transition agroécologique**, en s'attachant à comprendre la réponse des écosystèmes naturels et agricoles aux changements environnementaux, ainsi que les leviers et obstacles à la mise en œuvre d'une gestion écologique des écosystèmes. Les solutions basées sur la biodiversité et contribuant aux transitions écologique et agroécologique font l'objet d'une attention particulière.
- **Les dynamiques et la gestion de la biodiversité**, avec un accent sur l'amélioration de la gestion de la biodiversité naturelle et de l'agrobiodiversité fondé sur les connaissances de la génétique, de l'évolution et de l'adaptation des espèces agricoles et sauvages ainsi que des interactions intra et interspécifiques.

La recherche favorisant **la durabilité dans les territoires périurbains**, tels que le Plateau de Saclay où l'université est située, est un axe particulier de C-BASC et englobe les trois niveaux d'organisation. Néanmoins, les recherches menées couvrent par ailleurs un large éventail d'échelles organisationnelles et spatiales et de contextes, y compris l'Europe et les pays du Sud. L'innovation au sein de C-BASC se concentre sur le transfert de connaissances et sur la co-conception d'innovations dans les systèmes agricoles et alimentaires avec les agriculteurs, l'industrie, les consommateurs, les décideurs politiques et un large éventail d'autres acteurs non académiques.

Les objectifs de formation de C-BASC se concentrent sur des programmes interdisciplinaires où nous pouvons jouer un rôle constructif en créant des liens entre cinq Graduate Schools (GS) et en renforçant les liens entre formation, recherche et innovation. Par exemple, Paris-Saclay a une forte compétence en matière de recherche et de formation sur les systèmes alimentaires, mais pourrait bénéficier d'un renforcement de son offre sur les approches interdisciplinaires de la durabilité des systèmes alimentaires. Dans ce cas comme dans d'autres, nous travaillerons avec les GS pour concevoir et mettre en œuvre une variété d'outils, notamment des programmes d'études interdisciplinaires, des cours couvrant plusieurs programmes de master ou de doctorat, des écoles d'été pour les doctorants et les scientifiques, et des cours basés sur des projets réunissant des étudiants de plusieurs disciplines pour aborder des problèmes sociétaux prioritaires pour l'université.

Executive Summary

C-BASC brings together scientists from 17 laboratories of the Paris-Saclay University to contribute to the study, design and implementation of the ecological and agroecological transitions through interdisciplinary research, training and innovation. The ecological transition, which has become the leitmotif of French environmental policy, is a shift to new ways of producing and consuming in order to tackle the combined challenges of climate change, loss of biodiversity, resource scarcity and environmental risks. The agroecological transition focuses more specifically on the transition to sustainable agricultural and food systems that encompass environmental, economic and social dimensions. CBASC addresses in particular the scientific and societal challenges related to the interactions between the protection and restoration of biodiversity, climate change adaptation and mitigation, and transitions in agricultural and food systems that increase societal benefits and reduce negative environmental impacts. In doing so, it puts the Paris-Saclay University in position to be a major actor in the transition to sustainability at local, national and international levels.

Research and innovation in C-BASC relies on a combination of observations, experiments, and models spanning three axes that are distinguished by the levels of organization that are the focus of study:

- **Understanding and accompanying the transition to sustainable socio-ecological systems**, with a focus on the study of the conditions for emergence of individual behaviors, social organization, public policies and corporate strategies in favor of public goods especially biodiversity and ecosystem services, as well as the innovative design of response options that contribute to sustainability.
- **Ecosystem management and the agroecological transition**, with a focus on understanding the response of natural and agricultural ecosystems to environmental change, as well as the levers and barriers to implementing environmentally sound ecosystem management. Biodiversity-based solutions that contribute to the ecological and agroecological transitions are a particular emphasis.
- **Dynamics and management of biodiversity**, with a focus on improving management of natural and agro-biodiversity based on knowledge of the genetics, evolution and adaptation of agricultural and wild species as well as intra- and inter-specific interactions.

Research **fostering sustainability in periurban territories**, such as the Saclay Plateau where the university is located, is a particular focus of C-BASC and encompasses all three levels of organization. More broadly though, research covers a wide range of organizational and spatial scales and contexts including Europe and the Global South. Innovation in C-BASC focuses on knowledge transfer and on co-design of agricultural and food system innovations with farmers, industry, consumers, policy-makers and a wide range of other non-academic actors.

Training objectives for C-BASC focus on interdisciplinary curriculums where we can play a constructive role in creating links between five Graduate Schools (GS) and reinforcing ties between training, research and innovation. For example, Paris-Saclay has strong competence in food systems research and training, but could benefit from strengthening its offer on interdisciplinary approaches to food system sustainability. In this case and others, we will work with the GS to design and implement a variety of tools including interdisciplinary curriculums, courses covering several Master's or PhD programs, summer schools for PhD students and scientists, and project-based courses bringing together students from several disciplines to address societal problems prioritized by the university.

C-BASC builds on an eight-year interdisciplinary research program "LabEx BASC" that was funded by the French government. In addition to pursuing stronger integration of disciplines to address key scientific and societal challenges, C-BASC reinforces research on the continuum of agricultural production, transformation, distribution and consumption of food. C-BASC will also play a decisive role in creating a 'Living Laboratory' for implementing the ecological and agroecological transitions on and around the Saclay Plateau in collaboration with a wide range of non-academic partners.

Part 2: General framework of the project

2.1 Description of the scientific, technical or societal issues addressed

International, National and Local Context

Interactions between agricultural and food systems, climate, and biodiversity are at the heart of the social, economic and environmental transitions needed to meet international, national and local sustainability goals[1]. These interactions have begun to receive considerable attention as a key sustainability nexus where trade-offs need to be recognized and avoided where possible, and where synergistic solutions are identified and implemented. Food systems – including agricultural production, transformation, distribution and consumption – are under tremendous pressure to provide food for a growing and more affluent population. At the same time, agriculture and food systems are also under tremendous pressure to become more sustainable because they are the primary driver of biodiversity loss at global and regional scales, a major contributor to climate change and a significant source of air, water and soil pollution[2]. Climate change will add to pressures on biodiversity and agriculture because it is projected to become a primary driver of biodiversity loss in the next few decades and have increasingly large impacts on agriculture and food systems[3]. As such, strong climate mitigation and adaptation measures are essential, and land-based measures can play a major role. But land-based mitigation and adaptation measures can have positive or large detrimental effects on biodiversity and food security[4]. Importantly, biodiversity must be viewed as more than just a conservation issue, because biodiversity can make major contributions to sustainable agriculture, to climate adaptation and mitigation, and to reducing air, soil and water pollution[5].

At the international level, the ambition of C-BASC is to contribute to the study and implementation of the United Nations' 2030 Agenda on Sustainable Development and the European "Green Deal". At the European Union level, the UN Sustainable Development Goals related to food, climate and biodiversity are reflected in four of the main elements of the recently adopted "Green Deal": i) Farm-to-Fork: designing a fair, healthy and environmentally-friendly food system, ii) Preserving and restoring ecosystems and biodiversity, iii) A zero pollution ambition for a toxic-free environment and iv) Increasing the EU's climate ambition for 2030 and 2050[6]. We aim to contribute to each of these individual elements, but also to the more difficult task of identifying and implementing coherent policies and strategies across multiple sustainability goals[7].

At the national level, the objective of C-BASC is to contribute to the study and implementation of two high-level policy, research and innovation objectives: the "ecological transition" and the "agroecological transition"[8]. Key elements of these interrelated transitions are the recognition that degradation of the environment is a serious problem, transformative change across all facets of society is urgently needed to address multiple environmental crises, and transformative change must address issues of economic and social justice. These transitions are of sufficiently high national policy priority that the French environmental ministry is titled the "Ministry of the Ecological Transition" and the agroecological transition is one of the main policy objectives of the agriculture ministry. The research strategies of our parent institutions reflect these high priorities[9]. The terms "ecological transition" and "agroecological transition" are highly polysemic, so it is important to define them and be explicit about the elements of these transitions addressed in C-BASC.

The "ecological transition" is defined in French environmental policy as an evolution towards a new economic and social model of sustainable development that renews our ways of consuming, producing, and living together to meet the major environmental challenges of climate change, resource scarcity, the accelerated loss of biodiversity and the multiplication of environmental health risks. Within this broad context, C-BASC focuses on the facets related to protection and restoration of biodiversity, land-based climate mitigation, adaptation of organisms, ecosystems and socio-ecological systems to climate change, and reductions in pollution.

The agroecological transition is a closely related policy objective that is a vital component of achieving the ecological transition. C-BASC's contribution to the agroecological transition can be broadly defined as the integrative study and design of the transitions to sustainable agricultural and food systems that encompass environmental, economic and social dimensions[10]. The science of agroecology has historically

put an emphasis on the agricultural production, so one of our challenges is to bring together the agricultural production and the food system aspects of the agroecological transition[11]. To this end, CBASC covers sustainable production, transformation, distribution, and consumption of food. The food system facets of our strategy focus on (i) changes in food consumption practices and their impact on the environment, (ii) design, production and distribution of foods with low environmental impact, iii) development of value for co-products in the logic of circular economy and (iv) identification of supply and demand levers to steer actors toward sustainable practices.

At local level, C-BASC addresses two of the societal challenges prioritized by the Paris-Saclay University: "Biodiversity, agriculture and food" and "Energy, climate, environment, sustainable development"[12]. These challenges acknowledge the importance of interdisciplinary research and innovation focusing on the biodiversity-agriculture-food-climate nexus, and we will work closely with our five partner Graduate Schools to develop research strategies to address these challenges (see Parts 2.2&2.3). An advantage of being part of the Paris-Saclay University is that it provides opportunities to establish local research and training partnerships that complement our existing strengths (see Part 2.3). For example, we will work closely with the "Convergence Institute CLAND"[13] which studies land-based climate mitigation and adaptation at large regional to global scales, to complement our work centered on territorial scales. We will also collaborate with the "Alliance for Climate Action Now" (AllCAN, led by engineering programs at Paris-Saclay) which is focusing on the energy, housing and transport sectors that are essential components of the ecological transition, but outside the scope of C-BASC. Other areas where we will build ties with the Graduate Schools and other local consortiums include animal sciences, health and hydrology.

C-BASC builds on achievements of the "Laboratoire d'Excellence" Biodiversity, Agroecosystems, Society, Climate consortium at Paris-Saclay University (LabEx BASC, www6.inrae.fr/basc). The LabEx BASC was funded by the French national government from 2012 to 2020. The C-BASC project brings together many of the same research teams as the LabEx BASC, but has reinforced the capacity to study food systems by integrating three new laboratories focusing on food science (see Part 2.3).

Interdisciplinary research and training are necessary to address the potential synergies and tradeoffs in achieving multiple production, social and environmental goals. To understand the complex relationships in the biodiversity-agriculture-food-climate nexus and to make contributions to decision-making in real world contexts, national and institutional science strategies highlight the importance of interdisciplinary research[14]. The acknowledgement that interdisciplinary research built on strong disciplinary foundations is critical to responding to societal issues is not new, but the need to make rapid and concrete steps to implement interdisciplinary approaches has become an imperative. Contributions to interdisciplinary research and to mobilizing this knowledge for decision making are among the most important added values of C-BASC.

One of the objectives of C-BASC is to reinforce links in research, innovation and training across a gradient of human intervention ranging from intensively cultivated to natural ecosystems. Studies in C-BASC cover the full gradient from high input agricultural systems at one end of the spectrum, to lightly managed semi-natural ecosystems such as some forests and wetlands at the opposite end of the spectrum, with many ecosystems such as pastures, prairies and managed forests in the middle. C-BASC capitalizes on the tremendous potential for synergies due to the similarity in the tools and concepts used to study ecosystems across the full range of this gradient[15]. In addition, the ecological and agroecological transitions are best addressed by treating the full gradient of these ecosystems and their interactions, and this is especially pertinent for the C-BASC project since most or our work is on multifunctional landscapes. Achieving this objective requires overcoming long-standing barriers that have separated policy and research on "agricultural" vs. "natural" systems (see Part 2.2).

Our research and innovation goals over the five-year time frame include:

- Increasing the international recognition of Paris-Saclay University as a hub for sustainability science in partnership with our associated Graduate Schools and research consortiums (see Part 2.3).
- Consolidating and following-up research activities initiated in the LabEx BASC, as well as the initiation of new inter-laboratory and interdisciplinary research on sustainable food systems.

- Strengthening of existing partnerships and creation of new partnerships with non-academic actors for knowledge transfer and co-design.

- Consolidation of a "Living-Lab" for the southwest periurban area of Paris (see Part 2.2).

With relatively modest funding from the university for the Interdisciplinary Programs, C-BASC cannot fund large projects and this proposal should, therefore, be read as a research, innovation and training strategy for the contributing teams and the university, rather than as a major research funding proposal. We will primarily operate through funding small projects on emerging research topics, supporting partnerships with non-academic actors, networking, and communication, but with an overall objective of leveraging additional resources (see Part 4). C-BASC benefits from substantial human resources with approximately 370 permanent staff contributing to research, innovation and training activities.

Research and Innovation Strategy

The research strategy of C-BASC is structured as a nested hierarchy of three organizational levels: Axis 1) examines the barriers and levers in socio-ecological systems that can facilitate or hinder the ecological and agroecological transitions; Axis 2) focuses more specifically on how management of natural and agro-ecosystems and the accompanying transformations of food systems can contribute to or hamper these transitions; and Axis 3) explores the capacities and limits of organisms, populations and ecological communities to adapt to rapidly changing pressures. A fourth axis on the study of sustainability of periurban areas integrates across these three levels of organisation. There are two reasons for choosing this hierarchical structure. First and foremost, complexity theory suggests that hierarchical approaches greatly facilitate the study of middle-number systems, such as ecosystems or socio-ecological systems[16]. To avoid overwhelming complexity, higher levels generally should not treat the detailed dynamics and processes at lower levels, whereas lower levels should treat much of the information from higher levels as external constraints. The dialog between the study of different levels of organisation is therefore through qualitative or quantitative simplification of possibilities passed up from lower levels and constraints imposed by higher levels[14]. Second, this structure brings together scientists working on the components of the biodiversity-agriculture-food-climate nexus within each organizational level. This hierarchical structure is not, however, intended to constrain research and design activities to a single organizational level.

Axis 1) Understanding and accompanying the transition to sustainable socio-ecological systems – The individual and collective appropriation of solutions for sustainability transitions are frequently hindered by unwillingness or incapacity of actors to change, and public policy incentives that are too weak or too broad to be effective. Overarching questions addressed in this axis include: i) What leeway is there for socio-ecological systems to evolve, and what transitions need to be organized to encourage the development of sustainable land management and food systems? ii) On what criteria should public incentives be based, and should they focus on results (e.g., ecosystem services, social benefits) or means (e.g., conservation actions, cropping practices, etc.)? iii) How do global drivers, such as climate change, global markets and international policy, interact with local drivers, such as land use planning and regulations by local governments, to influence local and global sustainability? Research and innovation activities in C-BASC that address ecological and agroecological transitions at the organisational level of socio-ecological systems include the:

- Study and design of response options that contribute to sustainability at local to regional scales including: land use planning; diversification of agricultural production; protection and restoration of natural habitats; creating the conditions that lead to reductions in food waste and transitions to healthy and sustainable diets – including innovation in food processing and distribution, policy, education, labeling and economic incentives; and creating a circular economy with our work focusing on use of organic residues as agricultural fertilizer and building local food supply chains[17].
- Study of feedbacks and interactions between local and global drivers especially those related to land use. This includes the study of how local and global drivers influence land use at local scales and in how in turn land use effects regional climate, biodiversity and pollution[18]. Economic costs of land use change and its impacts are evaluated through effects on land managers' income, costs of production, prices of agricultural goods and changes in consumer prices[19].

- Understanding and evaluation of the conditions of emergence as well as the effects of individual behaviors, social organization, public policies and corporate strategies in favor of public goods especially biodiversity and ecosystem services. We seek to understand decision processes (which result from private agents, including self-organized initiatives, and from public decision makers at various temporal and spatial scales) and their interactions to accelerate the movement towards more resilient socio-ecological systems. We also assess the expected and unintended effects of public policy instruments such as subsidies and other incentives[20].

Axis 2: Ecosystem Management and the Agroecological Transition – Understanding how ecosystems respond to environmental change and management, as well as the obstacles to implementing sound ecosystem management are a critical component of the study and design of socio-ecological transitions. How can agricultural ecosystems be managed to be more biodiversity and environmentally friendly? How can biodiversity contribute to the agroecological transition? How can food processing, distribution and consumption contribute to the agroecological transition? How can agricultural and natural ecosystems be managed to increase their contribution to climate mitigation and capacity to adapt to climate change? What are the barriers to and opportunities for implementing these management measures and how can obstacles such as insufficient knowledge transfer and lack of suitable management alternatives be overcome? To address these questions at the level of practitioners activities in C-BASC include the:

- Study and design of agroecological responses at farm, field and landscape levels including: i) biodiversity-based measures (see Box 1), and ii) changes in soil management, with a particular focus on tillage, pesticide and fertilizer use and soil organic matter amendments and their effects on soil carbon storage and greenhouse gas emissions, pollution, soil fertility, and soil biodiversity[21].
- Study and design of food system transformations including food transformation, distribution and consumption that facilitate the adoption of agroecological production practices. This will include, for example, overcoming barriers to greater incorporation of legumes in diets[22].
- Study of management strategies for forests and other natural ecosystems for climate mitigation – especially bioenergy and ecosystem carbon sequestration – and climate adaptation by favoring climate resilient tree species, increasing tree diversity, and thinning of forest stands[23].
- Understanding and prediction of climate change impacts on agricultural and natural systems and development of climate indicators for the agricultural and forest sectors[24].
- Evaluation of the multifunctionality of mixed-use landscapes in particular through innovative multicriteria approaches analyzed in collaboration with stakeholders. This includes the study and design – including through scenario development – of spatial patterns for agricultural and natural areas and of practices that connect biological populations, promote ecosystem services provision and support multifunctionality for economic, social, climatic and cultural benefits[25].

Box 1 – Biodiversity-based agroecological measures – Reinforcing biological diversity at the level of fields, farms and landscapes can potentially address multiple environmental challenges by reducing pesticide use, fertilizer use, soil erosion and nutrient losses, while at the same time enhancing biodiversity, resilience in the face of climate change, and biocontrol of insect pests. But there are often technical impediments, and biodiversity-based measures sometimes result in reduction in yields and increases in agricultural pests, weeds and diseases. Scientists in the C-BASC consortium study a wide range of biodiversity-based measures including on-farm selection of crops, varietal mixtures of crops, inter-cropping, diversification of crop rotations – especially by including leguminous crops, planting of flower strips and hedges and agroforestry[26]. Overcoming reluctance to adopt these measures will require demonstrating their efficacy across multiple criteria with experiments, observations and models; overcoming economic and socio-technical barriers to transformation, distribution and consumption in food systems; and co-designing viable means of implementation[27].

Axis 3: Dynamics and Management of Biodiversity[28] - To address the challenges of biodiversity loss and the contribution of biodiversity to the agroecological and ecological transitions, we need to better understand the mechanisms of rapid species adaptation at the population level, and species interactions at the ecological community level. How do species and ecological communities adapt to changing environmental pressures, such as climate change and habitat degradation, and biological pressures, such as diseases and changes in predator-prey relationships? How can analysis of genetics, genomics and the

deep history of evolution contribute to understanding adaptation and natural and artificial selection in plants and animals? How can this understanding be used to better manage agricultural and "wild" biodiversity and their interactions? Research focuses on:

- Understanding mechanisms of evolution, natural/artificial selection and domestication, relationships between genes and phenotypic traits, and the links between landscape structure, species community composition, population demography, management practices and characteristics of the ecosystems.
- Developing innovative fundamental approaches around questions related to the ability of populations or species communities, including domesticated ones, to survive and adapt to changing environments. This includes setting-up experimental designs to study species interactions including crop/insect or human/insect, as well as the role of social interactions.
- Monitoring and understanding the dynamics of biological diversity. This relies on (i) experimental designs that allow surveying spatial/generational changes of populations and communities, or on experimental evolution coupled with high-quality phenotyping; and (ii) the identification of molecular signatures of past demographic or selective events through molecular surveys of populations coupled with environmental measurements (i.e., molecular ecology).

We will also initiate a working group on methodological challenges such as genomics, phenotyping and the mathematical, statistical and computational modeling required to tackle the big-data associated with the analysis of high-throughput gene sequencing and phenotyping data.

Axis 4: Fostering sustainability in periurban territories[29] - This axis relies heavily on research carried out in the three hierarchical axes described above that addresses the specificities of periurban systems. Periurban systems are subject to new pressures and expectations that are particularly relevant to C-BASC objectives. These include new laws requiring for example farmland preservation in urban planning documents and the valorization of urban organic residues, and growing demand of urban dwellers for local food, periurban biodiversity, and reduction of air, soil and water pollution in the context of ongoing urbanization projects. Activities in this axis include:

- Land use and land management impacts on the environment and societal demands – We are analyzing how land use and management in periurban contexts impact agricultural production, biodiversity, and air, soil and water quality. We also analyze the biophysical processes at the interface of urban, agricultural and natural areas such as atmospheric exchanges and hydrology. An important dimension is the understanding of societal demands: Which ecosystem services are expected? Which management practices are desired or not?
- Territorial metabolism - Our aims are to characterize and design methods for managing material and immaterial flows between urban, periurban and rural systems, and to analyze the organizational and technical changes needed to better manage the ecological transition in periurban areas. These include changes in agricultural practices, urban gardens, consumer supply chains, recycling and waste recovery.
- Study and design of sustainable food systems – This focuses on the levers that enhance the role local supply chains and create synergies between local and external food supply chains. This includes an emphasis on participatory design that mobilizes a wide range of actors such as farmers, consumers, local politicians, and scientists.
- Adaptation of socioecological systems in periurban areas to global changes - This focuses on scenario development and prospective approaches in which we examine the vulnerability and resilience of periurban areas facing changes in demography, climate, land use, etc. This also involves analyzing the reaction of periurban areas to these changes using monitoring data and conceptual and numerical models. This axis includes biophysical and social science dimensions, and relies on strong interactions with territorial stakeholders.

The Saclay Plateau is an important proving ground for such studies because it is undergoing major changes and is a very rich "model" system in which we have recently made substantial investments. In particular, we will continue our fruitful collaboration with the agri-urban programs Terre et Cité and the Association de la Plaine de Versailles in the context of developing a "Living Lab" for the southwest periurban area of Paris (see Box 2 in section 2.2). The genericity of concepts and methodologies will be explored by comparing and sharing with other regions in France and abroad including the Global South.

Networks: Three topics that are transversal to all four axes have generated broad interest in the C-BASC community and will be supported by the establishment of networks:

- *Pollutants and ecotoxicology network* – This is a continuation of a local network that cooperates with regional and national networks to support research on the biological and physical dynamics of pollutants and and development of biological and technical solutions for environmental monitoring[30]. In C-BASC it will broaden its scope to cover evaluation and mitigation of the adverse side effects of pollutants in the context of global changes, as well as the analysis of the socioeconomic, regulatory and other responses that can reduce pollution.
- *Modeling network* – Mathematical models are heavily used in all fields of research in C-BASC[31]. This new cross-theme network will organize workshops and discussion groups on topics of broad interest to modelers such as open source code, hierarchical Bayesian methods, and model uncertainty. This network will also work with Graduate Schools to promote student participation in modeling courses and research.
- *Agroecology network* – This is the continuation of a local network established in 2018[32]. This interdisciplinary network will be reinforced with the arrival of food science colleagues and will collaborate with national agroecology networks supported by the IRD, AgroParisTech and INRAe.

Innovation: C-BASC seeks to engender and accompany transformative change through innovation in management practices, social organization and public policy. In particular, innovation activities focus on i) knowledge transfer by traditional methods such as providing expertise and decision support tools and ii) participatory approaches to the conception, application and evaluation of transformative solutions (i.e., co-design)[33]. These activities are intrinsic to much of the work described above. Innovation activities also include technological approaches (e.g., optical sensors for precision agriculture[34]), but this not our primary focus.

Knowledge transfer by C-BASC scientists takes many forms including providing expertise for practitioners such as farmers and natural resources managers; local governments; public agencies (e.g., Chambers of Agriculture, OFB – French agency for biodiversity, ADEME- French agency for the ecological transition); national agricultural technical institutes (e.g., Arvalis for cereals and Terres Inovia for oilseeds); national environmental, agricultural and justice ministries; and international assessments and conventions (IPCC, IPBES, CBD). Scientists in C-BASC also develop and deploy a wide range of decision support tools[35]. The role of C-BASC is to encourage knowledge transfer by supporting emerging knowledge transfer projects and enhancing awareness of the availability of expertise through our web site and other channels.

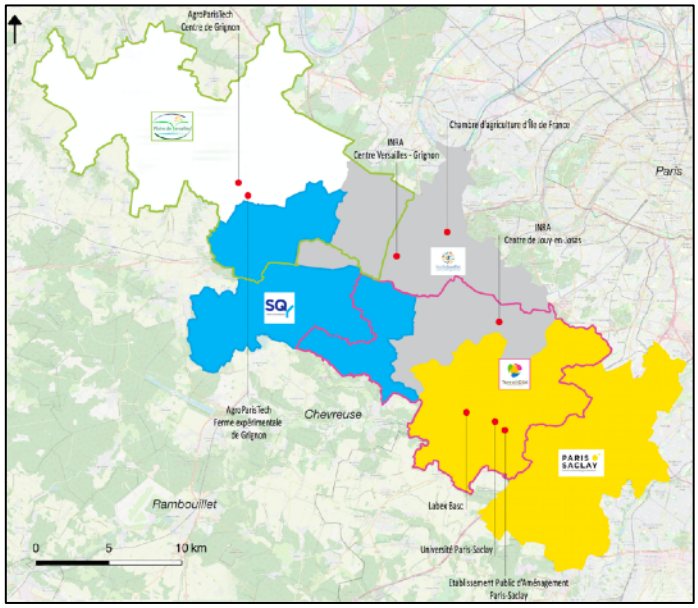
Co-design involves sustained dialog between researchers and non-academic actors in which all partners participate in the analysis of problems and the conception of solutions. C-BASC will intensify involvement in participatory approaches because they both enrich research and increase its socio-economic impact. C-BASC promotes these approaches through projects and networks, some of which also support national co-design actions such as the "Initiative for the DEsign in Agrifood Systems" (IDEAS, INRAe), "Biodiversity and sustainable agriculture in the tropical Andes" (BioINCA, IRD), and participatory plant breeding networks (e.g.,"Réseau Semences Paysannes"). C-BASC also promotes these approaches through its involvement in a local "Living Lab" (see Part 2.2). The participatory co-design process is also an object of research in C-BASC, providing the consortium with insights into the diversity of design approaches and dissemination methods.

2.2 Describe the added value of the project

The recently created Paris-Saclay University brings together 25% of the food and agricultural research community in France, and was 12th globally in the 2020 Shanghai ranking in Agricultural Sciences. CBASC brings together a substantial fraction of this research community, and provides added value by consolidating interactions between agricultural sciences and other fields of study, including ecology, sociology and climate sciences that are essential to address the university's overarching scientific and societal challenges. Nationally C-BASC is one of the few centers to assemble the wide range of disciplines in social and natural sciences essential for the study of sustainability in socio-ecological systems. Internationally, a small number of other centers have similar objectives that are backed up by a wide range of interdisciplinary staff. Two of the closest in scope and objectives are the Wageningen Environmental Research Institute and the Stockholm Resilience Center with which we have numerous contacts. Paris-Saclay University is certainly less well known than these institutes for environmental and sustainability sciences, but has the potential to achieve much greater visibility over the next several years if the scientific community is sufficiently well organized.

At the local level, C-BASC can greatly enhance the connection of the university with its surrounding communities. The member institutions of the university have historically had weak interactions with local stakeholders concerning agriculture, food systems and sustainable development. In 2013, the association Terre et Cité and the LabEx BASC initiated workshops to incite co-construction of research with local actors focusing on the preservation and management of agricultural and natural areas in and around the Saclay Plateau. We have met regularly since, and now work together in a wide range of projects including a European Union funded LEADER project (see Part 4). Our consortium is currently participating the development of a "Living Lab" that covers a larger peri-urban area (Box 2), and C-BASC will help ensure the continued development of this project[36].

Box 2. Towards a "Living Lab" for the southwest periurban area of Paris. The Living Lab is built on a collective of three agri-urban programs supported by the Paris region, farmers, citizens, local governments and researchers. Its goal is to promote the sustainability of agriculture, food systems and nature in the peri-urban areas surrounding the university. This collective recently received a grant from the Fondation de France for a "Living Lab" project focusing on creating a circular economy for food and organic matter fluxes at the local level to contribute to territorial sustainability.



In terms of the internal dynamics of the university, the Interdisciplinary Programs were initiated in part because Graduate Schools (GS), which have the mandate to organize and administer research and graduate training, are mostly in silos of closely related fields of study (with the notable exception of Biosphera, see Part 2.3). As outlined in Part 2.1, many of the overarching scientific and societal challenges of the university must be addressed with interdisciplinary approaches covering fields of study across Graduate Schools (see Part 2.3), so Interdisciplinary Programs like C-BASC help create ties across the Graduate Schools. Interdisciplinary Programs are also important for the institutional and social dynamics of the university. The creation of a multi-institutional university of an exceptional size such as the Paris-Saclay University is difficult, partly because of very different institutional cultures and priorities between universities, national research institutes and grandes écoles. C-BASC provides research and innovation opportunities offered by novel collaborations within the new university and reinforces bonds between institutions, laboratories and individual researchers.

2.3 Organisation of the project and its interactions with other objects

The C-BASC consortium

The C-BASC consortium brings together approximately 370 scientists and staff from 17 laboratories working in a wide range of fields of study (Figure 1). This is a relatively young consortium: several of the laboratories have been working closely together since the initiation of the LabEx BASC in 2012, others have joined over the last few years, and three focusing on food science — ALISS, PNCA and SayFood — are additions. Importantly, all 17 laboratories are now part of the Paris-Saclay University that was created in 2019, and will move together on the Saclay Plateau by 2022 with the exception of the CEARC and CIRED laboratories. Several scientists and teams at Paris-Saclay that are not in the core set of laboratories listed in Figure 1 have expressed interest in participating in C-BASC activities. The consortium is open to all who are interested in the objectives of C-BASC, although we will not be expanding the scope of the project in the near future in order to maintain the consortium at a manageable size. We may also require that funding proposals involve at least one person from the core set of laboratories.

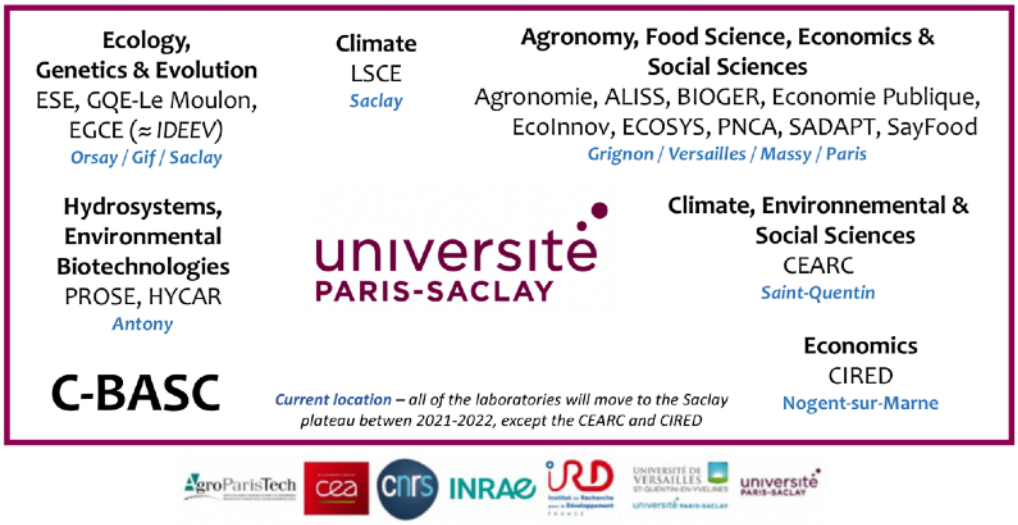


Figure 1. The laboratories, fields of study and institutions participating in the C-BASC program. *See Appendix 2 for a list of laboratories and numbers of personnel involved and Appendix 3 for a brief description of each laboratory.*

Governance

The coordination and governance of C-BASC will include three bodies, assisted by ad-hoc committees on training, innovation and other themes as deemed necessary.

- **Coordination Group** (= 1 coordinator, 2 deputy coordinators from different disciplines and 1 project manager) - is responsible for day-to-day management and represents the program in discussions with institutions and, when appropriate, non-academic partners. It will meet weekly or semi-weekly.
- **Steering Committee** (= Coordination group, 17 laboratory directors or their representatives, and 5 Graduate School representatives) - is the decision-making body. It discusses the strategies for research, training and innovation; monitors the progress of projects and networks; and elaborates and evaluates calls for proposals. It will meet quarterly, and be mobilized more frequently by e-mail.
- **Institutional Council** (= Coordination group, 1 representative of each parent institution) is an advisory body that ensures the alignment of C-BASC with the strategies of its parent institutions (see Figure 1), and provides strategic guidance. It will meet annually.

Interaction with Graduate Schools

Graduate Schools (GS) and C-BASC, like all the Interdisciplinary Programs at Paris-Saclay, have a common mission of reinforcing the interactions between research and training at the Master's and Doctoral levels. Compared to the GS, C-BASC has a stronger emphasis on research and on creating ties across GS to reinforce interdisciplinarity. C-BASC is associated with five GS as shown in Figure 2. The areas of research and training that are of shared interest, interactions on research themes and common graduate training programs are indicated in Figure 2. C-BASC has the most in common with the GS Biosphera, but has important ties with other GS based on shared interests and a significant number of researchers in C-BASC associated with them. An exception is the Sociology and Political Sciences GS, since only a few

researchers in C-BASC are associated with this GS, but both parties are interested in strengthening these ties.

Graduate Schools have the mandate to design and administer graduate training. As such, C-BASC's role is work with the GS to propose novel interdisciplinary training that is coherent with its research strategy and the needs for the "jobs of tomorrow", and work with the GS on implementation (see Part 3).

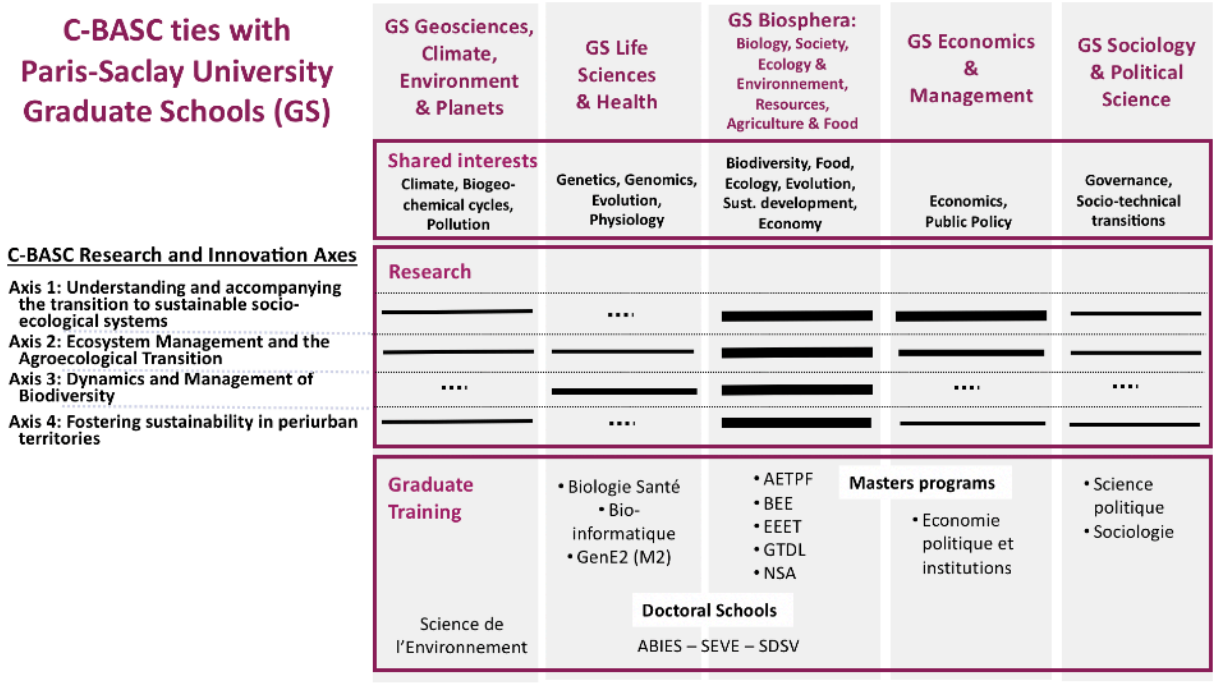


Figure 2. Relationships between C-BASC and five Paris-Saclay University Graduate Schools (GS). *Keywords in the "Shared Interests" box indicate common fields of study. Thickness of the horizontal bars in the "Research" box indicates the relative strength of the relationships broken down into C-BASC axes. Abbreviations in the "Training" box indicate Masters programs and Doctoral Schools affiliated with C-BASC and the GS. A brief description of the Masters programs and Doctoral Schools associated with C-BASC can be found in Appendix 4. Note that C-BASC will also interact with engineering degree programs at AgroParisTech that are not part of the Master's programs and somewhat independent of the GS.*

Interactions with other research consortiums at Paris-Saclay

Interactions with other consortiums focus on three topics: Land use-climate nexus: As noted in Part 2.1 the "Convergence Institute CLAND" and C-BASC both address this nexus and are highly complementary. IC-CLAND focuses on climate and land use at large regional and global scales with a macroscopic view of biogeochemistry and economics, whereas C-BASC focuses on smaller scale structures and functions and integrates much stronger biodiversity, food science and social dimensions. Interactions are already well established between these two programs, but will be intensified. **Food systems and the agroecological transition:** Plant biotechnology can potentially play an important role in the agroecological transition and C-BASC shares several researchers with a local plant sciences consortium that has this focus (Saclay Plant Sciences). C-BASC has relatively few researchers working on livestock: most of animal science scientists in the region are in a local animal sciences consortium (SAPS). Strengthening interactions with these consortiums is an important goal for C-BASC. **Transitions to sustainability in socio-ecological systems:** The "Maison des Sciences de l'Homme - Paris Saclay" has the goal of strengthening interdisciplinarity among the social sciences and between social sciences and other fields of research, with a strong focus on social transitions and innovation. C-BASC researchers participate in activities of the MSH, and the MSH has supported interdisciplinary research on the Saclay Plateau involving C-BASC researchers. Both parties wish to bolster interactions.

Part 3: Description of the methodology of reflection on “the jobs of tomorrow”

C-BASC and its five associated Graduate Schools (GS) are working together to strengthen interdisciplinary graduate and post-graduate training on several themes. Below we outline the means of implementation and interdisciplinary themes that are the subject of on-going discussions. Design and implementation will also directly involve the doctoral schools and Master's programs shown in Figure 2 (see also Appendix 4), as well as Engineering degree programs at AgroParisTech that are not part of the Master's programs in France. This strategy outlined below focuses on Master's and Ph.D. training because of the close ties between training and research at these levels. In the near future we will also open discussions on how C-BASC can contribute to undergraduate training programs.

Discussions on implementation of interdisciplinary training with the GS have focused on developing the means for Master's, Engineering and PhD students to identify and follow interdisciplinary pathways that build on existing programs. These means could include: i) creating on-line tools to help students identify interdisciplinary curriculums that correspond to their interests and opportunities in the job market; ii) developing courses that fill critical gaps in existing programs; iii) creating networks of students and professionals to provide visibility and support for interdisciplinary themes and iv) supporting the communities of practice among staff. In the short-term, we need to be modest in ambition because there are strong constraints on modifying recently validated Master's programs. As such, C-BASC, the GS and associated Master's, Engineering, and PhD programs will focus on reinforcing interdisciplinary training through creation of "summer schools" across multiple doctoral programs, optional block courses for doctoral and Master's students, project-based courses bringing together students from several disciplines to address societal challenges, and field courses that make use of the Saclay Plateau for hands-on training. Over the longer term, we may create new specialties within Master's programs.

Discussions of specific interdisciplinary themes with the GS are in early stages, in part because the newly created GS are in the midst of defining their research, innovation and training strategies. The GS Biosphera is the first of the five associated GS to have published its strategic outlook. It has identified eleven priority themes, most of which require interactions with other GS and correspond closely to themes of C-BASC including for example: Agrosciences and Agroecology; Bioeconomy; and "Territoires" and Societies. We have identified several themes with other GS where C-BASC could make contributions including climate and economy, and biomathematics. Three examples illustrate our collective approach:

Sustainable Food Systems – The food industry is rapidly taking on board Environmental, Social and Governance (ESG) analysis to identify and react to material risks and growth opportunities. Existing Master's programs at Paris-Saclay cover aspects of food system sustainability related to economics (EEET), food science (NSA) and food processing (Fipbes). The university could benefit, however, from a clearly indicated Master's curriculum covering the full spectrum of food system sustainability issues in order to address the expanding job market related to ESG in the food sector. This can be done by complementing existing programs and backing this up with the community of practice in C-BASC.

Sustainable Periurban territories - Territorial governance in France is evolving towards "Etablissements Publics de Coopération Intercommunales" generally involving one or more metropolitan areas with extended competence over the administration of water, food, climate, and energy. To handle these competences, these new entities are seeking to hire people with engineering and masters level training in interdisciplinarity and in the management of different nexuses at territorial scales. This training challenge can be met by complementing existing programs (for example the GTDL Master's program, see Appendix 4) and backing this up with the community of practice in C-BASC

Biomathematics – Graduate training programs covering aspects of biomathematics and theoretical biology at Paris-Saclay can be found in multiple GS including Biosphera, Life Sciences and Health, Geosciences, and Mathematics and in training programs for Ph.D. students. However, training in biomathematics *per se* is not particularly visible, even though it is in high demand, especially with the explosive growth of big-data analysis in biology. Several scientists in the C-BASC consortium are very active in promoting biomathematics training at Paris-Saclay and the objective of C-BASC in collaboration with the GS is to increase its visibility and support this community of practice (see Networks in Part 2.2).

Part 4: Project viability plan

The long-term viability of this consortium, like other Interdisciplinary Programs, will depend on several inter-related factors: i) the continued relevance of the overarching scientific and societal challenges; ii) support of institutions and personnel for the scientific strategy; iii) the availability of sufficient funding and personnel; iv) the impression of personnel, institutions and non-academic partners that the energy and funding invested in the consortium yields significant benefits; and v) the ability of the consortium to adapt to a changing scientific, societal and institutional context. Our viability plan focuses on a vision for the consortium over the coming decade.

There is every reason to believe that demands on universities and research institutions to address the overarching scientific and societal challenges that are the basis of our scientific strategy will only increase over the coming decade (see Part 2.1). Our scientific strategy is closely aligned with those of our parent institutions, so barring significant changes in institutional priorities it is reasonable to expect continued institutional support if we are successful in demonstrating added value of the consortium. The C-BASC proposal is built on long-term and extensive bottom-up consultations with and contributions from personnel, so we also expect continued support if we are successful in demonstrating a net benefit to the personnel involved.

With about 370 permanent employees involved in C-BASC, the investment of its parent institutions will be substantial. It is essential that this investment in personnel be accompanied by funding for a viable consortium. At a minimum, long-term funding needs to be at a level that indicates institutional support, permits coordination activities, and provides seed funding. This must be accompanied by leverage effects that provide significant added funding as outlined below.

Our experience is that seed funding provided to the consortium can have substantial leverage effects through two primary mechanisms: i) funding for networking and novel collaborative research projects helps establish collaborations and carry out proof-of-concept research that allows researchers to successfully apply for follow-up grants at local and national levels and ii) funding for coordination activities helps the C-BASC consortium to collectively obtain grants for place-based research and action.

Several examples from our experiences with the LabEx BASC illustrate the capacity of network and project funding to contribute to follow-up projects that leverage new sources of funding. Research on the contribution of organic matter additions to soil fertility and on the impacts of urbanization on biodiversity on the Saclay Plateau arose from BASC funded networks and projects and then went to successfully obtain funding from the "Pour et Sur la Développement Régionale" (PSDR) program and from an EU LEADER program[37]. Additional work on the urbanization and biodiversity topic has subsequently been funded by the Paris region and by the Maison de la Science de l'Homme (MSH)[38]. Another example is the work of A. Cornille, formerly a thesis student in the ESE lab and now a researcher at the GQE-Le Moulon lab, who was investigating the domestication of apples. Funding for two small projects from the LabEx allowed her work to take on broader dimensions, such as the study of co-evolution of insect pests, and to expand partnerships. This led to winning highly competitive CNRS ATIP funding for young researchers, and gaining substantial additional support for continued research on the topic[39]. In total, projects arising from LabEx BASC projects have raised approximately 5900k€ in leveraged funding by these mechanisms. We expect that C-BASC will continue to be successful in this regard, but acknowledge this will be challenging due to lower funding of C-BASC compared to the LabEx.

The LabEx BASC successfully contributed to several grant applications though the collective participation of the coordination team and groups of scientists. We have been particularly successful in obtaining funding for place-based research and innovation, especially for projects focusing on the Saclay plateau and its surroundings. Notable successes have been participation in projects coordinated by our partner Terre et Cité, including an EU LEADER project focusing on the Saclay Plateau[40] (1200k€), a "Fondation de France" project focusing on local fluxes in the "Living Lab" (100 k€) (see Part 2.2). Substantial additional opportunities for funding these types of research partnerships are opening up for C-BASC, reinforced by the coalescence of the partnership behind the "Living Lab" for the southwest Paris peri-urban area (see Part 2.2). We will extend this approach to collaboration with consortiums working on similar place-based research in France and internationally as part of our quest to share knowledge and seek generalizations that can contribute to the ecological and agroecological transitions at "territorial" scales. An example of

this is EU/USA funding to establish collaboration between consortiums in the southwest Paris and Santa Clara, California ("Silicon Valley") focusing on climate change, biodiversity and sustainable agriculture issues in peri-urban regions[41] (40k€). More broadly, we will continue to monitor regional, national and EU calls for proposals that provide opportunities for participation of the C-BASC community led by the coordination team. The next round of European Union funded projects could be of particular interest given the high visibility of "Green Deal" related research in the current discussions on the post-Horizon 2020 research agenda.

Our experience also suggests that interventions by coordination team are not particularly relevant for the large majority of research grants that encourage collaboration between sites rather than within sites (e.g., EU research calls, most of the French national research funding agency calls). These grants often limit participation to a small number of researchers per site, so individual researchers and teams are better placed to successfully participate in these types of proposals. This highlights the importance of seed funding from the university for networks and projects that emphasize within-site collaborations, because it fills an important niche for which we see no other obvious source of support.

A large part of our five-year budget is allocated to coordination activities, especially for a Project Manager for reasons we detail in Part 5. Funds allocated to coordination would be substantially reduced if one of our parent institutions were to take on the Project Manager position as a permanent contract (as they have done for the IC-CLAND consortium) or a civil service position (see Part 5). For this to happen, we will need to clearly demonstrate that C-BASC provides substantial added value, and we hope to do so before the end of the five-year period.

Along with our parent institutions we intend to evaluate the added value of C-BASC after about four years. If our institutions and the personnel see clear added value, we will adapt the project to new challenges and request an extension of funding for the consortium. In the absence of clear added value or a minimal budget support beyond 5 years we will discontinue the project.

Part 5: Budget request and its justification

Budget Request

Based on our discussions with the Paris-Saclay University, we should expect the budget outlined below. This budget is based on: i) roughly half of what was requested in unsuccessful renewal proposal of the LabEx BASC for the years 2021 and 2022 which would be allocated to C-BASC (≈ 230 k€ per year), ii) 105 K€ remaining from the LabEx BASC that will become available in the 2nd trimester of 2021, iii) 100 k€ per year for the years 2023-2025. It is our current understanding that this corresponds to what we can reasonably expect to receive ("advised budget"). We do, however, also provide a more optimistic budget in case additional funding becomes available for years 3-5 ("optimistic budget").

Table 1: *Budget request from the Paris-Saclay University "Interdisplinary Program" funding. All amounts are given without accounting for overhead.*

Year	Advised Budget	Optimistic Budget
1 -2021	230 k€ + ≈105 k€ rollover from LabEx BASC	230 k€ + ≈105 k€ LabEx BASC
2 - 2022	230 k€	230 k€
3- 2023	100 k€	150 k€
4 - 2024	100 k€	150 k€
5 - 2025	100 k€	150 k€
Total	865 k€	1015 k€

Funding priorities:

- Project Manager – A Project Manager is an indispensable part of the proper functioning of a large consortium based on our experience as well as that of the other LabEx and consortiums at Paris-Saclay that we interact with. The Project Manager in this case would have responsibility for: i) Participation in the general coordination including governance, dissemination of information and preparation of reports; ii) Coordination of communication, scientific networking, and partnerships; iii) Coordination of the administrative and financial management; and iv) Interacting with the Graduate Schools especially concerning training programs. Our experience in the LabEx BASC shows that this is a lot for one person to handle, but can be managed by a person with minimum of a Master's degree. In order to be competitive on the job market in the Paris region we need to provide a salary of about 55 k€ / year (all charges included). In the optimistic budget we are hoping that one of our parent institutions will take on this position as a permanent contract or civil service position.
- Functioning of the coordination office – This covers office material for Project Manager and travel to meetings on behalf of the consortium by the Project Manager or Coordinators.
- Networking – This would include modest funding for each of the 3 networks (See Part 2.1). The budget includes a small amount for local workshop organization and invited experts.
- Communication – Modest funding for booklets, flyers, kakemonos, etc. Note: the Project Manager is responsible for communication and interaction with the university communication unit.

- Training – Co-funding for inter-doctoral or inter-Masters "summer schools" and other inter-Graduate School actions (see Section 3). Note: the Project Manager is responsible for interactions with GS who take care of organization and administration.
- Small grants for emerging research topics, and for valorization with non-academic partners- These small grants (≈10-20 k€ per project) will be based on call for proposals with simple application procedures. As was the case in the LabEx BASC, we will emphasize novel collaborations between teams and with non-academic partners in these calls. Calls would be launched in 2021, 2022 and 2023 so that projects that were initiated would be finished by the end of the 5-year funding cycle. Most of the personnel involved in C-BASC when polled have strongly favored a small grants program as opposed to funding a very small number of larger grants given the modest overall budget.

Tentative Expenditures

The expenditures are presented as 5-year totals with no detail for annual budgets of the small grants program (Table 2). The funding allocation within grants program is purposely somewhat vague because it is not entirely clear when we can initiate spending and because we wish to have flexibility on allocation to emerging vs. partnership grants based on the number of submissions. In addition, our discussions with the university budget office indicate annual budget carryover will not be allowed with the possible exception of 2021 to 2022, so we will need to decide how to manage the year-to-year budgets for the calls for proposals. Note that a 17% increase in income in the optimistic budget compared to the advised budget and moving part of the Project Manager salary to institutions provides a 44% increase in funds allocated to the small grants program which we feel is very important part of the leverage that C-BASC has to implement its research and innovation strategy.

Table 2: *Tentative allocation of "Interdisciplinary Program" funding to C-BASC activities over 5 years. As in Table 1 all amounts are gross and do not take into account overhead. The Project Manager salary includes employer withholding. Note that the optimistic budget assumes that one of our institutions takes over the Project Manager salary after 3 years.*

Budget Item	**Advised Budget**	**Optimistic Budget**
Project Manager	275 k€ = 55 k€ / year * 5 years	165 k€ = 55 kEuros / year * 3 years
Functioning	40 k€ = 8 k€ / year * 5 years	50 k€ = 10 k€ / year * 5 years
Networking	24 k€ = 3 networks * 8 k€	30 k€ = 3 networks * 10 k€
Communications	40 k€ = 8 k€ / year * 5 years	55 k€ = 11 k€ / year * 5 years
Training	40 k€ = 8 k€ / year * 5 years	75 k€ = 11 k€ / year * 5 years
Small grants	445 k€ over 3 years (2021-2023)	640 k€ over 3 years (2021-2023)
Totals	**864 k€**	**1015 k€**

Appendix 1: Graduate Schools involved in the project

Graduate Schools involved in the project

GS BioSphERa	**x**	GS Geosciences, Climate, Environment and Planets	**x**	GS Health and Drug Sciences	
GS Chemistry		GS Cultural and Heritage Science		GS Public Health	
GS Computer Science		GS Life Sciences and Health	**x**	GS Engineering and Systems Sciences	
GS Law		GS Mathematics		GS Sociology and Political Science	**x**
GS Economics and Management	**x**	GS Occupations in Research and Higher Education		GS Sport, Movement, Human factors	
GS Education, Teaching, Training		GS Physics		The Institute of Light Sciences	

Appendix 2: List of participating teams

Surname and name of the Director (contact scientist*)	Laboratory/Team name	Number of faculty members (researchers + lecturer-researchers) and engineers / technicians participating in the project
Muriel Valantin-Morison	Agronomie	30
Olivier Allais	ALISS	7
Sabine Fillinger	BIOGER	12
Jean-Paul Vanderlinden	CEARC	4
Franck Lecocq	CIRED	5
Antoine Messean	Eco-Innov	3
Stéphane De Cara	EcoPub	17
Sabine Huout	ECOSYS	80
Laure Kaiser-Arnauld	EGCE	32
Jane Lecomte	ESE	61
Christine Dillmann	GQE-Le Moulon	13
Vazken Andréassian	HYCAR	15
Philippe Bousquet Nathalie de Noble-Ducoudré*	LSCE	10
Claire Gaudichon	PNCA	8
Théodore Bouchez Laurent Mazéas	PROSE	10
Philippe Martin	SAD-APT	43
Catherine Bonazzi	SayFood	20

Notes:

• Overall we estimate that there will be approximately 370 permanent personnel participating in C-BASC. This is coherent with the number of personnel who were actively involved in the LabEx BASC (e.g., who participated in funded projects, contributed to committees, frequently participated in BASC conferences and workshops, etc.), plus new personnel arriving from food science labs who have expressed interest in the project. As such, we believe this is a conservative estimate of participation.

• In almost all cases the number of personnel that are likely to participate in C-BASC is less than, and sometimes substantially less than (e.g., LSCE) the total number of permanent personnel in the laboratory. However, in many cases participants are from multiple teams within a laboratory and so we have listed participation by laboratory, rather than by teams.

Appendix 3: Brief description of research themes of participating laboratories and teams

Note that in most cases not all researchers in laboratories will be involved in C-BASC activities. The number of participating researchers per laboratory is indicated in Appendix 2 above.

Agronomie (UMR 211) – focuses on the assessment and design of sustainable cropping systems. An original feature of our work is to conduct these activities at different scales, from the field to global scales. Our activities are organized into three themes (1) Understanding and managing biological interactions, (2) Design and assessment of technical systems, (3) Global agronomy.

ALISS : Social Sciences and Food (UR 1303) – produces knowledge aiming at understanding the behaviors and the strategies of the food system actors in the perspective of the design and assessment of food policies.

BIOGER: BIOlogie et Gestion du Risque en agriculture (UMR 1290) – focuses on research on fungal diseases of European field crops (esp. wheat, rapeseed) and grapevine. Bioger undertakes multidisciplinary (including genomics, molecular biology and biochemistry, cell biology, genetics, evolution, epidemiology, modelling, phenotyping and taxonomy) and multiple scales (from gene to landscape) approaches.

CEARC: Cultures, Environnements, Arctique, Représentations, Climats (EA 4455) – members interested in BASC aim to build a transdisciplinary practice by focusing on the analysis of the interactions between human societies and their changing environments, notably climate change. This field is anchored in the economic and social sciences and humanities, yet also mobilizes climate sciences, well-being analysis, land use analysis and land use planning.

CIRED: Centre International de Recherche sur l'Environnement et le Développement (UMR 8568) – investigates the relationships between environment, natural resources and development, with focus on three key domains: energy, urban infrastructure, and agriculture and forestry. There is a strong emphasis on constant dialogue between social sciences, natural sciences and engineering knowledge to address these relationships.

Eco-Innov: Impacts ECOlogiques des INNOVations en productions végétales (UAR 1240) – aims to design technical and organizational innovations in plant production with three objectives: 1) generic methodologies to predict impacts of innovations at the scale of ecosystems; 2) design of innovative and sustainable production systems; 3) improvement of the assessment of innovations in support of public policies.

EcoPub: Economie Publique (UMR 210) – focuses on market mechanisms and the design of public policies in the fields of agriculture, land use, food, trade, and the environment. Empirical economics methods and theoretical approaches are used to shed light on the behavior of economic agents and the efficiency of public policy instruments. NB: The ALISS laboratory and EcoPub will be merging in 2021 (see ALISS lab description).

ECOSYS: Écologie fonctionnelle et écotoxicologie des agroécosystèmes (UMR 1402) – focuses on an integrated approach to study the functioning of agroecosystems and their relationships with the environment, especially through functional ecology and ecotoxicology concepts. They contribute to the quantification and forecast of ecosystem services through modeling of agronomic, environmental and health performances of agroecosystems under global changes pressure.

EGCE: Evolution, Génomes, Comportement, Ecologie (UMR 9191) - focuses on the forces and processes governing evolution (such as adaptation, speciation, genomes – environment interactions, interactions between species within ecosystems, individual behavior or genome plasticity) and its corollary, biodiversity. The approach is multidisciplinary (from genetics, genomics, physiology to ecology) and

combines field/experimental studies and modeling. It includes collaborations with Southern countries for sustainable development.

ESE: Ecologie, Systématique, Evolution (UMR 8079) - focuses on the origin and dynamics of biodiversity and their evolution, as well as ecosystem functioning via a multi-scale approach from genes to ecosystems. A transverse theme concerns the consequences of global changes for populations, communities and ecosystems, and responses to such changes. We combine in situ observations, experimentation, and mathematical modeling.

GQE-Le Moulon: Génétique Quantitative et Evolution-Le Moulon (UMR INRAe 0320/CNRS 8120) - focuses on the genetic and environmental determinants of complex trait variation at intra- and inter-specific levels, to understand the adaptation and evolution of populations/species and propose innovative breeding methods. A recent focus on agroecology has stimulated integration of environmental and social dimensions in models, and work on species interactions.

HYCAR - Hydrosystèmes Continentaux Anthropisés - Ressources, Risques, Restauration (UR INRAe) - research is organized around three key disciplines – hydrology, ecology, ecological engineering – and addresses water resources (quality and quantity), water-related risks (assessment, anticipation and management of hydrological hazards-related risks) and restoration of inland waters ecosystems subject to high human pressure.

LSCE: Laboratoire des Sciences du Climat et de l'Environnement (UMR 8212) - is one of the largest laboratories in France in climate and environmental studies, heavily involved in the writing of IPCC reports. Specific C-BASC-linked research includes: understanding how changes in land-cover and uses impact climate and atmospheric composition; tracking pollutions in soils, air and rivers; modelling the functioning of natural and agroecosystems, and of soil carbon sources/sinks.

PNCA: Physiologie de la Nutrition et du Comportement Alimentaire (UMR 914) - addresses the consequences on population health of diet, especially protein, transitions as well as the levers to achieve food choices in respect with sustainable food systems.

PROSE: PRocédés biOtechnologiques au Service de l'Environnement (UR INRAe) - focuses on environmental biotechnologies for the valorization of organic waste and effluents as bioressources contributing to the development of the bioeconomy. The natural diversity and conversion abilities of microbial ecosystems are harnessed in innovative environmental technology processes for the production of bioenergy or platform molecules for green chemistry applications.

SAD-APT: Sciences Action Développement Activités Produits Territoires (UMR 1048) - combines life and social sciences to study the dynamics of socio-ecological systems in agriculture (temperate, urban and peri-urban). They explore technical and social innovation for solving complex agricultural and ecological issues, as well as analyze multi-level governance and territorial development of rural areas, linking land uses and food systems.

SayFood – Food and Bioproduct Engineering (UMR 782) – is the result of the merger of GENIAL and GMPA and aims to propose new approaches in product and process engineering to develop new sustainable food systems (from design to consumption), with an integrated, innovative and interdisciplinary vision, including food science, microbiology, (bio)process engineering and consumer science.

Appendix 4: Brief description of associated Masters programs and Doctoral Schools

Master's programs

AETPF « Agrosciences, Environnement, Territoires, Paysage, Forêt »: This Master trains scientists who will intervene in agricultural production, the environment, and landscape and territorial governance.

BEE « Biodiversité, Ecologie et Evolution »: This Master trains students to be capable to understand and solve problems concerning biodiversity based on a good knowledge of the ecology, evolution and functioning of the living in interaction with its environment.

« Bio-informatique »: The Master's degree in Bioinformatics focuses on the high-level research and development requirements of companies and research organisations in bioinformatics, biostatistics and biotechnology, as well as life sciences and agronomy.

« Biologie-Santé »: This master gives a base of scientific knowledge and common skills and takes into account the reciprocal issues for Biology and Health. The principal link with C-BASC is with the Master M2 Gen2EV: Génétique, génomes et evolution - the objective of which is to train M2 students in the concepts and technologies of genetics and genomics today, regardless of the biological model.

Economie politique et institutions - This economics Master trains students who can become specialists in regional planning issues, with a focus on institutional approaches, as well as executives in various fields at the crossroads of public policy: development, tourism, sports and nature recreation, preservation of the environment, etc., in connection with local or international institutional actors.

EEET « Economie de l'Environnement, de l'Energie et des Transports »: This Master structures training in environmental economics in the Paris region, and is the main Master on this topic in France.

GTDL « Gestion des Territoires et du Développement Local »: This Master aims to equip the students with the necessary skills to analyze and anticipate, to sensitize, train and mobilize the actors around adaptive and innovative collective strategies.

NSA "Nutrition et Sciences des Aliments" : This master trains students to understand the interactions between food, diet and more largely food systems and health in individuals and populations. It brings together many disciplines such as food sciences and food process, consumer sciences, microbiology, toxicology, nutrition, epidemiology, neurosciences. This Master includes the Erasmus Mundus Joint Master Degree "Food Innovation and product design (Fipdes)".

« Science Politique »: The aim of this Master is to provide training in political science related to public policy. More precisely, this is focused on three main themes: local and national public action; international public action; and policy-related communication.

« Sociologie »: The sociology Master aims to train advanced specialists in this field of study. Trained in the theoretical and methodological developments of sociology, graduates will be able to put their knowledge to use in various demanding and stimulating professional contexts, primarily in research and tertiary-level teaching in the field of social sciences, and as experts in public and private organisations.

Doctoral Schools

ABIES « Agriculture, alimentation, biologie, environnement, santé »: is a thematic Doctoral School involving the following fields of research: Agronomic and environmental sciences, landscaping techniques and sciences (38% of the doctoral candidates), Food processing sciences (13%), Life sciences and health, plant and animal sciences (30%), Economic, social and management sciences applied to agriculture, food and the environment (14%), Engineering sciences applied to living matter

and the environment (5%).

SEVE « Sciences du végétal : du gène à l'écosystème »: is the only French doctoral school dedicated to the study of plants and their relationships with the environment. Research covers a broad range disciplines such as genetics, genomics, cell and molecular biology, physiology and metabolism, ecology and ecophysiology.

SDSV « Structure et dynamique des systèmes vivants »: is a doctoral school of biology addressing research in both its fundamental and applied aspects.

« Sciences de l'Environnement d'Ile de France »: covers multidisciplinary fields related to the understanding of the physical, chemical and biological equilibrium of the earth's environment.

Appendix 5: References

Note: Links to research pages lead to short descriptions and video presentations of work by researchers in the C-BASC consortium. The links take you to French language versions, but most pages are available in English by selecting "English" in the upper righthand corner of the web page. Videos are in French on YouTube. You can get moderately good automatic English translation by turning on subtitles in YouTube ("CC" button at bottom right of the video) and then selecting "Autotranslate" in Settings (click on gear shaped button at bottom right, then select "Subtitles/CC" and then select the "Autotranslate" option, then select the language to translate to).

[1] IPBES (2019) Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. E. S. Brondizio, J. Settele, S. Díaz, and H. T. Ngo (editors). IPBES secretariat, Bonn, Germany.

[2] IPBES (2019) / European Environment Agency. (2020) State of nature in the EU: Results from reporting under the nature directives 2013-2018

[3] IPCC (2019) Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems [P.R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.-O. Pörtner, D. C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M. Belkacemi, J. Malley, (eds.)].

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[5] IPBES (2019), IPCC (2019a), IUCN Nature-Based Solutions Web Site

[6] EU Green Deal - Main Web Page & EU Green Deal - Communication Brochure

[7] Nilsson, M., Chisholm, E., Griggs, D., Howden-Chapman, P., McCollum, D., Messerli, P., Neumann, B., Stevance, A.S., Visbeck, M., Stafford-Smith, M. (2018). Mapping interactions between the sustainable development goals: lessons learned and ways forward. Sustain. Sci. 13, 1489–1503. https://doi.org/10.1007/s11625-018-0604-z

[8] Ministry of the Ecological Transition Web Site & Ministry of Agriculture - Agroecology Web Page – both in French only

[9] INRAe Research Strategy / AgroParisTech Brochure (see esp. pg 40) / Paris-Saclay University Research Strategy / CNRS INEE Research Strategy / IRD Web Site & IRD Research Strategy / CEA - Climate and Environment

[10] Wezel, A., Bellon, S., Dore, T., Francis, C., Vallod, D., David, C. (2009). Agroecology as a science, a movement and a practice. A review. Agron. Sustain. Dev. 29, 503–515. https://doi.org/10.1051/agro/2009004

[11] Wezel et al. (2009).

[12] Paris-Saclay University Research Strategy

[13] CLAND web site

[14] Future Earth Web Site / French National Research Strategy see also Footnote 9 for institutional strategies

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[17] Toffolini Q, Jeuffroy MH, Meynard JM, Borg J, Enjalbert J, Gauffreteau A, Goldringer I, Lefèvre A, Loyce C, Martin P, Salembier C, Souchère V, Valantin-Morison M, Van Frank G, Prost L, (2020). Design as a source of renewal in the production of scientific knowledge in crop science. Agricultural Systems, 185, 102939 https://doi.org/10.1016/j.agsy.2020.102939

Co-design and transformative change in socio-ecological and socio-technical systems - presentations of research by C-BASC scientists:

Stimulate collective innovation capacities + Video - INDISS

Les réseaux socio-écologiques dans un monde en mutation + Video - SENAC

Evaluation of processes, methods and variables for the potential Mediterraneanization of socio-ecosystems in Western Europe - Tplus3

[18] **Interactions between land use, climate, air pollution and hydrology - presentations of research by C-BASC scientists:**

Urban heat islands and their interactions with air pollution - GaLoP

To what extent can a better knowledge of Biosphere-Atmosphere interactions help to better manage land use? - Flagship Project - Land use-Climate Feedbacks

Emissions de composés azotés par les cUltures à l'échelle régionale : REtroaction sur le fonctionnement des couverts via l'impact sur la Chimie Atmosphérique sous différents scénarios d'occupation des terres + Video - EURECA

The impact of pollutants on ecosystems in a context of global change: from knowledge to action + Video - CONNEXION

Development of an agricultural drain detection method: hydrology issues of the Saclay plateau + Video - DRAIN-ACT

[19] **Economics of transitions and decision making - presentations of research by C-BASC scientists:**

Agroecology and public policy instruments for sustainable multifunctional agricultural landscapes + Video - API-SMAL

Scenarios Towards Integrating Multi-scale Land-use tools + Video - STIMUL

[20] See footnote 18

[21] **Agroecology - presentations of research by C-BASC scientists:**

Greening agriculture through exogenous organic matter and legumes to foster ecosystem services + Video - LEADER PROLEG

Assessing biodiversity and beneficials in agroecological cropping systems through a network of stakeholders + Video - BASCULER

Designing wheat varietal mixtures in organic agriculture + Video - CASABio

Understanding the determinants of the corn-bean association: agricultural practices, plant-soil interactions and nutrition + Video - CoCulture

See also API-SMAL

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[23] **Forest management - presentations of research by C-BASC scientists:**

Adaptation to climate change of territories, linked to biodiversity - Video - Act-Lab

What are the impacts of the wood-energy policy in Provence-Alpes-Côte d'Azur region? + Video - FIBIOS

[24] **Climate impacts and adaptation - presentations of research by C-BASC scientists:**

What is the adaptive potential of fungus poluations responsible for wheat septoria to climate change? + Video - SEPTOVAR

See also Act-Lab / InSPRED / GaLoP / Flagship Project - Land use-Climate Feedbacks

[25] Assessing ecosystem services in transitioning agro-ecosystems + Video - ASSETS

[26] See footnote 20

[27] See INDISS footnote 16

[28] **Dynamics and Management of Biodiversity - presentations of research by C-BASC scientists:**
Integrative approaches of maize flowering time variations + Video - Itemaize
Adapative responses of insects face to anthropic pressures + Video - RADIANT
The service of regulation by predation + Video - Ravageurs
The dynamics of biodiversity and ecosystem services during peri-urban development - Dynamiques
Evaluer le caractère évolutif d'un champignon pathogène dans le contexte de changement global - EVOFUNGI
Prédire la réponse des insectes tropicaux ravageurs des cultures en Afrique subsaharienne - InSPRED
A conservatory, experimental and educational orchard of wild apple trees on the Saclay plateau + Video - Verger
Understanding and improving the adaptive capacity of agroecosystems through knowledge of genetics and evolution + Video - Flagship Project - Adaptation, Genetics, Evolution
Temporal evolution of bacteria fungi proportions in forest soils in spring + video - PRINTEMPS

[29] **Fostering sustainability in periurban territories - presentations of research by C-BASC scientists:**
Assessing ecosystem services in transitioning agro-ecosystems + Video - ASSETS
Towards the Sustainable Development of Peri-urban Areas - Flagship Project 4 - Periurban sustainability
Toits potagers et extensifs : biodiversité, sols et pratiques - Video - TROL
A 1:50,000 scale soil map for the Saclay plateau - Cartographie des sols
See also DRAIN-ACT / Ravageurs / Dynamiques / Terribio project footnote 37

[30] EcoBASC - BASC ecotoxicologists network - EcoBASC

[31] Models developed by and/or used by C-BASC scientists: https://www6.inrae.fr/basc_eng/Research/Models

[32] Agroecology network - Réseau AE

[33] See footnote 16

[34] A-FORCE – a start-up specializing in optical sensors for agriculture associated with the ESE lab www.force-a.com

[35] **Decision support tools - presentations of research by C-BASC scientists:**
Relocate wild plant species to improve the viability of their populations + Video - TranslocPlant
RPG Explorer Booster + Video - R&B
Other examples of decision support tools developed by and/or used by C-BASC scientists - Tools for Stakeholder Interactions

[36] terreetcite.org/vers-un-living-lab-agriculture-et-alimentation/

[37] LEADER PROLEG / Verger / Dynamiques / Cartographie des sols

[38] Terribio project - https://www.media-paris-saclay.fr/terribio-ou-comment-valoriser-les-productions-alimentaires-locales-rencontre-avec-romain-melot/

[39] A conservatory, experimental and educational orchard of wild apple trees on the Saclay plateau + Video - Verger

[40] terreetcite.org/avec-le-programme-leader/

[41] www.universite-paris-saclay.fr/en/news/highlights-franco-american-webinar-climate-biodiversity-solutions